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# GEOLOGICAL AND GEOMORPHOLOGICAL ASPECTS OF THE CENTRAL-WESTERN AREA OF THE CARSOLI BASIN (L'AQUILA, ITALY)

**ABSTRACT:** D'OREFICE M. & GRACIOTTI R., *Geological and geomorphological aspects of the central-western area of the Carsoli basin (L'Aquila, Italy).* (IT ISSN 1724-4757, 2005).

This paper presents the results of a geological and geomorphological study carried out in the central-western area of the Carsoli basin (AQ) during the survey of the Geomorphological Sheet 367 «Tagliacozzo».

The examined area belongs to a wide tectonic depression located at the point of contact between two different palaeogeographical domains that are separated by a tract of the «Olévano-Antrodoco» tectonic line.

Mainly lacustrine deposits crop out inside this area. Above, these deposits are delimited by a large, ancient sub-horizontal erosional surface. At present, only some remnants of this surface remain between 620 m and 658 m above sea level. The surface, which slopes slightly towards NW, has been dissected by a drainage network laid out according to a sub-dendritic pattern, whose main stream channels have NW-SE and N-S preferential direction.

Linear erosion, caused by the drainage network, has generated valleys and small valleys with steep slopes which are often subject to solifluction and little landslides. Of particular interest is the suffusion which gives rise to typical pseudo karstic forms along the valley incisions.

Next to the Bosco di Oricola, a remarkable sequence of volcanic terrains of local origin, dated 0,531 My, overlies the lacustrine sediments disconformably. Three main pyroclastic formations have been distinguished: heterolitic breccias, grey tuffs, and reddish tuffs. Only the last two formations crop out widely.

From the geomorphological point of view, the pyroclastic flow, made up of the unit of the grey tuffs that extends E-W between the Collina Rostere and the S.S. Tiburtina Valeria, is particularly important.

The flow is formed by a channeled body inside a pre-existing small fluvial valley cut into the lacustrine deposits. The course of the palaeovalley, in which the pyroclastic flow is channeled, indicates an ancient E-W drainage direction that is completely different from the present situation.

Over time, selective erosion has caused the relief inversion of the channeled pyroclastic body that is now a horizontal and tabular watershed.

The overlying reddish tuffs are thicker and have a wider extension than the underlying grey tuffs. The tops of the small cone-shaped hills that characterize the area between the Bosco di Oricola and the southern carbonatic spurs are largely made up of these materials. They create a peculiar landscape characterized by small conic reliefs, elongated festoons and circular bastions of tuff. Fluvio-denudational and gravitative deposits crop out in some parts of the area in question.

In conclusion, the existence of a local Middle Pleistocenic volcanism in this part of the Central Apennines has allowed for the acquisition of some useful morpho-stratigraphic, palaeogeographic, and palaeoenvironnemental information. This sector is a key area to be considered for a future morpho-evolutional reconstruction of the entire basin. However, considering the limited extension of the examined area, this goal can only be achieved following a careful geomorphological analysis of the whole Carsoli intermontane basin.

KEY WORDS: Geomorphology, Intrapenninic volcanism, Intermontane continental basins, Quaternary, Oricola-Carsoli (L'Aquila), Italy.

**RIASSUNTO:** D'OREFICE M. & GRACIOTTI R., *Aspetti geologici e geomorfologici del settore centro-occidentale della conca di Carsoli (L'Aquila, Italy).* (IT ISSN 1724-4757, 2005).

Nel presente lavoro vengono esposti i risultati di uno studio a carattere geologico e geomorfologico, realizzato nel settore centro-occidentale della conca di Carsoli (AQ), nell'ambito del rilevamento del Foglio Geomorfologico 367 «Tagliacozzo».

Il settore esaminato è parte di un ampia depressione di origine tettonica, collocata nel punto di contatto tra due differenti domini paleogeografici, separati da un tratto della linea tettonica «Olévano-Antrodoco».

All'interno dell'area in studio affiorano prevalentemente depositi di origine lacustre, limitati verso l'alto da una antica superficie di erosione sub-orizzontale, di cui attualmente rimangono solo alcuni lembi relitti. La superficie, debolmente inclinata verso NW, è fortemente dissecata da un reticolo idrografico, che nel settore esaminato è organizzato secondo un pattern subdendritico con direzione prevalente delle aste principali NW-SE e N-S. L'erosione prevalentemente lineare operata da tale reticolo idrografico ha generato una serie di valli e vallecole dai ripidi versanti, i quali sono spesso interessati da soliflusso e da piccoli movimenti franosi. Di indubbio interesse sono i fenomeni di suffosione che danno origine, lungo le incisioni vallive, a tipiche forme pseudocarsiche.

Nei pressi del Bosco di Oricola ai sedimenti lacustri si sovrappone, con contatto erosivo, una significativa sequenza di prodotti vulcanici di origine locale, datati a 0,531 M.a. Al loro interno sono state distinte tre principali unità piroclastiche: brecce eterolitiche, tufi grigi e tufi rossastri. Di queste tre unità solo le ultime due affiorano ampiamente.

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Particolare importanza, dal punto di vista geomorfologico, riveste la colata piroclastica costituita dall'unità dei tufi grigi, che si estende in direzione E-W tra la Collina Rostere e la S.S. Tiburtina Valeria. Essa è costituita da un corpo canalizzato all'interno di una preesistente vallecola fluviale incisa nei depositi lacustri. L'andamento della paleovalle in cui si è incanalata la colata piroclastica, indica un'antica direzione di drenaggio completamente diversa da quella odierna, prevalentemente NW-SE. L'erosione selettiva, ha casuato nel tempo l'inversione di rilievo del corpo piroclastico canalizzato, il quale costituisce attualmente un displuvio, caratterizzato da una morfologia tabulare sub-orizzontale.

