III SESSIONE
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GEO - ARCHEOLOGIA
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Chairman: A. ARNOLDUS-HUYZENDVELD

Mem. Descr. Carta Geol. d'It.
LIV (1999), pp. 201-206

Problems of conservation of geological-archaeological sites in the eastern Ukraine

Problemi di conservazione dei siti geologico-archeologici nell'Ucraina orientale

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ABSTRACT – The category of geo-archaeological site as a protected object is proposed and substantiated for the first time in Ukraine. The geo-archaeological sites are important for determination of geological age of the material cultures, for understanding of causative linkages within the system "environment - society". The evidences of environmental impact on migrations and collapses in the Old Cultures history are available in Ukraine as well as those of the human impact on environment.
The program of selection, preservation and geological studies of the geo-archaeological sites are presented in the paper. The objects of protection from the soil-geological view-point are determined at the geo-archaeological sites. The list of selected geo-archaeological sites for different periods are proposed for the Eastern Ukraine.

KEY WORDS – Geological-archaeological site, Pleistocene, Holocene.

RIASSUNTO – La categoria del sito geo-archeologico come oggetto protetto viene proposta e validata per la prima volta in Ucraina. I siti geo-archeologici sono importanti per la determinazione dell'età delle principali culture e per la comprensione dei legami di causalità nel sistema «ambiente-società». Le evidenze dell'impatto ambientale sulle migrazioni e sui crolli sociali nella storia delle Culture Antiche sono disponibili in Ucraina così come quelle dell'impatto umano sull'ambiente.
Il programma di selezione, la conservazione e gli studi geologici dei siti geo-archeologici sono presentati nell'articolo. Gli oggetti di protezione dal punto di vista pedo-geologico sono determinati sui siti geo-archeologici. Viene presentata la lista dei siti geo-archeologici per i diversi periodi per l'Ucraina orientale.

PAROLE CHIAVE – Sito geologico-archeologico, Pleistocene, Olocene.

1. – INTRODUCTION

The problem of preservation of geo-archaeological localities is of great importance for Ukraine. The famous multi-layered Auchelian - Mousterian - Late Paleolithic sites in Ukraine are characterized by well subdivided complete Pleistocene sequences. But none of such localitiesis is geologically protected. The very category of geo-archaeological site is absent in the existing list of geological sites (KOROTENKO *et alii,* 1987). Since the Mesolith, archaeological sites are related to the Holocene deposits. The last ones in some cases are of great thickness and clearly stratified into the horizons of different genesis containing the cultural layers of different age. The factors of an appearance and upset of the Old Cultures can be studied at such objects. But none of the Holocene sites is regarded as protected soil-geological monuments.

The valuable archaeological sites in Ukraine are protected at state, regional and local range. But with the exception of the world-famous Paleolithic monuments studied by natural sciences methods (the Korolevo, Dobranichevka, Mezhirich sites, so on), they are preserved not from the soil-geological view-point. So, most valuable stratigraphical sequences at the localities can be desroyed. Especially critical conditions for conservation of geo-archaeological sites exist in the Eastern Ukraine. There are no sites protected at the state range here. For example, the Bronze age settlement Bezymenne have been half-destroyed by locals

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just before its arrangement as some kind of geo-archaeological museum. To prevent such tragic accidents the national and regional strategy of geo-archaeological protection should be elaborated and realized.

The Eastern Ukraine is a natural transitional region between the forest-steppe and steppe zones. So, its nature is very sensitive and vulnerable to climatic changes. In the archaeological context, it is a cross-roads between the Old Cultures migration flows. Nomadic or husbandry settlement systems change one another during the last six millennia there. So the Eastern Ukraine is a quite appropriate important region to elucidate the cause and effect relationships within the system "environment-society".

2. – THE PROGRAM OF GEOTOP STUDIES AND PRESERVATION AT THE GEO-ARCHAEOLOGICAL SITES

At present, the program of the inventory of the Ukrainian archaeological sites ought to be carried out. We propose that soil-archaeological investigation should be the integral part of this program. Soil-geological signs must to be taken in account for the determination of the range of the site protection. Some sites are not of great significance by their own archaeology but unique in respect of continuous sequences, and so of importance value for another sites. The correlation of archaeological and geochronological dating at the same sites can be used for the working of the local calibration scales. It also approves that geology and archaeology of the sites are of great mutual importance and ought to be studied and protected together. We proposed to distinguish the sites valuable for both scientific areas as special type of protection objects - geo-archaeological ones represented in the lists of both types of sites.

The objectives of geotop investigations at the archaeological sites should include:

1. To determine the geological age of cultural layers by stratigraphical and geochronological methods
2. To reconstruct the palaeoecological setting of ancient men by the multi-disciplinary complex of lithological-palaeogeographical methods
3. To explain the selection of the site (settlement) locations and, finally, to explain the settlement pattern for every period
4. To reveal the impact of the settlement subsistense activity on the environment (local or regional one, with short or long-term consequences)
5. To estimate the natural conditions of the investigated period against the background of those of wider chronological interval (the Pleistocene, the Holocene)
6. To correlate the data obtained from the different sites. Judging from the last objective, to realize the program at all geo-archaeological sites is essentially important.

The complex of lithological-palaeogeographical methods includes lithological namely, palaeogeomorphological, palaeopedological, palynological, malacological ones. The other palaeoenvironmental indicators (microvertebrates, mammals, paleobotanical macrofossils) should be used whether they are preserved in the sites.

The accurate determination of right stratigraphical position of a cultural layer is a primary task of investigation. The problem is that the consequent soil-geomorphic processes can destort the real position of a cultural layer. For example, very slow hillwash processes along gentle slope can involve artifacts and transfer them somewhere down almost imperceptibly for archaeologists regarded them as a cultural layer "in situ". Plant roots, desiccation (or frost) fissures and especially pedofauna are the other potent factors of perversion of primary position of a cultural layer. At last, some types of soils are characterized by a deep downward reworking of the solum with embedded artifacts. To avoid mistakes, lithological-palaeogeographical studies need vast excavations allowing to trace the cultural layer extent along the soil catena and palaeorelief profile. The more number of sections located at different elements of relief has been excavated, the better for palaeoecological reconstruction. So, the complex of sites located hereabouts is always preferable to be regarded as geo-archaeological site than a single locality. The top surface pollen samples should be analysed to make correct interpretation of palaeoenvironment based on the comparison with the present environmental conditions at the site locality.

The objects of protection at the archaeological sites from the soil-geological point of view should include the preservation of the most complete soil-geological sequences (in some cases even without cultural layers, dated by geochronology only), the sequence with the cultural layers in their primary undistorted stratigraphical position and those with their typical position (for the demonstration of postsedimentary processes), the sequences with cultural layers in household structures: pits, dwelling deep floor, so on (for the illustration of different sedimentation rates) and,

at last, standard natural sequences located at some reasonable distance from the site. This allows to estimate the human disturbance of the environment.

3. – GEO-ARCHAEOLOGICAL SITES PROPOSED FOR PROTECTION IN THE EASTERN UKRAINE

The task of a scientist-geoprotectionist is to provide the scientific subsumption for the selection and conservation of valuable objects. For many years, the Author studies the natural sequences of the Eastern Ukraine and co-works with archaeologists in the pollen and soil-stratigraphical investigations of some sites of Mousterian, Late and Final Palaeolithic, Mesolithic, Neolithic, Bronze Age, Scythian and Medieval cultures. The stratigraphical basis for the studies of the Palaeolithic is the Ukrainian Stratigraphical Scheme of the Pleistocene (VEKLICH *et alii*, 1993). Stratigraphical basis for studies of the Holocene is the Blytt - Sernander scheme in the modification of HOTINSKY (1977). More than 20 environmental oscillations have been recognized (GERASIMENKO, 1995) from the Holocene deposits (fig.1). The reconstruction of ecotones for each stage of the Late Pleistocene have been revealed as well as the dynamics of their complicated fluctuations within every stage. The chronological (and stratigraphical) units of both schemes have been related to the stages of material cultures development. Of course, both schemes should be further elaborated and probably corrected in details. But some interesting conclusions for archaeology can be drown from the diagrams just now. For example, direct relations between arid climatic events and collapses of husbandry or sedentary subsistence system (1800-1700 BC, 1000-700 BC, 200 AD). In order to elucidate the geological age and peculiarites of the development of the material cultures, such geo-archaeological sites are proposed to be protected in the Eastern Ukraine (fig. 2).

