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40 ani de geomorfologie organizată în România

Desfășurarea celui de al XXII-lea Simpozion Național de Geomorfologie la Oradea în 7 și 8 aprilie 2006 ne-a oferit prilejul unei retrospective a manifestărilor organizate de geomorfologii români în perioada 1966–2006. Ca participant activ la manifestările respective ne putem permite, în deplină cunoștință de cauză, o analiză a realizărilor de până acum și o schițare a tendințelor de dezvoltare în viitor.

Ca orice știință, geomorfologia a trecut prin mai multe etape de dezvoltare, fiecare reflectând un anumit spirit al timpului respectiv. Ultimii 40 de ani au cunoscut desfășurarea unui efort continuu pentru organizarea reuniunilor anuale, uneori bianuale, a geomorfologilor, prilejuri de prezentare a rezultatelor cercetărilor și de discuții. În toată această perioadă a existat un grup activ de geomorfologi specialiști proveniți din facultățile de geografie ale universităților, din Institutul de Geografie al Academiei Române, sau de la alte institute de cercetare de profil, la care se adăugau cadre didactice din învățământul preuniversitar pasionate de studiul reliefului. Treptat s-a creat o tradiție a reuniunilor anuale care a consolidat și dezvoltat nucleul geomorfologilor specialiști, contribuind la creșterea interesului pentru cunoașterea și înțelegerea reliefului în sfere din ce în ce mai largi.

Nu este deci de mirare entuziasmul cu care s-a trecut, în aprilie 1990, la înființarea Asociației Geomorfologilor din România (AGR), prima reuniune a membrilor Asociației desfășurându-se la Cluj-Napoca, în luna noiembrie a aceluiași an, în cadrul celui de al XIII-lea Simpozion Național de Geomorfologie.

Formarea unui grup de geomorfologi preocupat continuu de dezvoltarea științei lor își are rădăcina în discuțiile desfășurate în cadrul simpozionului internațional de geomorfologie aplicată derulat între 25 mai și 4 iunie 1967 la București și Cluj-Napoca. Organizat de Comitetul Național de Geografie din România în colaborare cu Uniunea Geografică Internațională, cu sprijinul Academiei Române și Ministerului Învățământului, Simpozionul a reunit geomorfologi români din mai multe generații, la care se adăugat personalitățile cele mai importante ale momentului din Europa (J. Tricart, J. Dresch, J.P. Bakker, M. Klimaszewski, J. Roglic, J.F. Gellert, T. Gerlach, L. Starkel, K. Klimek etc.). Organizarea impecabilă a acestui simpozion s-a datorat geomorfologilor din generația mai puțin cunoscută în prezent reprezentată prin T. Morariu, V. Mihăilescu, V. Tufescu, N.Al. Rădulescu, C. Martiniuc, V. Băcăoanu, N. Popp, M. Iancu, P. Coteț.

Câțiva ani mai târziu asistăm la prima inițiativă de organizare a unor discuții tematice în cadrul unor simpozioane la care să participe majoritatea geomorfologilor din țară. Această inițiativă a aparținut profesorului Gr. Posea și colaboratorilor săi mai tineri (I. Ilie, N. Popescu, M. Ielenicz, E. Vespremeanu) și s-a concretizat prin desfășurarea primului simpozion național de geomorfologie la Brașov între 1 și 4 iunie 1972. Tema simpozionului, „Realizări în studiul

reliefului României în ultimii 25 ani“, a impus realizarea unor sinteze la nivel regional și pe probleme. Sintezele regionale au vizat toate unitățile de relief din România, dar mai ales Carpații și Subcarpații. Principalele probleme dezbătute s-au referit la pedimentele, piemonturile, terasele, glacisurile, carstul, suprafețele de nivelare, din România.

Simpozionul de la Brașov, din 1972, a prezentat o importanță deosebită pentru geomorfologia românească din cel puțin două motive: (i) a fost primul moment de sinteză geomorfologică națională nerepetat, din păcate, până în prezent și (ii) a catalizat energiile geomorfologilor români de toate vârstele prin hotărârea de a se organiza anual asemenea întâlniri.

După primul simpozion de la Brașov au urmat 21 de simpozioane, fiecare cu anumită tematică, dar în special legată de valențele practice ale geomorfologiei în consonanță cu solicitările și comenzile sociale specifice perioadei istorice prin care trecea România. De cea mai mare însemnătate au fost aplicațiile practice de teren care urmau fiecărui simpozion, prilej de analiză în natură a problemelor reliefului din diferite regiuni ale României.

Dintre aceste simpozioane unele au reprezentat momente de cotitură în dezvoltare geomorfologiei românești. Astfel, al V-lea simpozion desfășurat la Suceava în anul 1981, se remarcă prin organizarea primei mese rotunde cu tema „Regionarea geomorfologică a teritoriului României“, al VIII-lea simpozion, desfășurat la Zalău în 1985, prin participarea excepțională, prin prezentarea primelor rapoarte ale celor nouă comisii de lucru intersimpozioane și prin tematica foarte variată, al X-lea simpozion, desfășurat la Tulcea în anul 1987, prin implicarea directă în analiza programului de amenajare a Deltei Dunării, al XIV-lea simpozion desfășurat la Târgoviște în anul 1991, prin organizarea primului Forum al geomorfologilor români.

Tematica comunicărilor a urmat principalele direcții de analiză din geomorfologie: procese, forme, regionale, morfogeneză. Analiza proceselor actuale a avut prioritate la toate simpozioanele. Din păcate, celelalte trei direcții, dar mai ales analizele morfogenetice, au avut pondere din ce în ce mai redusă pe măsură ce ne apropiem de momentul actual. Remarcăm, în același timp, lipsa preocupărilor pentru sintezele pe probleme (suprafețe de nivelare, terase, pedimente etc.) la nivel național.

Simpozioanele desfășurate în ultimii 15 ani relevă apariția și dezvoltarea unor fenomene negative în abordările geomorfologice. Între acestea îndepărtarea de teren și ignorarea dialogului cu natura prin înlocuirea acestuia prin analizele GIS ni se par cele mai grave. La acesta se adaugă precaritatea lecturilor, prin ignorarea lucrărilor apărute în literatura geomorfologică abundentă publicate în editurile Lumii. În acest fel, rezultatele cercetărilor proprii nu sunt raportate teoretic și metodologic la realizările specifice momentului și astfel sunt scoase din contextul științific.

Revenirea cu aceleași rezultate în lucrări diferite, graba publicării unor rezultate insuficient fundamentate prin cercetări la teren, goana pentru publicarea unui număr cât mai mare de lucrări sunt alte aspecte negative care tarează mersul actual al geomorfologiei spre dezvoltare și perfecționare.

Îngrijorătoare este, de asemenea, participarea din ce în ce mai redusă a geomorfologilor de diferite vârste la simpozioanele care se organizează de Asociația Geomorfologilor din România. Continuarea acestei tendințe va duce la dispersia forțelor și la slăbire generală a interesului pentru studiul reliefului și implicit a comunității geomorfologilor români.

Suntem convinși că aceste aspecte negative sunt de moment și că se va reveni la concentrarea forțelor în favoarea dezvoltării atât a geomorfologiei în ansamblul ei național, cât și a fiecărui geomorfolog în parte.

Emil VESPREMEANU

Relative sea-level changes throughout the last 6000 years on the Taman Peninsula (Black Sea, Azov Sea, Russia): a geoarchaeological study

Eric FOUACHE¹, Alexei POROTOV², Christel MÜLLER³, Youri GORLOV⁴,
N. BOLOKHOVSKAYA², M. KAITAMBA²

Key-Words: sea-levels, geoarchaeology, neo-tectonics, Holocene, Black Sea, Russia.

The Taman peninsula is geologically attached to the western end of the Caucasus. It was the site of a Greek settlement as early as the 6th century BC. Our geoarchaeological methodology combines geomorphological, archaeological and paleoenvironmental (sedimentology, carbon-datings on sea-shells) data in order to reconstruct the evolution of the coastline. After the peak of the last post-glacial transgression, a main island and four islets were located between Crimea and the Taman peninsula. The alluviation of the Kouban river then filled the space and is the origin of the island's attachment to the mainland. At the time of the Greek colonisation the process was not over. The present sea level appears regionally to be the highest level ever reached on the peninsula over the last 6000 years. It seems that for the Anapa area and the Tchouchtchka Spit area it is possible to propose a sea-level curve characterised by a slow, continuous rise during the past 6000 years. On the Taman peninsula itself, the sedimentary record of this slow ascent has been distorted by a heavy tectonic subsidence. On at least two areas on the peninsula, we have identified this neo-tectonic subsidence effect, linked to the effect of the activity of mud volcanoes. In spite of this very active neotectonics, our data confirm the possibility for a period of downturn in seawater during the so-called « Phanagorian Regression » from the end of the 2nd millenium BP up to the 1st millenium AD.

Introduction

The Taman peninsula, situated to the south of Russia, is limited to the west by the Kerch Strait, called Bosphorus Cimmerius in Antiquity, to the north by the Sea of Azov, the Palus Maeotis of Antiquity, to the south by the *pontus euxines*, the current Black Sea, and to the East by the present Kouban delta and the vast marshy deltaic plain of the Pre-Kouban (Fig. 1). The geoarchaeological study of the Taman peninsula and the Kouban delta is the result of a partnership between the Russian Academy of Sciences, the Moscow Archaeological Institute, the Moscow State University, the French School of Archaeology in Athens, the French CNRS and the French Ministry of Foreign Affairs. The results presented here have been obtained within the

frame of the Franco/Russian archaeological survey of the Taman Peninsula, directed by Christel Müller and Youri Gorlov (Fouache *et al.* 2000).

According to the results of studies carried out over the last thirty years, it seems that the Holocene transgression in the Black Sea, which starts later than the global ocean evolution around 7500 BP (Ryan, Pitman 1998), was characterised by a succession of rapid sea-level fluctuations (Pirazzoli, 1991; Ismailov *et al.* 1989). Those fluctuations (Fig. 2) have been related mostly to climatic changes during the Holocene and the possible distortion due to the neo-tectonics factor has been neglected. The new data we obtained by drilling on the Taman peninsula confirm (Fig. 1) the

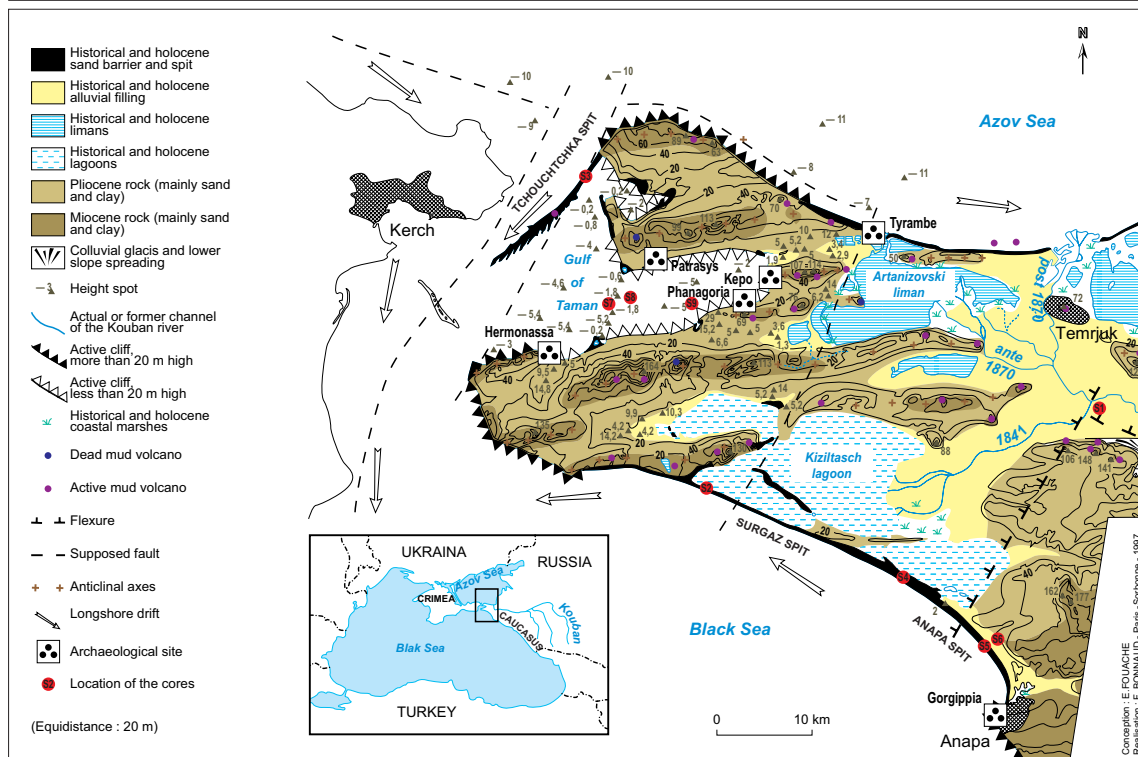


Fig. 1. Geomorphological map of the Taman peninsula

importance of the neo-tectonics effect (Fouache *et al.* 2004). It is also obvious that the Kouban river, by deposit of alluviations, is at the origin of the junction of islands to the mainland, but the main object of our study was to propose a paleogeographical reconstruction of the peninsula around 6th century BC.

The historical importance of the area during Antiquity

The period we are interested in is that of the Greek colonization in the 6th century BC. It amounted to the founding of essentially Milesian colonies such as Hermonasa, Phanagoria, Kepoi and Patrasys to name but the most important ones. From 480 BC, these cities came under the dominion of the kingdom of the Arkheanaktides of which the capital was probably Panticapaeum, the modern-day Kerch. It is the formation of the kingdom called Bosphorus, of which the most famous monarch was Leukôn 1st of the Spartocides dynasty who kept up dynamic commercial relations with Athens in the 4th century BC and expand-

ed his realm at the expense of the indigenous tribes of the Asian area, the Sindes and the Meotes. The prosperity of Bosphorus ended with the intervention of Mithradates Eupatôr at the end of the second and the beginning of the first century BC. In 10 AD, with the accession of King Aspourgos, the kingdom of Bosphorus became a trading partner with Rome for the following four centuries.

The necessity of a geoarchaeological approach

The reconstruction of the paleogeography of the peninsula during the time of the Greek colonization could not have been carried out without a close collaboration between archaeologists and geographers. The mobility of the landscape was illustrated by ancient texts as well as by the existence of submerged vestiges under the waters of the Taman Gulf. The archaeologist had three questions for the geographer.

The first question concerns the peninsula itself: was it a peninsula, an island or separate islands during the 6th century BC? We know

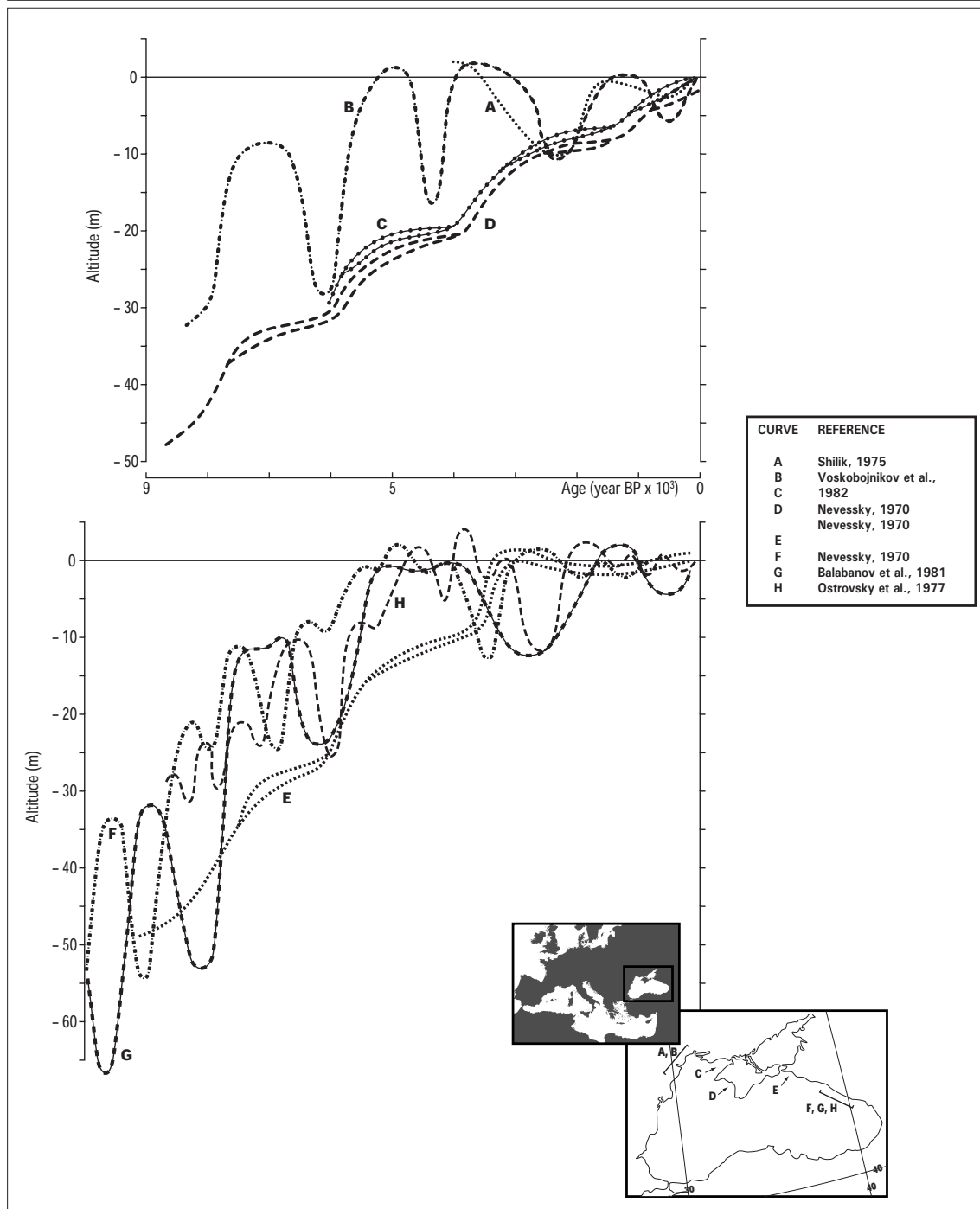


Fig. 2. Reconstitution of Holocene Sea level fluctuations in Black Sea (adapted from Pirazzoli 1991)

that the Greek cities of Asian Bosphorus were under the control of a sort of administrator, described in the document of the High Empire and called the “Island Official” (with the word *island* in the singular). We can also find, in other literary texts, many allusions to this island or to these islands where cities

were built, without being able to describe exactly their perimeter based on these sources alone. Such is the case with Strabo, Pomponius Mela, Denys of Alexandria and Ammien Marcellin.

The second question is closely linked to the first. Strabo and Pomponius Mela described

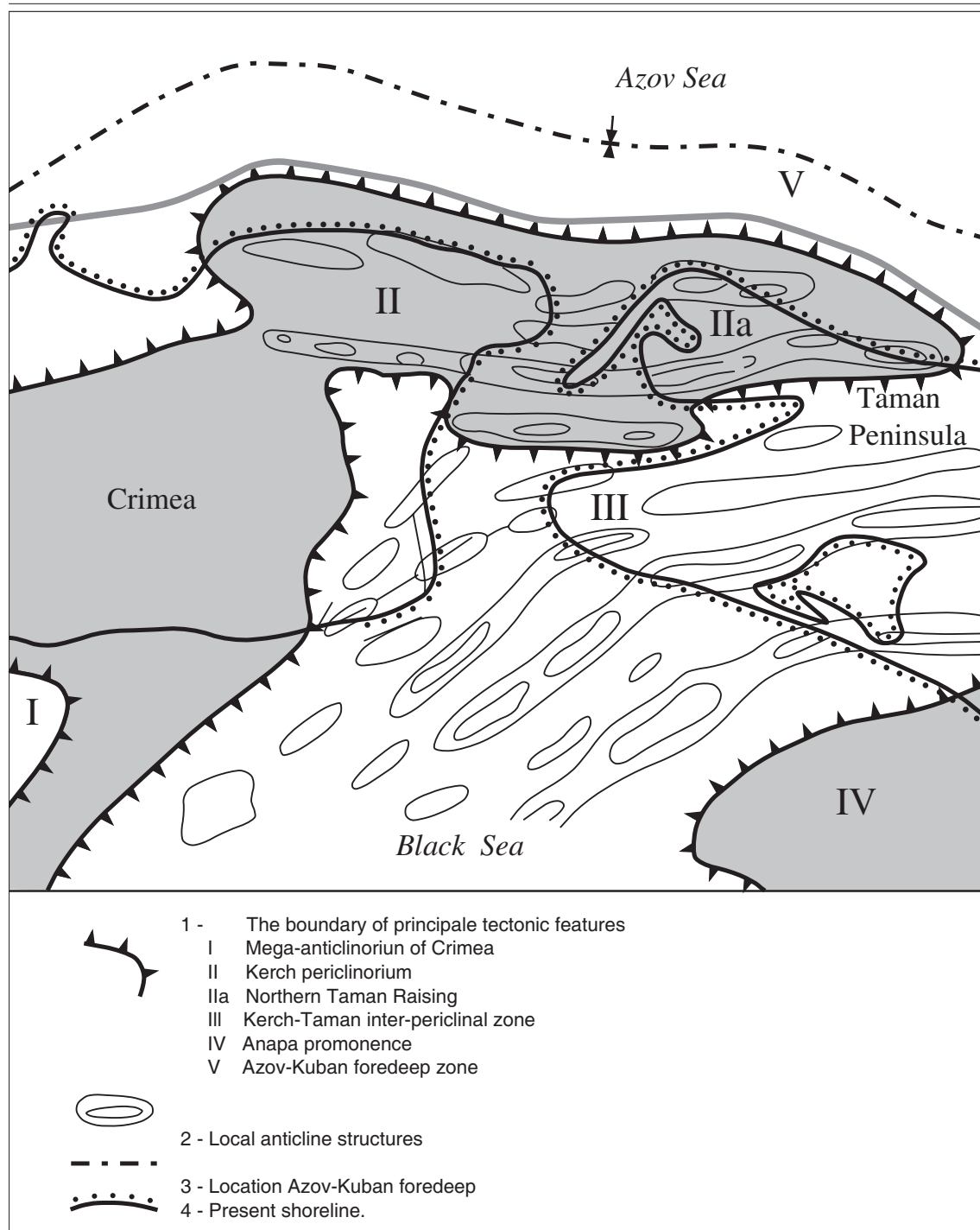


Fig. 3. The general features of geological structure of Kerch-Taman region (Andreev et al., 1976).

the former river Hypanis or Coracanda or even Antikeites in a confused way. Where should we place the ancient course of this river, which has at least two branches if these authors are to be believed?

The last question concerns the relative variations of sea level and therefore the contours

of the peninsula, which goes with the problem of the number of islands.

Methodology

For this study we have designed a geomorphological map and then we have drilled six boreholes (Fig. 1) on the peninsula down to

12 meters deep: one in the Kouban delta (S1), one on the Burgaz Spit (S2), one on the Tchouchtchka Spit (S3) and three on the Anapa Spit (S4, S5 and S6). We have also used the archival material collected in the end of the 1960s by E.N. Nevesky (1967) for the Russian Shirshof Institute of Oceanology. This material was kindly given to us by Professor L.A. Nevesky and concerns the Gulf of Taman (S7, S8 and S9). Due to practical reasons, we had to collect samples on the field and to determine the stratigraphy and lithology on the spot.

To reconstruct the relative sea-level fluctuations, it was not possible to use archaeological indicators except for determination of a global submersion since Late Antiquity (Abramov 1999, Nikonov 1994, Blavatsky 1985). We have been unable to find precise archaeological indicators, such as jetties and fishponds, on the peninsula, and the method proposed by Flemming (1979) or Pirazzoli (1979) and used by us in Turkey (Fouache *et al.* 1999) and Croatia (Fouache *et al.* 2002b), was impossible to enforce here. So we concentrated on identification of shell assemblages, characteristic of thanatocenose fauna accumulated at a medium sea level, that reflect an average position of sea-level with an error margin of ± 1 m.

Extracted shell material has been determined and paleo-environmentally interpreted (Kaplin *et al.* 2001) by T. Yanina at the Geographical Faculty of Moscow State University (Tab. 1). Classical radiocarbon dating on these shells was performed at the Geological Institute of the Russian Academy of Sciences and at the Geographical Faculty of Moscow State University. A calibration was carried out, following Stuiver and Braziunas (1993), taking into account the sea water reservoir effect.

Geological setting

The formations of which the Taman peninsula is made are found on the other side of the Kerch Strait in the Crimea. These formations are made up of Miocene and Pliocene rocks,

essentially clay, sands and very occasionally limestone (Touzla Cape or Aclileion Cape). These rocks were deposited on the bottom of the sea, in the position of a retro-arc basin which stretched from the north to the Viennese Carpathians to the present Black Sea. The Alpine orogenesis, through its compressive tectonics, provoked the emergence of these rocks and their folding along the anticlinal and synclinal WSW/ENE axes and the group of NNE/SSW faults (Chnioukov *et al.* 1981). The current relief of the Taman peninsula is the result of the evolution of folded ridges in the open air since the end of Pliocene. The folded ridges have been levelled (Blagovolin 1962; Blagovolin, Pobedonostsev 1973), which explains the extension of plateaux eroded into cliffs. Since as early as the end of the Pliocene, along the anticlinal axes, diapirism has caused alignments of mud volcanoes (Chnioukov *et al.* 1981), giving birth to eruptive cones, the largest of which are over 100 m high and occupy the highest point of the topography.

The general features of the geological structure of the Taman peninsula are defined by its layout in the area of contact between the folded structure of the Causasus and mountainous Crimea. According to geological data (Chnioukov *et al.* 1981, Andreev *et al.* 1981, Peklo *et al.* 1981, Naumenko 1977), this area includes several tectonic zones (Fig. 3). The northern Taman zone (IIa, Fig. 3) is linked with the uplifting movement of Crimea's mega-anticlinorium. The Anapa prominence (II, Fig. 3) is in the same type of uplifting context due to the proximity of the Caucasus. Between these two areas, the Kerch-Taman inter-periclinal trough is located (III, Fig. 3).

Tectonic faults are superimposed on this general feature (Plachotny *et al.* 1989). On the basis of geophysical, geological and geomorphological data, the Taman area comprises several blocks limited by a number of local and regional faults (Fig. 4) of sublatitudinal and submeridional directions. Three principal blocks can be observed from west to east: the Kerch/Gdanovsky, the Vishesteblevsky and the Djiginsky areas.

N°/Depth (m)	Index		14C Age Years BP	Calibrated Age (Yrs Cal.)
S1 (11 - 11.5)	GIN-9942	Peat	5949 +/- 80	4884 BC
S2 (3.2 - 3.5)	GIN_9934	Ostrea edulis, Cerastoderma glaucum, Chlamys glabra	1130 +/- 100	1310 AD
S2 (3.6 - 3.8)	GIN-9935	Ostrea edulis, Chione gallina, Cerastoderma glaucum	1380 +/- 90	1287 AD
S2 (7.8 - 8.0)	GIN-9939	Cerastoderma glaucum	2080 +/- 200	605 AD
S2 (8.1 - 8.2)	GIN-9938	Cerastoderma glaucum	2820 +/- 110	317 BC
S2 (10 - 10.3)	GIN-9937	Cerastoderma glaucum	3180 +/- 290	767 BC
S3 (2.8 - 3.0)	MGU-1504	Cerastoderma glaucum, Chione gallina, Solen vagina	1260 +/- 60	1380 AD
S3 (4.2 - 4.5)	MGU-1520	Cerastoderma glaucum, Cardium exiguum, Chione gallina, Loripes Lacteus, Divaricella divaricata, Mysella bidentata, Paphia discrepans, Gastrana fragilis, Abra alba, Ostrea edulis, Mytilus galloprovincialis	3390 +/- 150	945 BC
S3 (7.7 - 8.0)	MGU 1502	Cerastoderma glaucum, Mytilus galloprovincialis, Chione gallina, Solen vagina, Paphia discrepans, Cardium exiguum, Ostrea edulis, Gastrana fragilis, Abra ovata, Loripes lacteus	4700 +/- 150	2633 BC
S3 (9.0 - 9.3)	MGU 1501	Cerastoderma glaucum, Chione gallina, Ostrea edulis, Paphia discrepans	5430 +/- 120	3611 BC
S4 (6.7 - 7.0)	MGU 1575	Cerastoderma glaucum, Loripes lacteus, Ostrea edulis, Chione gallina, Donax sp.	1930 +/- 60	711 AD
S4 (7.8 - 8.1)	MGU 1565	Cerastoderma glaucum, Ostrea edulis, Chione gallina, Donax sp.	2660 +/- 60	69 BC
S4 (10 - 10.3)	MGU 1574	Cerastoderma glaucum, Abra ovata	3370 +/- 45	918 BC
S5 (2.5 - 3.0)	MGU 1517	Cerastoderma glaucum	1595 +/- 50	1051 AD
S5 (3.0 - 3.5)	MGU 1529	Cerastoderma glaucum	3390 +/- 120	945 BC
S5 (5.5 - 6.0)	MGU 1516	Cerastoderma glaucum	3730 +/- 100	1399 BC
S5 (6.5 - 7.0)	MGU 1515	Cerastoderma glaucum	4220 +/- 100	1989 BC
S6	?	?	1570 +/- 100	?
S6	?	?	3340 +/- 80	?
S7 (1.2 - 1.5)	MGU 1549	Chione gallina, Loripes lacteus, Mytilus galloprovincialis, Ostrea edulis, Cardium exigum, Paphia discrepans, Iruus irus, Tellina fabula, Gastrana fragilis, Abra ovata	1250 +/- 50	1392 AD
S7 (1.8 - 2.0)	MGU 1553	?	2541 +/- 70	160 AD
S8 (0.8 - 1.05)	MGU 1564	Cerastoderma glaucum, Abra ovata, Mytilaster lineatus, Loripes Lacteus, Gastrana fragilis	1160 +/- 50	1141 AD
S8 (1.9 - 2.4)	MGU 1548	Abra ovata, Loripes Lacteus, Cardium exiguum	2130 +/- 70	551 AD
S9 (1.0 - 1.15)	MGU 1545	Cerastoderma glaucum, Mytilaster lineatus, Chione gallina, Loripes lacteus, Abra ovata, Chlamys glabra, Gastrana fragilis, Nassa reticulata, Retusa trunculata, Gifrobia ventrosa, Rissoa sp., Bittium reticulatum	1240 +/- 50	1398 AD
S9 (2.0 - 2.35)	MGU 1546	Cerastoderma glaucum, Chione gallina, Gastrana fragilis, Ostrea edulis, Cardium exiguum, Abra ovata, Nassa reticulata, Retusa trunculata, Gifrobia ventrosa, Rissoa sp., Bittium reticulatum	2060 +/- 70	624 AD

Tab. 1: Radiocarbon datings from the Taman Peninsula.

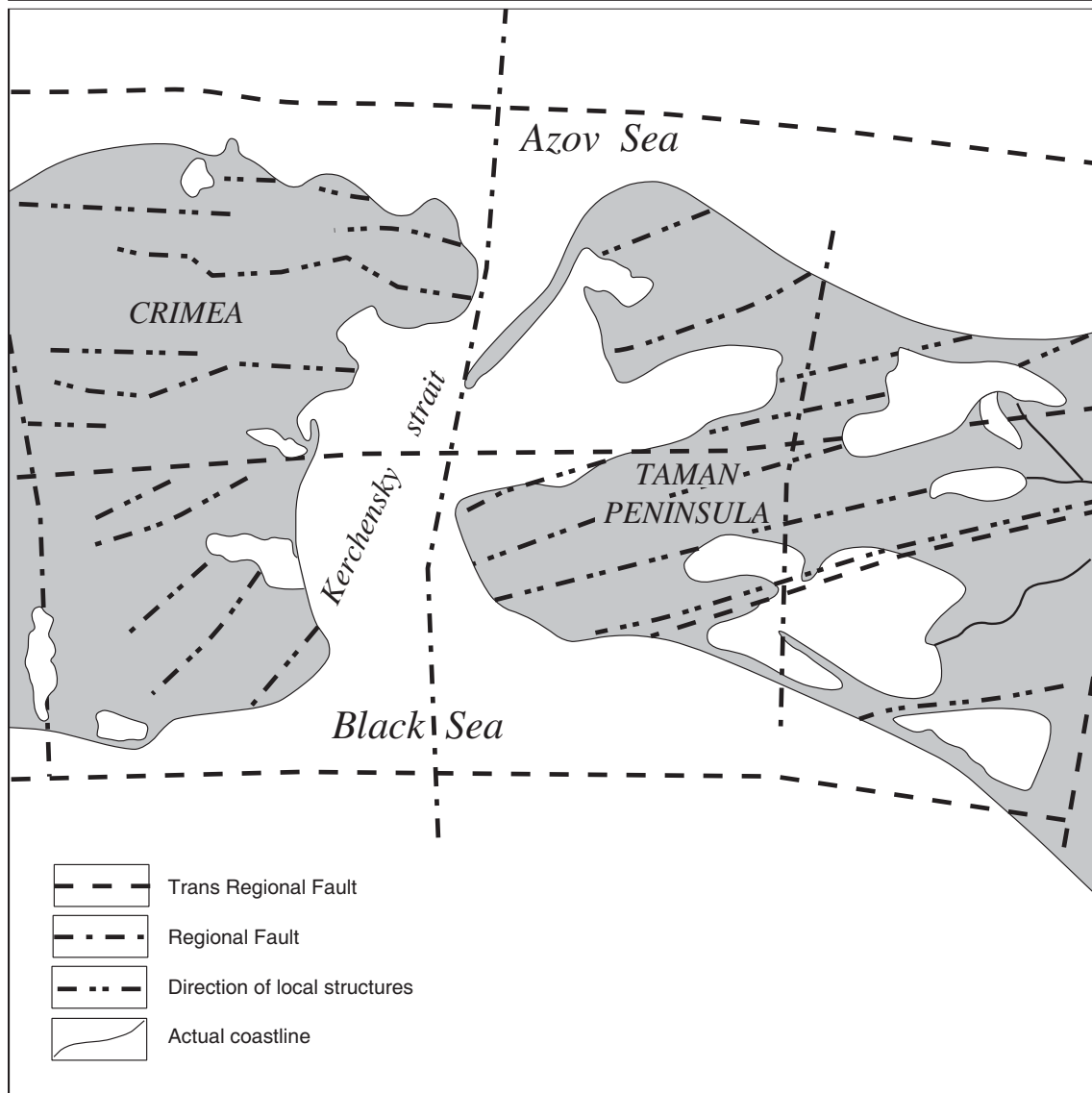


Fig. 4. Regional pattern of tectonic structure (Kerch-Taman area)

Results

From the bottom to its upper part, the S1 core (Fig. 5), located in the Kouban delta, contains peat, marine semi-closed bay sediments and then deltaic sediments. Palynological analysis confirms that there was a marine environment during the Greek colonisation (Bolihevskaya *et al.* 2004). The radiocarbon dating obtained on the peat (5940 $\pm$ 50 BP) shows that the maximum penetration of the sea occurred at that time. Cores S1, S2 and S6 were also studied (Bolihevskaya *et al.* 2004) to establish changes of vegetation (Fig. 10). The palynological results have shown

that the warmest and dry conditions prevailed in the intervals 4100-3950, 3500-3300/3200, 2800-2400, 1650-1300 and 1000-900/800 yrs BP. The maxima of humidity for the studied period correspond with the chronological intervals 4500-4300 and 3950-3500 yrs BP, corresponding with the spread of forest communities. During an interval from 2500 up to 1500 BP (5th century BC - 5th century AD) the dominance of the steppe formation was interrupted by phases of wetter climate, which caused at first expansion of the wood-steppe vegetation, and then wide circulation of broad-leaved woods in the landscape.

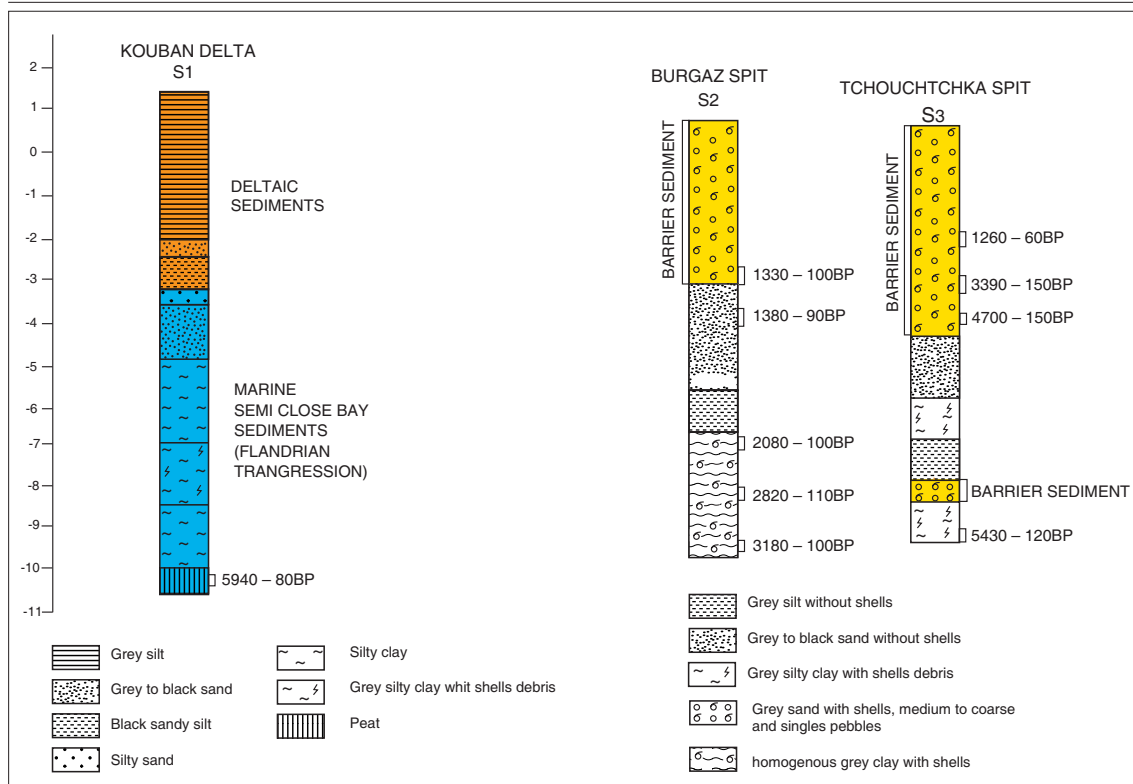


Fig. 5. Cores S1, S2, S3

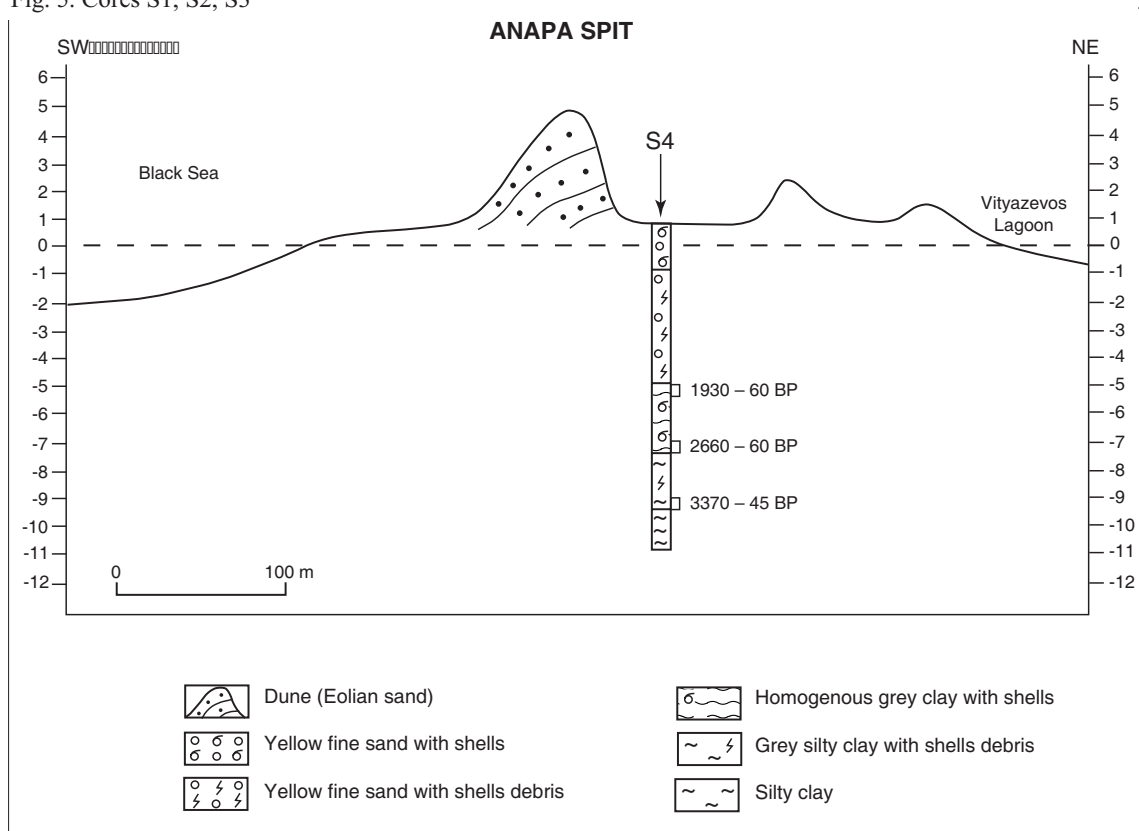


Fig. 6. Core S4

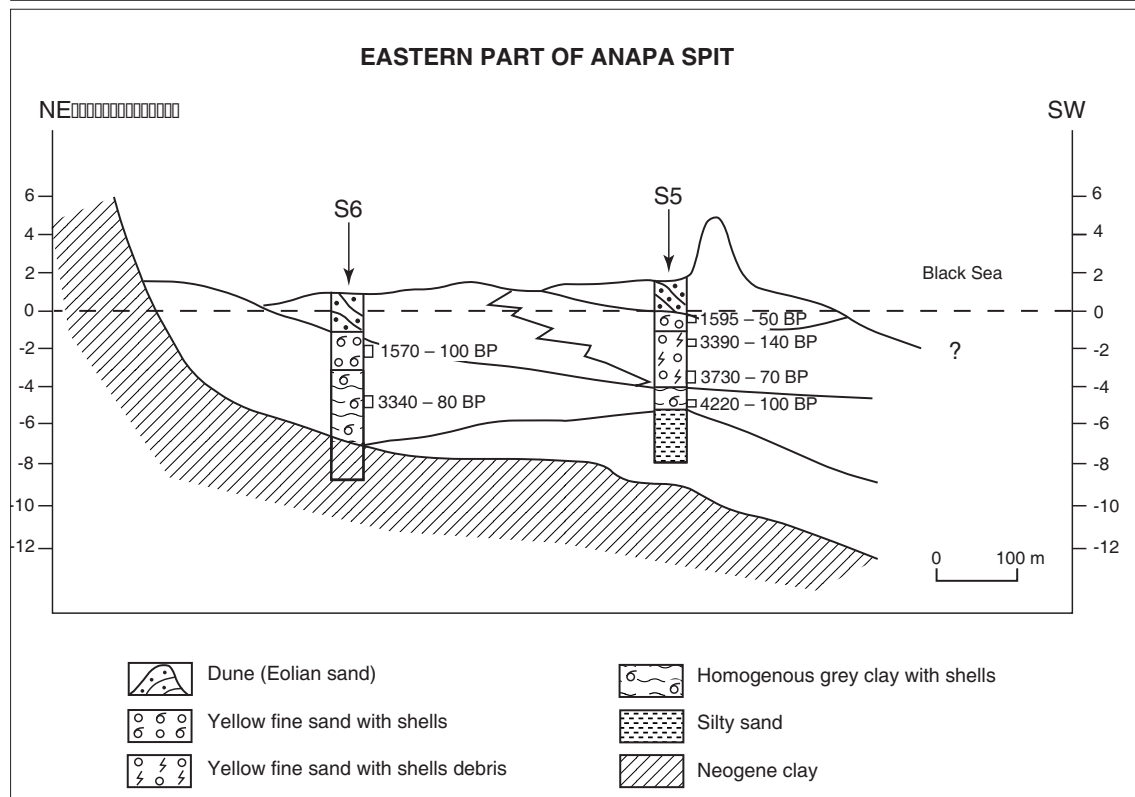


Fig. 7. Cores S5 and S6

The other cores show an alternation between sandy biotrititic sediment characteristic of beaches and mainly clayey sediments rich in shells (S2 and S3 Fig. 5, S4 Fig. 6, S5 and S6 Fig. 7, S7, S8 and S9 Fig. 8). The biggest paleogeographical change since Antiquity occurs in the gulf of Taman, where most of the city of Phanagoria is now under water (Fig. 8). Was this post-antic submersion homogenous all over the peninsula?

Following the coherence of our results, the deeper the shells, the older the radiocarbon dating, for each core we have reconstructed a local relative sea level curve (Fig. 9). Then we could distinguish two zones with a rather similar curve: at Burgaz Spit and Western Anapa Spit (S2 and S3) on the one hand, at Tchouchtchka Spit and eastern part of Anapa Spit (S5 and S6) on the other. The gulf of Taman is a transition zone between two other areas. We can also distinguish a global dissymmetry between contemporaneous sea levels. The greatest difference is observed for ancient sea levels. For example, in 1000 BC

the sea level is located around –2m below the present sea level in S5, around –4m in S3 and around –9.5m in S2 and S4. We observed for all the curves a relative sea level stabilisation between 500 BC and 500 AD.

Such differences for such a relatively small area at the scale of the Taman peninsula are undoubtedly due to unequal subsidence, itself due to the neo-tectonic effect. How can this neo-tectonic effect be explained?

Discussion

There is a perfect correlation between tectonic units and the three different groups we observe on relative sea level curves (Fig. 10). Burgaz Spit (S2) and Western Anapa Spit (S4) are located in two characteristic uplifting areas. The Gulf of Taman (S7, S8 and S9), Tchouchtchka Spit (S3) and the eastern part of Anapa Spit (S5 and S6) are located in a global subsiding zone. The Taman Gulf is a transition zone between two other areas. Tectonic measurements (Nikonov 1994, Nikonov *et al.* 1997) confirm the neo-tectonic

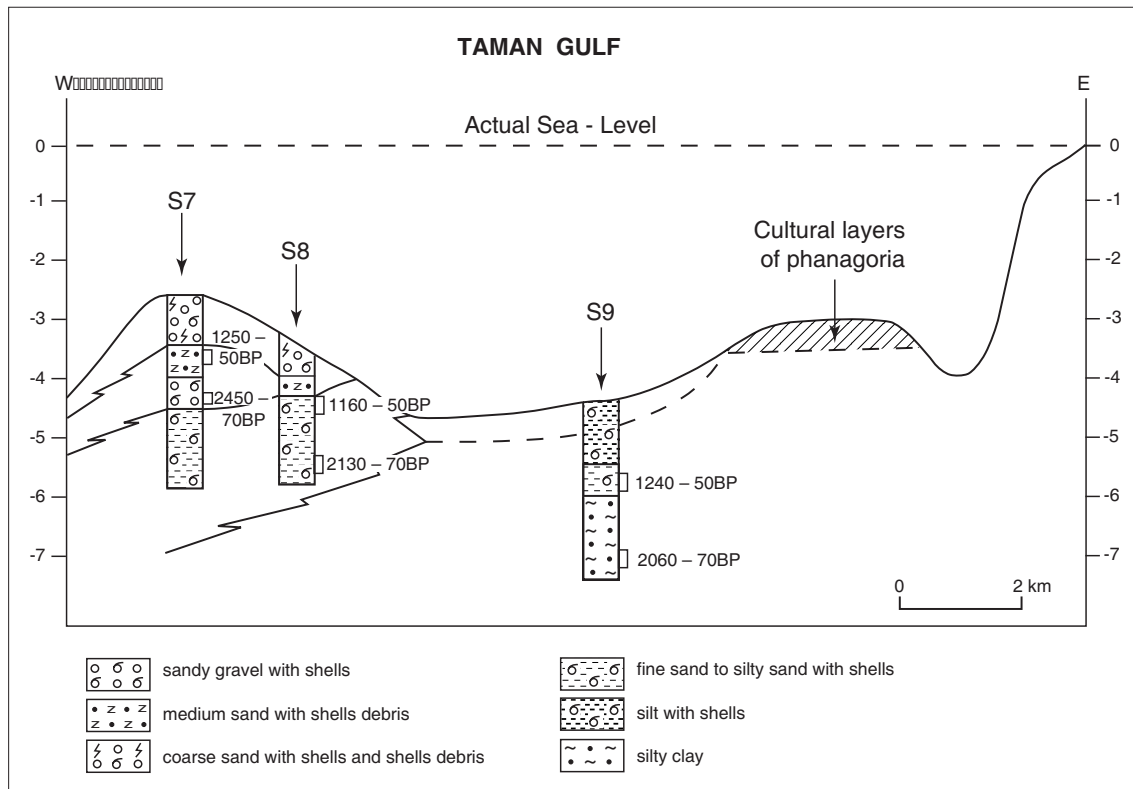


Fig. 8. Cores S7, S8 and S9

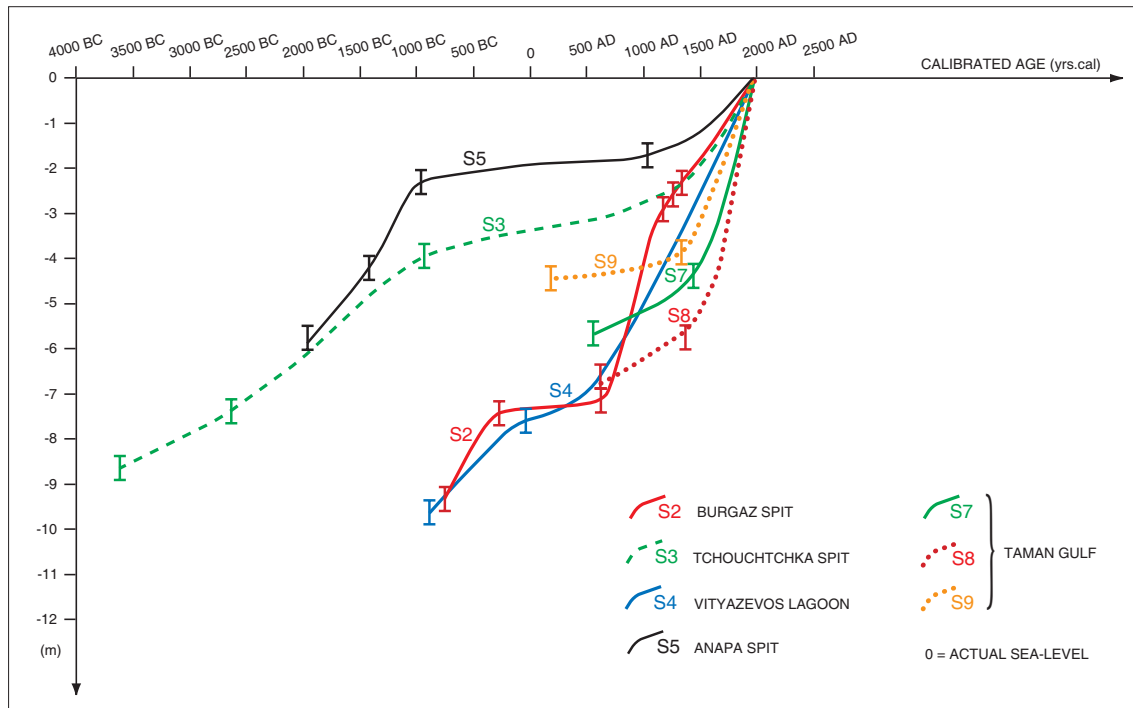


Fig. 9. Relative regional sea-level fluctuations in Taman Peninsula

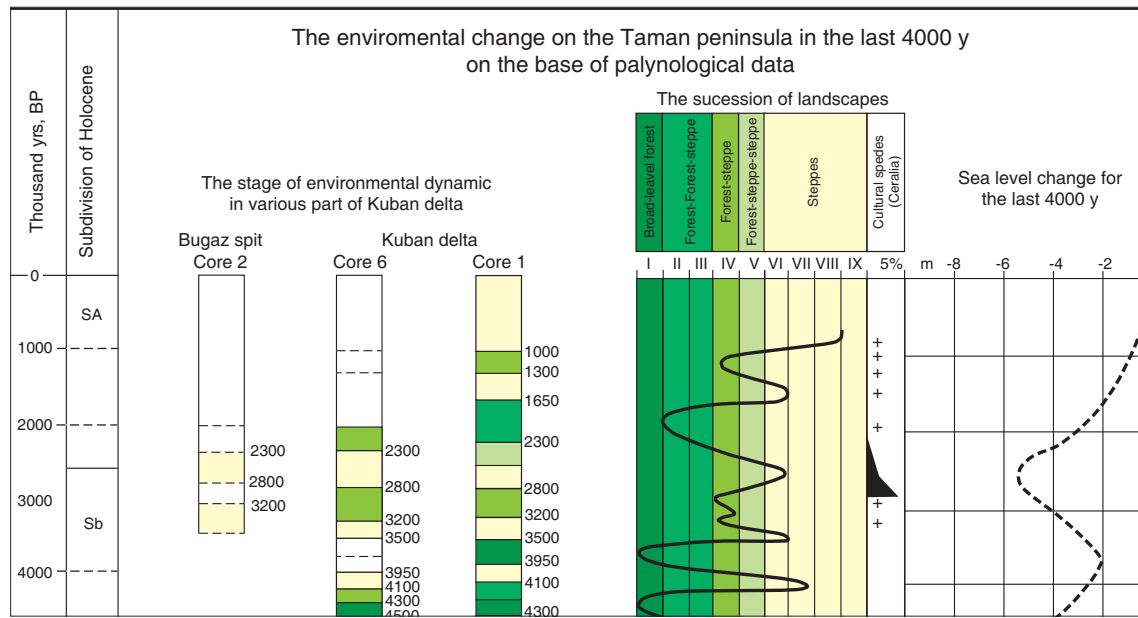


Fig. 10. The enviromental change on the Taman peninsula in the last 4000 year on the base of palynological data

subsidence in the central zone of the Taman peninsula. The present-day subsidence at Temrjuk in the Kouban delta nowadays is estimated between 3.5 and 4 mm/year, and the tectonic part is estimated between 2 and 3 mm/year. For the Black Sea side, south of the peninsula, the global subsidence, during the Upper Pleistocene, is estimated at 2.5 mm/year. These data confirm that the subsidence rate varies from one point to another in the peninsula.

In this context the relative stabilisation of sea curves between the 5th century BC and the 5th century AD can be considered as a consequence of a period of downturn in sea level (Bolihevskaya *et al.* 2004) from the end of the 2nd millenium BP up to the middle of the 1st millenium AD, during the so-called “Phanagorian Regression” and it is possible to propose a “real sea level curve” (Fig. 10).

From a general point of view, our results confirm that the neo-tectonic effect explains the rapid variations in relative sea level fluctuations on a regional scale and that this factor has been neglected in sea level changes studies around the Black Sea.

Our data confirm the models proposed by Neveseky (1958) for the position of shore-lines around 9th to 5th century BC (Fig. 11). We

can specify that, except for the presence of beach-barriers and spits, there were also at that time one main island and at least three islets, maybe four, surrounded by lagoons and marshy areas (Fig. 12). The junction of the islands to dry land by the Kouban river came late, during the Late Antiquity and Early Middle Ages.

Conclusion

The results of our analysis of regional sea level variations in different tectonic zones of the Taman peninsula confirm the differential tectonic movement during the historical times within an approximate rate of 0.5 to 1.2 mm/year. Our results confirm the necessity to take into account the tectonic impact in paleo-environmental studies and sea level reconstructions in the Black Sea for the Late Holocene.

The consequences for archaeological investigations are very important. Most coastal archaeological vestiges are underwater on the peninsula, but not at the same altitude according to their position on the peninsula. Our results highlight the interest of an underwater survey but also the interest to study environmental changes and landscape dynamics for paleogeographical studies.

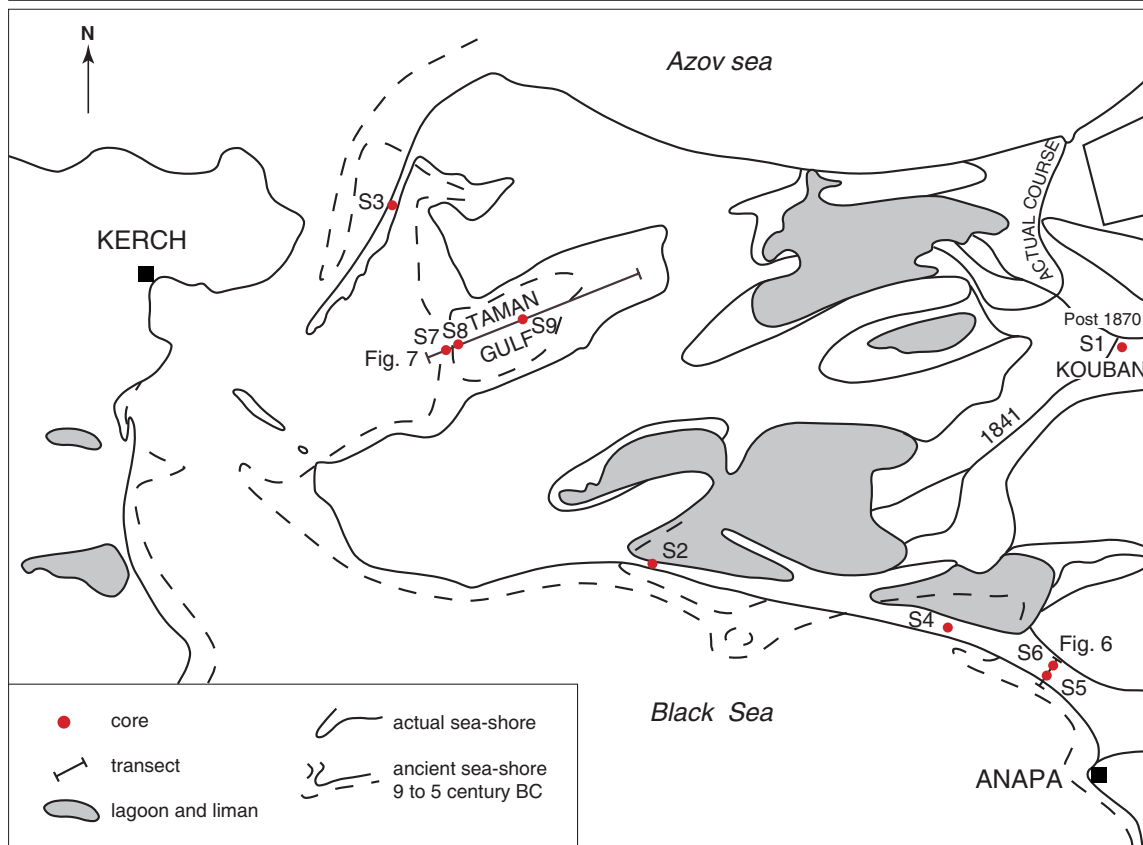


Fig. 11. Possible reconstitution of sea-shore IX to V century BC (Adapted from Nevesky 1958)

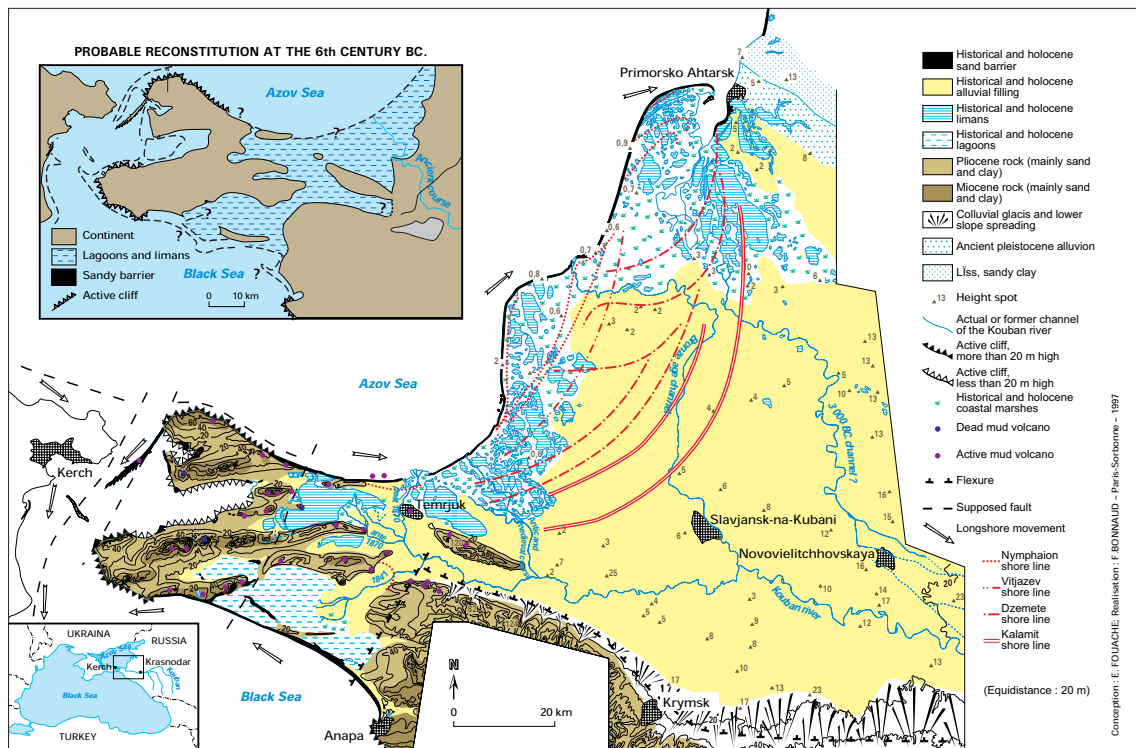


Fig. 12. Geomorphological map of the Taman peninsula and the Kouban delta

REFERENCES

- ABRAMOV A.P. (1999), Underwater archaeology and paleogeographical reconstruction of classic Patrasys. In: *Patrasys: Results of research*. (in Russian). V. 1, Moscow; IA RAN: 63.
- AMMIEN MARCELLIN, *Res Gestae*, XXII, 8, 30.
- ANDREEV V.M., KAZANTZEV R.A., PANAEV V.A. (1981), The tectonics of zone of coupling of Caucasus and Crimea. (in Russian). *Tectonics and Stratigraphy*, **20**: 22-28.
- BALABANOV I.P., KVIRKRLIYA B.D., OSTROVSKY A.B. (1981), The recent history of formation of the engineering-geological conditions and the forecast of long-term development of coastal zone of Pitsunda peninsula: 202. *Mitsniebra*, Tbilisi.
- BLAGAVOLIN N.S. (1962), Geomorphology of the Kerch-Taman region. (in Russian). *RAS*, Moscow.
- BLAGAVOLIN N.S., POBEDONOSTSEV S.V. (1973), Recent vertical movements of the shores of Black and Azov Seas. (in Russian) *Geomorphology*, **3**: 46-55.
- BLAVATSKY V.D., (1985), The underwater archaeological research on the northern shoreline of the Black Sea. In: *Classic Archaeology and History*: 167-173. (in Russian) *Science*, Moscow.
- BOLIKHOVSKAYA N., KAITAMBA M., POROTOV A., FOUACHE E. (2004), *The environment changes of northeast Black sea's coastal region during the Middle and Late Holocene*. Chapter 17 in E.M. Scott (ed.) *Impact of the Environment on human Migration in Eurasia*. Kluwer Academic Publishers (Netherlands). 209-223.
- CHEPALYAGA A., (1984), Inlands sea basins. In: *Late Quaternary Environments of the Soviet Union* (eds. A.A. Velichko, H.E. Wright, C.W. Barnosky): 229-247. London, Longman.
- CHNIOUKOV E.F., Alenkini, V.M., Put A.L. (1981), The geology of shelf of Ukraine: the Kerch Strait (Kiev). (in Russian) *Naukova Dumka*: 180.
- CHNIOUKOV E.F. (1986), – *Mud Volcanoes in the region of Kerch and Taman*. (in Russian) Moscow.
- FLEMMING N.C. (1979), Archaeological indicators of sea-level. In *Les indicateurs de niveaux marins*, séminaire du 2 décembre 1978. Océanis. Fascicules Hors-Série. Volume 5, 184-191.
- FOUACHE E., SIBELLA P., DALONGEVILLE R. (1999), Holocene variations of the shoreline between Antalya and Andriake (Turkey). *IJNA*, 28.4. pp.305-318.
- FOUACHE E., DUFAURE J.-J., FAIVRE S. (2000), New observations on the evolution of the Croatian shore between Poreč and Zadar over the past 2000 years. *Zeitschrift für Geomorphologie*, Suppl. Bd 122. pp.3-46.
- FOUACHE E., MÜLLER C., GORLOV Y., GAIBOV V., POROTOV A. (2000), Geoarchaeological study of the Taman peninsula and the Kouban delta (Black Sea, Azov Sea, Russia). In Vermeulen F., De Dapper M. (eds.), *Geoarchaeology of the landscapes of classical antiquity: colloque international Gand*, 23-24 Octobre 1998. Coll. Babesch. Supplement, 5. Leiden: Stichting Bulletin antieke beschaving. pp.97-104.
- FOUACHE E., POROTOV A., MULLER C., GORLOV Y. (2004), The role of neo-tectonics in the variation of the relative mean sea level throughout the last 6000 years on the Taman Peninsula (Black Sea, Azov Sea, Russia). Colloque *Rapid Transgressions into semi-enclosed basins*. PICG 464. Gdansk, Polish Geological Institute, 8-9-10 mai 2003. Polish Geological Institute, Volume 11, Special papers, pp. 47-58.

- ISMAILOV J., ARSLANOV K., TERTYCNAJA T., CERNOV S. (1989), Reconstitution and dating of the shorelines of the Kouban delta in the Holocene. (in Russian) *Review of the University of Leningrad*, Ser. VII, **3**, 21: 61-69.
- KAPLIN P.A., POROTOV A.V., YANINA T.A., GORLOV Y., FOUACHE E. (2001) (in Russian) *Proc. Moscow State University, Geography*, **2**, 51-57.
- NAUMENKO P.I. (1977), About the location of the ore deposit on Kerch-Taman Region in relation with regional tectonic structures. (in Russian). *Geological Journal*, Moscow, **37**, 6: 28-37.
- NEVESKY E.N., (1958), About the recent transgression of Black Sea (in Russian). *Proc. of the Oceanographical Institute of the Academy of Sciences of USSR*, **28**: 23-29.
- NEVESKY E.N. (1967), The sedimentation in inner shelf zone: 255. (in Russian) *Nauka*, Moscow.
- NEVESKY E.N. (1970), Holocene history of the coastal shelf zone of the USSR in relation with processes of sedimentation and condition of concentration of useful minerals. *Quaternaria*, **12**: 78-86.
- NIKONOV A.A. (1983), Flooded remains of constructions located along the Bosphorus of the Cimmerians. (in Russian) *Russian Archaeology*, **3**: 57-66.
- NIKONOV A., (1994), Digns of recent tectonic activity in fault areas in the southern Azov sea and the Strait of Kerch. (in Russian) *Geotektonika*, **5**: 16-27.
- NIKONOV A. ENMAN S.V., MISHIN A.V. (1997), The recent vertical Earth crust movements on the Azov and Black Sea shorelines. (in Russian) *Proc. RAS*, **357**, **6**: 818-822.
- OSTROVSKY A.B., IZMAYLOV S.A., ABALABANOV I.P., SKIBA S.I., SKRYABINA N.G., ARSLANOV S.A., Gey N.A., SUPRUNOVA N.I. (1977), New data on the paleohydrological regime of the Black Sea in the Upper Pleistocene and Holocene. In: *Paleogeography and deposits of the Pleistocene of the Southern sea of the USSR*: 131-141. (in Russian) *Nauka*, Moscow.
- PEKLO V.P., MOLOVITSKY Y.P., SIDORENKO C.F. (1974), Geological structure of Taman, western submergence of the Caucasus and adjacent part of Black Sea. In: *The tectonic and the seismicity of the Black Sea region (Kishinev)*: 109-114. (in Russian) Stiinca.
- PIRAZZOLI, P. (1979-80), Les viviers à poissons romains en Méditerranée. In *Les indicateurs de niveaux marins, séminaire du 2 décembre 1978. Océanis. Fasc. Hors-Série* **5**, 184-191.
- PIRAZZOLI P. (1991), *World Atlas of Holocene Sea-Level Changes*. Elsevier Oceanography Series, 58.
- PLACHOTNY L.G., PASYNKOV A.A., PALINSKY R.V. (1989), Tectonical location and zoning of Kerch peninsula. (in Russian). *Sovjet geology*, Moscow, **3**: 77-84.
- POMPONIUS MELA, *Chor.*, I, 112.
- RYAN W., PITMAN W. (1998), *Noah's flood. The new scientific discoveries about the event that changed history*. Simon and Schuster, New York.
- SHILIK K.K. (1997), Oscillations of the Black Sea and Ancient Landscapes. In: *Landscapes in flux: Central and Eastern Europe in Antiquity* (eds. J. Chapman, P. Dolukhanov): 115-129
- STRABO, *Geography*, XI, 2, 9-10 and I, 112.
- STUIVER M., BRAZIUNAS T.F. (1993), Modeling atmospheric ¹⁴C influences and radiocarbon ages of marine samples back to 10000 BC. *Radiocarbon*, **35**, 1: 137-139.

¹ Université de Paris 12, EA 435 Géonat, UMR 8591 CNRS/Paris 1,
eric.g.fouache@wanadoo.fr

² Moscow State University, Geography Faculty

³ Université de Paris 1, Ecole Française d'Athènes

³ Russian Academy of Sciences, Institute of Archaeology

Coastal changes and human activities at Istron-Kalo Chorio (NE Crete, Greece) during the Upper Holocene

K. THEODORAKOPOULOU¹, K. PAVLOPOULOS¹, T. TSOUROU⁴,
M. TRIANTAPHYLLOU⁴, K. KOULI⁴, D. VANDARAKIS, Y. BASSIAKOS², B. HAYDEN³

Additional index words: Paleogeography, sea level changes, paleoclimate, human activity

The Istron area is located in northeastern Crete, Gulf of Mirabello, on an alluvial fan of Holocene age. The archaeological importance of this area is pointed out not only by its archaeological remains, but also by its significant location. Many important Minoan sites, like Gournia, Kavousi, Pseira, have been discovered near Istro. There are indications of human installations from the Neolithic to the Roman period, proving the continuous human activity in this area. The significant geological location, as it represents an area with intense tectonic activity, the geomorphological regime of the area and the climatic changes, influenced human installations as well as the evolution of the civilization. The study of sea-land interactions during the last seven millennia in relation to the eustatic sea level oscillations and the regional neotectonic regime, as well as the geomorphologic observations and analyses on deposited sediments, aims to reveal the paleogeographic evolution of the landscape and its impact on prehistoric, classical and Roman establishments. Therefore, a geomorphological mapping of the coastal area along with the drilling of five boreholes and the excavation of six trenches, have been accomplished. Moreover, pollen and microfaunal (benthic foraminifera and ostracodes) analyses have been performed. Six samples were dated using AMS and Conventional radiocarbon techniques providing temporal control of the sediments. Sea level rise along with sea-land interactions to the landscape evolution and the transgression of sea in 5000 BP have been verified. Additionally, several implications for the use of land and human impact civilization have been concluded.

Introduction

The Istro area is located in northeastern Crete, Gulf of Mirabello, on an alluvial fan of Holocene age. It has been inhabited since the Final Neolithic period, demonstrating great historical and archaeological importance. Its significant location, near important minoan settlements like Gournia, Kavousi, Pseira, as well as its archaeological remains, give evidence for a prominent minoan center with its 'commercial' harbor. First archaeological researches of the area started in 1903 by Richard Seager and Harriet Boyd, resulting to the excavation of the area in 1910–1912, by Edith Hall, supported by the University Museum in Philadelphia. (Hall 1914). In 1986, an intensive survey project of the area was undertaken by the University of Pennsylvania Museum and Baylor University,

directed by Barbara Hayden and Jeniffer Moody. Fieldwork and laboratory analyses have been done, whereas several scientific activities have been performing until today.

Series of boreholes and backhoes had been done in 2004, under the direction of the Laboratory of Archaeometry of N.C.S.R 'Demokritos' in Athens. Several analyses have been performed on cores taken from the area, although more results are needed for a detailed scientific approach.

This study attempts to determine the depositional environments the last 6.000 years, as well as climate and sea level changes recorded during that period, with the use of micromorphological, micropaleontological and palynological methods, in addition to radiocarbon dating of plant remains.



Fig. 1. Location map of the area.

Geographical and geological setting

The broader survey area of Istron extends from the north coast of Crete, where it flanks the central to western portion of the Gulf of Mirabello, south to encompass the Meseleroi Valley, and from the Kentromouri area, just west of the small plain around Gournia, west to the Kalo Chorio or Istron River valley. The two main riverine systems are the Istron (today known as Kalos Potamos), which extends into the Kalo Chorio or Istron Valley from the west. Its main tributary flows into the sea, just east of the small headland of Priniatikos Pyrgos. The other system, the Xeropotamos river, which is always dry during summer months, extends east and north, to merge with the sea in the small Phrouzi basin, near the eastern edge of the survey area.