I soprastanti tufi rossastri presentano uno spessore ed un'estensione areale maggiore di quella dei tufi grigi sottostanti. La porzione superiore delle collinette, che caratterizzano la zona compresa tra il Bosco di Oricola ed i contrafforti carbonatici meridionali, è in gran parte costituita da questi materiali. Essi danno luogo ad un paesaggio peculiare, contraddistinto da piccoli rilievi dalla forma conica, festoni allungati e bastioni tufacei di forma circolare.

Sedimenti più recenti, legati soprattutto ad una deposizione connessa al processo fluvio-denudazionale ed a quello gravitativo, affiorano in limitate zone del territorio esaminato.

In definitiva l'esistenza in questa porzione dell'Appennino centrale di un vulcanismo locale medio-pleistocenico, ha consentito di acquisire alcune utili informazioni di carattere morfostratigrafico, paleogeografico e paleoambientale. Tutto ciò fa di questo settore un'area chiave da tenere in considerazione per una futura ricostruzione morfoevolutiva dell'intera conca. Comunque, data la limitata estensione dell'area considerata, tale obiettivo potrà essere raggiunto solo dopo un'attenta analisi geomorfologica estesa a tutto il bacino intermontano di Carsoli.

TERMINI CHIAVE: Geomorfologia, Vulcanismo intrappenninico, Bacini continentali intermontani, Quaternario, Oricola-Carsoli (L'Aquila).

## INTRODUCTION

In the Autumn of 1997, during the realization of the Foglio Geomorfologico 367 «Tagliacozzo» (Geomorphological Sheet 367 «Tagliacozzo» - scale of 1:50,000) by the National Geological Survey (now APAT - Dipartimento Difesa del Suolo - Servizio Geologico d'Italia), geomorphological and geological surveys (scale of 1:10,000) were conducted of the central-western part of the Carsoli basin, near Oricola (AQ) (fig. 1). These surveys were carried out because the continental volcanite formations discovered, which were previously noticed by Crema (Regio Ufficio Geologico, 1926) have a significant superficial distribution (in several places remarkably thick), as well as particular morphological, petrographical, mineralogical, and geochemical features.

In the last years, all these features led us to hypothesize the existence of an intrapenninic monogenic volcanism of the Middle-Pleistocene age in the Carsoli depression (Bosi & Locardi, 1991/2; Barbieri & *alii*, 1997; 2000-2002). This volcanism essentially consists of flow, surge, and the fall of pyroclastic rocks, located mainly in the examined area and less extensively throughout the southern sector of the Carsoli basin, dated to 0.531 My B.P. by radiometric methods (Bosi & *alii*, 1991). The existence of this local volcanism is

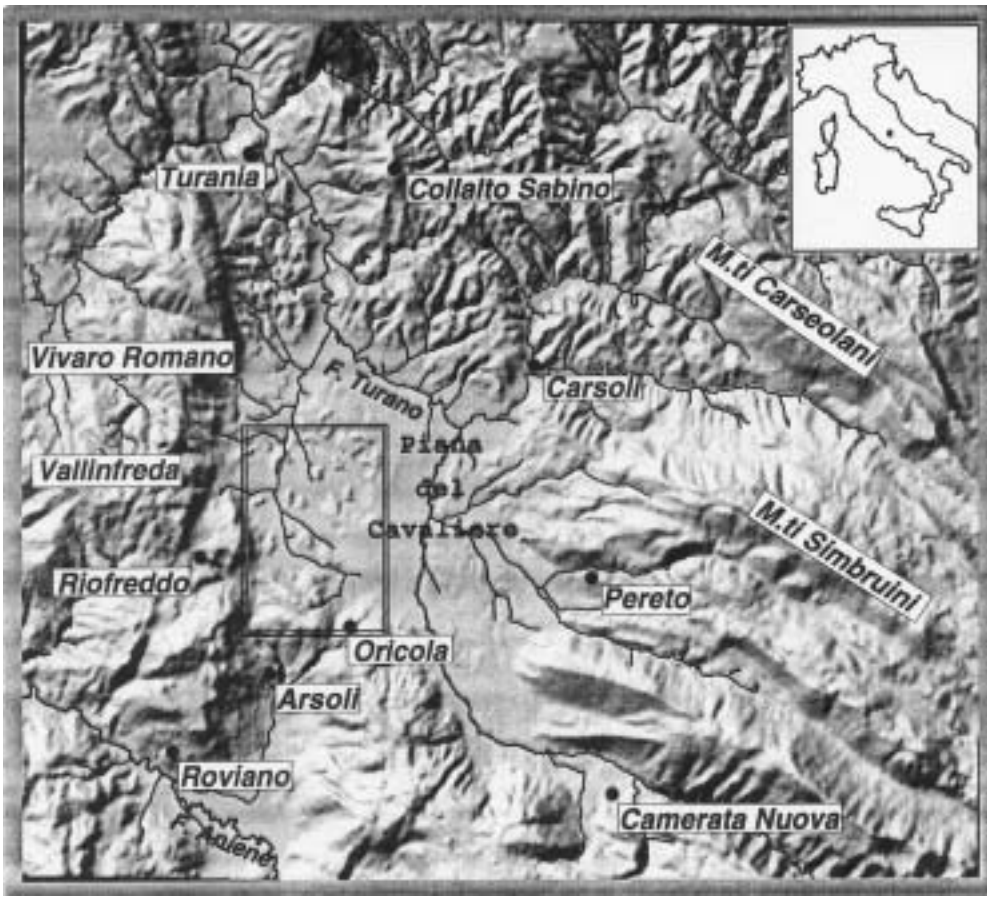


FIG. 1 - Shaded relief from the Digital Elevation Model at 25 m resolution. Carsoli basin and surrounding reliefs. Study area is framed.

not only of minero-petrographic and volcanologic interest, but is also an excellent subject to research Quaternary geology and geomorphology.