3.1. – THE DONETSK REGION

3.1.1. – *Paleolithic*

Korniyiv Yar (excavation by KOLESNIK, 1986) - 1 - a single stratigraphically subdivided section with the Acheulian artifacts.

Zvanivka (excavation by KOLESNIK, 1977-1981) - 2 - demonstrates the Mousterian cultural layer related to the 5b isotopic substage.

Bilokuz'mynivka (excavation by TSVEYBEL', 1966-1970, by KOLESNIK, 1986) - 15 - the multi-layered Mousterian complex related to the 5c, 5a and 4 isotopic stage.

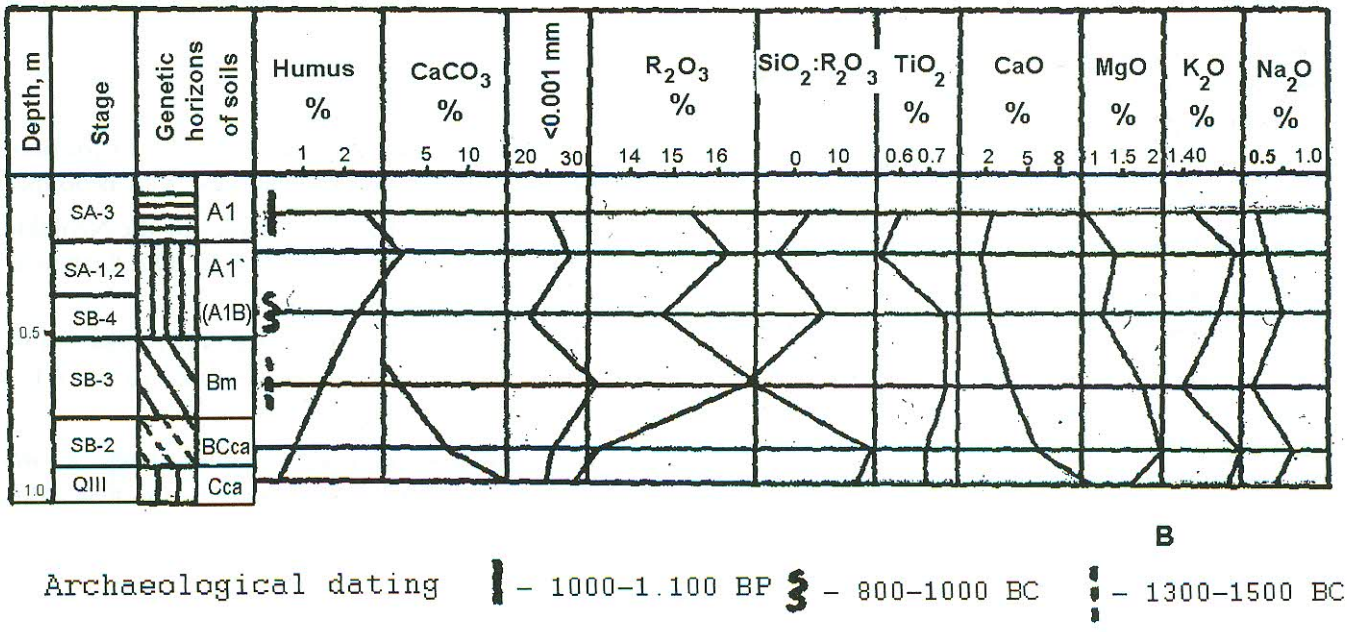

Fig. 1. – Diagram of the stages of vegetation dynamics in the Holocene and their relations to the stages of the material culture development for the South-Eastern Ukraine. The comparison with the stages of the Kaidaky temperate interval of the Pleistocene (isotopic subtage 5e): prognostic aspects.

– Diagramma degli strati della dinamica della vegetazione nell'Olocene e delle loro relazioni con gli strati dello sviluppo delle colture principali per l'Ucraina Sud-Orientale. Il confronto con gli strati dell'intervallo temperato di Kaidaky del Pleistocene (substage isotopico 5e): aspetti rivelatori.

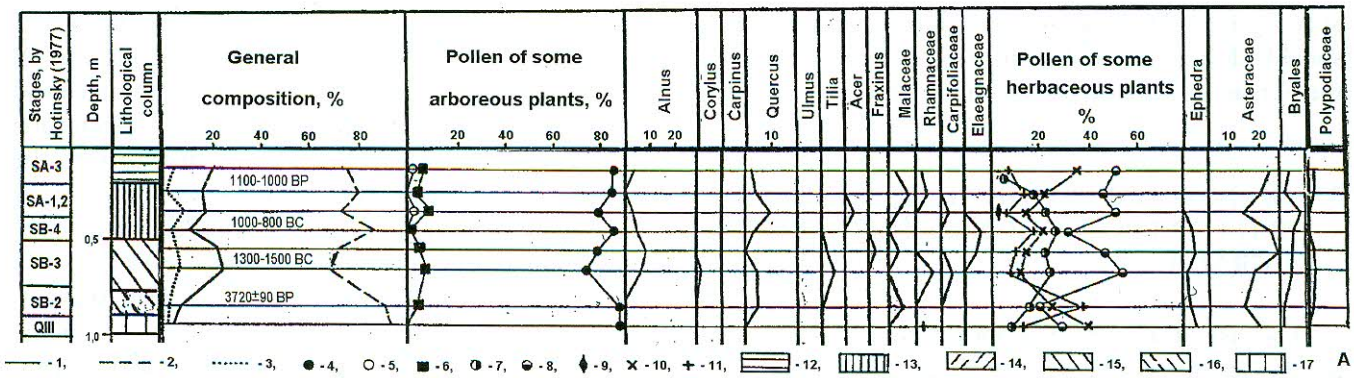

Fig. 2. – Map of archaeological localities in the Eastern Ukraine proposed to be preserved as geoarchaeological sites. A - Auchelian, B - Mousterian, C - Late Paleolithic, D - Final Paleolithic, E - Mesolithic, F - Neolithic, G - Bronze Age, I - Scythian, K - Medieval sites. The names of localities: 1 - Korniyiv Yar, 2 - Zvanivka, 3 - Pidgorivka, 4 - Starobil'sk, 5 -Shevchenko, 6 - Peredil'sk, 7 - Rogalyk, 8 - Synychyne, 9 - Sloboda, 10 -Novoselivka, 11 - Illichivka, 12 - Glyboke Ozero, 13 - Ol'khova, 14 - Sydorove, 15 - Bilokuz'mynivka, 16 - Kurdyumivka, 17 - Bila Gora, 18 - Sabivka, 19 - Minchekur, 20 - Zymivnyky, 21 - Igren', 22 - Stari Kaydaky, 23 - Kamyanka - Dnieprovs'ka, 24 - Amvrosievka, 25 - Novoklynivka, 26 - Bezymenne, 27 - Lyapina Balka, 28 - Kamyshuvata - Buyluvata, 29 - Chokrak, 30 - Kitey, 31 - Sary-Kaya, 32 - Kabazi, 33 - Grotto Skalisty

– Mappa delle località archeologiche nell'Ucraina Orientale proposte per essere conservate come siti geoarcheologici. A - Auchelian, B - Mousterian, C - Late Paleolithic, D - Final Paleolithic, E - Mesolithic, F - Neolithic, G - Bronze Age, I - Scythian, K - Medieval sites. The names of localities: 1 - Korniyiv Yar, 2 - Zvanivka, 3 - Pidgorivka, 4 - Starobil'sk, 5 -Shevchenko, 6 - Peredil'sk, 7 - Rogalyk, 8 - Synychyne, 9 - Sloboda, 10 -Novoselivka, 11 - Illichivka, 12 - Glyboke Ozero, 13 - Ol'khova, 14 - Sydorove, 15 - Bilokuz'mynivka, 16 - Kurdyumivka, 17 - Bila Gora, 18 - Sabivka, 19 - Minchekur, 20 - Zymivnyky, 21 - Igren', 22 - Stari Kaydaky, 23 - Kamyanka - Dnieprovs'ka, 24 - Amvrosievka, 25 - Novoklynivka, 26 - Bezymenne, 27 - Lyapina Balka, 28 - Kamyshuvata - Buyluvata, 29 - Chokrak, 30 - Kitey, 31 - Sary-Kaya, 32 - Kabazi, 33 - Grotto Skalisty

Kurdyumivka (excavation by KOLESNIK, 1987-1992) - 16 - the most complete and thick Upper Pleistocene section among the Mousterian localities of the region.