From the west to east the four main promontories are Ioannimiti, Nisi Panteleimon, Elias to Nisi and Vrionisi. The small sandy headland of Priniatikos Pyrgos projects from a long beach that extends from the base of Ioannimiti to Nisi Panteleimon. (Fig. 1)

In Istro area, as in most of Crete, the mountains and sea have been largely stable since the earliest phases of human settlement. The main topography was formed in the Pleistocene or earlier.

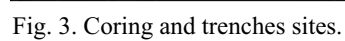
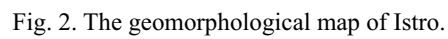
There are 6 broad geomorphic units and two main drainage systems in the survey area. The geomorphic units comprise a) the coast strip and promontories, b) the Istron river valley and flood plain, c) the Prina basin, d) the Meseleroi basin, e) the Scinavria massif and f) the hills and ridges south of Vrokastro and the Koloumbous hills to the south. (Hayden 2004, Moody 1997)

Six bedrocks dominate the area: crystalline limestones, marls, sandstones, granodiorites, greenstone conglomerates and limestone breccio-conglomerates (I.G.M.E, Ag. Nikolaos sheet 1/50.000, 1987). The crystalline limestones are of Upper Cretaceous date and are considered part of a tectonic nappe. The greenstone conglomerate, which forms the base of Neogene series, includes pebbles of limestone, dolomites, phyllites, quartzites, cherts and greenstone. With the reemergence of the island in the upper Pliocene, the soft Neogene deposits began to erode. (Fytrolakis 1980, Fassoulas 2001) (Fig. 2)

Millennia of erosion reexposed the older, buried, hard limestones and igneous rocks. The product of this weathering process is a sandy sediment full of black and gold mica, white to pink angular feldspar and milky quartz. (Hayden 2004, Myer 1984).

Many of the limestone cliffs that tower above the wider valleys and coast are the result of local faulting. Subsidence along the coast is also largely the result of local tectonism. (Fleming 1978, Dermitzakis 1969, Karotsieris et al.2000). This is evidenced by walls of Middle or Late Minoan I date submerged to at least one meter immediately west of Priniatikos Pyrgos.

In the cliffs of the coastal promontories at least one submerged solution notch was observed about 1.80m below sea level. (Mourtzos 1988, Moody 1987). Solution notches are formed in the littoral splash zone by boring animals like *Dendropoma*, which can dissolve the bedrock and are indicative of earlier sea levels. All this also suggests that relative sea level around the Gulf of Mirabello was lower than it is today, at least



during the Bronze Age, possible until the Roman period. The sea level during the Bronze Age may have been at least two meters lower. It is not clear, however, if relative sea level has risen continuously or fluctuated from Roman times to present. (Fig. 3)

Archaeological investigations — human evolution

First archaeological researches of the area started as mentioned before in 1903 by Richard Seager and Harriet Boyd, resulting to the excavation of the area in 1910–1912, by Edith Hall, supported by the University Museum in Philadelphia. (Hall 1914). In 1986, an intensive survey project of the area was undertaken by the University of Pennsylvania Museum and Baylor University, directed by Barbara Hayden and Jennifer Moody.

Continuous human activity is confirmed since the Final Neolithic period (4500 BC). During the *Final Neolithic-Early Minoan I* (4500–2700 BC) period, most of the human activities have been detected along the coastal area, where Ioanimiti, Priniatikos Pyrgos, Nisi Panteleimon and Elias to Nisi, consisted the main archaeological sites. There are no architectural remains in this area, except from many ceramic shreds, stone tools and some obsidian flakes, indicating commercial relations with Melos island. Priniatikos Pyrgos may have been the main Minoan-commercial harbour. (Hayden 2004).

During the *Early Minoan II-III* (2700–2100 BC), 70% of sites are located 1.5 km from the coast, whereas duplication of sites is mentioned in relation with the precedent period. This is probably owed to the prosperity and wealth that also characterizes most of the contemporaneous sites in Crete. The discovery of ceramic shreds of 'Vasilike ware' confirms the commercial relations with other Minoan centers. (Cherry 1983, Branigan 1988, Haggis 1999)

Priniatikos Pyrgos, Phrouzi and Ioanimiti continue to be the main sites of the period.

In *Middle Minoan I-II period* (2100–1700 BC) a decrease of sites (36%) in the coastal

area is mentioned with an increase inland. It is noted that during this period in Crete, many sites are installed on hills or naturally protected areas. Priniatikos Pyrgos, Ioanimiti, Vryonisi and Elias to Nisi had also been the main sites of the period. There are indications of commercial relations with the Palatial center of Malia. (Cadogan 1990).

In *Middle III-Late Minoan I* (1700–1450 BC) the decrease of installations and population is more evident. This phenomenon is usual to other contemporaneous sites in Crete. Possible tectonic activity or immigration resulted to the abandonment of the precedent sites. (Watrous & Blitzer 1999) During *Late Minoan II-IIIB* (1450–1200 BC) few installations are indicated along the coastal area. Most of them are found around Vrokastro area. Many Minoan sites have been abandoned or destructed hence tectonic activity, the Thera eruption or the Mycenaean invasion. This is a transitional period not only in Istros but all over Crete. (Driessen & Mac Gillivray 1989) (?aggis 1992).

The next period, *Late Minoan IIIC-Geometric* (1200–700 BC) is also a transitional period, where the reduction of sites and population is generalized not only in Crete but also in Greek Mainland. There is a preference for walled settlements and Vrokastro with its harbor Elias to Nisi, is the most important site of the period. (Hall 1914) It is noted that during this 'Dark period' the invasion of Dorians has been occurred. (Coldstream 1991).

During *Archaic, Classical and Hellenistic period* (700–31BC), Nisi Panteleimon has been the main 'town' of Istros. Oleros, in Messeleroi basin has been the Southern center of the region. After 2nd BC, Oleros and Istros had been under the control of Hierapytna. (Sanders 1982, Hayden 2004)

Finally, during the *Roman period* (31BC–800AD), Priniatikos Pyrgos had been the main Town-harbor. Many architectural remains, ceramic shreds etc were discovered near Priniatikos Pyrgos. There are also indications of a sunken Roman town near

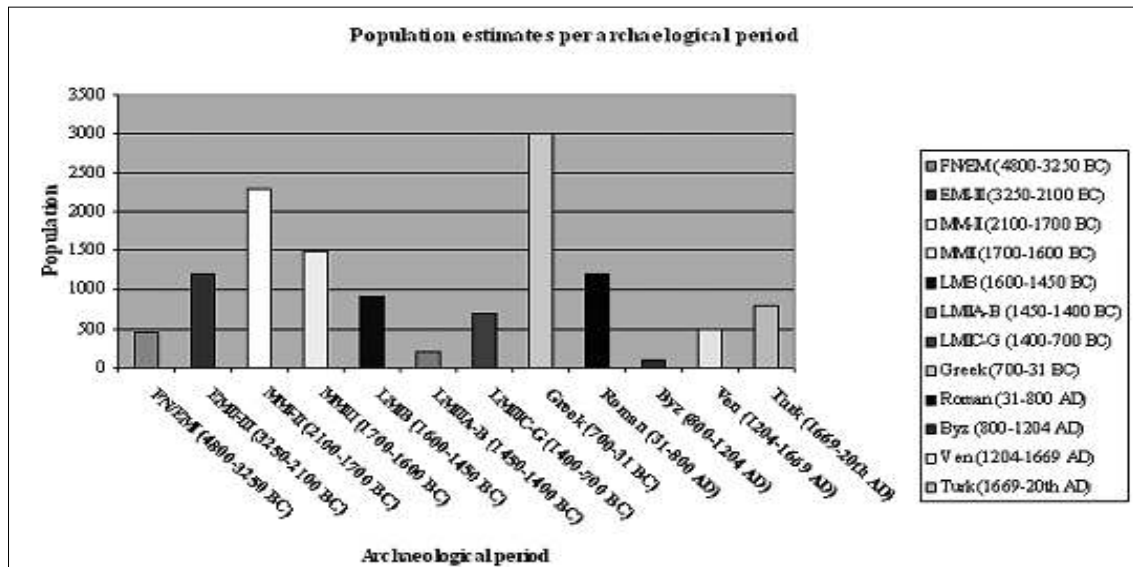


Fig. 4. Graph showing the population estimates per archaeological period.

Ioanimiti and some architectural remains of a probable monastery or watch station in Vryonisi. (Hayden 2004) An increase in population and establishment of rural installations is also noted during this period. (Wagstaff & Cherry 1982)

The habitation in the area is continuous until the Modern times. Some estimates have been done for the evolution of population in this area. There is an increase from the Final Neolithic to Middle Minoan period, a significant decrease from Middle Minoan III-Archaic period and a peak of population during the Classical period (around 3.000 habitants). These fluctuations are strongly connected with the cultural evolution and the main characteristics of each period. The tendencies of the increase or decrease of population rates are also found in other archaeological sites in mainland Greece. (Fig. 4)

Methods

To obtain information about the Holocene stratigraphy, six trenches were excavated with a mechanical digger (trenches 1–6). The trenches were restricted parallel to the coastal area. In addition, five boreholes were drilled with a drilling machine. Trenches were opened 3.50 m below mean sea level, whereas the deepest borehole reached ~13 m in depth. (Fig. 5) Five sedimentary units, named

A, B, C, D, E, F and G, respectively, were recognized after grouping of the sedimentary phase characteristics. The units will be described in detail below.

Moreover, undisturbed sediment samples were collected in dark plastic tubes from the cores of boreholes, in several depths, for the performance of OSL dating technique (Aitken 1990, Huntley 1985) in the Laboratory of Demokritos in Athens. Plant and charred material were also collected from several layers of the sedimentary sequence for the use of ^{14}C dating method. These samples were analyzed in Beta Analytic Inc. and the results will be discussed below.

Undisturbed blocks of sediment were selected from the excavated trenches and boreholes for micromorphological study, micropaleontological and pollen analysis.

Additionally, the geomorphological mapping of the coastal area provided several information for the alluvial fan delta of Kalos Potamos, for the submerged beach-rocks and Roman ruins at -1.5m and revealed the geomorphological evolution of the area through the centuries. GIS techniques were used for the geomorphological mapping of the area.

The results of the above mentioned analyses along with the observations of the archaeological remains, gave evidence for sea – land interactions during the last 6.000 years and impact on human installations.

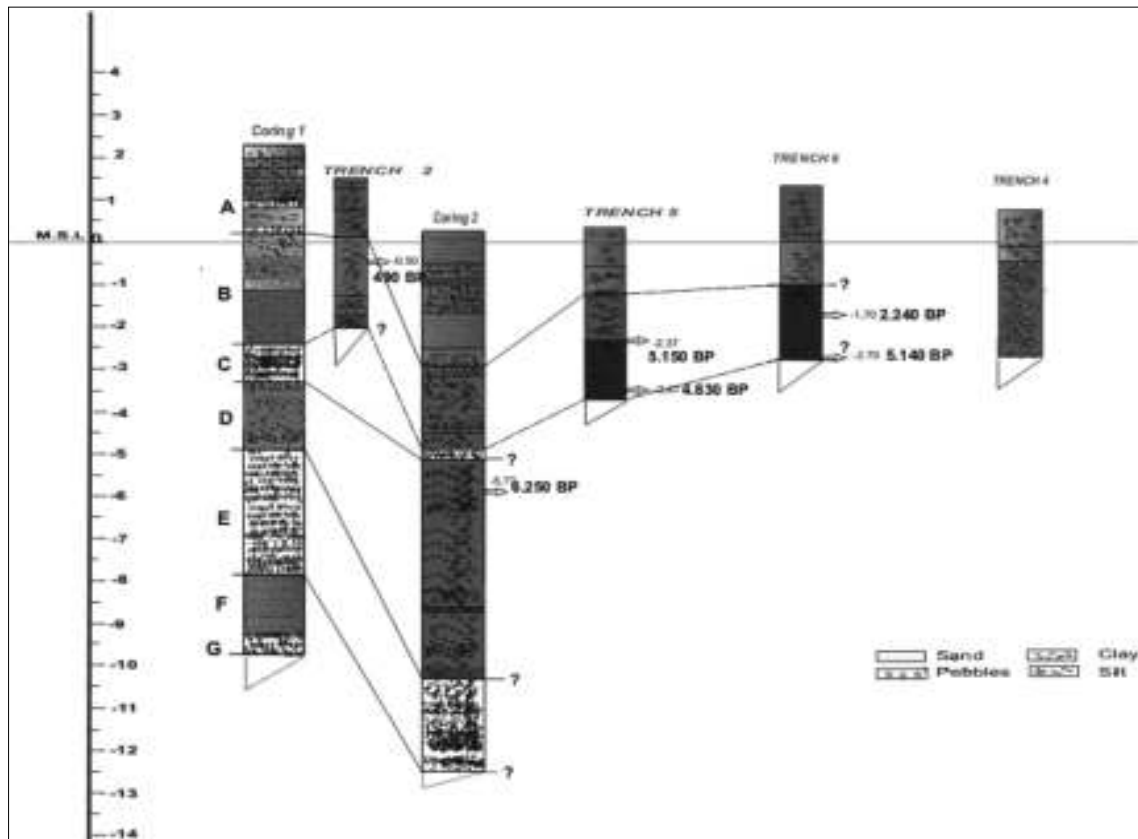


Fig. 5. The main sedimentological units.

Sampling site	Depth	Dating (Cal.)
Trench 2	2m, plant material	490 BP/1460 A.D
Trench 5	2.80m, charred material	5.150 BP/3180BC
Trench 5	3.90m, charred material	4.830 BP/2880BC
Trench 6	3m, plant material	2.240 BP/290BC
Trench 6	4m, charred material	5.150 BP/3200BC
Coring 2	6.30m, plant material	6.250 BP/4300BC

Table 1. Results of radiocarbon datings ^{14}C . (Beta Analytic Inc)

Results

Dating. The ^{14}C method was used to date charred and plant material from layers of the sedimentary sequence. Six samples were analyzed by AMS technique to Beta Analytic Inc. (Table 1)

Five samples were collected from trenches 2, 5 and 6 and one from the coring 2. In trench 2, plant material was collected at 2m depth consisting of gray silt. It gave an age of about 490 Cal BP/1460 AD.

Two samples of charred material were collected from trench 5, at 2.80 m and 3.90 m depth, in a dark gray silty sand sequence, giving an age of about 5.150 Cal BP/3180 BC and 4830 Cal BP/2880 BC respectively. There is an inconsistency to these datings, probably related to transferred material from overlaying layers.

In trench 6, two samples in 3 and 4 m depth of plant and charred material, in a dark gray silty sequence, were collected respectively. The upper was dated to about 2240 Cal BP and the lower to 5150 Cal BP.

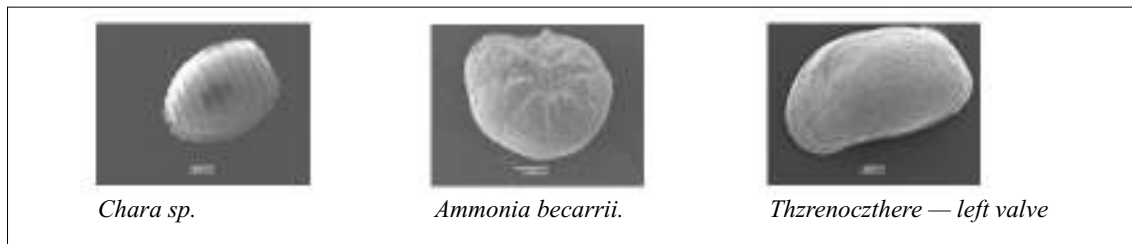


Fig. 6. Ostracods and foraminifera detected in micropaleontological analysis.

Finally, in core 2, plant material from 6m depth in a gray silty sand sequence, was dated to about 6.250 Cal BP.

Sedimentological analyses. After grouping of the sedimentary phase characteristics in trenches and cores, we recognized 5 sedimentological units (Fig. 5): Sedimentary unit A is the youngest and is represented by topsoil with human activities remains. Most of the sequence is consisted of dry brown/olive brown clay, sand or silty sand with small pebbles, indicating a terrestrial environment, whereas some layers of pebbles in core 1 revealed fluvial interferences. The layer of pebbles does not appear in other cores or trenches. Considering that the drilling place of core 1 is near to the river flux, it is clear that river's influence is more intense in core 1 than the others.

Unit B (2240-5150 BP) is mainly consisted of gray-dark gray sand or silty sand/clay with some pebbles. It is characterized by overbank deposits of the river with influence of brackish and sea storm water. Traces of planktonic and benthic foraminifera in a very bad state of preservation were found, indicating that they had been transported.

The predominance of conglomerates stream bed deposits characterized Unit C (5000–5.500 BP ?). This unit is mainly presented in core 1 and to lesser extent in core 2, related to the possible flow of the river.

This sedimentary unit is followed by a sequence of gray-dark gray silt/silty sand, composing Unit D (5500–6250 BP). Over bank deposits, with some swallow stagnant fresh water predominate to this sequence, revealing low-energy events and quiet conditions. This unit is mainly represented in core 2, indicating that a possible swamp with stag-

nant fresh water may have been in this site between 6250–5500 BP.

Finally, Unit E (E, F, G) (>6500–10000 BP) is characterized by fluvio-torrential stream-bed and over banking deposits. This unit is also presented in core 2, indicating a possible influence or removal of the river's flow during this period. This sequence is possible related to the 'Older Fill'. (Vita-Finzi 1966, 1969)

Micropaleontological analyses. Seven samples from trenches 2, 3, 5 and 6 were selected for micropaleontological analyses. All the samples belonged to the sedimentological unit B, which is mainly consisted of gray-dark gray sand or silty sand/clay with some pebbles and is characterized by overbank deposits of the river with influence of brackish and sea storm water. Traces of benthic and planktonic foraminifera along with some types of ostracodes, were detected after the analyses of the samples.

In trench 2, two samples were selected in 1.7 m and 2 m respectively. In 1.7 m depth, nor planktonic or benthic foraminifera were detected, whereas 1–2 specimens of *Tyrrhenocythere amnicola* from the ostracodes were documented. *Tyrrhenocythere amnicola* characterises brackish-water deposits of the Mediterranean region (Bate et al., 1985. A stereo-Atlas of Ostracod shells). In 2 m depth, very few (< 5) planktonic and benthic foraminifera in a very bad state of preservation were found, showing that they were transported. Moreover, few (< 5) ostracodes specimens of *Tyrrhenocythere amnicola* and *Candona* spp were detected. These types of ostracodes, indicate freshwater to brackish environment. (Fig. 6)

Trench 3 was proven barren. In trench 5,

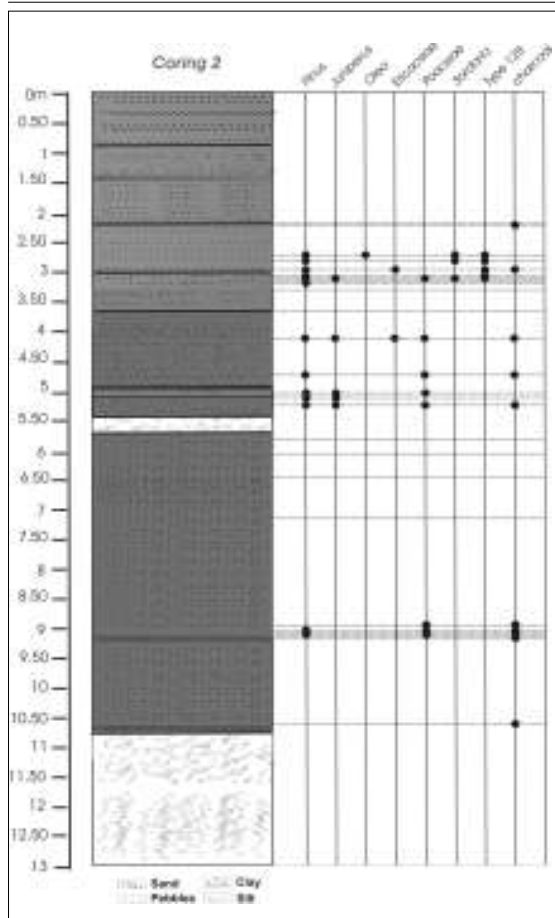


Fig. 7. The palynological diagram of Istro.

only one sample from 2.8 m depth was analysed and very few (< 5) planktonic and benthic foraminifera were also found in a very bad state of preservation and 1–2 specimens of *Candona* spp. from the ostracodes. These species indicate also freshwater to brackish environment.

In trench 6, two samples were selected in 3m and 4m respectively. In 3 m depth, very few (< 5) planktonic and benthic foraminifera in a very bad state of preservation were detected and few (< 5) ostracod specimens of *Tyrrhenocythere amnicola*, which characterise brackish-water deposits of the Mediterranean region. In 4 m depth, very few (< 5) benthic foraminifera along with ostracod specimens of *Tyrrhenocythere amnicola* which also characterises brackish-water deposits of the Mediterranean region, were documented.

Pollen analyses. 26 samples from core C2 were studied palynologically, 12 of them were proved barren. (Fig. 7) Abundant charcoal was detected in levels 215, 293, 410, 450–490 and 515–520 cm. The layer in 210–215 cm depth, was proven barren with abundant of charcoal. The species detected in 270–307 cm depth had been: *Pinus*, *Olea*, *Juniperus*, *Ericaceae*, *Helianthus*, *Sinapis*, *Tubuliflorae*, *Liguliflorae*, *Sordaria*, Type 128. The layer in 312–390 cm was almost barren with few traces of *Pinus* and charcoal. In 410 cm–520 cm depth several types of pollen were detected, like *Pinus*, *Ericaceae*, *Juniperus*, *Quercus*, *Poaceae*, *Sinapis*, *Teucrium*, *Convovulus*. The layers in 570–650 cm and 707–713 cm were also proven barren. *Pinus*, *Poaceae*, *Cerealia* type, *Liguliflorae* were documented in 890–910 cm depth, whereas the layers in 910 920 cm and 1050 1060 cm were also proven barren with organic material.

Pollen concentrations were very low, while pollen diversity was relatively high in the first part of the core and extremely low in the lower part (890–910 m).

The pollen content of the upper samples points to open xerophytic vegetation with scarce pine and juniper trees and high herb diversity. The presence of *Olea* at the level of 270 cm is interesting as a big discussion has risen on whether this — typical Mediterranean — tree occurs in Crete by origin (Bottema and Sarpaki, 2003).

Poaceae values are too low and no cereal pollen was detected on the upper part of the core, while on the lower part Poaceae are abundant and *Cerealia*-type pollen were found. The presence of spores of *Sordaria* in the level 270–307 indicates human activity-herding in the area. Closing level 270–307 shows characters of shallow stagnant to slowly moving (fresh) waters (type 128).

Palynofacies analysis of the barren samples divides them into two distinct groups: barren samples with organic material remains such as plant tissues, hyphas ect. and completely barren samples. The latter could possibly point depositional conditions not favoring the preservation of any organic material or oxidizing conditions.

Sea level changes. The melting of ice-sheets covered North Europe and America during the end of the Last Glacial period and the onset of the Holocene, resulted in sea level rising. Sea transgressed about 120–130 m. Especially during 16000–8000 BP the annual rates of sea level rise, have been estimated about 15–20 mm/y (Lambeck 1996)

The evidence for sea-level change along the Greek coastline is inferred from a variety of geological and archaeological indicators, the latter being more plentiful for about the last 4 000 years. (Fouache et al 2005) The archaeological evidence consists of the positions of structures that, at their time of construction, are believed to bear a known relation to the position of the sea. (Flemming 1978).

According to Lambeck's sea level curve for the island of Crete, sea level had been at –130 m at 18000 BP, –56 m at 10000 BP, –6 m at 6000 BP and –1.5 m at 2000 BP. (Lambeck 1995, 1996). It is obvious that from 6000 BP–2000 BP, sea rose at about 4.5 m, therefore, the estimated rate of sea level rise is about 1.12 mm/y.

Conclusions

From the above mentioned observations and results, we can conclude the following for the impact of environmental changes to human activities and evolution of civilization. Continuous human activities in the area since the Final Neolithic period to Roman times are confirmed by the archaeological remains. Most of the remains found in the coastal area consisted of ceramic shreds, stone tools, etc whereas some architectural remains were found submerged near Priniatikos Pyrgos (Minoan period) and between Ioanimiti and Priniatikos Pyrgos (Roman period).

The sedimentological analysis of cores and trenches resulted the identification of 5 main sedimentological units. It is obvious that the influence of Kalos Potamos river is more intensive to core 1 than others. Taking into consideration the results from the radiocarbon datings with the sedimentological analyses, we

can assume that since 6250 BP, the river's flow was near to coring site 1 (east of Priniatikos Pyrgos). Moreover, considering the presence of stream bed deposits in coring 2, in layers older than 6250 BP, we can also assume that the river's flow was near to coring site 2 (western of Priniatikos Pyrgos). Nevertheless, it is assumed from the sedimentological analysis, that sediment deposits in the area between Ioanimiti and Priniatikos Pyrgos insinuate slow and quiet conditions of deposition while river's influence is less intense than in Priniatikos Pyrgos area. Furthermore, the existence of some ostracods in trench 5 of *Candona* spp that indicate brackish-fresh water environment along with the occurrence of pollen ?128 in Core 2 implying stagnant, shallow, fresh water, give evidence for the existence of a possible small swamp in the area of coring 2, during the Bronze Age.

Generally, from the pollen analyses we can conclude that: The pollen content of the samples points to open xerophytic vegetation with scarce pine and juniper trees and high herb diversity. The presence of *Olea* in the level of 270 cm 5000 BP is interesting since it starts a big discussion on whether this -typical Mediterranean- tree occurs in Crete by origin (Bottema and Sarpaki, 2003).

Poaceae values are too low and no cereal pollen was detected. The presence of spores of *Sordaria* in the level 270–307 indicates human activity-herding in the area.

According to Istro sea level curve, coming from radiocarbon datings along with underwater observations, from 6250–2240 BP, sea level rose about 4 m. The rate of sea level rise for this region per year is estimated at 0,99 mm/y approximately and agrees with Lambeck's sea level curve for Crete and Eastern Mediterranean region.

For the complete palaeoenvironmental reconstruction of this area more analyses, observations and data are needed to give evidence on the geologic, geomorphologic and environmental changes that interfered with human activities and influenced the cultural evolution of the area.

REFERENCES

- AITKEN, M. (1990), 'Science-based dating in archaeology', Longman, New York.
- BATE, R.H., NEALE, J.W., SHEPPARD, L.M., SIVETER, D.J. (1978), 'A stereo-Atlas of ostracod shells', The British Micropaleontological Society.
- BOTTEMA, S., SARPAKI, A. (2003), 'Environmental change in Crete: a 9000-year vegetation history and the effect of the Santorini eruption.' *The Holocene* 13.5, pp. 733–749.
- BRANIGAN, K. (1988), 'Pre-Palatial, The foundations of Palatial Crete. A survey of Crete in the Early Bronze Age', 2nd ed., Amsterdam.
- CADOGAN, G. (1990), 'Lasithi in the Old Palace Period', *BICS* 37, pp. 72–74.
- CHERRY, J.E. (1983), 'Evolution, revolution and the origins of complex society in Minoan Crete', in O. Krzyszkowska, L. Nixon (ed.), *Minoan Society*, Bristol, pp. 34–45.
- COLDSTREAM, J. (1991), 'Knossos: an urban nucleus in the Dark age?', in D. Musti, A. Sacconi, L. Rocchetti, M. Rocchi *et al* (ed.), *La transizione dal Miceneo all'alto arcaismo, dal palazzo all'citta*, pp. 287–300, Studi Micenei ed Egeo-Anatolici. Rome: Consiglio Nazionale delle Ricerche.
- DERMITZAKIS, M. (1969), 'Geological researches of the Neogene deposits of the Hierapetra province', *Ann. Geol. Des Pays Hellen.* 21, pp. 342–484.
- DRIESSEN J and MACGILLIVRAY J, 1989, 'The Neopalatial period in East Crete', in Transition le monde Egeen du Bronze moyen au Bronze recent, *Aegaeum* 3, 99–111, Belgium
- FLEMMING N.C, 1978, 'Holocene eustatic changes and coastal tectonics in the Northeast Mediterranean: implications for models of crustal consumption', *Philosophical Transactions of the Royal Society of London* A289:405–458
- HAGGIS D.C, 1992, 'The Kavousi-Thriphti survey: An analysis of settlement patterns in an area of Eastern Crete in the Bronze Age and Early Iron Age, Ph.D diss, University of Minnesota, Ann Arbor:UMI Dissertation Services.
- HAGGIS D.C, 1999, 'Staple finance, Peak sanctuaries and economic complexity in Late prepalatial Crete', in A. Chaniotis eds, *Minoan farmers to Roman traders: sidelights on the economy of Ancient Crete*, 53–85, Stuttgart
- HALL E, 1914, 'Excavations in Eastern Crete, Vrokastro', University of Pennsylvania Museum, Anthropological Publications 3:3:79–185.
- HAYDEN B, 2004, 'Reports on the Vrokastro area, Eastern Crete. Volume 2: The settlement history of the Vrokastro area and related studies', University of Pennsylvania, Museum of Archaeology and Anthropology, Philadelphia .
- HUNTLEY D, Godfrey-Smith D, Thewalt M and Berger G (1985), 'Optical dating of sediments', *Nature* 313, 105–107
- IGME, Ag.Nikolaos Sheet 1/50.000, 1987
- JACKSON J.A, 1994, 'Active tectonics of the Aegean region', *Ann. Rev. Earth planet. Sci.* 22, 239–271.
- KAROTSIERIS, Lozios S and Dermitzakis ?, 2000, 'The neotectonic structure of Ierapetra Ag.Nikolaos region (Lasithi, Crete), *Annales Geologiques des pays Helleniques*, T.XXXVIII, Fasc.C, 77–115
- LAMBECK K, 1996, 'Sea-level change and shore-line evolution in Aegean Greece since Upper Paleolithic time', *Antiquity* 70, 588–610
- MOODY J.A, 1997, 'The Cretan environment: Abused or just Misunderstood?' in P.N

Kardulias and M.T. Shutes, eds, *Aegean Strategies*, 61-77.

MYER G.H, 1984, 'Ceramic Petrography', in P.P Betancourt, ed, *East Cretan White-on-Dark ware*, Museum Monograph 51, University of Pennsylvania Museum , Philadelphia.

SANDERS I.E, 1982, '*Roman Crete*', Warminster, Wilts:Arts and Philosophy Press
2001, 'Field guide for the geology of Crete, Museum of Natural History of Crete, University of Crete, Herakleion

FYTROLAKIS, 1980, 'The geological structure of Crete: problems, observations and conclusions', PhD Thesis, NTUA, Athens

VITA FINZI C, 1966, 'New Elysian fields', *A.J.A* 70, 175-178

VITA FINZI C, 1969, 'The Mediterranean valleys', Cambridge

WAGSTAFF J.M & Cherry J.E, 1982, 'Settlement and population change', in C.Renfrew and M. Wagstaff eds, *An island Polity: the archaeology of exploitation in Melos*, 136-155, Cambridge University Press.

WATROUS L.V & Blitzer H, 1999, 'The region of Gournia in the Neopalatial Period', in P.P Betancourt, V.Karageorgis, R. Laffineur and W.Neiemeier eds, *Meletemata III Aegaeum* 20:905-909, Belgium.

¹ Department of Geography, Harokopio University of Athens

² Laboratory of Archaeometry, N.C.S.R Demokritos, Athens

³ University of Pennsylvania Museum of Archaeology and Anthropology

⁴ Department of Geology, University of Athens

Geomorphology and geoarchaeology of three sites in the Potenza Valley Survey Project (The Marches, Italy): Potentia, Montarice and Helvia Recina

Tanja GOETHALS, Morgan de DAPPER, Frank VERMEULEN

Mots clés: géoarchéologie, Holocène, Potentia, Montarice, Ricina, fleuve Potenza, les Marches, Italie
Géomorphologie et géoarchéologie de trois sites dans le projet " Potenza Valley Survey " (les Marches, Italie) : Potentia, Montarice et Ricina. Le fleuve Potenza (775 km²) est un de ces cours d'eau parallèles qui dévalent le versant oriental de l'Apennin d'Ombrie et des Marches (Fig. 1), en Italie centrale. En 2000, le projet géoarchéologique " Potenza Valley Survey " s'est établi par une collaboration entre les départements d'archéologie et de géographie de l'Université de Gand. Les objectifs principaux sont l'étude de l'évolution et les influences mutuelles du paysage et de l'occupation humaine dans la vallée du fleuve Potenza durant le premier millénaire qui a précédé notre ère et le millénaire qui l'a suivi ; et la mise en place d'une méthodologie géoarchéologique. Cette contribution traite de l'intégration de diverses techniques géomorphologiques et archéologiques afin de résoudre quelques questions spécifiques qui concernent trois sites dans la vallée du fleuve Potenza : Potentia, Montarice et Ricina. Dans le cas de la ville romaine de Potentia (Fig. 3 et 4), située dans la plaine côtière du fleuve Potenza, il s'agissait de retrouver les anciens tracés du fleuve et les diverses positions du littoral. Le site protohistorique de Montarice (Fig. 5 et 6), sur une colline qui surplombe la plaine côtière, a été étudié relativement aux autres sites protohistoriques le long de la côte Adriatique. On s'est aussi intéressé à la question des ressources en eau et à leur distribution dans la ville romaine de Ricina (Fig. 7), sur la rive gauche du fleuve Potenza à 15 km de la côte. Pour répondre à ces questions il a été procédé à l'examen des sources écrites, des cartes topographiques et géologiques et des photos aériennes, mais également à des sondages et profils géoélectriques, à des forages à la tarière, à des datations radiométriques ¹⁴C et à des datations par luminescence stimulée optiquement. Des analyses malacologiques ont également été réalisées.

Introduction

The Potenza valley has been studied since 2000 in the geoarchaeological framework of the project "The Potenza Valley Survey. From Acculturation to Social Complexity in Antiquity: A Regional Geo-Archaeological and Historical Approach". The multidisciplinary nature of the project is reflected in the collaboration of the Department of Archaeology and Ancient History of Europe and the Department of Geography of the Ghent University (Belgium) (Vermeulen & Boullart, 2001; Vermeulen et al., 2002; Vermeulen, 2003).

Two goals were set: to understand the evolution and mutual influence of the landscape

and human occupation in the Potenza valley during the 1st millennium Before Common Era (BCE) and the 1st millennium Common Era (CE), corresponding to the Piceni, Roman and early medieval cultures; and to refine the geoarchaeological methodology. In this contribution, the settings of two Roman sites (Potentia and Helvia Recina) and one Iron Age site (Montarice) in this valley are analyzed, illustrating this methodology.

The focus of Mediterranean archaeological research has shifted in the past years, from excavation to prospection, and from strictly archaeological to geoarchaeological. Interdisciplinary studies, initiated in this time-

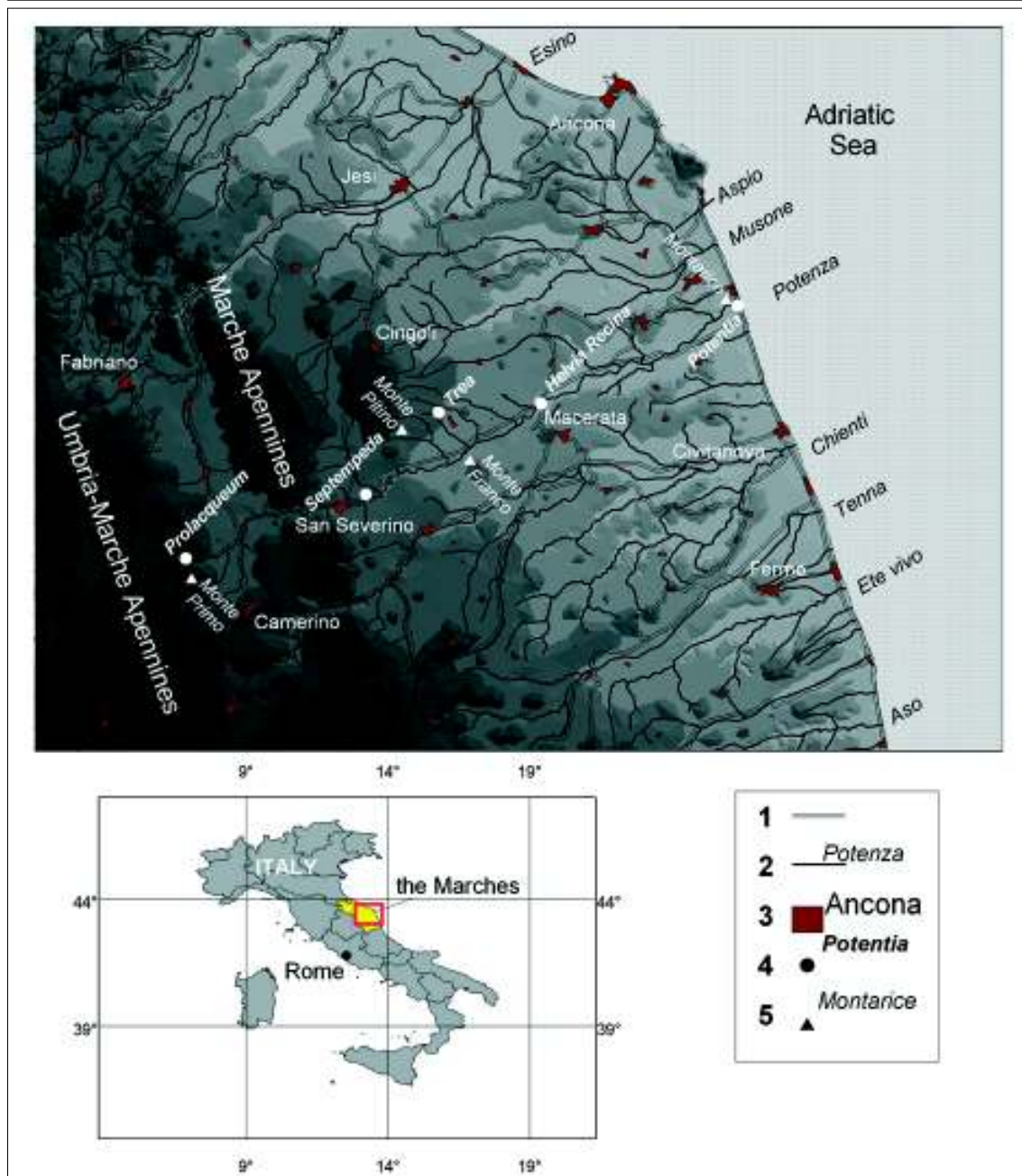


Fig. 1. Location of the study area in Italy and the Marche region. Source data provided by the Ufficio Cartografia e Informazioni Territoriali, Regione Marche. 1: road network; 2: streams; 3: agglomerations; 4: Roman cities; 5: protohistorical sites.

frame, complete the classical research methods. Thus, the Potenza Valley Survey project was established in collaboration with the regional archaeological service (*Soprintendenza per i Beni Archeologici delle Marche*): the archaeological service provided the excavation reports and communicated about the current level of archaeological knowledge in

the region. The Potenza Valley Survey project sums the results of the implementation of new techniques in order to solve unanswered questions concerning the situation of sites in relation to the hydrography, the presence of smaller archaeological sites, the different aspects of the past landscape, and the influence of geomorphology on the Roman road networks.

Localisation

The Potenza river is one of the streams that water in parallel the eastern side of the Umbria-Marche and Marche Apennines (Fig. 1). Its elongated basin (775 km²), situated entirely in the *Provincia di Macerata*, is perpendicular on the main relief units. From the Apennine mountain ridges to the Adriatic Sea it traverses two mountain chains, oriented NNW–SSE and built up in folded Mesozoic limestone and marls; the gravely piedmont at their feet consisting of interfingering dejection cones; and the hilly terrains of the Adriatic foreland modeled on detritic Pliocene to Quaternary deposits (clays, sands and conglomerates) (Servizio geologico d'Italia, 1967). These deposits, more and more recent from west to east, now slope monoclinaly ENE-wards, attesting their establishment by progradation and tilting following the quaternary upheaval of the Apennines (starting approximately 0.6 Ma ago, Ambrosetti et al., 1982).

All streams south of Ancona flow WSW–ENE-wards parallel to each other, in elongated, asymmetrical basins – their thalwegs being situated at the southern border of the alluvial plain. Traffic and trade throughout history were concentrated along the axes of the river valleys. The Potenza valley bottom was such a corridors, hosting a branch of the Via Flaminia from Rome to Ancona. In early-medieval times, the valley was situated on the border between the Byzantine areas in the north and the Longobard zones in the south, which adds to its geographical importance.

The Potenza river basin has continuously been occupied since the first millennium BCE, and even before that. However, preferred location of the population varied throughout those last 3000 years. The Iron Age Piceni culture reoccupied the elite sites of the Bronze Age and their surroundings, on hilltops overlooking the river. Four of those sites are well-known: Monte Primo, Monte Pitino, Monte Franco and Montarice (Fig. 1). Also smaller (scattered) sites are present, almost without exception near water sources,

be it a well or a river confluence. The Roman age sites are situated lower in the landscape: of the four Roman towns and one vicus known along the river valley – Potentia, Helvia Recina, Trea, Septempeda and Prolacqueum (Fig. 1) – only Trea is not located on the alluvial plain. They were all abandoned in medieval times and either never overbuilt (Potentia, Septempeda) or only partially overbuilt (Helvia Recina, Trea, Prolacqueum). Therefore all five large sites provide optimal opportunities for survey techniques such as remote sensing.

Geoarchaeology

Geoarchaeology *sensu strictu* has been defined by G. Rapp and C.L. Hill (1998) as the use of geologic concepts, methods, and knowledge base in the direct solution of archaeological problems. Such solutions can range from deciding on the integrity of artefact sets or the chronological context, to a broader approach determining palaeo-landscape habitat and human-environment interactions.

Geoarchaeology is a young and dynamic science, still to be defined clearly. According to G. Rapp and C.L. Hill (1998) the fluidness of the definition itself is a manifestation of the classification process within science. After taking into consideration of a number of projects that have been labelled as geoarchaeological, this definition can change to integration of geo-sciences and archaeology to come to a holistic image of the interaction between man and his environment – in past times.

This contribution specifically deals with three palaeo-environments and their reconstructed evolution through different geomorphological and archaeological techniques. After archaeological surface survey and a reconnaissance phase in which existent literature, maps and aerial photographs are consulted, a geomorphological survey is carried out: the topography is analysed and the outcropping sediments and rocks are mapped. In areas where erosion is equal to or greater than accumulation, the evidence is

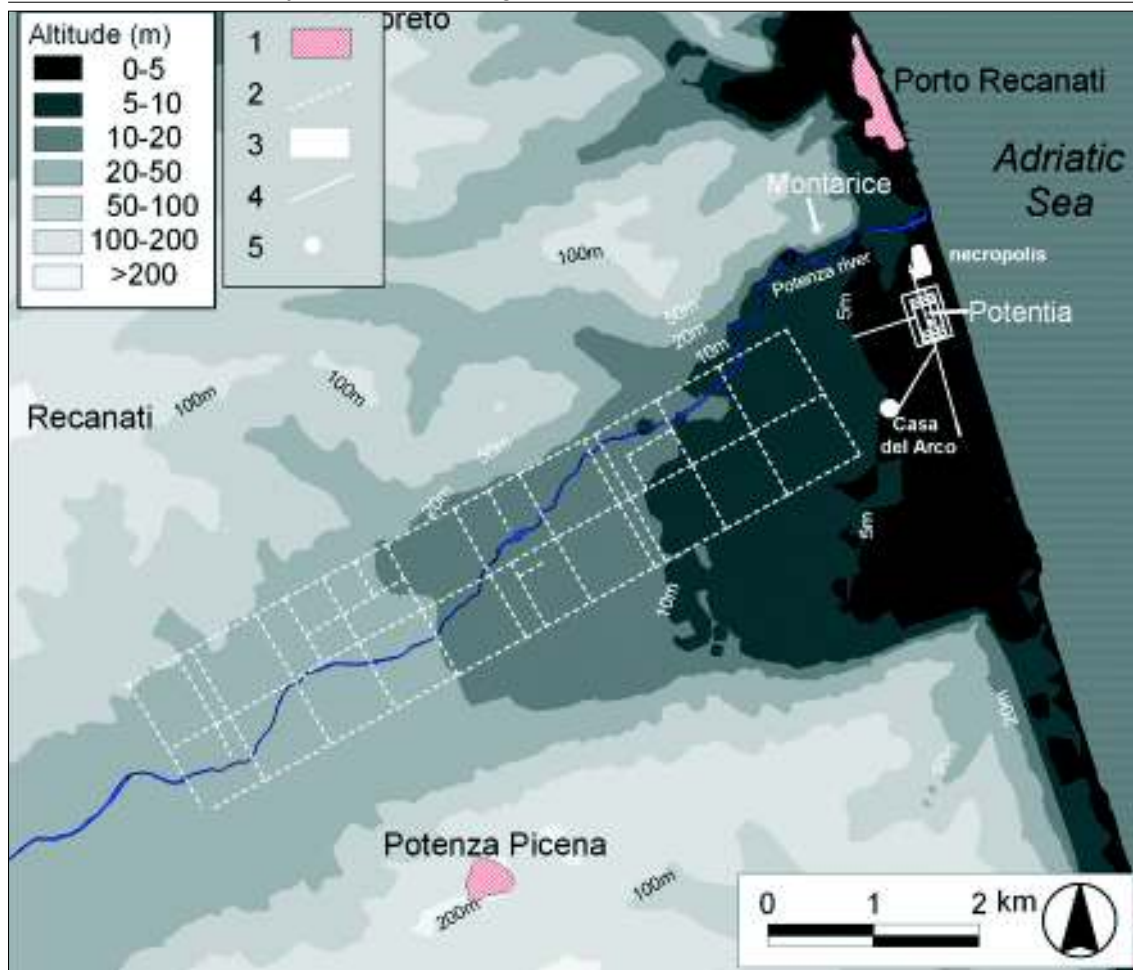


Fig. 2. Location of Potenza and Montarice in the coastal plain. 1: agglomerations; 2: centuriation of Potenza; 3: necropolis of Potenza; 4: street pattern of Potenza; 5: Casa del Arco site.

located near the surface, and geomorphological survey is extended consequently. In areas where accumulation is greater than erosion, such as alluvial plains, techniques that pierce the subsoil are proper, such as augerings and geoelectrical survey. Topographic survey is necessary in such areas with microrelief, since a small altitudinal difference, not even indicated on topographical maps, can have important consequences on the land use possibilities. Once the sediment succession is understood, the hypotheses made regarding the age and environment of the events can be confirmed or rejected by methods such as dating with OSL or ^{14}C , mollusc analysis and pollen analysis (not applied in this project). The final result is to be presented in the form of a geomorphological map.

Potenza

Archaeological setting. Roman colonisation of the Marche region emerged in the third century BCE on the coast, with the founding of multiple harbour towns that controlled over the Adriatic Sea (Paci, 2001), even though the presence of the Via Flaminia would induce one rather to think the influence from Rome invaded the region from the west. Examples of such colonies are Firmum Picenum (Fermo), Pisaurum (Pesaro), Auximum (Osimo), Numana and Cluana and later on Fanum Fortunae (Fano), Sena Gallica (Senigallia) and Cupra Marittima (Cupramarittima).

The harbour town Potenza was the first town to be founded in the Potenza valley, in 184 BCE. The street plan of the city, as reconstructed by the archaeological team, is rectangular,

having the decumanus maximus WSW–ENE oriented (252–72°N) and the cardus maximus NNW–SSE oriented (342–162°N), which is almost parallel to the coastline (343–163°N).

During Roman times, the swampy alluvial plain inland of Potentia was centuriated for cultivation for the first time. The system consisted of squares of 20×20 actus or 705×705m, with two longitudinal axes, one of them corresponding with the actual Strada Regina (SS16), oriented WSW–ENE (242–62°N) (Fig. 2; Alfieri, 1968).

When the town was abandoned in early medieval times, its inhabitants probably fled to the nearby hilltop sites such as Potenza Picena (founded in the 10th century) and Recanati (founded in the 8th and 9th centuries). Later on, the town of Porto Recanati was founded (in the 13th century), north of the Potenza river mouth, on a marine terrace at the base of an inactive cliff. However, a Romance church preceded the town of Porto Recanati in the 11th century.

Geomorphological setting of the coastal plain. On the 3.6 km wide coastal plain of the Potenza the Holocene and historical changes are due to an interaction of both anthropogenic changes and natural sea level changes. During the early Holocene, in response to the Flandrian transgression, the coastline at the Marchean river mouths retrograded to about 4 or 5 km inland of the present coastline (Coltorti, 1989). According to Coltorti (1989) the coast of the Marches was apperead at that time like an alternation of rocky promontories and pocket beaches and the shoreline did not move substantially until at least 4,000 years ago, in spite of the sediments which were transported to the sea by the meandering streams. Indeed the maximum sea level was reached in the period between 7,000 and 4,000 years ago according to G. Calderoni et al. (1996). *However, according to our own fieldwork, it is difficult to believe that there was no trace of the beach ridge on which Potentia is situated.*

Sediments started to accumulate at the Potenza river's mouth about 4,000 years ago,

according to M. Coltorti (1997), as a consequence of the first systematic land reclamation and following soil erosion in the middle courses of the river during the Bronze and Iron Ages. According to K.W. Butzer (1982) slash-and-burn was gradually replaced by sedentary agriculture. Other authors invoke a climatic worsening of the Boreal to Sub-Atlantic time span, which would have caused a reduction of the vegetation density upon the slopes, leading to soil erosion and increase of streams' solid load (Vita-Finzi, 1969; Delano-Smith, 1979). Whatever the cause is, the aggradation of floodplains at least during protohistory is amply testified in the Mediterranean context (e.g. Bruneton et al., 2001 for the Rhône valley; and Marchetti, 2002 for the Po plain) and even on European scale (Taylor & Lewin, 1997 in Wales).

Simultaneously, the decrease in the rate of sea level rise led to a new sedimentation equilibrium. In the 3rd century BCE the coastline was rectilinear, the sandy-gravelly beach ridges being in a direct line with the cliffs, and coastal lagoons and swamps situated behind those beach ridges (Ortolani & Alfieri, 1979). Thus during the Roman Age, the transported fine sediments were trapped at the river mouth by the beach ridges and settled in the lagoons. Stagnant waters from the resulting swamps engendered malaria.

Roman roads were constructed on the beach of the internal lagoons, because the beaches of the bays themselves were not stable and could be pierced during storm tides. Roman ports such as Cupra Marittima, Torre di Palma and Martinsicuro (Truentum) were constructed "at the foot of active marine cliffs", uninfluenced by river dynamics (Alfieri, 1983; Coltorti, 1997).

Most river sedimentation took place during the Roman Age and the early Middle Ages, diminishing afterwards due to anti-erosion measures, population decline and natural reforestation after the "barbaric invasions". This sedimentation filled the lagoons and swamps, turning them gradually into dry land. During the Medieval Climatic Optimum

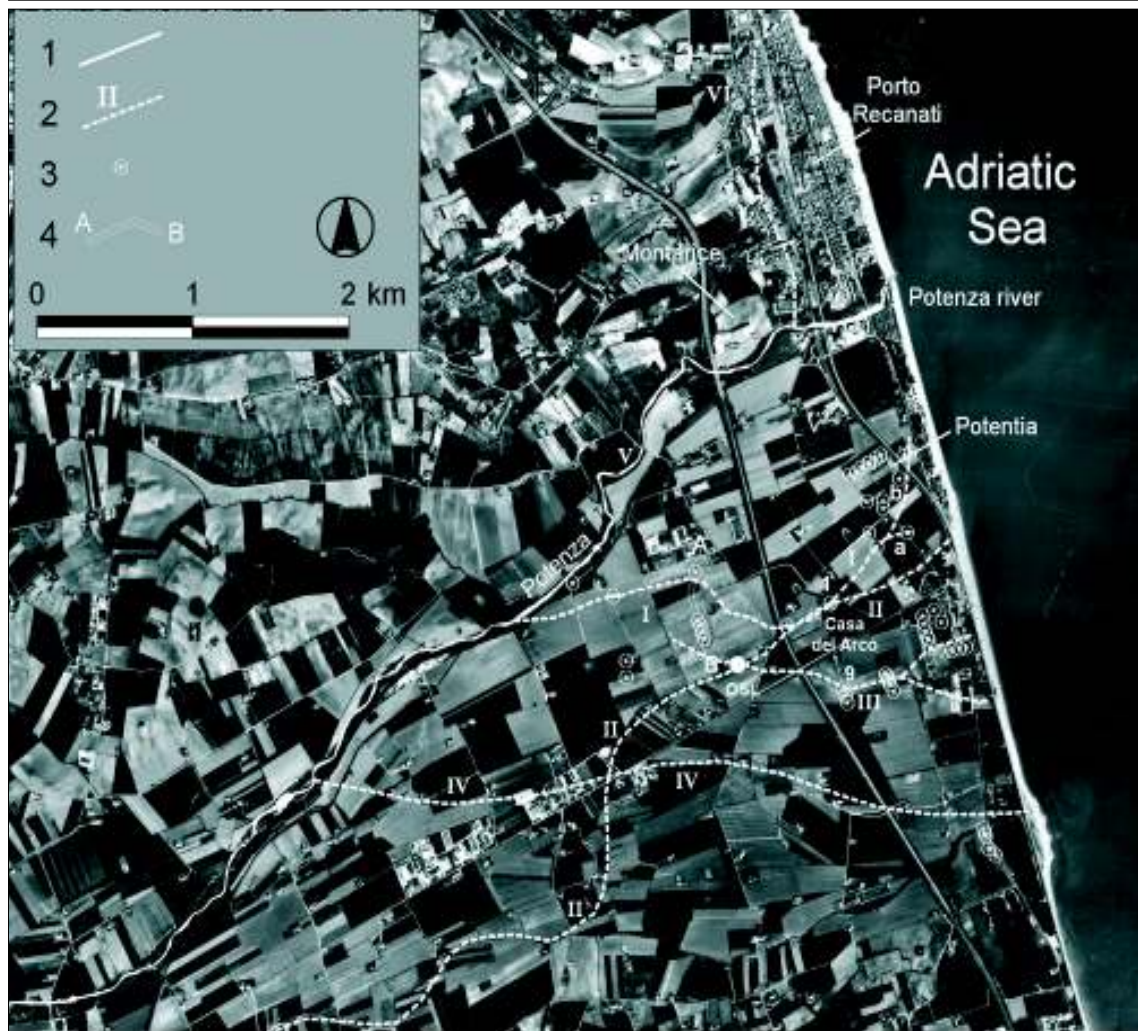


Fig. 3. Overview of the fieldwork in the Potenza coastal plain. 1: present Potenza river bed; 2: presumed and attested past river beds mentioned in the text; 3: augering locations; 4: location of the section of fig. 5. I: Roman and medieval river bed; II: presumed Roman course of U. Moscatelli and L. Vettorazzi (1988); III: terrace gravel; IV: pre-Roman course of M. Ortolani & N. Alfieri (1947); V: present course of the river Potenza; VI: late-medieval course of M. Ortolani & N. Alfieri (1947). Background: rectified aerial photograph of the IGM nr. 1150 – Flight of 30/03/1994.

(8th–12th century CE) deforestation and population pressure again helped increase the solid loads of rivers, thus favouring coastline progression (Aringoli *et al.*, 2003). At that time the coastal plain was covered with thick forests, which were cut down from the 15th century onwards for land reclamation (Baldetti *et al.*, 1983).

The marine terrace at the base of the cliffs north and south of the Potenza river valley, making these cliffs inactive, was probably free of floods in the Middle Ages. After all, the first buildings on this kind of marine terraces were constructed in the 11th century,

e.g. at Porto Recanati, which provides at least a terminus ante quem date. The only active cliffs are present along the Monte Conero massif and in the north of the Marche. The terrace is nowadays about 500 m wide and situated 5 to 6 m above sea-level. M. Coltorti (personal communication) attributed this marine terrace to the Holocene unit “Sintema del fiume Musone (MUS)”, and indeed the terrace must have originated in the later Holocene, when the Flandrian transgression slowed down, and the uplift of the coastal region outbalanced the sea-level rise.

A new generation of beach ridges – parallel to the previous ones – resulted from spit elongation by longshore drift, the spits attached to the marine terrace. This occurred probably from the 16th century to the end of the 19th century, as many authors record a seaward migration of the coastline in the Marches of up to more than 500 m (Giarizzo, 1963; Ortolani & Alfieri, 1979; Jacobelli et al., 1982; Anselmi, 1986). According to M. Coltorti (1997), the lower tracts of the rivers were at that time strongly aggrading in a braidplain system, because of the deforestation for land reclamation or *appoderamento* of the entire periadriatic zone. The remaining coastal swamps, amongst them the ones of the Potenza river, were filled up with sediments; forests were cut down; and many rivers were diverted and/or straightened. The anti-erosion measures and reforestation of the slopes with the “alberata” system stopped the coastline progression of the by fluvial sediment supply in the 20th century.

The low rectilinear coast is now under erosion, with Monte Conero massif north of the Potenza coastal plain as principal source of sediments with, but the principal redistributing wind is the southwest sirocco (Curzi, 1986). Periodical floods at present still affecting large part of the coastal plain, e.g. in December 1982 and November 1999 (personal communication of inhabitants). These floods are of marine origin, depositing marine shells at the surface (pelican's foot or *Aporrhais pespelicani*; Van Damme, 1984).

Geoarchaeological results. The Potenza did not always follow its present course in the extreme north of the coastal plain. Based of historical data, field work and marks on aerial photographs, remains of previous river beds have been identified, both south of the present course of the Potenza.

One river bed, 500 to 600 m south of Potentia, certainly existed in Roman times, since a Roman bridge was built over it at the Casa del Arco site (Fig. 3, I; Ortolani & Alfieri, 1947; field-checked). The road crossing the bridge leads from Urbs Salvia over

Pausulae to Potentia. Parts of the bed appear on oblique low-altitude aerial photographs. An augering (Fig. 3, 1; Casa del Arco) close to the bridge revealed a fining upward profile: gravel starting at a depth of 400 cm below the surface indicating the thalweg of the river, with above a fine sand deposition between 210 and 400 cm indicating river bank breakdown material, topped by 210 cm of fine sandy clay flood sediments. The surface is at 410 cm above sea level, which agrees with the ground water table in the augering 400 cm depth. A ¹⁴C-dating on some pieces of charcoal, a few mm large, found in the gravel lag of the river, indicated the interval 630 ± 25 BP or between 1290 and 1400 CE. Two datings higher in the profile were progressively younger: 355 ± 30 BP or between 1450 and 1640 CE at 240 cm depth and 80 ± 25 BP or after 1690 CE at 150 cm depth. This is the same course of which sediments appear in the deep augering on fig. 4, the incision being dated here at 100 BCE to 60 CE and the filling at 1520 to 1660 CE.

This implies that the Roman course was not only in use during Roman Age, but also during the Middle Ages, up to the 14th century. Analogous sediment successions have been found in three other augering profiles, which allows an approximated reconstruction of the course. However, this bed cuts partly through the Roman centuriation system of the fertile “Ager Potentinus”. The mouth of this bed has either moved to a more northward course, or formed a delta system. M. Ortolani and N. Alfieri (1947) already identified the morphology of a fossil delta, which they ascribed to the Roman Age at this location. Fact is that at least two debouchments are present (Fig. 3, a and b). The northernmost has erased part of the city structures, as indicated on oblique low-altitude aerial photographs. This may have played a role in the abandonment of the city, together with the upcoming malaria thriving in the nearby marshy conditions. The exact location of the Roman harbour has certainly been influenced by these river dynamics.

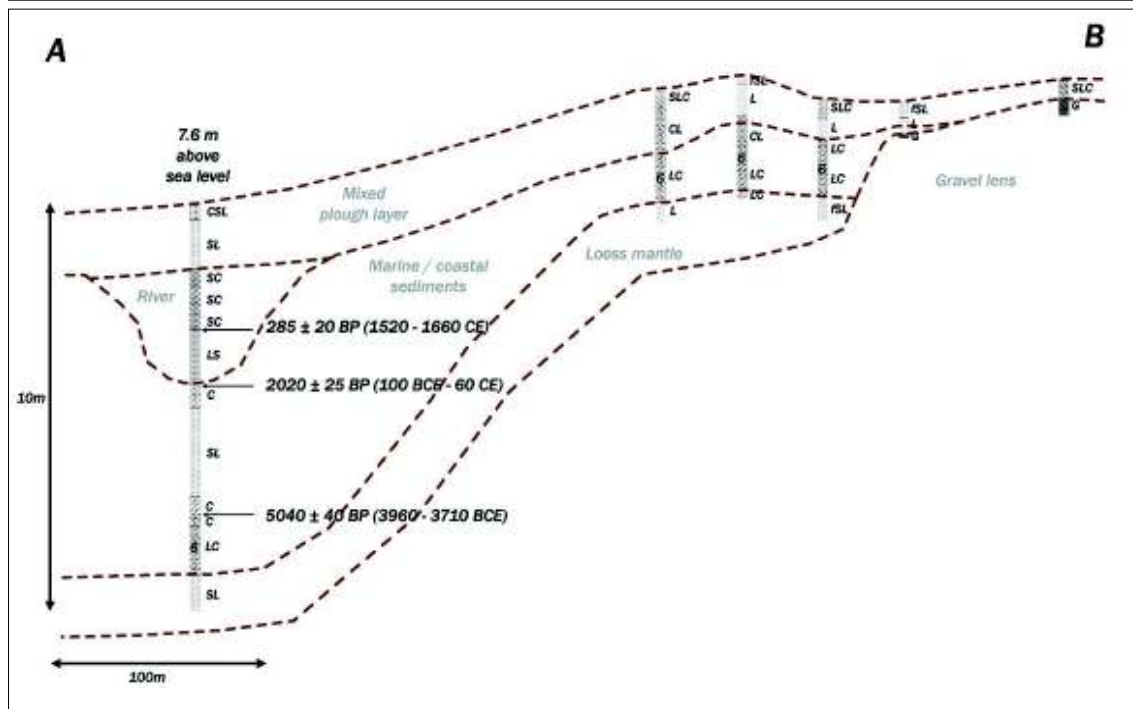


Fig. 4 Approximate north-south augering section through the coastal plain. The location is indicated on figure 4. C: clay; CL: clayey loam; CSL: clayey sandy loam; fSL: fine sandy loam; G: gravel; L: loam; LC: loamy clay; LS: loamy sand; SC: sandy clay; SL: sandy loam; SLC: sandy loamy clay; 6: marine shells.

The “Roman course” (Fig. 3, II) assumed by U. Moscatelli and L. Vettorazzi (1988) and G. Paci (2001) for the Roman Age Potenza, is based on archaeological finds and directions of groundwater flow. However, this hypothesis can be rejected, since loose and permeable late-Quaternary sediments underlie the coastal plain up to a depth of at least 10m, so groundwater flow does not represent the superficial historical courses.

Traces of crop marks and soil marks on aerial photographs have been identified in the field as an extensive gravel deposit (Fig. 3, III), occurring on surface of 1.5 km in length and 100 to 150 m wide. Its thickness could not be explained. This seems a remaining terrace of an older bed, although it is situated closer to the surface than the Roman bed, at 120 cm depth below the surface (at augering 9, see fig. 3, surface at 500 cm above sea level) instead of 400 cm. An OSL-dating nearby (Fig. 3, OSL) on quartz in a loamy sand lens of 30 cm, taken from 160 cm in depth, indicated an age of 3600 ± 400 years. The thinner sediment cover can be explained

by the greater distance from the present Potenza and the slightly higher topographical position of the gravel beds. The transition between this terrace and the floodplain is illustrated with the augering section of fig. 4.

M. Ortolani & N. Alfieri (1947) supposed the pre-Roman course to have been in the very south of the coastal plain, as precursor of the Fosso Pilocco streamlet. This hypothesis is based on the morphology of a fossil delta. This could not be verified by field-checking, since large part of the Fosso Pilocco's bed is now fortified, as well as the mouth. However, this is very much possible, since it satisfies the asymmetry-postulation of the Marchean rivers, and it could have been responsible for the breakdown of the terrace mentioned in the previous paragraph. However, the diversion from the present Potenza river is probably more upstream than their design. In that case M. Ortolani and N. Alfieri's postulation (1947), that the “has a tendency to move northwards and never vice versa”, is correct.

The present course of the Potenza river (Fig. 3, V), one km north of Potentia, is clear-

ly artificial. All rivers in the Marche show a marked asymmetry, towards being displaced to the south, with a well developed terrace sequence on their left banks and a stunted terrace sequence at their right banks. The cause is still a matter of discussion (Dramis et al., 1992; Rasse, 1994; Coltorti et al., 1995), but the result is unarguable. Paradoxically, the Potenza river flows nowadays at the foot of the northern interfluvium and the Montarice site, displaced to the very north of the coastal plain. Only the Musone river, neighbouring the Potenza river to the north, does the same. However, in the case of the Musone, ample passages point to a deliberate rerouting for land reclamation (Ortolani & Alfieri, 1947). In the late Middle Ages and early Renaissance, large tracts of land in the Marche coastal plains were reclaimed (Cencini & Varani 1991; Nanni & Vivalda 1987). Less sources mention the Potenza, but M. Buli and M. Ortolani (1947) cite the consent of Pope Gregory IX (1170-1241) given to the inhabitants of Porto Recanati to make the rivers Potenza, Musone and Aspio debouch together. At the new mouth, a new harbour would be built. Though this project was clearly neglected and finally abandoned in 1474, this illustrates the ideas that occupied the government. There is, on the other hand, also the epigraph which M. Ortolani and N. Alfieri (1947) mentioned, now situated near the railway station of Porto Recanati, which reads: “Arcus hic est pars pontis Potentiae veteris dictae le Fiumarelle” or “this arch is part of the bridge over the old Potentia, called Fiumarelle”. This could be a diverted arm of the Potenza (Fig. 3, VI) or an attempt to fulfil the task to which Pope Gregory IX consented.

In the framework of the project, geoelectrical and geomagnetical measurements have been carried out, in order to survey the texture of the subsoil and the city structures. The weakening of the signals in both cases on the inland side of Potentia, can be explained by the morphology of the beach ridges: a steep seaward slope and a gentle landward slope, identical to the currently active beach ridge.

As the beach ridge surface slopes gradually landwards, so does the city of Potentia, built on this surface. Later on, floods deposited sediments behind the ridges and thus covered the structures with a gradually thickening clayey layer, which explains the fading geophysical signals.

Montarice

During aerial surveys and subsequent field walks, a major protohistorical site was checked at Montarice, at the end of the northern interfluvium of the Potenza coastal plain (Fig. 2). This site had been described in literature. Linear traces in a field of sunflowers attracted E. Percossi Serenelli (1995) to presume the ancient enclosure of this imposing site which might be the location of a Piceni settlement. A following small-scale excavation indicated Bronze Age occupation and “sporadic Iron Age material” (unpublished excavation by D. Lollini in 1976; mentioned in Percossi Serenelli, 1985). A field check within the framework of the Potenza Valley survey of the general topography and of some of the internal traces and spots indicated that this site was no doubt also very important in the Iron Age, as a pre-urban circumvallated site or oppidum (Boullart, 2003). The site was probably only recently ploughed up and discovered, as can be appreciated from the large number and the slight wear of the found sherds (Boullart, 2003).

The Montarice site is situated on a slightly east/seaward-sloping surface of about 4.2 ha large, at 45 to 53 m altitude, covered with a thick – probably early-Pleistocene – marine gravel stratum upon a substrate of marine sandstones and clays (Fig. 5), which also crop out at Monte dei Priori, on the opposite side of the Potenza valley). During the Flandrian transgression the plateau functioned as a real headland overlooking the bay at the Potenza river mouth. The entrance road to the site was located in the south of the hill in the 19th century (IGM map 1/25.000 of 1892 – F118 III NE Loreto), coming from the nearby Colle Burchio, until the construction of the motor-

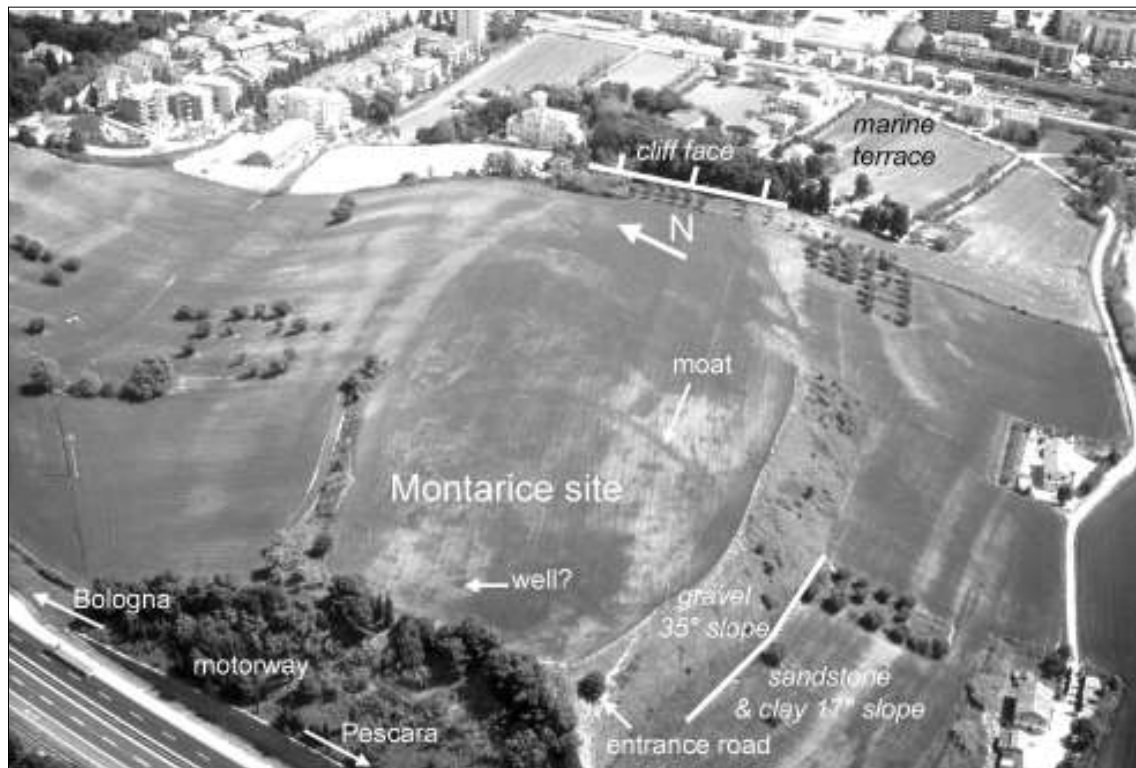


Fig. 5. Overview of the Montarice site with indication of the special features: in *italics* geological features, in regular print archaeological features. North arrow is drawn by approximation. Background: contrast-enhanced oblique aerial photograph taken by Jacques Semey.

way Bologna-Pescara. It is not excluded that this entrance road goes back to much older times.

Steep slopes – 35° – border the plateau except on the east-side. On that side linear traces on aerial photographs suggest an ancient enclosure. The steep slope at the west-side is probably due to the recent construction of the motorway Bologna-Pescara, annihilating part of the site, but the others seem natural (Fig. 5).

Consequently, the defence of the site could be secured by the raising of only one or two enclosures: one which is attested on the aforementioned eastside and possibly one somewhere on the west-side; the other slopes, covered with slope-waste material and probably overgrown with a spiny bush-vegetation at that time, provided natural defence. Moreover, the site enjoys ample view on the coastal plain of the Potenza. This leads to suspect the site had a role in the control over the river mouth and of the Adriatic shore by the local Piceni-elite.

Below the steep edge on the south-facing slope, a dark greyish zone of earth mixed with many artefacts has been distinguished, which can be identified as either an outflow zone of the site, or an isolated unit. At the end of the southern interfluvium of the Potenza coastal plain, the Monte dei Priori location, a smaller protohistorical site is attested in a similar position as the Montarice site. It either preceded Montarice, or it was its counterpart (Boullart, 2003).