The aim of this work is to describe the main geological and geomorphological aspects of this part of the Central Apennines, considering the occurrence of these pyroclastic products. Their study and cartographic description, in fact, allows for the acquisition of useful morpho-stratigraphic, palaeogeographic, and palaeoenvironmental information, crucial for the morpho-evolutional reconstruction of the whole Carsoli basin in the near future.

To better focus on the geological and geomorphological features of this sector, a geomorphological sketch on a scale of 1:10,000 has been drawn, showing the spatial distribution of the continental deposits and the erosional and depositional landforms.

Considering the scarcity and discontinuity of the outcrops, the survey was carried out by sampling several man-made cuts, by auger drillings, by many electrical vertical soundings (Servizio Geologico Nazionale, 1998), and also by several mechanical continuous core drillings (Servizio Geologico Nazionale, 2000). In addition, the data obtained through drilling in the area for water or building infrastructure, have provided further information.

Section n° 367090 (Oricola) of the ortho photo map of the Abruzzi Region on a scale of 1:10,000 (surveyed in 1981 and elaborated in 1982), integrated with a multi-temporal, multi-scale photo analysis, has been used as cartographic support for the geomorphological survey and mapping. The methodologies and the standards illustrated in the guidelines of the geomorphological survey on a scale of 1:50,000 (Gruppo di Lavoro per la Cartografia Geomorfologica, 1994) were given general consideration during the realization of the geomorphological sketch.

## GEOLOGICAL FRAMEWORK

The area is located in the central-western sector of the intermontane sedimentary basin of Carsoli, North of the Oricola village (AQ), and belongs entirely to the hydrographic basin of the Turano river (fig. 1). This basin, whose altitude at the bottom ranges between about 565 m and 690 m, is roughly elliptical in shape, with one longer NNW-SSE axis measuring approximately 12 km and a smaller axis measuring 6 km which runs orthogonal to the first (fig. 2). It consists of a large depression that extends more than 50 km$^2$. It is the site of a large, ancient lake with a subsident bottom, that has permitted the accumulation of thick continental quaternary deposits.

The depression is bordered by carbonatic ridges (mainly of the Miocene age and belonging to the northwestern edges of the Simbruini Mountains) to the south and southeast (out of Map), by reliefs mainly formed by arenaceous and arenaceous-pelitic turbidites, of the Late Miocene age, to the north and east and by the eastern slopes of the Sabini Mountains (of Miocenic limestone-marly sediments) to the west (Cosentino & Parotto, 1992; Cosentino & *alii*, 1993; Compagnoni & *alii*, in press).

The intermontane basin of Carsoli has an interesting setting. It is located near the limit between two different Meso-Cenozoic palaeogeographic domains (fig. 2): to the east and southeast, carbonatic structures of the inner facies of the Latium-Abruzzi platform line up in an Apenninic direction; to the west, limestone-marly structures of the Sabina transitional facies (between the carbonatic platform and the Umbria-Marche pelagic basin) run north to south. These two domains are separated by a tract of the «Olevano-Antrodoco» tectonic line (Parotto & Praturlon, 1975; Castellarin & *alii*, 1978; Castellarin & *alii*, 1982; Damiani, 1984; Cipollari & Cosentino, 1992) that runs north to south and borders the foot of the eastern Sabini Mountains. On the surface, the path of this tectonic line is morphologically marked by a clear sloping break.

Geoelectrical prospecting carried out in the Carsoli basin (Servizio Geologico Nazionale, 1998) to reconstruct the deep arrangement of the carbonatic and turbiditic substrate, has uncovered that the latter is strongly affected by extensive tectonic elements that have thrown it down and broken it into blocks. Their spatial distribution gives rise to structural highs and lows under the continental shallow sequence, which cover the substrate in unconformity. Next to the Bosco di Oricola, this prospecting recorded the highest point of the deepest carbonatic substrate, registering altitudes that lie under the present sea level until reaching about 100 meters above sea level.

### MARINE SUCCESSION

From the lithostratigraphic point of view, the carbonatic rocks cropping out in the studied area are represented by the «briozoan and lithotamnia limestone» formation of the Langhian p.p.-Serravallian p.p. age (Compagnoni & *alii*, in press) belonging to the Latium-Abruzzi platform domain. This formation is made up of well stratified, whitish bioclastic calcarenites, with medium to thick layers and rare sedimentary structures. The «briozoan and lithotamnia limestone» formation fills the whole southern and southwestern part of the examined area.

Above the Miocene limestone, in the areas of structurally low, terrigenous sediments belonging to the «*Orbulina* marls» formation of the Serravallian p.p.-Messinian age (Compagnoni & *alii*, in press) are present. This formation, represented by calcareous marls, clayey marls, marly clays, and shales, crops out in Paterra.

The *Orbulina* marls are followed stratigraphically by the Messinian silicoclastic turbidites, which are mainly arenaceous, thickly and massively layered, with rare interbeddings of arenaceous-pelitic and pelitic-arenaceous lithofacies in thin layers (Compagnoni & *alii*, in press). The turbidites appear in two little zones: north of the Riofreddo railway station and south of Fonteritorto.

The carbonatic and terrigenous Cretaceous-Miocenic formations mentioned above are covered by a discordant continental succession, which crops out inside the basin. This succession is described in detail in the following section, starting with the oldest formations.