Bila Gora (excavation by KOLESNIK, 1988) - 17 - demonstrates the Upper Paleolithic cultural layer related to the 3 isotopic stage.

Synychyne (excavation by SNEZHKO, 1989,1995) - 8 - demonstrates the Late Paleolithic cultural layer related to the 2 isotopic stage.

Sydorove (excavation by KOLESNIK, 1993-1996) - 14 - demostrates the Final Paleolithic cultural layer related to the Late Glacial deposits (located in the valley).

Peredils'k (excavation by GORELIK, 1988-1994) - 6 - the complex of the Final Paleolithic sites (located at a plato).

Rogalyk (excavation by GORELIK, 1981-1984, 1988-1994) - 7 - the complex of Final Paleolithic sites located at slope. The most complete Holocene sequence in the region Pidgorivka (excavation by GURIN, 1987-1991) - 3 - the multi-layered Final Paleolithic and Eneolithic site with well stratified sequence.

3.1.2. – *Mesolithic*

Khutor Shevchenko (excavation by GORELIK, 1981-1984) - 5 - demonstrates the Mesolithic cultural layer related to the Preboreal 2 deposits.

Sabivka (excavation by GORELIK, 1988-1994) - 18 - demonstrates the Mesolithic cultural layer related to the Preboreal 1 deposits.

Zymivnyky (excavation by GORELIK, 1981-1984) - 20 - the complex of Mesolithic sites related to the Preboreal, Boreal and the beginning of Atlantic period.

3.1.3 – *Neolithic*

Minchekur (excavation by GORELIK, 1988) - 19 - demonstrates the Neolithic layer related to the AT 1 deposits.

Illichivka - 11 - the stratified complex of the Neolithic and Bronze Age sites (excavation by DEGERMENGY, 1992-1993, by TSYMYDANOV).

Ol'khova (excavation by GORELIK, 1981-1984) - 13 - the Late Neolithic cultural layer related to the AT 2 deposits.

Starobil'sk (excavation by GURIN, 1987-1989) - 4 - the most complete and thick sequence at the Eneolithic site (the AT 3 deposits).

3.1.4. – *Bronze and Medieval Ages*

Novoselivka (excavation by ZIMIDANOV, 1988-1989) - 10 - the stratified complex of multi-layered Bronze age and Medieval localities at the sand terrace dunes.

Glyboke Ozero (excavation by GERSHKOVICH,1991) - 13 - the stratigraphical subdivision of different stages of the Late Bronze and Scythian cultures. The most complete section of the Subboreal deposits in the region.

Sloboda (excavation by SHVETSOV, 1995-1996) - 9 - the most complete stratigraphically subdivided sequence of the Medieval localities in the region.

3.2. – THE PRYAZOVA (NEAR THE SEA OF AZOV REGION)

3.2.1 – *Paleolithic*

Amvrosievka (excavation by BORISKOVSKY and PIDOPLICHKO, 1948-1950, by KROTOVA, 1978-1994) - 24 - the Late Paleolithic complex: a base camp and a bison kill site related to the isotopic stage 3 - 2 boundary.

Novoklynivka (excavation by KOVAL, 1995-1996) - 25 - the Final Palaeolithic site related to the Late Glacial deposits.

3.2.2 – *Bronze and Medieval Ages*

Bezymenne (excavation by GORBOV, 1990-1995) - 26 - demonstrates the stratigraphical subdivision of different stages of the Late Bronze cultures. The most complete section of the Holocene in the region.

Lyapina Balka (excavation by GORBOV, 1993-1994) - 27 - the Late Bronze settlement related to the specific deposits of a depression.

Kamyshuvata - Buylovata (excavation by GORBOV, 1992) - 28 - the complex of localities of different stages of the Bronze Age demonstrated the changes of subsistence system patterns according to the environmental changes.

3.3. – THE MIDDLE DNIEPER AND CRIMEAN REGIONS

3.3.1 - *Palaeolithic*

Kabazi (excavation by KOLOSOV, CHABAY, 1985-1995) - 32 - the complex of multi-layered Mousterian sites related to the isotopic stage 5, 4, 3.

Stari Kaidaky (excavation by GROMOV,1946-1947, by VEKLICH, 1955) - 22 - demonstrates the Mousterian site related to the isotopic stage 5.

Sary-Kaya (excavation by KOLOSOV, 1977-1986, KOLOSOV & CHABAY, 1992) - 31 - the Late Paleolithtic site related to the isotopic stage 3.

Grotto Skalisty (excavation by KOEN, 1992-1993) - 33 - the Final Palaeolithic site related to the Late Glacial.

3.3.2 – *Neolith - Medieval Cultures*

Igren' (excavation by DOBROVOL'SKY, 1949, by TELEGIN, 1954-1957) - 21 - stratified multi-layered complex of Mesolithic, Neolithic, Bronze Age sites.

Kamyanka-Dnieprovs'ka (excavation by HAVRYLUK, 1989-1991) - 23 -the most complete sequence of the Late Holocene at the Scythian site.

Chokrak (excavation by MASLENNIKOV, 1977-1996) - 29 - the different phases of existence of the Antique town and the medieval findings related to SA 1-3.

Kitey (excavation by BESSONOVA,1970, by MOLOV, 1974) - 30 - sequence of the Antique town related to SA 2 deposits.

At the present, some of the sites have been subjected to the multi-disciplinary studies according to the above-mentioned program. For example, at the Final Palaeolithic complex of sites Rogalyk (7), some dozen of sections have been inspected. Palaeogeomorphological, palaeozoological, palaeopedological, palynological, radiocarbon, thermoluminescence and palaeomagnetic studies have been carried out. This site as well as the Amvrosievka site (27) for the Upper Palaeolith, the Glyboke Ozero (13), Bezymenne (26) settlements for the Bronze Age can be regarded as the key geo-archaeological sites. Some of sites have not been investigated in detail yet. But all of them provide the prospective possibilities for future investigation and should be protected thoroughly.

Acknowledgements

My thanks go first to Drs. A. GORELIK, V. GORBOV, Y. GERSOKOVICH, Y. GURIN, A. KOLESNIK, V. KOEN, A. KROTOVA, V. CHABAY *who have initiated the geological studies of the archaeological localities in the investigated region and made possible the selection of the sites proposed as geo-archaeological ones.*

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Mem. Descr. Carta Geol. d'It.
LIV (1999), pp. 207-218

Monuments as "Geotopes": volcanic building stones from the roman area used to construct ancient Roma

Monumenti come «Geotopi»: materiali vulcanici da costruzione dell'area romana utilizzati per edificare l'antica Roma

De Rita D. (*) & Giampaolo C. (*)

Abstract – We studied building stones from the most representative monuments built between the Archaic and Imperial Ages (1000 BC to 300 AD) and we localized the source excavation areas for these stones. From these data, some general inferences can be made about: 1) the roman civilization's excavation technologies through the ages, which allowed it to use rock types with progressively better physical-mechanical characteristics; 2) the increasing size of the empire which permitted increased access to different raw materials, and 3) the increasingly improved network of roads that connected the city with the surrounding countryside.

Many of the sites that the Romans used as building-stone quarries are still recognizable today and we believe that these cultural heritage sites must be protected in the future as "twins" of the ancient monuments for three main reasons. First, the study of these sites can provide extensive information regarding the sociological-environmental interconnection described above. Second, more pragmatically, these old quarries can be used as a source of restoration material for the monuments. Third, these sites provide a unique educational opportunity for the public to learn about the processes and products of explosive volcanism, both within the ancient monuments of the city and within their natural settings. In the past, the protection of historical monuments has been obvious in human culture; the protection of the natural "Geotopo" and public education for the importance of this protection is still an idea which must be promoted.

Key Words – Colli Albani, Monti Sabatini, Building stones, Monuments, Archeology, Geotopo.