The genesis of the 35° south-slope can be questioned. The first impressions were about that slope being part of an undercut bank of a river, but which river? More likely slope instability was engendered by a mass movement: slope would be part of the apical detachment zone of a rotational landslide (Fig. 6). At the opposite side of the motorway Bologna-Pescara, south of Colle Burchio, such a landslide of the same size and one the same lithologies figures. The Montarice landslide would be older, as the traces are more eroded than the Colle Burchio landslide

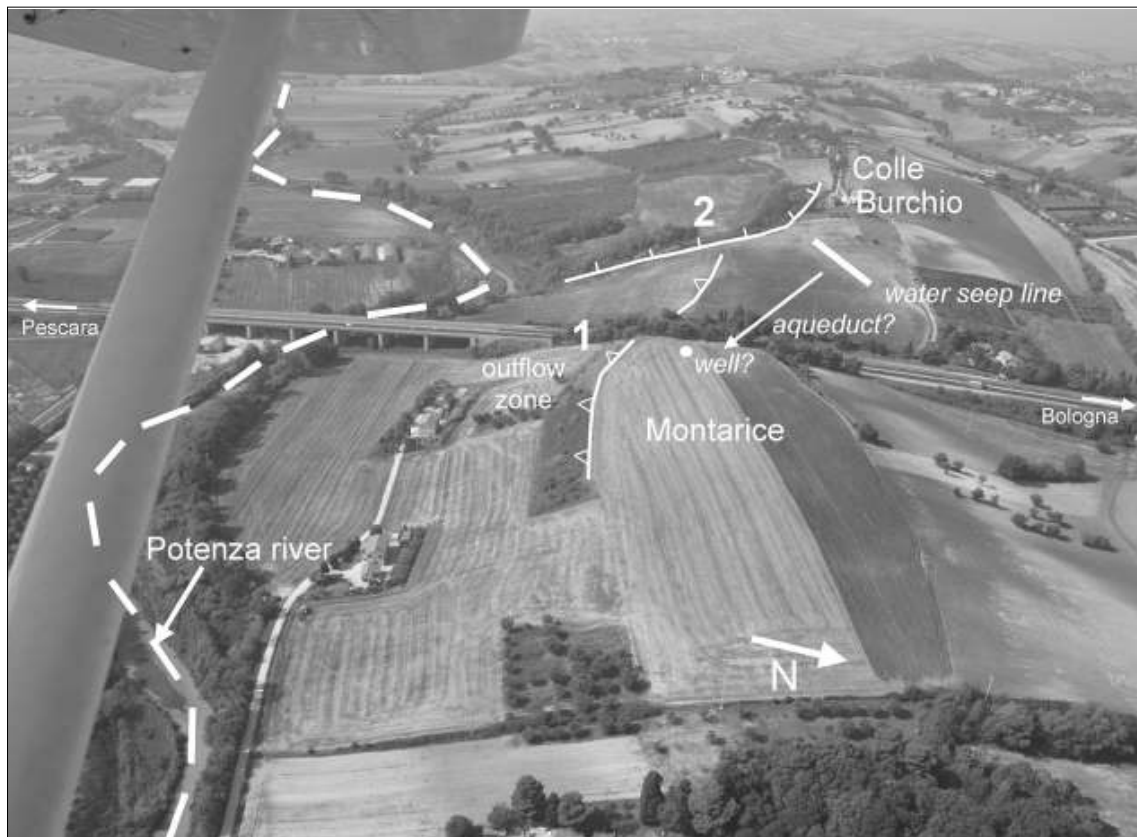


Fig. 6. Montarice and Colle Burchio landslides (in regular print) and water problematics (in italics). 1: Montarice landslide scar; 2: Colle Burchio landslide scar. North arrow is drawn by approximation. Background: oblique aerial photograph taken by Rudi Goossens.

traces, but still visible as soil marks. In that case, the entrance road to Montarice mentioned before is built on the top edge of a landslide lobe. This could also explain the “bumpy” morphology with irregular contour ridges of the slope, the dark greyish outflow zone of archaeological material mentioned before and the fan-like accumulation of material at the foot of the slope, which made even the present artificial course of the Potenza take an outward bend.

The geological situation provides also an easy source of water, as the gravel terrace stocks plenty of water. Even at present water seeps out of the terrace after a slightly rainy day, this being probably one of the triggers of the mass movements. Roughly two ways of procuring water are at hand: either wells were dug into the above terrace, or the water was captured below, at the base of the gravel terrace (Fig. 6). Capture at the base of the gravel terrace is a plausible solution. Along the seep

line, capture is difficult, but at the downhill end of the seep line, where flow is gathered in a single well, the yield would be consistent. Since the terrace slopes eastward, the best capture point would be on the south-slope of Colle Burchio. The motorway is constructed in this point, which makes sense because two river gullies had created a saddle there previously. However, it includes either an aqueduct or manual labour to bring the water up to the site. The aqueduct hypothesis is least likely, since this aqueduct would have to cross a gap of more than 10m deep and 160m wide, which would only be done if no other options were available. The well-hypothesis is likely. Digging a well in terrace material is not the easiest job, but in the long-run a profitable solution. A round soil mark of 4.5 m on the aerial photographs of Montarice can easily correspond to a well.

This setting has geological analogies along the entire Adriatic coast, with a late-

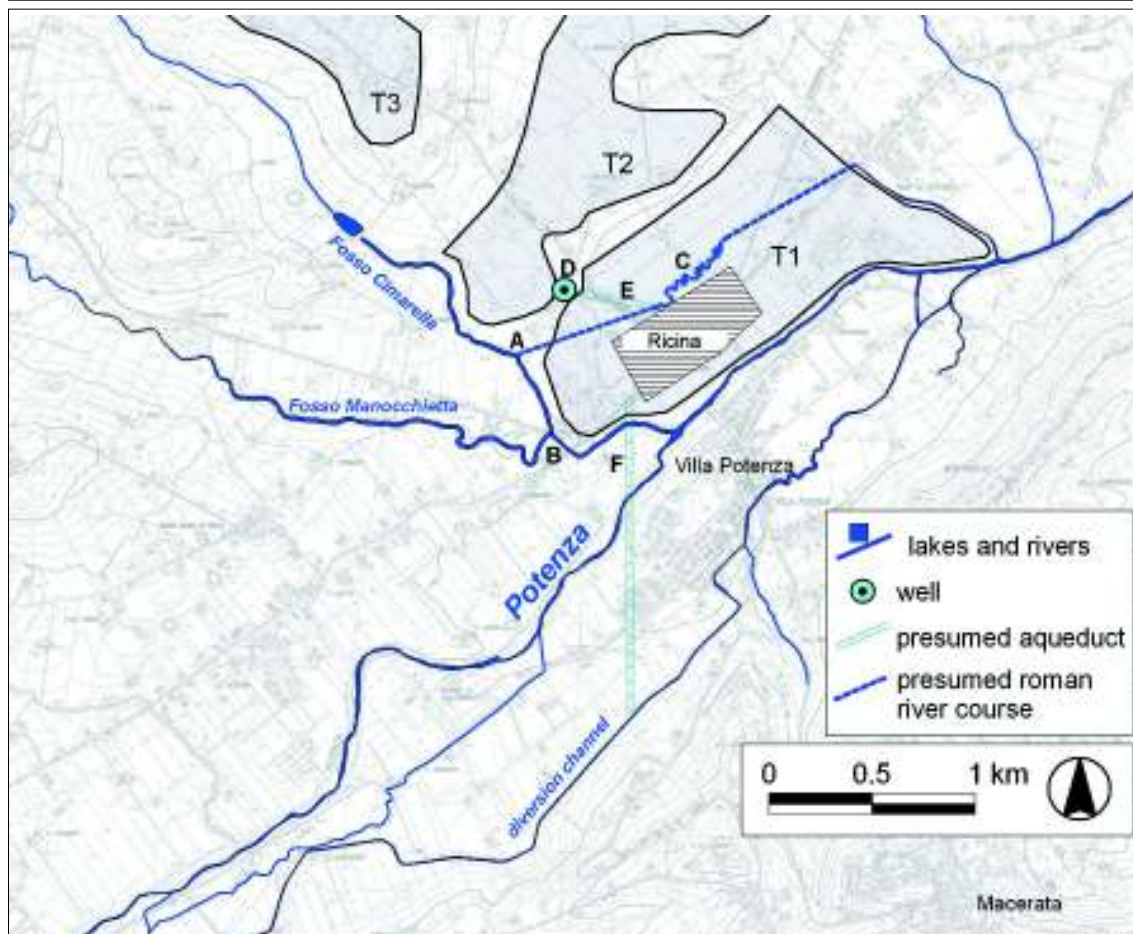


Fig. 7. Situation of Helvia Recina and location of research points cited in the text. A, B, C, D, E, F: points cited in the text; T1, T2, T3: terraces of the Potenza river. Background: topographical map IGM on a scale of 1/10,000.

Pleistocene marine terrace upon a late-Tertiary substratum, ending with a cliff and steep lateral slopes. It is an ideal situation for defensive hilltop sites with control over the river and over the coast, for observing the maritime commercial routes of Greek merchants (Luni, 1992). Iron Age sites in the same situation in the Marche region have been found and excavated at Montedoro di Scapezzano near Senigallia, and near Pesaro (Boullart, 2003).

Helvia Recina

Helvia Recina is a Roman town situated at 15 km from the coast. The first mention of the city is in 40 BCE, so we can assume that the founding of the city took place about a century later than Potentia. The city is built on the late-Pleistocene river terrace on the left bank of the Potenza river (Fig. 7). A large part of

the city's structures is covered by the present town Villa Potenza. Little traces are left: only the theatre, a mosaic floor, and remnants of baths, a bridge and the decumanus maximus. The remainder is overbuilt, covered with sediments or taken away to provide building material for the nearby city of Macerata. But some can be seen as crop marks, such as part of the city structures, and a cistern.

The Potenza is supposed to have been navigable up to Helvia Recina, as most of the rivers of the Marche have been navigable until the 15th century (Coltorti, 1991). Just like Potentia, the town was abandoned during early medieval times and the inhabitants probably also fled to nearby hilltop sites, in this case to Macerata. This relocation to higher grounds was later labelled as the "incastellamento" movement.

Three topics were raised by the archaeological team, all relevant to the water resources of the city: the presence of a meandering rivulet just north of the city in Roman Age, the origin of the water when Helvia Recina was founded and the origin of water for the baths.

The possible presence of a rivulet in Roman Age, *id est* during the occupation of Helvia Recina, was indicated by grass marks on an aerial photograph of 01/05/2003. The rivulet is not active nowadays. Geo-electrical measurements enabled the precise localisation of the river course, at the points with the highest resistivity values. Augerings at these points revealed gravel outcroppings – with upward fining sediments above – at diverse depths below the surface, corresponding with consecutive thalwegs.

Geomorphological evidence proves that that the rivulet was beheaded at point A (Fig. 7), where the present Fosso Cimorella abruptly changes in direction to debouch in Fosso Manocchietta. First, the rivulet has to meet the carrying capacity demand for gravel of up to 3cm (found in the augerings), in a meandering channel pattern (which normally takes less bedload sediments than a braiding channel pattern). This implies that the rivulet had a quite large watershed, which can only be the watershed of Fosso Cimorella. Moreover, the part of present day Fosso Cimorella between point A (Fig. 7) and the debouchment in Fosso Manocchietta (Fig. 7, B) has an artificial morphology: a narrow bed (1.6 m) with no gravel bars (one would expect gravel deposits in a natural bed, given the area of the watershed) and a left bank of which the lower part slopes 37° and the upper part 5°; while upstream the bed is 6 m large out, of which only 2 m were in use in October 2004, and has banks sloping 30° to 34° uniformly. Moreover, the debouchment of the Fosso Cimorella is fortified with concrete and hanging 2 m above Fosso Manocchietta. And finally a depression in the landscape is still present between the beheading point and the grass marks of a meandering channel (Fig. 7; C), in some places with outcropping gravel,

as seen on the field and derived from the contour lines of the topographic map at a scale of 1/10,000.

Unfortunately, it was not possible to extract an uncontaminated charcoal sample for ¹⁴C-dating from the augerings. However, it can be presumed that this rivulet was present during Roman Age, out of reasons. Firstly, M. Coltorti (1991) mentions that the streams in the Marche region had a meandering middle course in Roman times, which converted progressively to braided from the Middle Ages to the end of the 19th century. Thus, a younger age would imply a braided channel pattern, which is not the case here. An older stream, on the other hand, would be buried deeper under the surface of alluvium and colluvium. Secondly, the Romans could derive profit from the rivulet: it represents the northern limit of the city, provided them with extra protection, could serve as wash-place and perhaps even had recreational values. However, direct water supply was not possible, since the rivulet is situated lower than the city topographically. In the populous Late Middle Ages, on the other hand, the need for reclamation of all land, even marginal land, was high. Thus it is much more likely that the river has been diverted in late-medieval times, simultaneously with the diversions of the coastal plain, than in Roman times.

To fill the town cistern for daily use, the Romans would have needed a small but steady amount of water, available at a low energy cost. The rivulet is not ideal, since it is situated lower than the cistern and thus would require pumping up or manual transport of the water. Upstream however, a well was found (Fig. 7, D). According to locals, the well was perennial until about a decade ago, so it is logical to assume its functioning also in Roman Age. Indeed, the well is situated on the escarpment between two terraces of the Potenza river (Fig. 7, T1 and T2). The gravel of the upper terrace stores water at its base like a sponge, releasing gradually the water along a seep line, where the interface between the terrace and the bedrock crops out. Although it

is not a proof, it can be taken into consideration that a ditch now leads straight from the well to the location of the cistern (Fig. 7, E).

A considerably larger amount of water than this would have been needed by the time the baths were built (in the 2nd century CE, Mercado 1977–1980). According to excavations, the cistern could hold vast quantities of water. This could be linked with the presence of crop marks in the field between the Fosso Manocchietta and the Potenza river (Fig. 7, F), located 6 m apart, approximately 5 m x 2 m large, aligned almost perfectly on north-south direction. Augerings revealed that the crop marks occur on river terrace gravels covered with a layer of fine sediments 40 cm thick. At the crop marks, the gravel begins deeper under the surface, at 55 cm, as if a hole was made in it to host a pole or pillar and after this was removed (to be re-used as building material), the hole was filled with finer sediments. It could well be aqueduct arcade or venter bridge pillars. It has been mentioned that the depth of the 15 cm poles of in the gravel is little, but this can be attributed to the collapsing of the walls of the pole-holes before the sediment cover was deposited. Given the asymmetry of the Potenza river valley, the terraces north of Potenza are located further apart than the ones south of Potenza., and thus the south is better suited for water captation. At present, a diversion channel of Potenza (Fig. 7) is used for hydroelectricity. When producing the line of the aqueduct southward (Fig. 7, E), the field work team encountered remains of conglomerate conduit parts with a large radius of curvature, consisting of conglomerate with a kind of cement on the interior, exactly at the crossing with the channel. The channel has a rate of descent of 1.5 m/km, slower than Potenza river's rate of descent 6.4 m/km. Consequently, on the 4 km between the diversion of the channel and the arrival south of the city, the altitude gain of the channel over the Potenza is 20 m. Considering the altitude of Helvia Recina, the aqueduct would have had a mean descent rate of 6 to 8 m/km, which is high but not improbable. It would lead to a high water velocity and thus

possible erosion on the conduit, avoiding accumulation of calcium carbonates and sediments in the conduit. This is a system that is relatively easy to construct and to maintain.

The age of the aqueduct is not determinable: the cement could have been renewed regularly as long as the aqueduct was in use, so this dating possibility is out, and the typology and material of the conduit parts is so simple that it could be Roman as well as fairly recent according to Roman ceramics specialists. Despite the absence of foolproof evidence, it is likely that the aqueduct was built during Roman Age and afterwards either abandoned or re-used and fortified. First of all, the construction has Roman finger prints all over it, the Romans being obsessed with building aqueducts only for the supply of water for baths (even if they had relied quite happily on wells for drinking water in the centuries before; Hodge, 1989), and the almost perfect north-south orientation is typically Roman. Moreover, although the Romans preferentially built aqueducts 1 m below or at ground level, they frequently used closed inverted siphons on pillars (a so-called venter bridge) to cross river depressions (Hodge, 1989). The Romans had no difficulty in making lead pipes that could withstand the pressure, but as lead was heavy and expensive to transport, the siphon part had to be as small as possible, by reducing the altitudinal range. Consequently, it would only be near the river that the conduit would be raised above ground level, on the venter bridge. This can explain why the crop marks are only found at this point. Secondly, after Roman Age, no city was to be supplied with water any more, hence the question rises: for what purpose a later societies would it build an aqueduct. One could argue that the water could be used for agriculture in the floodplain. This is true, but it is doubtful that they would go through the trouble of both digging a channel and building an aqueduct on good agricultural hilly land just to provide some more water to the floodplain where the water from the well could be used as well for irrigation purposes.

Conclusions

It has been made clear in this contribution that at the various sites and settings of the geoarchaeological project, different questions pop up and a new approach is needed. Around Potentia and Helvia Recina, situated on the coastal plain influenced by coastal processes, and the alluvial plain with dominant accumulation respectively, the main research methods were augering, resistivity survey and levelling.

Montarice on the other hand is a hilltop site, with erosion processes, landslides and remnant terraces, so the evolution in Quaternary geology is more important and has to be studied through geomorphologic reasoning and comparison with analog sites.

The geomorphologic research in the Potenza valley survey project, and especially in the coastal plain, has entered a phase of

specific problem solving. In the future, the study of the environmental situations of sites will continue, through detailed geomorphological mapping and a land evaluation of the study area in central Potenza valley. The foundations are laid; the work itself is under construction.

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BIBLIOGRAPHY

ALFIERI N. (1968) *La centuriazione romana nelle basse valli del Potenza e del Chienti*. Studi Maceratesi 4, pp. 215-225.

ALFIERI N. (1983) *Le Marche e la fine del mondo antico*. In: Alfieri N. (ed) Istituzioni e società nell'alto medioevo marchigiano. Ancona, pp. 9-34

AMBROSETTI P., Carraro F., Deiana G. & Dramis F. (1982) *Il sollevamento dell'Italia Centrale tra il pleistocene inferiore e il pleistocene medio*. In: Contributi conclusivi per la realizzazione della Carta Neotettonica d'Italia, Pubbl. N. 513 del Progetto Finalizzato Geodinamica (Progetto finalizzato geodinamica C.N.R.).

ANSELMIS S. (1986) *Soldati, corsari e regine nella Senigallia del settecento (1707-1739)*. Comune di Senigallia Ed., 273 pp. Mentioned in: Coltorti, 1997.

ARINGOLI D., BISI C., CANTALAMESSA G., DI CELMA C., FARABOLLINI P., FAZZINI M., GENTILI B., MATERAZZI M. & PAMBIANCHI G. (2003) *Recent variations of Italian Central Adriatic coastline*. In: Castaldini D., Gentili B., Materazzi M. & Pambianchi G., Proceedings of the workshop on "Geomorphological sensitivity and system response" Camerino-Modena Apennine (Italy) 4th-9th July 2003.

BALDETTI E., GRIMALDI F., MORONI M., COMPAGNUCCI M. & NATALI A. (1983) *Le basse valli del Musone e del Potenza nel Medioevo*. Archivio Storico Santa Casa, Loreto, pp. 95.

BOULLART C. (2003) *Piceni Settlements: Untraceable or Neglected?* Picus XXIII, pp. 155-188.

- BRUNETON H., ARNAUD-FASSETTA G., PROVANSAL M. & SISTACH D. (2001) *Geomorphological evidence for fluvial change during the Roman period in the lower Rhone valley (southern France)*. Catena 45, pp. 287-312.
- BULI M. & ORTOLANI M. (1947) Le spiagge marchigiane. In: Bevilacqua E. (Ed.) Marche. CNR, Comitato Nazionale per la Geografia, pp. 95-147.
- BUTZER K.W. (1982) *Archaeology as human ecology: Method and theory for a contextual approach*. Cambridge University Press, pp. 364.
- CALDERONI G., CILLA G., DRAMIS F. & FARABOLLINI P. (1996) *Dinamica fluviale olocenica nella media valle del fiume Potenza*. Geografia Fisica e Dinamica Quaternaria 19, pp. 19-28.
- CENCINI C. & VARANI L. (1991) *Per una storia ambientale delle pianure costiere medio-Adriatiche*. Geografia Fisica e Dinamica Quaternaria 14, pp. 33-44.
- COLTORTI M. (1989) *Il quaternario continentale e l'evoluzione del paesaggio della regione Marchigiana*. Laboratorio didattico di ecologia del Quaternario: La preistoria e studi preliminari di preistoria nella provincia di Ascoli Piceno - Atti del corso di aggiornamento per personale direttivo e docente della scuola - Cupra Marittima, 29 Nov. - 7 Dic. 1989.
- COLTORTI M. (1991) *Modificazioni morfologiche oloceniche nelle pianure alluvionali marchigiane: alcuni esempi nei fiumi Misa, Cesano e Musone*. Geografia Fisica e Dinamica Quaternaria 14 (1), pp. 73-86.
- COLTORTI M. (1995) *I fiumi marchigiani: evoluzione morfologica, modificazioni antropiche e tendenze attuali*. In: Biondi (ed.) Salvaguardia e Gestione dei Beni Ambientali nelle Marche, Tipolitografia Trifogli, Ancona, pp. 199-228.
- COLTORTI M. (1997) *Human impact in the Holocene fluvial and coastal evolution of the Marche region, Central Italy*. Catena 30, pp. 311-335.
- CURZI P.V. (1986) *Cenni di geologia dell'adriatico nel tratto marchigiano*. Studi Geologici Camerti, Volume Speciale "La Geologia delle Marche" (1986), pp. 135-145.
- DELANO SMITH C. (1979) *Valley changes: some observations from recent field and archive work in Italy*. Papers in Italian Archaeology II, BAR International Series 102.
- DRAMIS F., GENTILI B. & PAMBIANCHI G. (1992) *La depressione morfostrutturale di Macerata*. Studi Geologici Camerti, volume speciale (1992/1), pp. 123-126.
- GIARIZZO A. (1963) *Senigallia - Ricerche di geografia urbana*. Bollettino della Società Geografica Italiana, S IX - 4 (9-10), pp. 444-496.
- HODGE A.T. (1989) *Aqueducts*. In: Barton I.M. (ed.) Roman public buildings. Exeter Studies in History No. 20, pp. 190.
- JACOBELLI P., MANGANI G., PACI V. (1982) *Atlante storico del territorio marchigiano*. Cassa di Risparmio Ancona, Vol. 1, 315 pp; Vol. 2, pp. 242. Mentioned in: Coltorti, 1997.
- LUNI M. (1992) *Montedoro di Senigallia*. In: Bibliografia topografica della colonizzazione greca in Italia e nelle isole tirreniche, X, Pisa-Roma, pp. 336-337. Mentioned in Boullart, 2003.
- MARCHETTI M. (2002) *Environmental changes in the central Po Plain (northern Italy) due to fluvial modifications and anthropogenic activities*. Geomorphology 44 (2002), 361-373.
- MERCANDO L. (1977-1980) *Rinvenimenti e notizie di mosaici pavimentali nel Maceratese*. In: Atti del XIII Convegno di Studi Maceratesi, pp. 31-53.
- MOSCATELLI U. & Vettorazzi L. (1988) *Aspetti delle divisioni agrarie romane nelle Marche*. In: Le Marche - Archeologia, Storia, Territorio. Arcevia 1988, pp. 7-84.
- NANNI T. & VIVALDA P. (1987) *Influenza della tettonica trasversale sulla morfogenesi delle pianure alluvionali marchigiane*. Geografia Fisica e Dinamica Quaternaria 10, pp. 180-192.
- ORTOLANI M. & ALFIERI N. (1947) *Deviazioni di fiumi piceni in epoca storica*. Riv. Geogr. Ital. 54, pp. 2-16.

- ORTOLANI M. & ALFIERI N. (1979) *Sena Gallica*. In: Alfieri N. (ed.) Una città adriatica. Insediamento, forme urbane, economia e società nella storia di Senigallia. Senigallia: 21-29.
- PACI G. (2001) *Il Piceno tra III e II sec. a.C.* In: Percossi Serenelli (ed.) *Potentia*. Quando poi scese il silenzio... Federico Motta Editore, pp. 189.
- PERCOSSI Serenelli E. (1985) *Frequentazione ed insediamento nel territorio di Recanati dalla preistoria all'età romana*. Picus V, pp. 99-135.
- PERCOSSI Serenelli E. (1995) *Potentia: fonti letterarie e fonti archeologiche*. Studi Maceratesi 29, pp. 27-55.
- RAPP G. & HILL C.L. (1998) *Geoarchaeology - The Earth-Science Approach to Archaeological Interpretation*. New Haven & London, Yale University Press, pp. 274.
- RASSE M. (1994) *L'Apennin Ombrien - morphogénèse d'une dorsale récente*. Atelier national de reproduction des thèses - Université de Lille, Lille.
- SERVIZIO GEOLOGICO D'ITALIA (1967) *Carta geologica d'Italia 1:100 000, F124 Macerata*. Roma, Servizio geologico d'Italia.
- TAYLOR M.P. & LEWIN J. (1997) *Non-synchronous response of adjacent floodplain systems to Holocene environmental change*. *Geomorphology*, 18 (1997), 251-264.
- VAN DAMME (1984) *The freshwater Mollusca of Northern Africa: Distribution, Biogeography and Palaeoecology*. *Developments in Hydrobiology*, 25, pp. 1-164, Junk, Den Haag.
- VERMEULEN F. & BOULLART C. (2001) *The Potenza Valley Survey: Preliminary Report on Field Campaign 2000*. Babesch - Bulletin antieke beschaving - Annual Papers on Classical Archaeology No. 76 - 2001, pp.1-18.
- Vermeulen F., Monsieur P. & Boullart C. (2002) *The Potenza Valley Survey: Preliminary Report on Field Campaign 2001*. Babesch - Bulletin antieke beschaving - Annual Papers on Classical Archaeology No. 77 - 2002, pp. 49-71.
- VERMEULEN F. (2003) *The Potenza Valley Survey: Preliminary Report on Field Campaign 2002*. Babesch - Bulletin antieke beschaving - Annual Papers on Classical Archaeology No. 78 - 2003, pp. 71-106.
- VITA FINZI C. (1969) *The Mediterranean Valleys - Geological changes in historical times*. Cambridge University Press.

Tanja Goethals, Department of Geography, Ghent University (B) - tanja.goethals@ugent.be

Morgan De Dapper, Department of Geography, Ghent University (B) -

morgan.dedapper@ugent.be

Frank Vermeulen, Department of Archaeology and Old History of Europe, Ghent University

(B) - frank.vermeulen@ugent.be

Beach and sand dune species plant of deltaic shore between Cape Buival-Câșla Vădanei (Sărăturile marine field)

Daniela STRAT

Cuvinte-cheie: deltaic shore, beach, sand dunes, wash-over funs, rare species, ecological types of plants, richness flora, biogeomorphological role.

Beach and sand dune species plant of deltaic shore between Cape Buival-Câșla Vădanei (Sărăturile marine field). Țărmul deltaic Sărăturile dintre Cap Buival și Câșla Vădanei reprezintă sectorul cu cea mai completă și complexă morfologie emersă: plaje largi, adesea cu două trepte (berma de vară și berma de iarnă) dune, organizate într-un cordon dunar, conuri de rever, benciuri de eroziune nisipoase. Fiecare dintre aceste subunități ale sistemului de țărm constituie habitate pentru anumite specii de plante, în funcție de condițiile microecologice pe care le oferă. Există, de asemenea în cadrul țărmului, specii ubicviste. Unele sunt specii pioniere și astfel joacă un rol important în succesiunea ecologică primară. Câteva dintre speciile de plante identificate pe țărmul Sărăturile sunt specii cu statut de specii rare pentru flora europeană și flora României (*Convolvulus persicus*, *Eryngium maritimum*, *Plantago coronopus*, *Ephedra distachia*, *Corispemum nitidum*, *Argusia sibirica*). Diversitatea specifică este mai mare la Cap Buival decât în restul țărmului.

O parte dintre speciile de plante prezente în domeniul țărmului, prin habitus și dezvoltarea supraterană și subterană a cormului (sistem radicular, tulpină) contribuie la formarea și stabilizarea dunelor (au rol biogeomorfologic), funcționând ca niște capcane de nisip.

În cadrul Rezervației Biosferei Delta Dunării, Câmpul marin Sărăturile nu face parte din categoria ariilor strict protejate. În acest context sunt permise anumite activități economice. Presiunea exercitată asupra sistemului de țărm este indusă de pășunatul comutelor mari a căror efectiv a crescut foarte mult în ultimii. Animalele, pe lângă faptul că se hrănesc cu o parte din speciile prezente, prin călcare și bătătorire contribuie la destabilizarea dunelor incipiente, embrionare, precum și a celor mai vechi. În plus, excrementele reprezintă intrări de nutrienți nespecfici în sol precum și vectori de diseminare a altor specii de plante, ruderales, care nu sunt proprii biocenozelor de țărm.

Introductions

The total length of analyzed deltaic shore is almost 13 km. This shore is the half-south part of Sărăturile beach ridge plain from Danube Delta (Fig. 1), which is the most important wetland area from Europe, even of world, and it is a Biosphere Reserve.

This shore has geomorphologic complete and complex features. On the first half (about 6 km), Vespremeanu (1987) has identified the next sub-units: a large beach, with summer and winter berm, sand dunes and wash-over funs (Fig. 2) The second half of the shore is very simple (Vespremeanu, 1987): an erosion sandy bench, which is cut in marine field (beach ridge plain) (Vespremeanu-Stroe, 2004), and the wash-over funs (Fig 3). There are no sand dunes in this part of shore.

On this deltaic shore could be identify specific habitats populated with many species of plants, most of these are rare species. In addition, these kinds of habitats, especially dunes system that develop over many years, there are in the Annex 1 of the European Community Habitats Directive although Sărăturile marine field are not strictly protected area but we consider that could be a possibility in the future for it.

The focus of this paper is on the plant species that grows on shore system and the relation which exists between every subunit of shore and the ecological types of plants. Natural vegetation covers the beach, dunes and wash-over funs. It is composed of psam-mophyllous, halophyllous and xerophyllous species. Mostly are pioneer plants. The



Fig. 1. The Danube Delta and the Sărăturile Deltaic Shore.

majority is grassy plants and only four are shrubs (*Eleagnus angustifolia*, *Hiphophaë rhamnoides*, *Tamarix ramosissima* and very rare individuals of *Amorpha fruticosa*, an invasive species and unassuming like all this plants).

Near the St. George arm mouth, to Cape Buival, the richness flora is much larger than on the rest of the shore and in this place there are other species than can be found on the north shore because of fresh water influences and nutrient enrichment caused mainly by mineralizing organic matter. The meeting of fresh water and salt water creates several habitats and many species exploit the mosaic nature of shore ecosystems.

Some plants are rare and endemic species for Romanian flora or European scale such as *Ephedra distachia*, *Eryngium maritimum*, *Euphorbia seguierana*, *Argusia sibirica*, *Centaurea arenaria* subsp. *borysthenica*, *Corispemum nitidum*, and *Convolvulus persicus*. For exemple, *Eryngium maritimum* and *Argusia sibirica*, which were have completely disappeared on the coastal sands in the region of port Varna (Bulgaria) during the construction of the port (A. Petrova and I. Apostolova, 1995), they could found on the Sărăturile shore.

Works methods

The flora of every part of this sandy shore has not investigated in detail up to now. Last two years (2003–2004), we made an inventory of plants. We performed same relevé and transects along of entire analyzed shore. Transects began at the high-water mark (the end summer berm when is seaward line vegetations) and extended inland trough barrier dunes to the first occurrence of extensive woody shrub cover. In this way, it was overtaken plants and their community for every form of shore. It is about by across-shore compositional variability of specific biodiversity.

We was consulted a few papers about Romanian flora and other papers about European flora (Oleg Polunin, 1991, David Burnie, 2004). Plant identifications and nomenclature follows Ciocârlan (1994), Sârbu *et al.* (2001), Prodan and Buia (1966). We had identified 36 plant species but the checklist is still not complete. It has been described the characteristic and differential species for each sub-unit of shore.

Results and discussions

Every analyzed component of shore is populates with characteristic species. Beaches are dynamic geomorphic environments where morphologic change can be rapid and pronounced. They overwashed periodically by storms waves especially in the winter season but same events, very powerful, could be summer too. Topography and vegetations are strongly influenced by over wash events. The burial-tolerant plant species recolonize over wash sediments and prevents excessive loss of sediments of sand by deflation. If the sediments are by the horizontally extensive rhizome networks of burial-tolerant plants they are unavailable to form protective fore dunes.

At the same time, the shore system is a very particular biogeomorphologic environment. A network of feedbacks among vegetation, landforms, and sediment mobility (Stallins and Parket, 2003) characterizes it. On deltaic shore, these interactions constitute a sensi-



Fig. 2. The central sector of the Sărăturile Shore with a large beach, the foredune and dune barrier which is very well consolidated.



Fig. 3. The Sărăturile Shore al Câșla Vădanei witha erosion sandy beach.



Fig. 4. *Argusia sibirica*, a rare species on the shore Sărăturile.



Fig. 5. *Eryngium maritimum*, a Mediterranean species that grows on sandy beaches. Around of this plant and *Salsola kali* forms embryonic dunes.



Fig. 6. *Salsola kali*, on the beach. This is a pioneer plant, a psammophytical and halophytical plant.

tive biogeomorphyc system, rather than a collection of independents components. The presence or absence of some species is controlled local gradients of energy, moisture and nutrients.

On the shore dune, there are transverse environmental gradients of salt spray exposure, incremental sediment mobility, and soil moisture as primary factors that distinguish dune vegetation. In response to physical gradients, dune vegetations often develop its characteristic compositional zonation parallel to the shoreline.

Over relatively short temporally scales, dune plant species promote sediment deposition, which ultimately shapes dune landforms. Dune landforms, in turn, influence sediment mobility, the spatial pattern and frequency of disturbance events, and the structure of physical gradients

On the beach there is halophytic and psammophytic species (Fig. 4, 5, 6): *Salsola kali*, *Eryngium maritimum*, *Convolvulus persicus*, *Argusia sibirica*, *Xanthium strumarium*.

The community *Eryngio-Xanthietum strumarium* forms the initial stage of the psammosere on the fore dune, usually near the shoreline where it influenced by the waves. The fore dunes and the ridges dunes covered by annual species (*Xanthium strumarium*, *Eryngium maritimum*) and by rizomatous geophytes (*Elymus sabulosus*, *Convolvulus persicus* and *Cynodon dactylon*). The species of genus *Elymus* are major element on Pontic dunes (K. V. Sýkora *et al.* 2003). These species grow on embryonic dunes along the fringes beaches. They have deep roots, which it can exploit deep water resources. Although *Convolvulus persicus* grows on all sub-units of shore, this species prefer high mobile sand dunes. On the high dunes, grow rare shrubs: *Tamarix ramossissima*, *Hippophaë rhamnoides* and *Elaeagnus angustifolia*.

The back dune and the wash-over fun are peopled with many species such as *Salsola kali*, *Eryngium maritimum*, *Centaurea arenaria*, *Euphorbia seguierana*, *Petasites spurius*, *Linum austriacum*, *Linaria sp.*, *Atriplex sp.*,



Fig. 7. The populations of *Petasites spurius* and *Convolvulus persicus* on wash-over dunes. In back ground, inland of marine field, it can see wooden vegetations (Shrubs with *Eleagnus angustifolia* and *Hippophaë rhamnoides*).

Polygonum arenaria, *Centrospermun*, *Daucus sp.* and *Convolvulus persicus*.

In the second part of the shore, on the marine field, immediately above the scarp, the characteristic species are *Xanthium strumarium*, *Convolvulus persicus*, *Cynodon dactylon*, *Daucus sp.*, *Eryngium maritimum* and *Ephedra distachia*. This has found only one place, by only 80–100 m². This plant is very rare species for Romanian flora as well as the *Convolvulus persicus*. Although this species it has considered rare species long time, even a natural monument. In this moment, this problem is doubtful because there is an abundant population on the Sărăturile shore where there is communities of *Convolvulus persicus* (**Convolvuletum persici**, Borza 1931, Sanda et al. 1998).

Convolvulus persicus is better to be on the list of rare species because there is not any prediction about the evolutions of populations of this species and. The geographical area of this species is very restricted: only south Sea

Caspian littoral and west Black Sea littoral. This plant is protecting in all countries where it grows: Iran, Kazakhstan, Azerbaijan, Romania, Bulgaria and Turkey.

Generally, on the analyzed shore, there is a balance between the human activities and the natural processes. It is still intact; still show a natural face, which is quite remarkable. In the winter, the erosion affected the beach and the dunes, especially the foredune. Summer, the rhizomatous plants (*Convolvulus persicus*, *Elymus sabulosus* and *Cynodon dactylon*) and other, ephemeral plants make a cover, which protects the dunes against the deflations.

Trough exist only few plant well for eat, the horned cattle graze on the shore and near it. This activity tramples and destroys the vegetations, especially the rare species, and the shore dunes. This fact is a kind of biogeomorphological process, too. In this case, the biological influence of cows is not only mechanical by treading underfoot the dunes and the

plants, and by grazing, but through nutrients incoming. It is about the cow's excrements that determine local enrichment of sand. In this case, on this shore can grow other plants, nonspecific for the natural conditions. It is about establishment of ruderal species especially on the dunes, there when they not affected by the storm-over wash. The micro fauna from the soil changes it, too.

Each sub-unit of shore is a habitat for certain plants species.

The Cape Buival shore. In this place, the shore has a beach very large and embryo and dynamic dunes. Habitats and observed plants in the Cape Buival are:

1. The high beach habitat. This beach is very large and very flat. On this habitat mostly is annual vegetation: *Eryngium maritimum*, *Spergularia salina*, *Salsola kali*, *Suaeda* sp., *Lactuca seriola*, *Polygonatum arenaria*, *Statice gmelini*, *Xanthium strumarium*, *X. spinosum*, *Euphorbia chamaesyce*, *Plantago arenaria*, *Plantago coronopus* and very rare and young shrubs of *Tamarix ramosissima*. *Argusia sibirica* and *Elymus sabulosus* is perennial rhizomatous geophytes.

2. The embryo and dynamic dunes habitats. In around of *Salsola* and *Eryngium* form embryo dunes. The others species are: *Convolvulus persicus*, *Xanthium strumarium*, *Linum austriacum*, *Hippophae rhamnoides*, *Elaeagnus angustifolia*, *Tamarix ramosissima*, *Amorpha fruticosa*, *Polygonatum arenaria*, *Fagopyrum* sp. and *Elymus* sp. *Cuscuta* sp., a parasitical plant, which lives on the *Xanthium spinosum* and *Convolvulus persicus* but it prefer, especially, *Eryngium maritimum*.

The shore between Cape Buival and R 49. This shore has a large beach, sand dunes and wash-over fan. The list of species for each habitat has based on five relevés. The habitats and their species are:

1. The high beach habitat

In this habitat, three are dominant: *Salsola kali*, *Xanthium strumarium* and *Eryngium maritimum*. The other species are *Convolvulus persicus*, *Argusia sibirica* and *Petasites spurius*.

2. The dunes habitat

On this habitat, there are same species as well as on beach but grows individuals by *Centaurea arenaria*, *Elymus sabulosus*, *Petasites spurius*, *Corispermum nitidum* and *Cynodon dactylon*, *Euphorbia seguierana* and shrubs (*Elaeagnus angustifolia*, *Hippophae rhamnoides*), too. *Tamarix ramosissima* is very rare.

3. The back dunes and the wash-over fan habitats

The species of these habitats are *Petasites spurius*, *Elymus sabulosus*, *Euphorbia seguierana*, *Cynodon dactylon*, *Corispermum nitidum*, *Equisetum* sp., *Centaurea arenaria*, *Polygonum arenarium*, *Helicrysum arenarium*, *Linum austriacum*, *Convolvulus persicus* and *Linaria vulgaris* (Fig. 7).

The shore between R49 and Câșla Vădanei. On this shore, the beach and the sand dunes are missing. The species, which were have found on the marine field immediately above the scarp, are *Convolvulus persicus*, *Xanthium strumarium*, *Eryngium maritimum*, *Argusia sibirica*, *Cynodon dactylon*, *Ephedra distachia*, *Fagopyrum esculentum*, *Linum austriacum*, *Pulicaria dysenterica*, *Aristolachia clematis*, *Linaria vulgaris*, *Atriplex tatarica*, *Ephedra distachia*, *Rubus caesius*.

The checklist of plant species that has identified on the Sărăturile shore between Cape Buival - Câșla Vădanei (2003-2004)

1. *Aeluropus littoralis* (Gouan) Parl. — Gramineae
2. *Argusia sibirica** (L.) Dandy — Boraginaceae
3. *Aristolachia clematis* L. — Aristolochiaceae
4. *Atriplex tatarica* L. — Chenopodiaceae
5. *Amorpha fruticosa* L. — Leguminosae
6. *Corispermum nitidum** (Kit.) — Chenopodiaceae
7. *Centaurea arenaria* Bieb. subsp. *borysthénica** (Gruner) Dost. — Compositae
8. *Cynodon dactylon* (L.) Pers. — Gramineae
9. *Convolvulus persicus** L. — Convolvulaceae



Fig. 8. The shrub of *Hippophaë rhamnoides* with fruits.

10. *Cuscuta campestris* Yunck. — Cuscutaceae
11. *Ephedra distachia** (L.) — Ephedraceae
12. *Eryngium maritimum** (L.) — Umbelliferae
13. *Elymus sabulosus* Bieb. — Gramineae
14. *Euphorbia seguierana* L. — Euphorbiaceae
15. *Euphorbia chamaesyce* L. — Euphorbiaceae
16. *Eleagnus angustifolia* L. — Elaeagnaceae
17. *Equisetum* sp. — Equisetaceae
18. *Fagopyrum esculentum* (L.) Gaertner — Polygonaceae
19. *Helicrysum arenarium** (L.) — Compositae
20. *Hippophaë rhamnoides* L. — Elaeagnaceae (Fig. 8).
21. *Lactuca tatarica* (L.) C. Mey. — Compositae
22. *Linum austriacum* L. — Linaceae
23. *Linaria vulgaris* Miller. — Scrophulariaceae
24. *Petasites spurius* (Retz.) Rchb. — Compositae
25. *Plantago arenaria* W. et K. (*Plantago indica* L.) — Plantaginaceae
26. *Plantago coronopus** L. — Plantaginaceae
27. *Polygonum arenarium* W. et K. — Polygonaceae
28. *Pulicaria dysenterica* (L.) Bernh. — Compositae
29. *Rubus caesius* L. — Rosaceae
30. *Rumex maritimus* L. — Polygonaceae
31. *Scabiosa ucranica* L. (*S. argentea*) — Dipsacaceae
32. *Salsola kali* (L.) subsp. *tragus* (L.) Nym. — Chenopodiaceae
33. *Spergularia maritima* (All.) Chiov. — Caryophyllaceae
34. *Suaeda maritima* (L.) Dumont — Chenopodiaceae
35. *Statice gmelinii* (Willd) Ktze — Plumbaginaceae
36. *Tamarix ramosissima* Ladeb. — Tamaricaceae
37. *Xanthium strumarium* L. — Compositae
38. *Xanthium spinosum* L. — Compositae



Fig. 9. The horned cattle on the Sărăturile beach at Sf. Gheorghe.

Conclusions

Morphologically, the deltaic shore between Cape Buival - Câșla Vădanei is the most complex and complete shore from Romanian sandy littoral. Each sub-unit of shore is a habitat for certain plants species. The check-list of plant species that has identified on the Sărăturile shore between Cape Buival - Câșla

Vădanei (2003–2004) has 36 species. Same species are rare for European and Romanian flora and the others are important for them geomorphological role. They helped to the constructions and stabilizations of shore dunes. Some species, rare species, and the relief of shore are in danger to be destroyed because of horned cattle graze (Fig. 9).

REFERENCES

- BAUER, Bernard O. (1991), „Aeolian Decoupling of Beach Sediments“, in *Annals of the Association of American Geographers*, (81)2, 1991, pp. 290–303.
- BURNIE, David, (2004), *Flora spontanei del mediterraneo*, Dorling Kindersley Limited, London.
- CIOCĂRLAN, V., (1994), *Flora Deltei Dunării. Cormophyta*, Editura Ceres, București.
- DONIȚĂ, N., IVAN, Doina (1992), „Marea unitate P — Vegetația litorală și halofilă“, în *Vegetația României*, Editura Tehnică, București.
- HANGANU, J., GRIDIN, M., DROST, H.J., CHIFU, T., ȘTEFAN, N., SÂRBU, I. (1994), „Explanation to the vegetation map of the danube Delta Biosphere Reserve 1:100 000“, Flevovericht, Nr. 356.

OLTEAN M., NEGREAN Ghe., POPESCU A. (1994), „Lista roșie a plantelor superioare din România“, în *Studii, sinteze, documentații de ecologie*, nr. 1, Academia Română, Institutul de Biologie, pp. 12 – 46.

PETROVA, A., APOSTOLOVA I. (1995), „Rare plant species on coastal sand dunes and sand beaches in Bulgaria – status and conservation problems“ în *Coastal management and habitat conservation*, vol. I, Editors: A.H.P.M. Salman, H. Berends, M. Bonazountas, EUCC, Leiden, The Netherlands.

POLUNIN, Oleg, (1991), *Guia de Campo de las Flores de Europa*, Ediciones Omega S.A. Barcelona

SANDA, V., POPESCU, A., (1992), „Contribuții la cunoașterea structurii fitocenozelor de pe grindurile din Delta Dunării“, în *Ocrotirea Naturii și a Mediului Înconjurător*, tomul 36, Nr. 2, Editura Academiei Române.

SANDA, V., POPESCU, A., STANCU, Daniela Ileana (2001), *Structura cenotică și caracterizarea ecologică a fitocenozelor din România*, Editura Conphis.

SANDA, Vasile (2002), *Vademecum ceno-structural privind covorul vegetal din România*, Editura Vergiliu.

SÂRBU, I., IVĂNESCU, Lăcrămioara, ȘTEFAN, N., MÂNZU, C. (2001), *Flora ilustrată a plantelor vasculare din estul României, vol. II, Determinator*, Editura Universității „Alexandru Ioan Cuza“, Iași.

STALLINS, J. Anthony, PARKET, Albert J., „The Influence of Complex Systems Interactions on Barrier Island Dune vegetation Pattern and Process“, in *Annals of the Association of American Geographers*, (93)1, 2003, pp. 13–29.

SÝKORA, K. V., BABALONAS, D., PAPASTERGIADOU, E. S. (2003), „Strandline and sand-dune vegetation of coasts Greece and some other Aegean countries“, in *Phytocoenologia*, 33(2-3), pp. 409–446, Berlin-Stuttgart.

PUȘCARU-SOROCEANU, Evdochia (1966), *Flora și vegetația Dobrogei maritime*, în Dobrogea maritimă, Biblioteca Geografului, nr. 4, București.

TAINĂ, Șt. (2002), „Specii reprezentative pentru evaluarea biodiversității floristice din România“, în *Conservarea biodiversității speciilor vegetale și animale*, coordonator David Davidescu, Editura Academiei Române, București.

VESPREMEANU, E. (1987), *Probleme de geomorfologie marină*, București.

VESPREMEANU-STROE, Alfred, PREOTEASA, Luminița (2005), „The morphodynamics of coastal dunes from Sărăturile beach ridge plain during 1995-2001“ in *Revista de geomorfologie*, Nr. 4–5/2002–2003, pp. 159–166.

*** Biological diversity Act, State Gazette, No. 77/ 9.08.2002

***Caspian Environmental Program. Transboundary Diagnostical Analysis National Report of Republic of Kazakhstan, Almaty, 1998, in www.caspianenvironment.com.

www.turhanuslu.net

*** Raportul privind starea mediului în Rezervația Biosferei Delta Dunării în anul 2004, www.rbdd.ro

*** Directive 92/43/CEE du Conseil (1) du 21 mai 1992/Anexe 1:Types d’habitats naturels d’interet communautaire dont la conservation necessite la designation de zones speciales de conservation, <http://eunis.eea.eu.int/habitats.jsp>.

Freshwater travertines in Central Apennine (Italy): genesis and climatic and neotectonic significance

P. FARABOLLINI, B. GENTILI, M. MATERAZZI, G. PAMBIANCHI

Key words: *freshwater travertines, climatic changes, neotectonics, Quaternary.*

The aim of this study is to present, through the use of new geomorphologic, sedimentological and geochemical data, a synthesis of the knowledge of the genesis of freshwater travertine deposits in the calcareous ridge of the Central Apennines (Italy).

Different areas in the Umbria-Marche and Latio-Abruzzi Ridges have been chosen as very good examples of typical travertine deposition in the central Apennines.

All the areas, even if characterized by different extensions, thicknesses and differences in the hydrochemistry of circulating waters, show similar features (depositional environment, climatic conditions, structural and neotectonic conditioning) significant in the reconstruction of the dynamics of travertine deposition.

The more or less intense deposition of travertine (very different even in the same area, during different phases) is related to the changing of the hydrogeological conditions in time. Valley deepening, consequent to climatic changes (such as glacial-interglacial transition) and/or periods of more intense tectonic uplift, caused the rapid lowering of the piezometric surface inside carbonate aquifers; this fact together with climatic improvement increased the hydrologic regime of the rivers, favouring travertine deposition. Subsequently, the process decreased in time, in the same way as a box, filled with water and with a hole in the bottom of it, progressively empties.

Such phenomenon, together with the above mentioned climatic changes which aim at a new equilibrium, seem to be the most important causes of the progressive decrease (and sometimes interruption) of travertine depositional processes.

In the Acquasanta Terme area also, where the rising up of thermal water along fractures produced the primary condition for travertine formation, deposition occurred in a fluvial environment, along tributary valleys, on the right side of the Tronto river; this is testified by the presence, at the base and inside the deposit, of alluvial gravelly material, fluvial facies and typical "fall" structures.

Absolute and relative dating confirmed that travertine formation occurred starting at the end of the Middle Pleistocene and mainly during the transition between glacial and interglacial periods. However, the presence of older deposits (formed in the Early or Middle Pleistocene) in the same areas and that are no longer visible, is not to be excluded

Introduction

Travertine deposits are among the most characteristic continental deposits of central Italy. Their origin in time, sometimes uncertain due to scarcity of chronological elements, should be somewhere within a period that occurs between the Middle Pleistocene and recent times.

Travertine deposition is usually connected to rising waters oversaturated with CO₂. Facies analysis evidences a depositional mechanism characterized by laminar and turbulent flows. The former produces the deposition of stromatolitic crusts, and tough -cross

bedded coarse sands and phytoclastic gravels associated with small channels; the latter (mainly in correspondence to morphological steps along the river) formed the typical phytothermal phases (CHAFETS & FOLK, 1984; PEDLEY, 1990; VILES & GOUDIE, 1990; D'ARGENIO & FERRERI, 1992 and *ref. within*; GOLUBIC *et al.*, 1993 and *ref. within*; CILLA *et al.*, 1994 and *ref. within*; FARABOLLINI, 1995 and *ref. within*; MATERAZZI, 1996 and *ref. within*).

Several classifications have been proposed by different authors. Already in the 1978,

BUCCINO *et al.* (1978) evidenced, along the Tanagro river valley (Campania-Italy), the existence of phytoclastic and phytohermal facies and proposes a fluvial dynamics model to explain their genesis.

Afterwards CHAFETS & FOLK (1984), analyzed many travertine deposits in central Italy and in the central-western United States; taking into account the role of the different vegetation species in controlling the deposition process, they identified five main mechanisms. In 1990 PEDLEY classified numerous travertine deposits from all-around the world, on the basis of their depositional angle, water flow typology, microbiological colonisation and environmental temperature. The author distinguished five different categories: "spring", "fall", "fluvial", "swampy" and "lacustrine" travertine, each one characterized by different detritic or bio-built facies associations. A prerequisite is the almost total prevalence of the precipitation due to the vegetable or bacterial organisms, and a small contribution due to the inorganic processes.

GOLUBIC *et al.* (1993), recognized for the Rocchetta al Volturno travertines (central-southern Apennines, Italy), six associations of lithofacies based on their main sedimentological and stratigraphic characteristics and on their fossil content (including vegetable supports).

Recently FARABOLLINI *et al.* (2004) proposed, for travertine deposits of Adriatic Central Italy, a large scale depositional model that, in some cases, includes various morphological situations. They distinguished four different environments: "springs and slopes", "cascades", "riffles and pools", "alluvial plains".

The present work, based on detailed geomorphological surveys and facies analyses and using the classification defined by FARABOLLINI *et al.* (2004), describes some of the most characteristic travertine deposits present in the Umbria-Marches-Abruzzi Apennine area.

Geological and geomorphological setting

The area studied is bound by the Apennine Chain to the west, by the Adriatic coast to the east and by the Esino and Tronto rivers to the north and to the south respectively (Fig. 1). On the basis of physiographic, geomorphological and structural characteristics, it is possible to distinguish two different sectors: the chain area (and in particular its easternmost portion) and the pedemountain belt, near the Adriatic coast.

The chain area is characterized by a series of mountain ridges (with a height of 2000 m and over) aligned from a NW-SE to a N-S direction. They are made up of mainly calcareous, marly-calcareous and marly formations of Jurassic-Cretaceous age. The ridges are interrupted by deep transversal valleys incised by the main rivers (Potenza, Chienti, Tronto, Salinello, Pescara). The structural setting is made up of E and NE verging thrusts which have determined the overlaying of calcareous formations on sandy-pelitic ones (PAROTTO & PRATURLON, 1975; DEIANA & PIALLI, 1992; GHISSETTI *et al.*, 1994).

Hilly reliefs and gentler slopes characterize the piedmont belt. They are composed of isolated ridges, due to the culmination of meso-cenozoic calcareous terrains, and of reliefs like the *mesa*, *cuesta* and *plateaux*, imposed on terrigenous lithologies essentially arenaceous-pelitic and pelitic-arenaceous, with the intercalation of conglomeratic layers (SERVIZIO GEOLOGICO D'ITALIA, 1969; CANTALAMESSA *et al.*, 1986; CENTAMORE *et al.*, 1991). The age of these formations ranges from the Late Miocene to the Early Pleistocene, period in which the filling of foredeep and *piggy-back* basins with shallow marine deposits occurred (ORI *et al.*, 1991; BIGI *et al.*, 1995).

The structuring of the area occurred between the Early Pliocene and the Middle Pleistocene (CALAMITA *et al.*, 1991 and *ref within*; BIGI *et al.*, 1995; COLTORTI & PIERUCCINI, 2000). In a first phase, compressive tectonics produced the placing of the main thrusts along the

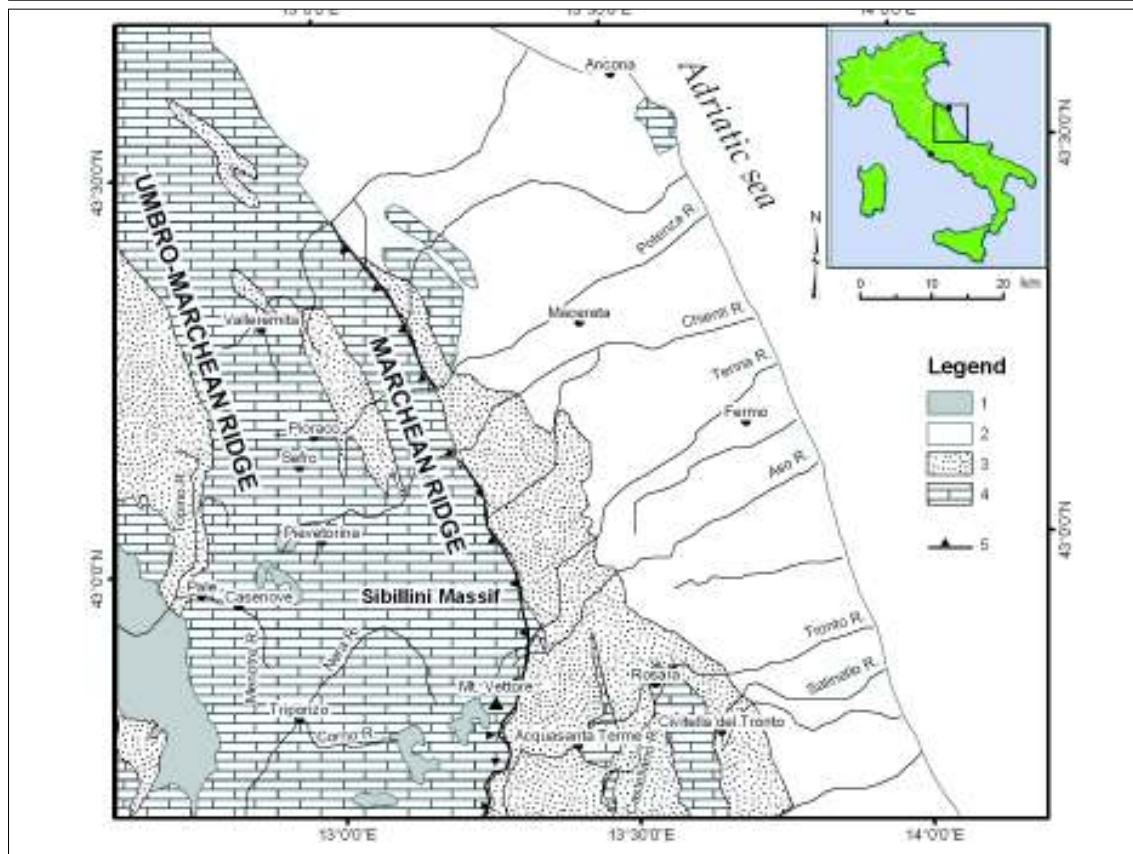


Fig.1. Location of the main travertine deposits in the area studied

mountainous ridges, progressively involving also the easternmost foredeep elements. Afterwards, Quaternary extensional tectonics, accompanied by a generalized tectonic uplifting, took place (DRAMIS, 1992). These tectonic events, mainly starting at the end of the Early Pleistocene (DRAMIS *et al.*, 1992; CENTAMORE *et al.*, 1983; DRAMIS, 1992; COLTORTI & PIERUCCINI, 2000 and *ref within*), caused fragmentation and displacement at different heights of the “summital paleosurface”, whose limited remnants are still present on the reliefs tops. At the base of the calcareous chain, a second planation surface, attributed to Villafranchian (DEMANGEOT, 1965) and embanked in the previous one, has been evidenced. This second surface has been observed in the whole area and, moving toward the sea, within the Miocene-Pliocene-Pleistocene deposits. It is well preserved, as wide limbs, on the watersheds of the main rivers and shows altitude variations compara-

ble to the summital paleosurface and to the deposits of the Crotonian-Sicilian trasgressive regressive cycle (DRAMIS, 1992; FARABOLLINI, 1995).

Important fault systems, NW-SE and NS oriented and with high displacement, developed along the chain and caused the formation of wide intramountain basins. At the same time in the pedemountain area, dip-slip fault, also with a N-S direction but characterized by modest displacement, was being created. Intense uplift and consequent tectonic displacements, strongly conditioned the morphogenesis of the Marches-Abruzzi area and, in particular, the lay out and evolution of the hydrographic network and the mass movement typology (DRAMIS, 1992; GENTILI & PAMBIANCHI, 1994; DRAMIS *et al.*, 1995).

Gravitational morphogenesis, by means of the action of phenomena on different scales, played an important role in modelling calcareous landscape; tectonic-gravitational movements, deep seated slope deformations

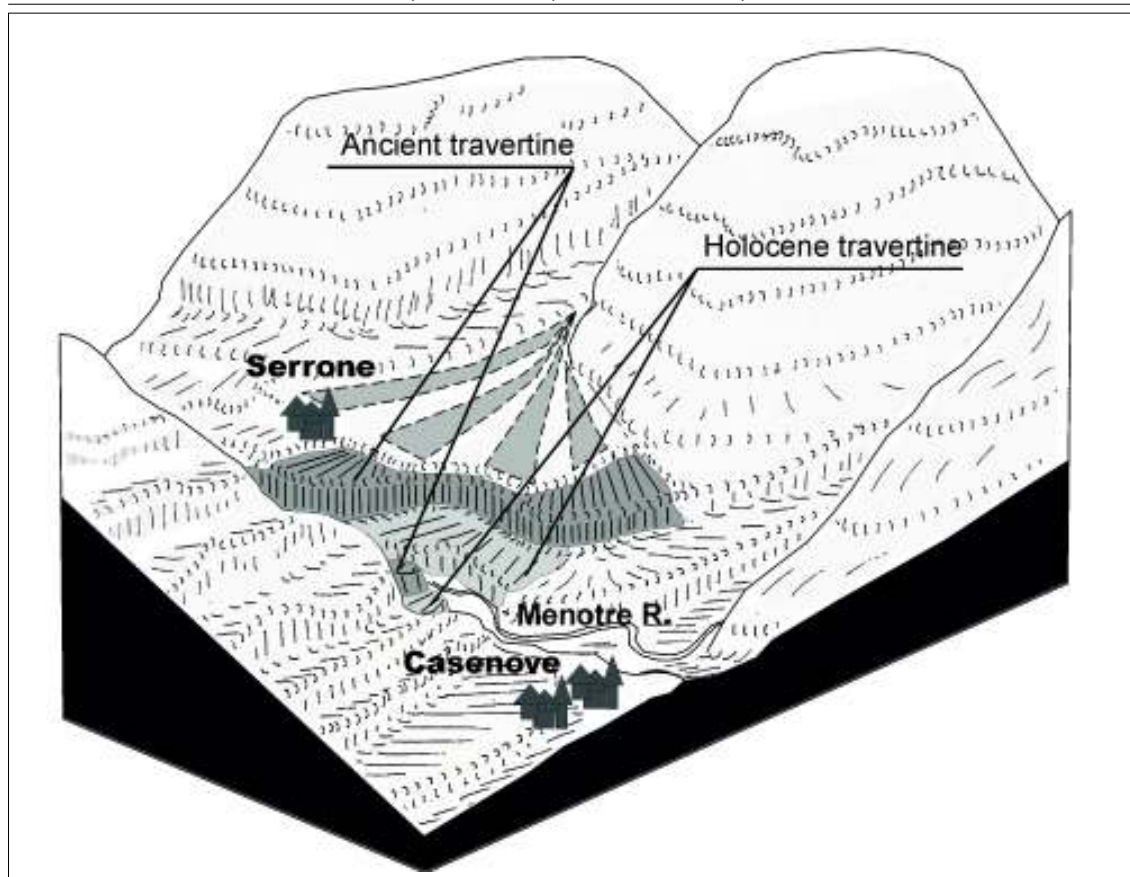


Fig. 2. Block diagram showing travertine deposits located in the Casenove and Serrone area.

and large landslides were the main typologies. The latter in particular, during the Middle Pleistocene-Holocene interval, caused a lot of damming phenomena along the river valleys (GENTILI & PAMBIANCHI, 1994; ARINGOLI *et al.*, 1998); some of these left evident steps, still visible, where, sometimes, travertine deposits are present.

The chain sector shows a somewhat articulated morphology, influenced, during the Quaternary, by alternating climatic phases contemporary with the above mentioned generalized uplift. These conditions left very evident traces made of regularised slopes and stratified deposits, the latter were produced by crioclastism on the slopes without vegetation and deposited by rill processes and surficial mass movements. The most spectacular phenomena are observed on the eastern flanks of the chain, where it is possible to recognize numerous landslide bodies (falls prevalently); mountainwards fissures, steps, trenches,

undulations and an intense fracturing of bedrock have been produced (DRAMIS *et al.*, 1982; GENTILI & PAMBIANCHI, 1994; DRAMIS *et al.*, 1995).

In the vast piedmont area, gravity driven morphogenetic processes are responsible for the widespread and intense landsliding. Processes connected to surface waters modelled a well developed hydrographic network and wide fluvial valleys with a SW-NE direction and low gradient. These valleys, occupied by the main rivers, form broad alluvial plains and little beaches in correspondence with the mouths (COLTORTI, 1981; DRAMIS *et al.*, 1982; COLTORTI *et al.*, 1991; FARABOLLINI, 1995).

Geomorphological evolution caused the formation of thick Quaternary continental deposits within the chain area and inside the main intramountain basins; these deposits are made up of slope, alluvial and lacustrine deposits and of wide travertine bodies. On the

contrary in the piedmont area, along the main rivers, four orders of alluvial terraces and two different generations of travertines are present; fluvial deposits in particular are located at different heights on the thalweg and are connected either to cold Pleistocene climatic conditions or, in recent times, to human activity (COLTORTI, 1981; COLTORTI *et al.*, 1991; FARABOLLINI, 1995).

The travertines

The deposits of Casenove – Serrone (Menotre river). The Menotre river (Fig.1) initially flows in a N-S direction along a sinclinalic valley where marly-calcareous terrains (“*Scaglia rosata*” and “*Scaglia cinerea*” formations) outcrop. Along its middle-final portion, up to the confluence with the Topino river, it runs roughly E-W, crossing the anticlines made by the calcareous formations (“*Maiolica*” and “*Calcare massiccio*”). With respect to other zones of the ridge, the valley floor is wider and flattened because of the presence of a structural step near the locality of Pale that strongly reduces linear erosion mountainward.

The sketch in Fig. 2, synthetically shows the situation in the Casenove and Serrone area, two villages located a few hundreds meters apart, where wide travertine deposits, up to 20–25m thick, are present. The thickness is related to two different depositional phases: the former, older one, is visible at Serrone, on the hydrographic left of the Menotre river, at an elevation of about 20m with respect to the valley floor; the latter, younger one, outcrops next to Casenove, along the present river.

The existence of two different depositional events, was hypothesized on the basis of geomorphologic and stratigraphic considerations. First of all, there is a substantial difference in the nature of the deposits: the higher and older one of Serrone is very tough and resistant and it is made up of the thick phytohermal facies of a “pools and riffles” environment (FARABOLLINI *et al.*, 2004b); the younger one of Casenove, presents a higher phytoclastic component, even if it is still associated with the same environment.

The presence of an older deposit is confirmed by a large alluvial fan, attributed to the Late Pleistocene, (Materazzi, 1996) that partially covers the Serrone deposit. That of Casenove, on the basis of its location with respect to the recent alluvial deposits along the valley floor, has been attributed to the Holocene.

A similar situation is visible at Rasiglia (Fig.1), where travertine was deposited in two different phases, in a slightly terraced position above the thalweg. Analogies concerning facies typologies and elevation on the thalweg, allow us to correlate these deposits with those of Casenove and Serrone, similarly hypothesizing a “riffles and pools” environment. The origin of these deposits seems to be essentially connected to the particular morphology of the Menotre river, characterized by a steep gradient, rapids and small waterfalls; this situation was ideal for the formation of travertine. At Rasiglia a further favourable condition was the presence of a short and narrow valley segment that produced a consequent increase of the water velocity and turbulence.

The deposits of Triponzo (Nera and Corno rivers). The village of Triponzo was built on a very tough travertine bank, present on both valley sides, at the confluence of the Nera and Corno rivers within the Umbria-Marches Ridge (Fig.1).

Geomorphological survey in the area allowed us to confirm that travertine is present in two distinct phases: the former is older and located higher with respect to the village; the latter, Holocene in time, was deposited near the actual valley floor (Fig. 3).

The oldest deposit reaches a maximum thickness of about 60 m on the left side of the valley, while on the right one it is a little less thick. The presence, inside and on top, of colluvial fersiallitic paleosoils and stratigraphic correlations with alluvial deposits allow us to attribute this phase of deposition to the last interglacial period. These travertines are mainly made up of phytohermal facies of “cascade” environment, characterized by very

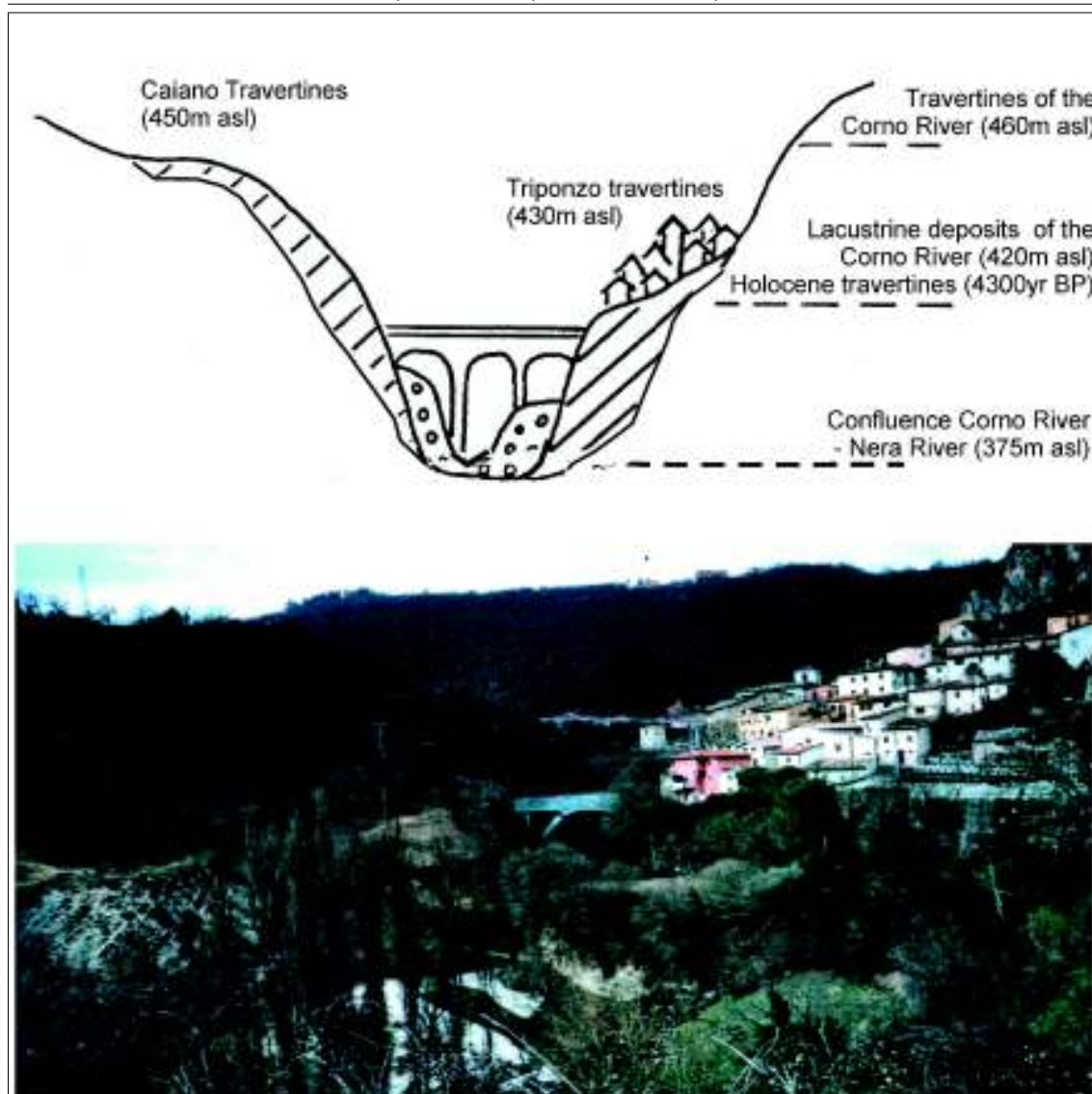


Fig. 3. The travertine deposit of Triponzo; Photo and transversal schematic cross section (above).

low porosity and a strong presence of calcite due to the secondary circulation of water. Similar facies, stratigraphically correlated with the previous ones even if of minor thickness, are visible also in some deposits along the Corno river.

A younger phase is present near Triponzo along the valley floor and is composed of two small terraces located on both sides and about 30 m thick. These deposits have a greater phytoclastic component with respect to the older ones and are made up of prevalently calcareous sands and gravels alternated with banks of phytothermal travertine a few meters thick.

The presence, a little mountainward along

the Corno river, of a thick peaty-clayey deposit about 40 m thick, allows us to hypothesise that in the past the forming travertine constituted a natural dam on the river; as a consequence a long lacustrine event occurred. The age of the younger phase of travertine is therefore associated with that of the lacustrine deposit; VINKEN (1968), on the basis of absolute dating, gave ages between 8800 and 4300 yr B.P.

Also the deposit of "Colle il Tonno", about 1 km valleyward of Triponzo, is Holocene in time and can be related to the others described above. Hanging about 40 m over the thalweg, it is made up of alternating phytothermal and

phytostatic facies, a few meters thick, forming the typical “pools and riffles” system. The greater thickness of the phytostatic facies within the Holocene travertine (as compared to the older generation), is connected to a gentler gradient and a more regular morphology of the Nera and Corno river beds in this period.

The deposits of Pale (Menotre river). The village of Pale is placed about 3 km mountainward of the confluence between the Menotre and Topino rivers (Fig. 1). It is built up over a thick and wide bank of phytohermal travertine, deposited in correspondence to a very abrupt morphological step (almost 200 m in a few hundred meters) along the Menotre river (Fig. 4).

This travertine, actually inactive, shows a clear “cascade” morphology: compacted, almost without phytostatic facies, it is more intact in the upper portion (in proximity of the village) while it is dissected and strongly eroded in the lower one, where, too, large blocks which fell from above are visible.

The origin of the deposit is probably connected to the structural setting of the area: the above mentioned structural threshold is located on the western flank of the Mt. Serrone anticline, where the older “Calcare massiccio” formation, in the core, passes to the less resistant terrain above. In this context, a progressive deepening of the Topino river inside marly formations occurred, while Menotre, strongly conditioned by its structural binds, maintained a steeper profile and formed a real fall near the present village of Pale. This morphological setting favoured, probably during the warm and humid phase at the end of the Middle Pleistocene, an intense travertine deposition; today the deposit is separated into three different steps (Fig. 4) due to the regressive erosion of the structural threshold.

The deposits of Sefro (Potenza river). It is located along the Scarsito stream, a right tributary of the Potenza river (Fig. 1) that flows about SW-NE entirely incised in the “calcareous formations” (“Calcare massiccio” and “Scaglia rosata”). The longitudinal profile is

gentle and the valley floor is wide (about 150 m) and flattened due to the presence valley ward, of a structural threshold at the confluence between the Scarsito and Potenza rivers; at this point, where today the village of Pioraco is located, a huge travertine deposit of “cascade” environment is present.