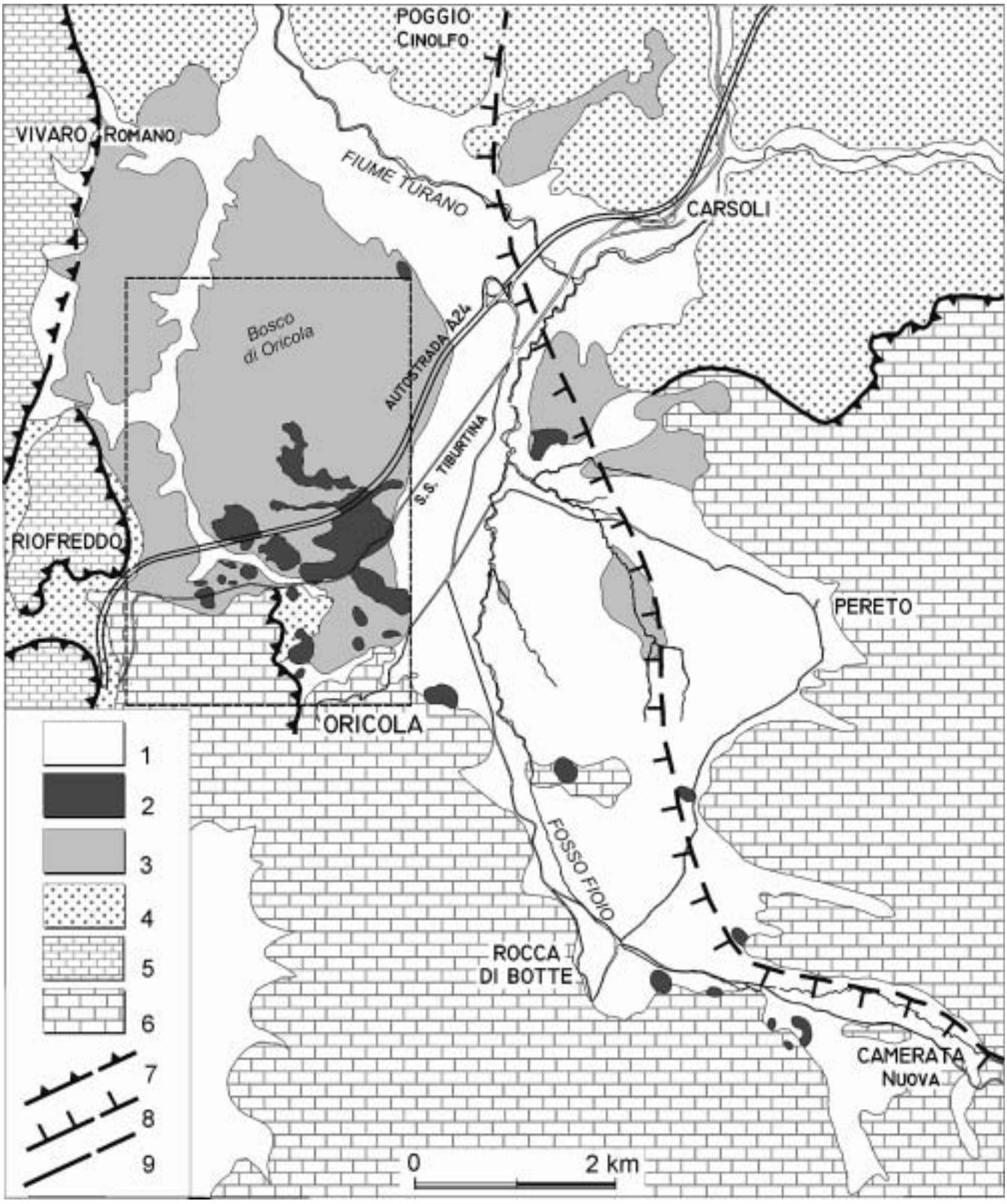


FIG. 2 - Simplified geological scheme of the whole Carsoli basin (modified after Società Geologica Italiana, 2003). Study area is framed. 1) alluvial deposits and ancient to recent detritic covers; 2) undifferentiated pyroclastic deposits; 3) lacustrine deposits; 4) terrigenous sediments (*Orbulina* marls and silicoclastic turbidites); 5) carbonatic sediments in the Sabina transitional facies; 6) carbonatic sediments in the Latium-Abruzzi platform facies; 7) overthrusting (dashed: not outcropping); 8) direct fault (dashed: not outcropping); 9) generic fault.

## CONTINENTAL SUCCESSION

### *Lacustrine deposits*

The lacustrine sediments, in abundance in the examined area, are the most ancient continental deposits that crop out within the Carsoli intermontane basin. They are linked to the presence of a palaeolake that probably filled this basin from about the Lower Pleistocene to the beginnings of the Middle Pleistocene period.

The ages put forth for these deposits vary. According to Raffy (1982), these deposits can be ascribed to the Middle Pleistocene age, Accordi & *alii* (1986) and Compagnoni & *alii* (in press) indicate them as (?)Plio-Pleistocenic in age, while according to Detti (1988) and Colica & *alii* (1995), their date should range from the Early to the Middle Pleistocene.

In the rare sections recognized inside the Bosco di Oricola, the lacustrine deposits are well stratified and marked by alternations of grey-blue clayey-silty layers and yellowish silty-sandy layers; the latter being more frequent in the upper part of the outcrops. These layers have a tabular shape according to the scale of the outcrop and are mainly characterized by a thin plane-parallel lamination.

The transition from the silty-sandy to the lower clayey-silty layers is frequently marked by limonithic alteration coatings as well as load casts. On the whole, the stratification in the studied area is sub-horizontal.

According to the data from some drillings carried out in the center of the basin in search of water, the thickness of these deposits is definitely more than 100 m. The electrical prospecting carried out by the National Geological Survey estimates that the thickness varies from a few meters along the borders of the depression, to more than 200 m in the depocentral zone of the basin, located inside the Bosco di Oricola.