Riassunto – In questa nota gli Autori, attraverso il riconoscimento e la catalogazione delle pietre di origine vulcanica utilizzate nell'edificazione dei principali monumenti storici di Roma, ricostruiscono i trascorsi dell'uomo nel suo paesaggio naturale. A partire dall'età arcaica fino a quella imperiale, vengono indicate le pietre di origine vulcanica maggiormente impiegate nell'edificazione dei monumenti. Per ogni pietra viene indicata l'area originale di cavatura, in modo da ripercorrere, per grandi linee, un itinerario temporale, contenente informazioni sia sulla capacità tecnologica di cavare ed utilizzare pietre con caratteristiche fisico-meccaniche via via migliori, sia sull'ampliamento del territorio che poteva essere utilizzato a scopi pratici e sulle vie di collegamento tra la città e la campagna circostante. Molti dei siti romani utilizzati come cave di approvvigionamento delle pietre da costruzione sono tutt'oggi riconoscibili e questi dovrebbero essere tutelati come beni culturali da gemellare ai monumenti. La protezione del monumento storico è ovvia nella cultura dell'uomo, mentre quella del «Geotopo» naturale lo è molto meno. La difesa del Geotopo naturale sotto i suoi molteplici aspetti è ancora una conquista che necessita l'evidenzazione dell'opportunità della protezione culturale. I siti naturali gemelli dei monumenti romani, dovranno rappresentare la documentazione naturale delle caratteristiche litologiche delle unità piroclastiche da cui derivano, nonchè delle modalità di trasporto e di deposizione della nuvola eruttiva che originò il deposito, della sua collocazione nel paesaggio e delle relazioni tra paleomorfologia e deposito.

Parola-Chiave – Colli Albani, Monti Sabatini, Pietre da costruzione, Monumenti, Archeologia, Geotopo.

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1. – INTRODUCTION

The ancient monuments and architectural heritage conserved in Roma over the last few thousand years are important resources in terms of their aesthetic and historical values. In addition, their building stones give important information on society's daily needs and its ability to use natural resources from the roman region to resolve these difficulties. As is well known, ancient Roma developed in a geologically favorable region with immense resources. The city of Roma is situated between two recently active volcanic districts, Sabatini volcanic district to the north and Colli Albani volcanic district to the south, whose predominantly explosive products dominate the landscape of Roma (fig. 1). Besides the excellent hydrological resources, used as both potable water and as a mode of transportation, and fertile soil, resulting from the breakdown of volcanic material, the volcanic stones, used to build the infrastructure of the burgeoning city of Roma, cannot be considered of secondary importance. The historical use of building stones for shelter, defense and ornamentation is tangible evidence of the evolution of the roman civilization. The stones provide a record of the region's history in terms of the fundamental elements of human habitat and, of the evolution of human technological capacity to derive necessary materials from the geological environment.

In this note we identify the volcanic rocks used in the principle historical monuments of Roma and show how the use of different volcanic building stones traces man's changing interaction with his environment through time. We studied building stones from the most representative monuments built between the Archaic and Imperial Ages (1000 BC to 300 AD) and we localized the source excavation areas for these stones. From these data, some general inferences can be made about: 1) the roman civilization's excavation technologies through the ages, which allowed it to use rock types with progressively better physical-mechanical characteristics; 2) the increasing size of the empire which permitted increased access to different raw materials, and 3) the increasingly improved network of roads that connected the city with the surrounding countryside.

Many of the sites that the Romans used as building-stone quarries are still recognizable today and we believe that these cultural heritage sites must be protected in the future as "twins" of the ancient monuments for three main reasons. First, the study of these sites can provide extensive information regarding the sociological-environmental interconnection described above. Second, more pragmatically, these old quarries can be used as a source of restoration material for the monuments. Third, these sites provide a unique educational opportunity for the public to learn about the processes and products of explosive volcanism, both within the ancient monuments of the city and within their natural settings. In the past, the protection of historical monuments has been obvious in human culture; the protection of the natural "Geotopo" and public education for the importance of this protection is still an idea which must be promoted.

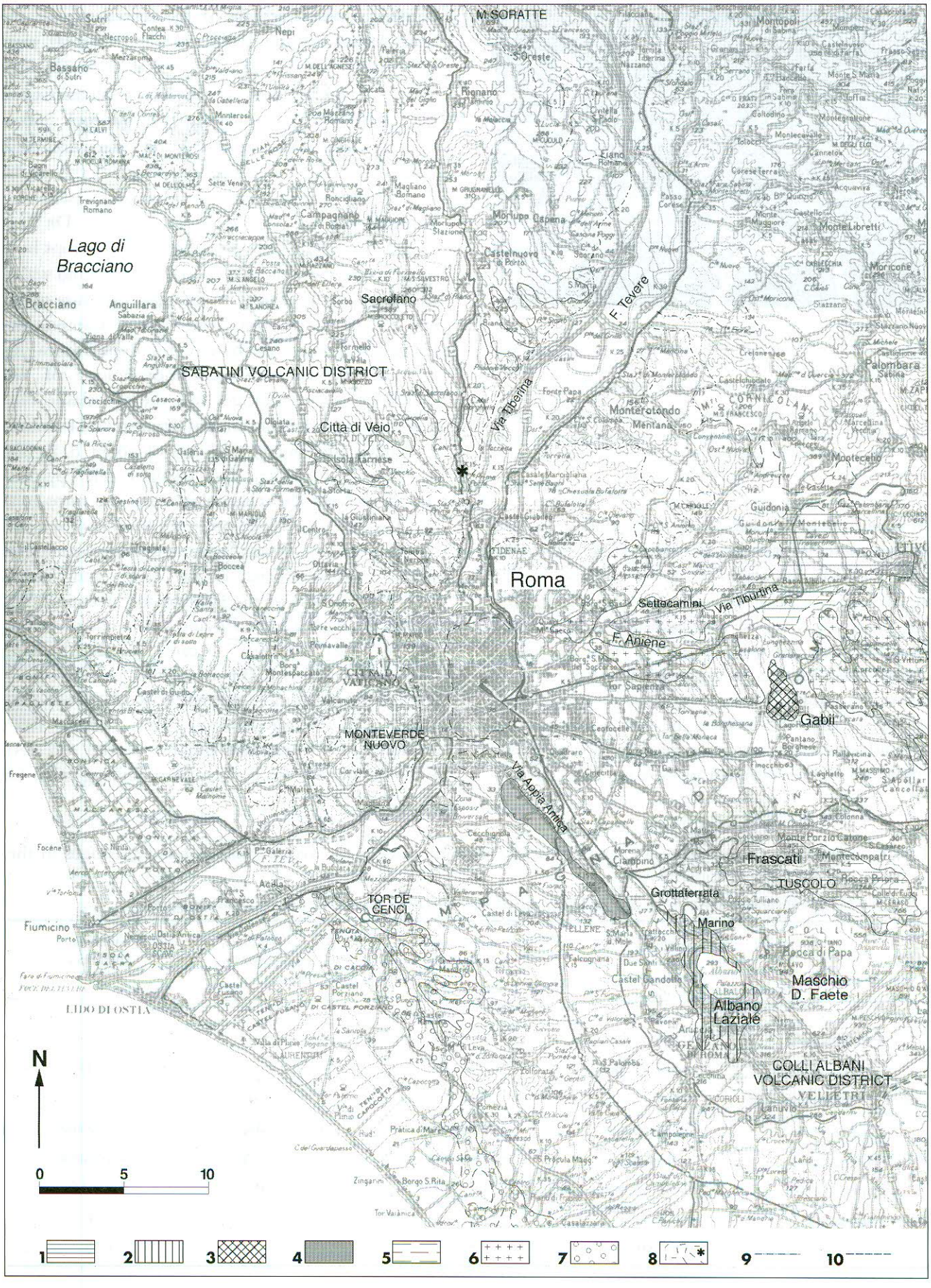
2. – THE VOLCANIC ROCKS USED BY THE ROMAN CIVILIZATION

2.1. – THE "PISOLITHIC TUFF" OR "CAPPELLACCIO"

In the most ancient parts of Roma the most commonly used building stone was the so called "pisolithic tuff" (or "cappellaccio"), a unit that outcrops within the area which immediately surrounded the slowly developing city. Because of the limited excavation and transport capabilities of the most ancient Romans, the

Fig. 1. – Location of Roma city between two recently active volcanic districts: Sabatini volcano to the north and Colli Albani to the south, whose predominantly explosive products dominate the landscape of Roma. 1 - Distribution of the yellow "Via Tiberina" tuff along Tevere River course. Star symbol indicates the Grotta Oscura locality. 2 - Distribution of the "pisolithic tuff" in the Tor de' Cenci - Fosso di Malafede area. 3 - "Lionato tuff" distribution along the Aniene River course, where most of historical quarries are located. 4 - Distribution of the "sperone" at the north-eastern margin of Tuscolano-Artemisio caldera rim. 5 - Extension of the Capo di Bove lava flow. 6 - Distribution of the peperino around Gabii crater. 7 - Distribution of the peperino around Albano crater. 8 - Travertine. 9 - Limits of the Colli Albani volcanic district. 10 - Limits of the Sabatini volcanic district.