At Sefro in particular, a travertine bank of limited thickness (3-5 m), more or less continuous for about 80 m, is visible on both valley sides. It shows a typical “pool and riffle” morphology (MATERAZZI, 1996; FARABOLLINI *et al.*, 2004b), even though phytohermal facies are more developed. The presence along the actual valley floor and its relationship with fluvial and lacustrine deposits that date to the Holocene (MATERAZZI, 1996), allow us to attribute the deposition of travertine to the warm and humid initial phase of this period. In addition, a little valley ward on the hydrographic left, another travertine bank is present. It is deposited over the remnants of an alluvial terrace of the end of the Middle Pleistocene, made up of fairly well cemented gravels; on the top, the Upper Pleistocene stratified slope deposits cover the travertine, allowing us to attribute the depositional phase to the last interglacial period. A reddish paleosoil, partially, and attributed to the final warm and humid phase of Middle Pleistocene interglacial periods (COLTORTI *et al.*, 1991), is visible where fluvial gravels and travertine come into contact.

The deposits of Pievetorina (Chienti river). Near the village of Pievetorina, along a left tributary of the Chienti river (Fig. 1) two different travertine generations are present. Both generations are visible on the right side of the valley: the older one is deposited several tens of meters above the thalweg while the younger one is present a few meters above the valley floor. This latter is the most significant one because of its longitudinal extension that reaches several hundreds of meters, even if it is present only on the right side.

The oldest deposits, less extended and generally buried by a widespread detritic cover,



Fig. 4. Aerial photo of the travertine deposit at Pale; (1, 2 and 3 represent different steps within the deposit).

form a small terrace, a few meters thick and about 20 – 30 m long, partially hidden by the vegetation.

On the contrary, the younger ones are composed of a thick sequence (of up to 10 m) of travertine facies and are well recognizable

because of the recent fluvial incision. They are made up of travertine gravels, sands and silt (typical phytoclastic facies) alternated with phytothermal and stromatolithic travertine. On the top, an alluvial brown paleosoil, containing pebbles of phytothermal traver-



Fig. 5. Panoramic view of alluvial deposits at the base of travertine deposits in the Acquasanta Terme area

tine up to 10 cm in thickness, close the sequence.

The deposit of Valleremita (Giano river).

It is located at the confluence of the Valleremita stream and the Giano river within the Umbria-Marches ridge (Fig. 1), and is characterized by a length of about 1 km, a width of about 200 m and an average thickness of 15 – 20 m or more. The travertine has the shape of a large alluvial fan deposited over an alluvial deposit of the Upper Pleistocene (CALDERONI *et al.*, 1996). The base of the deposit (8-10 m) is composed of an almost continuous bank of phytohermal and stromatolitic travertine, very compact and with rare thin levels of phytoclastic sands intercalated. Upward, several channels filled by a thin layer of stromatolitic travertine and calcareous gravels and sands, up to a few meters in width, are present. The sequence goes on with several meters (5-10 m) of sandy phytoclastic travertine, characterized, in the lower portion, by three different brown paleosoils (10-15cm thick), laterally continuous for the whole width of the deposit (MATERAZZI, 1996).

On the sequence top, radiometric dating carried out on a charcoal fragment found inside a paleosoil level gave an age of 4535 ± 80 yr BP (CALDERONI *et al.*, 1996).

The deposit of Acquasanta Terme (Tronto river). The travertine deposit of Acquasanta Terme, well known as “Acquasanta Terme marbles” for their manufacturing and their ornamental properties, shows elevated thickness (even several hundreds of meters) and an area of several square kilometres in extension (BONI & COLACICCHI, 1966a and b). It is composed of three different levels located at as many different heights on the thalweg; the younger level is present a few meters above the valley floor while the oldest is about 250m above it.

Travertine deposition in the area has been so far associated to thermal water (still present) oversaturated with calcium carbonate which rises up along deep fractures (BONI & COLACICCHI, 1966a) or is connected with a buried regional tectonic structure that would conditioned travertine deposition also in other localities of central Italy (Triponzo, Cotilia, MINISSALE *et al.*, 2003).

Further studies, based on the relationship between travertine and the alluvial deposits of the Tronto river and its tributaries (FARABOLLINI *et al.*, 2003 and 2004a), evidenced that travertine formed during interglacial periods, along the tributary valleys of the Tronto river, when climatic improvement produced the development of vegetation and the consequent increase of CO₂ in the circulating waters (DRAMIS *et al.*, 1999); these waters, besides, mixed with the thermal ones described above (MATERAZZI, 2003).

Geomorphological survey and facies analysis confirmed that travertine deposition, characterized by “cascade” and secondary dome-shaped structures (i.e. Castel di Luco), occurred in a typical fluvial environment. This fact is testified to by a characteristic fluvial architecture (grading and stratification) and by the presence, at the base of each level of travertine, of alluvial deposits associated with fan systems inside the tributary valleys



Fig. 6. Stratified alluvial sands and gravels underlying travertine deposit at Civitella del Tronto.

(Fig. 5). The remnants of an older alluvial fan without travertine on top, located higher up and attributed to the Middle Pleistocene, confirms the hypothesis that alluvial fan systems govern travertine formation and the start of deposition after the Middle Pleistocene.

The deposits of Civitella del Tronto (Salinello river). At Civitella del Tronto (Fig. 1), travertines are composed of three main plates (Monte Santo, Civitella del Tronto and Colle San Nicola) wedge-shaped toward the south and with a thickness ranging from 15 to 50 m. All together, they look like a lens whose greatest thickness is at the Civitella del Tronto deposit oriented in the same direction as the Salinello river.

Travertines are generally deposited over coarse alluvial deposits and show the typical “pool and riffle” environment (PREITE MARTINEZ *et al.*, 1990; FARABOLLINI, 1999; FARABOLLINI *et al.*, 2004b) (Fig. 6): phyto-clastic facies are prevalent in the lower portion while phytohermal and microhermal ones (PREITE MARTINEZ *et al.*, 1990) increase upward. The thickness of phytohermal facies and the presence of channels filled with flu-

vial gravels and pisolithes 2-3 cm in diameter, suggest a steep longitudinal profile locally interrupted by high morphologic steps (falls) (FARABOLLINI, 1999; FARABOLLINI *et al.*, 2004b).

Pollen analyses (DE SANCTIS & FREGONESE, 1981), gave evidence that deposition occurred in a typical interglacial environment. On the other hand, the relationship between all travertine plates and a limb of alluvial terrace located about 50 m down valley and attributed to the end of the Middle Pleistocene (DRAMIS *et al.*, 1982) and the presence, at the base of the travertine (Fig. 6), of another alluvial deposit associated to an older valley floor (FARABOLLINI, 1999), confirmed that travertine deposition is strictly connected to the Salinello river dynamics and occurred during an interglacial phase older than the end of the Middle Pleistocene.

Depositional mechanisms, paleo-environmental significance and chronology

Travertine deposition in the Umbria-Marches-Abruzzi area is a very important process because it can be used to reconstruct

the Quaternary paleo-environmental context. In particular, different depositional phases can be related to well defined climatic and/or historical periods.

Travertine deposition along river beds during the Quaternary, is a generalized phenomenon, more or less contemporary in temperate or sub-tropical countries (HENNING *et al.*, 1983; FORD & PEDLEY, 1996 and *ref. within*; MATERAZZI, 1996; FARABOLLINI *et al.*, 2004 a and b). In absence of particular phenomena (i.e. the presence of thermal waters), climatic conditions are fundamental to explain the genesis and development of these deposits. In particular, deposition may occur where a high gradient or irregularities of the river longitudinal profile are present. If the gradient is very steep or a real fall exists a “Cascade” environment (FARABOLLINI *et al.*, 2004b), characterized by a dominance of phytothermal facies, may form. If the gradient is a little gentler, or small steps are present, a “riffles and pools” environment (FARABOLLINI *et al.*, 2004) develops: in this case deposit is formed of alternating layers of phytoclastic and phytothermal facies. In both cases the associated water turbulence and the presence of aquatic vegetation (moss and algae) are fundamental factors: in particular the latter, using dissolved CO₂ for their metabolism, are encrusted with calcium carbonate and constitute a “skeleton” for travertine built up.

Sometimes, where travertine deposition creates a real dam, lacustrine episodes or overflowing phenomena may happen along the river (as observed at Triponzo and Pale).

As evidenced by several authors (GULLENTOPS & MULLENDERS, 1972; NICOD, 1986; GOLUBIC *et al.*, 1993), the great amount of calcium carbonate in solution, responsible for travertine formation, is due to a strong presence of CO₂ in waters circulating inside calcareous bedrock; this fact was in turn connected to vegetation development and the consequent presence of very high thicknesses of soils during interglacial periods. A considerable vegetable cover also favoured the regularisation of the hydrologic regime: the

soil's capacity to hold infiltrating waters, which came back in the thalweg much later, allowed a greater enrichment of carbon dioxide.

More recently DRAMIS *et al.* (1999) also evidenced the role played by groundwater temperature changes in controlling the calcium carbonate dissolution equilibrium. In particular, differences between the lower temperature of groundwaters (influenced by deep penetration into calcareous aquifers of glacial period surface temperatures) and higher external temperatures at the springs may have caused, for a more or less long time depending on the thermal capacity of the aquifers, a greater loss of CO₂ and consequent strong travertine deposition. The process may have been continued until the thermal disturbance in the ground was exhausted and a normal heat flux towards the surface was re-established.

The combined effects of climate and Pleistocene tectonics, also allow us to explain the different development (thickness and extension) of the oldest travertine deposits with respect to the Holocene ones. First of all, the longer duration of the glacial and interglacial periods of the Lower and Middle Pleistocene may justify the higher deposition. On the other hand, strong Pleistocene tectonic uplift (DRAMIS, 1992), which favoured river down-cutting mainly during interglacial periods, caused a rapid lowering of the piezometric levels inside carbonate aquifers and a consequent increase of fluvial discharge (FARABOLLINI *et al.*, 2003). This effect gradually decreased as a result of the new base level (Fig.7).

The climatic factor, together with Pleistocene tectonic events, also allow us to explain differences in the development of ancient travertine deposits (as far as their area and their thickness are concerned), usually greater with respect to those of the Holocene. On one hand, in fact, the greater length of the cold phase in the interglacial periods of the lower and middle Pleistocene could justify a greater development of travertine precisely because of longer lasting favourable condi-

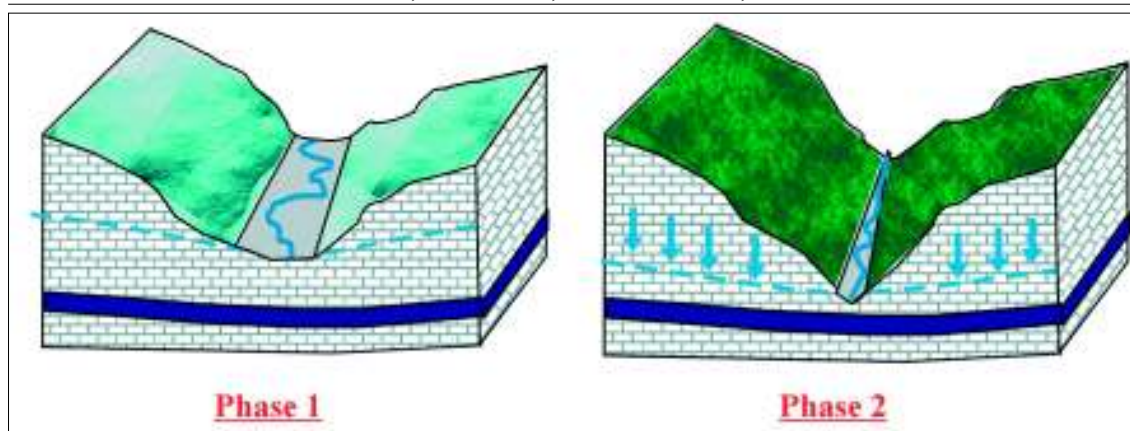


Fig. 7. Schematic representation of neotectonic and hydrogeological variations (phase 1: initial condition; phase 2: together with tectonic uplift increasing during the Late Quaternary).

tions of deposition. On the other hand, strong Pleistocene tectonic uplifting (DRAMIS, 1992) also favoured, especially in the interglacial periods characterised by an increase in linear erosion, the deepening of the river valleys, with the resultant rapid lowering of the piezometric surface and the increase of the hydrologic regime of the water courses (FARABOLLINI *et al.*, 2003). This effect, initially more intense, gradually diminished as a new equilibrium was established with the new basic piezometric level (Fig. 7)

Chronological data are in perfect agreement with previous indications. As far as the oldest travertines, (Civitella del Tronto, Sefro, Pale, Acquasanta Terme), for which absolute dating is not available, relationships with other geomorphological elements (alluvial deposits, alluvial fans, slope waste deposits, palaeosoils, etc.) allowed us to attribute travertine deposition to the warm-humid phases of the interglacial periods older than the Late Pleistocene

The younger deposits (Pievetorina, Sefro, Valleremita) instead, on the basis of radiometric dating, can be attributed to the Early Holocene, as well as those observed in other localities of the central Apennines (CILLA *et al.*, 1994; CALDERONI *et al.*, 1996; MATERAZZI, 1996).

Conclusions

The study carried out on several deposits in the Umbria-Marches-Abruzzi area allowed us

to verify the existence of three fundamental conditions governing travertine deposition:

1- a high energy depositional environment: all deposits developed along fluvial systems which were more or less developed, characterised by steep profiles, morphological steps or structural thresholds. Their belonging to a fluvial environment is also testified to by the location (symmetric and parallel to the river axis), by the presence of typical fluvial facies and by their relationship to alluvial deposits;

2- favourable climatic conditions: climatic changes occurring between glacial and interglacial periods (such as during the Middle Pleistocene, the Late Pleistocene and the Holocene) strongly influenced the genesis and development of travertine in the areas. Also in the Acquasanta Terme this effect contributed to deposition in a system highly regulated by thermalism;

3- neotectonics and hydrogeological conditions changing in time: valley deepening, consequent to climatic changes (such as glacial-interglacial transition) and/or periods of more intense tectonic uplift, caused rapid lowering of the piezometric level inside carbonate aquifers. This fact increased the hydrologic discharge of the rivers and, together with climatic improvement, favoured travertine deposition, in correspondence to the above mentioned morphological steps.

Also at the Acquasanta Terme, a change of the hydrogeological regime, could have

played a very important role in travertine deposition together with the action of thermal waters. In this case too, deposition of travertine occurred in a fluvial environment, along tributary valleys, where mixing of thermal water and freshwater was present.

Progressive lowering of piezometric levels, together with the above mentioned climatic changes, which aim at a new equilibrium, seem to be the most important causes of the progressive decreasing (and sometimes interruption) of travertine depositional processes.

REFERENCES

- ARINGOLI D., GENTILI B., MATERAZZI M. & PAMBIANCHI G. (1998), *Damming phenomena caused by landslides along the Potenza, Chienti and Tenna river valleys (Central-southern Marche)*. Analele Universitatii Din Oradea, (Romania). Seria Geografie-Geomorfologie, Tom. VIII-A-, p. 123-131.
- BIGI S., CANTALAMESSA G., CENTAMORE E., DIDASKALOU P., DRAMIS F., FARABOLLINI P., GENTILI B., INVERNIZZI C., MICARELLI A., NISIO S., PAMBIANCHI G. & POTETTI M. (1995), - *La fascia periadriatica marchigiano-abruzzese dal Pliocene medio ai tempi attuali: evoluzione tettonico-sedimentaria e geomorfologica*. Studi Geol. Camerti, vol. spec. 1995/1, p. 37-49.
- BONI C. & COLACICCHI R. (1966), *Indagine geologica sui travertini della provincia di Ascoli Piceno*. Camera di Commercio, Industria, Artigianato e Agricoltura di Ascoli Piceno.
- BONI C. & COLACICCHI R. (1966b), *I travertini della valle del Tronto*. Mem. Soc. Geol. It., **5**, p. 315-339.
- BUCCINO G., D'ARGENIO B., FERRERI V., BRANCACCIO L., FERRERI M., PANICHI C. & STANZIONE D. (1978), *I travertini della bassa valle del Tanagro (Campania): studio geomorfologico, sedimentologico e geochimico*. Boll. Soc. Geol. It., **97**, p. 617-646.
- CALAMITA F., CELLO G., CENTAMORE E., DEIANA G., MICARELLI A., PALTRINIERI W. & RIDOLFI M. (1991), *Stile deformativo e cronologia della deformazione lungo tre sezioni bilanciate dall'Appennino umbro-marchigiano alla costa adriatica*. Studi Geol. Camerti, vol. spec. CROP 03, p. 295-314.
- CALAMITA F., CENTAMORE E., DEIANA G. & RIDOLFI M. (1995), *Caratterizzazione geologico-strutturale dell'area marchigiano-abruzzese esterna*. Studi Geologici Camerti, Vol. spec. 1, p. 171-182.
- CALDERONI G., CILLA G., DRAMIS F., ESU D., MAGNATI M. & MATERAZZI M. (1996), *La deposizione di travertino nelle aree prossimali dei fiumi Esino, Potenza e Chienti durante l'Olocene antico (Appennino centrale marchigiano)*. Il Quaternario, **9**(2), p. 481-492.
- CANTALAMESSA G., CASNEDI R., CENTAMORE E., CHIOCCHINI U., COLALONGO M.L., CRESCENTI U., MICARELLI A., NANNI T., PASINI M., POTETTI M. & RICCI LUCCHI F. (1986), *Il Plio-Pleistocene marchigiano-abruzzese*. Studi Geol. Camerti, vol. spec. "La geologia delle Marche" - Guida all'escursione, 43 pp.
- CENTAMORE E., CANTALAMESSA G., MICARELLI A., POTETTI M., BERTI D., BIGI S., MORELLI C. & RIDOLFI M. (1991), *Stratigrafia e analisi di facies dei depositi del Miocene e del Pliocene inferiore dell'avanfossa marchigiano-abruzzese e delle zone limitrofe*. Studi Geol. Camerti, vol. spec. CROP 11, p. 125-131.
- CENTAMORE E., COLTORTI M., DRAMIS F., CANTALAMESSA G., D'ANGELO S., DI LORITO L., SACCHI L. & SPOSATO A. (1983), *Aspetti neotettonici e geomorfologici del Foglio 133-134, Ascoli Piceno-Giulianova*. Pubbl. n.513 del P.F. Geodinamica, p. 371-386.
- CHAFETS H.S. & FOLK R.L. (1984), *Travertines: depositional morphology and the bacterially constructed constituents*. Journal of Sedimentary Petrology, **54**(1), p. 289-316.

CILLA G., COLTORTI M. & DRAMIS F. (1994), *Holocene fluvial dynamics in mountain areas: the case of the river Esino (Appennino Umbro-Marchigiano)*. Geog. Fis. Dinam. Quat., 17, p. 163-174.

COLTORTI M. (1981), *Lo stato attuale delle conoscenze sul Pleistocene ed il Paleolitico inferiore e medio della regione marchigiana*. Atti I Conv. Beni Culturali e Ambientali delle Marche, Paleane Ed., p. 63-122.

COLTORTI M., CONSOLI M., DRAMIS F., GENTILI B. & PAMBIANCHI G. (1991), *Evoluzione geomorfologica delle piane alluvionali delle Marche centro-meridionali*. Geogr. Fis. Dinam. Quat., 14, p. 87-100.

COLTORTI M. & PIERUCCINI P. (2000), *A late Lower Pliocene planation surface across the Italian Peninsula: a key tool in neotectonic studies*. Journal of Geodynamics, 29, 323-328.

DEIANA G. & PIALLI G. (1992), *The structural provinces of the Umbro-Marchean Apennines*. Mem. Soc. Geol. It., p. 473-484.

DEMANGEOT J. (1965), *Geomorphologie des Abruzzes adriatiques*. CNRS, Memoires et Documents, Paris, p. 403pp.

DE SANCTIS L. & FREGONESE D. (1981), *I travertini di Civitella del Tronto*. Geo-archeologia, p. 51-60.

DRAMIS F. (1992), *Il ruolo dei sollevamenti tettonici ad ampio raggio nella genesi del rilievo appenninico*. Studi Geol. Camerti, vol. spec. 1992/1, p. 9-16.

DRAMIS F., AGOSTINI S., COLTORTI M., CRESTA S., D'ANGELO S., PANTEALONE A., PICA A., ROSSI A., SACCHI L. & SPOSATO A. (1982), *Aspetti fisiografici e morfogenesi in atto nei bacini dei fiumi Salinello e Vibrata*. Antropologia Contemporanea, 5(1/2), p. 183-188.

DRAMIS F., FARABOLLINI P., GENTILI B. & PAMBIANCHI G. (1995) – Neotectonics and large scale gravitational phenomena in Central Apennines, Italy. In: O.Slymaker Ed., Steepland Geomorphology, John Wiley and Sons Ltd, p. 199-217.

DRAMIS F., MATERAZZI M. & CILLA G. (1999), *Influence of climatic changes on freshwater travertine deposition: a new hypothesis*. Physics and Chemistry of the Earth, Part-A, Solid Earth and Geodesy, 24(10), p. 893-897.

FARABOLLINI P. (1995), *Evoluzione geomorfologica quaternaria dell'area periadriatica tra Ancona e Vasto*. Università di Perugia, Tesi di dottorato inedita, 154 pp.

FARABOLLINI P. (1999), *Il ruolo delle acque correnti superficiali: esempi dall'area della Montagna dei Fiori (TE)*. Studi Geol. Camerti, Vol. Spec. 1999, p. 93-102.

FARABOLLINI P., FOLCHI VICI D'ARCEVIA C., GENTILI B., LUZI L., PAMBIANCHI G. & VIGLIONE F. (1995) – *La morfogenesi gravitativa nelle formazioni litoidi dell'Appennino centrale*. Mem. Soc. Geol. It., 50, p. 123-136.

FARABOLLINI P., GENTILI B., MATERAZZI M. & PAMBIANCHI G. (2003), *Freshwater Travertines deposition in mountain area: examples of climatic and tectonic interaction from central Apennine (Italy)*. Proc. Intern. Workshop on "Climate Changes, active tectonics and Related geomorphic effects in high Mountain Belts and Plateaux", Addis Ababa 9-10 dicembre 2002, p. 46-48.

FARABOLLINI P., GENTILI B., MATERAZZI M. & PAMBIANCHI G. (2004a), *Travertines deposition in the Acquasanta Terme area (southern Marches, Italy): an example of climatic and tectonic interaction*. The 32nd International Geological Congress (32IGC), August 20-28, 2004, Florence, Italy.

FARABOLLINI P., MATERAZZI M., MICCADEI M. & PIACENTINI T. (2004b), *I travertini dell'Italia centrale adriatica: genesi, cronologia e significato geomorfologico e paleoambientale*. Il Quaternario, 17(2/1), p. 259-272.

GENTILI B. & PAMBIANCHI G. (1994), *Gravitational morphogenesis of the Apennine chain in Central Italy*. Proc. 7th Int. IAEG Congr., Sept. 1994, Balkema Rotterdam.

- GHISETTI F., FOLLADOR U., CASNEDI R. & VEZZANI L. (1994), *Assetto tettonico delle zone esterne dell'Appennino abruzzese: elementi di analisi stratigrafico-strutturali*. Atti Tic. Sc. Terra, ser. spec., **2**, p. 5-43.
- GOLUBIC S., VIOLANTE C., FERRERI V. & D'ARGENIO B. (1993), *Algal control and early diagenesis in Quaternary travertine formation (Rocchetta a Volturno, Central Apennines)*. Boll. Soc. Paleont. It, vol. spec., **1**, p. 231-247.
- GULLENTOPS F. & MULLENDERS W. (1992) – *Age et formation des depots de tuf calcaire Holocene en Belgique*. In : Processus periglaciaire etudes sur le terrain. Simp. Int. Geom., Con gres et Colloques de l'Univ. de Liegi, **67**, p. 113-135.
- HENNING G.J., GRÜN R. & BRUNNACKER K. (1983) – *Speleothems, travertines and paleoclimates*. Quat. Res., **20**, p. 1-29.
- MATERAZZI M. (1996) – *I travertini dell'Appennino umbro-marchigiano: genesi evoluzione e cronologia*. Tesi di dottorato inedita. Università di Perugia, 1996.
- MATERAZZI M. (2003) – *Rapporti tra idrologia superficiale ed ipogea nell'area del rio Garrafo e di Acquasanta Terme (AP): indagini idrochimiche e cenni sulla vulnerabilità all'inquinamento degli acquiferi carbonatici*. In: DI MARTINO V. & FELIZIANI R. (2003), *Conoscenza e gestione degli ambienti ipogei. Il caso di studio delle grotte del Rio Garrafo*. Grafiche Martintype, Colonnella, p. 21-31.
- MINISSALE A., KERRICK D.M., MAGRO G., MURRELL M.T., PALADINI M., RIHS S., STURCHIO N.C., TASSI F. & VASELLI O. (2002) – *Geochemistry of Quaternary travertines in the region north of Rome (Italy): structural, hydrologic and paleoclimatic implications*. Earth and Plan. Sc. Letters, **203**, p. 709-728.
- NICOD J. (1986) – *Facteurs physico-chimiques de l'accumulation des formations travertineuses*. Mediterranee, **1-2**, p. 161-164.
- ORI G.C., SERAFINI G., VISENTIN C., RICCI LUCCHI F., CASNEDI R., COLALONGO M.L. & MOSNA S. (1991), *The Plio-Pleistocene adriatic foredeep (Marche and Abruzzo, Italy): an integrated approach to surface and subsurface geology*. 3rd E.A.P.G. Conf., Florence, 85 pp.
- PAROTTO M. & PRATURLON A. (1975), *Geological summary of the Central Apennines*. In: OGNIBEN *et al.*, EDS. *Structural model of Italy: Maps and explanatory notes*. Quaderni Ric. Sci., C.N.R., **90**, p. 257-311.
- PEÑA J.L., SANCHO C. & LOZANO M.V. (2000) – *Climatic and tectonic significance of late Pleistocene and Holocene tufa deposits in the Mijares river canyon, eastern Iberian range, northeast Spain*. Earth. Surf. Proc. Land., **25**, p. 1403-1417.
- PREITE MARTINEZ M., SEVERA F., TURI B. & FREGONESE D. (1990), *I travertini di Civitella del Tronto. Aspetti geochimici e giacimentologici*. Rend. Fis. Acc. Lincei, ser.9, **1**, p. 15-24.
- SERVIZIO GEOLOGICO D'ITALIA (1969), *Carta Geologica d'Italia alla scala 1:100.000 Foglio n.133-34 - Ascoli Piceno - Giulianova*.
- VILES H.A. & GOUDIE A.S. (1990) – *Tufas, travertines and allied carbonate deposits*. Progr. Phys. Geogr., **14**, p. 19-41.
- VINKEN R. (1968) – *Zur Entstehung und Altersstellung der travertine limnischen Sedimente fluviatelen terrassen in gebiet der mittleren Nera und des Corno (Umbria, Mittelitalien)*. Eiszeitalter und Gegenwart, **19**, p. 5-30.

General and peculiar morphological characteristics of the drainage system dynamics in alpine basins: the case of the Arvan (French Alps) and Slănic (Romanian Carpathians and Subcarpathians) basins

Florina GRECU, Laura COMĂNESCU, Robert DOBRE, Lavinia VĂCARU

Key words: the Arvan, the Alps, the Slanic, The Curved Carpathians and SubCarpathians, geology, morphometric analysis, morphohydrographic basin

General și particular în studiul dinamicii bazinelor morfohidrografice alpine. Studiu de caz: bazinul Arvan (Alpii Francezi) și Slănic (Carpații Românești).

Lucrarea își propune să prezinte comparativ specificul dinamicii rețelei hidrografice a două bazine situate în regiunea de orogen: Arvan (Alpi) și Slănic (Carpații și Subcarpații de Curbură), utilizând metoda morfometrică. Modelul drenajului realizat în ambele bazine și calcularea unor parametrii morfometrici legat de acesta relevă dinamica deosebit de activă a bazinelor hidrografice și frecvența mare a talvegurilor elementare.

Densitatea segmentelor de râu pentru bazinul Arvan este de 30,65 segmente/km², în timp ce pentru bazinul Slănic aceleași parametru are o valoare mult mai mică de 13,7 segmente/km². Suprafața ce revine drenajului segmentelor inferioare la bazinul Slănic este aproape dublă față de bazinul Arvan, fapt datorat numărului mare de segmente inferioare care se înscriu în circurile glaciare, în torenții de grohotiș și în cadrul culoarelor de avalanșe.

Dinamica activă a rețelei de drenaj din cadrul celor două bazine este ilustrată și de indicele de realizare a bazinului care pentru Arvan este de 96%, ceea ce arată o stare de echilibru, iar pentru Slănic este de 145 % indicând o stare de dezechilibru la nivelul întregului bazin. Analiza subbazinelor de ordine imediat inferioare relevă și alte caracteristici ale dinamicii.

1. General data

Of vital importance for the systematization of slope drainage are the precipitation quantity and the particularities of the topographic surface (rock formation, relief morphometry and morphography, vegetation, etc.) all in the context of the tectonic and neotectonic movements. Consequently all morphohydrographic systems react differently to energy and matter inputs as dictated by the ratio resistance factors/leveling factors of the topographic surface. The theoretical and methodological research of the morphohydrographic basins also results into some general, genesis and evolution related studies of this type of relief such as modeling (based on Horton's laws), analysis based on the morphologic theories (especially that of fractals), systemic analysis (the process - response system, the domino system, etc.), the holistic analysis, etc. In

order to exemplify two hydrographic basins were studied— the Arvan and the Slanic (Grecu and all, 2006), located more or less at the western and the eastern ends of the alpine-carpathian orogen greatly similar yet with many particularities.

The Arvan basin is situated in the French Alps of Savoie, the Maurienne region. It mostly overlaps the geographic region Pays des Arves, located south of Arc, between the Belledonne Massif (in the north-west), the Grandes Rousses (in the south-west and south) and the Grande-Chible ridge (in the east), which goes on southwards with glacial cirques and ridges that reach their maximum height in Aiguilles d'Arves (Aiguilles Centrale 3 515 m) the highest in the basin also (Fig. 1).

The basin is drained by the homonym river which flows into the Arc River (tributary on

Fig. 1. Location of the Arvan hydrographic basin.

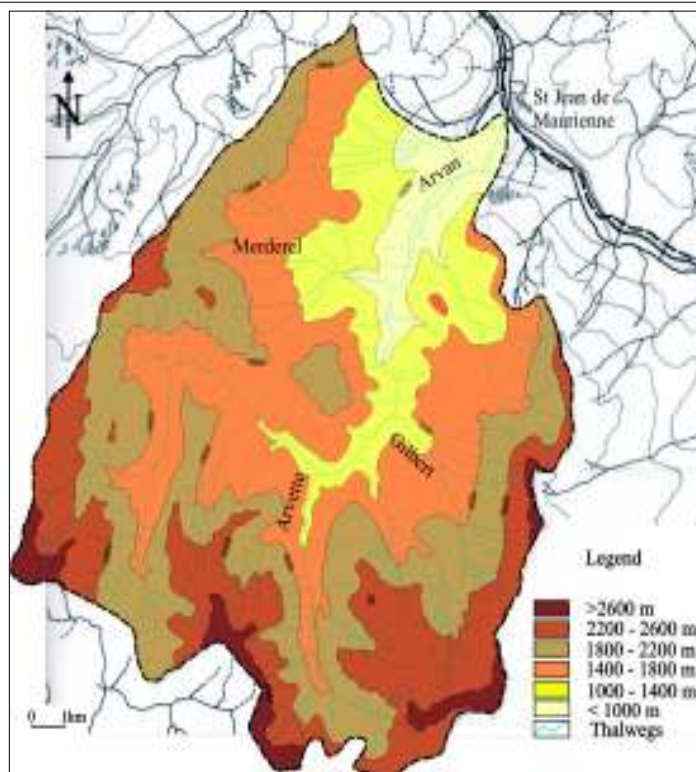
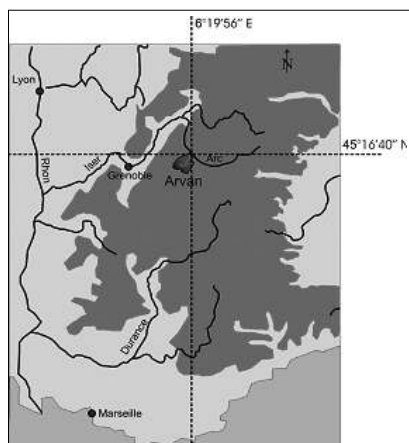


Fig. 2. Hypsometric map of the Arvan hydrographic basin

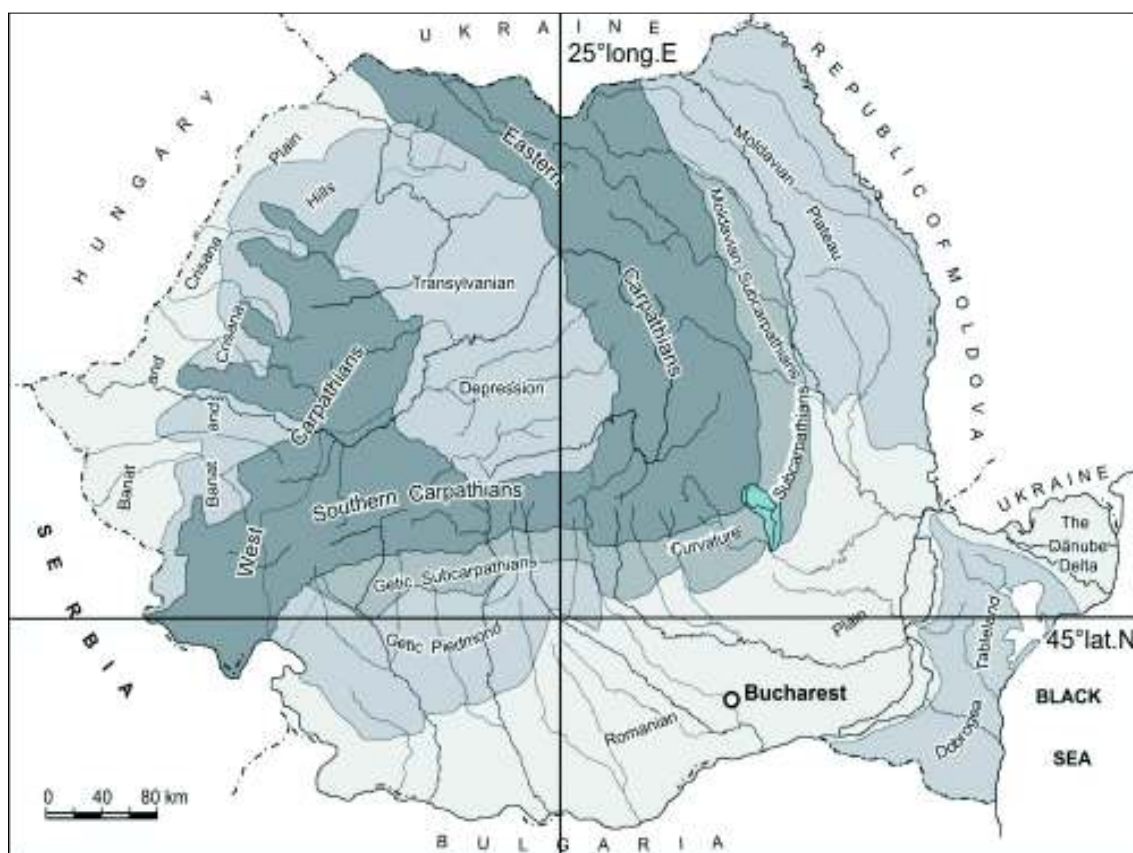


Fig. 3. Location of the Slănic hydrographic basin.

the left of Isere) in the St. Jean de Maurienne settlement located at 550m. Therefore the difference in altitude is of about 2965m on a 25 km distance. The basins surface is of about 220 km² or, translated in the Horton-Strahler system a rank 7 basin. The Arvan River springs at the altitude of 1 270 m where the Arvan Gully (west-east oriented, rising from about 2 300 m) flows into the Arvette (south-north oriented, joining along the new formed river) near the Entraigues settlement (Fig. 2). (We consider the Arvette River to be the spring since it rises as a permanent river at the altitude of 2 500 m from the gullies draining the glacial cirque located below Aiguille Centrale, which keep growing regressively up to 3 000 m). The neighboring hydrographic basins are Valloirette in the east and Gordon in the west (tributaries on the left of the Arc River) as well as Romanche in the south (tributary on the right of the Drac River that flows into Isere).

The hydrographic basin of Slanic, located in the curving area of the Carpathians and SubCarpathians, is part of the Buzau basin being its tributary on the left (Fig. 3). The Calnaului and Saratelului Basins form its eastern and western limits. Its north-western limit is given by the Basca Rosilei basin while the Zabalei basin forms its northern limit on a few kilometers. The basin's surface is of 433 km², a rank 6 basin as translated in the Horton-Strahler system. The maximum altitude of the basin (1 400 m), the altitude where the river rises (1 350 m) and the altitude where it flows into the Buzău - minimum altitude (125 m) show a difference in altitude of 1 275 m of the basin and 1 225 m of its main drainage course on 64 km only (calculated for the river).

From the above mentioned data is obvious that the Arvan's relief energy is 2, 3 times higher than that of Slanic, fact also evident in the field pointed by the fast deepening valleys and by the major breach located at 1 100–1 300 m. This particularity plays a very important role in the systematization and dynamics of the drainage network.

2. Geology – determining factor for the genesis and evolution of the drainage network

The structural and geologic analysis of a geologic map at a 1:50 000 scale (including its written text) (*Carte géologique de la France à 1/50 000, St.-Jean-de-Maurienne, 1977 and La Grave, 1976*) suggest that the Arvan basin belongs to the external area of the Alps, more accurately to the dauphinoise and ultra-dauphinoise area (Fig. 4).

The Dauphinoise area includes the western part of the Belledonne Masif as well as the northern part of the Grandes Rousses Massif. This area has a Precambrian-Paleozoic crystalline foundation formed of gneiss and migmatite. The sedimentary layer is of Triassic and Liassic age. The Grand-Châtelard crystalline massif (located in the northern part of the basin) stands representative for the analyzed area.

The Ultra-dauphinoise area develops east from the major tectonic contact suggested by the very thick Triassic gypsum that cross the entire region from north to south, almost along the same alignment as the Arvan. To its east there lies the Jurassic with a similar lithology to that of the dauphinoise area. To the south the Jurassic is represented by the Aiguilles d'Arves flysch.

The Liassic covers large areas between the crystalline massifs of Belledonne, Grandes-Rousses, Grand-Châtelard and the ultra-dauphinoise overlap. Here can be observed two great lithologic formations, an inferior one formed of limestone and a superior one made up of clay and schist separated by a sandstone- limestone formation.

The mid-Jurassic is represented by black and grey clay schist that alternate with sandstone and limestone layers. This formation outcrops on the left of the Arvette River, in Saint Sorlin. It also outcrops on a 200 m distance in the Fontcouverte area more exactly in the Villard point where it is very thick—up to tens of meters being formed of pink-grezoase conglomerates that alternate with black clay schist.

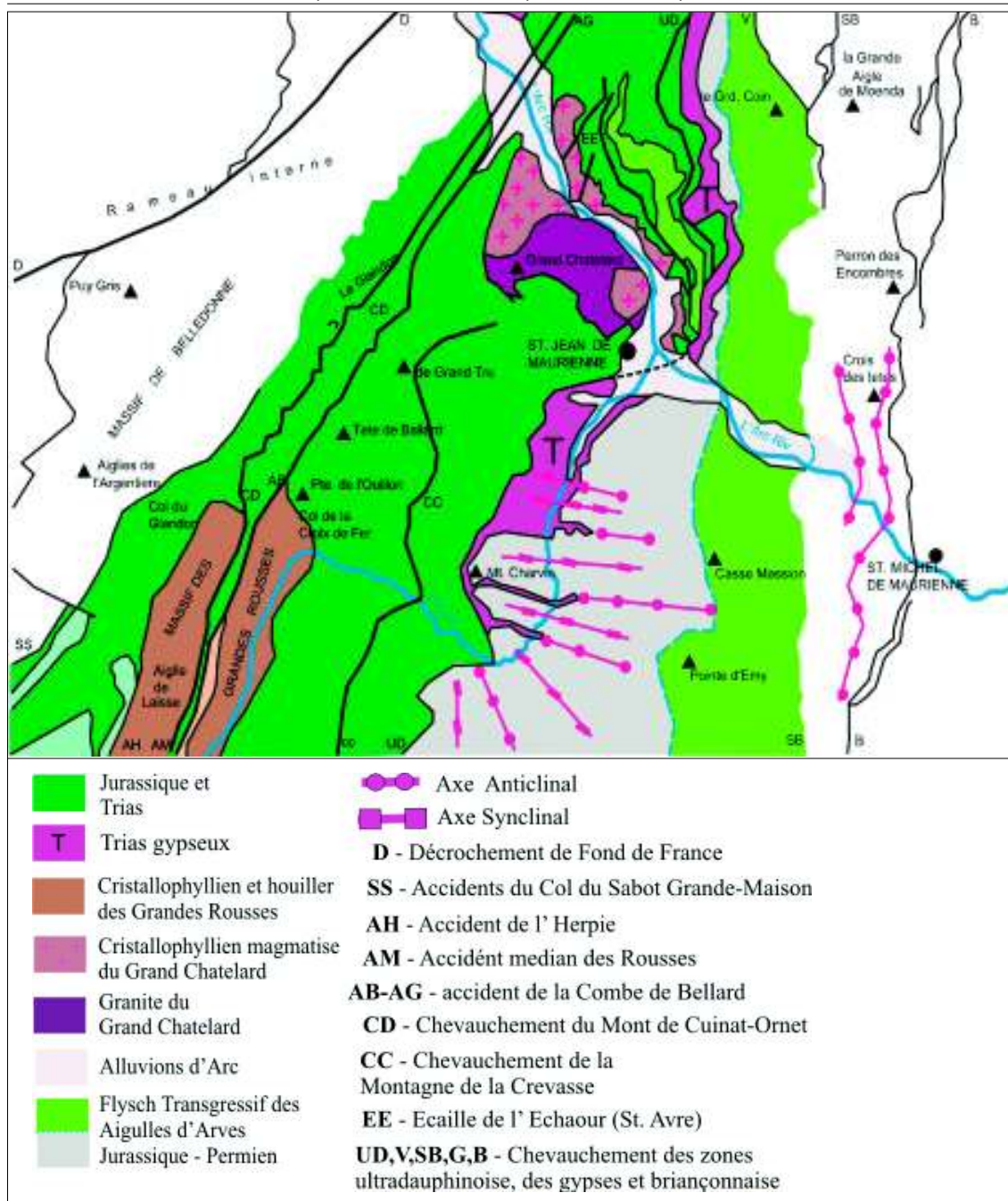


Fig. 4. Geologic map of the Arvan hydrographic basin.

The Triassic is formed of gypsum and anhydrites that outcrop discontinuously along the Arvan. Here also outcrop schists with sandstone intrusions (on the northern slope of Mont Charvin) as well as yellow and purple-greenish clays. The Liassic is similar to that present in the western part of the dauphinoise area but thicker. The same is true for the mid and superior Jurassic from

the external areas: black marls, and black grezos limestone.

The numulitic schist and clay flysch (the Aiguilles d'Arves flysch) is present as four different formations: sandstone with conglomerates in foundation (Casse Massion); limestone based flysch (the western slope of the Grande Chible ridge); schist based flysch (a formation of limestone, sandstone and

black silica schist in the upper course of Montricher and Albane); sandstone; limestone and conglomerates, formation made up of limestone and black schist in the upper side (Fig. 4)

The Quaternary deposits resulted through accumulation determined by the glacial (Vivian, 1969) periglacial, gravity determined, and fluvial processes. These vary in thickness and cover different surfaces; the best represented being the glacial and periglacial ones.

The movements that took place in the Miocene, pushing higher the crystalline schists have great importance in the dynamics of this area. At the end of the Miocene and in the Plio-Quaternary new movements took place leading to the folding of the sedimentary formation as well as to the final shaping of today's structures.

In the Slanic basin the superficial deposits, of great importance in the relief's dynamics, develop like almost parallel stripes with a north-south direction, from the oldest to the youngest, these stripes are almost perpendicular to the main drainage course being at the same time in accordance with the main relief (Sandulache and all., 1968; Visarion and all., 1977).

The oldest superficial deposits were formed in the Mesozoic (Senonian-Danian) displayed parallel with Slanic's upper course, these are also known as the Hangu formation composed of tough grey sandstone-limestone (limestone based flysch), marls and grey clays. In the upper side of the formation are present clayey sandstones intrusions similar to Tarcau sandstone while at the base there are microconglomerates with green schist elements.

The largest part of the superior basin, the Carpathian one, up to Lopatari overlaps on the Paleocene flysch made up of: sandstone-schist flysch (the Colti facies), and the grezo-limestone based flysch (the Lesunt formation) of Paleocene-Eocene age; the Fusaru sandstone (mica sandstone) and Kliwa sandstone (quartz sandstone) facies of Oligocene age (Dumitrescu and all., 1970).

Downstream from Lopatari the Slanic basin enters the SubCarpathians, first cutting through Miocene molasse (marls, clays, sandstones, salt and salt breccia) followed by Pliocene molasse (gravels, sands, clays) and near its mouth, through Quaternary deposits (loess and alluvia)

The Slanic basin is located in the Carpathians and the SubCarpathians area of great tectonic mobility (Badea, Niculescu, 1964). The upper basin, up to Lopatari, flows through an area rising up every year with high and very high intensity (+ 2... 4 mm/an), while its middle and inferior basin, excepting its mouth, are rising up with medium-intensity. The area where the Slanic flows into the Buzau River knows a constant lowering movement (Visarion and all., 1977).

As far as the formations' resistance to erosion is concerned it is obvious that the two basins differ very much both regarding the extension of the different formations as well as their disposition compared to the direction of the flow.

In the case of the Slanic basin, the most resistant formations are those forming the Carpathian and inner SubCarpathians flysch. Further downstream there follow mid-tough, erodible and very erodible. The least resistant formations are the Romanian and Quaternary deposits from the inferior basin (Fig. 5). Since these are only partly cemented they are easily washed away by the dynamic unorganized or organized water running down the slopes or flowing through the river's valley. The Arvan basin overlaps entirely the Mesozoic sedimentary formation build of resistant and mid-resistant rocks. Quaternary deposits such as: slide rocks, moraines, slope deposits, etc, are present discontinuously on small surfaces in the entire basin; these are generally mobile not cemented rocks.

3. The present-day morphometry of these morphographic basins, result of the landscape dynamics and evolution

The drainage model is the best tool to illustrate the drainage network's dynamics. This

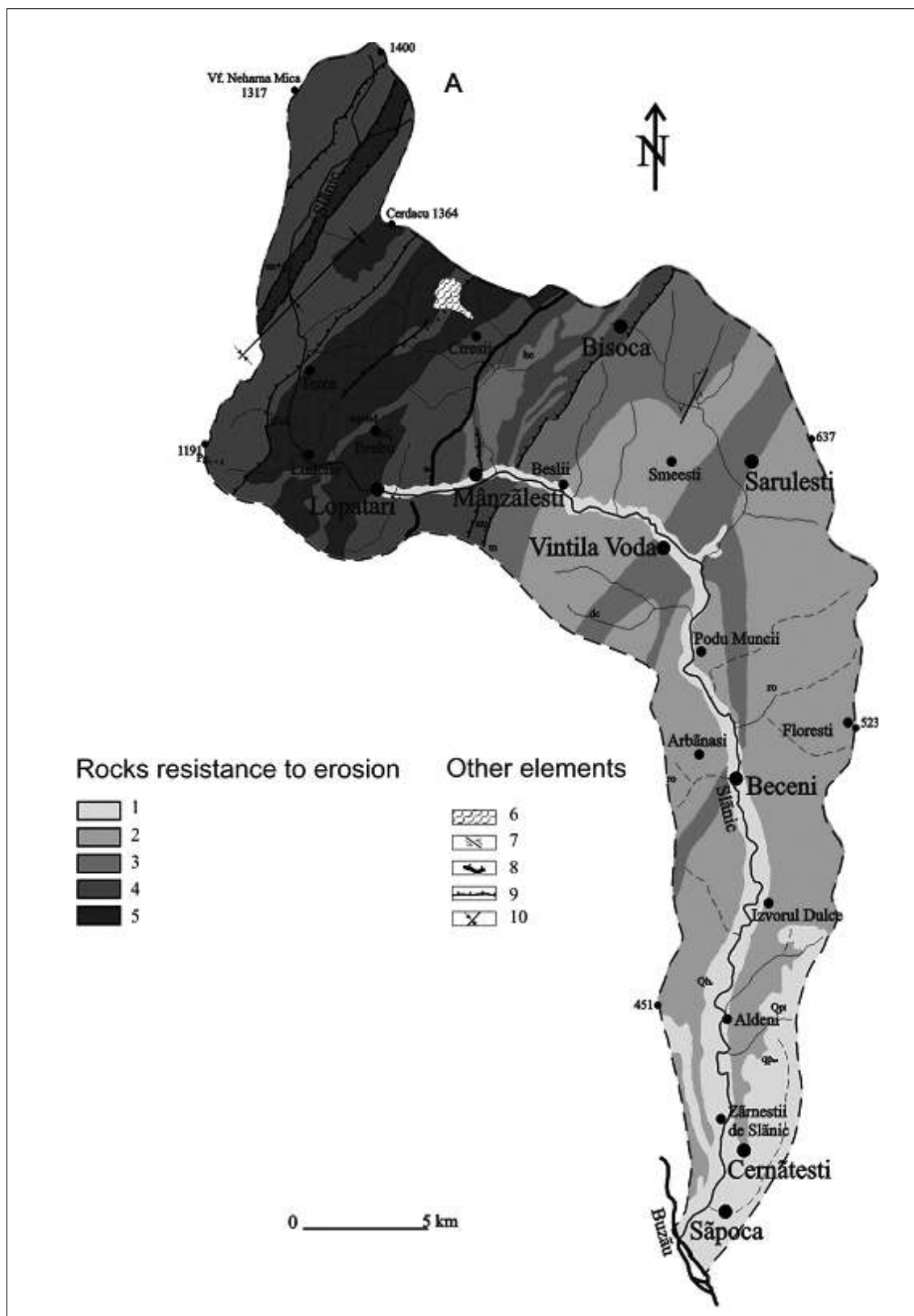


Fig. 5. Rock roughness map. 1. very soft rocks; 2: soft rocks; 3: semihard rocks; 4: hard rocks; 5: very hard rocks; 6: landslides; 7 strike-slip fault; 8: nappe; 9: reverse fault; 10: syncline axis

model is based on the hierarchic system suggested by Horton in 1945, modified by Panov in 1948 (quoted by Zavoianu, 1978) and brought to its final form by Strahler in 1952. Rivers of greater rank are older while those ranked 1 or 2 are younger, therefore it is their morphometric features that are more influenced by the present day state of the basin and by the climatic factors.

The hydrographic network of the Arvan and the Slanic basins was ranked on topographic maps at a 1:25 000 scale by using and checking the laws that define the drainage model (Fig. 6, 7). The river segments ranked between 3 – 6 (7) behave according to the law stating that the number of river segments ranked successively upwards form a reversed geometric progression, where the first element is represented by the number of rank 1 segments the ratio is equal to the junction ratio R_c calculated as the average of all individual ratios of two upwards consecutive values: $(N_1/N_2 + N_2/N_3 + N_3/N_4)/3$. The number of rank 1 and 2 segments was calculated as follows: $N_1 = N_2 \times R_c$ (Zavoianu, 1978; Grecu, 1980, 1992).

For the Arvan, the river segment density calculated as ration between the total number of river segments (6744 out of which 6649 are ranked 1, 2, and 3) and the basins total surface (about 220 km²) proved to be quite high 30.65 segments/ km². If we only consider rank 1, 2, and 3 river segments then the number per unit is of 30.22 which means that each segment drains a 3.30 ha surface (table 1).

As far as the Slanic basin is concerned with the use of the same method we observe that on each km² there are 13.7 river segments out of which 11 are rank 1 rivers; hence their great importance for the drainage systematization, each segment draining an average 9.1 ha. If we also consider rank 2 rivers then the number of segments per unit is higher (13.2) and each segment drains an average 7.5 ha.

An interesting observation is the fact that the surface drained by low ranked segments is almost double for Slanic River as compared to the Arvan. The explanation is simple: the

low ranked river segments present in the glacial cirques flow on slide rocks and avalanche scar leading to a subjective overrated evaluation of these segments (Fig. 8, 9).

The high number of low rank river segments in both basins suggests a fast response of the basin to precipitations as well as active erosion. The high partial values of the junction ratio in the case of gullies (rank 1 and 2, between 2 and 3) as well as between the rank 3 and 4 segments for the entire basin and most importantly of rank 5 and 6 segments (eg: Gilbert-Arvan, $RC_1 = 5.7$; Coca-Slanic $RC_2 = 6.8$) underlines their high frequency, most of the rank 1, 2, and 3 segments maintaining their rank. These are the gullies from the glacial cirques which directly influence Horton's laws. As a matter of fact for the Arvan basin there is evidently a threshold between the superior basin, where most of the low ranked, gully segments are grouped and the inferior basin (rank 4, 5, 6, 7); this fact is underlined by the junction ratio as well as by the great numeric difference between the low rank segments and the high rank ones.

Length determination of all ranks river segments and adding them up depending on the rank, suggests that the sums of the upwards successive ranks are inclined to form a reversed geometric progression where the first element is represented by the total length of 1 rank segments and the ratio by the lengths' ratio (R_l). Here also the law is better verified for the low rank segments while in the case of the high rank segments there may appear mishaps especially for the extended basins. With the help of the low ranked segments was determined the ratio of all lengths $R_L = 2.00$ for the Arvan (Fig.8) (table 1) and $R_L = 2.50$ for the Slanic (Fig.9).

Starting from the sum of all lengths and the number of river segments of each rank was determined the average segment length per rank for each basin. The three sets of values graphically represented by mid-logarithmic coordinates suggest that the average lengths of the upwards successive segments incline to form a direct geometric progres-

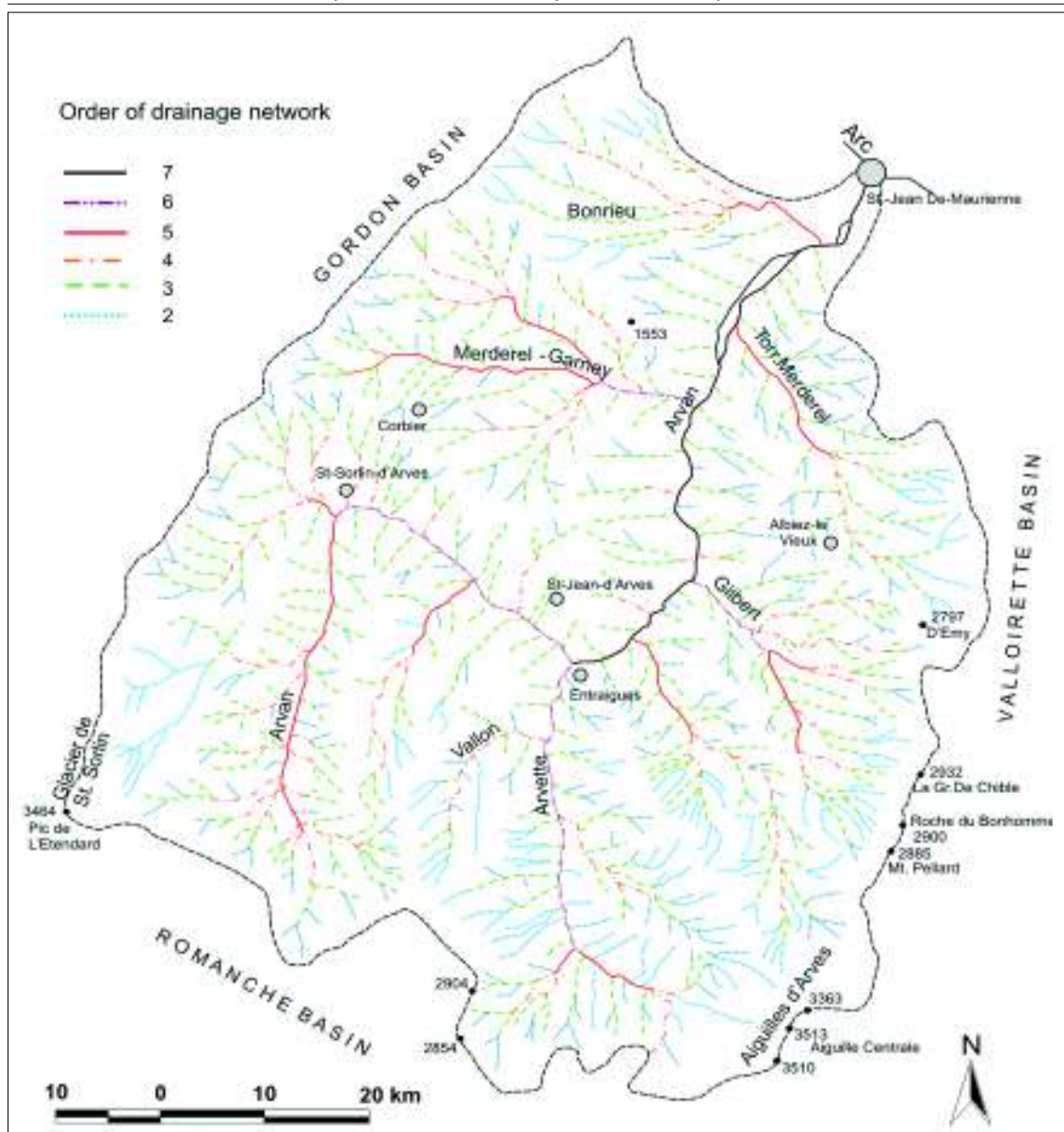


Fig. 6. Stream hierarchy according to the Horton-Strahler system for the Arvan hydrographic basin

sion where the first element is represented by the average length of a rank 1 segment and the ratio is given by the ratio of all average lengths R_I .

This law is important since it enables the evaluation of the average length of rank 1 and 2 segments that are very important for the drainage. Thus the average length of rank 1 segments is 0.14 km (Arvan) and 0.26 km (Slanic) while that of rank 2 segments is of 0.30 km (Arvan) and 0.54 (Slanic) (Fig.8,9).

The length of the drainage slope is shorter for the Arvan then for Slanic suggesting the

influence of the steep slope of the glacial cirques (Fig.10, 11A, B).

The average lengths for the inferior course ranked 1 and 2 rivers don't show significant differences between rank 6 basins that rise in the glacial area (Arvette, Arvan – rank 6, Gilbert – only partially). In the entire basin trough, the shortest are the rank 1 and 2 rivers which barely reach 0.09 – 1.6 km. The smallest average length of rank 2 rivers, 0.18 km (the average rank 1 length being 0.07 km) is encountered in the Arvette basin, which is also the longest 1.60 (the average rank 1

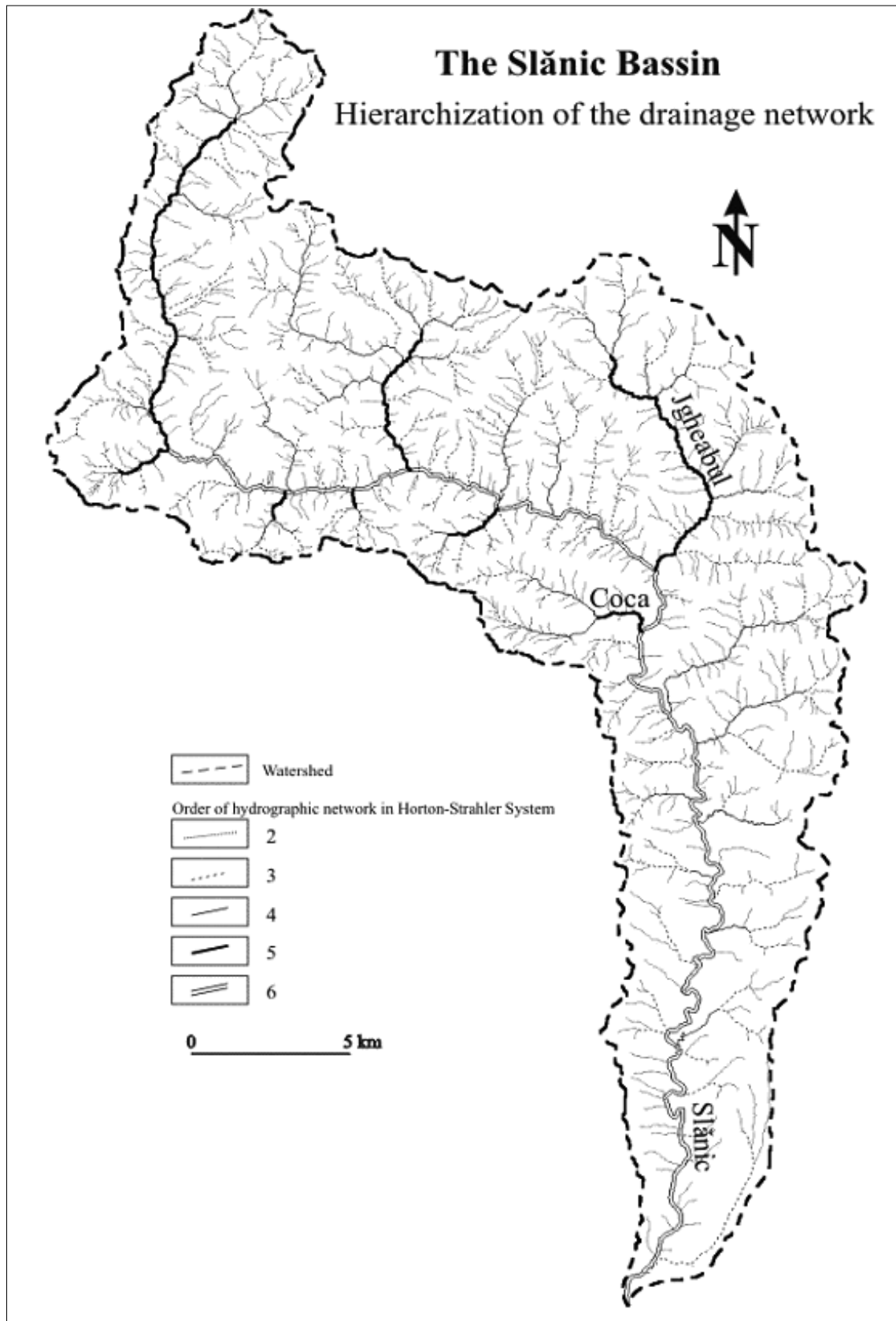


Fig. 7. Stream hierarchy according to the Horton-Strahler system for the Slănic hydrographic basin

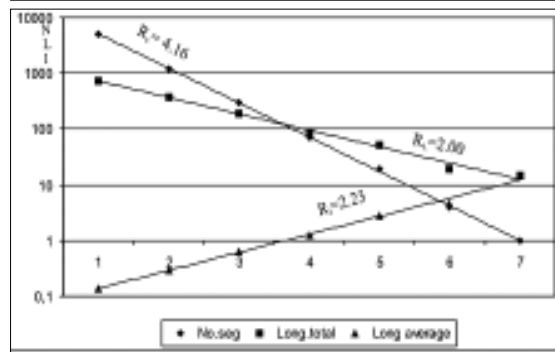


Fig. 8. Drainage Model for the Arvan hydrographic basin

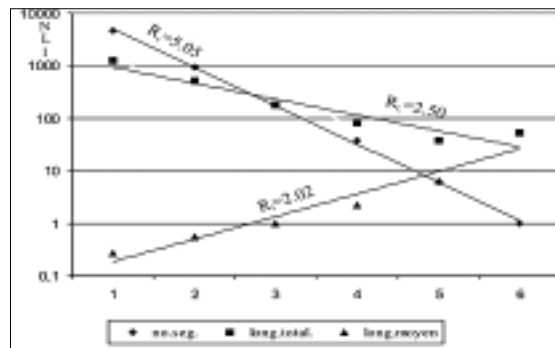


Fig. 9. Drainage Model for the Slanic hydrographic basin



Fig. 10 B - Downward erosion of the Garney river



Fig. 10 A - Expansion through regressive erosion of the hydrographic network in Garney's upper basin

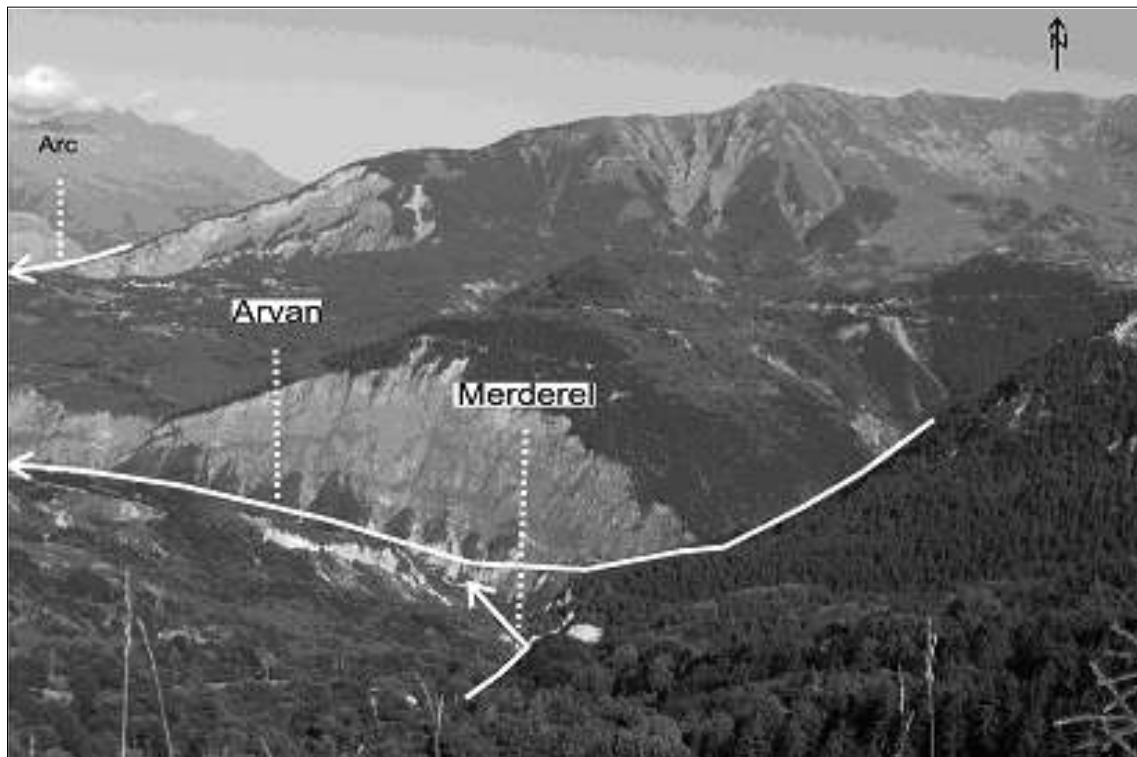


Fig.11 A. Leveled surface on the right of the Arvan River along its upper and middle course (1400)



Fig. 11 B. South eastern watershed of the Arvan basin. Order 1 and 2 streams developed in glacial cirques

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ord.7	Ratio
Number of river (N)	M	-	-	296	71	19	4	1	$R_C = 4.16$
	C	5122	1231	296	71	17	4.75	0.96	
Summed length (L) (km)	M	-	-	187.72	89.17	52.50	19.65	14.72	$R_L = 2.00$
	C	751	375.44	187.72	94.00	47	23.5	11.75	
Medium length (I) (km)	M	0.14	0.30	0.63	1.25	2.80	4.52	14.72	$R_I = 2.23$
	C	0.09	0.20	0.45	1.01	2.27	4.52	10.07	

Table 1 - The drainage model-Arvan basin

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ratio
Number of river (N)	M	-	-	73	18	4	1	$R_C = 4.20$
	C	1305	311	74	18	4.28	0.95	
Summed length (L) (km)	M	138	75	41.2	22	13	6.65	$R_L = 1.83$
	C	135	74	41.2	22	12	6.56	
Medium length (I) (km)	M	0.10	0.25	0.55	1.22	1.25	6.65	$R_I = 2.29$
	C	0.10	0.23	0.53	1.22	2.79	7.44	

Table 2 - The drainage model -Arvan Torr basin (upper to Arvette basin confluence)

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ratio
Number of river (N)	M	-	-	73	17	6	1	$R_C = 4.37$
	C	1395	319	73	17	4	1.37	
Summed length (L) (km)	M	100.4	60.12	36	18.3	8.95	8.85	$R_L = 1.67$
	C	85.22	51.03	30.56	18.3	10.95	6.55	
Medium length (I) (km)	M	0.07	0.18	0.49	1.07	1.49	8.85	$R_I = 2.61$
	C	0.05	0.153	0.40	1.07	2.79	7.28	

Table 3 - The drainage model -Arvette basin

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ratio
Number of river (N)	M	-	-	37	9	3	1	$R_C = 3.36$
	C	418	124	37	11	3.27	0.97	
Summed length (L) (km)	M	-	-	27.8	11.575	9.65	2	$R_L = 2.8$
	C	217.95	77.84	27.8	9.92	3.54	1.26	
Medium length (I) (km)	M	0.52	0.62	0.75	1.28	3.21	2	$R_I = 1.2$
	C	0.50	0.61	0.75	0.95	1.14	1.36	

Table 4 - The drainage model -Merderel basin (Garney)

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ratio
Number of river (N)	M	549	96	24	6	2	1	$R_C = 3.74$
	C	391	104.6	28	7.48	2	0.53	
Summed length (L) (km)	M	185	65.8	22.95	8.07	1.72	2.15	$R_L = 2.84$
	C	185	65.8	22.95	8.07	2.84	1.00	
Medium length (I) (km)	M	0.34	1.6	0.96	1.54	0.86	2.15	$R_I = 1.3$
	C	0.51	0.73	0.96	1.25	1.62	1.70	

Table 5 - The drainage model -Gilbert basin

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ord.6	Ratio
Number of river (N)	M		944	179	37	6	1	$R_C = 5.05$
	C	4767	944	186	37	7.32	1.45	
Summed length (L) (km)	M		507	179	81	38	53	$R_L = 2.50$
	C	1267	507	203	81	32	13	
Medium length (I) (km)	M		0.537	1	2.19	6.33	53	$R_I = 2.02$
	C	0.266	0.537	1.08	2.19	4.43	8.94	

Table 6 - The drainage model -Slanic basin

Parameters	M C	Ord.1	Ord.2	Ord.3	Ord.4	Ord.5	Ratio
Number of river (N)	M	134	35	5	2	1	$R_C = 3.83$
	C	73.3	19.5	5	1.3	0.33	
Summed length (L) (km)	M	49	14.17	3.37	5.65	2.25	$R_L = 2.87$
	C	27.7	9.67	3.37	1.17	0.4	
Medium length (I) (km)	M	0.36	0.4	0.67	2.82	2.25	$R_I = 1.18$
	C	0.37	0.5	0.67	0.89	1.18	

Table 7 - The drainage model -Coca basin

length being 0.34 Gilbert basin). These values agree with those of the junction ratio and are due to the development of these segments in the glacial cirques with high relief energy. The gully segments of the Gilbert basin develop in glacial cirques with low relief energy and on quaternary deposits, which are less steep than those of Arvette (Fig.11A, B).

The active dynamics of the drainage network is also suggested by the accomplishment index of the basin (I_n) regarding the rank (related to the number of river segments) valid for both basins (Grecu, 2004). The value of this index ($I_n = 96\%$) suggests an equilibrium state for Arvan. Its value for the low ranked basins is of 0.53 (53%) (the Gilbert basin) suggesting a disequilibrium state of the basin. The same state of evolution is suggested by the accomplishment index of the lengths' sum $I_L = 60\%$ and of the average length of river segments $I_l = 78\%$ (Table 1–5). Its value within the Slanic river basin (1.45 that is 145%) is greater than 1 (100% - equilibrium) and suggests a disequilibrium state of the basin, having too many river segments for a rank 6 river. At the same time, some rank 5 basins (part of the middle course

of the Slanic) have not reached the equilibrium state (the Coca basin $I_n = 33\%$).

Conclusions

The results of the comparative analysis between the Slanic and the Arvan hydrographic basins show that:

- the law of stream numbers, the law of stream total and average length applies both to the Arvan and the Slanic, hydrographic basins located in orogeny areas with pretty different geologic, evolution and geomorphologic features;
- the comparative analysis of the drainage models (Fig.8, 9) shows similitude in their morphography making the two models comparable as far as their drainage is concerned;
- the different morphometric parameters were calculated (the density of each order streams, the thalweg density for the first two orders, their average and summed lengths, the area necessary for 1st order streams to develop, and the accomplishment index of the drainage basins), their results evidencing differential morphodynamics for the two drainage basins.