The sandy fraction of the lacustrine sediments is characterized by an abundance of silicoclastic grains; pyroclastic levels are completely absent. The abundance of silicoclastic sediments indicates that the lacustrine deposits originated from the erosion of the Messinian terrigenous formations that almost completely mantled the carbonatic reliefs near the Carsoli basin during the emplacement of the lacustrine deposits.

The lacustrine succession is covered with quite thin alluvial sediments, marked by coarse, cross-stratified sands and small erosion channels.

### *Volcanic deposits*

An interesting and peculiar series of volcanic terrains, dated about 0.531 My (Bosi & *alii*, 1991), rest on an articulated erosive surface, shaped on the river and lacustrine deposits. The volcanites are local products, connected with the presence of a Middle Pleistocene intrapenninic monogenic volcanism in this area (Bosi & Locardi, 1991/2; Barbieri & *alii*, 1997; 2000-2002).

Within the volcanic sequences, made mostly of subaerial tuffs, there is no evidence of palaeosoils or erosive surfaces indicating long eruptive stasis. The inclination of the layers is quite minimal and there are many crossed laminations as well as dune structures on a metric scale. Frequently, the varying depositional facies have heteropic or channelled lateral relations. Some remarkable angular unconformities has been also noticed.

The contact with the underlying lacustrine deposits is always very clear along a slightly undulated erosional surface (fig. 3) and it is characterized by Fe, and Mn, hydroxide mineralizations and by reddish flecks in the silty-sandy lacustrine levels.

The whole stratigraphy can be reconstructed from several outcrops in the Bosco di Oricola. Generally three main pyroclastic formations can be found. These correspond to different eruptive phases and listed from bottom to top are as follows:

1) heterolitic breccias related to the craterization phase;
2) grey cineritic tuffs with lapilli together with crossed lamination from surge, and structurally massive grey lapilli tuffs from the pyroclastic flow;
3) reddish tuffs with lapilli, with dunes or parallel lamination from surge and airfall.

Only the last two main units appear widely, while the first one, tied to the early opening phases of the conduit, is

FIG. 3 - Grey tuffs stratigraphically overlying the lacustrine deposits by an erosional surface. Bosco di Oricola.

not so extensive. It has, however, been found in some continuous core drillings intentionally carried out in the area (Servizio Geologico Nazionale, 2000). In the geomorphological sketch, the grey tuffs and reddish tuffs has been mapped separately, as they behave differently during the exogenous processes essentially because of their different genetic characteristics.

The grey tuffs have facies varying from thin cineritic layers with plane-parallel or crossed lamination to massive banks of cinerites. The latter appear welded and very cohesive with signs of jointing by contraction and obvious conchoidal fracture.

The most important outcrop, given its thickness and length, corresponds to the pyroclastic body extending between the Collina Rostere (630 m above sea level) and the S.S. Tiburtina Valeria national road (605 m above sea level) along a narrow strip running east-west, measuring about 1,9 km in length and a maximum of 50 m in width (Map). The products of this body show different aspects from one outcrop to another even at a short distance. In the Bosco di Oricola, the volcanites are well stratified with coarsening upward layers, in which a few cemented, slightly undulated volcanic sands with clearly evident impact structures are inserted. Near the «Civita Nord» service area along the A24 Highway, the volcanites are characterized by a rhythmic succession of small layers of grey, thin and coarse cinerites at the bottom, with levels rich in vegetable moulds completely replaced by calcite and disposed along their major axis. Most of them are moulds of wood fragments, branches, and needleshaped conifer leaves, mainly of the Pinacee Family (Giardini & Follieri, 1992).

Another facies variation is recognizable at the bottom of the Collina Rostere. It consists of massive banks built up by coarse ashes and small lapilli, containing many heterometric angular carbonatic clasts, chaotically dispersed within the matrix. This facies can be interpreted as a pyroclastic flow associated with the eruptive phase that produced the grey tuffs. According to the mineralogical composition and the modal analysis, these lithologies can be classified as phono-foidites and foidites. Assuming that all the carbonate present in these rocks is igneous (Barbieri & *alii*, 2000-2002), when the content of the carbonatic matrix is $\geq 50\%$ of the total volume of the rock, these lithologies can be considered as carbonatitic or carbonatites s.s.

The reddish tuffs are formed by several layers of tephra and coarse cineritic tuffs, with pumiceous lapilli and accretionary cineritic rims in several places. Stratigraphically they overlie both the lithoid volcanites and the lacustrine deposits described above (fig. 4). These deposits have a maximum thickness of about 15 m and cover an area larger than the underlying eruptive units, showing close vertical stratigraphic relations with these latter (Map). The bedding is both horizontal and inclined, reflecting the morphology of the substrate formed by the previous units.

In the reddish tuffs, sharp angular unconformities, sindepositional channels, mantling forms, and dune structures, also of metrical dimensions, occur (fig. 5). The tuffs are not compact and moreover are frequently affected by limonithic coatings as well as intense pedogenetic alteration in their upper levels. According to their structural characteristics, they have been interpreted as an alternation of surge and airfall deposits.