– Posizione della città di Roma tra due distretti vulcanici attivi ancora in tempi recenti: i vulcani Sabatini a nord e i Colli Albani a sud, i cui prodotti prevalentemente esplosivi dominano il territorio di Roma. 1 - Distribuzione del tufo giallo «Via Tiberina» lungo il corso del Fiume Tevere. L'asterisco indica la località Grotta Oscura. 2 - Distribuzione del «tufo pisolitico» nell'area Tor de' Cenci - Fosso di Malafede. 3 - Distribuzione del «Tufo Lionato»lungo il corso del Fiume Aniene, dove è localizzata la maggior parte delle cave storiche. 4 - Distribuzione dello «sperone» al margine nord-orientale del bordo della caldera Tuscolano-Artemisio. 7 - Distribuzione del peperino intorno al cratere di Albano. 8 - Travertino. 9 - Limiti del distretto vulcanico dei Colli Albani. 10 - Limiti del distretto vulcanico dei Sabatini.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Lago di Bracciano
SABATINI VOLCANIC DISTRICT
Città di Veio
Roma
F. Tevere
F. Aniene
Via Tiburtina
Via Appia Antica
MONTEVERDE NUOVO
TOR DE' CENCI
Frascati
TUSCOLO
Grottaferrata
Marino
Rocca di Papa
Maschio D. Faete
Albano Laziale
COLLI ALBANI VOLCANIC DISTRICT
Gabii
Settecamini
Monterotondo
Mentana
Sacrofano
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Fig. 2. – Rupe Tarpea. Outcrop of the "pisolithic tuff" and of the "lionato tuff" in the Campidoglio area in the center of Roma. The deepening of the base of the "Lionato tuff" indicates the location of the ancient valley filled by the tuffs.

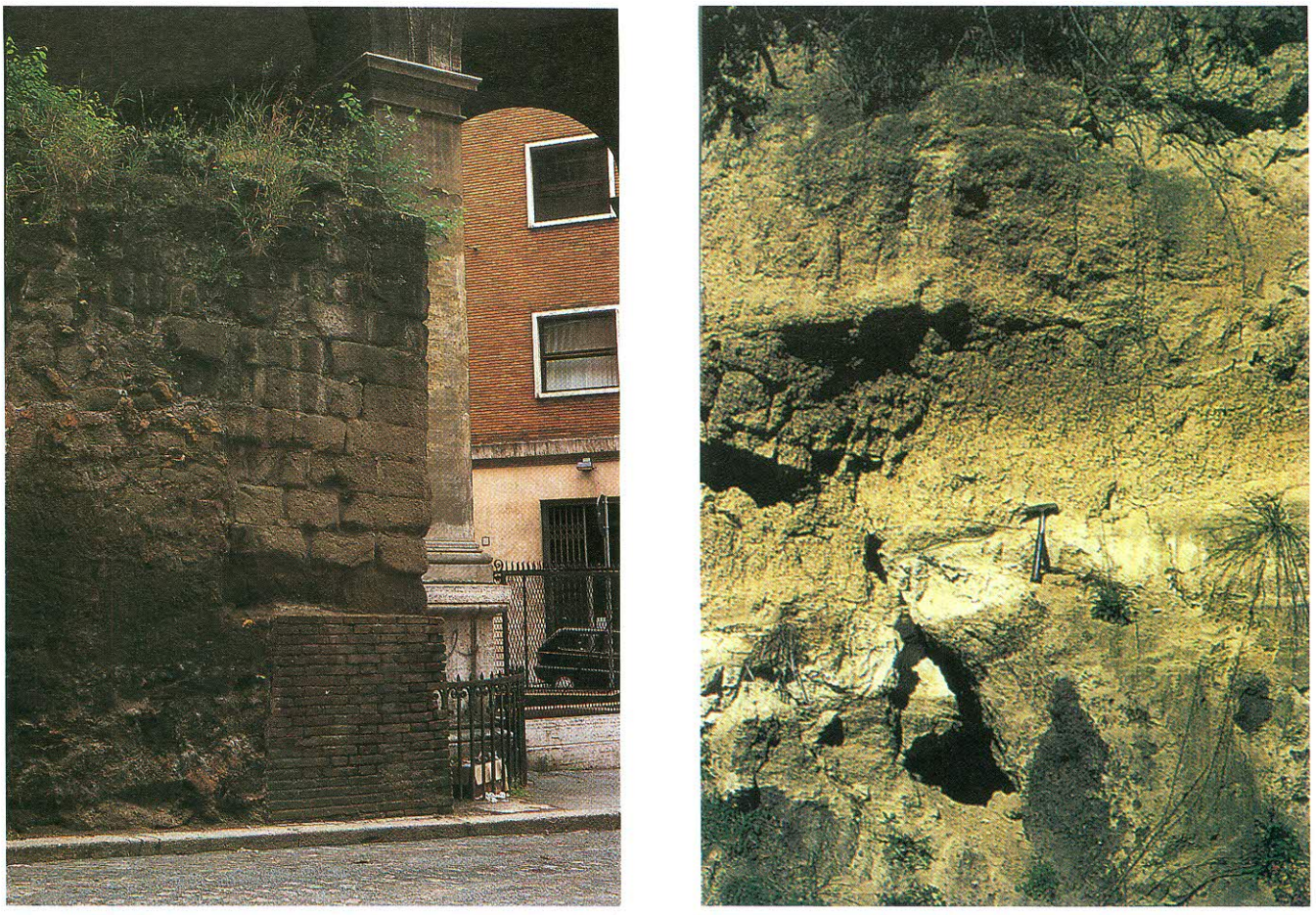
– Rupe Tarpea. Affioramento del «tufo pisolitico» e del «tufo lionato» nell'area del Campidoglio nel centro di Roma. L'incupirsi della base del «tufo lionato» indica la posizione dell'antica valle riempita dai tufi.

areas of supply and habitation were similar; the size and geometry of the blocks were at approximation rock, linked to the action of weathering and, finally, the structures were elementary and simple. Although the physical-mechanical characteristics of the "pisolithic tuff" are definitely inferior to those of subsequently used building stones (see Tab. 1) the ease of excavation and limited amount of transport made this material an efficient choice in the Archaic period. The "pisolithic tuff" is not a single unit, however, but rather consists of different pyroclastic flows emitted during the oldest activity of the central area of the Colli Albani volcanic district, around 500,000 years B.P. (DE RITA *et al.*, 1988; 1995; ROSA, 1995). The high degree of fragmentation of the pumice ash matrix and the presence of accretionary lapilli in this rock, indicate that the eruption involved the interaction with water. The erupted products extend across the central area of the district, reaching as far as its periphery, located 30-40 km from the volcanic source (DE RITA *et al.*, 1992; 1995). The "pisolithic tuff" outcrops both in parts of the southern section of the city and within its central historical area; for example, exposure of the tuff can be clearly seen at the foot of Campidoglio Hill where it forms the base of the Rupe Tarpea (fig. 2). The reconstructed paleomorphology of the Campidoglio area indicates that the pyroclastic flow was channeled along an ancient drainage and eventually attained a maximum thickness of about 10 m (DE RITA *et al.*, 1992; 1995). The "pisolithic tuff" pyroclastic flows were also channeled along the once-great Velabro Valley (today completely obliterated by urbanization). As early Roma began to development in this area - at the confluence of the Tevere and Velabro Rivers, at the base of the Palatino and Aventino Hills and in front of Tiberina Island - it is not surprising that the "pisolithic tuff" became the first building stone used in the city. The use of the "pisolithic tuff" in the first roman monuments can be observed in the oldest parts of the Serviane Walls (LUGLI, 1957; COARELLI, 1974 and bibliography therein) (fig. 3A). Some of the quarries that supplied building stone for

TAB. I – Main physical-mechanical characteristics of volcanic rock types mainly used as building stones in the ancient roman monuments

– Principali caratteristiche fisico-meccaniche dei tipi di rocce vulcaniche usati come materiali da costruzione

	weight per unit of volume Kg/m^3	compression breaking load Kg/cm^2	compression breaking load after imbibition Kg/cm^2	imbibition coefficient weight %
pisolithic tuff	1300 ÷ 1500	90 ÷ 100	–	–
lionato tuff	1460 ÷ 1850	52 ÷ 115	59 ÷	6 ÷ 14
yellow "Via Tiberina" tuff	1340 ÷ 1710	70 ÷ 127	55 ÷ 171	5.0
sperone	not available	not available	not available	not available
lapis gabinus	not available	not available	not available	not available
lapis albanus	1540 ÷ 2180	55 ÷ 130	58 ÷ 145	6.3 ÷ 4.0
travertine	2424	572	657	1.4
leucitite	2810	2856	-	0.73



A B

Fig. 3. – A) Serviane Walls, built with blocks from the "pisolithic tuff", present in Via Salandra, close to Termini railway station. B) Natural outcrops of the "pisolithic tuff" in the Tor de' Cenci area, south of Roma.