BIBLIOGRAPHY

- BADEA L., NICULESCU, GH. (1964), Harta morfostructurală a Subcarpatilor dintre Slănicul Buzăului și Cricovul Sărat. *Studii și cercetări de geologie, geofizică, geografie – Geografie*. XI. p. 89–106.
- BATTIAU-QUENEY (1993), *Le relief de la France*, Compes et croquis, Masson Geographie, Paris.
- DUMITRESCU, I., SĂNDULESCU, M., BANDRABUR, T. (1970), *Harta geologică - foaia Covasna*, Comitetul de Stat al Geologiei, Institutul Geologic, București.
- GRECU, Florina (1980), Modelul morfometric al lungimii rețelei de râuri din bazinul Hârtibaciu. *Studii și cercetări de geologie, geofizică, geografie – Geografie*. t.XXVII. 2. p. 261–269.
- GRECU, Florina (1992), *Bazinul Hârtibaciului. Elemente de morfohidrografie*. Editura Academiei, București, 160 p.
- GRECU, Florina (2004), Quantification of some elements of drainage basins in Romania. *Geografia Fisica e Dinamica Quaternaria*. 27. p. 29–36
- GRECU, Florina, ZĂVOIANU, I., ZAHARIA, Liliana, COMĂNESCU, Laura (2006), Analyse quantitative du réseau de drainage du bassin morpho-hydrographique Slănic–Buzău (Roumanie). *Geomorphologie. Relief. Processus. Environnement* (in press).

HORTON, R.E. (1945), Erosional development of streams and their drainage basins: Hydrophysical approach to quantitative morphology. *Geol.Soc.Am.Bull.* 56(3). p. 275 - 370.

ROVÉRA, G. (1993), *Instabilité des versants et dissolution des évaporites dans les Alpes internes: l'exemple de la montagne de Friolin (Peisey-Nancroix. Savoie)*. Revue de géographie alpine. No 1. p. 71–84.

SANDULESCU, M., GHENEA, C., MOTAS, I. (1968), *Harta geologică- foia Ploiești*,Comitetul de Stat al Geologiei, Institutul Geologic, București.

STRAHLER, A. N. (1952), Hypsometric (area-altitude) analysis of erosional topography, *Bull.Geol.Soc. Am.* 63. p. 1117–1142

VISARION, M., SANDULESCU, M., DRĂGOESCU, I., DRĂGHICI, M., CORNEA, I., POPESCU, M. (1977), *Republica Socialistă România. Harta mișcărilor crustale verticale recente. scara 1: 1 000 000*, Institutul de geologie și geofizică, București.

ZAVOIANU, I. (1978), *Morfometria bazinelor hidrografice*, Editura Academiei, București. 176 p.

*** (1976), *Carte géologique de la France à 1/50 000. La Grave*, Service Géologique National.

*** (1977), *Carte géologique de la France à 1/50 000. St.-Jean-de-Maurienne*, Service Géologique National.

*** (1998), *Carte topographique. 1:25 000. Valloire (Aiguilles d'Arves. Col du Galbier)*,Institut Géographique National (IGN).

*** (1998), *Carte topographique. 1:25 000. Le Bourg D'Oisans. L'Alpe D'Huez (Grandes Rousses.Sept Laux)*, Institut Géographique National (IGN).

University of Bucharest, Faculty of Geography
Department of Geomorphology and Pedology

The contribution of geomorphological mapping to environmental tourism in protected areas: examples from the Apennines of Modena (Northern Italy)

Doriano CASTALDINI¹, Jairo VALDATI², Dorina Camelia ILIES³

Keywords: Geomorphological mapping, Environment, Geo-Tourist map, Tourist-Environmental Map, Apennines of Modena, Northern Italy

Abstract. This paper considers the contribution of geomorphological documents and the criteria and methodology used for the implementation of tourist - environmental maps in two protected areas located in hilly and mountain areas of the Apennines of Modena (Northern Italy). The hilly area is the Natural Reserve of Salse di Nirano; the “*Salse*” are small mud volcanoes formed by emissions of salt water mixed with mud and pushed up by methane rising to the surface along ground discontinuities. The mountain area consists of the Upper Tagliole Valley, located within the Frignano Park; it is mainly characterized by glacial and cryogenic landforms.

Geomorphological maps and Digital Terrain Models (DTM) have been produced. Geo-tourist maps were derived from the geomorphological maps; the geo-tourist maps combine the most evident geomorphological features with fundamental tourist information. The goal was to produce maps that could be easily interpreted by tourists to help them understand the landscape.

The geo-tourist maps and the DTM are the cartographic documents characterising tourist-environmental maps; these are thematic pocket foldable maps printed on both sides with illustration notes both in English and Italian. In addition, the tourist-environmental maps contain a synoptic description of the geological, geomorphological, botanical and zoological aspects, accompanied by photographs and information on excursion trails, visitor centers, behaviour rules, refreshment points and overnight-stay places and, finally, cultural and tourist attractions in the protected and surrounding areas.

The tourist-environmental maps form part of the initiatives taken by Public Boards to improve the knowledge, utilisation and appraisal of the environment of protected areas. These studies show how geomorphological investigations can effectively contribute to the production of maps which can be used in the field of environmental tourism.

1. Introduction

In the past decade several papers, research projects and scientific meetings have been carried out at an international level regarding the preservation of geological heritage (whose elements are defined, according to the various authors, as “Earth science sites”, “Geologic Assets”, “Geotopes”, “Geosites” or “Geomorphosites”) (Reynard, 2004) and its diffusion and appraisal also outside the realms of academic research (for example, Wimbledon *et al.*, 1995; Eberhard, 1997; Barrettino *et al.*, 1999; Panizza, 2001; Piacente and Poli, 2003; Reynard *et al.*, 2003).

Very recently, within the framework of the 32nd International Geological Congress

(Florence, Italy, 20-28 August 2004), many oral and poster presentations focused on “Geological Heritage and Tourism” and “Cultural Heritage: International Approaches and Perspectives” (Italy, 2004). Also within the framework of the 6th International Conference on Geomorphology (Zaragoza, Spain, 7–11 September 2005) special sessions on “Geomorphological sites: Research, Assessment and Improvement” and “Natural-Cultural Heritage” were held (Gutierrez *et al.*, 2005).

Moreover, the “Recommendation Rec (2004) 3 of the Council of Europe on conservation of geological heritage and areas of spe-



Fig. 1. Location of the study areas: 1) Regional Natural Reserve of Salse di Nirano; 2) Upper Tagliole Valley (Frignano Park)

cial geological interest” underline the importance of the Earth Heritage and Geodiversity and the tools to create opportunities for education, recreation and tourism (Panizza, 2005).

This paper considers the contribution of geomorphological documents and the criteria and methodology used for the production of tourist–environmental maps in two protected areas located in hilly and mountain, areas of the Apennines of Modena (Northern Italy)(Fig. 1).

2. Geographical, geological and geomorphological settings of the study areas

The Province of Modena is located in northern Italy, in the Region Emilia-Romagna; the southern sector of its territory belongs to the Northern Apennines whereas the northern

sector belongs to the Po Plain. The Apennine sector has an altitude ranging between about 150 m a.s.l. along its margin and about 2,000 m a.s.l. along the watershed between the Adriatic and Tyrrhenian sides of the Apennines; the highest peak is Monte Cimone (2,165 m a.s.l.).

The main geological units forming the Apennines of Modena are as follows (Bettelli *et al.*, 1989).

1) Tuscan Units, made up of Tertiary siliciclastic deep-water turbidites, continuously cropping out along the Apennines chain’s axis and mainly representing the infilling of distinct migrating Tertiary foredeep basins.

2) Ligurian Units made up of deep-sea sediments including Jurassic Ophiolites followed by thick sequences of Cretaceous to Eocene calcareous or terrigenous turbidites.



Fig. 2. Aerial view of the Regional Natural Reserve of Salse di Nirano. The sub-circular shaped depression, at the bottom which the mud volcanoes are found, and the “calanchi” (badlands) are quite evident (photo L. Callegari).

3) The mainly terrigenous epi-Ligurian sequences of the Middle Eocene to the Late Messinian, unconformably resting on the previously deformed Ligurian Units. The epi-Ligurian sequences and the Ligurian Units are exposed in the middle Apennine.

4) The belt of Plio-Quaternary marine terrigenous deposits unconformably overlying the Ligurian Units and the epi-Ligurian sequence cropping out at the Apennine margin and dipping under the alluvial deposits of the Po Plain.

An account of the geographical, geological and geomorphological setting of the two study areas follows.

Regional Natural Reserve of Salse di Nirano. The hilly area, includes the Regional Natural Reserve of Salse di Nirano located in the Apennines of Modena margin (Fig. 2). The “*Salse*” are small mud volcanoes formed by emissions of salt water mixed with mud and pushed up by methane rising to the sur-

face along ground discontinuities. The Natural Reserve covers an area of 207 ha and ranges in elevation from 140 m to 308 m a.s.l.; the extent of the area covered by the “*Salse*” is about 10 ha, in an altitude ranging between 200 m to 220 m a.s.l. It is therefore a lowhill territory, with a mean annual precipitation of about 800 mm and a mean annual temperature ranging between 12 and 13 °C.

Within the Italian territory, the *salse* can be found in many Apennine areas. Since they are one of the most developed pseudo-volcanic phenomena of the whole Italian territory, Salse di Nirano have always aroused great interest and were first described by Pliny The Elder, around 50 A.D., in his monumental work “*Naturalis Historia*”. Many other authors followed (for example Stoppani, 1873; Bertacchini *et al.*, 1999; Gorgoni, 2003). In 1982, the Natural Reserve of Salse di Nirano was established in the area by the Emilia-Romagna Region with the aim of



Fig. 3. Cone-shaped mud volcanoes. They show a clear alignment in correspondence with a fault/fracture (photo J. Valdati).

safeguarding and preserving the natural and environmental characteristics of the site.

The form of the craters depends on the density of the muddy mixture: if it is dense, “cones” of various height (single, double or multiple) may develop (Fig. 3); if it is liquid, ground level “pond-shaped mud-volcanoes” occur. Due to the affinity to real volcanoes, the *salse* are also called “mud volcanoes” (Bertacchini *et al.*, 1999).

The origin of the *salse* is linked to the presence, at a depth of hundreds or a few thousands meters, of methane accumulations. The methane rises upwards along discontinuities in the ground (fractures or fault lines), meets saline waters accumulated in water-bearing strata and carries it up to the surface. The waters, seeping through clayey sediments, dilute, and the latter sediment become muddy. The clay materials ejected from the craters cover the surrounding ground with mudflows. The number of craters can vary with time, as does their location: in the case of Nirano, the cartographic and photographic documents indicate a considerable stability during the last

hundred years. A recent detailed survey has identified nearly forty craters (Gorgoni, 2003).

From a lithologic point of view, in the Natural Reserve of Salse di Nirano only marine silt-clay soil types (Plio-Pleistocene age) are exposed. The main streams are Rio Chianca, Rio delle *Salse* and Rio Serra. Some small ponds, marshy areas and swamp deposits are also found.

The main anthropogenic landforms include an abandoned quarrying area and an artificially flattened area corresponding to a disused farming area (a worm “farm” for anglers). Nearly everywhere it is possible to observe badlands (“*calanchi*”) in most cases stabilized by vegetation. The *calanchi* are one of the most spectacular landforms of erosion of the Apennine margin (Fig. 2). They are typically composed of clayey soils and are characterised by a very fine drainage network and short, steep slopes with narrow interfluves.

The deposits are mostly made up of very fine materials deposited by the main water-courses or by rill-wash on the slopes. Landslide bodies are quite common; they



Fig. 4. The glacial cirque in the north-eastern slope of M.Rondinaio (1964 m a.s.l.) remodelled by cryogenic, nivation and slope processes (photo D. Castaldini).

include small earth flows. Most landslide deposits have been colonized by vegetation which has contributed to stabilize them.

2.2. The Upper Tagliole Valley

The Tagliole Valley is one of the most important valleys of the Apennines of Modena owing to the characteristics of the landscape. It is located in the Park of the High Apennines of Modena, or Frignano Park. The main hamlets of the valley are Le Tagliole (1,158 m a.s.l.), Ronchi (1,146 m a.s.l.) and Rotari (1,218 m a.s.l.). In this area winter tourism is not developed as much as in other areas of the Modena Apennines like, for example, in the Mt. Cimone area. The valley is frequented by excursionists, especially in the summer, owing also to the presence of several lakes

The climate is considerably influenced by several geographical factors, among which are the altitude and location near the watershed. Below 1,000 m a.s.l., the average annual temperature is about 10°C, whereas above this elevation it progressively decreases to 6°C in the area around the watershed. Annual precipitation ranges from 1250 mm in the lower part to over 2,000 mm in the upper part.

The geomorphological studies in the upper sector of the Apennines of Modena, started at the end of 19th century. In the last decades, the geomorphological features of this area were described by Carton and Panizza (1988), Ferrari and Panizza (1992) and Bertacchini *et al.* (1999).

The study area, corresponding to the Upper Tagliole Valley, with elevations ranging from 1,480 a.s.l., to 1,990 m. a.s.l., is mainly characterised by glacial and cryogenic landforms (Carton and Panizza, 1988). The Macigno Formation (Mid-Upper Oligocene - Lower Miocene?), belonging to the Tuscan Units, is exposed in the Upper Tagliole Valley. It is made up of sandstones with interbedded thin beds of pelitic sediments dipping northwards.

The head of the valley is located in the wide glacial cirques of Monte Giovo (1,991 m a.s.l.) and Monte Rondinaio (1,964 m a.s.l.)(Fig. 4). The cirques have vertical faces which have undergone slope, cryogenic and running water processes. Their scarps are therefore covered with debris produced by various processes. The rock glacier found at the bottom of the cirque of Monte Giovo is of particular interest. At various altitudes, vast glacial deposits and numerous moraine ridges



Fig. 5. Panoramic view of Lake Santo which is the largest lacustrine basin of the whole Apennines of Modena (photo J.Valdati).

are found. Owing to the barrage of runoff waters, glacial landforms have determined the formation of the Lakes Torbido (1,675 m a.s.l.), Turchino (1,613 m a.s.l.), Baccio (1,554 m a.s.l.) and Santo (1,501 m a.s.l.) (Fig. 5), together with other small depressions which are now completely filled with swamp deposits. The running water processes have also formed gullies, gorges and waterfalls. Various glacial traces testify the presence of glaciers during the last glacial period (Würm) which ended about 10,000 years B.P. The considerable difference in height between the highest peaks and the valley floor (1,000-1,100 m) witnesses the high relief energy of the Tagliole Valley.

3. Study methodology

In order to provide information about the physical landscape of each study area, a geomorphological map and a Digital Terrain Model (DTM) have been produced by means of ArcView GIS computer programme. The

Regional Technical Map (CTR) of the Emilia-Romagna Region, at the 1:5,000 scale, was used as the topographic basis for their elaboration. Detailed morphological aspects are illustrated in a geomorphological map, produced from bibliographic research, analysis of aerial photographs of various periods (1973, 1994 and 2000) and field survey. In producing the geomorphological map of the study areas the legends used for recent geomorphological maps (for example Gruppo Nazionale Geografia Fisica e Geomorfologia, 1995; Castaldini *et al.*, 1998; Pasuto *et al.*, 2005) were applied with some modifications.

The general morphological picture of each study area is effectively provided by the DTM which was computer-elaborated through the transformation of altimetric data (5 m equidistance contours) into a Triangular Irregular Network (TIN). A geo-tourist map was derived (with appropriate simplifications and integrations) from the geomorphological map (Fig. 6). A geo-tourist map can be con-

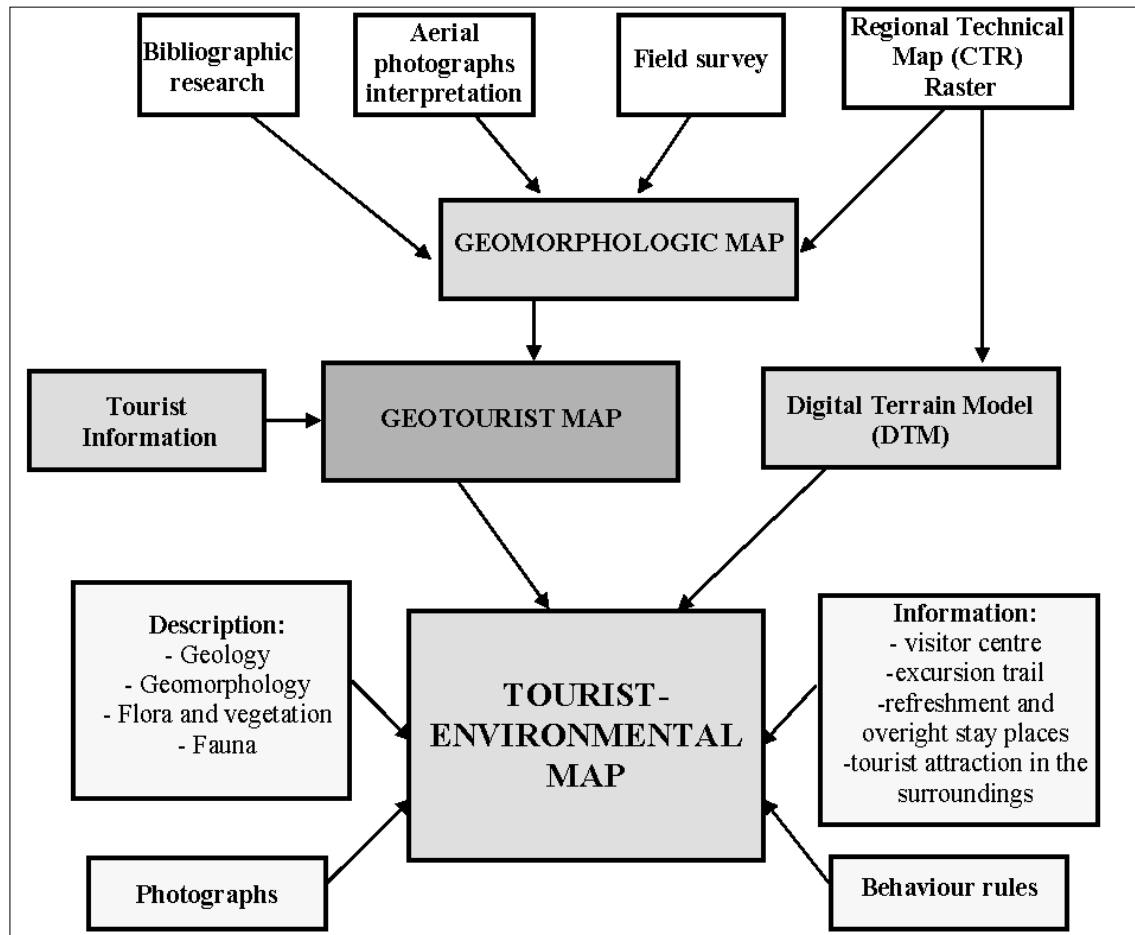


Fig. 6. Scheme of elaboration of the various documents.

sidered as a thematic map. The latter are maps which focus on a particular aspect and, consequently, are aimed at specific users. First of all, in the preparation of a thematic map, the set of data that are going to be most utilised must be chosen, so that a language and mapping system are set up (Papotti, 2002). Therefore, a geo-tourist map combines the most evident geological and geomorphological aspects with basic tourist information (for example parking places, footpaths, picnic areas, overnight-stay places, etc.). The aim was to produce maps that could be easily interpreted by tourists to help them understand the landscape. In detail, the legend was divided into two clearly distinct categories. In the first the symbols representing the geological and geomorphological aspects are illustrated, whereas in the second category the symbols concerning tourist information are

shown. Regarding the geomorphological aspects, the geo-tourist map illustrates all the elements of the landscape that a tourist can observe and identify. An effort was made to use simple, clear and graphically pleasing symbols with short captions, avoiding specialized terminology. In any case, the legend adopted is scientifically correct. As for tourist information, this has been indicated with the commonly used symbols for tourists. In the geo-tourist map and in the DTM the excursion trails are shown in order to facilitate the interpretation of the landscape and the elevation points for the tourist willing to walk along the trails suggested.

The geo-tourist maps and the DTM are the cartographic documents characterising tourist-environmental maps (Fig. 6). The tourist-environmental maps are foldable, pocket-size, maps printed on both sides which

the tourists can consult in the field while visiting the protected areas. These are maps with illustration notes both in English and Italian. In addition, the tourist-environmental maps contain a synoptic description of the geological, geomorphological, botanical and zoological aspects, accompanied by photographs and information on excursion trails, visitor centres, code of behaviour, refreshment points and overnight-stay places and, finally, cultural and tourism attractions in the protected and surrounding areas. Taking into account the use in the field of the maps, the descriptions contain concise information; the tourist who wishes to obtain more detailed information on the different topics can do so at home reading relevant books.

These maps have been called “tourist–environmental” maps because, besides the most evident geological and geomorphological aspects and basic tourist information, they provide further information (such as information on the flora, vegetation and fauna) concerning the environment.

The tourist - environmental maps of the study areas

In this section the main characteristics of the tourist-environmental maps of the study areas are described. These documents, which were originally produced in colour, are here presented in black and white and at a smaller dimension (the original dimensions are 48 cm x 63 cm).

Regional Natural Reserve of Salse di Nirano. The tourist-environmental map of the Regional Natural Reserve of Salse di Nirano was printed with the financial support of the Municipality of Fiorano Modenese in the year 2004 (Barozzini et al., 2004).

The front side (Fig. 7) contains the geo-tourist map of the Reserve and its description. Regarding the geomorphological aspects, the geo-tourist map shows all the elements of the landscape that a tourist can observe and identify. In particular with regards to the mud volcanoes (“*salse*”) – the main attraction of the Reserve – symbols graphically indicate both the “cone-shaped” forms and the “pond-

shaped” forms have been used on the map so that the tourist can immediately locate them.

As for tourist information, the commonly used symbols for tourist maps have also been adopted in this case. They include:

1) General information (for example, Ca’ Tassi visitor center, excursion trails, panoramic points along the excursion trails, picnic areas).

2) Wildlife information (bird-watching points).

3) Logistic information (main access roads, parking places, refreshment and overnight-stay places, consisting of a restaurant, a holiday farm and a bed & breakfast).

For further details on the geo-tourist map of the Reserve refer to Castaldini *et al.* (2005 b).

The other contents on the front side of the tourist-environmental map include:

i) The title of the tourist-environmental map, the list of the authors, the location of the Reserve.

ii) The description of the excursion trails which are proposed in order to appreciate the natural environment. These include: a) “*Salse*” trail (allowing the mud-ejecting points to be observed from both close up and panoramic viewpoints); b) Walk around the ponds (where birdwatching can be practiced); c) Walk from the *Salse* Valley to the Chianca Valley (along this trail it is possible to observe closely, “*calanchi*” and a typical example of a marsh. 4) “*Calanchi*” trail (the observation of several examples of badlands).

iii) The services offered at the “Ca’ Tassi” Visitor Centre. The Centre can receive visitors and school groups and, besides the possibility of hiking guides, one can find a naturalistic museum and library, the auditorium and multi-function room and shopping facilities.

iv) The behaviour rules which the visitors should follow due to the high vulnerability of the mud-ejecting points.

The back side of the tourist-environmental map (Fig. 8) contains the DTM which provides the general morphological picture of the territory. By examining it, the presence of a sub-circular shaped depression, similar to a



Fig. 8. Back side of the tourist-environmental map of the Regional Natural Reserve of Salse di Nirano

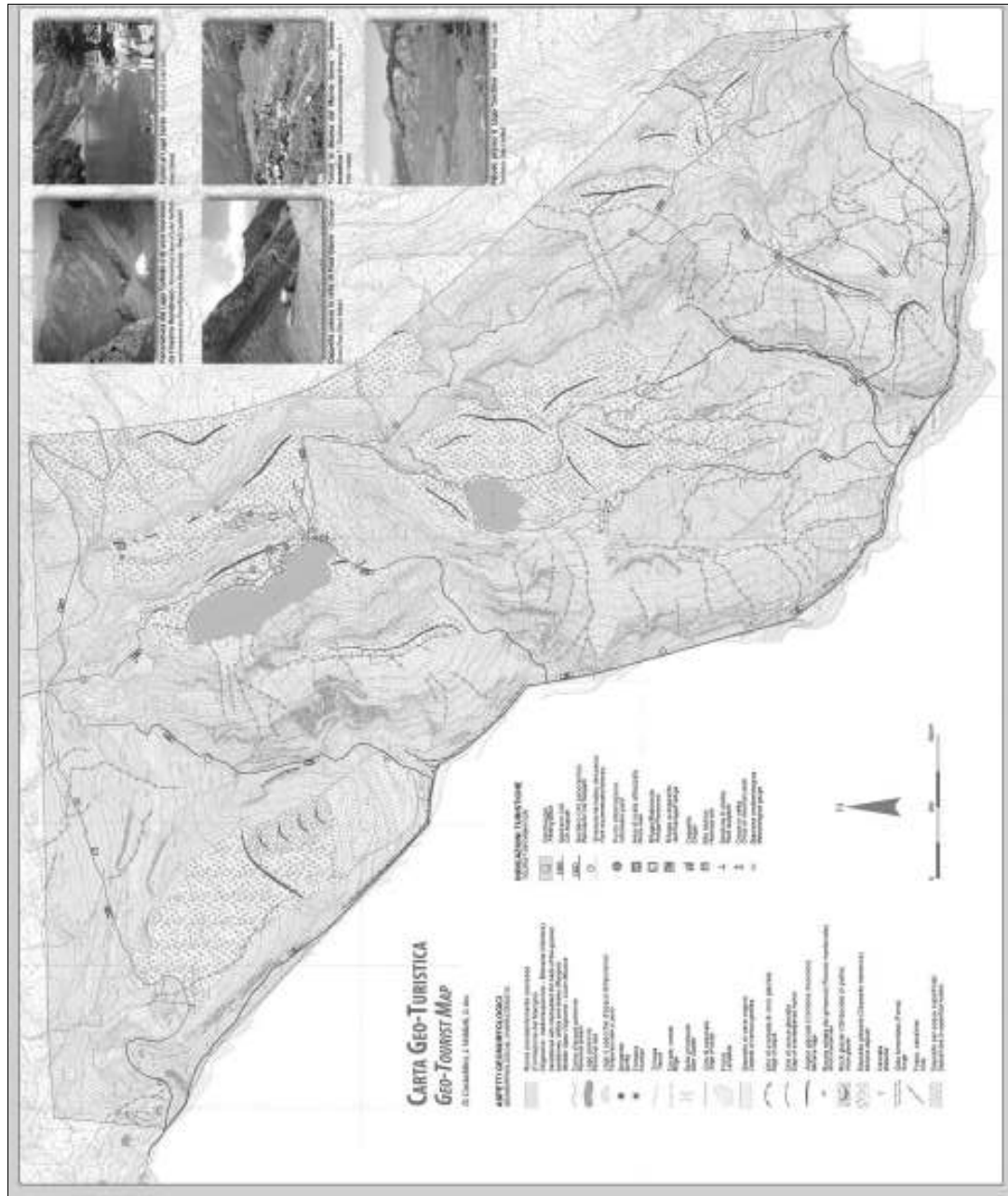
caldera, is quite evident even to non-experts. The most recent hypothesis is that the depression could be the result of a collapse in correspondence of a “mud-diapir” at the end of its uplifting activity. On the floor of this depression the mud volcanoes are found. Also the “calanchi” (badlands) are quite evident. The DTM clearly shows that these landforms are absent only in the southern part of the Reserve. Furthermore, the excursion trails have been indicated in order to provide the visitor with information on their elevation development.

The other contents on the back side of the tourist-environmental map include:

- i) Description on the Reserve and *Salse* phenomenon (refer to section 2.1).
- ii) Information on the guided visit and the opening time of Cà Tassi Visitor Centre and on the refreshment and overnight stay places of the Reserve;
- iii) Description of the flora and vegetation. The *salse* comprise a very particular environment because the saline mud and the physical

characteristics of the clays favour the survival of only those vegetation species that can adapt to this type of environment. Those species, defined as *halophiles* (salt resistant) and *xerophiles* (tolerant to dry conditions), constitute a peculiarity within the flora community of the Salse di Nirano area. The most tolerant species to the saline conditions is the *Puccinellia borreri*, a graminaceous plant which lives near the craters abundantly during spring time. The flora of the badlands is characterized by dense shrubs dominated by brooms which cover the slopes.

iv) Description of the fauna. Due to the limited extent of the Reserve, the fauna does not differ significantly from that of the surrounding hilly territory. Species living in areas characterised by stretches of cultivated and uncultivated fields, shrubs and small woods can be found, such as roe deer (*Capreolus capreolus*) and porcupine (*Hystrix cristata*). Among the birds, open areas are frequented by raptors such as the buzzard (*Buteo buteo*) and the kestrel (*Falco tinnunculus*)



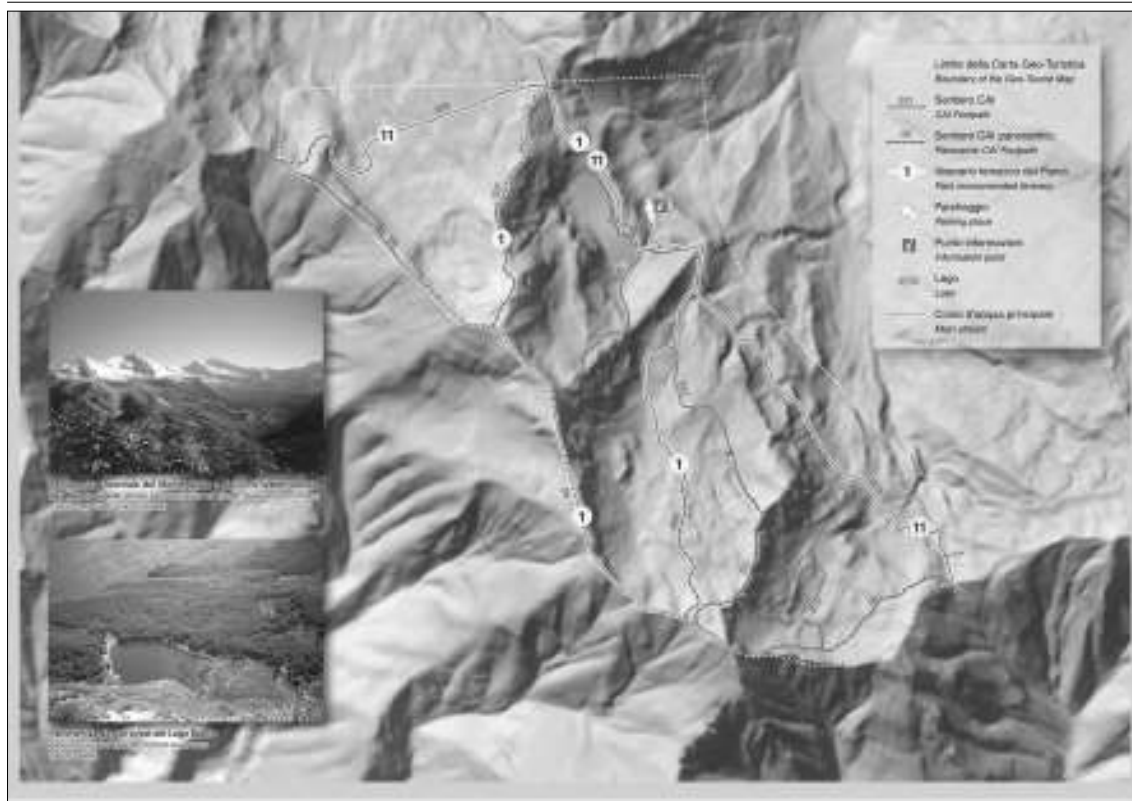


Fig. 10. Back side of the tourist-environmental map of the Upper Tagliole Valley (Frignano Park)

v) Indication of the tourist attractions in the surrounding areas including the Sanctuary of the Virgin Mary in Fiorano, the Spezzano Castle, the Ferrari Cars Gallery in Maranello and the spa in Salvarola Terme

4.2 Upper Tagliole Valley (Frignano Park). The tourist-environmental map of the Upper Tagliole Valley (Frignano Park) was printed with the financial support of the Frignano Park in the year 2005 (Castaldini et al., 2005 a). The structure of this map is quite similar to that of the Natural Reserve of Salse di Nirano.

The main element of the front side (Fig. 9) is the geo-tourist map. Regarding the geomorphological aspects, the geo-tourist map illustrates, with simple, clear, graphically pleasing symbols and short captions, the elements of the landscape which have been described in section 2.2. As for the tourist information, the map includes logistic information (such as parking place, picnic areas, refuges, information point) as well as general information (such as footpaths and park recommended

itineraries, chapels, historical sites, rock sculptures, crucifixes on mountain peaks and meteorological station). Most of the tourist facilities are located near Lake Santo and are easy to reach.

The other contents on the front side of the tourist-environmental map include:

i) The title of the tourist-environmental map, the list of the authors, and the location of the Tagliole Valley.

ii) The description of the excursion itineraries. The Upper Tagliole Valley offers many opportunities to conduct excursions since the area is characterised by eight well signed footpaths of the Italian Alpine Club (C.A.I.). In particular, two thematic itineraries of the park are recommended. One is a geomorphological route focusing on the landforms created by glaciers, which occupied the Tagliole Valley some 10,000 years ago. The other route runs along two stretches of the ancient “Via dei Remi”, a road utilised in the 18th century for the transport of timber to Pisa, where the material was used for shipbuilding.

ii) Description of information points and visitor centres where tourist-environmental information on the Upper Tagliole Valley and the Frignano Park is available.

The back side of the tourist-environmental map (Fig. 10) includes the DTM. On closer examination, the Upper part of the Tagliole Valley can be observed. The Torrent Tagliole flows across this valley from south to north at an altitude ranging from 1,400 to 1,050 m a.s.l. On the western-side of the torrent, at the head of the valley, the wide glacial cirques of Monte Rondinaio and Monte Giovo are quite evident. Lake Santo, with its typical “bean-shaped” form, and Lake Baccio, a sub-circular small impoundment, are also evident. Furthermore, the footpaths and recommended itineraries, parking places and information points are indicated on the map.

The other contents on the back side of the tourist-environmental map include:

i) The illustration of the Park of the High Apennines of Modena, or Frignano Park, which was established in 1988 by the Emilia-Romagna Region (the term “Frignano” is derived from the ancient pre-Roman people of “Liguri Friniati”). This Park safeguards a considerable area of the Apennines of Modena in the proximity of the Tuscan-Emilia watershed and stretches over an area of 15,791 ha. The highest peaks of the Northern Apennines are found within the Park, including Monte Cimone (2,165 m a.s.l.), Monte Giovo (1,991 m a.s.l.), Monte Rondinaio (1,964 m a.s.l.), Monte Libro Aperto (1,936 m a.s.l.), Monte Femmina Morta (1,881 a.s.l.) and Monte Spigolino (1,827 m a.s.l.). The protected area is subdivided into zones having different levels of conservation: the actual Park covers an area of about 9,000 ha and the so-called pre-Park covers an area of about 6,000 ha. The Park is managed by a consortium of public boards whose administrative centre is located in Pievepelago. The park’s protected areas are located in seven municipalities.

ii) Description of flora and vegetation. The arboreal vegetation of the Upper Tagliole

Valley, situated at an altitude above 1,000 m a.s.l., is characterised by deciduous broad-leaf mesophyll woods with a domination of beech trees (*Fagus sylvatica*), associated with other mixed broad-leaf species, mainly found at lower altitudes. At higher altitudes, beyond the treeline, the beech woods give way to meadows and scattered shrubs with a widespread dominance of bilberry (*Vaccinium myrtillus*) and cranberry (*Vaccinium gaultherioides*) shrubs. Wetland environments, consisting of ponds, temporary marshes, peat bogs, springs and streams, are populated by species whose southernmost habitats are found in the Tuscan-Emilia Apennines, such as *Eriophorum scheuchzeri* and *Swertia perennis*. Small insectivore species (*Drosera* and *Pinguicula*) grow in the peat bogs rich in sphagna and *Cyperaceae*.

iii) Description of fauna. Generally speaking, the animal species commonly found in beech woods and high mountain meadows of the Northern Apennines are present in the Upper Tagliole Valley, although the widespread presence of glacial landforms allows a higher concentration of species typical of rocky habitats and wetlands. The Black redstart (*Phoenicurus ochrurus*), the Northern wheatear (*Oenanthe oenanthe*) and the Water pipit (*Anthus spinoletta*) are commonly found in high mountain meadows. Among the most typical mammals of this habitat, the Snow vole (*Chionomys nivalis*) is worthy of note. Small rodents are the favourite prey of the European asp (*Vipera aspis*), a rather rare reptile. The numerous wetland places host the European common frog (*Rana temporaria*), the Italian Alpine newt (*Triturus alpestris apuanus*) and the European common toad (*Bufo bufo*). Various ichthyic species, coming also from the Po Plain, have been introduced in Lake Santo and Lake Baccio, where they live together with the Brown trout (*Salmo trutta*), which is the only autochthonous species of this area.

iv) List code of behaviour.

v) Useful information for guided visits and other information related to the two

Excursion Centres (important meeting points for hosting organised groups of visitors within the Park boundaries) and the four refuges located near Lake Santo.

vi) Description of the tourist attractions in the surroundings which include Pievepelago (a large village with a picturesque centre), Ponte della Fola (a 15th century bridge which is the only example of a two-arch cambered bridge in the Northern Apennines), Roccapelago (an impressive medieval settlement built on top of a rocky cliff), the so-called “Celtic huts” (unusual rustic sandstone buildings with step-like sloping tops and roofs originally covered with straw), the picturesque hamlet of Sant’Anna Pelago, the Romanesque Oratory of San Michele Pelago (with rare apse decorations going back to the late 12th century), Fiumalbo (a village with very ancient origins recognised as a “city of art”) and the medieval village of Riolunato.

5. Conclusions

The tourist-environmental maps described in this paper are part of the initiatives taken by public boards (a local administration and a park) for improving the knowledge, utilisation and appraisal of the environment of protected areas. These maps therefore were produced to meet the ever-growing educational needs of public boards and to contribute to transfer of information from scientific research to possible users and local communities.

The geo-tourist maps, found on the front side of the tourist-environmental maps, are original documents within the framework of geomorphological studies. The aim was to produce maps that could be easily interpreted by tourists with an average education and help them to understand the surrounding landscape.

The geo-tourist maps and the DTM (found on the back side of the tourist-environmental maps) have been produced by means of ArcView GIS computer programme. Therefore, since these documents are presented in the digital format, they can be eas-

ily updated and/or integrated with additional data.

The text of the different topics described in the tourist-environmental maps (geological, geomorphological, botanical, zoological and logistic aspects), has been implemented by university experts with the collaboration of representatives of the protected areas. Therefore it should be emphasized that this work was proposed and produced thanks to the aggregation of university researchers with the cooperation of public boards.

The tourist-environmental maps were printed with the financial support of the Municipality of Fiorano Modenese and of the Frignano Park which manage the studied protected areas. The maps are sold at visitor centres and at information points within the protected areas. These studies show how geomorphological investigations can effectively contribute to the production of maps which can be utilised in the field of environmental tourism.

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REFERENCES

- BAROZZINI E., BERTOINA I., CASTALDINI D., DALLAI D., DEL PRETE C., CHIRIAC C., GORGONI C., ILIES D.C., SALA L. and VALDATI J. (2004), *Riserva Naturale Regionale delle Salse di Nirano*: Carta Turistico-Ambientale. Comune di Fiorano-Assessorato Ambiente. Eliofofototecnica Barbieri, Parma.
- BARRETTINO D., VALLEJO M. and GALLEG0 E. (eds.) (1999), *Towards the balanced management of Geological Heritage in the New Millenium*. Sociedad Geologica de Espaa, Madrid, 146 pp.
- BERTACCHINI M., GIUSTI C., MARCHETTI M., PANIZZA M. and PELLEGRINI M. (eds.) (1999), *I Beni Geologici della Provincia di Modena*. Artioli Ed., Modena, 104 pp.
- BETTELLI G., BONAZZI U., FAZZINI P., GASPERI G., GELMINI R. and PANINI F. (1989), *Nota illustrativa alla carta geologica schematica dell'Appennino modenese e delle aree limitrofe*. Mem. Soc. Geol. It., 39, p. 487-498.
- CARTON A. and PANIZZA M. (a cura di) (1988), *Il paesaggio fisico dell'Alto Appennino emiliano*. Grafis Ed. 182 pp.
- CASTALDINI D., CAREIO F. and PULCINELLI A., (1998), *Geomorfologico delle valli del Rio delle Pozze e del Torrente Motte (Abetone, Appennino Tosco-Emiliano)*. Geogr. Fis. Dinam. Quat. 21, 177-204, Torino.
- CASTALDINI D., VALDATI J., ILIES D., C., BAROZZINI E., BATOLI L., DALLAI D., DEL PRETE C. and SALA L. (2005a), *Carta Turistico Ambientale dell'Alta Valle delle Tagliole, Parco del Frignano*. Parco del Frignano, Eliofofototecnica Barbieri, Parma
- CASTALDINI D., VALDATI J., ILIES D., C. and CHIRIAC C. .with contributions by Bertogna I. (2005b), *Geo-tourist map of the Natural Reserve of Salse di Nirano (Apennines of Modena, Northern Italy)*. Il Quaternario, Italian Journal of Quaternary Sciences 18 (1) – Volume Speciale, p. 245-255.
- EBERHARD R. (ed.) (1997), *Pattern and Process: Towards a Regional Approach to National Estate Assessment of Geodiversity*. Techn. Series no. 2, Australian Heritage Commission and Environment Forest Taskforce, Environment Australia, Canberra, 102 pp.
- FERRARI C. and PANIZZA M. (a cura di) (1992), *Oltre il limite degli alberi*. Assessorato Ambiente e difesa del suolo, Regione Emilia-Romagna, 270 pp.
- GORGONI C. (2003), *Le salse di Nirano e le altre salse emiliane - I segreti di un fenomeno tra mito e realt.* Comune di Fiorano Modenese. Tip. ABC, Sesto Fiorentino (Firenze), 128 pp.
- GRUPPO NAZIONALE GEOGRAFIA FISICA E GEOMORFOLOGIA (1995), *Carta geomorfologica del bacino del Trionto*. S.E.L.C.A., Firenze
- GUTIERREZ F., Gutierrez M., Desir G., Guerrero J., Lucha P., Marin C., and Garcia-Ruiz J.M. (ed.) (2005), *Sixth International Conference on Geomorphology*. Abstracts Volume. Zaragoza (Spain), 7-11/9/2005.
- ITALIA (2004), 32nd IGC Florence – *Scientific Sessions: abstracts (part 1)*, p. 138-139.
- PANIZZA M. (2001), *Geomorphosites: Concepts, methods and examples of geomorphological survey*. Chinese Science Bulletin, 46, 4-6.
- PANIZZA M. and PIACENTE S. (2003), *Geomorfologia culturale*. Pitagora Ed., Bologna, 350 pp.
- PANIZZA M. (2005), *Foreword*. Il Quaternario, Italian Journal of Quaternary Sciences 18 (1) – Volume Speciale, p. I.
- PAPOTTI D. (2002), *Riflessioni preliminari ad una standardizzazione della simbologia per l'esursionismo*. Bollettino dell'A.I.C., 114-115, 55-66.

PASUTO A., SOLDATI M. and SIORPAES C. (2005), *Carta Geomorfologica dell'area circostante Cortina d'Ampezzo (Dolomiti, Italia)*. Carta a scala 1:20.000, S.E.L.C.A., Firenze

PIACENTE S. and POLI G. (eds.) (2003a), *La memoria della Terra, la terra della memoria*. Università di Modena e Reggio Emilia – Regione Emilia-Romagna, Edizioni L'Inchiostroblu, Bologna, 159 pp.

PLINY THE ELDER (around 50 A.D.), *Historia Mundi Naturalis*. Book II-85. Einaudi Ed., Torino.

REYNARD E., (2004), *Geosite*. In Goudie A.S. (Ed.), *Encyclopedia of Geomorphology*. Vol. 1, p 440, Routledge, London and New York

REYNARD E., HOLZMANN C., GUEX D. and SUMMERMATTER N. (eds.) (2003), *Géomorphologie et Tourisme*. Act. Réunion Annuelle Soc. Suisse de Géomorphologie, 21-23/9/2003, Finhaut (Suisse), 216 pp.

STOPPANI A., (1873), *Il Bel Paese*. Milano, 651 pp.

WIMBLEDON W.A.P., BENTON M.J., BEVINS R.E., BLACK G.P., CLEAL C.J., COOPER R.G. and MAY V.J. (1995), *The developement of a British methodology for selection of geological sites for conservation*. Part 1, *Modern Geology*, 20, 159-210.

¹Dipartimento di Scienze della Terra, Università di Modena e Reggio Emilia, Largo S. Eufemia 19, Modena, Italy. Corresponding author: castaldini.doriano@unimore.it

²Dipartimento di Scienze della Terra, Università di Modena e Reggio Emilia, Largo S. Eufemia 19, Modena, Italy and CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior), Brasília, Brazil. valdati.jairo @unimore.it

³Department of Geography, Tourism and Territorial Planning, University of Oradea, Universităţii 1, Oradea, Romania. ilies@uoradea.ro

Climatic features of the Muscel Valley (Buzău Subcarpathians, Romania) as from the registered data during 1961–2003

Federica BIAGIONI, Franco RAPETTI

Keywords: Buzău Subcarpathians, extreme rainfall events, Thornthwaite, types of climate.

Riassunto. L'area di studio è un bacino di circa 20 km², localizzato nella Curvatura dei Subcarpazi rumeni, fortemente interessata da erosione e movimenti di massa sia per le sue caratteristiche geologiche che climatiche: queste ultime in particolare sono l'oggetto del presente studio che ha come scopo principale quello di caratterizzare il clima della valle del Muscel ma anche quello di fornire dati utili a future ricerche volte a stabilire le relazioni tra la franosità e le condizioni climatiche. Gli elementi utilizzati per questo studio sono le temperature giornaliere dell'aria, le precipitazioni mensili e gli eventi pluviometrici estremi. La serie copre il periodo 1961-2003 ed è stata registrata alla stazione termopluviometrica di Pătârlagele (45°20'N), situata nel tratto finale del torrente Muscel e gestita dall'Istituto di Geografia dell'Accademia Rumena.

Per il periodo analizzato il valore medio annuo delle temperature è stato di 10.4 °C, con un campo di variazione tra 8.9 °C (1976) e 11.7 °C (1989–1994); la tendenza interannuale è generalmente positiva, specialmente a partire dagli anni '70. Le temperature invernali sono state analizzate attraverso il conteggio dei giorni con gelo (numero di giorni con $T_{\min} \geq 0^{\circ}\text{C}$), giorni di gelo (numero di giorni con $T_{\max} \geq 0^{\circ}\text{C}$) e le temperature minime assolute di ciascun anno. Le temperature estive invece sono state analizzate attraverso il conteggio del numero di giorni tropicali (numero di giorni con $T_{\max} \geq 30^{\circ}\text{C}$), il numero di giorni con $T_{\max} \geq 35^{\circ}\text{C}$ e le temperature massime assolute di ciascun anno della serie.

Anche per quanto riguarda le precipitazioni sono stati calcolati i valori medi, in particolare la media del periodo è risultata pari a 630.1 mm, con un campo di variazione oscillante tra 389.0 mm (2000) e 857.2 mm (1969). Il regime generale delle piogge presenta un massimo principale in estate (40%), stagione caratterizzata da frequenti e intensi temporali che talvolta rappresentano veri e propri eventi estremi: un esempio è rappresentato dall'evento del 2 Luglio 1975, giorno in cui cadde il 25.5% del totale delle piogge di quell'anno. L'andamento pluviometrico interannuale mostra una tendenza negativa che diventa più evidente a partire dagli anni '90.

Infine, sulla base dei parametri ricavati dallo sviluppo del bilancio idrico-climatico, calcolato con il metodo di Thornthwaite, è stato possibile studiare il ciclo dell'acqua nel suolo e definire il tipo climatico medio ($C_1 B'_1 d b'_3$), quello dell'anno più arido ($D B'_1 d b'_3$) e quello dell'anno più umido ($B_1 B'_1 r b'_3$).

Introduction

The overall climate of Romania is temperate continental of transition bearing different regional features such as: mountain conditions over the high relief brought by the cold air masses from the sarmatic region or steppe features in the plains. The general climate is determined by many factors, the most important being its geographical settings. In fact, because it extends over 5 degrees of latitude, Romania registers a 3°C thermic difference between its northern and southern regions.

The Carpathians also play an important role in the climatic zonation separating the north-western area, characterized by an oceanic influence, from the eastern one, where continental features are more evident. Another important factor is the Black Sea, which exerts a thermic regulation effect over the south-east of the Country where the Buzău Subcarpathians are located. Here, fairly mild Winters and cool Summers are typical, moreover, the climate of this region is dominated

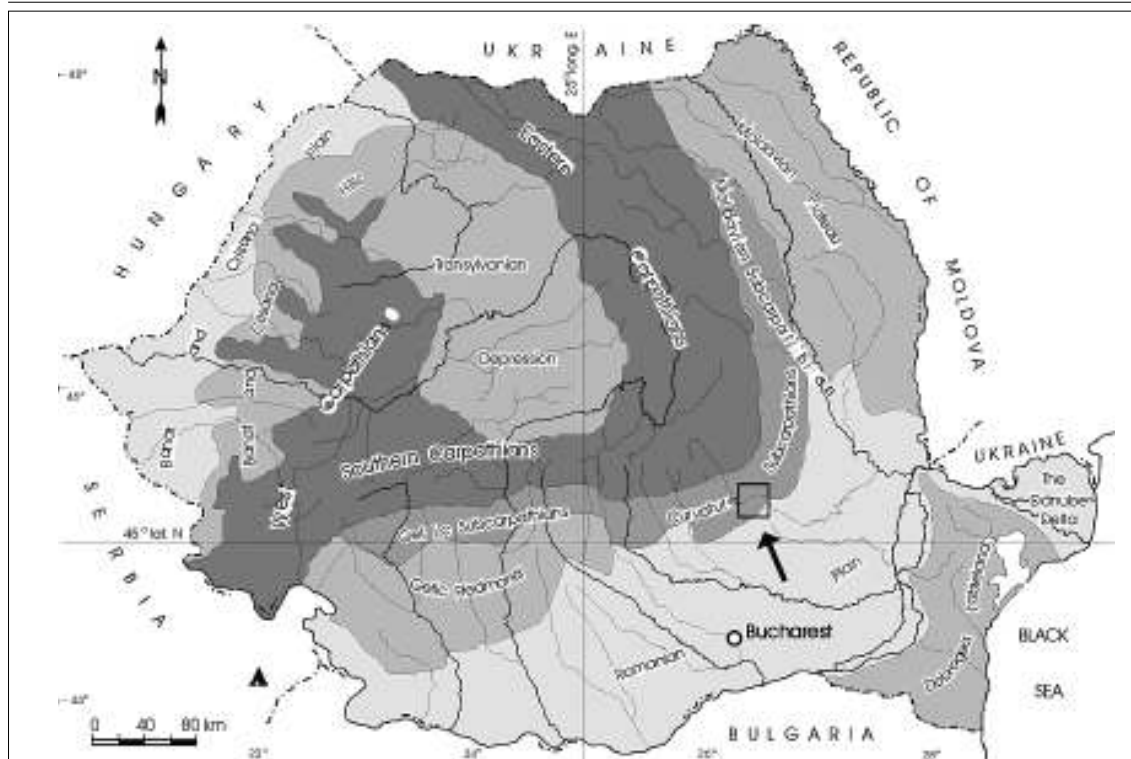


Fig. 1. Geographic sketch of Romania with physiographic units (grey areas). Location of the study area is indicated.

by air masses coming from north/north-east during Winter, when the Siberian anticyclone arrives in Transylvania, while in Summer western masses prevail (Bogdan *et al.*, 1980; Bogdan, Mihai, 1977; Neamu, 1980).

The Buzău Subcarpathians have been studied by various authors, all underlining the intensity and variety of the present-day slope processes classifying almost 85% of the slopes as unstable (Bălțeanu, 1971, 1983, 1994; Bălțeanu, Dinu, Cioacă, 1996; Dinu, Cioacă, 1998). Among the major factors that generate or facilitate the development of mass movements and erosion processes, authors indicate the less erosion-resistant lithology, the neotectonic movements (0,5-1 mm/y), the strong earthquakes that affect the entire Vrancea region, and the intensity of rainfall. Starting from these researches, the present paper, a climatic study of a small catchment located in this area (Muscel valley) (Fig. 1), could represent a contribution for future studies focused on the relationship between climate and mass movements in this region.

The hydrographic basin of the Muscel river, tributary on the right of the Buzău, covers an area of about 19.70 sq km. Its borders are given by a range of hills, among which Vârful Pătârlagele (908.7 m), Piatra Scrisa (754.3 m) and Vârful Catnei (790.9 m) are the highest. As far as their geology is concerned Oligocene flysch formations (Kliwa sandstone) mount to almost 33% of the basin's surface, while the rest mostly consists of highly folded and faulted Miocene and Pliocene marls, clays, sandstone and sand (Bălțeanu, 1983).

The data analysed in this research were recorded by the thermopluviometric station located in the final sector of the Muscel river (Pătârlagele) over the period 1961–2003. It consists the daily recorded maximum and minimum temperatures, monthly precipitation and extreme rainfall events. The August temperatures for 1961 are missing so we considered them to be equivalent to the average of the following August months. According to WMO current climate is defined by the mean the meteorological features monitored

	J	F	M	A	M	J	J	A	S	O	N	D	Year	Range
Max	4.0	5.7	10.4	16.5	22.0	25.1	27.0	26.7	22.6	17.1	10.6	5.2	16.1	23.0
Min	-5.1	-4.0	-0.7	4.5	9.2	12.6	14.2	13.6	9.8	4.7	0.5	-3.5	4.6	19.3
Mean	-0.5	0.9	4.9	10.5	15.6	18.9	20.6	20.2	16.2	10.9	5.6	0.9	10.4	21.1

Tab. 1. Mean monthly temperatures and yearly range (°C)

	Winter						
	T _{min}	T _{max}	T _{mean}	Days T _{min} = 0°C	Max.n°cons frost days	Days T _{max} = 0°C	Absolute T _{min}
Min	-8.8	0.7	-3.3	81	14	3	-25.5
Date	1985	1963	1963	1966	1990/99	1989	1963
Max	-1.0	8.3	3.3	136	76	46	-11.4
Date	1966	1989	1966	2003	1985	1985	1970
Mean	-4.2	5.0	0.4	113.1	29.2	18.0	-

Tab. 2. Range of mean Winter temperatures, days with T_{min} = 0°C, days with T_{max} = 0°C, maximum number of consecutive frost days and absolute minimum temperatures

in a given location for the past 30 years (normal values). The choice of this conventional time length results as a compromise of the necessity of considering a sufficiently long period in which the climatic conditions are defined and stable, keeping in mind at the same time the variations of the climatic features given by an excessively long interval (Rosini, 1988).

The study series record 43 years. This is not much longer than the conventional period therefore we consider it representative for studying the climate of the area.

In the present work, the results of air temperature, precipitations and extreme rainfall events analysis are presented. Moreover, the Thornthwaite's method was used to obtain the water balance and the climatic classification of the studied area.

Air temperatures

The air temperature study is based on the analysis of the data recorded at Pătârlagele station between 1961 and 2003. Besides daily temperatures, the mean monthly, seasonal and annual temperatures were calculated and analysed. The region has a mean annual temperature of 10.4 °C. The coldest month is January, with a mean temperature of -0.5 °C; this value is below 0.0 for most of the studied years. The warmest month is July, with a mean temperature of 20.6 °C. The annual thermic

range is 21.1 °C varying from 23.0 °C, where we consider the mean of maximum temperatures, to about 19 °C if we consider the mean of minimum temperatures. (Tab. 1).

The mean temperature amplitude is 2.8 °C, representing the difference between the mean temperature of the coldest year (1976 with 8.8 °C) and that of the warmest years (1989–1994 with 11.7 °C).

Winter temperatures. After the analysing the maximum, minimum and mean temperatures of the Winter months, the features of this season were examined concerning some parameters normally used in climatology, such as frost days (number of days with T_{min} = 0 °C), maximum number of consecutive frosty days, number of days with T_{max} = 0 °C and the absolute minimum temperatures. (Pinna, 1977) (Tab. 2).

The mean Winter temperature is 0.4 °C and ranges from -3.3 °C (1963) to 3.3 °C (1966), the mean value of minimum and maximum temperatures are -4.2 °C and 5.0 °C respectively. The number of days with T_{min} = 0 °C, which are on average 133.1 per year, varies from 81 (1966) to 136 (2003), while the number of days with T_{max} = 0 °C ranges between 3 (1989) and 46 (1985).

1963 and 1985 registered the coldest Winters: these years recorded the absolute minimum temperatures of the study period, -25.5 °C (January, 23, 1963) and -24.6 °C (January, 17,

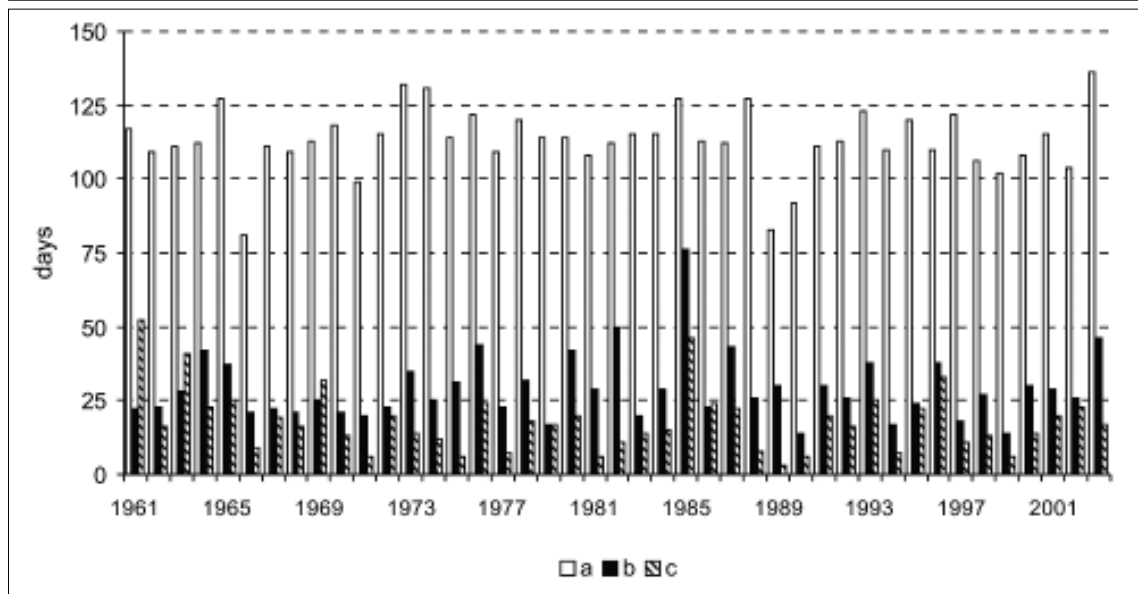


Fig. 2. Interannual trend of number of days with $T_{\min} = 0^{\circ}\text{C}$ (a), consecutive days with $T_{\min} = 0^{\circ}\text{C}$ (b) and days with $T_{\max} = 0^{\circ}\text{C}$ (c) recorded at Patârlagele (1961–2003).

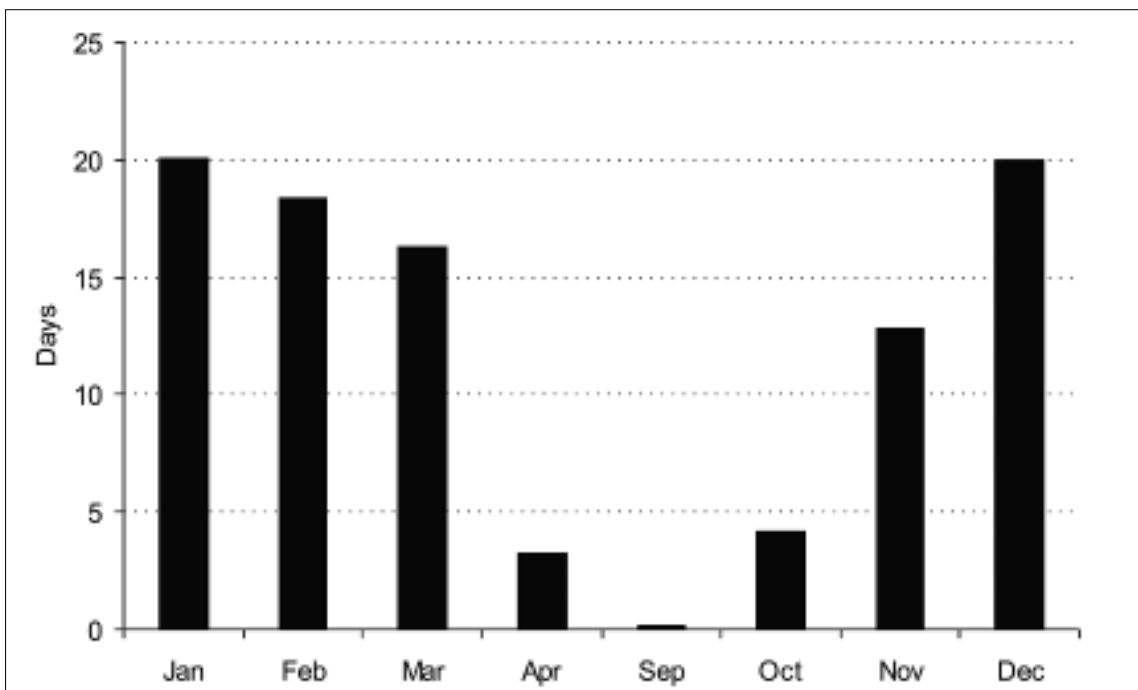


Fig. 3. Monthly trend of the number of days with freeze-thaw cycle at Patârlagele (1961–2003).

1985). Moreover, 1985 had the maximum number of consecutive frost days (76) and the maximum number of days with $T_{\max} = 0^{\circ}\text{C}$ (46). The frost days and the days with $T_{\max} = 0^{\circ}\text{C}$ do not show a significant variation along the study period, except for the particularly cold years already mentioned (Fig. 2).

Winter months are also characterised by a

lot of freeze-thaw cycles, about 65% of their days per year. Moreover each day is likely characterised by different freeze-thaw cycles, not evaluated because the data set consists only of daily values. For this reason it is not possible to better analyse this parameter in spite of its importance in triggering slope instability (Fig. 3).

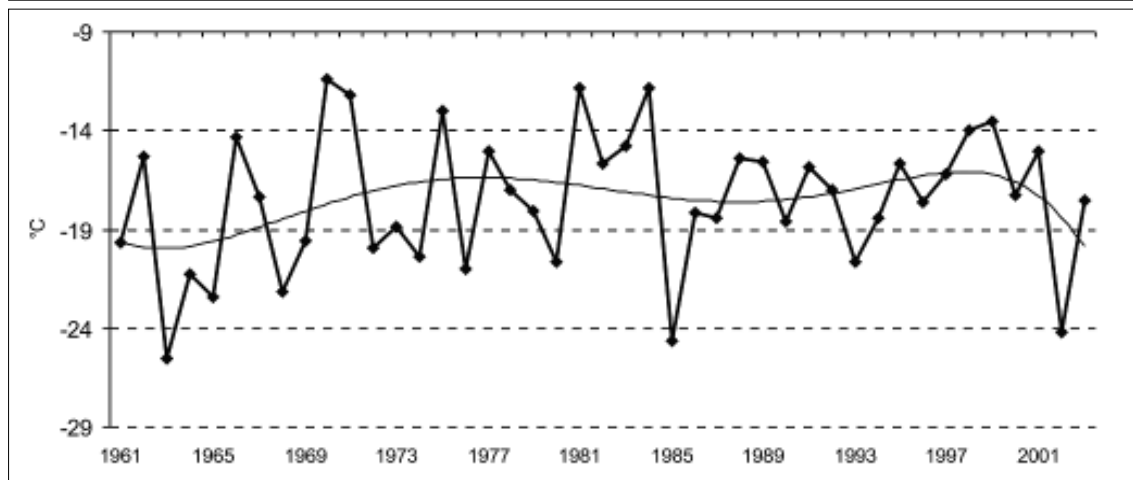


Fig. 4. Interannual trend of the absolute minimum temperatures at Patârlagele (1961–2003).

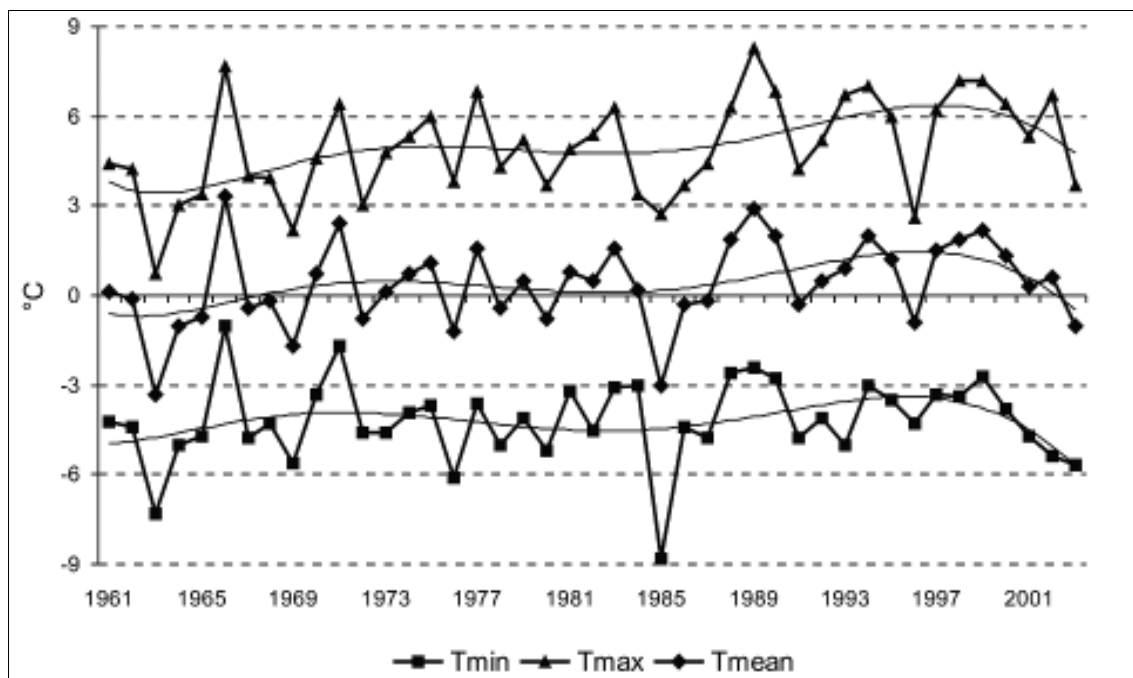


Fig. 5. Interannual trend of minimum, maximum and mean winter temperatures at Patârlagele (1961–2003).

In contrast with the parameters analysed above, the absolute minimum temperature shows a positive trend. This behaviour is more evident if we consider that the absolute minimum temperature exceeded -19°C ten times in the period 1961–2003 and 23 times in the last two decades (Fig. 4).

Also the mean minimums and maximums present a similar trend, but to a slightly lesser extent, with two negative oscillations: the first in the period 1975–1985 while the second started at the beginning of the new century (Fig. 5).

Summer temperatures. Besides the analysis of mean, maximum and minimum temperatures, the climatic features of the Summer months were examined concerning the number of tropical days ($T_{\text{max}} < 30^{\circ}\text{C}$), maximum number of consecutive tropical days, number of days with $T_{\text{max}} = 35^{\circ}\text{C}$, and the absolute maximum temperatures (Tab. 3).

The mean Summer temperature is 19.9°C and ranges from 17.6°C (1976) to 21.3°C (1999), the mean values of the minimum and maximum temperatures are 13.5°C and 26.3°C

			Summer				
	Tmin	Tmax	Tmean	Tropical days	Max.n°cons. tropical. days	Days Tmax = 35°	Tmax asso- luta
Min	11.2	23.9	17.6	1	1	0	30.4
Date	1976	1984	1976	1978	1978	vari	1978
Max	15.1	28.3	21.3	40	12	8	39.0
Date	1999	1987/2000	1999	2000	1987	1987	1987
Mean	13.5	26.3	19.9	16.5	4.9	0.7	-

Tab. 3. Range of mean Summer temperatures, number of tropical days, maximum number of consecutive tropical days, number of days with $T_{\max} = 35^{\circ}\text{C}$ and absolute maximum temperatures

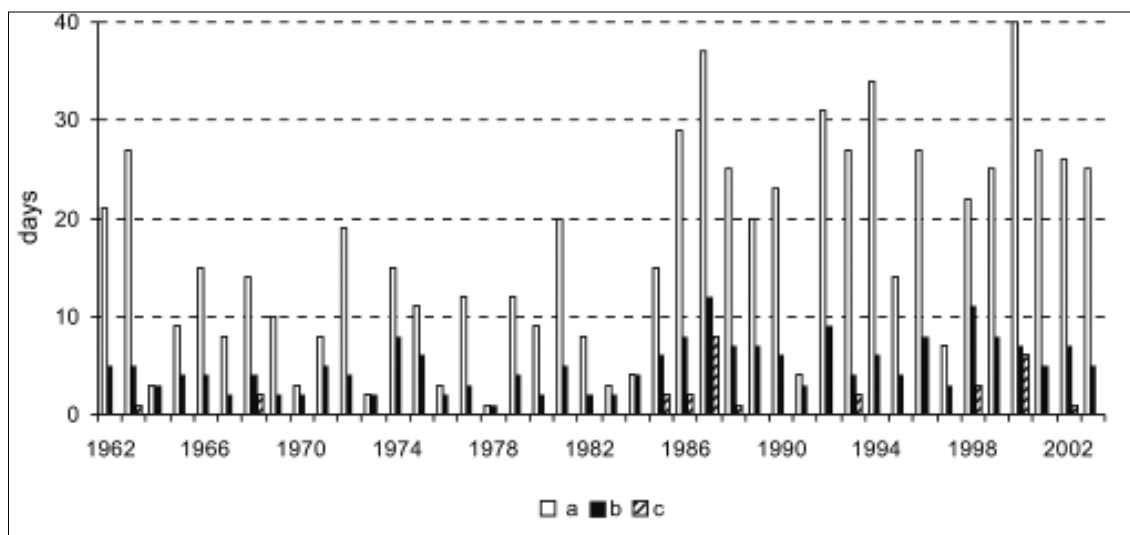


Fig. 6. Interannual trend of number of tropical days (a), maximum number of consecutive tropical days (b), number of days with $T_{\max} = 35^{\circ}\text{C}$ (c) at Patàrlagele (1961–2003).

respectively. The number of tropical days, with a mean value of 16.5 days per year, varies between 1 (1978) and 40 (2000). Less frequent are the days with $T_{\max} = 35^{\circ}\text{C}$ in fact this value is reached only in about a quarter of the analysed years. The Summer of 1976 is the coolest of the series, this only once the mean summer temperature lowered below 18°C . Also the summer of 1978 was very cool, the temperature of only one day exceeded 30°C .

The trend of the summer parameters that we analysed underlines a general increase in temperatures over the last few decades (Fig. 6).

The trend of the number of tropical days shows a remarkable increase since the second half of the 1980s. In fact in the period 1961–1980 the temperature exceeded 30°C for 210 times, while between 1981 and 2003 this

threshold was exceeded 493 times, 247 of which in the last 7 years. Also the trend of days with $T_{\max} = 35^{\circ}\text{C}$ shows a similar pattern but it is less marked. The values exceeding 35°C were recorded for 3 times during the period 1961–1980 and 25 times in the period 1981–2003. Also the absolute maximum temperatures show the same trend (Fig. 7).

Comparing the general trend of the interannual Summer mean temperatures shows an increase that is more evident for the maximum temperatures than for the minimum ones (Fig. 8).

In conclusion, the air temperature analysis highlights a general positive trend, interrupted by a first oscillation during the 70s and another one that started at the beginning of the 21st century, following a period charac-

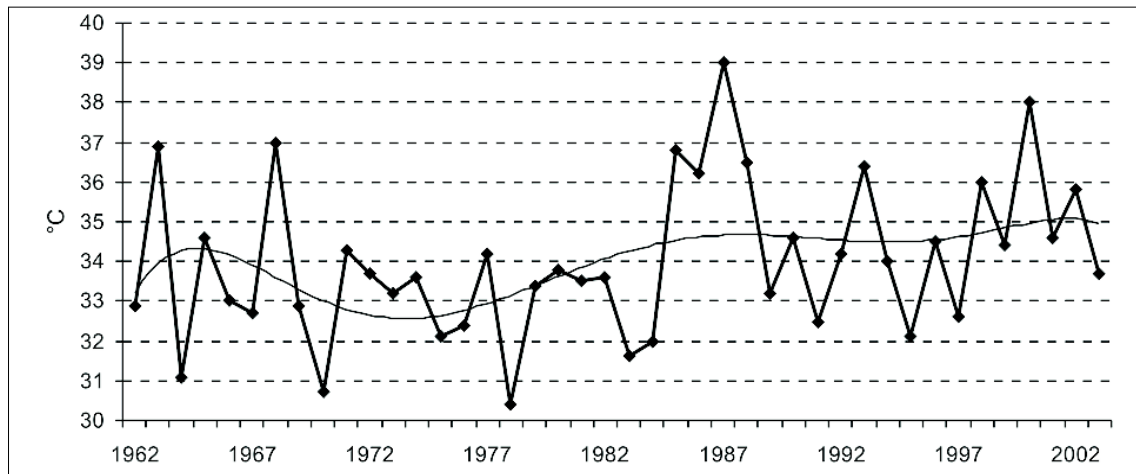


Fig. 7. Interannual trend of the absolute maximum temperatures at Patârlagele (1961–2003).