The outcrop of Fonteritorto, next to the Tiburtina road, is particularly interesting; in the man-made cut, probably the front of an abandoned quarry, it is possible to see 15 m thick reddish tuffs frequently alternated with

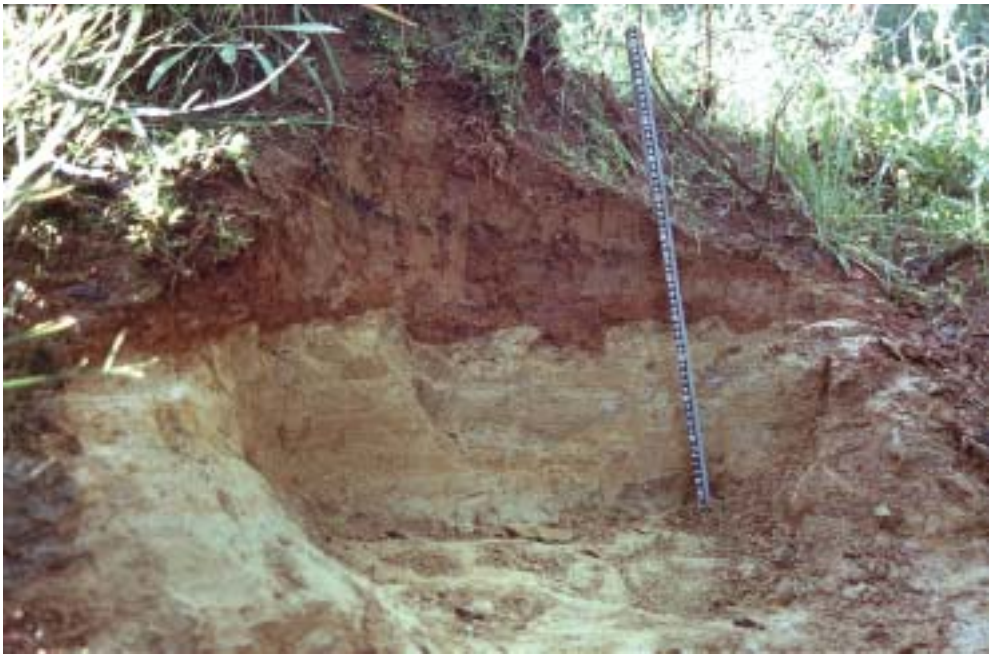

FIG. 4 - Reddish tuffs stratigraphically overlying the lacustrine deposits by an erosional surface. Man-made trench near the «Civita Nord» service station. Bosco di Oricola.

FIG. 5 - Reddish tuffs in a man-made cut for the building of a factory near the Oricola-Pereto railway station.

cineritic levels. Angular discordances associated with canalizations and the superimposition of different eruptive pulses are also recognizable.

In the outcrops located inside the ex-Stacchini Sud powder factory (Collina Rostere) and north of the Oricola-Pereto railway station, the reddish tuffs are affected by small, apparently reverse, faulting, with offsets ranging from a few centimeters to some decimeters (fig. 6).

## GEOMORPHOLOGICAL ASPECTS

The studied area belongs to a wide depression of tectonic origin that later became the site of a large lacustrine basin, with a subsident bottom, in which thick continental deposits were added. These latter come mainly from the erosion of terrigenous Upper Miocenic formations, mostly appearing along the western and eastern borders and to a lesser extent along the southwestern border of the Carsoli basin (fig. 2).

The carbonatic structures delimiting the basin were affected by tectonic dislocations that strongly conditioned the morphological arrangement of the area, often transforming the carbonatic rocks along the different tectonic lines into incoherent detritic masses and enhancing their erodibility. Erosion by the esogenous processes, mostly gravitational and fluvio-denudational, generated narrow detritic belts and fans of mixed origin at the foot of carbonatic relief slopes (Barbieri & *alii*, 1998). These deposits crop out only marginally in the studied area.

Moderate karstic processes occur on these intensely fractured rocks, mainly as micro and macro-epigeous forms:

FIG. 6 - Collina Rostere, ex-Stacchini Sud powder factory. Subvertical wall in the reddish tuffs affected by small reverse faulting.

evolved karren, rare dolines, and irregularly bounded open depressions. The karst depressions are often filled with colluvial and eluvial products (soil sediments, volcanic deposits, and alteration products).

In the area under examination, the carbonatic reliefs are bordered at their base by small belts of terrigenous sediments (mainly sandstone turbidites and «*Orbulina* marls»). These two formations are often subject to solifluction and, although only in certain areas, by sheet and gully erosion and by erosion due to channelized surface waters.

Towards the top, the lacustrine deposits are limited by an ancient and wide sub-horizontal erosion surface, of which only a part is included in the area studied. At present, only some remnants of this surface remain between 620 m and 658 m above sea level. The surface, which slopes slightly towards NW, has been dissected by a drainage network, laid out according to a sub-dendritic pattern, whose main stream channels (generally 3$^{rd}$ and 4$^{th}$ hierarchical order) have NW-SE and N-S preferential direction. On the whole, the drainage density ranges from 4 to 5 km/km$^2$.

Different small valleys and some gullies are cut into the main valleys. The latter, generally filled with sandy-silty deposits, have a wide, flat floor and steep (slope gradient 25°-30° circa) symmetrical slopes. The small valleys are mainly concave or flat floor type, and subordinately are «V» shaped with steep slopes reaching or exceeding 30° slope gradient. Unlike the larger valleys, such landforms arise from mostly temporary regimen streams, with a low hierarchical order (generally from 1$^{st}$ to 3$^{rd}$) and a length that varies between 100 m and 600 m. The concavity of the small valleys is often attributable to the presence of colluvial deposits in the lower part of the slopes of the «V»-valleys, while the origin of the flat floor valleys is usually due to filling of the river bed by alluvial sediments.

The slopes shaped in the lacustrine deposits are very often subject to solifluction and minor landslides, generally of the roto-translational type.

The suffusion that occurs inside the lacustrine sediments is particularly interesting. It originates mainly in the transition areas between the sandy and silty-clayey fractions at the top of the incisions cutting the steep slopes. The running water, filtering through the most permeable sandy levels, produces subsurface passageways, as a result of the erosive action on the finest particles. The collapse of some parts of such tunnel roofs affects the surface by producing typical pseudo karst forms aligned along the small valleys and gullies. These forms are characterized by closed hollows with diameters that vary from a few meters to 10 meters (fig. 7), and by small cavities or collapsed wells. Some pebbles, formed by clayey-silty fragments eroded by the walls of the conduit and transported by the turbulent movement of the stream, have been found at the exit of the tunnels in some sub-horizontal sections.