– A) Mura Serviane, costruite con blocchi di «tufo pisolitico», presenti in Via Salandra, vicino alla stazione ferroviaria Termini. B) Affioramenti naturali del «tufo pisolitico» nell'area di Tor de' Cenci, nella zona sud di Roma.

the Walls are still recognizable in archaeological excavations below Termini railway Station. Beyond representing a historical and archaeological monument of incalculable value, the Serviane Walls can thus also be considered as "Geotopo", documenting human use of a natural resource and the relationship established, to varying degrees through time, between natural resources and human technology. Many other works of the Archaic period, preserved near the Foro di Cesare, were made with this stone; for example an Archaic cistern was excavated in the tuff and its walls were recovered by small blocks of the same material. In addition, the earliest hut village at the top of the Palatino Hill is constructed of "pisolithic tuff".

The corresponding natural "Geotopo" is much more difficult to define because most of the ancient quarries have by now been destroyed or obliterated, whereas the more recent ones are besieged by urbanization or have been used for refuse disposal. One locality which still preserves a "pisolithic tuff" outcrop with characteristics analogous to those found in the tuff blocks of roman constructions, is located at Tor de' Cenci - Fosso di Malafede, an area, already protected because of the important information it contains on the natural environment. We propose the Tor de' Cenci area as a "Geotopo" twinned with the "Geotopo" of the Serviane Wall (fig. 3B). An educational program should be developed so that Tor de' Cenci may also document the lithological characteristics of the "pisolithic tuff", the transport and depositional mechanisms acting on the ash cloud that formed the deposit, the deposit's spatial distribution and the relationship between preexisting paleomorphology and the volcanic deposit. Because the Tor de'

A B

Fig. 4. – A) Aventino. Serviane Walls restored with blocks of the yellow "Via Tiberina tuff". B) Natural outcrops of the yellow "Via Tiberina tuff" along Via Tiberina, north of Roma.

– A) Aventino. Mura Serviane restaurate con blocchi del «tufo di Via Tiberina» giallo. B) Affioramenti naturali del «tufo di Via Tiberina» giallo lungo la Via Tiberina, nella zona nord di Roma.

Cenci area has been excavated during every period since the roman epoch, it also provides historical documentation on the types of construction materials used and on the extraction techniques employed through time.

2.2. – The yellow "Via Tiberina tuff"

With increasing technological evolution and the expanding extent of controlled territory, small blocks of tuff originating from outside the city began to be used in buildings. One of the first lithotypes that was substituted for the "pisolithic tuff" was the yellow "Via Tiberina tuff", which was outcropping to the north of Roma at Grotta Oscura (the Grotta Oscura tuff; Coarelli, 1974 and bibliography therein) along Via Tiberina. The yellow "Via Tiberina tuff" is a pyroclastic flow deposit which originated from the Sacrofano volcano, located around 30 km to the north of Roma in the eastern sector of the Sabatini volcanic district (Fig. 1); (De Rita *et al.*, 1993). The related eruption, dated at around 500,000 years B.P., likely involved at least the partial interaction of water and rising magma. The eruption caused the deposition of more than one flow unit (Cioni, 1993 recognized at least 7 units) that covered a surface of more than 400 km^2 and attained a total volume equal to approximately 8 km^3 (De Rita, *et al.* 1993; Rosa, 1995). The considerable quantity of erupted material caused a significant impact on the surrounding environment, such as the obstruction of the Tevere River near Monte Soratte, and the movement of its valley towards the east, approximately in coincidence with its present course (Alvarez, 1972; 1973; Rosa, 1995).

Because the physical-mechanical characteristics of the "Via Tiberina tuff" are significantly better than those of the "pisolithic tuff" (see Tab. 1); (Nappi *et al.*, 1979) the "Via Tiberina tuff" was commonly used either as an ornamental stone or as a building stone for houses. It is important to note that the use of this tuff became common only after the roman conquest of Veio, the city which dominated the region rich in this natural resource (Coarelli, 1974 and bibliography therein). The use of this tuff in roman buildings is still well documented today. A large part of the Serviane Walls has been restored with this stone since 396 AD, following the damage caused to the original wall by the Gaelic invasion. Where presently visible (fig. 4A) the wall is constructed of rows of 59 cm-high blocks alternatively placed horizontally and vertically, thereby creating a structure that is up to 10 m high and sometimes greater than 4 m thick (Coarelli, 1974 and bibliography therein). The restoration took place in various locations simultaneously, as testified by the reconstructed rock junctions which do not always fit together perfectly. The total length of the wall has been calculated at around 11 km, encompassing a surface of 426 hectares and thus enclosing the largest city on the Italian peninsula. Even though the Grotta Oscura area quarries are now located within a military area and are thus not directly observable, the working faces of many old quarries are still visible along Via Tiberina.

These were operated up to modern times and were only recently abandoned. We believe that some of these should be protected as "Geotopo", twinned to the sites of the first documented restorations of the Serviane Wall and, more generally, used as references for construction or restoration of buildings by the Romans after the Gaelic Invasion (fig. 4B).

2.3. – The "Capo di Bove" lava flow (melilite leucitite)

The roman ability to obtain building stones of optimal physical-mechanical characteristics was very high during the Republican Period (end of the IV - III centuries), as demonstrated by the extensive use of lava blocks for paving stone. Via Appia, the consular road between Roma and the Colli Albani area, was built during this period directly on the upper surface of the Capo di Bove lava flow (fig. 5). This unit erupted around 280,000 years B.P. (Bernardi *et al.*, 1982) and forms one of the most impressive extrusions of the Faete edifice, located in the central area of the Colli Albani volcanic district (fig. 1); (de Rita *et al.*, 1988). The lava was channeled in a valley that was almost radial about the central volcanic structure and extended 20 km to the area on which Roma was eventually built. The flow was named after the ox head perched on the Tomb of Cecilia Metella, which was built at the distal end of the flow. The highly under-saturated chemistry of the lava permitted it to flow great distances from its eruptive vent, and allowed it to form a very smooth and flat upper surface, a feature which was directly exploited by the Romans for the construction of the Appia. Via Appia Antica is without a doubt the most famous monument that can be considered as a human "Geotopo", and represents human use of lava blocks for road constructions. Many roman quarries were subsequently reused for similar purposes and then abandoned; some of these are still visible along Via Appia and we believe they should be preserved as testimony to their use in the past and for public education to observe lava flow characteristics in an environment of predominantly explosive volcanism (fig. 5).

2.4. – The "peperino", and the "lionato tuff"

The most interesting period relative to the goals of this study is most certainly the Imperial Epoch, a time span which began a long period of prosperity for the

Fig. 5. – Appia Antica road. Quarries of leucititic lava flow blocks. – *Via Appia Antica. Cave di massi dal flusso di lava leucitica.*

roman civilization. During this time Roma greatly extended its dominion across the entire Mediterranean area and as a result the Romans introduced many "exotic" stones for ornamentation and construction of both their public and private buildings. However, many of these buildings still used local building stones for their foundations and internal structures. The higher technological ability allowed a more rigorous selection of the lithotypes. The monuments of this epoch used three principle types of volcanic building stone from the roman area: the "lionato" (or "litoide", or "Monteverde" tuff, or "Aniene" tuff), the "peperino" and the "sperone" tuffs.

The "lionato tuff" is a pyroclastic flow deposit that erupted from the central area of the Colli Albani volcanic district during the Tuscolano-Artemisio phase, around 400,000 years B.P. (De Rita *et al.*, 1988). The eruption of the "lionato tuff", which was immediately followed by that of the "Villa Senni tuff" about 336,000 years B.P., caused the collapse of the central area of the volcano and marked the close of the Tuscolano-Artemisio eruptive phase. The lithological and depositional characteristics of the "lionato tuff" indicate that it sustained limited water/magma interaction during eruption, whereas its high degree of lithification is due to zeolitic alteration of the glassy matrix.