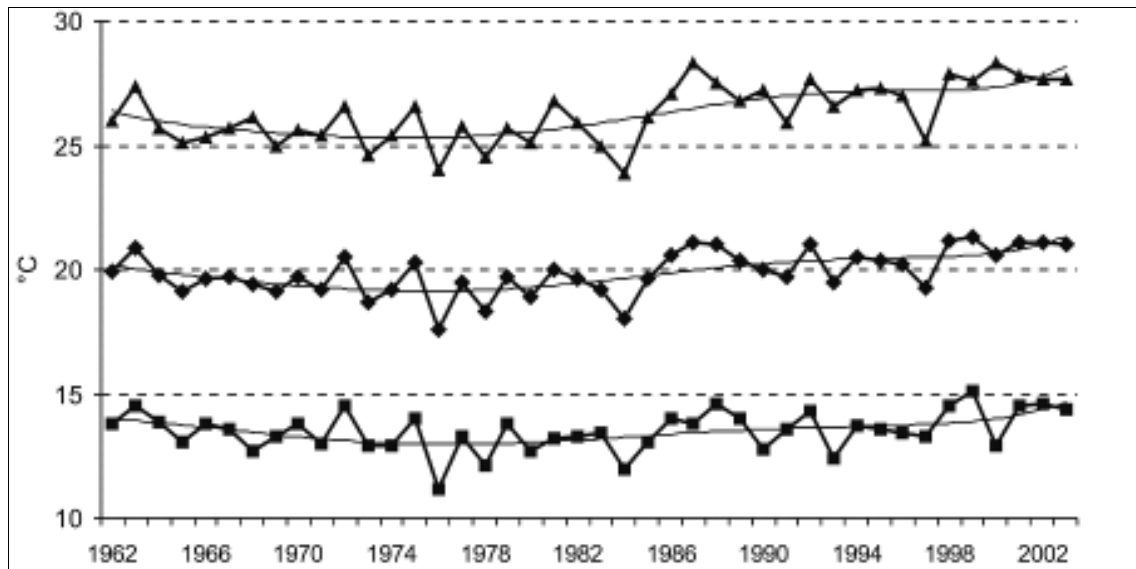


Fig. 8. Interannual trend of maximum, minimum and mean Summer temperatures at Patârlagele (1961–2003).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Min	1.7	1.3	2.6	6.3	10.8	35.4	9.2	0.1	4.8	0.8	0.5	0.5	389.0
Date	1989	1967	2002	1968	1982	1981	1977	1962	1983	2000	1990	1975	2000
Max	108.3	94.4	97.5	101.4	208.2	188.1	282.5	180.4	129.5	131.0	167.8	182.3	857.2
Date	1965	1969	1962	1997	1988	1969	1975	1972	2001	1972	1966	1969	1969
Mean	30.0	29.2	29.0	43.3	80.6	93.2	91.4	70.0	45.9	38.8	40.9	37.8	630.1

Tab. 4. Mean monthly and yearly rainfall at Patârlagele (1961–2003).

terised by a fast and constant increase in temperatures.(Fig. 9)

Rainfall

The data set available consisted of monthly values of precipitation and extreme pluviometric events for each year (Tab. 4).

The mean annual rainfall is 630.1 mm, ranging from 389.0 (2000) to 857.2 (1969). The rainiest month is June, followed by July and May, while March is the poorest in the least precipitations (Fig. 10).

The general rainfall regime has a main maximum during Summer (40%) followed by Spring (24%). During the study period, six

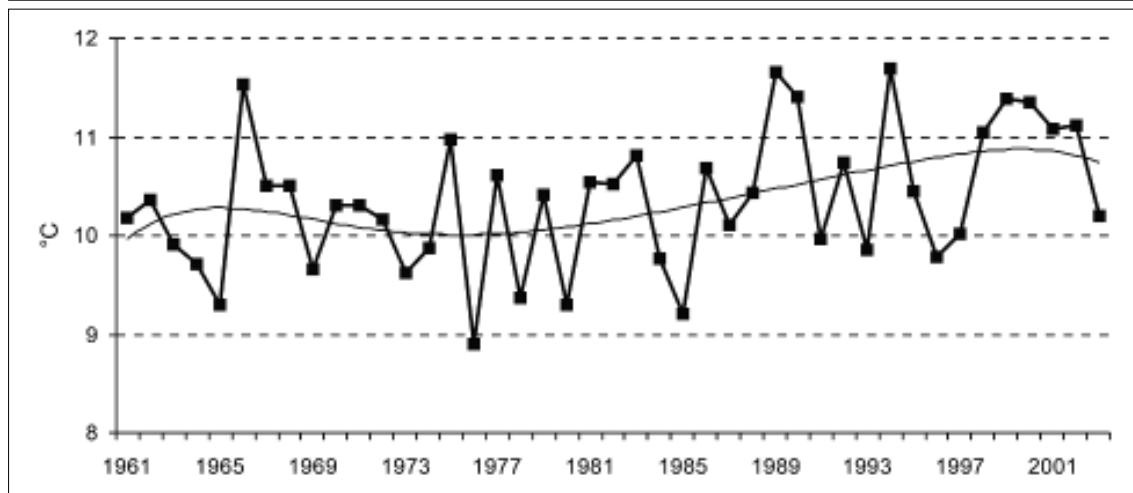


Fig. 9. Interannual trend of annual mean temperatures at Patârlagele (1961–2003).

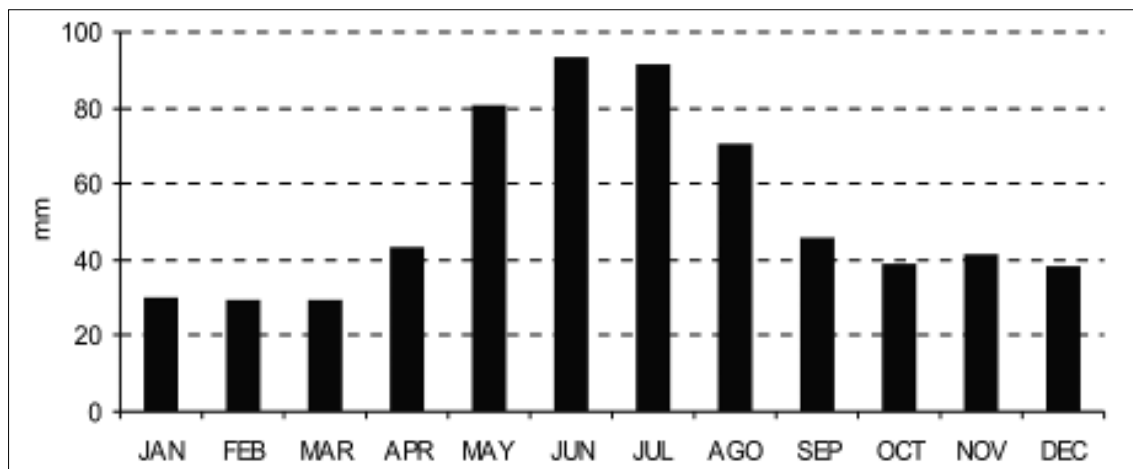


Fig. 10. Monthly rainfall regime at Patârlagele (1961–2003).

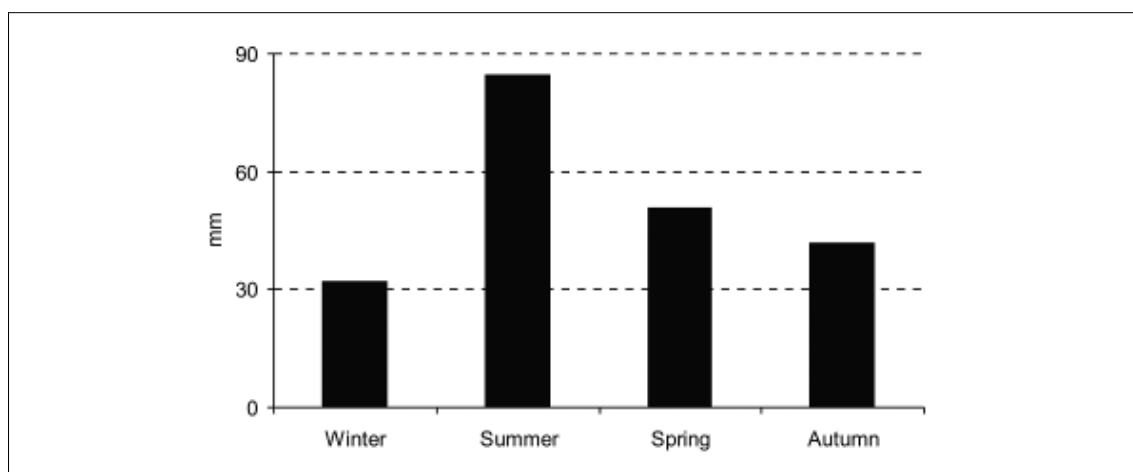


Fig. 11. Seasonal rainfall regime at Patârlagele (1961–2003).

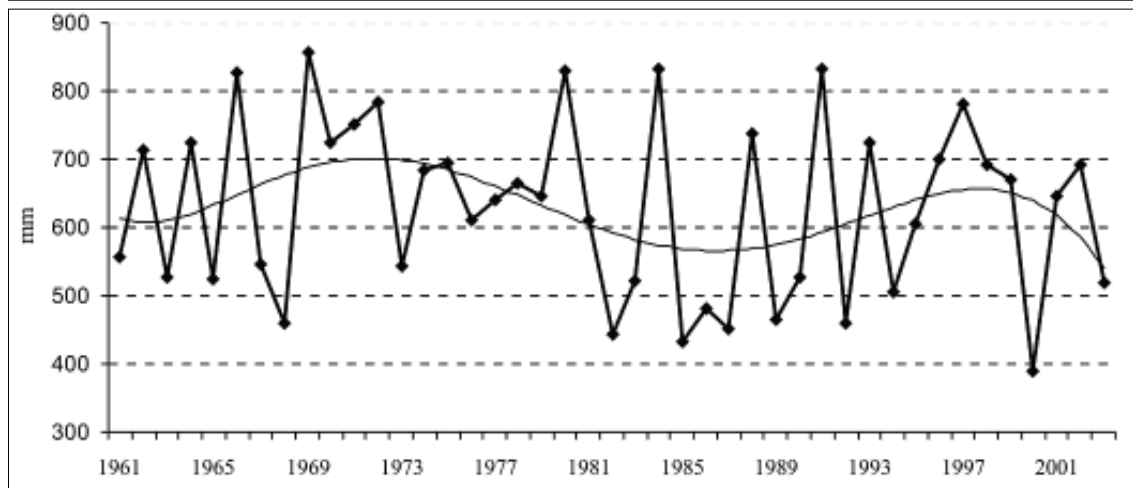


Fig. 12. Interannual trend of rainfall (mm) at Patârlagele (1961–2003).

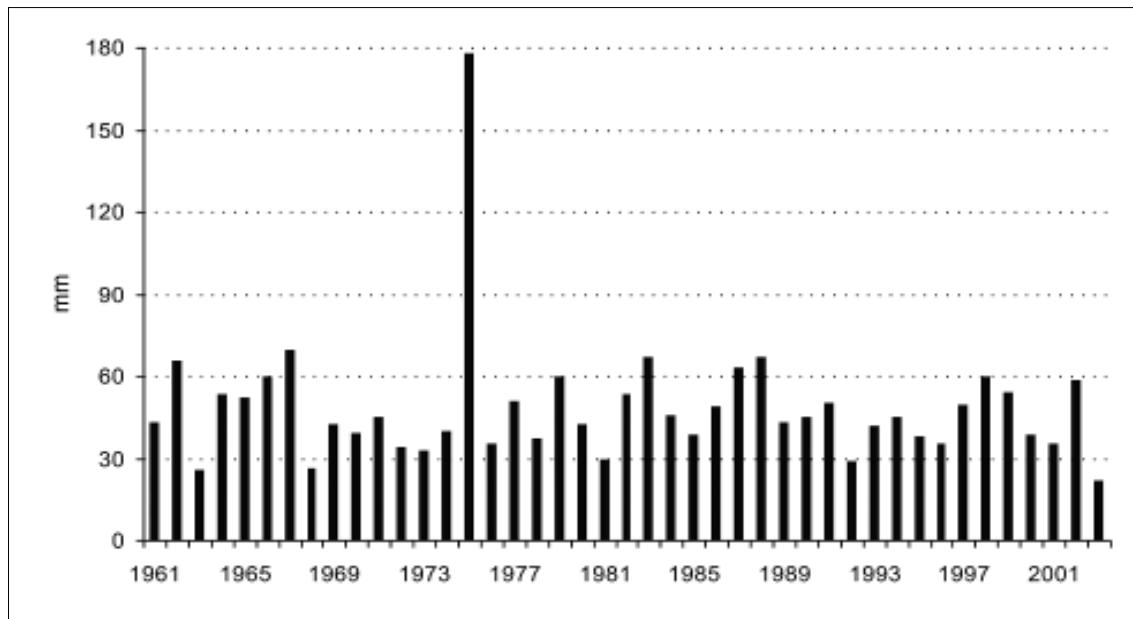


Fig. 13. Maximum daily rainfall at Patârlagele (1961–2003).

years had summer rainfalls of more than 50% of the total rainfall of the year while in 1983 this value surpassed 75% (Fig. 11).

The interannual precipitation variability is 2.2, this parameter expresses the ratio between the amount of rainfall in the most humid and most arid year.

The interannual trend of rainfall shows a general negative trend characterised by wide fluctuations. The amount of precipitation shows increases between 1965 and 1975 and again in the first half of the 1990s. It is important to underline that also during the period characterised by a negative trend we can have

very rainy years such as 1984, 1988 and 1991 (Fig. 12).

Extreme rainfall events. During Summer the study area experiences torrential rainfalls, which have a great impact on the slopes triggering mass movements and causing floods. The maximum daily rainfall for each year of the study period ranges generally between 30 and 70 mm. These low values underline the exceptional nature of the event that occurred on July, 2nd, 1975 when 177.8 mm of rain fell in 24 hours. This value corresponds to 25.5% of the total amount of rain that fell in 1975 (Fig. 13).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Min. min	0.0	0.0	0.2	33.7	76.6	98.5	114.3	100.0	62.0	31.5	0.0	0.0	621.9
Date	Sever.	Sever.	1987	1997	1991	1966	1979	1976	1996	1979	1993	Sever.	1976
Max	8.3	18.8	39.8	68.4	114.3	129.9	154.8	140.5	101.0	60.2	30.9	9.5	710.9
Date	1983	1966	1990	1961	2003	1964	1987	1992	1994	1966	1969	1985	1994
Mean	1.7	4.2	18.3	50.3	91.7	116.2	131.2	118.1	77.8	43.7	16.7	2.9	672.8

Tab. 5. Monthly and annual EP and its range.

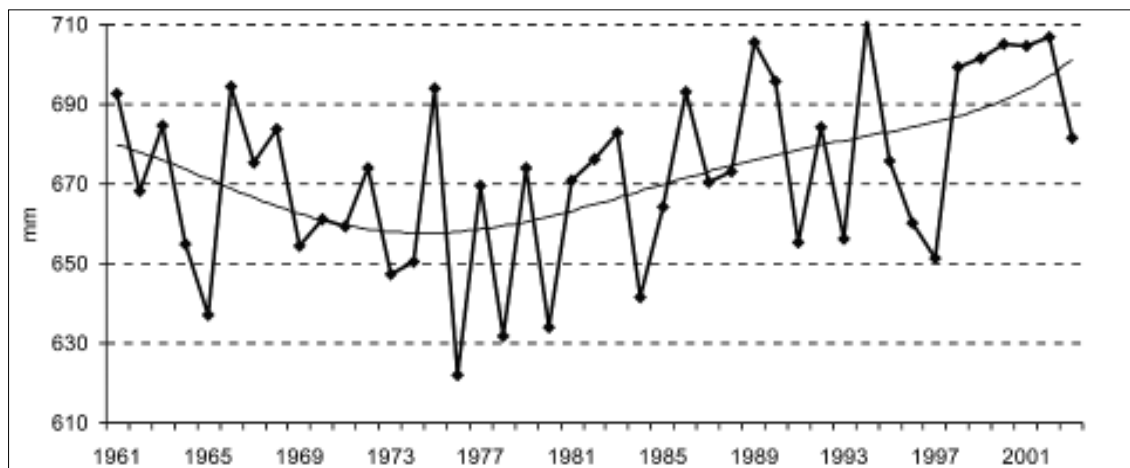


Fig. 14. Interannual trend of EP at Patàrlagele (1961–2003).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Min. min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Date	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.
Max	90.7	91.8	83.1	39.1	119.4	46.7	84.8	0.0	14.6	98.1	59.7	89.1	225.4
Date	1966	1984	1962	1962	1988	1991	1975	Sever.	1972	1972	1966	1969	1984
Mean	7.7	8.9	14.1	5.1	14.1	3.6	3.0	0.0	0.3	2.3	1.6	7.2	67.8

Tab. 6. Mean monthly and annual Surplus and its range.

Water balance and climatic classification according to Thornthwaite

In order to calculate the climatic classification and the water balance for the study area, we chose Thornthwaite's method due to its capacity of representing the water needs of the vegetation, and in order to assess soil susceptibility to erosional processes (Thornthwaite, 1948; Thornthwaite, Mather 1957). Thornthwaite's method is based on the concept of Potential Evapotranspiration (EP), defined as the amount of water that would be evaporated under an optimal set of conditions, such as an unlimited supply of water (Tab. 5).

The mean annual value of EP is 672.8 mm and varies from 621.9 mm (1976) to 710.9 mm

(1994). The mean value of CEET (the ratio summer/ annual EP), is 54.3% but some years it exceeds 58% (1987–1988). The interannual trend of EP shows a decrease starting at the beginning of the 1970s with the lowest values recorded in 1976, 1978 and 1980. In contrast, in the last two decades there has been a weak but uniform increase (Fig. 14).

Adopting Thornthwaite's method, knowing the values of EP and rainfall, it is possible to calculate other parameters such as Deficit (D) and Surplus (S) (Tab. 6).

The annual average of Surplus is 67.8 mm ranging from 0.0, a value recorded in many years, to 225.4 mm (1984). During August and September the Surplus remains close to 0.0, while it reaches the highest values in March and May.

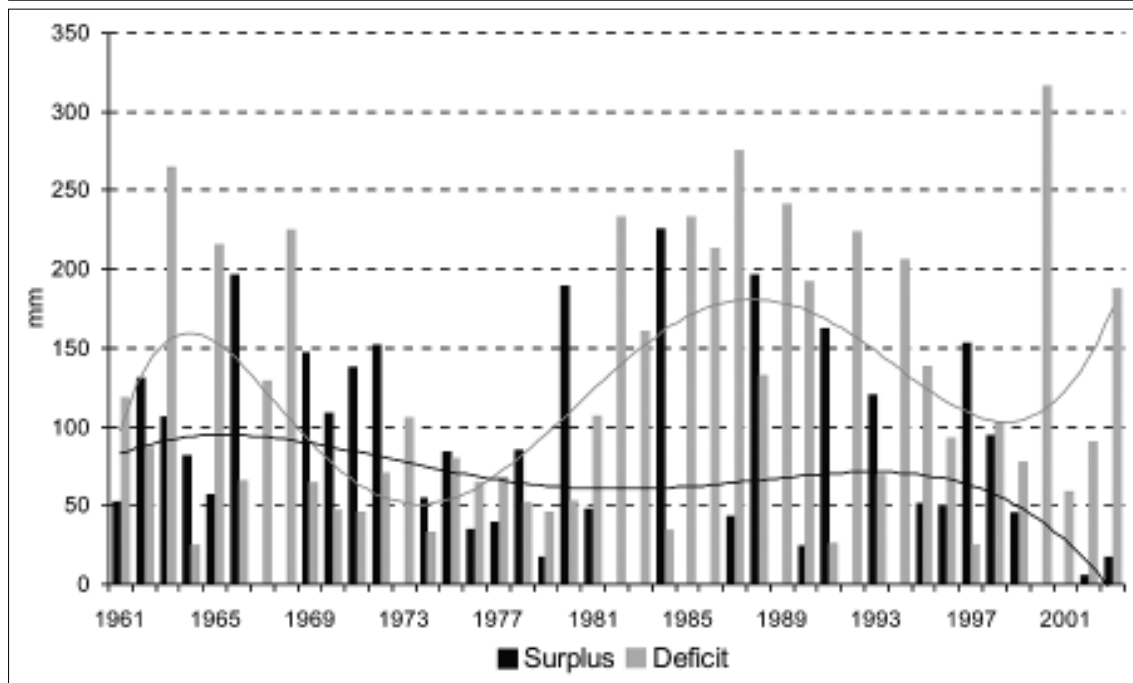


Fig. 15. Interannual trend of Surplus and Deficit at Patârlagele (1961–2003).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Min. min	0.0	0.0	0.00 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.3
Date	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	Sever.	1964
Max	4.1	0.5	10.3	36.8	56.7	61.6	90.6	92.2	67.5	37.8	8.5	2.2	315.9
Date	1983	1995	1989	1983	1982	1968	1987	2000	1987	2000	1990	1971	2000
Mean	0.2	0.0	1.2	4.6	11.3	12.8	25.0	31.4	24.4	10.4	1.6	0.1	122.9

Tab. 7. Mean monthly and annual Deficit and its range.

	J	F	M	A	M	J	J	A	S	O	N	D
Min	27.4	51.9	46.9	37.5	11.7	20.3	13.1	6.8	6.5	5.0	4.7	7.6
Date	1989	1989	1989	1976	2000	2000	2000	2000	2000	2000	2000	2000
Max	209.3	269.4	150.0	150.0	150.0	150.0	150.0	143.7	150.0	150.0	150.0	218.5
Date	1996	1969	Sever.	Sever.	Sever.	Sever.	Sever.	1997	1972	1972	1964	2002
Mean	125.7	142.2	129.3	121.9	105.7	94.3	76.5	59.7	51.8	57.8	76.7	106.8

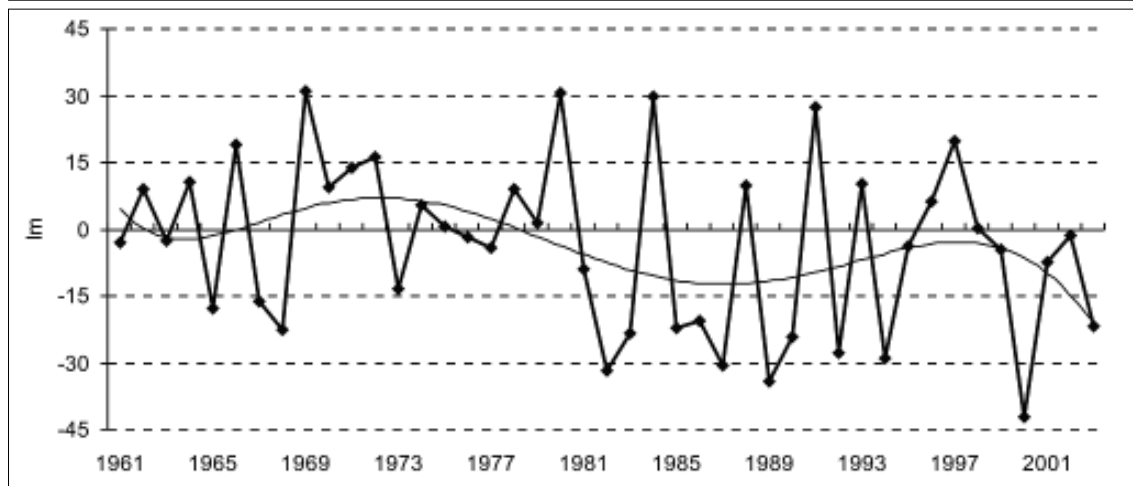
Tab. 8. Mean monthly and annual soil moisture budget and its range.

The Deficit, which supplies an estimation of the duration and intensity of the arid period, presents a mean annual value of 122.9 mm and varies from 24.3 mm (1964) to 315.9 mm (2000) (Tab. 7).

The interannual trend of Surplus is negative and this tendency became particularly obvious in the last year of the series, while the general trend of Deficit shows wide oscillations (Fig. 15).

Soil moisture budget. The amount of water held in the soil depends on the rainfall and EP, while the amount of water that the

soil can hold depends on the characteristics of the ground, such as texture and quantity of organic substances contained. This parameter is known as field capacity and its value is 150 mm in the Muscel valley. During an average year the field capacity is never reached while during the study period this value is reached and even exceeded in almost all the months (Tab. 8). When the soil is saturated the Surplus becomes an underground, hypodermic and superficial flow.

Fig. 16. Interannual trend of I_m at Pâtârlagele (1961–2003)

	EP	S	D	CEET	I_m
Min. values	621.9	0.0	24.3	50.7%	-42.0
Date	1976	Several	1964	1966	2000
Max. values	710.9	225.4	315.9	58.4%	31.0
Date	1994	1984	2000	1987	1969
Mean values	672.8	67.8	122.9	54.3%	-3.6

Tab. 9. Summary of water balance parameters.

	Years	Climatic formula	Description
Most arid year	2000	D B'1 d b'3	Semiarid, first mesothermic, no water excess, CEET 53.2% quasi
Most humid year	1969	B1 B'1 r b'3	Humid, first mesothermic, small deficit, CEET 53.5%
Average year	1961-2003	C1 B'1 d b'3	Subarid, first mesothermic, small excess of water, CEET 54.3%

Tab. 10. Summary of climatic formulas.

Climatic formula. Some important indices can be calculated combining EP, S and D. In particular the relation $I_m = (S - D) / EP$ results into the index of global moisture (I_m), which is the most important index in the climatic classification suggested by Thornthwaite (Fig. 16).

The mean value of I_m for the study period is -3.6 and this corresponds to the subarid type C_1 . The minimum value recorded in this period was -4.2 (2000) and corresponds to type D (semiarid), while the maximum is 31 and represents the humid type (B_1) (Tab. 9).

Using the analysed values it is possible to obtain a climatic formula composed of four letters. The first indicates the I_m , the second represents the EP, the third is the Index of aridity or humidity and the last is the value of

CEET. This formula indicates the climatic features of the study area, taking into consideration latitude, temperatures, precipitation and soil field capacity (Tab. 10)

Conclusions

The analysis of the thermopluviometric data recorded at Pâtârlagele station in the period 1961–2003 enables us to define the general climatic characteristics of the study area and, at the same time, to identify the rainiest period and the extreme rainfall events.

The mean yearly temperature is 10.4 °C ranging from 8.9 °C (1976) to 11.7 °C (1989–1994). The general trend shows an increase since the end of the 1970s, consisting in greater increase of Summer temperature as

compared to those of Winters; the pattern is quite regular even if sometimes it is interrupted by some cold years. In particular since 2000, a rapid decrease of temperatures has occurred which is much more evident in 2003, when it was very hot in many European countries. This anomalous heat wave did not affect Romania probably because the Azores Anticyclone, responsible for this event together with the North-African anticyclone, only slightly influences this area.

Regarding rainfall, the mean yearly precipitation is 630.1 mm, ranging from 389 mm (2000) to 857.2 mm (1969), with the main

maximum in Summer. This season is affected by extreme rainfall events, the most well-known is that of July 2nd 1975, which caused widespread floods and many mass movements in the valley. The general trend is negative, especially in the few last years.

The climate of the Muscel valley is classified as subarid, first mesothermic, characterised by a small excess of water and with a CEET of 54.3%. In the last years a tendency to dryness has been recorded due to the increase in temperatures and decrease in rainfall, giving semiarid features to the climate.

BIBLIOGRAPHY

- BĂLTEANU, D. (1971), *Observații preliminare asupra proceselor de modelare actuala a versanților în perimetrul stațiunii de cercetare geografice Patîrlagele*. In *Geografia Județului Buzău și a împrejurimilor* (Zavoianu ed.), București, pp. 7–14.
- BĂLTEANU, D. (1983), *Experimentul de teren în geomorfologie. Aplicații la Subcarpații Buzăului*. Ed. Academia Română, pp. 153.
- BĂLTEANU, D. (1994), *Geomorphological hazard in the Romanian Subcarpathians*, Edit. Academia Română, pp. 17.
- BĂLTEANU, D., DINU, M., CIOACĂ, A. (1996), *Some case studied of geomorphological risk in the Curvature Carpathians and Subcarpathians*, Rev. Roum. de Geogr., 40, pp. 51–59.
- BOGDAN, O. et al. (1980), *Frecvența inversiunilor de temperatură pe valea Buzăului*, In *Geografia Județului Buzău și a împrejurimilor* (Zavoianu ed.). București, pp. 76–94.
- BOGDAN, O., MIHAI, E. (1977), *Ritmicitate fenomenului îngheț-dezgheț în Subcarpații Buzăului*, St. Cercet. Geofiz. Geogr. Seria Geogr., 24(1), pp.20–32.
- DINU, M., CIOACĂ, A. (1998), *Some considerations on the evolution of Subcarpathians slopes*, An. Univ. Oradea Seria Geog. Geomor., 8, pp.145–152.
- GRECU, Florina (2004), *Quantification of some elements of drainage basins in Romania*, Geog. Fis. Din. Quat., 27, pp. 29–36.
- NEAMU, G. (1980), *Observații climatice și topoclimatice în bazinul Văii Muscelului*, In *Geografia Județului Buzău și a împrejurimilor* (Zavoianu ed.). București, pp. 95–101.
- PINNA (1977), *Climatologia*, Ed. Torinese, pp.442.
- ROSINI, E. (1988), *Introduzione all'agrometeorologia. Parte Prima: le basi della climatologia*, E.R.S.A. Servizio Meteorologico Regionale. Bologna, pp. 1–158.
- THORNTHWAITE, C.W. (1948), *An Approach Toward a Rational Classification of Climate*, Geographical Review, 38, pp. 55–94.
- THORNTHWAITE, C.W., MATHER, J.R. (1957), *Instruction and tables for computing potential evapotranspiration and the water balance*, Publication in Climatology, Centerton, New Jersey, 10 (3), pp. 186–311.
- *** (1983), *Geografia României*, vol. I, Editura Academiei, București.

Phenomenes geographiques de risque dans la Depression de la Transylvanie

Virgil SURDEANU, Victor SOROCOVSCHI

Cuvinte-cheie: Transilvania, fenomene geografice de risc, hărțile expunerii la riscuri geomorfologice și hidroclimatice

Fenomene geografice de risc în Depresiunea Transilvaniei. Lucrarea propune prezentarea fenomenelor geografice de risc ce afectează Depresiunea Transilvaniei, situată în interiorul arcului carpatic. Metodologia utilizată urmează trei etape principale: evaluarea statistică a datelor folosite; analiza manifestării temporale și spațiale a fenomenelor de risc pornind în principal de la studii de teren; cuantificarea și cartografierea vulnerabilității la fenomene de risc pe zone sau sectoare. Fenomenele geografice de risc identificate sunt: alunecări de teren (vechi și recente, pe versanți sau la contractul acestora cu albia majoră, în regiunile ocnelor prăbușite); inundațiile de pe Mureș, Târnave, Someș, Olt; ploile intense cu precădere din nordul regiunii; seceta din vestul Depresiunii Transilvaniei, unde se manifestă fenomenul de foehn. Harta de sinteză a riscului indus de fenomenele geografice menționate scoate în evidență particularitățile județelor Cluj și Mureș, care se numără printre cele mai expuse la risc. Printre măsurile de protecție contra alunecărilor de teren menționăm modelarea noii morfologii create, drenajul, împăduririle.

Introduction

La Transylvanie este la plus vaste aire dépressionnaire (environ 26 000 km²) sur le territoire de la Roumanie. Flanquée, à l'extérieur, par les Carpates, qui l'entourent tels un « anneau », la Dépression de la Transylvanie, a eu, jusqu'au Crétacé supérieur, une évolution commune avec eux. Submergée pendant la phase laramique du cycle alpin et inondée par les eaux de la mer, elle est devenue un vaste bassin de sédimentation, avec des dépôts dont l'épaisseur atteint des valeurs maximales (Fig. 1).

La Dépression de la Transylvanie est entièrement emplacede sur un fondement appartenant à l'orogène carpatique, fortement tectonisé, avec des surhaussements et des effondrements notables. Ce fait est mis en relief par les trois styles tectoniques étagés: l'un inférieur, fort tectonisé, l'étage moyen, moins affecté par la tectonique et celui supérieur (tortonien, sarmatien et badénien), affecté par les mouvements pliocènes et la déformation du sel gemme, qui, par endroits, met au jour les gisements. De tels

phénomènes se font voir aussi en bordure de la dépression, où le sel gemme occupe une surface d'environ 16 206 km².

Son actuelle morphologie, illustrée par des plis diapirs, cuestas et, dans la partie centrale, par de dômes, aux altitudes moyennes variant de 400 à 500 m, c'est l'ouvrage sculptural d'un réseau hydrographique, pour la plupart, de provenance carpatique, favorisé par la lithologie: des roches tendres, appartenant au Sarmatien et au Badénien (argiles, marnes, sables, tufs volcaniques, gypse).

Méthode de travail

L'étude des risques géographiques exige et suppose l'élaboration d'une méthodologie qui permet une analyse phénoménologique objective.

Dans une **première étape**, on a procédé à l'examen statistique de toutes les informations détenues (sources bibliographiques, cartes, séries de données sur le climat et l'hydrologie, ou sur l'évolution d'utilisation des terrains etc.) pour une période variant de 50 à 100 ans.

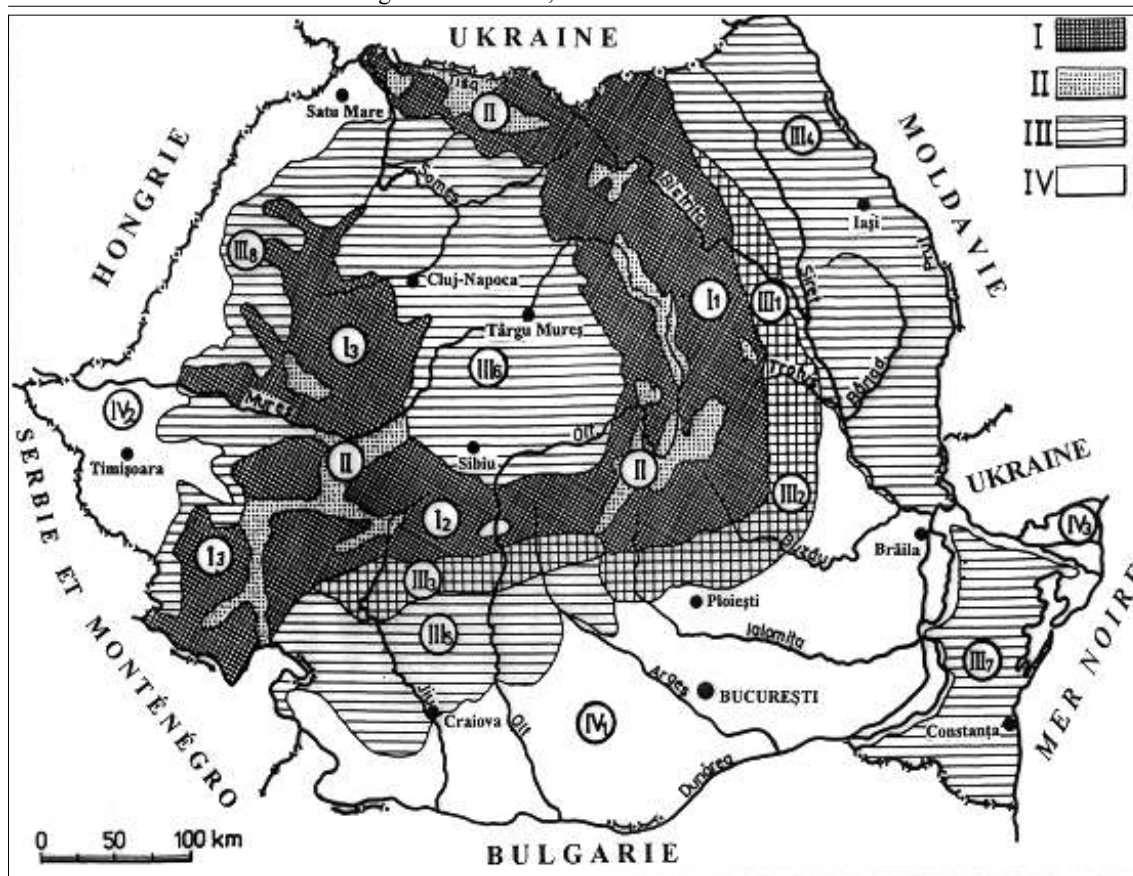


Fig. 1. Les grandes unités morphologiques de la Roumanie. I. Unités montagneuses: I.1. Carpates Orientales; I.2. Carpates Méridionales; I.3. Carpates Occidentales; II. Unités de dépressions intramontanes. III. Unités de collines et plateaux. III.1. Souscarpates de la Moldavie; III.2. Souscarpates de Courbure; III.3. Souscarpates gétiques; III.4. plateau de la Moldavie; III.5. Plateau gétique; III.6. Plateau de la Transylvanie; III.7. Plateau de la Dobroudja; III.8. Collines d'Ouest. IV. Unités de plaines. IV.1. Plaine roumaine; IV.2. Plaine d'Ouest.

En fait, ce faisant, on a établi une base de données qu'on a travaillées, pour en déduire les valeurs moyennes et extrêmes, mais aussi, les écarts et les seuils, à partir desquels on peut parler de risque géographique.

Une **seconde étape**, reposant, en particulier, sur des études dans le terrain, a eu comme but l'analyse du mode dont les phénomènes générateurs de risque se manifestent dans le temps et l'espace, ce qui nous a permis de dresser des cartes de sectorisation, pour toute la Dépression de la Transylvanie. Les phénomènes géographiques qui nous ont occupé sont les glissements de terrain, les inondations, les pluies abondantes, la sécheresse; tous, on les a analysés dans le contexte de l'intervention anthropique, souvent, extrêmement dynamique.

Dans une troisième étape, on a quantifié le degré de vulnérabilité enregistré dans diverses zones ou secteurs, suite aux phénomènes générateurs de risque. A ce propos, nous tenons à remercier le **Centre National de Protection Civile**, qui nous a offert des informations extrêmement précieuses sur les phénomènes de risque, avec leur dégâts matériels et les pertes de vies humaines, au niveau des moindres unités administratives, les communes.

Résultats

Pour toute la Dépression de la Transylvanie, on a dressé des cartes de vulnérabilité géomorphologique et hydroclimatique.

Dans le premier cas, celui de la vulnérabilité géomorphologique, on a constaté que :



Fig. 2. Depression de la Transylvanie. Processus de modelage actuel. 1. Surfaces affectées prédominamment par l'érosion torrentielle: a. actives; b. stabilisées. 2. Surfaces à prédominance des glimées; 3. Surfaces affectées par les glissements de terrain: a. actifs; b. stabilisés. 4. Surfaces aux processus éoliens; 5. Surfaces aux processus pseudokarstiques et karstiques; 6. Surfaces aux processus de dissolution du sel.

- les glissements de terrain représentent la constante caractéristique du modelage dans la Dépression de la Transylvanie. La morphologie, la dynamique et l'évolution des surfaces affectées par les processus sont en étroite corrélation avec le substratum géologique, la morphologie préexistante et avec l'évolution climatique, du Pléistocène jusqu'à présent (Fig. 2);

- les anciennes surfaces aux glissements

monticulaires («glimées») de grande ampleur deviennent le support de nouvelles générations de glissements, produisant des dommages considérables;

- les plus grandes surfaces affectées par les glissements se trouvent dans la zone des dômes, des cuestas et des plis diapirs, et là où, au jour, paraissent les gypses et les tufs volcaniques. Dans les derniers cas, les glisse-



Fig. 3. Glissement de terrain du Dej.

ments constituent la conséquence des changements chimiques et minéralogiques produits dans les argiles au cours du temps;

- la grande densité des glissements est en étroite dépendance de la fragmentation marquée de la région. Parfois, ils occupent presque entièrement les versants des vallées de 1^{er} et de 2^e ordres;

- sur les versants, se réalise une zone d'arrachement de 2,0 à 5,0 m de haut, en moyenne, au cas des vallées de 4^e et de 6^e ordres;

- le contact des versants avec le lit majeur se fait par un glacis de glissement, lequel, fréquemment, vers sa base, est accompagné d'aires de surhumectage;

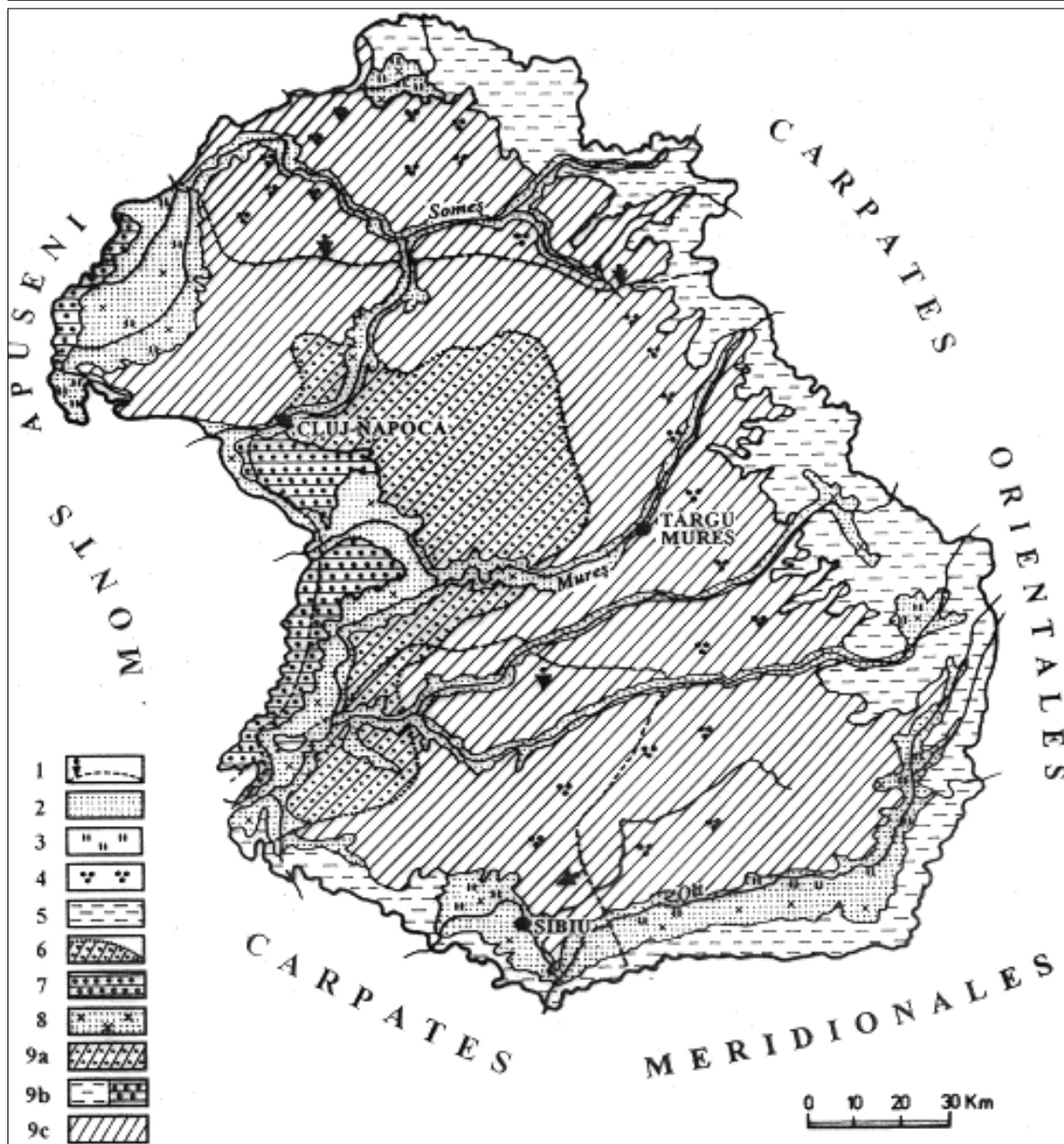


Fig. 4. Phénomènes hydroclimatique de risque dans la Dépression de la Transylvanie. 1. Surfaces à précipitations abondantes durant 24 h (>140 mm); 2. Surfaces inondables; 3. Excès d'humidité dans les aires dépressionnaires et couloirs; 4. Excès d'humidité dans les collines de la zone de plateaux; 5. Excès d'humidité dans les collines de bordure; 6. Surfaces affectées de phénomènes de sécheresse; 7. Effets du foehn et de la sécheresse dans les collines de bordure; 8. Inversion de température, gels et gelées dans les dépressions et couloirs; 9. Surfaces à vulnérabilité: a. grande; b. moyenne; c. mineure.

- les glissements récents, enregistrés pendant la dernière décennie, représentent une réactivation des anciennes surfaces dégradées par le processus. Ils connaissent, dans ce cas, une dynamique de 0,4 à 1,25 m/an et évoluent, en moyenne, 1 à 5 ans;

- les glissements affectant les zones d'exploitation du sel constituent un cas à part. Les

effondrements de mines, qui s'y sont produits, ont provoqué des mouvements de glissement compensatoires sur des grandes étendues. Un tel phénomène s'est passé récemment à Dej, le département de Cluj, en janvier 1998, affectant une superficie de 0,25 km² et entraînant un volume de 3 mil. m³ (Fig. 3);

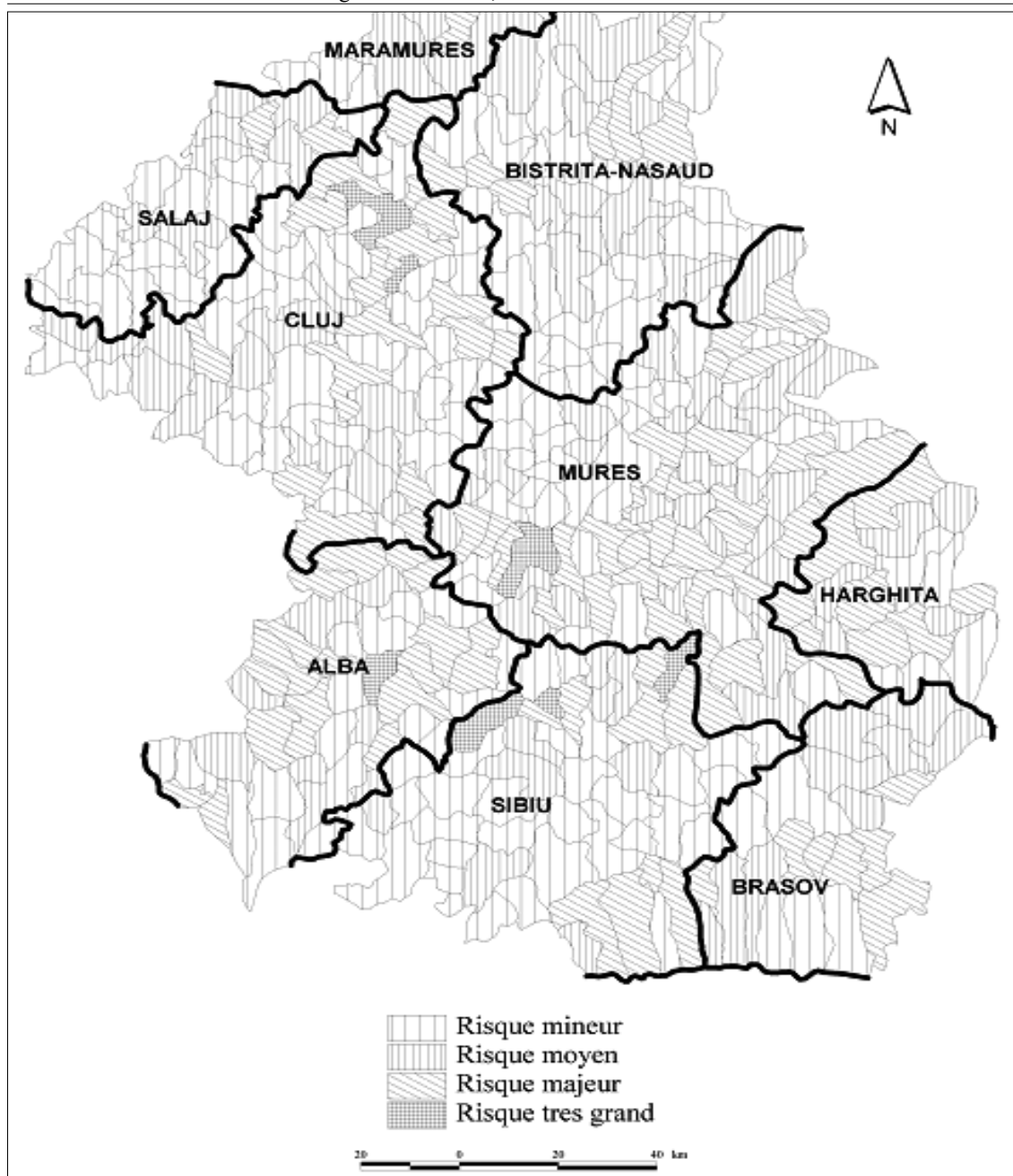


Fig. 5. Carte des phénomènes hydroclimatique de risque

- les surfaces endommagées par les glissements, anciens et récents, sont dégradées aussi par l'érosion torrentielle active, si bien qu'on y enregistre une érosion moyenne spécifique allant de 5 à 250 t/ha/an.

L'évolution, dans le temps et l'espace, des torrents se trouve en rapport de dépendance étroite avec le climat, caractérisé par une alternance marquée de périodes extrêmement pluvieuses et de sécheresse.

L'élaboration de la carte des phénomènes hydroclimatiques de risque repose sur deux critères fondamentaux : **la circulation des masses d'air** et les **particularités de la surface active**.

- la situation de la Dépression de la Transylvanie et la coupure relative de l'espace montagneux vers le nord-ouest et le sud-ouest impriment particularités à la circulation des masses d'air dans ce pays de collines. Ainsi,

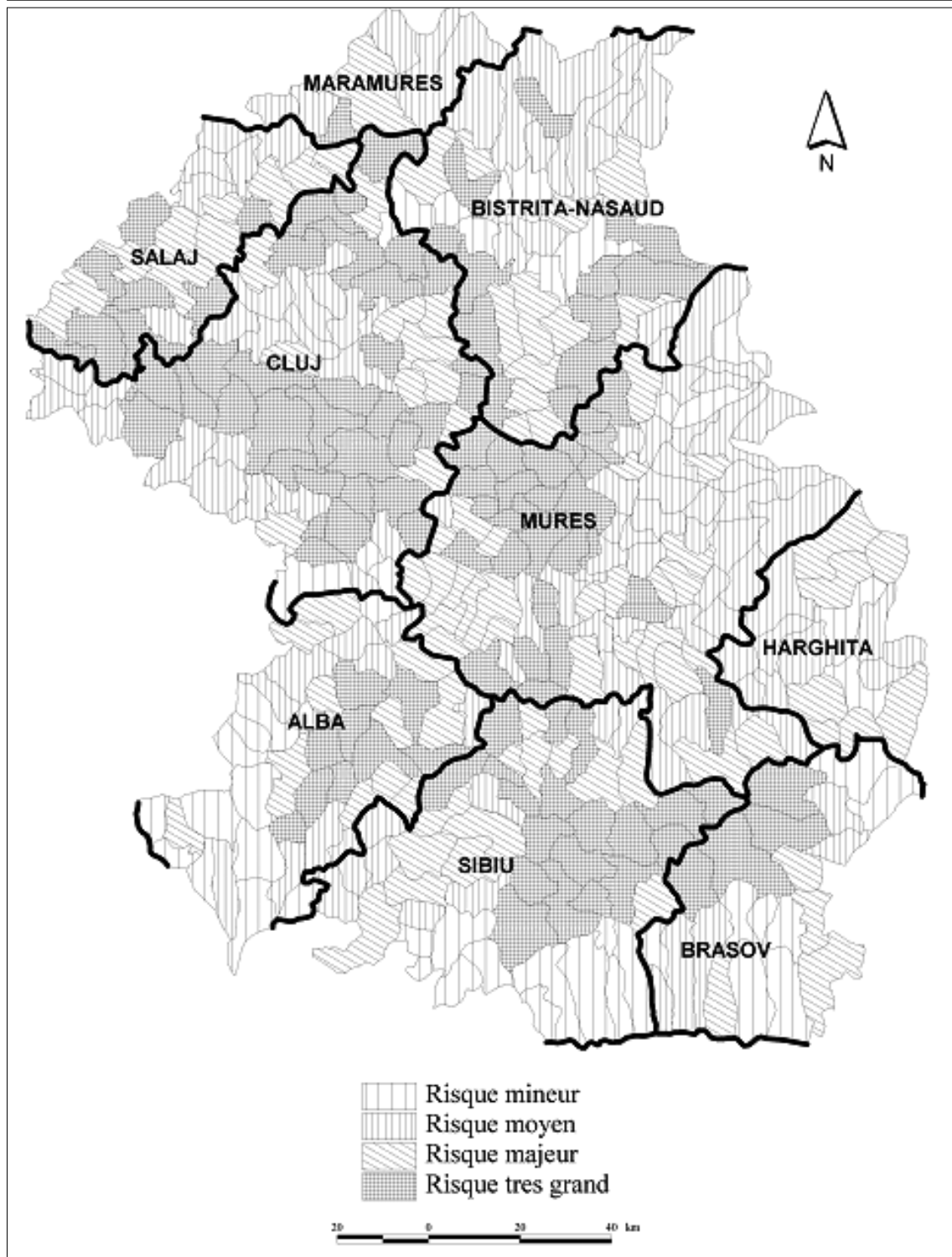


Fig. 6. Carte d'exposition aux risques geomorphologiques

les masses de l'air maritime, de nature atlantique ou méditerranéenne, pénètrent légèrement à l'intérieur de la dépression transylvaine par les « portes » du Meseș et du Mureș,

influant, en particulier, sur les territoires du nord, de l'est et du sud-ouest. Dans la zone située à l'abri des Monts Apuseni, la circulation locale, à caractère de föhn, contribue à

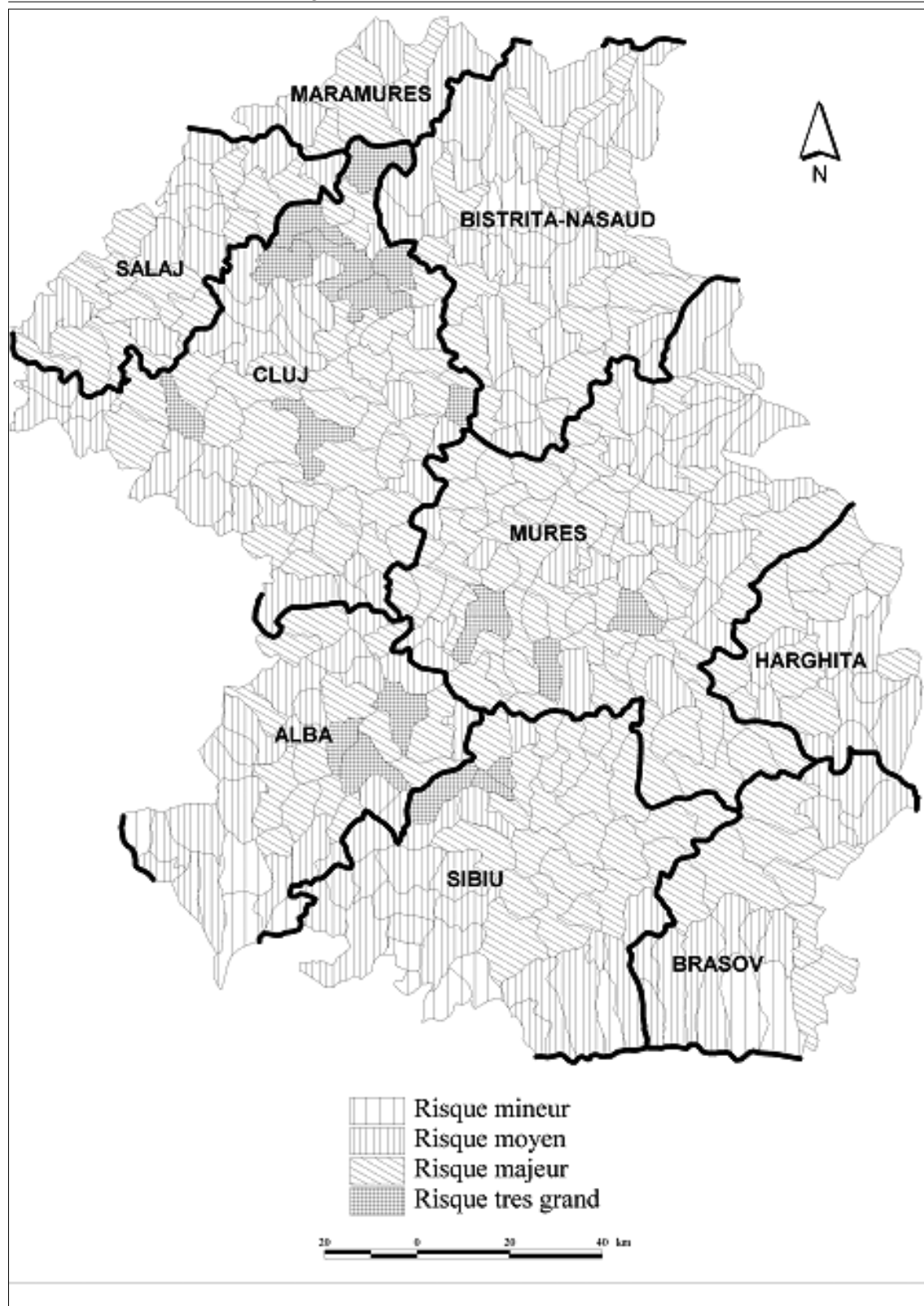


Fig. 7. Carte des risques liés aux phénomènes géographiques

l'intensification du phénomène de sécheresse;

- la cyclogenèse orographique signalée durant l'intervalle octobre-avril détermine des quantités supplémentaires de précipitations, ayant pour effet le maintien de l'excès d'humidité sur les versants et dans les aires dépressionnaires exposées à l'advection de l'air humide;

- une autre caractéristique du climat transylvain ce sont les pluies abondantes de la saison chaude de l'année, dont la durée est la plus grande de tout le pays, provoquant des crues catastrophiques, soit au printemps (10-13 mai 1970), soit en été (1-6 juillet 1975);

- les vagues de froid à température basses (-30° – 35°) sont données par la circulation polaire, ultrapolaire et de blocage, qui affectent plus rarement la Dépression de la Transylvanie;

- les temps secs, avec des températures maximales au-dessous de 40°C , déterminés par la pénétration de l'air sous-tropical, sont plus fréquents que la sécheresse.

- suivant l'intensité avec laquelle les phénomènes climatiques de risque se manifestent, on a délimité aussi des zones ayant différents degrés de vulnérabilité : grande, moyenne et mineure.

- les phénomènes hydrologiques de risque se manifestent avec une plus grande fréquence dans les couloirs des grandes vallées et dans les aires dépressionnaires traversées par les rivières allochtones (Mureș, Târnave, Someș, Olt), provoquant fréquemment des inondations catastrophiques (1970, 1975, 1981, 1985, 1995, 2000). Comme on le voit, les inondations se produisent avec une cyclicité de 5 à 6 ans, et de 11 ans, et causant des dégâts matériels considérables.

- la carte des phénomènes hydroclimatiques de risque met en évidence plusieurs zones, suivant la prédominance de l'un ou de l'autre (Fig. 4);

- la partie nord de la dépression, où prédominent les pluies abondantes (plus de 140 mm/24 h);

- la partie ouest de la dépression, dont le climat est marqué par la circulation de type fœhn et les phénomènes de sécheresse;

- les couloirs des vallées et les aires dépres-

sionnaires, affectés par les inversions de température, les gels, les gelées et le brouillard;

- les collines du nord, de l'est et du sud, les couloirs des grandes vallées et les dépressions de bordure, ayant comme spécifique l'excès d'humidité.

L'étape suivante, on a élaboré **les cartes d'exposition aux risques géomorphologiques, hydroclimatiques**, et finalement, une **carte de synthèse des risques géographiques**. Pour ce faire, on a quantifié les informations recueillies à une échelle de valeurs allant de 1 à 4, c'est-à-dire, de risque mineurs à risques très grands.

Les différenciations ont été établies sur la base des cartes de vulnérabilité au risque et le calcul des dommages matériels enregistrés pendant la dernière décennie.

En ce qui concerne **les risques géomorphologiques**, ayant trait surtout aux mouvements de terrain (Fig. 5) nous estimons que les plus grandes surfaces endommagées par le processus se trouvent dans les départements Cluj, Mureș, Sibiu et Alba. En témoignent les chiffres illustrant les dégâts produits rien qu'au cours de cette décennie: 725.901.000 \$, dans le département de Cluj; 252.090.000 \$, le département Alba; et, beaucoup moins, 91.275.000 \$, dans le département de Brașov.

Les effets désastreux du processus ont ravagé surtout le milieu rural, où l'on a enregistré les plus grandes pertes (75% dans le département Cluj; 98% le département Alba; 100% le département de Brașov), endommageant terrains agricoles, voies de communications, habitats.

La **carte d'exposition aux risque hydroclimatique**, élaborée au niveau des unités administratives, met en relief le fait que les zones le plus fréquemment exposées aux risques majeurs se trouvent dans les communes appartenant aux départements Mureș, Alba, Sibiu, Brașov et Cluj, où les dommages matériels provoqués par les inondations de mars 2000 ont été estimés à plus de 3.000.000 \$. Le même phénomène hydroclimatique a affecté le département Bistrița en juillet 1998, avec des dégâts évalués à 935.000 \$.

La sécheresse est moins fréquente dans la Dépression de la Transylvanie et ses effets ravagent, en particulier, les terres dans les départements Mureș, Alba et Cluj. La dernière en date, de juin 2000, a produit des dommages équivalant à 1.300 millions \$.

La carte des risques dus aux phénomènes géographiques met en lumière les aspects suivants :

- dans le département de Cluj, du nombre total des localités, 68, dont 6 urbaines, 7 présentent un risque très grand et 35, un risque grand;
- dans le département voisin, de Mureș, des

93 localités, dont 6 urbaines, 3 présentent un risque très grand, et 58 des risques grands.

Parmi les mesures qu'on peut prendre afin de remédier aux désastres provoqués par les glissements et d'en empêcher la production d'autres, mentionnons surtout le remodelage de la morphologie nouvellement créée, les travaux de drainage, d'appui et de renforcement interne, et le boisement.

Afin d'éliminer les effets des inondations et de régulariser le transit de l'eau, on prévoit des constructions hydrotechniques : digues et barrages.

BIBLIOGRAPHIE

ALEXANDER, D. (2002), *Natural Disasters*, Ediția a IV-a, Routledge, London and New York.

BĂLTEANU, D., RĂDIȚA, Alexe (2001), *Hazarde naturale și antropogene*, Editura Corint, București.

BĂLTEANU, D. ȘERBAN Mihaela (2005), *Modificările globale ale mediului. O evaluare interdisciplinară a incertitudinilor*, Editura C.N.I. „Coresi”, București.

DAUPHINE A. (2001), *Risques et catastrophes*, Armand Colin, Paris.

DE MARCHI Bruna, PELLIZZONI L., UNGARO D. (2001), *Il rischio ambientale*, IL MULINO, Bologna

DI ROSA G. (2000), *Rischio idrogeologico e difesa del territorio*, Dario Flaccovio editore, Palermo.

GISOTTI, G., BENEDINI, M. (2000), *Il dissesto idrogeologico*, Previsione, prevenzione e mitigazione del rischio, Carocci editore, Roma.

GRECU, Florina (1997), *Fenomene naturale de risc. Geologie și geomorfologie*, Editura Universității din București.

GUITON, M. (1998), *Ruissellement et risque majeur. Phénomènes, exemples et gestion spatiale des crues*, LCPC, Paris.

LEFÈVRE, C., SCHNEIDER, J.L. (2002), *Les risques naturels majeur*, Collection Geosciences, Paris.

MAC, I., PETREA, D. (2003), *Polisemia evenimentelor geografice extreme*, în *Riscuri și catastrofe*, vol. I, Casa Cărții de Știință, Cluj-Napoca.

MC GUIRE, B., MASON, I., KILBURN, C. (2002), *Natural Hazards and Environmental Change*, New York.

MOLDOVAN, Fl. (2003), *Fenomene climatice de risc*, Editura ECHINOX, Cluj-Napoca.

PERAGO, A. (2005), *Erosione e dissesto idrogeologico*, Maggioli editore, Dogana.

PIGEON, P. (2004), *Évaluation des politiques de gestion des risques naturels*, în *Risques naturels et aménagement en Europe*, Armand Colin, Paris.

SMITH, K. (2002), *Environmental hazards*, Ediția a III-a, Routledge, London and New York.

SOROCOVSCI, V. (2003), *Complexitatea teritorială a riscurilor și catastrofelor*, în *Riscuri și catastrofe*, vol. II, Casa Cărții de Știință, Cluj-Napoca.

SOROCOVSCHI, V. (2003), *Riscuri hidrice*, în *Riscuri și catastrofe*, vol. I, Casa Cărții de Știință, Cluj-Napoca.

SOROCOVSCHI, V. (2004), *Analiza riscurilor induse de inundațiile de pe râurile din nordul Podișului Transilvaniei*, în vol. *Fenomene și procese cu risc major la scara națională*, Coordonatori Florin Gheorghe Filip, Bogdan C. Simionescu, Editura Academiei, București.

SOROCOVSCHI, V. (2005), *Câmpia Transilvaniei. Studiu hidrogeografic*, Casa Cărții de Știință, Cluj-Napoca.

SOROCOVSCHI, V., PANDI, G. (2002), *Hydrological risk phenomena caused by rainfalls in the north-western part of Romania*, Third International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation, *Risk Analysis III*, Editor C.A.Brebia, WIT Press, Southampton, Boston.

SOROCOVSCHI, V., MOLDOVAN, Fl., Adina Eliza CROITORU (2002), *Perioadele excedentare pluviometric în Depresiunea Transilvaniei*, *Studia Univ. „Babeș-Bolyai”, Geogr.*, 2, XLVII, Cluj-Napoca.

SOROCOVSCHI, V., Mac, I. (2004), *Percepția environmentală și răspunsurile umane față de risc*, *Riscuri și catastrofe*, , în vol. *Riscuri și catastrofe*, Editor V. Sorocovschi, 1, Editura Casa Cărții de Știință, pp. 25–38.

SURDEANU, V.(1998), *Geografia terenurilor degradate*, Editura Presa Universitară Clujeană, Cluj-Napoca.

SURDEANU, V. (2003), *Gestionarea riscurilor — o necesitate a timpurilor noastre*, în *Riscuri și catastrofe*, vol. II, Casa Cărții de Știință, Cluj-Napoca.

SURDEANU V., MAC I., NICORICI Corina (1998), *Procese de modelare în Depresiunea Transilvaniei*. *An. Univ. Ecologice “D. Cantemir”, s. Științe socio-umane*, II, Tg. Mureș, pp. 505–521.

SURDEANU, V., SOROCOVSCHI, V. (2004), *L’Evolition du réseau de drainage naturel dans la Dépression de la Transylvanie*, Glasgow.

Université „Babeș-Bolyai”, Cluj-Napoca, Roumanie

Modelling processes on spoil heaps

Titu ANGHEL, BALAZSI Krisztina

Cuvinte-cheie: procese de modelare, haldă, dinamică morfogenetică, impact.

Procese de modelare pe tehnestructuri de tip haldă. Omul, prin activitățile miniere, generează tehnestructuri a căror dinamică este influențată de intensitatea și modul de exploatare a resurselor minerale. Modelarea geomorfologică locală este modificată direct sau și indirect, și indirect de către factorul uman. Are loc accelerarea proceselor dinamice cu realizarea tranziției ireversibile spre un peisaj nou, antropic, al cărui management este esențial pentru dezvoltarea unei societăți moderne.

Predicția posibilelor traiectorii ale schimbărilor peisagistice și realizarea unor modele de amenajare post-extractive vor căpăta o importanță însemnată în viitor. Problema gestionării dezechilibrelor morfodinamice apărute în cadrul tehnestructurilor de tip haldă reprezintă o provocare a societății contemporane.

Studiul nostru urmărește reliefaarea dinamicii geomorfologice din cadrul tehnestructurilor de tip haldă în vederea înțelegerii exacte a rolului pe care îl joacă omul în desfășurarea proceselor geomorfologice contemporane.

The human impact caused through the spoil heap techno-structures

The last 60 years have been characterized by a pronounced increase of the mining industry, both at the surface and in the underground. The morphologic result of such brutal human actions is represented by a series of techno-structures, which, if compared to the natural processes, have different geomorphic intensities and speed (Anghel and Balazsi, 2005).

Humans create an original hierarchy of landscape modeling dynamics, through a selective pattern of actions. Anthropocentric rearrangement of ground layers and artificial redistribution of the contained materials leads to a very unrealistic geomorphologic landscape with little chance for a durable functionality.

Mine exploitation generates an important quantity of residues. Because they don't have any practical use, these are stored in artificial accumulative heap techno-structures.

Through their construction, man causes direct, indirect and esthetic impact upon the environmental components.

The direct impact on the soil component refers to the destruction of texture, structure and fertility, not to mention the inappropriate use of the productive land (Table 1).

The indirect changes manifest through the occurrence of bitter or acid soils, or even of soils containing different solutions. Storing the excavated soil in micro heaps, with the purpose of conserving it, leads to its degradation, through erosive processes.

Spoil heap techno-structures have indirect effects on the hydrogeology: favored by the infiltration of rainwater, these modify the subterranean circulation, affect the accumulative structures, change profoundly the chemical composition, etc.).

The direct impact on the hydrographic network translates into the network's disorganization, water damming, underground and surface channeling, water flow change, water quality depreciation, etc. (example: pollutant content in the Motru river basin, Table. 2).

Through the rearranging and the spatial redistribution of rocks, the lithology and the geologic structure of the region is substantially modified. Because of these changes, the surface lithology is completely modified, and the structure is profoundly scarred by the human influence. This artificial structural hierarchy of the spoil heaps is deficient and

Mining basin	Exploitation area (ha)	Residue area (ha)	Building area (ha)	Other occupied areas (ha)
Valea Jiului	15569	277	192	79
Motru	3658	747	130	2881
Jilt	1632	627	87	918
Rovinari	7852	1029	450	6373
Vâlcea	1355	411	83	861
Ploiesti	1126	314	115	697

Table 1. Areas occupied by mining exploitations in Romania(Source: Fodor (1996), modified)

Nr. crt.	Content of the used waters	Maximal and minimal allowed values (mg/dm ³)	Pollutant content of the water (mg/dm ³)
1	Suspensions	10-50	0.4-416.4
2	Solid residue	750-1200	2.1-1259
3	Sulfates	200-400	0-692
4	Carbon dioxide	13.2-20	0-363
5	Bicarbonates	-	158-518.5
6	Ammoniac	0.3	0.01-8
7	Nitrates	3	0.02-3.4

Table 2. The concentrations of the pollution elements in the water of Motru basin (Source: Tomescu et al. (2001))

leads to a reduction of their resistance to the modeling agents, which causes an acceleration of the present day morphogenetic processes. The morphologic impact is direct, and the result of these processes is landscape reversion: the low lands – fields, valleys and depressions are transformed in man-made hills.

Human intervention leads to an indirect acceleration of the present day geomorphologic processes, with immediate impact on morphology. Due to the lack of vegetation, soil friability and maladjusted slopes, the anthropogene process' dynamics intensifies.

Areolar and linear erosion generate a micro-morphology, similar to gutters, gaps and rarely torrents. Mass movement processes are very active too on spoil heap techno-structures, being widely represented spectrum: landslides, subsidence, false slow slides, crumbling, capsizing, mudslide etc.

The impact on the atmosphere is direct, through the artificial change of its composition. Especially in the dry season, ground particles are mobilized as dust (suspended or sediment), by wind, running belts, transporta-

tion vehicles etc. Self-ignition of the spoil heaps: transportation vehicles exhaust gases, gas emissions resulted from the reactions that take place in the spoil heaps etc., determine a change in the chemical composition of the atmosphere.

The esthetic (visual) impact is the most difficult to integrate in the human society, especially because it lacks normal, natural relations with the surrounding environment. The spoil heap accumulative structures are come with desolating landscapes and need an integrated management of the geomorphologic landscape, based on environment feasibility studies and an industrial design that satisfies the needs of the present day society.

The impact on human communities is both direct – the necessity to relocate houses and industrial buildings, due to the threat of spoil heap slides and to the reduction of agricultural and forest activity – and indirect – affecting the general health and behavior of humans living nearby.