The emission of pyroclastic products in the Carsoli basin has generated deposits and morphological shapes typical of this volcanism. Furthermore, the distribution of these deposits is also coherent with this type of volcanic emission characterized by pyroclastic bodies in restricted areas of the basin. These parts are made by monogenic eruptive centers located at different topographic levels, often in older formations. The different eruptive centers, aligned along tectonic discontinuities, interfere with each other and cause tuff wedges whose deposits overlap and lead to spectacular disconformities.

FIG. 7 - Bosco di Oricola. Pseudokarst in the lacustrine deposits caused by suffusion.

The pyroclastic flow of the grey tuffs unit, described in the previous section, is one of the most important characteristics of the area due to its peculiar geomorphological aspects. Starting from the easternmost end located next to the railway crossing on the way to Civita, the flow deposits stretch across the A24 Highway (including the «Civita Nord» service station) and a part of the Bosco di Oricola, and continue, after a sudden interruption caused by a valley incision, under the powder factory located at the top of the Collina Rostere.

In general, the thickness of this flow decreases from the center (10 m in the man-made cuts of the «Civita Nord» service station) towards the two ends (roughly 1 meter next to the railway crossing and the Collina Rostere). On the basis of this information, a lenticular geometry of the volcanic body along a longitudinal section can be outlined.

Data from field and geognostic surveys indicate that these pyroclastic deposits form a channeled body within a small pre-existing valley cut in the lacustrine deposits. As a consequence of the selective erosion, over time «inversion of the relief» has occurred: the more resistant pyroclastic flow, which once filled the valley, now makes up the flat structural surfaces of the watershed (fig. 8). This is characterized by a structural surface with a sub-horizontal narrow top, extended, and delimited by vertical slopes that contrast with the easy reliefs modeled in the lacustrine deposits.

The present geomorphological configuration in addition to the competence contrast between the (rigid) grey tuffs and the (mainly plastic) underlying lacustrine sediments causes numerous gravitational phenomena which affect the borders of the pyroclastic flow in the outcrops of the Bosco di Oricola. Boulders and large blocks of volcanic materials on the descending slope, attributable to a roto-translational movement, are evidence of this. Such phenomena are more frequent along the southern slope affected by intense undercutting; a degradation slope about 4 m height results that delimits the southern reach of the volcanic body.

The reddish tuffs are thicker and have a wider superficial extension than the grey tuffs, with a fan shaped distribution that starts from the easternmost part of the area in question (about 200 m NW of the Oricola-Pereto railway station) and spreads towards the western fronts.

The top of the small hills between the Bosco di Oricola and the southern carbonatic mountains is mainly made up of these tuffs. The reddish tuff deposits cause a typical geomorphological landscape characterized by small hills with a conic or elongated shape, elongated festoons and circular bastions of tuff.

In some limited stretches of the examined area more recent sediments crop out due to fluvio-denudational and gravitational deposition. The fluvial deposits can be attributed to different depositional events and time periods. The older terraced fluvial deposits are constituted by conglomerates and incoherent gravel with heterometric pebbles in a silty-sandy matrix enriched with volcanic minerals. These deposits, which occur in the southern sector of the basin (outside of the area in question), belong to an older Middle-Upper Pleistocenic fluvial phase following the deposition of the Oricola volcanic deposits. Inactive Holocene alluvial deposits occur in the «Il Cavaliere» plain, located in the eastern sector of the area. In this area the fluvial deposits are formed by sandy-clay silt in a thin sub-horizontal strata. Active alluvial deposits, mainly formed by silty-sand and sandy-gravel (northwestern sector of the area), crop out in the present river-beds.

Mixed fans, in between the alluvial and the gravitational types, are located at the foot of the carbonatic reliefs next to the mouth of some deep incisions.

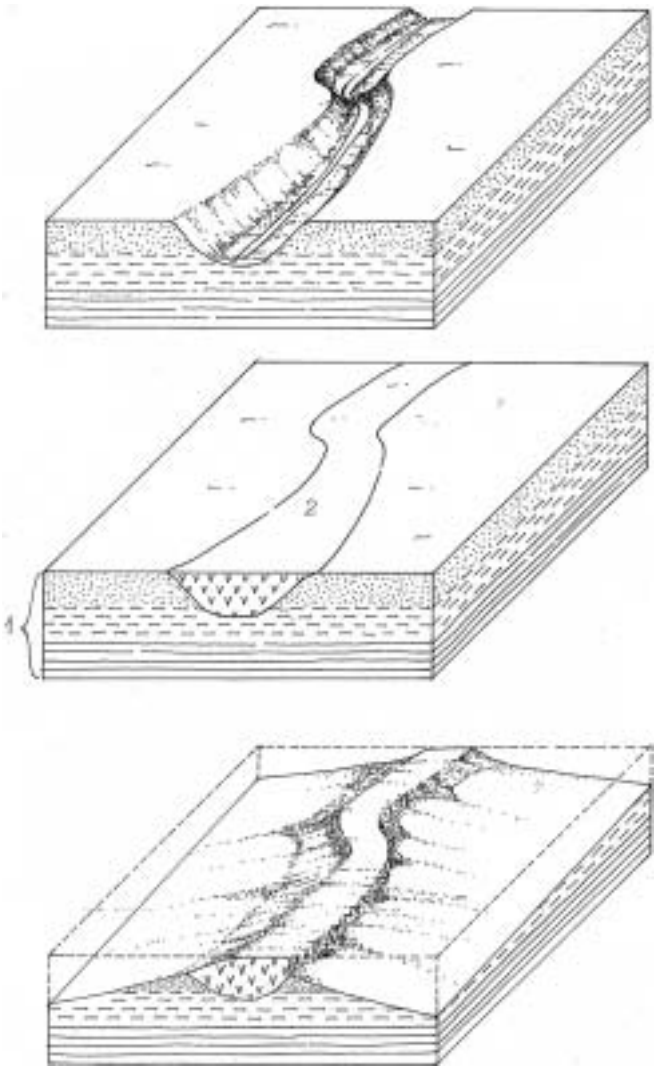


FIG. 8 - Schematic reconstruction of the «relief inversion» of the channeled pyroclastic flow extending east to west between the Collina Rostere and the S.S. Tiburtina Valeria. 1) lacustrine deposits; 2) pyroclastic flow.