The name "peperino" actually refers to two different lithotypes: the "lapis Gabinus" and the "lapis Albanus". Both of these deposits are the result of violent hydromagmatic eruptions, the former related to the Gabii (or Castiglione) craters and the later related to the Albano crater. The eccentric Castiglione and Albano craters were formed as a result of the final

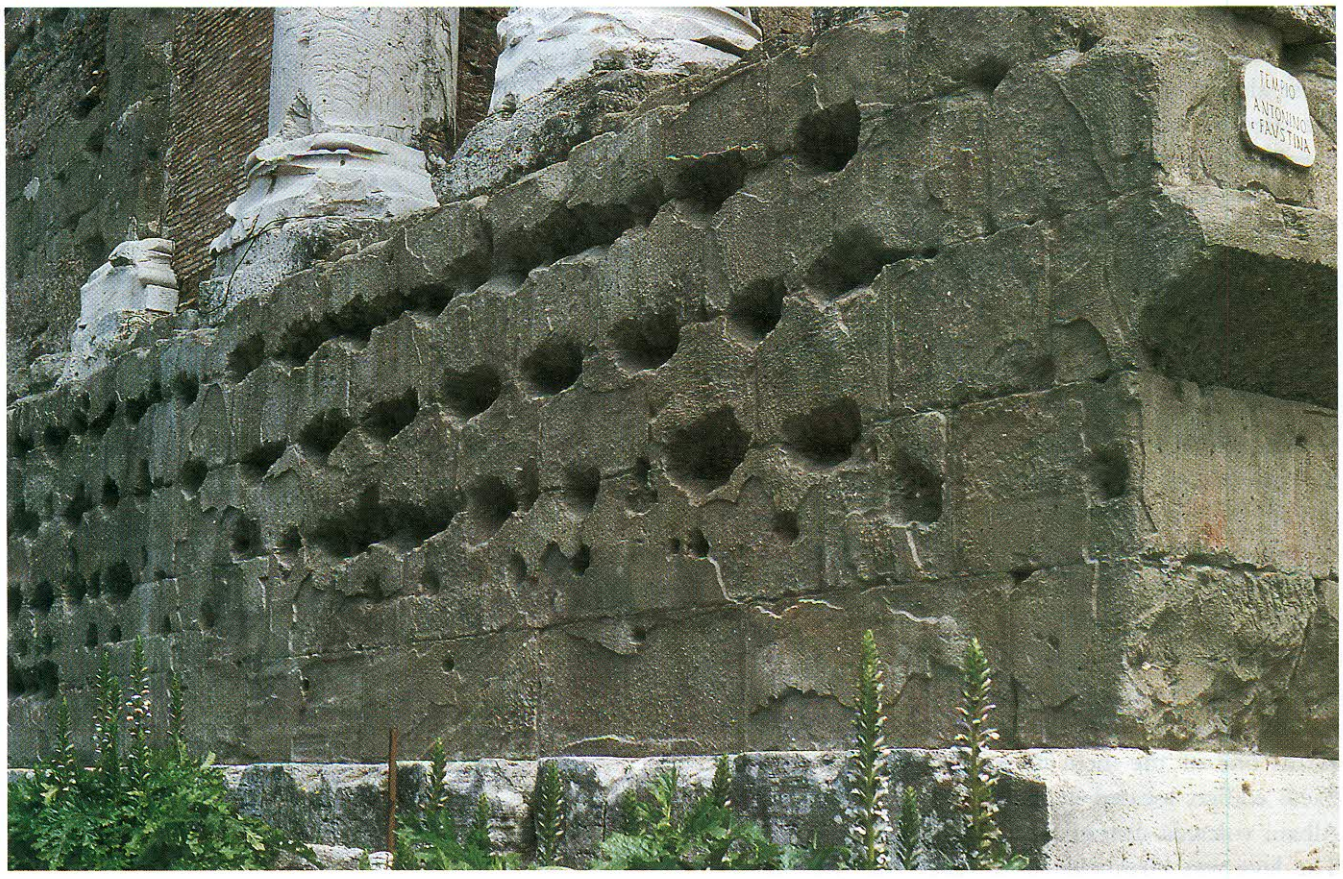


Fig. 6. – Foro di Cesare; the Antonino and Faustina temple whose basal structures are made with lapis Albanus.

– Foro di Cesare; il tempio di Antonino e Faustina le cui fondamenta sono fatte con lapis Albanus.

hydromagmatic activity of the Colli Albani volcanic district (DE RITA *et al.*, 1988; 1995). This region was active between approximately 200,000 years B.P. and also very recently: in particular "lapis Albanus" came from a detrital flow deposit erupted from the Albano crater during its final phase, at least 20,000 years ago (MERCIER, 1993). The two lithotypes have very similar lithologies and have, as their principle characteristic, a high level of lithification due to the presence of zeolites, in the rock matrix, that were derived from the alteration of volcanic glass. These rocks were used ubiquitously during the Imperial epoch. The most significant examples are visible in the Imperial Forums. In the most ancient of these forums the temple of Antonio and Faustina was constructed in part with "lapis Albanus" (fig. 6). In contrast the Forum of Augustus was largely created using "lapis Gabinus" and the "lionato tuff" (or "litoide"), with the latter unit also being used for the forum brick work and as a base for the temple of Marte Ultore (fig. 7). In addition, lapis Gabinus forms the foundation and walls of the Tabularium building at Campidoglio. The contemporaneous use of the "lapis Gabinus" and the "lionato tuff" suggests that the two lithotypes were quarried in closed areas of the volcanic district. In fact, the "lapis Gabinus" quarries occur along the border of the Castiglione crater (in the northern sector of the District near the Aniene River), not far from the "lionato tuff" quarries located along Via Tiburtina. It is highly probable that the Aniene River was the most direct route for transporting these two lithotypes from the countryside to the city. The "lapis Gabinus" quarries, abandoned during the roman Epoch, are still clearly visible at the edge of the crater. We believe these quarries would be excellent natural "Geotopo" to twin with the roman monuments (fig. 8); in this respect it is interesting to note that the Castiglione area is already being protected for the future creation of a scientific park. The quarries of the "lionato tuff" present a more complex situation, because these have been used since the roman Epoch, until quite recently. The "lionato" stone used during the roman Epoch was

most likely excavated in the Monteverde area (Monteverde tuff) and in the Settecamini area (Aniene tuff) (fig. 9). Some of these last underground quarries have been subsequently enlarged and reused. Because they often occur on private land, their protection as cultural heritage "Geotopo" is highly improbable and problematic. Some quarry areas have been used to create artificial lakes for sport fishing, a solution which may represent a good compromise between maintaining a cultural heritage for direct use by the public and protecting it in some way as a monument itself. The roman quarries of the "lapis Albanus" were located along the northern borders of the Albano crater, near the city of the same name, or in the valley below the town of Marino . The "lapis Albanus" differs from the lapis Gabinus because it was excavated until the end of the most recent epoch and is still mined to a small extent today. Many of the roman quarries are now destroyed or obliterated by urbanization in the Colli Albani area, although some very significant examples are still visible along Via dei Laghi between Via Appia and the city of Marino (fig. 10). We suggest that the ancient working faces of these abandoned quarries may be protected as "Geotopo", twinned to their corresponding monuments in Roma.

Fig. 7. – Foro di Augusto. This forum was largely created using "lapis Gabinus" and the "lionato tuff".

– Foro di Augusto. Questo foro è stato realizzato per la maggior parte usando «lapis Gabinus» e «tufo lionato».

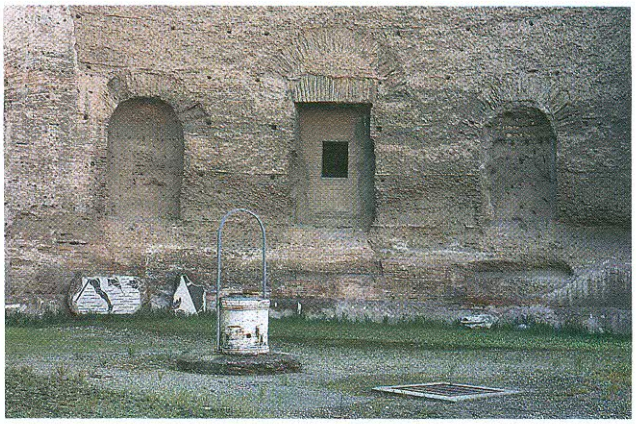


Fig. 8. – Ancient quarry (arrow) of "lapis Gabinus" on the north-eastern rim of Gabii crater.

– Antica cava (freccia) di «lapis Gabinus» sul bordo nord-orientale del cratere di Gabi.