The change of the natural environment due to mine exploitations determines environ-

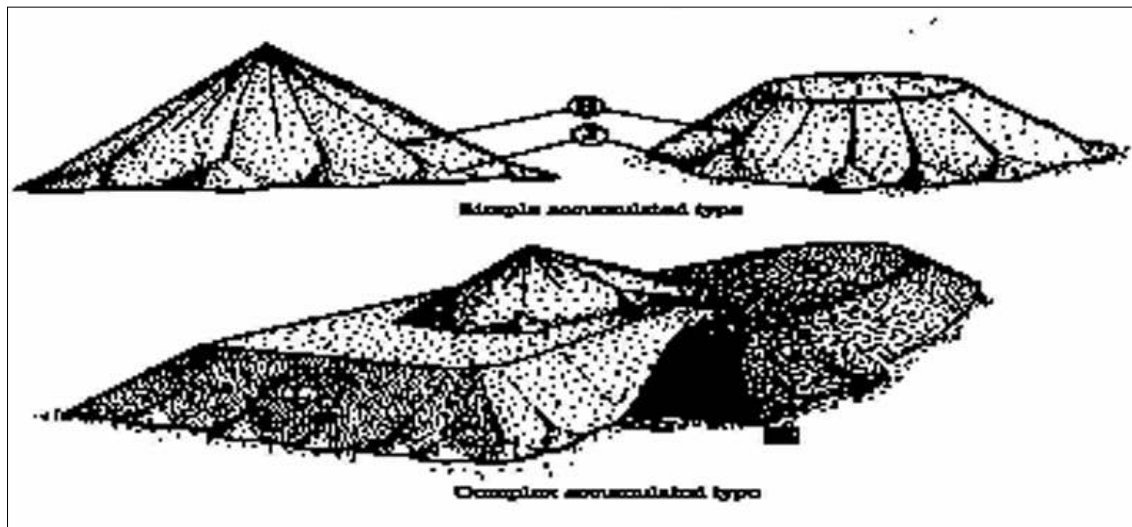


Fig. 1. Accumulated macroform types (Dávid, Karancsi, 1999.)

mental problems thus causing a local environmental unbalance. Among the actions taken to reduce the impact caused by the construction of spoil heaps, we mention the strict enforcement of construction rules, the correct choice of the storage sites, working to stabilize the soil and reduce the areas that are occupied, the reduction of the stored residues, permanent monitoring, reintroduction of the spoil heaps in the economical circuit.

Man, active morphogenetic agent

Essential modeling force of the earth crust, the human society generates both isolated and clustered forms of the landscape, forms that have their own physiognomies and dynamics. The creation of structures as result of technical activities has generated profoundly unnatural landscapes, realizing great changes at the geomorphologic level of the earth crust (Mac, 2003).

The process' dynamics obeys natural, objective laws, but is accelerated by the human intervention. Human can be considered the most active modeling agent of the earth crust, the results of their actions being noticeable on a historical time scale. The human factor has earned the attribute of main present day modeling agent both through the speed it manifests, at and the extent in space it manifests on.

Most man-made structures lead to a fragile environment, but man can also act as a stabilizing factor, through the amelioration activities that he carries (river arrangements, aqua territorial damns, landslides stabilization, torrent stopping, and reintroduction of used land into the economic circuit).

The spoil heaps are the result of the anthropic morphogenetic actions and is one of the most spectacular man-made accumulative forms, in terms of size and dimension of the geomorphologic process.

Man interferes on the environment in three ways: erosion, transport and accumulation; his actions differ essentially from those of the natural agents through speed of action, its intensity, and the process hierarchy especially (way of action). These man-made structures do not follow the logics of natural processes, but act upon a hierarchy of their own, generating conflicts among the components of the environmental system. We consider that this way of action requires special attention.

The spoil heap type morphology

Spoil heaps are outdoor accumulative forms resulting from open pit mining or underground mining, more precisely from the deposit of the resulting residual materials (heterogeneous rock mix). Their construction is done according to regulating laws extracted from exploitation monographs.

Our study does not intend to focus on the construction requirements, but we have to mention that the degree these requirements are obeyed to influences the rehabilitating process and the reduction of the present day geomorphic processes.

The spoil heaps hierarchy is realized by taking into consideration certain criteria. The most common criteria are: spoil heaps dimensions, their location in the region, their position in the basin, the type of materials they are comprised of, their geometry etc.

The dimension is a very important control variable. It offers us information regarding the variety of geomorphic processes that take place on the techno-structure. It was observed that the process variety increases with the size of the techno-structures. The spoil heaps have therefore been divided into three categories, or three type classes, by Brînduş et al. (1998):

- big spoil heaps, over 25.000 cubic meters, on which all present day geomorphic processes manifest (both structural dynamics and hydro-denudation processes);
- medium size spoil heaps, between 10.000 and 25.000 cubic meters; on which surface washing, torrent formation, gully formation, superficial land slides, crumbling, creep, slow slides, sufusions, and even cave-ins manifest;
- small spoil heaps, under 10.000 cubic meters, almost completely stabilized, small vegetation or trees; here only surface erosions with the use of, creep, and rarely crumbling manifest.

The spoil heaps can form accumulative complexes or they can be isolated, with their morphology varying from overlapped cone bodies to circular pyramids.

According to the morphology they receive during construction, spoil heaps can have one or more steps. Keeping the spoil heap techno-structures stable requires construction standards and maintenance (visual control, measuring, amelioration and hydro-technical fitting out of the heaps).

According to the morphology they lay on, spoil heaps divide into meadow and low land heaps (among the most stable), dry valley

heaps, slope heaps, depression located heaps and reception basin heaps.

The location of the heaps in the exploited area differentiates two accumulative types: interior heaps (located in the previously exploited area, characterized by one step of deposit, economical and easy to build) and exterior heaps (common in ores with a thick cover, in very inclined layers of ore or in deposits situated on extremely inclined slopes).

According to the material they contain, the spoil heaps can be: heaps made of friable materials (clay, sands, cover soil etc.), heaps made of tough materials (resulting from rock and metal exploitations), and chaotic heaps (soft and tough rocks in a heterogeneous mixture).

According to the material's granulometry, there are: smooth granulometry heaps (especially in carbon exploitation areas), brutish granulometry heaps (in rock and mineral exploitation areas) and heterogeneous granulometry heaps (in rock and metal exploitation areas).

Specific geomorphologic processes on the spoil heap technostructures

Anthropic modeling of the crust breaks the natural balance enabling the installation of an accelerated dynamic, reaching the end faster compared to the natural conditions. The unleashed human processes develop through self propagation, meaning that the linear ones sustain the areal ones and vice versa (Mac, 2003).

The human factor intervenes directly in the development of the morphogenetic processes through the creation of man-made forms, blocking of rivers, arrangement of the hydro-graphic network, creation of new base levels etc. Man affects the development and the natural evolution of most of the environment's components.

By overloading the terrain it lays on, a change in the geologic intimacy takes place (previous existing structures subside, neighboring areas will manifest curved soil lifts,

the hydrologic and geologic dynamics will be modified, and also the surface lithology).

The creation of spoil heap structures determines a change in the local climate (higher albedo, the wind encounters the new man-made obstacle, local micro-currents are generated, a false desertification appears, due to the lack of aquifer layers etc). The microclimatic changes have direct repercussions in the geomorphologic processes of the spoil heaps (acceleration of wind erosion, enlargement of the areas suffering from rain induced denudation, increase of landslide frequency, crumbling and mudslides frequency etc.).

By giving the extracted soil mobility, man accelerates its degradation (texture modification, texture destruction, lowering of fertility, even composition change — e.g. salting etc.). On the other hand, the sedimentation of conserved soil on the finalized spoil heaps, improving amendaments, adding components for the increase of the soil pH, are just some of the actions that generate equilibrium in the environmental system. Although already exposed in our study, the human dynamics in generating techno-structures is most spectacular.

A quick analysis of the phenomenon reveals the incredible force of the human modeling agent. To better acknowledge the power of the human intervention we can grossly differentiate between the necessary time to generate a glacia and the time it takes to generate a similar sized spoil heap.

Human intervention can be quantified through the changes it provokes to the natural environment. The disorganization of the hydrographic network, the profound aggression on the biotic domain, the acceleration of present day geomorphologic processes and the soil, and air pollution are evident.

The main characteristics of the spoil heap accumulative structures are: poor residue aggregation, chaotic structuring of the rocks, lack of material cohesion concerned, varied granule dimension, lack of functional systematization, lithological diversity, high friability etc. All these characterize the man-made accumulative structures and generate a

high risk to the present day geomorphic modeling.

The spoil heaps are accumulative techno-structures of large dimensions and undergo, accordingly, a very wide process spectrum.

The dynamic potential of the structures morphology is high especially when construction rules are not obeyed. The most unstable are the exterior spoil heaps, those deposited in the origin basins or on the hill sides.

Although neglected in literature, the physical and chemical degradation of the rocks through natural mechanisms (weathering) is strongly accelerated by mining exploitations. The human factor determines a strong disintegration of the rocks; they are broken down to small-size pieces that will be exposed to the chemical action of the degrading reagents.

Weathering is directly triggered by the human factor through the excavation of rock deposits that would have naturally encountered the degrading factors (weathering factors) only in thousands or even hundred of thousands of years. Indirect human actions lead to the change of the chemical composition of rain water, which gets enriched with chemically active compounds, resulted from the activity of various installations or factories situated in the vicinity of the spoil heaps. Also, through infiltration, the weathering water is enriched with active substances present in the rock layers of the spoil heaps, attacking the structures from the base. We also mention the fact that the frosting-defrosting action is more efficient on these structure, the temperature variations that the rocks are subjected to normally being highly increased.

The geological erosion from the spaces occupied by the spoil heap techno-structures is transformed in human induced erosion, characterized by a superior intensity and speed. The erosive process begins with the rain action, the spoil heaps are especially vulnerable to this type of erosion, due to their disaggregated structure, and to the lack of cohesion of the materials they comprise. Erosion begins when raindrops displace soil particles. Raindrops may gather into sheets of

water and flow over the surface (overland flow) to causing sheet erosion. Topography then channels water to producing rill and gully erosion. When the water from rills and gullies gathers, larger erosive streams and channels form. A single raindrop may move a splashed particle 60 cm vertically and 150 cm horizontally. The speed of a raindrop is more than ten times higher than the typical surface runoff velocities, which means that soil particles are more likely to be dislodged by raindrop impact than by surface runoff. Once the particles are mobilized, however, much less energy is required to keep them suspended or moving.

Thus, on the inferior area of the heap the poorly cohesive particles are hit by raindrops and mobilized to the lower part. The increase of the rain intensity causes the debut of the areolar erosion, creating a thin thread of water and suspended materials, that gets thicker and thicker in its movement towards the embankment. Here, the water accumulates, and gives birth to in-depth erosion. Small torrents are formed and they act on the morphology forming gutters. When the next intense rain comes, the gutter aspect can change to form a gap. Continuance towards the base of the spoil heap consecrates the gap type morphology. Depending on the climate and the construction standards on some spoil heaps, bigger torrents appear, generating canyon type morphology. In the case of the spoil heaps built in lower lands, rain formed water flows can reach the man-made accumulative deposit through lateral erosion, generating a new factor that produces instability in the accumulative system.

The spoil heaps influence indirectly the water flows, the eroded protosoil from their surface reaching the water flows and sensitively increasing the quantity of suspended particles. Consequently, these areas are confronted with strong degradation of the rivers doubled by a lowering erosive capacity and an increase of their deposits.

The accelerated erosion from within the spoil heaps precedes the massive movements

of material, sometimes triggering them. These material movements can widely vary in category and dimensions; the most frequent are land slides. These create the most obvious morphology as far as dimensions and impact are concerned.

Superficial land slides are caused by: insufficient compacting of the spoil heaps, the sharpness of the slopes angle, excessive humidity in rock layers, the frosting-defrosting process, the vibrations generated by the functioning machines, overloading etc.

The in-depth slides are less frequent, and are triggered by: insufficient compacting, inadequate slope angle adapted the soil and climate conditions, the alternation of rock layers susceptible to trigger slides, overloading, vibrations generated by the machines used on the construction site, advanced erosive processes, excessive rain etc.

Slides on the spoil heap's main body have the most disastrous effects, they can affect cities located downstream. They are triggered by the movement of the support rocks, sometime amplified by other favoring events, such as: underground springs, explosions in neighboring areas, intense rainfall etc.

Layered slides appear on unstable soil, characterized by a layering oriented towards the downstream areas, or by the existence of underground water at the base of the spoil heap.

In literature the slide had more than one sliding surface are mentioned. This kind of process is generated by the human neighboring activities, but also by the subsidence processes within the spoil heap. When the spoil heap's hearth is made of a soft clay layer and a thin layer of sand, there are favorable conditions for slides to happen (Fodor, 1995).

On the old well compacted spoil heaps, land slides are replaced by creep processes, or pseudo-solifluxions.

The land slide dynamics in the spoil heaps deposit area is more active in terms of speed and the intensity. In our opinion there are also differences of the mechanisms involved, compared to the natural structures. Generally

there are fewer development stages and they finalize in a much shorter time period.

Mud flows are also described in literature as plastic slides or spoil heap body enlargements. They are frequent in structures made of dusty incompact clays, especially under favoring conditions such as abundant rainfall, and slope angles sharper than 5 degrees. When the precipitations persist, mud flow can turn into dangerous mud torrents with high flow speeds, a serious threat to communities and industrial structures downstream.

Pseudo-solifluction appears generally in the spring, with the defrosting process of the spoil heaps interior.

Rock falls are frequent on the incompact slopes, especially on the active spoil heaps. Temporary accumulative cones of small morphologic importance get created. Solid material slides on self created paths when the spoil heaps are not consolidated, having as morphologic result two types of structures: flow beds and spreading cones. Structure cave-ins often happen on abrupt spoil heaps, on surfaces characterized by torrent formation or in lateral erosion sites caused by neighboring water flows.

Compaction is present even from the construction stage of the spoil heaps. It can be man induced (stabilizing compaction on the spoil heaps, done for soil stabilization) or natural compaction (support soil compaction, natural compaction of the accumulative structures, compaction resulted from the contraction and expansion caused by water).

The previous notions: natural compaction, man induced compaction and compaction of

the support field are introduced by us, the literature using expressions such as abnormal compaction, subsidence etc., that are, in our opinion, inadequate.

The isostatic compensations manifest through the lift of the areas surrounding the spoil heap, as a consequence of the spoil heap's compaction or that of the supporting field.

The increase in light of the soil around the spoil heap, is induced by the clay's proprieties, such as volume variation, and also by the presence of water inside the spoil heap. This level increase can be caused by the rain induced humidity (following a compacting period), by the frosting-defrosting processes (ice lenses get formed inside the spoil heap), or by the underground water.

The underground erosion (sufosion) appears on the spoil heap techno-structures due to the lack of draining, incompact material or deficient compacting: all these determine a high permeability, allowing rain water to infiltrate. The morphologic manifestations of this process are: sufosion depressions (that can store water, generating lakes or swamps), sufosion funnels and rarely sufosion valleys. On the morphology specific for the sufosion process, lakes can appear or even regular water flows. Stabilizing the process is very difficult, they are usually left to naturally dry out.

The volumetric and mechanic actions (Mac, 2003) are triggered by extreme drying of the soil in the exploited region; this leads to structural problems and curbing of both the topographic surface and the spoil heap.

BIBLIOGRAPHY

ANGHEL, T., BALAZSI, Krisztina (2005), *Considerații privind reabilitarea zonelor cu exploatare miniere la zi în Bazinul Oltenia*, în curs de apariție în volumul *Geografia în contextul dezvoltării contemporane*, Cluj-Napoca.

BRÂNDUȘ, C., CHIRIȚĂ, V., POPESCU, I. (1998), *Relieful antropoc minier din zona montană a județului Suceava*, Analele Universității „Ștefan cel Mare”, Suceava, (p. 67–73).

COSTA, J.E., FLEISHER, P.J. (1984), *Developments and Applications of Geomorphology*, Springer-Verlag, Berlin.

DAVID, L., KARANCSI, Z. (1999), *Analysis of anthropogenic effects of quarries in a Hungarian basalt volcanic area*, in 2nd International Conference of PhD Students, Section proceedings, Natural Sciences, University of Miskolc, Miskolc Heidelberg.

DUMA, S., (1998), *Studiul geoecologic al exploatărilor miniere din zona sudică a Munților Apuseni, Munților Poiana Ruscă și Munții Sebeșului*, Editura Dacia, Cluj-Napoca.

FODOR, D. (1995, 1996), *Exploatarea zăcămintelor de minerale și roci utile prin lucrări la zi*, vol. I și II, Editura Tehnică, București.

FODOR, D., (2001), *Impactul industriei miniere asupra mediului*, Editura Infomin, Deva.

LĂZĂRESCU, A., (1983), *Protecția mediului și industria minieră*, Editura Tehnică, București.

MAC, I. (2003), *Știința mediului*, Editura Europontic, Cluj-Napoca.

NORMAN, D.K., PETER, J., WAMPLER, P.J., THROOP, A.H., SCHINITYER, E.F., ROLOFF, J.M. (1997), *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon*, Division of Geology and Earth Resources, Open File Report 96-2, Revised Edition.

SURDEANU, V. (1998), *Geografia terenurilor degradate*, Editura Presa Universitară Clujeană, Cluj-Napoca.

TOMESCU, Viorica., SAVIN, C., PLEINICEANU, V. (2001), *Impactul exploatărilor miniere asupra fact de mediud în Bazinul Motru*, Studii și comunicări, Seria Științele Naturii, Craiova.

TOY, T.J., Hadley, R.F. (1987), *Geomorphology and Reclamation of Disturbed Lands*, Harcourt Brace JOVANOVIĆ, Publishers, Academic Press, Orlando, Florida.

ȚICLENU, N., TROTEA, T., STOICAN, I., DRAGOMIR, B., BARTUȘ, T., BARBU, V., PARASCHIV, V. (2003), *Utilizarea argilelor dintre stratele de cărbuni ca înlocuitori ai solurilor degradate în urma exploatării cărbunilor, în carierele din Oltenia*, Environment & Progress, Cluj-Napoca.

ZARUBA, Q., MENCL, V. (1976), *Engineering Geology*, Elsevier Scientific Publishing Company, Amsterdam-Oxford-New York.

Opportunité de l'utilisation de l'imagerie satellitale moyenne resolution dans le cas de phenomene de faible etendue; cas des volcans de boue

Abdelkader ABDELLAOUI¹, Ileana G. PĂTRU²,
Mihai IELENICZ, André OZER³

Mots clés: teledetection; volcan de boue; traitement d'image.

**Opportunitatea utilizării imaginilor satelitare de rezoluție medie în cazul fenomenelor de mică întindere.
Cazul vulcanilor noroioși.**

Vulcanii noroioși, rezultatul erupției în suprafața a scurgerilor noroioase bogate în fluide, sunt studiați de mult timp, pe pământ și în mare. Studiul vulcanilor noroioși prezintă interes din mai multe puncte de vedere: mai întâi din punct de vedere științific, datorita cantității importante de informații despre subsol și adâncimile pământului ; apoi din punct de vedere economic, prin faptul ca acești vulcani pot fi asociați cu prezenta resurselor naturale (gaz metan în cazul Pakistanului, de exemplu) ; dar și din punctul de vedere al turismului și al mediului înconjurător (în cazul Văii Buzăului, în România). Dacă un câmp de vulcani noroioși poate atinge un diametru de câțiva zeci de metri, (între o sută și două sute), vulcanii în sine au în general un diametru cuprins între 1 și 10 metri, prea redus în raport cu pixelul unei imagini satelitare cu o rezoluție slabă sau medie. Putem sa ne punem astfel problema posibilității de a studia zonele cu vulcani noroioși plecând de la imagini satelitare, mai precis de la imagini cu o rezoluție slabă sau medie. Articolul de față arată ca este totuși posibil sa se evidențieze fenomenele de o întindere redusă, (de la 1 la câțiva pixeli) pornind de la imagini satelitare și folosind mijloacele potrivite.

Les volcans de boue, résultant de l'extrusion en surface de coulées boueuses riches en fluides, sont depuis longtemps étudiés à terre et en mer. L'étude des volcans de boue est digne d'intérêt à plus d'un titre : au niveau scientifique d'abord par la quantité importante d'informations sur le sous sol et les profondeurs, au niveau économique ensuite par le fait que ces volcans peuvent être associés à la présence de ressources naturelles (gaz méthane dans le cas du Pakistan par exemple), au niveau touristique et environnemental (cas de la vallée de Buzeau, en Roumanie). Si un champ de volcans de boue peut atteindre un diamètre de quelques dizaines (voire une à deux centaines) de mètres, les volcans ont en général un diamètre de 1 à une dizaine de mètres trop réduite par rapport au pixel d'une image satellitale faible ou moyenne résolution. On peut alors s'interroger sur l'opportunité ou de la faisabilité de l'étude des zones de volcans de boue à partir de l'imagerie satellitale, notamment l'imagerie faible ou moyenne résolution. Le présent article montre qu'il est cependant possible de mettre en évidence des phénomènes de faible étendue (1 à quelques pixels) à partir de l'imagerie satellitale, moyennant des traitements appropriés.

Jusqu'à ces dernières années, l'imagerie faible et moyenne résolution est utilisée pour la localisation ou le suivi de phénomènes de grandes étendue (suivi de la végétation, phénomènes d'érosion, environnements urbains, etc..). Les phénomènes de faible étendue (de l'ordre de quelques pixels, voire quelques dizaines de pixels) n'ont pas fait l'objet d'études basées sur les traitement et l'interprétation de l'image satellitale. Pourtant, des anomalies particulières dans un contexte spécifique (foyer d'incendie, par exemple) peuvent être discernées même si elles n'occupent que l'espace de quelques pixels dans une image faible résolution. Nous montrons dans le présent article qu'il est possible, et intéressant, d'utiliser des images SPOT ou ASTER, moyennant des traitements spécifiques, pour l'étude de phénomènes de faible étendue.

Introduction

Les volcans de boue résultent de l'extrusion en surface de coulées boueuses riches en fluides. Ils sont généralement formés dans les zones de faiblesse de la croûte terrestre. Le phénomène



Fig. 1. Localisation des zones de volcanisme boueux dans le monde.

se produit lorsque le gaz trouve un passage à la surface. Mais un volcan de boue n'est pas seulement un drain de dégazage ; il peut aussi être une structure géologique active, avec une déformation de sa surface et des émissions de boue subactuelles.

Les volcans de boue sont associés à des dépôts sédimentaires anciens, à la présence de gaz organique à partir de dépôts d'hydrocarbures et à l'existence de fortes pressions internes qui ont tendance à pousser les gaz vers l'extérieur. C'est ainsi qu'ils sont souvent considérés comme un signe visible de la présence de réserves d'huiles et de gaz.

Plusieurs raisons ont poussé les scientifiques à étudier les volcans de boue à terre et en mer, principalement au sein des marges actives mais également sur les marges passives fortement sédimentées. Parmi ces raisons, nous citerons :

- leur importance potentielle dans de nombreux domaines : stabilité des marges continentales (déstabilisations sédimentaires, risques sismique), variations climatiques à plus ou moins long terme (dégagement de gaz à effet de serre dans l'hydrosphère et l'atmosphère), évolution des communautés biologiques profondes

- leur intérêt économique notamment comme indicateurs de la présence et du com-

portement des hydrocarbures en offshore profond, ainsi qu'à travers le stockage d'une quantité de méthane importante sous forme d'hydrates de gaz, pouvant représenter une source énergétique potentielle

- leur intérêt commercial pour l'exploitation touristique des zones de volcans de boue.

Les volcans de boue sont présents dans de nombreuses régions du globe, en mer comme sur les continents ; citons notamment : la mer méditerranée (Cita et al., Limonov et al.; Woodside et al. ; Robertson et al.), la Crimée, l'Azerbaïdjan (Hovland et al. ; Fowler et al.), le Turkménistan et l'Iran (Wiedicke et al.), l'Océan indien, l'Indonésie, etc.. La figure 1 ci-contre montre la plupart des sites de volcans de boue dans le monde.

En mer, ils sont étudiés par des méthodes bathymétriques et d'imagerie acoustique, tel le volcan de boue Hakon Mosby (HMMV) lors de la campagne ARKTIS XIX du Polarstern en juillet 2003 ; le traitement des données obtenues (Edy et al, 2004) permet, en particulier, de délimiter plusieurs coulées de boue. Sur la terre ferme des méthodes d'investigation classiques à partir de mesures terrain sont utilisées.

En Roumanie, la région de Vrancea, à la courbure des Carpates (figure 2), est le siège de volcans de boue étudiés depuis de nom-

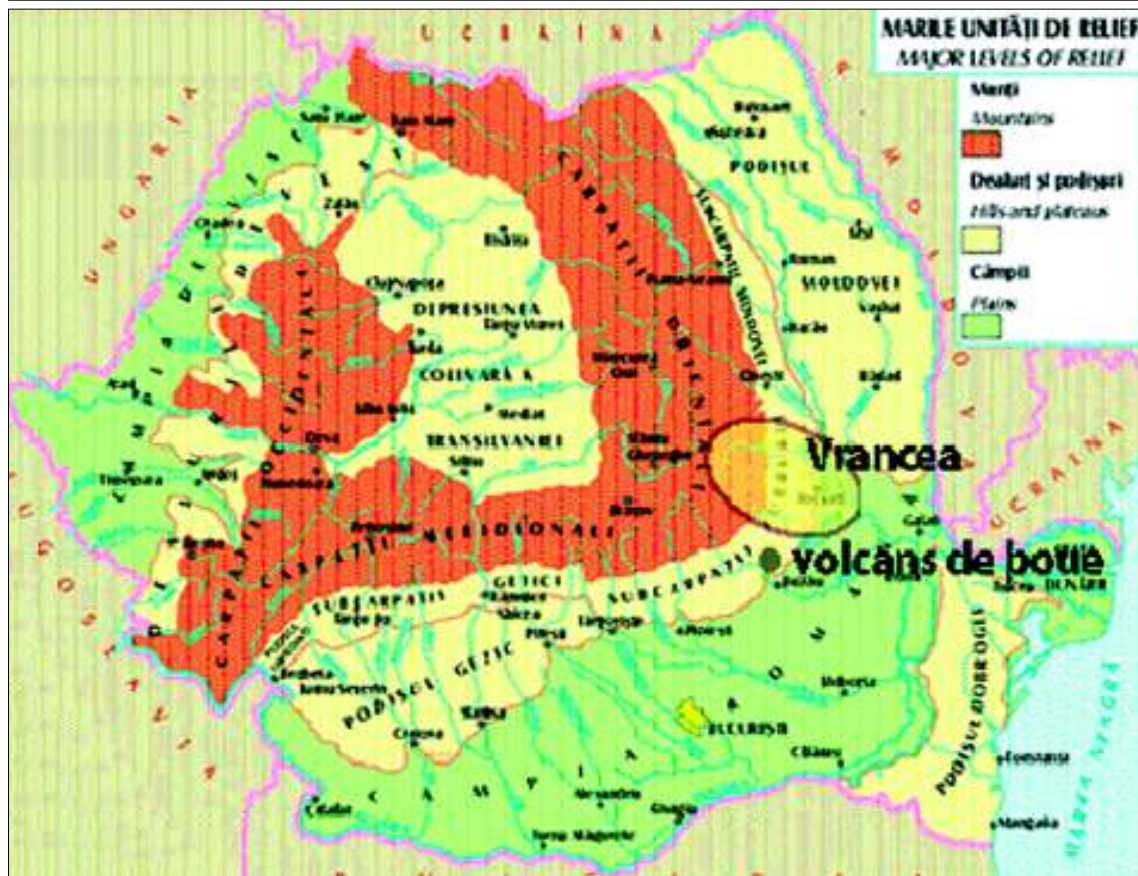


Fig. 2. La région de Vrancea et la région de volcans de boue en Roumanie.

breuses années (Badea et al.). La présente étude a pour objectif d'examiner l'opportunité de l'utilisation de l'imagerie satellitale pour la localisation et le suivi des zones de volcans de boue ; notre terrain d'étude est la zone de Buzeau ; nous utilisons trois sources de données : une image ASTER de 15 mètres de résolution prise en 2001, une image LANDSAT / TM de 30 mètres de résolution de 1988 et une photographie aérienne de 1985.

Présentation la zone d'étude

La région de Vrancea est riche en ressources minières, pétrolières et en gaz. La présence de faille favorise l'existence de phénomène de volcanisme boueux. Cette région est également exposée aux risques naturels comme beaucoup de régions en Roumanie. Située à la limite de trois unités tectoniques, elle est le siège de 95% des tremblements de terre en Roumanie (Van Hove, 2004). Citons à titre d'exemple les tremblements de terre de 1940 de magnitude

7.3, celui de 1977 de magnitude 7.2, celui de 1986 de magnitude 6.9 et celui de 1990 avec une magnitude de 7.1 sur l'échelle de Richter. La figure 2 situe la zone de Vrancea et la zone de volcanisme boueux.

Les volcans de boue de la région de Vrancea sont situés sur deux plateaux (Pâclele Mici et Pâclele Mari) alignés sur une large faille transversale d'orientation NNE-SSW. Ces volcans sont localisés au centre d'une dépression bordée par deux Cuestas, à l'ouest et à l'est, marquant les flancs de l'anticlinal Berca-Arbanasi. La figure 3, réalisée à partir d'un mosaïcage et d'un habillage de cartes géologiques de 1968 et 1969 au 1/200.000°, illustre la position particulière des deux volcans de boue (en bleu sur la figure 3) sur la faille (en rouge). Les deux zones de volcans s'étendent sur un territoire d'environ 200 mètres de diamètre pour la zone Nord et 300 mètres de diamètre pour la zone Sud.

Les documents utilisés et les premiers

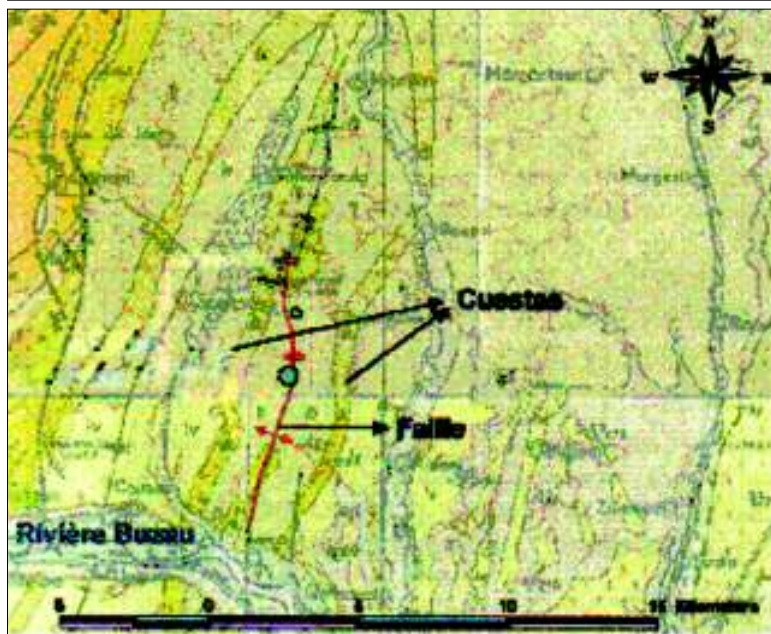


Fig. 3. Situation des volcans de boue en Roumanie : sur une faille , entre deux cuestas

traitements

Suivre l'évolution d'un phénomène naturel suppose d'en avoir une vue à plusieurs dates, donc utiliser des documents multi dates ayant des caractéristiques différentes (résolutions spatiale et spectrale, géométrie, facteur de bruit, etc..). Comme les images haute résolution spatiale ne sont disponibles que depuis peu, nous examinons la possibilité d'extraire suffisamment d'informations utiles à partir d'images moyenne ou faible résolution. Nous avons ainsi traité une image Aster de 2001 acquise dans le cadre du projet de recherche partagée sur les géorisques en Roumanie financé par l'Agence Universitaire de la Francophonie, une image Landsat/TM de 1988, et des photographies aériennes de 1995 également acquises dans le cadre du projet de recherche partagée.

Pour l'image Aster nous n'avons considéré pour cette étude que les canaux VNIR couvrant le visible et le proche IR avec une résolution de 15 mètres ; les canaux SWR et TNIR ont été écartés dans ce travail à cause de leur faible résolution spatiale relativement à l'étendue du phénomène étudié. Nous avons commencé par des traitements classiques (composition colorée, analyse en compo-

santes, analyse de texture). Nous présentons ici les seuls résultats concernant l'image ASTER.

La figure 4 montre trois traitements classiques sur la composante VNIR (3 bandes) d'un extrait de l'image Aster. Sur la composition colorée, on arrive déjà à localiser les 2 volcans nord et sud avec, sur chacun, les zones actives les plus importantes ; le réseau de coulée de boue à l'intérieur de la zone de volcans n'est pas discernable (faiblesse du contraste).

Un stretch de l'image accentue les détails au niveau des zones actives et permet de distinguer un peu plus nettement les coulées de boue sur la périphérie des volcans.

Un filtre passe haut fait apparaître les micro contours et les formes linéaires. Au niveau des deux volcans, et de façon plus nette pour le volcan sud, nous constatons un grand nombre de micro contours, signe d'une grande hétérogénéité et, probablement, d'une activité qui n'était pas discernable par les traitements précédents. Dans l'analyse en composantes principales, seule le premier néo canal est intéressant. Cependant, nous n'avons pas d'éléments significatifs nouveaux par rapport à ce qui précède.

La figure 5 montre les résultats de l'analyse

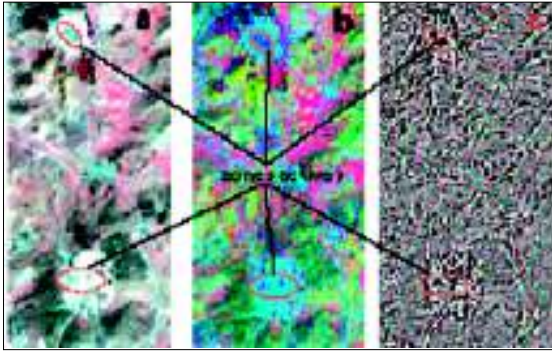


Fig. 4. Composition colorée, étalement dynamique et filtre sur image Aster VNIR

de texture sur la composante VNIR de l'image.

Ce traitement accentue de façon appréciable les détails au niveau des deux volcans. On voit ainsi que la texture de la surface n'est pas homogène. Cela peut être un estimateur de l'activité du volcan. Une absence d'activité se traduirait par une homogénéité plus grande de la surface et réciproquement.

Amélioration de l'analyse par le concept de « clonage »

Présentation. Rappelons qu'une image satellitale est constituée d'une série de N bandes (ou canaux) ; chaque bande est, en réalité, une vue du territoire imagé dans une région spécifique du spectre électromagnétique ; toutes les bandes d'une même image concernent le même territoire vu au même moment ; chaque bande est également constituée d'un ensemble de « pixels », réponse d'une portion élémentaire du territoire à l'excitation du rayonnement solaire ; la taille d'un tel élément dépend de deux facteurs principaux les propriétés optiques de l'imageur et la distance sol-imageur ; la réponse enregistrée par l'imageur est une combinaison des réponses des divers constituants du pixel ; plus le nombre de ces constituants est élevé plus cette réponse s'éloigne de celle d'un objet géographique « pur » ; enfin, plus un constituant aura une réponse propre élevée, et plus la réponse du pixel tendra vers celle de ce constituant ; ainsi, la réponse du pixel de la figure 7 sera obtenue par :

$$R_p = S_{élé}R_{élé} + S_{cont}R_{cont} \quad [1]$$

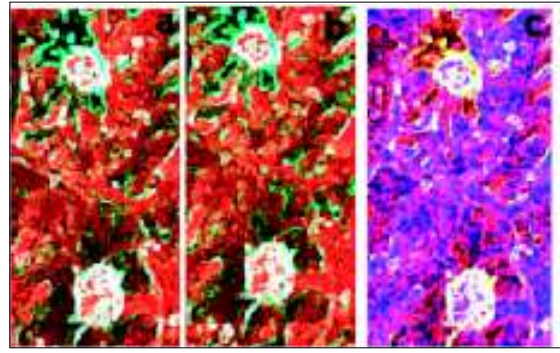


Fig. 5. Extrait des résultats de l'analyse de texture sur l'image Aster

dans cette formule, R désigne l'intensité du signal d'un élément et S sa superficie ; nous désignerons également par contraste d'un élément par rapport à son contexte, la différence absolue entre l'intensité du signal de l'élément et l'intensité du signal issu du contexte pris comme référence.

Si l'on se place dans le cas :

$$S_{élé} + R_{élé} - S_{cont} \cdot R_{cont} > \lambda > 0 \quad [2]$$

où λ est une valeur seuil dépendant entre autre de la dynamique de l'image alors la réponse de l'élément est « perceptible » par rapport à son contexte et l'élément est discernable.

Si maintenant l'on se place dans le cas :

$$S_{élé} + R_{élé} \gg S_{cont} \cdot R_{cont} \quad [3]$$

alors, la réponse de l'élément est prédominante, celle du contexte est pratiquement masquée et la réponse résultante du pixel sera confondue avec celle de l'élément « rouge » et le contexte ne serait pas vu. Nous raisonnons ainsi sur le produit $S \cdot R$ de la surface (relative) par la réponse radiative d'un élément de paysage. Cela signifie que la discernabilité d'un élément donné du paysage est augmentée par la réponse radiative, certes, mais aussi par sa surface relative (rapport de la surface de l'élément à la surface du contexte).

De la même façon, et dans le cas d'une image (plus exactement un canal donné d'une image), un pixel (entendons par là, la réponse

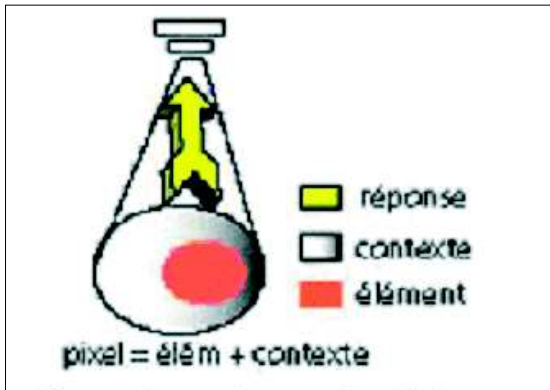


Fig. 6. Représentation de la réponse d'un élément de paysage

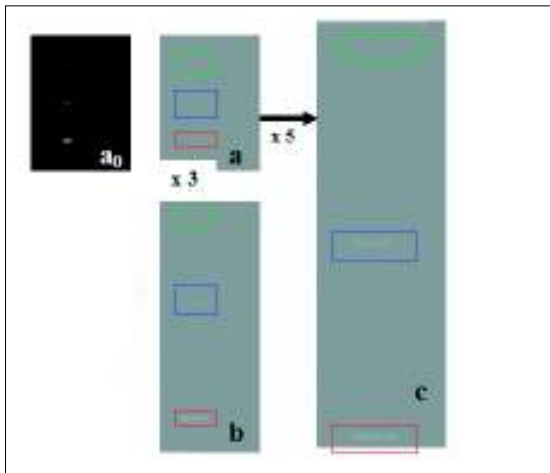


Fig. 8. Opération de clonage sur une image de synthèse simple

combinée des constituants du pixel) sera discernable si sa réponse est suffisamment importante par rapport à son contexte (réponses des pixels voisins); ainsi le sur la figure 8, le pixel 2 sera plus discernable que le pixel 1 ; dans le cas contraire, un élément de paysage sera discernable si son étendue spatiale est importante (elle occupe ainsi plusieurs pixels) comme cela est illustré par l'élément 3 de la figure 7.

Si nous considérons maintenant une image, avec une dynamique donnée pour laquelle certains éléments de paysage ne sont pas «visibles» malgré un processus d'amélioration (cela peut être dû au fait que ces éléments de paysage ont une faible étendue, donc occupent un nombre réduit de pixels), on peut imaginer qu'un zoom sur image amènerait une vision plus fine où l'on distinguerait les éléments cachés jusqu'alors. L'opération de zoom classique consiste en fait à augmenter la

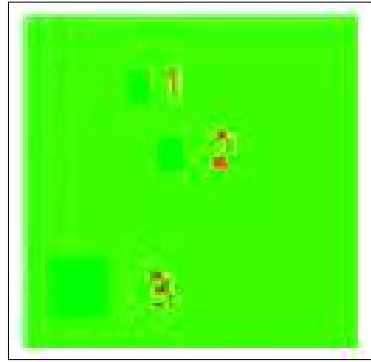


Fig. 7. La discernabilité d'un élément de paysage dépend de l'intensité du signal qu'il renvoie vers

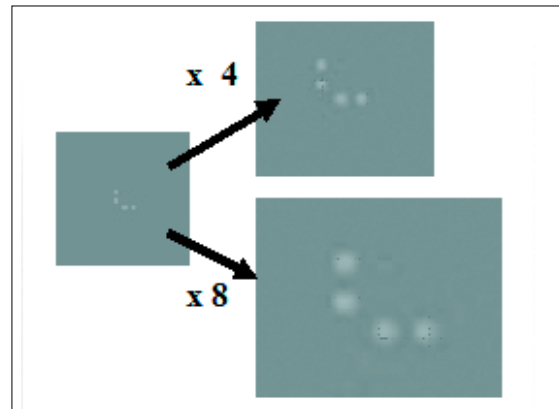


Fig. 9. Application de l'algorithme de clonage par des facteurs 4 et 8 sur une image de synthèse simple

dimension des pixels d'où une sensation de flou dès que l'on dépasse un facteur d'agrandissement. L'idée que nous introduisons consiste plutôt à « cloner » les pixels et les multiplier ; on obtient ainsi l'effet de la zone 3 sur la figure 7 ; le pixel 1 a été cloné par un facteur 2 et donc remplacé par un ensemble de $2 \times 2 = 4$ pixels identiques ; l'élément de paysage représenté par le pixel 1 occupe alors une plus grande surface apparente et devient discernable malgré son faible contraste.

Premiers résultats

Image de synthèse :

La méthode de clonage est d'abord testée sur des images de synthèse créée à partir d'un logiciel de traitement d'images classique, en l'occurrence Idrisi 32. Sur la figure 8 l'image (a) est l'image initiale créée avec une valeur de 146 sur une échelle de tons de gris allant

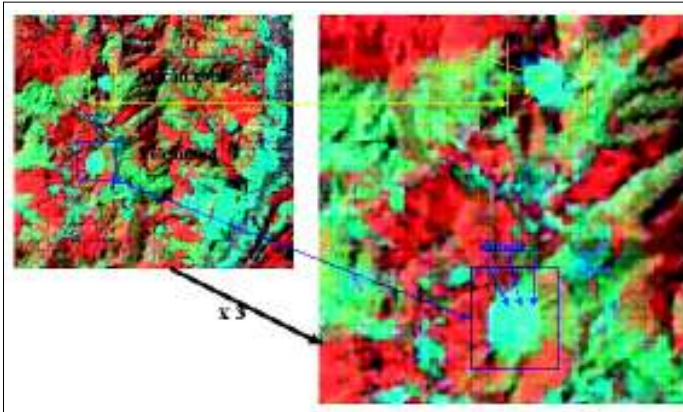


Fig. 10. Effet de clonage par un facteur 4 d'un extrait de l'image Landsat TM

de 0 à 255 ; sur cette image sont créés trois objets linéaires de même longueur et de valeurs respectives 148 mis en évidence par le cercle vert, 150 (rectangle bleu) et 155 (rectangle rouge) sur les niveaux de gris ; sur cette image seul le trait de niveau de gris 155 commence à être discerné ; c'est le seul objet de l'image qui vérifie la condition [2] ; les deux autres ne sont pas visibles à cause de leur trop faible contraste par rapport au fond (contexte). L'image b représente un clonage par un facteur 3 ; le trait de niveau 150 apparaît déjà (la condition [2] est maintenant vérifiée grâce à une augmentation du terme S dans la condition) mais pas celui de niveau de gris 148 ; enfin sur l'image c, qui représente un clonage par un facteur 5, les trois niveaux de gris sont maintenant visibles. L'image a_0 représente un étalement très fort de la dynamique possible sur cette image à cause de sa dynamique particulière.

La figure 9 confirme ces résultats pour un objet de forme géométrique différente ; l'opération de clonage a bien sur conservé la forme en la rendant plus discernable sans amener l'effet de flou caractéristique sur une opération de zoom classique.

Image Landsat :

L'image est de faible résolution et ne paraît donc pas adaptée pour l'étude de faible étendue ; cependant, si l'on désire suivre l'évolution du phénomène, elle demeure le seul outil capable de nous fournir un historique car on ne

dispose pas forcément d'images (ou de photographies) de meilleure résolution et plus anciennes.

La figure 10 montre un clonage par un facteur 3 d'un extrait de la composition colorée de l'image Landsat ; plusieurs détails, qui n'apparaissent pas sur l'image originale, sont visibles sur le clone, notamment au niveau des deux volcans. Ces détails concernent les parties actives des volcans qui ont un niveau de gris (ou de couleur) légèrement différent de celui du contexte ; les coulées de boue apparaissent également très légèrement en objets linéaires. Les niveaux de détails restent néanmoins assez faibles compte tenu de la résolution de l'image et des dimensions réelles des phénomènes observés. Ceci montre que, même sur une image faible résolution, des phénomènes de faible étendue (activité au sein du volcan : réseau de coulée de boue par exemple) peuvent être mis en évidence moyennant des traitements adéquats.

L'image Aster :

La figure 11 illustre les résultats de l'application de l'opération de clonage d'abord sur une composition colorée de l'image Aster, puis sur cette même image transformée par des opérations de stretch, d'application de filtres (ici un filtre passe haut) ou d'analyse texturale (schéma de la figure 12).

La figure 11.a nous montre l'apparition de détails qui n'étaient pas visibles sur l'image originale : forme des zones actives accentuée,

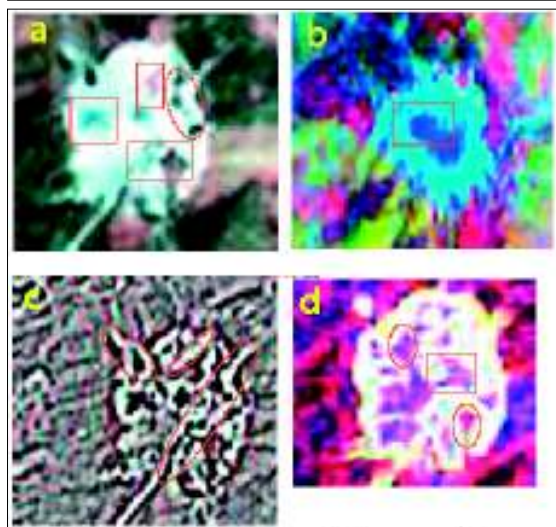


Fig. 11. Opération de clonage sur les résultats de traitements classiques de l'image Aster VNIR

coulées de boue, autres zones actives. Il va de soi que nous ne nous intéressons pas ici à la quantification de la superficie par une méthode classique de comptage de pixel et de conversion en surface (notons au passage que, conformément à l'analyse du paragraphe 4.1, même pareil calcul n'est qu'approximatif) ; notre objectif est ici de mettre en évidence l'activité du phénomène de volcanisme boueux et, éventuellement de suivre l'évolution de son intensité dans le temps. Comme les étendues sont dilatées par l'opération de clonage, l'estimation de surface devra introduire un facteur correctif, inverse du carré du facteur de clonage.

La figure 11.b correspond à un clonage après étalement de la dynamique ; les traces de coulées de boue ne sont pas apparentes ici mais d'autres détails sont mis en évidence.

La figure 11.c, amplifie la mise en évidence des micro contours ; en particulier elle rend visibles le réseau de coulée de boue dans le volcan.

La figure 11.d est intéressante; elle amplifie l'étendue de la différence de texture; quatre classes de texture apparaissent ainsi pour le volcan sud; cette différence de texture traduit l'hétérogénéité de la surface causée par l'activité du phénomène de volcanisme boueux de la zone étudiée. Le réseau de coulée de boue n'est pas directement observable sur cette

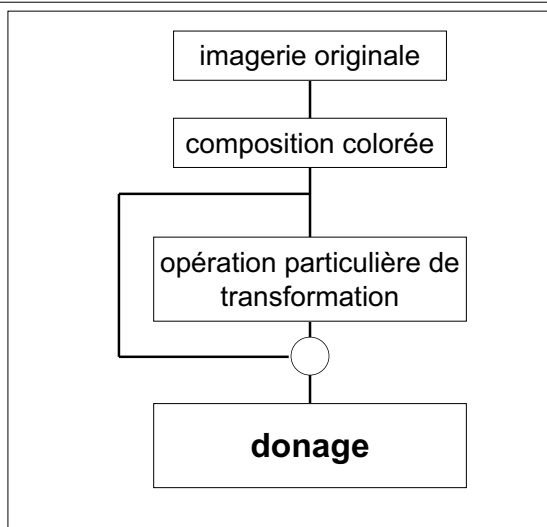


Fig. 12. Schéma synthétique de la chaîne de traitement

image.

La photographie aérienne :

Des trois documents, la photographie aérienne est celle qui a la meilleure résolution; elle fournira donc le plus de détails. Nous constaterons cependant que, dans une première analyse, le cratère du volcan (ici, le volcan sud) n'apparaît pas avec beaucoup de détails à cause de la dynamique de l'image ; la surface est quasiment d'apparence homogène, exceptés quelques détails grossiers que l'on pourrait mettre en évidence par un étalement de dynamique par exemple. Afin d'en améliorer le contraste, nous commençons par lui appliquer un stretch photographique (figure 13.b) qui a pour effet de mettre en évidence de manière plus marquée le volcan et de faire apparaître certains détails à peine discernables sur l'image originale comme la tache sombre en bas à droite du volcan qui devrait correspondre à une zone d'activité. Le clonage par un facteur 4 (figure 13.c) fait apparaître des détails que nous ne pouvions pas soupçonner au départ : deux zones actives apparaissent maintenant de manière très claire ; il en est de même des coulées de boue dont on voit le tracé de manière très nette ; en réalité, tout le réseau de collecte de la coulée de boue est mis en évidence et l'on peut pratiquement élaborer une carte de l'activité du volcan.

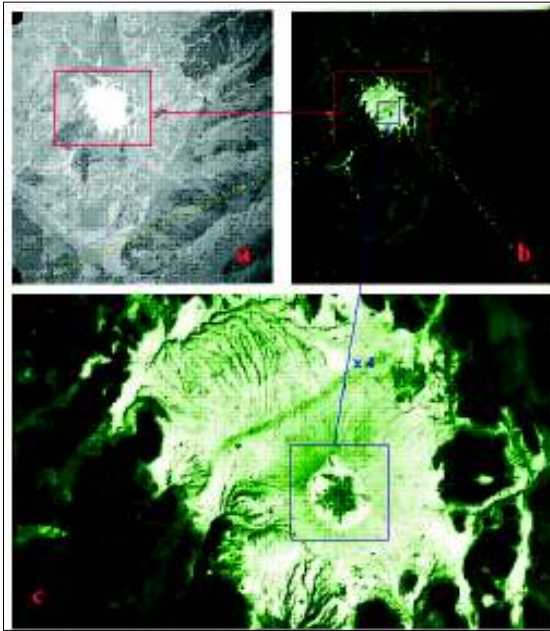


Fig. 13. Application de l'algorithme de clonage à un extrait de photographie aérienne.

Conclusion

Les phénomènes naturels de faible étendue ne sont pas étudiés à partir d'imagerie satellitales; les images faible ou moyenne résolution ne font pas apparaître les détails utiles par les traitements conventionnels; et les images hautes résolution sont encore relativement chères, elles ne sont pas disponibles pour des périodes anciennes et peuvent apparaître non justifiées pour des territoires accessibles pour des études terrain. La présente étude montre que l'utilisation de l'image faible ou moyenne résolution est exploitable pour ce type de phénomènes, notamment si l'on effectue une reconstitution multi date du phénomène. Les traitements conventionnels permettent déjà de mettre en évidence certains aspects; l'opération de clonage améliore très sensiblement l'analyse.

Les résultats de l'opération de clonage sur les photographies aériennes montre que cet algorithme est également applicable dans le cas d'images haute résolution.

Remerciements

Les images utilisées pour ce travail ont été acquises dans le cadre d'un projet de recherche partagée du Réseau thématique de télédétection entre les universités de Bucarest, Paris 12 et Liège. Une mission terrain a également eu lieu dans ce cadre sur le site des volcans de boue de la zone de Buzeau.

Nous remercions l'Agence Universitaire de la Francophonie pour ce financement.

REFERENCES

- BADEA L. et BU D., 1971 : *La dépression boutonnière de Berca et ses volcans de boue*. Revue Roumaine de Géologie, Géophysique et Géographie ; tome 15, n°2 : 145-152.
- CITA MB, RYAN WBF and PAGGI L, 1981: *Prometheusmud breccia. An example of shale diapirism in the Western Mediterranean Ridge*. Annales Géologiques des Pays Helléniques 30 : 543-569.
- FOWLER SR, MIDENHALL J., ZALOVA S., RILEY G., ELSEY G., DESPLANQUES A. and GULIYEV F., 2000: *Mud volcanoes and structural development on Shah Deniz*. Journal of Petroleum Science and Engineering 28: 189-206.
- HOVLAND M., HILL A. and STOKES D., 1997: *The structure and geomorphology of the Dashgil mud volcano, Azerbaïdjan*. Geomorphology 21: 1-15.
- LIMONOV AF, WOODSIDE JM, CITA MB and IVANOV MK, 1996: *The Mediterranean Ridge and related mud diapirism: a background*. Marine Geology 132 : 7-19.
- VAN HOVE J. Et al., 2004 : *Post-seismic Deformation in the Vrancea Region, Romania*. Publié sur site Internet : http://www.ecgs.lu/pdf/jlg92/JLG92_vanHove.pdf , 2 pages
- ZITTER Tiphaine AC, 2004: *Mud volcanism and fluid emissions in Eastern Mediterranean neotectonic zones*. Thesis / PhD (23 March 2004), Department of sedimentology and marine geology, Vrije Universiteit Amsterdam, Pays-Bas.

- (1) Département de géographie ; UFR LSHS Université Paris 12 -61,
avenue du Général de Gaulle ; 94010 Créteil
(2) Faculté de Géographie Université de Bucarest
(3) Département de Géomorphologie Université de Liège
Courriel(1): abdellaoui@univ-paris12.fr, benblidia@yahoo.com

Al XXI-lea Simpozion național de geomorfologie Sfântu Gheorghe, Delta Dunării, 27–30 mai 2004

Asociația Geomorfologilor din România (Președinte Prof. Emil Vespremeanu), în colaborare cu Facultatea de Geografie de la Universitatea din București, Stațiunea de Cercetări Marine și Fluviale Sfântu Gheorghe a Universității din București și cu Institutul de Geografie al Academiei Române, a organizat, la Sfântu Gheorghe (Delta Dunării), cel de al XXI-lea Simpozion Național de Geomorfologie, cu tema: **Relieful României sub incidența factorilor induși de schimbările globale**. La aceasta s-a adăugat tema mesei rotunde și aplicația de teren: **Relieful costier din România — forme, morfogeneza, morfodinamică**.

Ineditul simpozionului l-au constituit aplicațiile practice care s-au desfășurat în fiecare zi, după sesiunea de comunicări în: Insula Sacalin (Hidrodinamica gurii de vărsare a brațului Sfântu Gheorghe și evoluția Insulei Sacalin — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu-Stroe, Ștefan Constantinescu); sistemul plajă–dune dintre Sf. Gheorghe și Sulina (Comportamentul multianual al sistemului plaja-dune pe țărmul Sf. Gheorghe–sud de Sulina — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu Stroe, Ștefan Constantinescu, Luminița Preoteasa). În ultima zi, aplicația s-a făcut pe traseul de întoarcere: brațul Sf. Gheorghe, canalele Isacova-Litcov, Crișan pe br. Sulina, lacul Fortuna, brațul Sulina, Tulcea.

Majoritatea comunicărilor s-au înscris în tematica largă a metodelor și tehnicilor de cercetare cu aplicații la relieful României:

Utilizarea Tehnicii cu Cesium-137 în studiile de sedimentare (Ionița I., Mărgineanu R.), *Metoda dendrocronologică. Utilizare în geoecologie și geomorfologie* (Vuia F.), *Rolul factorilor climatici în declanșarea deplasărilor în masă. Aplicație GIS în Subcarpații Buzăului* (Micu M., Cheval S., Dragne Dana), *Influence des erreurs sur les MNT dans les études de risque* (Roussaux F., Grecu Florina), *Utilizarea metodei dendrocronologice în analiza avalanșelor. Studiu de caz — Abruptul prahovean al Bucegilor* (Voiculescu M., Vuia F.), *Calculul transportului de sedimente efectuat de curenți în lungul țărmului deltaic danubian* (Vespremeanu Stroe A.), *Utilizarea tehnicilor G.I.S. pentru evaluarea potențialului natural și construit. Studiu de caz: Municipiul Suceava* (Crăciunescu V., Berteza Gabriela), *Analiza prin tehnici G.I.S. a morfologiei sectorului de confluență Olt–Dunăre* (Filip F., Constantinescu Ș.), *Aplicații ale analizei Change Detection în studiul morfodinamicii actuale în Munții Postăvaru–Piatra Mare–Clăbucetele Predealului* (Mihai B., Șandric I.), *Rolul cartografierii geomorfologice în identificarea hazardelor naturale* (Rădoane N.), *Considerații asupra morfometriei bazinului Casimcea pe baza utilizării tehnicilor G.I.S.* (Flueraru C.), *Caracterizarea geomorfologică a modelului numeric altimetric al reliefului cu rezoluția de 10 metri* (Tudose C., Din D.)

Cea mai mare parte a lucrărilor au fost publicate în *Revista de geomorfologie* vol. 6/2004

Laura COMĂNESCU

Al XXI-lea Simpozion național de geomorfologie Oradea, 7–8 aprilie 2006

În perioada 7 – 8 aprilie 2006 a avut loc la Oradea, al XXII-lea Simpozion Național de Geomorfologie, în organizarea Asociației Geomorfologilor din România și a Universității din Oradea, Facultatea de Istorie – Geografie, Departamentul de Geografie, Turism și Amenajarea Teritoriului.

Cuvânt de deschidere au rostit: prof. univ. dr. Teodor Traian Maghiar, Rectorul Universității din Oradea, prof. univ.dr. Emil Vespremeanu, Președintele Asociației Geomorfologilor din România și prof.univ. dr. Nicolae Josan, organizatorul simpozionului.

Simpozionul desfășurat sub genericul

Relieful și Amenajarea Teritoriului a avut trei importante obiective:

1. Sesiunea de comunicări a debutat cu trei prezentări susținute în plen de către prof.dr.docent Grigore Posea – Președinte de onoare al A.G.R. (*Glacisurile din Câmpia de Vest*), prof.univ.dr. Ion Mac (*Morfosecvențe microscalare, suporturi pentru amenajări teritoriale*), prof.univ.dr. Emil Vespremeanu (*Din nou despre geomorfologia bazinului Mării Negre*) (ambii ex- președinți A.G.R.).

Cele circa 50 de lucrări, de înalt nivel științific, au fost grupate pe două mari secțiuni (*Relieful și amenajarea teritoriului și Procese geomorfologice*), în care au fost abordate subiecte atât teoretice cât și practice referitoare la geomorfologia întregii țări, predominând însă cele asupra Transilvaniei.

2. Aplicația practică (8 aprilie) s-a desfășurat pe traseul Oradea – Uileacu de Criș – Vadul Crișului – Șuncuiș – Oradea cu expuneri asupra problemelor: terase, glacisuri, procese actuale, amenajări hidrotehnice ale Crișului Repede la Luncaș și Tileagd, evoluția rețelei hidrografice, contactul Munților Plopiș cu Dealurile Oradiei. Aplicația de teren a continuat cu vizitarea peșterii Ungurului (recent amenajată) și servirea mesei la Șuncuiș, (*Pensiunea Perla Albastră*).

3. Cel de-al treilea obiectiv l-a constituit alegerea Consiliului Executiv al A.G.R. în cadrul Adunării Generale a A.G.R. În urma alegerilor componența consiliului este:

• **Președinte:** prof. Nicolae Josan (Universitatea din Oradea),

• **Vicepreședinți:** prof. Adrian Cioacă (Universitatea „Spiru Haret” - Bucurști), prof. Ion Ioniță (Universitatea „A.I. Cuza” - Iași), prof. Virgil Surdeanu (Universitatea „Babeș-Bolyai” – Cluj Napoca),

• **Secretar general:** prof. Florina Grecu (Universitatea din București),

• **Trezorier:** lect. dr. Marian Ene (Universitatea din București).

• **Membrii:** prof. Maria Rădoane (Universitatea „Ștefan cel Mare” - Suceava), prof. Petre Urdea (Universitatea de Vest - Timișoara), prof. Emil Vespremeanu (Universitatea din București), conf. Ioan Aurel Irimuș (Universitatea „Babeș-Bolyai” – Cluj Napoca), lect. drd. Stelian Nistor (Universitatea din Oradea).

Cel de-al XXII-lea simpozion de geomorfologie desfășurat la Oradea s-a detașat de cele anterioare prin participarea efectivă (numerică și calitativă) a tinerilor colegi, cu comunicări ce se înscriu în problematica actuală a cercetării geomorfologice mondiale, bazate pe rezultate experimentale și pe utilizarea tehnicii moderne de realizare și prezentare. Subliniem de asemenea efortul gazdelor pentru excelența și eleganta organizare, pentru asigurarea unui sejur instructiv în cetatea bihoreană, cu profunde semnificații istorice și geografice -Oradea.

Florina GRECU

RECENZII

• Florina GRECU (ed.), *Lucrări și rapoarte de cercetare (Research papers and reports)*, vol. I, Editura Universității din București, 2005, 218 pages.

This first volume of *Research papers and reports*, which presents the activity of the Research Centre for Land Degradation and Geomorphological Dynamics, includes eight summaries of studies made under the research

grants obtained from the National Research Council for Higher Education (NRCHE) and the Ministry of Education and Research (MER) in collaboration with partners from Cemagref-Lyon, Cemagref-Grenoble (France) and the Liège University (Belgium). The Acts of the Research Centre, recognised by NRCHE, are also appended.

Some of the summaries reflect the contribution of geographical research to such phenomena as

**Al XXI-lea Simpozion național de geomorfologie
Sfântu Gheorghe, Delta Dunării, 27–30 mai 2004**

Asociația Geomorfologilor din România (Președinte Prof. Emil Vespremeanu), în colaborare cu Facultatea de Geografie de la Universitatea din București, Stațiunea de Cercetări Marine și Fluviale Sfântu Gheorghe a Universității din București și cu Institutul de Geografie al Academiei Române, a organizat, la Sfântu Gheorghe (Delta Dunării), cel de al XXI-lea Simpozion Național de Geomorfologie, cu tema: **Relieful României sub incidența factorilor induși de schimbările globale**. La aceasta s-a adăugat tema mesei rotunde și aplicația de teren: **Relieful costier din România — forme, morfogeneza, morfodinamică**.

Ineditul simpozionului l-au constituit aplicațiile practice care s-au desfășurat în fiecare zi, după sesiunea de comunicări în: Insula Sacalin (Hidrodinamica gurii de vărsare a brațului Sfântu Gheorghe și evoluția Insulei Sacalin — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu-Stroe, Ștefan Constantinescu); sistemul plajă–dune dintre Sf. Gheorghe și Sulina (Comportamentul multianual al sistemului plaja-dune pe țărmul Sf. Gheorghe–sud de Sulina — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu Stroe, Ștefan Constantinescu, Luminița Preoteasa). În ultima zi, aplicația s-a făcut pe traseul de întoarcere: brațul Sf. Gheorghe, canalele Isacova-Litcov, Crișan pe br. Sulina, lacul Fortuna, brațul Sulina, Tulcea.

Majoritatea comunicărilor s-au înscris în tematica largă a metodelor și tehnicilor de cercetare cu aplicații la relieful României:

Utilizarea Tehnicii cu Cesium-137 în studiile de sedimentare (Ionița I., Mărgineanu R.), *Metoda dendrocronologică. Utilizare în geoecologie și geomorfologie* (Vuia F.), *Rolul factorilor climatici în declanșarea deplasărilor în masă. Aplicație GIS în Subcarpații Buzăului* (Micu M., Cheval S., Dragne Dana), *Influence des erreurs sur les MNT dans les études de risque* (Roussaux F., Grecu Florina), *Utilizarea metodei dendrocronologice în analiza avalanșelor. Studiu de caz — Abruptul prahovean al Bucegilor* (Voiculescu M., Vuia F.), *Calculul transportului de sedimente efectuat de curenți în lungul țărmului deltaic danubian* (Vespremeanu Stroe A.), *Utilizarea tehnicilor G.I.S. pentru evaluarea potențialului natural și construit. Studiu de caz: Municipiul Suceava* (Crăciunescu V., Berteza Gabriela), *Analiza prin tehnici G.I.S. a morfologiei sectorului de confluență Olt–Dunăre* (Filip F., Constantinescu Ș.), *Aplicații ale analizei Change Detection în studiul morfodinamicii actuale în Munții Postăvaru–Piatra Mare–Clăbucetele Predealului* (Mihai B., Șandric I.), *Rolul cartografierii geomorfologice în identificarea hazardelor naturale* (Rădoane N.), *Considerații asupra morfometriei bazinului Casimcea pe baza utilizării tehnicilor G.I.S.* (Flueraru C.), *Caracterizarea geomorfologică a modelului numeric altimetric al reliefului cu rezoluția de 10 metri* (Tudose C., Din D.)

Cea mai mare parte a lucrărilor au fost publicate în *Revista de geomorfologie* vol. 6/2004

Laura COMĂNESCU

**Al XXI-lea Simpozion național de geomorfologie
Oradea, 7–8 aprilie 2006**

În perioada 7 – 8 aprilie 2006 a avut loc la Oradea, al XXII-lea Simpozion Național de Geomorfologie, în organizarea Asociației Geomorfologilor din România și a Universității din Oradea, Facultatea de Istorie – Geografie, Departamentul de Geografie, Turism și Amenajarea Teritoriului.

Cuvânt de deschidere au rostit: prof. univ. dr. Teodor Traian Maghiar, Rectorul Universității din Oradea, prof. univ.dr. Emil Vespremeanu, Președintele Asociației Geomorfologilor din România și prof.univ. dr. Nicolae Josan, organizatorul simpozionului.

Simpozionul desfășurat sub genericul

nelle università d'Italia (Bari, Modena, Roma)

- dei dottorati in collaborazione o la preparazione del dottorato sotto la guida di alcuni specialisti d'Italia
- l'elaborazione di alcuni libri in collaborazione
- l'elaborazione di alcuni articoli in collaborazione e l'accesso alla pubblicazione dei geomorfologi rumeni nelle pubblicazioni di specialità d'Italia
- contratti di ricerca, realizzati o pronti a realizzarsi

L'agrandimento del gruppo di ricerca dei geomorfologi d'Italia e Romania con professori di Francia e Belgio permette una diversificazione della tematica, e anche una conoscenza più profonda del rilievo di punto di vista teorico e pratico non solo per i paesi già menzionati ma anche per altri territori fra il **carattere internazionale del workshop.**

Ringraziamo quindi a i fondatori del gruppo di lavoro, ma anche a quelli dedicati che hanno contribuito a l'idea di unità, continuità e sviluppo della sua attività.

Florina GRECU

The Xth Romanian – Italian – Franco – Belgian Geomorphologic Meeting, Romania, Mangalia 8 – 12 June 2005



Early June, took place the well-established scientific meeting of the Romanian, Italian, French and Belgian geomorphologists on the occasion of the Xth International Workshop discussing *Geomorphology and Environment*. This prestigious scientific meeting was hosted in old Callatis, Dobrogea.

The opening speech was delivered by professor Emil Vespremeanu, president of the Romanian Association of Geomorphology. The Italian, French and Belgian associations of geo-

morphology also voiced their thoughts through professor Dorian Castaldini, professor Eric Fouache and professor Morgan De Dapper.

The workshop was opened by a retrospective exhibition, put together by professor Florina Grecu, an emotional moment for most of the participants.

The awarding of the Xth workshop participation diplomas was another special moment.

During the two days, dedicated to scientific discussions, 22 studies approaching a vast geomorphologic thematic were presented. On this



occasion research studies performed all over the continent in the fields of applied geomorphology, dynamic geomorphology, costal geomorphology and geoarcheology were shared.

The presence of many young and endowed researchers who caught the audience's attention with their results was greatly appreciated.

The latter part of the workshop was reserved to an interesting field work in the Dobrogea area. Some of the specialists that dedicated their experience to studying this area: lect.dr. Ștefan Constantinescu, lect.dr. Laura Comănescu, lect.dr. Bianca Simion held discussions on applied geomorphology and offered some pointers and explanations.

On the closing day, professor Morgan De Dapper, Ghent University, offered some pointers on the location of the future XIth meeting.

The closing speech was held by the participating Associations presidents who underlined the success of the present edition and of the ten years of meetings.

Robert DOBRE

SIXTH INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY

Geomorphology in regions of environmental contrasts

7–11 septembrie, 2005, Zaragoza, Spania

La a VI-a Conferință Internațională de Geomorfologie, într-o organizare de excepție, de International Association of Geomorphologists și Universitatea din Zaragoza, au participat cu comunicări cadre didactice din Facultatea de Geografie din București și Institutul de Geografie, fiind de fapt singura delegație din România, formată din: prof. univ. dr. Emil Vespremeanu (Președinte al Asociației Geomorfologilor din România), prof. univ. dr. Florina Grecu (Secretar general al Asociației Geomorfologilor din România), conf. univ. dr. Ileana Pătru, lector. univ. dr. Laura Comănescu, M. Micu. România, prin prof. univ. dr. Dan Bălțeanu, membru corespondent al Academiei Române, a fost aleasă *coopted members* în Comitetul executiv al IAG, și va organiza o conferință regională, în anul 2008.

Președintele ales pentru perioada 2005–2009 este Profesorul Andrew Gaudie de la University of Oxford (vezi Newsletter 3/4 — 2005).

Rezumatele comunicărilor au fost publicate în *Abstracts Volume* (510 p.). (Pentru tematică, vezi articolul *Geomorfologia în primul deceniu al mileniului trei* de Emil Vespremeanu, *Revista de geomorfologie*, vol. 6).

Aplicațiile practice s-au desfășurat conform tradiției: înainte și după conferință (3–4–5 zile), dar și între sesiunile de comunicări (1 zi), în regiuni foarte interesante ca geomorfologie, civilizație și cultură.

Cea de-a VII Conferință va avea loc în Australia, la Melbourne, în 2009.

Pentru detalii, vezi www.geomorph.org.

Florina GRECU



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MISCELLANEA

ROMANIAN – ITALIAN – FRANCO – BELGIAN

Geomorphological workshop

Retrospect (1995- 2005)

Asociația Geomorfologilor din România

Associazione Italiana di Geografia Fisica e Geomorfologia

Groupe Francais de Géomorphologie

Association Belge de Geomorphologie

Accordo di collaborazione

1. Le basi della collaborazione tra i geomorfologi rumeni ed italiani, sono state messe nel 1994 dopo le discussioni e l'accordo verbale tra i professori Federici, Rodolfi, Panizza e Bălțeanu, Josan, Mac alla conferenza regionale di geomorfologia avvenuta a Praga.

2. Il presidente del gruppo italiano di geomorfologi, il professore Brancaccio, ha accettato la collaborazione con l' Associazione dei Geomorfologi Rumeni come scritto nella lettera del professore Rodolfi al professore Mac, vicepresidente del A.G.R.

3. In questa lettera si propone che il primo workshop fosse organizzato in Romania tenendo come tematica le frane.

4. Il gruppo italiano – rumeno si aveva proposto al inizio di studiare le frane, ma la tematica è stata diversificata e sviluppata con il tempo, come si può osservare qui sotto

Dear Colleague, following the decision taken during the last meeting of the Italian Geomorphological Group, and of behalf of its actual President, Prof. Ludovico Brancaccio, I accepted to act as meeting point of a small group of colleagues working in the subject of movement, according your Proposal,

Prof. Giuliano Rodolfi.

1. Cluj-Napoca 1995 (5 – 8 X)

Il primo workshop rumeno-italiano sulle frane è stato organizzato a Cluj Napoca tra 5 e 8 ottobre 1995 e tra i partecipanti sono stati presenti anche i membri fondatori. I discorsi e i studi nel campo si sono basati sulle glimee in Transilvania.

Le presentazioni sono state pubblicate in *Studia Universitatis*, che contiene anche il rapporto finale firmato dal professore Mac:

On the basis of the reciprocal agreement between the Geomorphologist's Association from Italy, represented by Mario Panizza and Giuliano Rodolfi, and The Geomorphologist's Association from Romania, represented by Ioan Mac, Dan Balteanu and Nicolae Josan, which have been established in Prague, August 1994 in order to stimulate the relationship in the field of geomorphology between Romanian and Italy, it has been organized the first "Romanian - Italian Workshop on Landslide" in Cluj-Napoca, Romania between October 5 and October 8, 1995.

At this first workshop, have participated 8 geomorphologists from Italy and 8 geomorphologists from Romania. This meeting has had a work character and the accommodation and the meals were assured by the colleagues from Romania. The transport from Bucharest to Cluj-Napoca and from Cluj-Napoca to Bucharest was also assured by the Romanian part in order to enable the Italian colleagues a better Knowledge of the Romanian territory.

There have been presented 16 papers, either through direct presentation - in the first day of the workshop, or correlated with the concrete territorial aspects - in the field applications in the next days.

The discussion have constituted the base of analysis for the scientific problems and the direct demonstration in the field have brought concrete arguments upon the workshop's

themes and problems.