Silty-clay colluvial deposits with a few elaborate scattered pebbles crop out where the morphological characteristics of the slope allow their deposition.

Gravitative deposits (scree slope and debris mantled slope), organized in a long, tight band at the bottom of the carbonatic relief, are formed by uncemented, heterometric, and angular carbonate clasts, with an earthy matrix.

The main man-made forms in the area are the open pit and hillside quarries. Historically speaking these quarries are very interesting as they were in use for the most part during the IV and III centries B.C. for quarrying the grey tuffs. The tuffs were used as building materials, in particular for the walls of the ancient town of *Carseoli* (Agostini, 1991; Gatti & Onorati, 1991). These archaeological data are found in the village of Civita di Oricola. In the environs of this village, open-pit quarries, used for quarrying brick clay, are found in the lacustrine deposits.

To date, quarrying of «briozoan and lithotamnia limestone» is concentrated in the northwestern sector of the Colle Orsini carbonatic ridge. The quarry (about 10,000 $m^2$), mainly used for mass concrete, has deeply altered the morphological structure of the carbonatic ridge.

Moreover, numerous dumps and embankments occur, built with the backfills from the excavations carried out during the construction of the A24 Highway and the improvements to the S.S. Tiburtina Valeria.

## CONCLUSIONS

Through examination of the field evidence (superficial distribution, geomorphological, geometric, and sedimentological characteristics of the continental deposits) and the geognostic data, some important geological and geomorphological aspects have been recognized in the central-western sector of the Carsoli basin. These results have been made possible thanks to the presence of local volcanites dated by $^{40}Ar/^{39}Ar$ radiometric methods. In fact, they contribute to clarify some local stratigraphy problems and they supply valuable information about some morpho-chronological, palaeoenvironmental, and palaeogeografic characteristics of the examined area.

Upon integration with data from the entire Carsoli basin, elements highlighted in the preliminary phase will be used in the future for a morpho-evolutional reconstruction of the whole area.

The intermontane basin of Carsoli, of which the studied area is an integral part, is tectonic in origin. In fact, geophysical prospecting carried out on the depression floor, has discovered that the carbonatic and arenaceous substrate underlying the continental cover has been strongly depressed and disarticulated by extensive tectonics. This surveying recorded the highest depth of the carbonatic substrate roof next to the Bosco di Oricola, with altitudes below the present sea level.

Since the Lower Pleistocene period, the basin has been the site for the deposition of an over 200 meter thick lacustrine succession, formed by alternations of tabular clayey-silty and silty-sandy layers. No pyroclastic horizons have been found within them. The lacustrine succession changes upwards into thin alluvial deposits characterized by coarse sands with crossed stratification and erosional channels.

The sedimentation, first lacustrine and then fluvial, stops at the beginning of the Middle Pleistocene period. In fact, a peculiar sequence of volcanic deposits, dating back to 531.000 years B.P. by Bosi & *alii* (1991), overlies, with an obvious erosive contact, a subaerial, erosive, and articulated surface, shaped in the alluvial and lacustrine deposits. These volcanites are local products, linked to the presence of a Middle Pleistocene intrapenninic monogenic volcanism in this area (Bosi & Locardi, 1991/2; Barbieri & *alii*, 1997; 2000-2002).

The volcanic activity, mostly subaerial, initially led to heterolitic breccias (only found in drillings) connected with the early phases of the opening of the conduit, then to surge and pyroclastic flow deposits (grey tuffs), and lastly to airfall and surge deposits (reddish tuffs). The absence of palaeosoils or extended erosive surfaces in the recognized volcanic sequences indicates that long eruptive stasis did not occur among the depositional events. Moreover particularly interesting is the presence, within the grey tuffs unit, of moulds of wood fragments, branches, and needle shaped conifer leaves, mainly of the Pinacee Family (Giardini & Follieri, 1992). This is evidence that volcanic activity mainly occurred in a subaerial depositional environment and in a climatic context different from the present one.

From the geomorphological point of view, it is important to remark that emplacement of the pyroclastic flow products occurred within the pre-existent palaeovalleys, generated during the above mentioned erosional period. In particular, the flow bordering the A24 Highway, next to the Bosco di Oricola, ran in a palaeoriver-bed oriented E-W. This indicates an ancient drainage direction that is completely different from that of today (mainly NW-SE).

After the volcanite emplacement, an intensive aerial erosive phase started as a result of the abstraction of the drainage network towards the northern sectors. This led to the removal of the upper part of the sequence related to the closure of the lacustrine basin. In this way, a wide erosional surface, inclined towards NW, originated.

At present, very little remains of this ancient surface. In fact, after a new linear erosive phase, the above mentioned ancient palaeosurface was dissected. This erosive phase is still continuing, with the deepening of the hydrographic network inside the lacustrine deposits and the development of peculiar pseudokarstic forms caused by suffusion.

As a consequence of the selective erosion, a «relief inversion» occurred over time involving the pyroclastic flow placed in the palaeoriver-bed now bordering the A24 Highway. In fact the pyroclastic flow, more resistant to erosion than the lacustrine sediments, now constitutes the flat structural surfaces of the watershed, generating a tabular morpho-structure.

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