Fig. 9. – Settecamini locality. Abandoned quarries of lionato tuff (Aniene tuff).

– Località di Settecamini. Cave abbandonate di tufo lionato (tufo dell'Aniene).

2.5. – The "sperone"

Finally, the monument which represents the most important symbol of Imperial Roma is the Colosseo. The structural base of the Colosseo was created, besides travertine, with "sperone" (fig. 11A), a rock type

which was used to a relatively limited extent. This welded scoria deposit resulting from lava fountains, erupted from the fractures which controlled the collapse of the central part of the Colli Albani volcano, less than 336,000 years ago. These rocks compose the entire northern border of the Tuscolano-Artemisio belt and are located at an elevation of between 200 and 600 m. Although no definitive roman quarries have been found, it is highly probable that the original sources were located near Grottaferrata and Frascati, close to the principle transportation routes to Roma, but now obliterated due to the growth of these two cities. Due to the welding of the scoria upon contact with the ground the "sperone" has probably good physical and mechanical properties, and it is likely that its use was limited only because of the difficult access and transportation to and from the quarries. All the depositional and lithological characteristics of the "sperone" can be clearly observed in the "Tuscolo" area, one of more impressive localities related to the history of Roma in the Colli Albani volcanic region (fig. 11B). We believe this site must be considered as a cultural heritage "Geotopo" in order to protect all of its unique geological, biological naturalist and archaeological characteristics. The perfectly preserved remains of a roman village and a small theater built entirely with the "sperone" are still visible at this location. Furthermore the Tuscolo area is within the perimeter of the Castelli Romani Park and would be an ideal location for a public education exhibit outlining the processes of lava fountaning in an explosive volcanic environment.

After the Imperial Epoch the study of volcanic rocks used as building stones in Roma becomes almost impossible, as the Romans began to use manufactured bricks as their most important construction materials. Furthermore, they became commonly reused the stones of more ancient monuments that were in ruins, deteriorated with age or demolished by subsequent

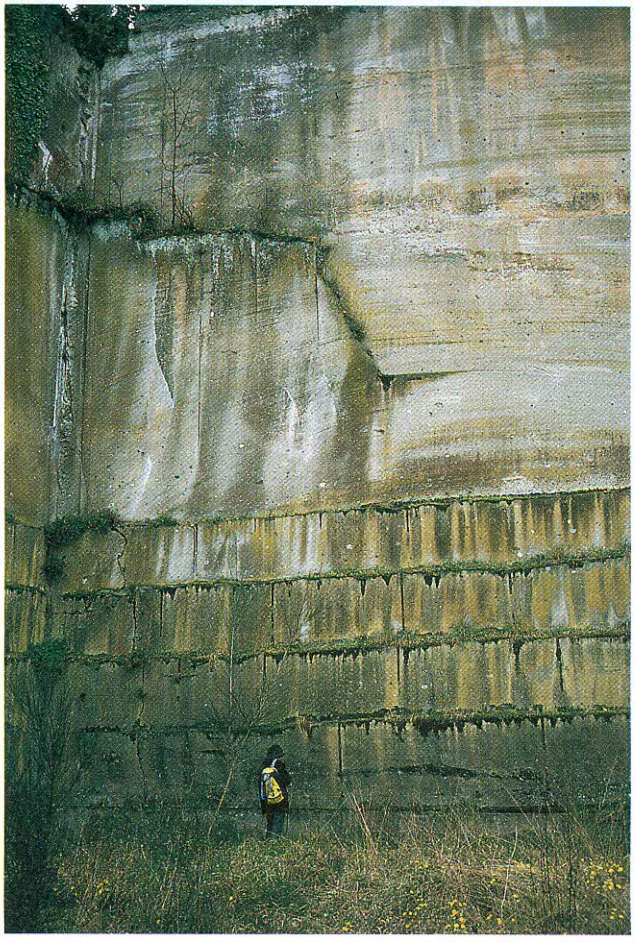


Fig. 10. – Active quarry of the "lapis Albanus" in the Marino village area.

– Cava attiva di «lapis Albanus» nella zona del paese di Marino.

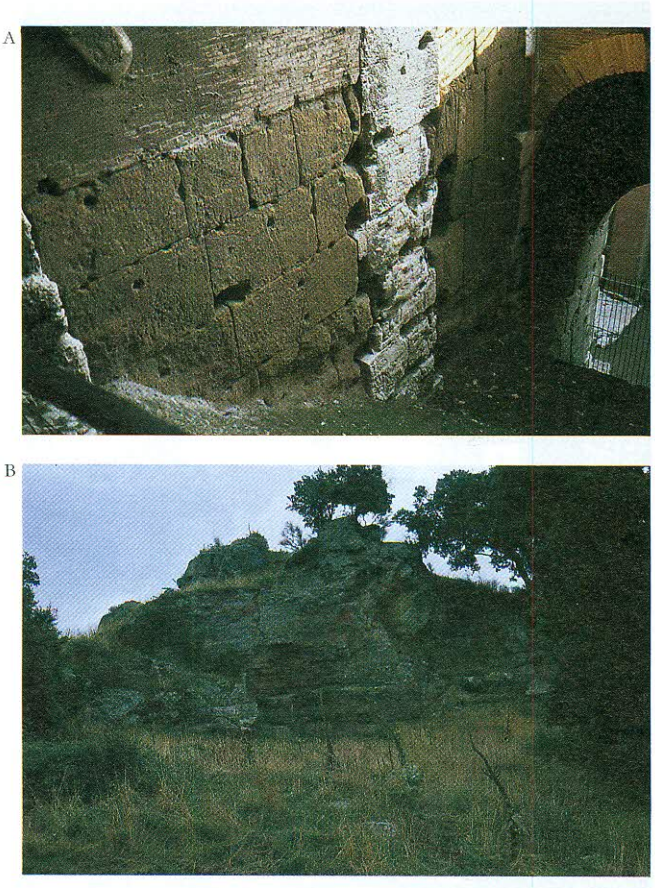


Fig. 11. – A) Colosseo. Blocks of "sperone" used together with travertine to build up the structure of the monument. B) Tuscolo locality. Natural outcrops of the "sperone" rocks.

– A) Colosseo. Blocchi di «sperone» utilizzati insieme con il travertino per realizzare la struttura del monumento. B) Località Tuscolo. Affioramenti naturali delle rocce «sperone».

emperors. The borders and power of the roman Empire were by this point so vast that the import and use of stone from around the world was very extensive. Beyond this point the link between man and his environment extended to the vast regions which reflected the power of Rome.

3. – CONCLUDING REMARKS

The use of volcanic stone as a construction material responded, through time, to the needs of the evolving civilization, representing further confirmation of the inseparable bond between man and nature. In this paper, we identify seven important volcanic building stones that were used in the constructions of many of the important monuments of ancient Roma. The types of stones used by the Romans to build, protect and beautify the city closely followed their societies, technological development. With time, rocks with increasingly better physical-mechanical characteristics were chosen and excavated at increasingly larger distances from their building sites in ancient Roma. For this reason it is important to protect both the ancient monuments, as well as the natural sites where the building stones were quarried. For each monument which contains the history of a period or of a fundamental phase of the evolution of the roman civilization it is possible to protect a quarry or an outcrop that remains as tangible evidence of the lithological and depositional characteristics of the stratigraphic unit from which the building stone was drawn. This twinning underlines the coupling of man and his habitat, and can represent a significant link between environment and cultural evolution. The protected natural sites could supply the original stone for restoration purposes. In addition, the human and natural twinned "Geotopo" provide a unique opportunity to develop public education about the different processes of explosive volcanic eruptions that formed the landscape of Roma, and how to read this information in the texture and composition of the rocks.

The lithotypes used for construction show comparable physical-mechanical characteristics (PENTA, 1956); all have an elevated level of lithification due to zeolites in the rock matrix, minerals which formed due to alteration of the glassy matrix. Furthermore, all units were produced by eruptions which involved, to different extents, the interaction of rising magma and ground water. In fact a direct connection appears to exist between the presence of zeolites and the level hydromagmatic activity. Based on this idea de Rita et al. (1986) hypothesized that the zeolites in this particular environment are syndepositional minerals whose development was strongly facilitated by favorable Eh and pH conditions. These observations become extremely interesting in the research and characterization of the building stones and clearly underline the necessity of mankind to clearly understand his environment in order to obtain the best benefits.

Acknowledgments

The Authors are indebted to Mary Jackson for critical reading of the manuscript, and helpful reviews.

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