As a result of this first workshop the following ideas have been shaped:

1. the character of the workshop was most adequate in analyzing the scientific problems;
2. the participants have brought into discussion both varied problems and diversified regional models;
3. there are many similar approaches of the problems between the Italian specialists and the Romanian ones;
4. in the same time there are also personal opinions in explaining the genetic conditions, processes and mechanisms, concerning the landslides, fact which leads a good manner of reciprocal knowledge;
5. the practical applications held in the Transsylvanian Depression have offered to the Italian colleagues regional models with a special character, which will constitute common points for the future approaches in the field of landslides;
6. it has been established that is very useful to deepen the studies in cooperation and by accomplishing comparative analysis between the situation from Italy and Romania it would be possible to elaborate evolutionary (schemes, hypothesis) meetings;
7. to fulfill this target we will intensify the information exchanges between the geomorphologists from Italy and Romania, integrated in this workshop. In this sense, a similar workshop will be organized in Italy, in 1996;
8. the participants at the first workshop have decided to elaborate a volume which will contain the materials as a result of the activity developed in Romania. This volume will be coordinated by the geomorphologists from the "Babeş-Bolyai" University of Cluj-Napoca and also supported by the participant institutions from Romania. The papers will be collected till December thest, 1995,
9. the participants at the first workshop are extremely pleased for the effective cooperation and for the efficient experience exchange;
10. the future cooperations will be perfected

both as problematic and as organization, through a reciprocal agreement between the geomorphologists from Romania and Italy. Until the next workshop, which will take place in Italy, the following persons are designated for the keeping in touch and for the informations exchange: Giuliano Rodolfi (from Italy) and Profesor Mac (from Romania). After the second workshop from Italy another person will be named for the same attributions.

2. Camerino – Chieti 1996

Il secondo workshop (Camerino – Chieti, 1996) fa parte del V *Seminario Deformazioni Gravitative Profonde di Versante e Incontro Italo – Rumeno sulle Frane*; Di punto di vista tematico i dibattimenti sulle frane profonde di terra cominciate a Cluj Napoca continuano

3. Oradea 1998 (3 – 5 VI)

Al workshop di Oradea, 1998 (il terzo) la tematica comprese anche la dinamica dei versanti, con applicazioni nelle colline e i Monti Apuseni.

I articoli sono stati pubblicati nel *Analele Universităţii Oradea*, 1998

4. Firenze - Pisa 1999 (2 – 4 VI)

A partire dal workshop di Firenze i programmi di geomorfologia cominciano ad essere guardati non solo come fenomeni naturali ma anche in relazione con l'attività del uomo

5. Bucureşti 2000 (27 V – 3 VI)

Il workshop di Bucharest, organizzato da la Facoltà di Geografia e i Istituto di Geografia dell' Accademia Rumena, si ha imposto grazie a:

- una tematica più varia sopra i processi geomorfologici nelle zone tectonici
- una ricerca nel campo di cinque giorni (due nei Carpatii Curburii e tre in Delta Dunarii)
- nuove proposte di tematică – una tematică più ampia dei processi geomorfologi.

6. Bari 2001 (9-13.V)

Il sesto workshop, di Bari, è stato caratterizzato da:

- una tematica molto varia
- ricerche nel campo (tre giorni) sopra il carst, il rilievo vulcanico, la dinamica dei versanti, la dinamica fluviale, la dinamica costiera, quindi tutto quello che ha di particolare il rilievo di Puglia e Basilicata, la cultura e la civilizzazione di queste zone.

7. Suceava 2002 (26 V – 1 VI)

Il workshop organizzato a Suceava ha proposto un dibattito sulla geomorfologia dell'ambiente delle regioni montane

- sono state riprese le discussioni sopra la necessità di allargare il gruppo di lavoro con altri paesi. Il professore Alain Marre, presidente del gruppo francese di geomorfologi, si mostrò interessato ad affiliarsi
- i discorsi e le discussioni sono basate su gli aspetti pratici e interdisciplinari con applicazioni nei Carpazi Orientali
- l'applicazione pratica ha sottolineato anche la cultura e la civilizzazione

8. Camerino – Modena 2003 (4 – 9 VII)

Il workshop organizzato a Camerino e Modena con applicazioni nei Apenini Nordici, con una tema teorica in apparenza, ha sottolineato il carattere pratico della geomorfologia

- è il primo simposio condotto da I.A.G. e i quattro paesi: Italia, Francia, Belgia, Romania e da i presidenti: Dramis, Marre, Dapper, Popescu
- i articoli sono stati pubblicati

9. Reims 2004 (03 – 06 VI)

A partire dal nono workshop (Reims, Francia) si osserva la riorientazione del gruppo di lavoro verso geoarcheologia, una direzione interdisciplinare, ma anche molto pratica

- il simposio ha incluso però anche altre sezioni di geomorfologia, imponendosi nel studio del quaternario diversi metodi di ricerca, molto qualitativi

- si ha stabilito che il workshop di 2006, di Belgio – Gent, basato su la geoarcheologia fluviale

10. Mangalia 2005 (8 – 12 VI)

Organizzato in Romania a Mangalia, sul litorale rumeno del Mare Nero, il workshop anniversario dibatterà problemi geomorfologici dell'ambiente

- dal punto di vista geoarcheologico, il litorale rumeno ha un grande potenziale per degli investigazioni

I risultati della collaborazione dei geomorfologi rumeni ed italiani e poi anche degli francesi e belgiani si concretizzano brevemente nelle direzioni:

Scientifico:

- il conoscenza e il confronto del livello di ricerca dei quattro paesi, il scambio di metodi, concetti, idee. Questo aspetto è stato favorito dalla specializzazione dei geomorfologi in relazione con la geologia o la geografia
- il conoscenza di qualche problema speciali del rilievo d'Italia, Romania e Francia
- il conoscenza della cultura e la civilizzazione di questi popoli nel campo
- la diversificazione della tematica del workshop, a partire da i frange di terra fino alla geomorfologia pratica, nuove direzioni della ricerca geomorfologica
- Relazioni di collaborazione nel programma Erasmus - Socrates e per la specializzazione di dottorato
- più di 60 studenti rumeni (nel periodo 1999-2005) hanno studiato nelle università di Bari, Roma, Modena, Camerino, Firenze, Palermo, Reims, Paris XII in seguito a i accordi tra i professori che si conoscono durante gli workshop
- gli studenti d'Italia (più pochi) hanno seguito dei corsi nelle università di Romania (Bucuresti, Cluj Napoca, Oradea, Suceava), anche per la elaborazione di alcune tesi
- dei corsi presentati da i professori in Italia, Romania, Francia.
- la progressione di alcuni professori giovani

nelle università d'Italia (Bari, Modena, Roma)

- dei dottorati in collaborazione o la preparazione del dottorato sotto la guida di alcuni specialisti d'Italia
- l'elaborazione di alcuni libri in collaborazione
- l'elaborazione di alcuni articoli in collaborazione e l'accesso alla pubblicazione dei geomorfologi rumeni nelle pubblicazioni di specialità d'Italia
- contratti di ricerca, realizzati o pronti a realizzarsi

L'agrandimento del gruppo di ricerca dei geomorfologi d'Italia e Romania con professori di Francia e Belgio permette una diversificazione della tematica, e anche una conoscenza più profonda del rilievo di punto di vista teorico e pratico non solo per i paesi già menzionati ma anche per altri territori fra il **carattere internazionale del workshop.**

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Florina GRECU

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morphology also voiced their thoughts through professor Dorian Castaldini, professor Eric Fouache and professor Morgan De Dapper.

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International Association of Geomorphologists
 Association Internationale des Géomorphologues
IAG/AIG Newsletter No. 22 (3/4 - 2005)

**The Future of the IAG Address by
 Andrew Goudie, President of the IAG,
 Zaragoza 2005**

First of all let me say that over the last four years, and under the dedicated leadership of Mario Panizza (Italy), the IAG has undertaken some important activities which should continue. I particularly think of the splendid programme of grant provision to support young research workers, particularly from developing countries, to go to conferences and workshops, including this Congress. The role of Professor Mauro Soldati (Italy) in this has been crucial and I am delighted that he will continue in this role on the new Executive Committee. I also appreciate the importance of having an active and informative web site and a full list of the world's geomorphologists, and salute the work done on our behalf by Dr Zibi Zwolinski (Poland). He too is willing to continue this role over the next four years. In a similar vein, Carol Harden (USA) has done great work on producing the Newsletter with regularity and on time and I am delighted that Mike Slattery (USA) is willing to take on this role. I also remember with admiration the organization of the regional Conference that was run by Irasema Alcantara Ayala in Mexico City. The Committee, and especially Denes Loczy (Hungary), our most able outgoing Executive Secretary, has also been active in encouraging the establishment of active geomorphological bodies in many countries, particularly less favoured ones. Through the good offices of President Mario Panizza (Italy), the IAG had a major presence at the International Geological Congress in Florence in 2004, and this is another initiative that needs to be repeated in Oslo in 2008. We also had a major presence shortly before that at the International Geographical Congress in Glasgow. The last four years has also seen a substantial number of IAG publications produced, and I am particularly grateful to those

colleagues who waived their royalties or fees so that the publisher of the Encyclopedia of Geomorphology (Messrs Routledge) could pay in around 32,000 Euros to IAG accounts. Our working parties have also been active, and over the next four years these will be coordinated by Mike Crozier (New Zealand).

With regard to the future, in addition to continuing the good work we are already doing, we need to take geomorphology forward in some new directions, and I have selected five collaborative research themes:

- 1) The landscape is one of God's greatest gifts to mankind, and landscape is the province of the geomorphologist. Landscape inspires the young and the public in general, but is I believe also becoming increasingly important in policy terms at the national and international levels. Increasing levels of foreign travel are exposing more and more people to great landscapes. The IAG needs to recognise the importance of World Heritage Site designations, of geosites and geoparks and of new agreements such as the European Landscape Convention. The developing fields of Geodiversity and Geomorphological Integrity are ones that need to be pursued. The IAG has been invited by IUCN to be involved in World Heritage Site selection, and we will be establishing a small ad hoc committee to take this forward, involving among others Denys Brunsden (Founding President, UK) and Piotr Migon (former Executive Secretary, Poland).
- 2) Geomorphology is useful, and we need to encourage the development of applied or engineering/environmental geomorphology through publications, setting appropriate standards of conduct, through developing our arsenal of techniques, and by transference of best practice. In the same vein, geomorphologists need to speak out more as geomorphologists and with

alacrity when great natural disasters occur. Our web site could be developed to that end. We will establish a new working group on Geomorphological Hazards, under the leadership of Professors Irasema Alcantara Ayala (Mexico), Sunil De (India), and Mohamed Benazzouz (Algeria).

3) The world faces Global Change. The geomorphological community has not been sufficiently involved with the burgeoning global change agenda either in terms of the science, the policy or the management. Our input to the Intergovernmental Panel on Climate Change has, in comparison to that of life scientists and social scientists let alone climatologists, been modest, and it shows in IPCC reports. In sensitive areas, 'geomorphological hotspots', geomorphological changes may be enormous. I think of the recent paper in *Nature* by David Thomas and his colleagues, which suggests that by the end of the century almost the entire mega-Kalahari will become a reactivated aeolian landscape. Streamflow in many semi-arid areas will probably be reduced by 60% or more – what are the geomorphological implications? The IAG should produce, as a collaborative endeavour, a major statement on the geomorphological implications of future global change, and we will establish a new working group, chaired by Olav Slaymaker (Past President, Canada).

4) We need to reach out more than we have to the geophysical community, most especially in the USA, where the AGU is not affiliated to the IAG. The work that is being done on denudation rates and geochemical cycling in relation to tectonics and climate is hard science of great importance, and the IAG needs to engage with its practitioners. Related to this is the need to be engaged in Earth System Science, and Professor Lothar Schrott (Germany) will chair a new working group in this area, which I hope will build upon the meeting to be held in Loughborough, UK, in 2006.

5) Planetary scale studies are another other frontier for geomorphological research.

The remote sensing images coming back from Mars, and the information that can be gained about the nature of our sea floor from side-scan sonar and 3D seismic studies, are staggering. The latter area is connected with the exploitation of the sea floor for hydrocarbon resources, and areas like the Congo Fan and the Nile fan have the most extraordinary mass movement, fluvial and salt tectonic features. I have also been struck by the increasing availability of free images of our own home planet - the NASA Zulu website of Landsat 7 images, the new Google Earth site, the University of Maryland site and MODIS images, enable us to recognise and map global distributions of phenomena, such as the world's great ergs, dust storm hotspots, the oriented lakes of the tundra, the worlds deflation depressions, and many others. Here is another clear area for international collaboration.

So then, I have highlighted five main areas for development: landscape conservation; the application of geomorphology; the geomorphological implications of global change; the role of geomorphological processes in Earth System Science; and the development of planetary scale studies of Mars, our ocean floors, and our land surface using the new technologies associated with remote sensing.

We need to get the message across that geomorphology is an important and active discipline, and I am pleased to say that Professor David Higgitt (Singapore) will be our first Communications Officer.

However, I am very worried by the financial viability of the IAG. I believe that we need to continue to increase the financial resources of the IAG, which are still modest. Publications can do this, and I welcome the decision to produce a Handbook of Geomorphology under the chief editorship of Basil Gomez (USA), royalties from which will come to the IAG. How about a manual of applied geomorphology? How about a guide to the world's most spectacular landform sites? We should also consider a legacy programme and approaches to foundations and major corporations. It may also be that

national subscriptions should be increased, at least in line with inflation but also to bring them more in line with comparable bodies such as INQUA. That will be something for Council to consider at its next meeting. André Ozer (Belgium) has been an excellent Treasurer over the last four years and will be handing over to Francisco Gutiérrez (Spain)

I am thrilled to have been given the honour to be President of the IAG, and I hope that you will all feel that you can approach me with ideas for taking the discipline forward between now and the next congress in Melbourne (Australia) in July 2009. We have a very full series of regional meetings scheduled for the next four years and will have 12 working groups operating over that period as well. Finally, may I pay a tribute to Mateo Gutiérrez-Elorza (Spain) and his colleagues for running such a splendid congress in Zaragoza? They will be a hard act to follow.

IAG Executive Committee Meeting Minutes

Zaragoza, Congress Hall, 8 September 2005

The President, Andrew GOUDIE, opens the meeting at 09:00 am and welcomes the participants. Are present: Franck AUDEMARD (Vice-President, Venezuela), Michael CROZIER (Vice-President, New Zealand), Morgan DE DAPPER (Secretary, Belgium), Andrew GOUDIE (President, UK), Francisco GUTTIEREZ (Treasurer, Spain), Michael SLATTERY (Publications Officer, USA). Are present from point 3 on: David HIGGIT, Mauro SOLDATI, Zbigniew ZWOLINSKI. Are excused from point 3 on: Dan BALTEANU, Monique FORT, Ying WANG

1. Agenda

The agenda proposed by the President is approved.

2. The future of the IAG – strategic overview

The President outlines his view of the future of the IAG, (to be presented at the second General Assembly), stressing the need to expand the number of working parties so that they cover major, active and developing themes in Geomorphology.

3. Cooptation of EC members

Following EC members are coopted: Dan BALTEANU (Romania), Monique FORT (France), David HIGGIT (Singapore), Mauro SOLDATI (Italy), Ying WANG (China), Zbigniew ZWOLINSKI (Poland). An effort will be done to coopt a member from Africa, south of the Sahara. A possible candidate is Mohammed UMER from Addis Abeba University, Ethiopia. The Secretary will further enquire.

4. Duties of EC members

Franck AUDEMARD: Vice-President, Latin-America

Dan BALTEANU: Central Europe

Michael CROZIER: Vice-President, Australia, New-Zealand, Oceania, Working Groups

Morgan DE DAPPER: Secretary

Monique FORT: Western Europe (especially those countries with roman language expression), Middle East, India

Andrew GOUDIE: President

Francisco GUTTIEREZ: Treasurer

Michael SLATTERY: Publications Officer, USA

David HIGGIT: Public Relations Officer; South-east Asia

Mauro SOLDATI: Training Officer

Ying WANG: China

Zbigniew ZWOLINSKI: Webmaster

Gaps: German-speaking countries of Western Europe (filled by Lothar SCHROTT, Germany, cf. 11.WG Earth Systems), Northern Europe (filled by Achim BEYLICH, Norway, cf. 11. WG SEDIBUD), North Africa (filled by Mohamed T.BENAZZOUZ, Algeria, cf. 11. WG Geomorphological Hazards), Africa south of the Sahara (cf. 2.), Indian subcontinent (filled by Sunil Kumar DE, India, cf. 11. WG Geomorphological Hazards), Meso-America (filled by Irasema ALCANTARA-AYALA, Mexico, cf. 11. WG Geomorphological Hazards)

5. Financial policy

It was reported that there was currently 62,000 Euro in the account of the IAG, but the President pointed out that c 32,000 Euros had come from royalties associated with the

Encyclopedia of Geomorphology, and this was a once and for all contribution. He pointed out that the IAG had substantial expenditure on Working Groups, Training Courses, and EC meetings. He suggested that the IAG should improve its income from publications, and noted that the Handbook of Geomorphology (edited by Basil Gomez and others) might bring in c. 9000 Euros. In addition he suggested that there should be a Legacy programme, that the fee paid to the International Council on Landslides (US\$ 2,000) should be cancelled, that the question of personal subscriptions should be revisited, that commercial sponsorship should be explored, that a proposal to increase the subscriptions for National Bodies should be brought forward to the next meeting of Council, and that the organizers of the Melbourne Conference and other meetings should be encouraged to make sure that a sufficient profit was made to make a substantial contribution to the IAG's overall budget.

The proposal to cancel the subscription to the ICL was approved.

It was noted that the Past Treasurer (A. Ozer) would hand over the finances to the New Treasurer (F. Gutierrez) in January 2006.

6. Website

Zbigniew ZWOLINSKI, Past and new Webmaster, reports: The membership database is ongoing but the response is low and slow. A new call will be launched. For the website news more feedback is needed. David HIGGIT proposes to respond quickly to major news-breaking "geomorphological" events (flooding, landslides, earthquakes, volcanic eruptions, tsunamis, hurricanes).

7. Training of young geomorphologists

Mauro SOLDATI, Past and new Training Officer, reports: During the past quadriennium young geomorphologists (mostly from less favoured countries) were supported, enabling them to take part in training courses, symposia and regional/international conferences. The EC unanimously agrees to continue this effort.

During the next years more requests for funding are likely to be expected. The ques-

tion is how to deal with this situation. The President suggests continuation of support for activities that were successful (e.g. Tierra del Fuego, Windsor). It is decided that a minimum budget will be defined in order to properly manage the proposals received. At the next EC meeting a decision will be taken concerning the budget for the first two years. In the meantime, it is decided to support the following activities for the first year:

- BGRG Post-graduate Training Course, Windsor, UK, December 2006: 2 grants for PhD students from Eastern Europe (evaluating commission: GOUDIE, SOLDATI, ZWOLINSKI);
- CONICET IV Post-graduate Field Course in Tierra del Fuego, Argentina, November 2006: 2 grants for young geomorphologists from Latin America;
- IAG Regional Conference, Brasil, September 2006: grants (number to be defined) for young geomorphologists from less favoured countries (except Latin America).

It is agreed that the EC will have to encourage the organisers of Regional Conferences to devote part of the budget to grants for young geomorphologists.

8. Publications

Publications are very important for the IAG. Wiley's contribution is declining, but the Cambridge University Press is keen to expand. The following suggestions were made:

- WG on Global Change, edited by Olav SLAYMAKER
- WG on Hazards, edited by Irasema ALCANTARA-AYALA
- Handbook/Recipe on 'Applied Geomorphology' including legal issues
- Glossary of Geomorphology for students, hardcopy, multilingual (English, French, Spanish)
- Biographies (cf. Dorothy SACK's 'History of Geomorphology'), Andrew GOUDIE's extensive archive of photographs could be included
- A book of major world landform sites, edited by Piotr MIGON.

9. Newsletter

A more efficient way of diffusion is necessary. Michael SLATTERY will consult the Past Publication Officer Carol HARDEN.

10. Scientific Meetings

- 2006, Mongolia. A Joint International Meeting on 'Environmental Changes and Earth Surface Processes in Semi-arid and Temperate Areas' will be organised in Mongolia from June 9th to 15th by the Institute of Geography of the Mongolian Academy of Science, the Japanese Geomorphological Union, the International Geographical Union (GC21) and Kanazawa University. The organisers ask the official support of the IAG. The EC unanimously agrees as long as there are no financial implications. The decision will be communicated by the Secretary.
- IAG Regional Conferences:
 - 2006, September, Goiânia, Brazil: Franck AUDEMARD will attend.
 - 2007, June, East Malaysia
 - 2007, July, Svalbard Archipelago, Spitsbergen, Norway
 - 2008, April, Israel
 - 2008, September, Braşov, Romania
- 2008, International Geological Conference, August 5th-14th, Oslo, Norway. It is proposed that Monique FORT prepares a programme with session.
- 2008, UNESCO & IUGS, International Year of Planet Earth
- 2009, IAG International Conference, Melbourne, Australia

11. Working Groups

- Continuing WG's:
 - Geoarcheology: Eric FOUACHE (France)
 - Large Rivers: Avijit GUPTA (UK)
 - Geomorphological Sites: Emmanuel REYNARD (Switzerland)
 - Arid Regions: Yang XIAOPING (China)
- New WG's:
 - SEDIBUD, Sediment Budgets in Cold Environments: Achim BEYLICH (Norway)
 - Rocky Coasts Geomorphology: Wayne

STEPHENSON (Australia)

- Carpatho-Balkan-Dinaric Regional Working Group: not yet defined
- Human Impact on the Landscape: Dénes L?CZY (Hungary)
- Small Catchments: Andrzej KOSTRZEWSKI (Poland)
- Earth Systems: Lothar SCHROTT (Germany)
- Geomorphological Hazards: Irasema ALCANTARA-AYALA (Mexico), Sunil Kumar DE (India), Mohamed T.BENAZ-ZOUZ (Algeria)
- Global Change and Geomorphology : Olav SLAYMAKER (Canada)

A budget has to be foreseen for the 8 new WG's. A decision as to the amount has to be taken during the next EC-Meeting. WG's must formulate a strategy and must have a tangible output (training manuals, international meetings and publications).

12. World Heritage Sites

The IAG will cooperate with The World Conservation Union (IUCN, www.iucn.org) on this. An ad hoc commission (a call for active members has to be launched; Denys BRUNSDEN (UK), Piotr MIGON (Poland), Michael CROZIER (New-Zealand), Andrew GOUDIE (UK) are ready to take part) will formulate a Top-20 of landscapes to be protected.

13. Any Other Business

New stationary will be prepared by the Secretary

Michael SLATTERY will formulate a statement concerning the organisation of the important group of US-geomorphologists which is at the present day diluted over different organisations: American Geophysical Union (AGU), Geological Society of America (GSA), Geomorphology Special Group of the Association of American Geographers (AAG).

14. Next EC Meeting

Andrew GOUDIE will convene the next EC Meeting in Oxford – UK. Date: 31st March and 1st April 2006 Programme: informal dinner on the Friday evening, intensive all day (9

am – 5 pm) committee meeting on the Saturday. The IAG will pay for accommodation and food. It is hoped that at least a portion of the travel costs could be provided by the institutions or national bodies of those attending.

The meeting is closed at 11 am.

Coordinates of the EC Members

Franck AUDEMARD FUNVISIS
Venezuelan Foundation for Seismological
Research Earth Sciences Department Final
Calle Mara, Urb.El Llanito CARACAS 1030
Apdo.Postal 76880 CARACAS 1070-A
Venezuela

faudemard@funvisis.gob.ve

Phone: + 58 (0)212 2575153

Dan BALTEANU University of Targoviste
Institute of Geography Department of Human
Geography 12, Dimitrie Racovita Street,
Sector 2 BUCHAREST Romania

balteanu@rnc.ro geoinst@rnc.ro

Phone: +40 (0)21 3155990

Michael CROZIER Victoria University of
Wellington Institute of Geography, School of
Earth Sciences PO Box 600 WELLINGTON
New Zealand

Michael.Crozier@vuw.ac.nz

Tel: +64 (0)4 463 5279 Fax: +64 (0)4 463
5186

Morgan DE DAPPER Ghent University
Department of Geography Krijgslaan, 281
(S8) B-9000- GENT Belgium, EU

morgan.dedapper@UGent.be

Phone: + 32 (0)9 2644690 Fax: + 32 (0)9
2644982

Monique FORT Université Paris7-Denis
Diderot Géographie, Histoire, Sciences de la
Société UFR GHSS, Case 7001 2, Place
Jussieu F- 75 251 PARIS Cedex 05 France,
EU

fort@paris7.jussieu.fr

Phone : + 33 (0)1 44 277669 Andrew
GOUDIE St Cross College St Giles
OXFORD OX1 3LZ United Kingdom, EU

andrew.goudie@st-cross.oxford.ac.uk

Phone: + 44 (0)1865 278493 (secretary); +
44 (0)1865 278492 (direct) Fax: + 44 (0)1865
278484

Francisco GUTIÉRREZ SANTOLALLA
Universidad de Zaragoza Departamento de
Ciencias de la Tierra Edificio Geológicas C/.
Pedro Cerbuna, 12 50009 ZARAGOZA
España, EU

fgutier@unizar.es

Phone: + 34 (0)976 761090 Fax: + 34
(0)976 761088

David HIGGITT National University of
Singapore Department of Geography 1, Arts
Link SINGAPORE 117570

geodlh@nus.edu.sg

Phone: + 65 6516 6809 Fax: + 65 6777
3091

Michael SLATTERY Texas Christian
University Institute for Environmental
Studies P.O.Box 298830 FORTH WORTH,
TX 76129 USA

m.slattery@tcu.edu

Phone: + 1 (817) 257 7506 Fax: + (817) 257
7789

Mauro SOLDATI Università Degli Studi di
Modena e Reggio Emilia Dipartimento di
Scienze della Terra Largo S.Eufemia, 19
41100 MODENA Italy, EU

soldati@unimore.it

Phone: + 39 (0)59 2055842

Ying WANG Nanjing University
Department of Urban and Resource Sciences
Physical Geography NANJING China

wangying@nju.edu.cn

Zbigniew ZWOLIŃSKI Adam Mickiewicz
University Institute for Paleogeography and
Geoecology Dziegielowa, 27 61-680
POZNAŃ Poland, EU

zbbzw@amu.edu.pl

Phone: + 48 (0)61 8296176

Young Geomorphologists

IAG Grants for the "Post-graduate

Research Training Workshop", Cumberland Lodge, Windsor Great Park (UK), 18-21 December 2005

The selection procedure of the six PhD students in Geomorphology from Eastern Europe who submitted a request for an IAG grant has been completed upon examination of the candidates' CVs and PhD research project abstract.

IAG Grants have been awarded to: Marek Ewertowski (Poland) and Luminita Preoteasa (Romania).

Editor's Note

The success of the IAG/AIG Newsletter

depends upon the contributions that we receive. Please assist by sending commentaries, reviews of regional or national meetings and field trips, summaries of issues pertinent to geomorphology, and announcements of future meetings and workshops. Your contributions should be forwarded to the IAG/AIG Publications Officer:

Mike Slattery, *Institute for Environmental Studies and Department of Geography, PO Box 298830, Texas Christian University, Fort Worth TX, 76129, USA. Fax (817) 257-7789; Phone (817) 257-7506; E-mail: m.slattery@tcu.edu*

International Association of Geomorphologists

President

Andrew Goudie
School of Geography
and the Environment
University of Oxford
Mansfield Road
Oxford OX1 3TB, UK
Ph: +44 1865 271921
Fax: +44 1865 271940

a n d r e w . g o u d i e @ s t -
cross.oxford.ac.uk

Vice-Presidents

Franck Audemard Funvisis	Michael Crozier
Venezuelan Foundation for	Victoria University of
Seismological Research	Wellington
Apdo.Postal 76880	Institute of Geography
CARACAS 1070-A	Wellington, New Zealand
Venezuela	Ph: +64 (0)4 463 5279
Ph: +58 (0)212 2575153	Michael.Crozier@vuw.ac.nz
faudemard@funvisis.gob.ve	

IAG Account number: 068-2376668-01 - DEXIA Banque Av. Centenaire, 42 - B-4102 Ougrée, Belgium Account IBAN: BE 43-0682-3766-6801 SWIFT: GKCCBEBB

From January 1, 2006:

IAG Account number: 0128 0409 7101 0000 1961 Bankinter, C/. Juan Carlos I, 50009 Zaragoza, Spain Account IBAN ES 79 0128 0409 7101 0000 1961 SWIFT code: BKBKESMM

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MISCELLANEA

ROMANIAN – ITALIAN – FRANCO – BELGIAN

Geomorphological workshop

Retrospect (1995- 2005)

Asociația Geomorfologilor din România

Associazione Italiana di Geografia Fisica e Geomorfologia

Groupe Francais de Géomorphologie

Association Belge de Geomorphologie

Accordo di collaborazione

1. Le basi della collaborazione tra i geomorfologi rumeni ed italiani, sono state messe nel 1994 dopo le discussioni e l'accordo verbale tra i professori Federici, Rodolfi, Panizza e Bălteanu, Josan, Mac alla conferenza regionale di geomorfologia avvenuta a Praga.

2. Il presidente del gruppo italiano di geomorfologi, il professore Brancaccio, ha accettato la collaborazione con l' Associazione dei Geomorfologi Rumeni come scritto nella lettera del professore Rodolfi al professore Mac, vicepresidente del A.G.R.

3. In questa lettera si propone che il primo workshop fosse organizzato in Romania tenendo come tematica le frane.

4. Il gruppo italiano – rumeno si aveva proposto al inizio di studiare le frane, ma la tematica è stata diversificata e sviluppata con il tempo, come si può osservare qui sotto

Dear Colleague, following the decision taken during the last meeting of the Italian Geomorphological Group, and of behalf of its actual President, Prof. Ludovico Brancaccio, I accepted to act as meeting point of a small group of colleagues working in the subject of movement, according your Proposal,

Prof. Giuliano Rodolfi.

1. Cluj-Napoca 1995 (5 – 8 X)

Il primo workshop rumeno-italiano sulle frane è stato organizzato a Cluj Napoca tra 5 e 8 ottobre 1995 e tra i partecipanti sono stati presenti anche i membri fondatori. I discorsi e i studi nel campo si sono basati sulle glimee in Transilvania.

Le presentazioni sono state pubblicate in *Studia Universitatis*, che contiene anche il rapporto finale firmato dal professore Mac:

On the basis of the reciprocal agreement between the Geomorphologist's Association from Italy, represented by Mario Panizza and Giuliano Rodolfi, and The Geomorphologist's Association from Romania, represented by Ioan Mac, Dan Balteanu and Nicolae Josan, which have been established in Prague, August 1994 in order to stimulate the relationship in the field of geomorphology between Romanian and Italy, it has been organized the first "Romanian - Italian Workshop on Landslide" in Cluj-Napoca, Romania between October 5 and October 8, 1995.

At this first workshop, have participated 8 geomorphologists from Italy and 8 geomorphologists from Romania. This meeting has had a work character and the accommodation and the meals were assured by the colleagues from Romania. The transport from Bucharest to Cluj-Napoca and from Cluj-Napoca to Bucharest was also assured by the Romanian part in order to enable the Italian colleagues a better Knowledge of the Romanian territory.

There have been presented 16 papers, either through direct presentation - in the first day of the workshop, or correlated with the concrete territorial aspects - in the field applications in the next days.

The discussion have constituted the base of analysis for the scientific problems and the direct demonstration in the field have brought concrete arguments upon the workshop's

themes and problems.

As a result of this first workshop the following ideas have been shaped:

1. the character of the workshop was most adequate in analyzing the scientific problems;
2. the participants have brought into discussion both varied problems and diversified regional models;
3. there are many similar approaches of the problems between the Italian specialists and the Romanian ones;
4. in the same time there are also personal opinions in explaining the genetic conditions, processes and mechanisms, concerning the landslides, fact which leads a good manner of reciprocal knowledge;
5. the practical applications held in the Transsylvanian Depression have offered to the Italian colleagues regional models with a special character, which will constitute common points for the future approaches in the field of landslides;
6. it has been established that is very useful to deepen the studies in cooperation and by accomplishing comparative analysis between the situation from Italy and Romania it would be possible to elaborate evolutionary (schemes, hypothesis) meetings;
7. to fulfill this target we will intensify the information exchanges between the geomorphologists from Italy and Romania, integrated in this workshop. In this sense, a similar workshop will be organized in Italy, in 1996;
8. the participants at the first workshop have decided to elaborate a volume which will contain the materials as a result of the activity developed in Romania. This volume will be coordinated by the geomorphologists from the "Babeş-Bolyai" University of Cluj-Napoca and also supported by the participant institutions from Romania. The papers will be collected till December thest, 1995,
9. the participants at the first workshop are extremely pleased for the effective cooperation and for the efficient experience exchange;
10. the future cooperations will be perfected

both as problematic and as organization, through a reciprocal agreement between the geomorphologists from Romania and Italy. Until the next workshop, which will take place in Italy, the following persons are designated for the keeping in touch and for the informations exchange: Giuliano Rodolfi (from Italy) and Profesor Mac (from Romania). After the second workshop from Italy another person will be named for the same attributions.

2. Camerino – Chieti 1996

Il secondo workshop (Camerino – Chieti, 1996) fa parte del V *Seminario Deformazioni Gravitative Profonde di Versante e Incontro Italo – Rumeno sulle Frane*; Di punto di vista tematico i dibattimenti sulle frane profonde di terra cominciate a Cluj Napoca continuano

3. Oradea 1998 (3 – 5 VI)

Al workshop di Oradea, 1998 (il terzo) la tematica comprese anche la dinamica dei versanti, con applicazioni nelle colline e i Monti Apuseni.

I articoli sono stati pubblicati nel *Analele Universităţii Oradea*, 1998

4. Firenze - Pisa 1999 (2 – 4 VI)

A partire dal workshop di Firenze i programmi di geomorfologia cominciano ad essere guardati non solo come fenomeni naturali ma anche in relazione con l'attività del uomo

5. Bucureşti 2000 (27 V – 3 VI)

Il workshop di Bucharest, organizzato da la Facoltà di Geografia e i Istituto di Geografia dell' Accademia Rumena, si ha imposto grazie a:

- una tematica più varia sopra i processi geomorfologici nelle zone tectonici
- una ricerca nel campo di cinque giorni (due nei Carpatii Curburii e tre in Delta Dunarii)
- nuove proposte di tematică – una tematică più ampia dei processi geomorfologi.

6. Bari 2001 (9-13.V)

Il sesto workshop, di Bari, è stato caratterizzato da:

- una tematica molto varia
- ricerche nel campo (tre giorni) sopra il carst, il rilievo vulcanico, la dinamica dei versanti, la dinamica fluviale, la dinamica costiera, quindi tutto quello che ha di particolare il rilievo di Puglia e Basilicata, la cultura e la civilizzazione di queste zone.

7. Suceava 2002 (26 V – 1 VI)

Il workshop organizzato a Suceava ha proposto un dibattito sulla geomorfologia dell'ambiente delle regioni montane

- sono state riprese le discussioni sopra la necessità di allargare il gruppo di lavoro con altri paesi. Il professore Alain Marre, presidente del gruppo francese di geomorfologi, si mostrò interessato ad affiliarsi
- i discorsi e le discussioni sono basate su gli aspetti pratici e interdisciplinari con applicazioni nei Carpazi Orientali
- l'applicazione pratica ha sottolineato anche la cultura e la civilizzazione

8. Camerino – Modena 2003 (4 – 9 VII)

Il workshop organizzato a Camerino e Modena con applicazioni nei Apenini Nordici, con una tema teorica in apparenza, ha sottolineato il carattere pratico della geomorfologia

- è il primo simposio condotto da I.A.G. e i quattro paesi: Italia, Francia, Belgia, Romania e da i presidenti: Dramis, Marre, Dapper, Popescu
- i articoli sono stati pubblicati

9. Reims 2004 (03 – 06 VI)

A partire dal nono workshop (Reims, Francia) si osserva la riorientazione del gruppo di lavoro verso geoarcheologia, una direzione interdisciplinaria, ma anche molto pratica

- il simposio ha incluso però anche altre sezioni di geomorfologia, imponendosi nel studio del quaternario diversi metodi di ricerca, molto qualitativi

- si ha stabilito che il workshop di 2006, di Belgio – Gent, basato su la geoarcheologia fluviale

10. Mangalia 2005 (8 – 12 VI)

Organizzato in Romania a Mangalia, sul litorale rumeno del Mare Nero, il workshop anniversario dibatterà problemi geomorfologici dell'ambiente

- dal punto di vista geoarcheologico, il litorale rumeno ha un grande potenziale per degli investigazioni

I risultati della collaborazione dei geomorfologi rumeni ed italiani e poi anche degli francesi e belgiani si concretizzano brevemente nelle direzioni:

Scientifico:

- il conoscenza e il confronto del livello di ricerca dei quattro paesi, il scambio di metodi, concetti, idee. Questo aspetto è stato favorito dalla specializzazione dei geomorfologi in relazione con la geologia o la geografia
- il conoscenza di qualche problema speciali del rilievo d'Italia, Romania e Francia
- il conoscenza della cultura e la civilizzazione di questi popoli nel campo
- la diversificazione della tematica del workshop, a partire da i frange di terra fino alla geomorfologia pratica, nuove direzioni della ricerca geomorfologica
- Relazioni di collaborazione nel programma Erasmus - Socrates e per la specializzazione di dottorato
- più di 60 studenti rumeni (nel periodo 1999-2005) hanno studiato nelle università di Bari, Roma, Modena, Camerino, Firenze, Palermo, Reims, Paris XII in seguito a i accordi tra i professori che si conoscono durante gli workshop
- gli studenti d'Italia (più pochi) hanno seguito dei corsi nelle università di Romania (Bucuresti, Cluj Napoca, Oradea, Suceava), anche per la elaborazione di alcune tesi
- dei corsi presentati da i professori in Italia, Romania, Francia.
- la progressione di alcuni professori giovani

nelle università d'Italia (Bari, Modena, Roma)

- dei dottorati in collaborazione o la preparazione del dottorato sotto la guida di alcuni specialisti d'Italia
- l'elaborazione di alcuni libri in collaborazione
- l'elaborazione di alcuni articoli in collaborazione e l'accesso alla pubblicazione dei geomorfologi rumeni nelle pubblicazioni di specialità d'Italia
- contratti di ricerca, realizzati o pronti a realizzarsi

L'agrandimento del gruppo di ricerca dei geomorfologi d'Italia e Romania con professori di Francia e Belgio permette una diversificazione della tematica, e anche una conoscenza più profonda del rilievo di punto di vista teorico e pratico non solo per i paesi già menzionati ma anche per altri territori fra il **carattere internazionale del workshop.**

Ringraziamo quindi a i fondatori del gruppo di lavoro, ma anche a quelli dedicati che hanno contribuito a l'idea di unità, continuità e sviluppo della sua attività.

Florina GRECU

The Xth Romanian – Italian – Franco – Belgian Geomorphologic Meeting, Romania, Mangalia 8 – 12 June 2005



Early June, took place the well-established scientific meeting of the Romanian, Italian, French and Belgian geomorphologists on the occasion of the Xth International Workshop discussing *Geomorphology and Environment*. This prestigious scientific meeting was hosted in old Callatis, Dobrogea.

The opening speech was delivered by professor Emil Vespremeanu, president of the Romanian Association of Geomorphology. The Italian, French and Belgian associations of geo-

morphology also voiced their thoughts through professor Dorian Castaldini, professor Eric Fouache and professor Morgan De Dapper.

The workshop was opened by a retrospective exhibition, put together by professor Florina Grecu, an emotional moment for most of the participants.

The awarding of the Xth workshop participation diplomas was another special moment.

During the two days, dedicated to scientific discussions, 22 studies approaching a vast geomorphologic thematic were presented. On this



occasion research studies performed all over the continent in the fields of applied geomorphology, dynamic geomorphology, costal geomorphology and geoarcheology were shared.

The presence of many young and endowed researchers who caught the audience's attention with their results was greatly appreciated.

The latter part of the workshop was reserved to an interesting field work in the Dobrogea area. Some of the specialists that dedicated their experience to studying this area: lect.dr. Ștefan Constantinescu, lect.dr. Laura Comănescu, lect.dr. Bianca Simion held discussions on applied geomorphology and offered some pointers and explanations.

On the closing day, professor Morgan De Dapper, Ghent University, offered some pointers on the location of the future XIth meeting.

The closing speech was held by the participating Associations presidents who underlined the success of the present edition and of the ten years of meetings.

Robert DOBRE

SIXTH INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY

Geomorphology in regions of environmental contrasts

7–11 septembrie, 2005, Zaragoza, Spania

La a VI-a Conferință Internațională de Geomorfologie, într-o organizare de excepție, de International Association of Geomorphologists și Universitatea din Zaragoza, au participat cu comunicări cadre didactice din Facultatea de Geografie din București și Institutul de Geografie, fiind de fapt singura delegație din România, formată din: prof. univ. dr. Emil Vespremeanu (Președinte al Asociației Geomorfologilor din România), prof. univ. dr. Florina Grecu (Secretar general al Asociației Geomorfologilor din România), conf. univ. dr. Ileana Pătru, lector. univ. dr. Laura Comănescu, M. Micu. România, prin prof. univ. dr. Dan Bălțeanu, membru corespondent al Academiei Române, a fost aleasă *coopted members* în Comitetul executiv al IAG, și va organiza o conferință regională, în anul 2008.

Președintele ales pentru perioada 2005–2009 este Profesorul Andrew Gaudie de la University of Oxford (vezi Newsletter 3/4 — 2005).

Rezumatele comunicărilor au fost publicate în *Abstracts Volume* (510 p.). (Pentru tematică, vezi articolul *Geomorfologia în primul deceniu al mileniului trei* de Emil Vespremeanu, *Revista de geomorfologie*, vol. 6).

Aplicațiile practice s-au desfășurat conform tradiției: înainte și după conferință (3–4–5 zile), dar și între sesiunile de comunicări (1 zi), în regiuni foarte interesante ca geomorfologie, civilizație și cultură.

Cea de-a VII Conferință va avea loc în Australia, la Melbourne, în 2009.

Pentru detalii, vezi www.geomorph.org.

Florina GRECU

International Association of Geomorphologists
 Association Internationale des Géomorphologues
IAG/AIG Newsletter No. 22 (3/4 - 2005)

**The Future of the IAG Address by
 Andrew Goudie, President of the IAG,
 Zaragoza 2005**

First of all let me say that over the last four years, and under the dedicated leadership of Mario Panizza (Italy), the IAG has undertaken some important activities which should continue. I particularly think of the splendid programme of grant provision to support young research workers, particularly from developing countries, to go to conferences and workshops, including this Congress. The role of Professor Mauro Soldati (Italy) in this has been crucial and I am delighted that he will continue in this role on the new Executive Committee. I also appreciate the importance of having an active and informative web site and a full list of the world's geomorphologists, and salute the work done on our behalf by Dr Zibi Zwolinski (Poland). He too is willing to continue this role over the next four years. In a similar vein, Carol Harden (USA) has done great work on producing the Newsletter with regularity and on time and I am delighted that Mike Slattery (USA) is willing to take on this role. I also remember with admiration the organization of the regional Conference that was run by Irasema Alcantara Ayala in Mexico City. The Committee, and especially Denes Loczy (Hungary), our most able outgoing Executive Secretary, has also been active in encouraging the establishment of active geomorphological bodies in many countries, particularly less favoured ones. Through the good offices of President Mario Panizza (Italy), the IAG had a major presence at the International Geological Congress in Florence in 2004, and this is another initiative that needs to be repeated in Oslo in 2008. We also had a major presence shortly before that at the International Geographical Congress in Glasgow. The last four years has also seen a substantial number of IAG publications produced, and I am particularly grateful to those

colleagues who waived their royalties or fees so that the publisher of the Encyclopedia of Geomorphology (Messrs Routledge) could pay in around 32,000 Euros to IAG accounts. Our working parties have also been active, and over the next four years these will be coordinated by Mike Crozier (New Zealand).

With regard to the future, in addition to continuing the good work we are already doing, we need to take geomorphology forward in some new directions, and I have selected five collaborative research themes:

- 1) The landscape is one of God's greatest gifts to mankind, and landscape is the province of the geomorphologist. Landscape inspires the young and the public in general, but is I believe also becoming increasingly important in policy terms at the national and international levels. Increasing levels of foreign travel are exposing more and more people to great landscapes. The IAG needs to recognise the importance of World Heritage Site designations, of geosites and geoparks and of new agreements such as the European Landscape Convention. The developing fields of Geodiversity and Geomorphological Integrity are ones that need to be pursued. The IAG has been invited by IUCN to be involved in World Heritage Site selection, and we will be establishing a small ad hoc committee to take this forward, involving among others Denys Brunsden (Founding President, UK) and Piotr Migon (former Executive Secretary, Poland).
- 2) Geomorphology is useful, and we need to encourage the development of applied or engineering/environmental geomorphology through publications, setting appropriate standards of conduct, through developing our arsenal of techniques, and by transference of best practice. In the same vein, geomorphologists need to speak out more as geomorphologists and with

alacrity when great natural disasters occur. Our web site could be developed to that end. We will establish a new working group on Geomorphological Hazards, under the leadership of Professors Irasema Alcantara Ayala (Mexico), Sunil De (India), and Mohamed Benazzouz (Algeria).

3) The world faces Global Change. The geomorphological community has not been sufficiently involved with the burgeoning global change agenda either in terms of the science, the policy or the management. Our input to the Intergovernmental Panel on Climate Change has, in comparison to that of life scientists and social scientists let alone climatologists, been modest, and it shows in IPCC reports. In sensitive areas, 'geomorphological hotspots', geomorphological changes may be enormous. I think of the recent paper in *Nature* by David Thomas and his colleagues, which suggests that by the end of the century almost the entire mega-Kalahari will become a reactivated aeolian landscape. Streamflow in many semi-arid areas will probably be reduced by 60% or more – what are the geomorphological implications? The IAG should produce, as a collaborative endeavour, a major statement on the geomorphological implications of future global change, and we will establish a new working group, chaired by Olav Slaymaker (Past President, Canada).

4) We need to reach out more than we have to the geophysical community, most especially in the USA, where the AGU is not affiliated to the IAG. The work that is being done on denudation rates and geochemical cycling in relation to tectonics and climate is hard science of great importance, and the IAG needs to engage with its practitioners. Related to this is the need to be engaged in Earth System Science, and Professor Lothar Schrott (Germany) will chair a new working group in this area, which I hope will build upon the meeting to be held in Loughborough, UK, in 2006.

5) Planetary scale studies are another other frontier for geomorphological research.

The remote sensing images coming back from Mars, and the information that can be gained about the nature of our sea floor from side-scan sonar and 3D seismic studies, are staggering. The latter area is connected with the exploitation of the sea floor for hydrocarbon resources, and areas like the Congo Fan and the Nile fan have the most extraordinary mass movement, fluvial and salt tectonic features. I have also been struck by the increasing availability of free images of our own home planet - the NASA Zulu website of Landsat 7 images, the new Google Earth site, the University of Maryland site and MODIS images, enable us to recognise and map global distributions of phenomena, such as the world's great ergs, dust storm hotspots, the oriented lakes of the tundra, the worlds deflation depressions, and many others. Here is another clear area for international collaboration.

So then, I have highlighted five main areas for development: landscape conservation; the application of geomorphology; the geomorphological implications of global change; the role of geomorphological processes in Earth System Science; and the development of planetary scale studies of Mars, our ocean floors, and our land surface using the new technologies associated with remote sensing.

We need to get the message across that geomorphology is an important and active discipline, and I am pleased to say that Professor David Higgitt (Singapore) will be our first Communications Officer.

However, I am very worried by the financial viability of the IAG. I believe that we need to continue to increase the financial resources of the IAG, which are still modest. Publications can do this, and I welcome the decision to produce a Handbook of Geomorphology under the chief editorship of Basil Gomez (USA), royalties from which will come to the IAG. How about a manual of applied geomorphology? How about a guide to the world's most spectacular landform sites? We should also consider a legacy programme and approaches to foundations and major corporations. It may also be that

national subscriptions should be increased, at least in line with inflation but also to bring them more in line with comparable bodies such as INQUA. That will be something for Council to consider at its next meeting. André Ozer (Belgium) has been an excellent Treasurer over the last four years and will be handing over to Francisco Gutiérrez (Spain)

I am thrilled to have been given the honour to be President of the IAG, and I hope that you will all feel that you can approach me with ideas for taking the discipline forward between now and the next congress in Melbourne (Australia) in July 2009. We have a very full series of regional meetings scheduled for the next four years and will have 12 working groups operating over that period as well. Finally, may I pay a tribute to Mateo Gutiérrez-Elorza (Spain) and his colleagues for running such a splendid congress in Zaragoza? They will be a hard act to follow.

IAG Executive Committee Meeting Minutes

Zaragoza, Congress Hall, 8 September 2005

The President, Andrew GOUDIE, opens the meeting at 09:00 am and welcomes the participants. Are present: Franck AUDEMARD (Vice-President, Venezuela), Michael CROZIER (Vice-President, New Zealand), Morgan DE DAPPER (Secretary, Belgium), Andrew GOUDIE (President, UK), Francisco GUTTIEREZ (Treasurer, Spain), Michael SLATTERY (Publications Officer, USA). Are present from point 3 on: David HIGGIT, Mauro SOLDATI, Zbigniew ZWOLINSKI. Are excused from point 3 on: Dan BALTEANU, Monique FORT, Ying WANG

1. Agenda

The agenda proposed by the President is approved.

2. The future of the IAG – strategic overview

The President outlines his view of the future of the IAG, (to be presented at the second General Assembly), stressing the need to expand the number of working parties so that they cover major, active and developing themes in Geomorphology.

3. Cooptation of EC members

Following EC members are coopted: Dan BALTEANU (Romania), Monique FORT (France), David HIGGIT (Singapore), Mauro SOLDATI (Italy), Ying WANG (China), Zbigniew ZWOLINSKI (Poland). An effort will be done to coopt a member from Africa, south of the Sahara. A possible candidate is Mohammed UMER from Addis Abeba University, Ethiopia. The Secretary will further enquire.

4. Duties of EC members

Franck AUDEMARD: Vice-President, Latin-America

Dan BALTEANU: Central Europe

Michael CROZIER: Vice-President, Australia, New-Zealand, Oceania, Working Groups

Morgan DE DAPPER: Secretary

Monique FORT: Western Europe (especially those countries with roman language expression), Middle East, India

Andrew GOUDIE: President

Francisco GUTTIEREZ: Treasurer

Michael SLATTERY: Publications Officer, USA

David HIGGIT: Public Relations Officer; South-east Asia

Mauro SOLDATI: Training Officer

Ying WANG: China

Zbigniew ZWOLINSKI: Webmaster

Gaps: German-speaking countries of Western Europe (filled by Lothar SCHROTT, Germany, cf. 11.WG Earth Systems), Northern Europe (filled by Achim BEYLICH, Norway, cf. 11. WG SEDIBUD), North Africa (filled by Mohamed T.BENAZZOUZ, Algeria, cf. 11. WG Geomorphological Hazards), Africa south of the Sahara (cf. 2.), Indian subcontinent (filled by Sunil Kumar DE, India, cf. 11. WG Geomorphological Hazards), Meso-America (filled by Irasema ALCANTARA-AYALA, Mexico, cf. 11. WG Geomorphological Hazards)

5. Financial policy

It was reported that there was currently 62,000 Euro in the account of the IAG, but the President pointed out that c 32,000 Euros had come from royalties associated with the

Encyclopedia of Geomorphology, and this was a once and for all contribution. He pointed out that the IAG had substantial expenditure on Working Groups, Training Courses, and EC meetings. He suggested that the IAG should improve its income from publications, and noted that the Handbook of Geomorphology (edited by Basil Gomez and others) might bring in c. 9000 Euros. In addition he suggested that there should be a Legacy programme, that the fee paid to the International Council on Landslides (US\$ 2,000) should be cancelled, that the question of personal subscriptions should be revisited, that commercial sponsorship should be explored, that a proposal to increase the subscriptions for National Bodies should be brought forward to the next meeting of Council, and that the organizers of the Melbourne Conference and other meetings should be encouraged to make sure that a sufficient profit was made to make a substantial contribution to the IAG's overall budget.

The proposal to cancel the subscription to the ICL was approved.

It was noted that the Past Treasurer (A. Ozer) would hand over the finances to the New Treasurer (F. Gutierrez) in January 2006.

6. Website

Zbigniew ZWOLINSKI, Past and new Webmaster, reports: The membership database is ongoing but the response is low and slow. A new call will be launched. For the website news more feedback is needed. David HIGGIT proposes to respond quickly to major news-breaking "geomorphological" events (flooding, landslides, earthquakes, volcanic eruptions, tsunamis, hurricanes).

7. Training of young geomorphologists

Mauro SOLDATI, Past and new Training Officer, reports: During the past quadriennium young geomorphologists (mostly from less favoured countries) were supported, enabling them to take part in training courses, symposia and regional/international conferences. The EC unanimously agrees to continue this effort.

During the next years more requests for funding are likely to be expected. The ques-

tion is how to deal with this situation. The President suggests continuation of support for activities that were successful (e.g. Tierra del Fuego, Windsor). It is decided that a minimum budget will be defined in order to properly manage the proposals received. At the next EC meeting a decision will be taken concerning the budget for the first two years. In the meantime, it is decided to support the following activities for the first year:

- BGRG Post-graduate Training Course, Windsor, UK, December 2006: 2 grants for PhD students from Eastern Europe (evaluating commission: GOUDIE, SOLDATI, ZWOLINSKI);
- CONICET IV Post-graduate Field Course in Tierra del Fuego, Argentina, November 2006: 2 grants for young geomorphologists from Latin America;
- IAG Regional Conference, Brasil, September 2006: grants (number to be defined) for young geomorphologists from less favoured countries (except Latin America).

It is agreed that the EC will have to encourage the organisers of Regional Conferences to devote part of the budget to grants for young geomorphologists.

8. Publications

Publications are very important for the IAG. Wiley's contribution is declining, but the Cambridge University Press is keen to expand. The following suggestions were made:

- WG on Global Change, edited by Olav SLAYMAKER
- WG on Hazards, edited by Irasema ALCANTARA-AYALA
- Handbook/Recipe on 'Applied Geomorphology' including legal issues
- Glossary of Geomorphology for students, hardcopy, multilingual (English, French, Spanish)
- Biographies (cf. Dorothy SACK's 'History of Geomorphology'), Andrew GOUDIE's extensive archive of photographs could be included
- A book of major world landform sites, edited by Piotr MIGON.

9. Newsletter

A more efficient way of diffusion is necessary. Michael SLATTERY will consult the Past Publication Officer Carol HARDEN.

10. Scientific Meetings

- 2006, Mongolia. A Joint International Meeting on 'Environmental Changes and Earth Surface Processes in Semi-arid and Temperate Areas' will be organised in Mongolia from June 9th to 15th by the Institute of Geography of the Mongolian Academy of Science, the Japanese Geomorphological Union, the International Geographical Union (GC21) and Kanazawa University. The organisers ask the official support of the IAG. The EC unanimously agrees as long as there are no financial implications. The decision will be communicated by the Secretary.
- IAG Regional Conferences:
 - 2006, September, Goiânia, Brazil: Franck AUDEMARD will attend.
 - 2007, June, East Malaysia
 - 2007, July, Svalbard Archipelago, Spitsbergen, Norway
 - 2008, April, Israel
 - 2008, September, Braşov, Romania
- 2008, International Geological Conference, August 5th-14th, Oslo, Norway. It is proposed that Monique FORT prepares a programme with session.
- 2008, UNESCO & IUGS, International Year of Planet Earth
- 2009, IAG International Conference, Melbourne, Australia

11. Working Groups

- Continuing WG's:
 - Geoarcheology: Eric FOUACHE (France)
 - Large Rivers: Avijit GUPTA (UK)
 - Geomorphological Sites: Emmanuel REYNARD (Switzerland)
 - Arid Regions: Yang XIAOPING (China)
- New WG's:
 - SEDIBUD, Sediment Budgets in Cold Environments: Achim BEYLICH (Norway)
 - Rocky Coasts Geomorphology: Wayne

STEPHENSON (Australia)

- Carpatho-Balkan-Dinaric Regional Working Group: not yet defined

- Human Impact on the Landscape: Dénes L?CZY (Hungary)

- Small Catchments: Andrzej KOSTRZEWSKI (Poland)

- Earth Systems: Lothar SCHROTT (Germany)

- Geomorphological Hazards: Irasema ALCANTARA-AYALA (Mexico), Sunil Kumar DE (India), Mohamed T.BENAZ-ZOUZ (Algeria)

- Global Change and Geomorphology : Olav SLAYMAKER (Canada)

A budget has to be foreseen for the 8 new WG's. A decision as to the amount has to be taken during the next EC-Meeting. WG's must formulate a strategy and must have a tangible output (training manuals, international meetings and publications).

12. World Heritage Sites

The IAG will cooperate with The World Conservation Union (IUCN, www.iucn.org) on this. An ad hoc commission (a call for active members has to be launched; Denys BRUNSDEN (UK), Piotr MIGON (Poland), Michael CROZIER (New-Zealand), Andrew GOUDIE (UK) are ready to take part) will formulate a Top-20 of landscapes to be protected.

13. Any Other Business

New stationary will be prepared by the Secretary

Michael SLATTERY will formulate a statement concerning the organisation of the important group of US-geomorphologists which is at the present day diluted over different organisations: American Geophysical Union (AGU), Geological Society of America (GSA), Geomorphology Special Group of the Association of American Geographers (AAG).

14. Next EC Meeting

Andrew GOUDIE will convene the next EC Meeting in Oxford – UK. Date: 31st March and 1st April 2006 Programme: informal dinner on the Friday evening, intensive all day (9

am – 5 pm) committee meeting on the Saturday. The IAG will pay for accommodation and food. It is hoped that at least a portion of the travel costs could be provided by the institutions or national bodies of those attending.

The meeting is closed at 11 am.

Coordinates of the EC Members

Franck AUDEMARD FUNVISIS
Venezuelan Foundation for Seismological
Research Earth Sciences Department Final
Calle Mara, Urb.El Llanito CARACAS 1030
Apdo.Postal 76880 CARACAS 1070-A
Venezuela

faudemard@funvisis.gob.ve

Phone: + 58 (0)212 2575153

Dan BALTEANU University of Targoviste
Institute of Geography Department of Human
Geography 12, Dimitrie Racovita Street,
Sector 2 BUCHAREST Romania

balteanu@rnc.ro geoinst@rnc.ro

Phone: +40 (0)21 3155990

Michael CROZIER Victoria University of
Wellington Institute of Geography, School of
Earth Sciences PO Box 600 WELLINGTON
New Zealand

Michael.Crozier@vuw.ac.nz

Tel: +64 (0)4 463 5279 Fax: +64 (0)4 463
5186

Morgan DE DAPPER Ghent University
Department of Geography Krijgslaan, 281
(S8) B-9000- GENT Belgium, EU

morgan.dedapper@UGent.be

Phone: + 32 (0)9 2644690 Fax: + 32 (0)9
2644982

Monique FORT Université Paris7-Denis
Diderot Géographie, Histoire, Sciences de la
Société UFR GHSS, Case 7001 2, Place
Jussieu F- 75 251 PARIS Cedex 05 France,
EU

fort@paris7.jussieu.fr

Phone : + 33 (0)1 44 277669 Andrew
GOUDIE St Cross College St Giles
OXFORD OX1 3LZ United Kingdom, EU

andrew.goudie@st-cross.oxford.ac.uk

Phone: + 44 (0)1865 278493 (secretary); +
44 (0)1865 278492 (direct) Fax: + 44 (0)1865
278484

Francisco GUTIÉRREZ SANTOLALLA
Universidad de Zaragoza Departamento de
Ciencias de la Tierra Edificio Geológicas C/.
Pedro Cerbuna, 12 50009 ZARAGOZA
España, EU

fgutier@unizar.es

Phone: + 34 (0)976 761090 Fax: + 34
(0)976 761088

David HIGGITT National University of
Singapore Department of Geography 1, Arts
Link SINGAPORE 117570

geodlh@nus.edu.sg

Phone: + 65 6516 6809 Fax: + 65 6777
3091

Michael SLATTERY Texas Christian
University Institute for Environmental
Studies P.O.Box 298830 FORTH WORTH,
TX 76129 USA

m.slattery@tcu.edu

Phone: + 1 (817) 257 7506 Fax: + (817) 257
7789

Mauro SOLDATI Università Degli Studi di
Modena e Reggio Emilia Dipartimento di
Scienze della Terra Largo S.Eufemia, 19
41100 MODENA Italy, EU

soldati@unimore.it

Phone: + 39 (0)59 2055842

Ying WANG Nanjing University
Department of Urban and Resource Sciences
Physical Geography NANJING China

wangying@nju.edu.cn

Zbigniew ZWOLIŃSKI Adam Mickiewicz
University Institute for Paleogeography and
Geoecology Dziegielowa, 27 61-680
POZNAŃ Poland, EU

zbbzw@amu.edu.pl

Phone: + 48 (0)61 8296176

Young Geomorphologists

IAG Grants for the "Post-graduate

Research Training Workshop", Cumberland Lodge, Windsor Great Park (UK), 18-21 December 2005

The selection procedure of the six PhD students in Geomorphology from Eastern Europe who submitted a request for an IAG grant has been completed upon examination of the candidates' CVs and PhD research project abstract.

IAG Grants have been awarded to: Marek Ewertowski (Poland) and Luminita Preoteasa (Romania).

Editor's Note

The success of the IAG/AIG Newsletter

depends upon the contributions that we receive. Please assist by sending commentaries, reviews of regional or national meetings and field trips, summaries of issues pertinent to geomorphology, and announcements of future meetings and workshops. Your contributions should be forwarded to the IAG/AIG Publications Officer:

Mike Slattery, *Institute for Environmental Studies and Department of Geography, PO Box 298830, Texas Christian University, Fort Worth TX, 76129, USA. Fax (817) 257-7789; Phone (817) 257-7506; E-mail: m.slattery@tcu.edu*

International Association of Geomorphologists

President

Andrew Goudie
School of Geography
and the Environment
University of Oxford
Mansfield Road
Oxford OX1 3TB, UK
Ph: +44 1865 271921
Fax: +44 1865 271940

a n d r e w . g o u d i e @ s t -
cross.oxford.ac.uk

Vice-Presidents

Franck Audemard Funvisis	Michael Crozier
Venezuelan Foundation for	Victoria University of
Seismological Research	Wellington
Apdo.Postal 76880	Institute of Geography
CARACAS 1070-A	Wellington, New Zealand
Venezuela	Ph: +64 (0)4 463 5279
Ph: +58 (0)212 2575153	Michael.Crozier@vuw.ac.nz
faudemard@funvisis.gob.ve	

IAG Account number: 068-2376668-01 - DEXIA Banque Av. Centenaire, 42 - B-4102 Ougrée, Belgium Account IBAN: BE 43-0682-3766-6801 SWIFT: GKCCBEBB

From January 1, 2006:

IAG Account number: 0128 0409 7101 0000 1961 Bankinter, C/. Juan Carlos I, 50009 Zaragoza, Spain Account IBAN ES 79 0128 0409 7101 0000 1961 SWIFT code: BKBKESMM

Visit the IAG/AIG Web Site at: <http://www.geomorph.org>

**Al XXI-lea Simpozion național de geomorfologie
Sfântu Gheorghe, Delta Dunării, 27–30 mai 2004**

Asociația Geomorfologilor din România (Președinte Prof. Emil Vespremeanu), în colaborare cu Facultatea de Geografie de la Universitatea din București, Stațiunea de Cercetări Marine și Fluviale Sfântu Gheorghe a Universității din București și cu Institutul de Geografie al Academiei Române, a organizat, la Sfântu Gheorghe (Delta Dunării), cel de al XXI-lea Simpozion Național de Geomorfologie, cu tema: **Relieful României sub incidența factorilor induși de schimbările globale**. La aceasta s-a adăugat tema mesei rotunde și aplicația de teren: **Relieful costier din România — forme, morfogeneza, morfodinamică**.

Ineditul simpozionului l-au constituit aplicațiile practice care s-au desfășurat în fiecare zi, după sesiunea de comunicări în: Insula Sacalin (Hidrodinamica gurii de vărsare a brațului Sfântu Gheorghe și evoluția Insulei Sacalin — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu-Stroe, Ștefan Constantinescu); sistemul plajă–dune dintre Sf. Gheorghe și Sulina (Comportamentul multianual al sistemului plaja-dune pe țărmul Sf. Gheorghe–sud de Sulina — cu explicații oferite de Emil Vespremeanu, Alfred Vespremeanu Stroe, Ștefan Constantinescu, Luminița Preoteasa). În ultima zi, aplicația s-a făcut pe traseul de întoarcere: brațul Sf. Gheorghe, canalele Isacova-Litcov, Crișan pe br. Sulina, lacul Fortuna, brațul Sulina, Tulcea.

Majoritatea comunicărilor s-au înscris în tematica largă a metodelor și tehnicilor de cercetare cu aplicații la relieful României:

Utilizarea Tehnicii cu Cesium-137 în studiile de sedimentare (Ionița I., Mărgineanu R.), *Metoda dendrocronologică. Utilizare în geoecologie și geomorfologie* (Vuia F.), *Rolul factorilor climatici în declanșarea deplasărilor în masă. Aplicație GIS în Subcarpații Buzăului* (Micu M., Cheval S., Dragne Dana), *Influence des erreurs sur les MNT dans les études de risque* (Roussaux F., Grecu Florina), *Utilizarea metodei dendrocronologice în analiza avalanșelor. Studiu de caz — Abruptul prahovean al Bucegilor* (Voiculescu M., Vuia F.), *Calculul transportului de sedimente efectuat de curenți în lungul țărmului deltaic danubian* (Vespremeanu Stroe A.), *Utilizarea tehnicilor G.I.S. pentru evaluarea potențialului natural și construit. Studiu de caz: Municipiul Suceava* (Crăciunescu V., Berteza Gabriela), *Analiza prin tehnici G.I.S. a morfologiei sectorului de confluență Olt–Dunăre* (Filip F., Constantinescu Ș.), *Aplicații ale analizei Change Detection în studiul morfodinamicii actuale în Munții Postăvaru–Piatra Mare–Clăbucetele Predealului* (Mihai B., Șandric I.), *Rolul cartografierii geomorfologice în identificarea hazardelor naturale* (Rădoane N.), *Considerații asupra morfometriei bazinului Casimcea pe baza utilizării tehnicilor G.I.S.* (Flueraru C.), *Caracterizarea geomorfologică a modelului numeric altimetric al reliefului cu rezoluția de 10 metri* (Tudose C., Din D.)

Cea mai mare parte a lucrărilor au fost publicate în *Revista de geomorfologie* vol. 6/2004

Laura COMĂNESCU

**Al XXI-lea Simpozion național de geomorfologie
Oradea, 7–8 aprilie 2006**

În perioada 7 – 8 aprilie 2006 a avut loc la Oradea, al XXII-lea Simpozion Național de Geomorfologie, în organizarea Asociației Geomorfologilor din România și a Universității din Oradea, Facultatea de Istorie – Geografie, Departamentul de Geografie, Turism și Amenajarea Teritoriului.

Cuvânt de deschidere au rostit: prof. univ. dr. Teodor Traian Maghiar, Rectorul Universității din Oradea, prof. univ.dr. Emil Vespremeanu, Președintele Asociației Geomorfologilor din România și prof.univ. dr. Nicolae Josan, organizatorul simpozionului.

Simpozionul desfășurat sub genericul

Relieful și Amenajarea Teritoriului a avut trei importante obiective:

1. Sesiunea de comunicări a debutat cu trei prezentări susținute în plen de către prof.dr.docent Grigore Posea – Președinte de onoare al A.G.R. (*Glacisurile din Câmpia de Vest*), prof.univ.dr. Ion Mac (*Morfosecvențe microscalare, suporturi pentru amenajări teritoriale*), prof.univ.dr. Emil Vespremeanu (*Din nou despre geomorfologia bazinului Mării Negre*) (ambii ex- președinți A.G.R.).

Cele circa 50 de lucrări, de înalt nivel științific, au fost grupate pe două mari secțiuni (*Relieful și amenajarea teritoriului și Procese geomorfologice*), în care au fost abordate subiecte atât teoretice cât și practice referitoare la geomorfologia întregii țări, predominând însă cele asupra Transilvaniei.

2. Aplicația practică (8 aprilie) s-a desfășurat pe traseul Oradea – Uileacu de Criș – Vadul Crișului – Șuncuiș – Oradea cu expuneri asupra problemelor: terase, glacisuri, procese actuale, amenajări hidrotehnice ale Crișului Repede la Luncaș și Tileagd, evoluția rețelei hidrografice, contactul Munților Plopiș cu Dealurile Oradiei. Aplicația de teren a continuat cu vizitarea peșterii Ungurului (recent amenajată) și servirea mesei la Șuncuiș, (*Pensiunea Perla Albastră*).

3. Cel de-al treilea obiectiv l-a constituit alegerea Consiliului Executiv al A.G.R. în cadrul Adunării Generale a A.G.R. În urma alegerilor componența consiliului este:

• **Președinte:** prof. Nicolae Josan (Universitatea din Oradea),

• **Vicepreședinți:** prof. Adrian Cioacă (Universitatea „Spiru Haret” - Bucurști), prof. Ion Ioniță (Universitatea „A.I. Cuza” - Iași), prof. Virgil Surdeanu (Universitatea „Babeș-Bolyai” – Cluj Napoca),

• **Secretar general:** prof. Florina Grecu (Universitatea din București),

• **Trezorier:** lect. dr. Marian Ene (Universitatea din București).

• **Membrii:** prof. Maria Rădoane (Universitatea „Ștefan cel Mare” - Suceava), prof. Petre Urdea (Universitatea de Vest - Timișoara), prof. Emil Vespremeanu (Universitatea din București), conf. Ioan Aurel Irimuş (Universitatea „Babeș-Bolyai” – Cluj Napoca), lect. drd. Stelian Nistor (Universitatea din Oradea).

Cel de-al XXII-lea simpozion de geomorfologie desfășurat la Oradea s-a detașat de cele anterioare prin participarea efectivă (numerică și calitativă) a tinerilor colegi, cu comunicări ce se înscriu în problematica actuală a cercetării geomorfologice mondiale, bazate pe rezultate experimentale și pe utilizarea tehnicii moderne de realizare și prezentare. Subliniem de asemenea efortul gazdelor pentru excelența și eleganta organizare, pentru asigurarea unui sejur instructiv în cetatea bihoreană, cu profunde semnificații istorice și geografice -Oradea.

Florina GRECU

RECENZII

• Florina GRECU (ed.), *Lucrări și rapoarte de cercetare (Research papers and reports)*, vol. I, Editura Universității din București, 2005, 218 pages.

This first volume of *Research papers and reports*, which presents the activity of the Research Centre for Land Degradation and Geomorphological Dynamics, includes eight summaries of studies made under the research

grants obtained from the National Research Council for Higher Education (NRCHE) and the Ministry of Education and Research (MER) in collaboration with partners from Cemagref-Lyon, Cemagref-Grenoble (France) and the Liège University (Belgium). The Acts of the Research Centre, recognised by NRCHE, are also appended.

Some of the summaries reflect the contribution of geographical research to such phenomena as

7. Maria Hosu, *Expunerea la risc geomorfologic a aşezarilor din cadrul Văii Someşului, urmare a morfodinamicii fluviale şi instabilităţii versanţilor*
8. Nicoleta Ionac, *Radiaţia ultravioletă, factor de risc pentru sănătatea umană*
9. Gh. Mahara, O. Gaceu, *Depunerile de gheaţă din Munţii Bihor-Vlădeasa şi impactul lor asupra mediului înconjurător*
10. Tudose, F. Moldovan, *Riscuri asociate evoluţiei vremii în bazinul hidrografic Someş - Tisa în luna iulie 2005*
11. H- V Conliu, A. Conliu, *Percepţia inundaţiilor în culoarul Mureşului dintre Reghin şi confluenţa cu Arieşul*
12. Oana Moigradean, *Percepţia riscurilor induse de inundaţii. Rezultatul unui sondaj de opinie desfăşurat în depresiunea Almaj-Agrij*
13. Gh. Romanescu, *Riscul inundaţiilor în amonte de Lacul Izvorul Muntelui şi efectul imediat asupra trăsăturilor geomorfologice ale albiei*
14. V. Surdeanu, N. Berindean, P. Olariu, *Factorii naturali şi antropici care determină formarea zăpoarelor în bazinul superior al râului Bistriţa*
15. G. Pandi, Cs. Horvath, *Riscuri asociate colmatării Lacului Roşu*
16. L. C. Stănga, L. Minea, *Vulnerabilitatea la eroziune a unor soluri zonale din Carpaţii Orientali*
17. *Rezervaţia Biosferei Delta Dunării. Protecţie versus impact antropic*
18. K. Konecsny, *Reducerea gradului de împădurire ca factor de risc în formarea inundaţiilor în bazinul hidrografic Tisa Superioara*
19. L. Minea, *Riscuri hidrice induse de activităţile antropice. Studiu de caz poluarea apei râului Trotuş*
20. I. Arghiuş, Al. Ozunu, *Fenomene de risc asociate exploatării sării în perimetrul urban Ocna Mureş*
21. E. Varrel, *Les apports de l'acquisition geometrique haute densite par scannage 3D dans la prevention et le traitement les chutes de blocs*
22. R. Lambert, *Une nouvelle methodologie pour les cartes d'avalanches*
23. S. Veyrat-Charvillon, *Cartographie fonctionnelle des apports sedimentaires du bassin versant torrentiel*
24. Villemin, *La scannerisation 3D lidar: une nouvelle technologie au service de l'etude des escarpements instables presentanon de l'outil*

Robert DOBRE