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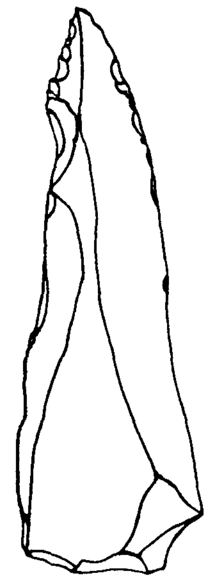

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AQUILA AND SUBEQUAN BASINS: AN EXAMPLE OF QUATERNARY EVOLUTION IN CENTRAL APENNINES, ITALY [1]

Key-words: Apennines, Aquila and Subequan basins, Quaternary, geomorphology, stratigraphy, neotectonics, gravity faults.

1. Introduction

Airphotogeological and field researches have been carried out with the purpose to point out the quaternary geological evolution of the Aquila and Subequan intra- apenninic basins (f. 1). We have recognized a set of geomorphic surfaces of quaternary continental deposits, their stratigraphic relationships and gravity fault systems with Apenninic trend. Thanks to these data we have been able to reconstruct the chronological sequence of sedimentary and erosional cycles and the tectonic movements that took place in these basins since Lower Pleistocene.

1.1 *Physical outline*

The investigated area is a narrow depression lengthened in the Apenninic direction, NW-SE, for 60 km, between the ridge of Sirente M. (2348 m) - Ocre M. (2204 m) at W and the Gran Sasso range (2912 m) at NE (f. 1). Southward the depression divides in two branches: the Aterno river flows in the western one.

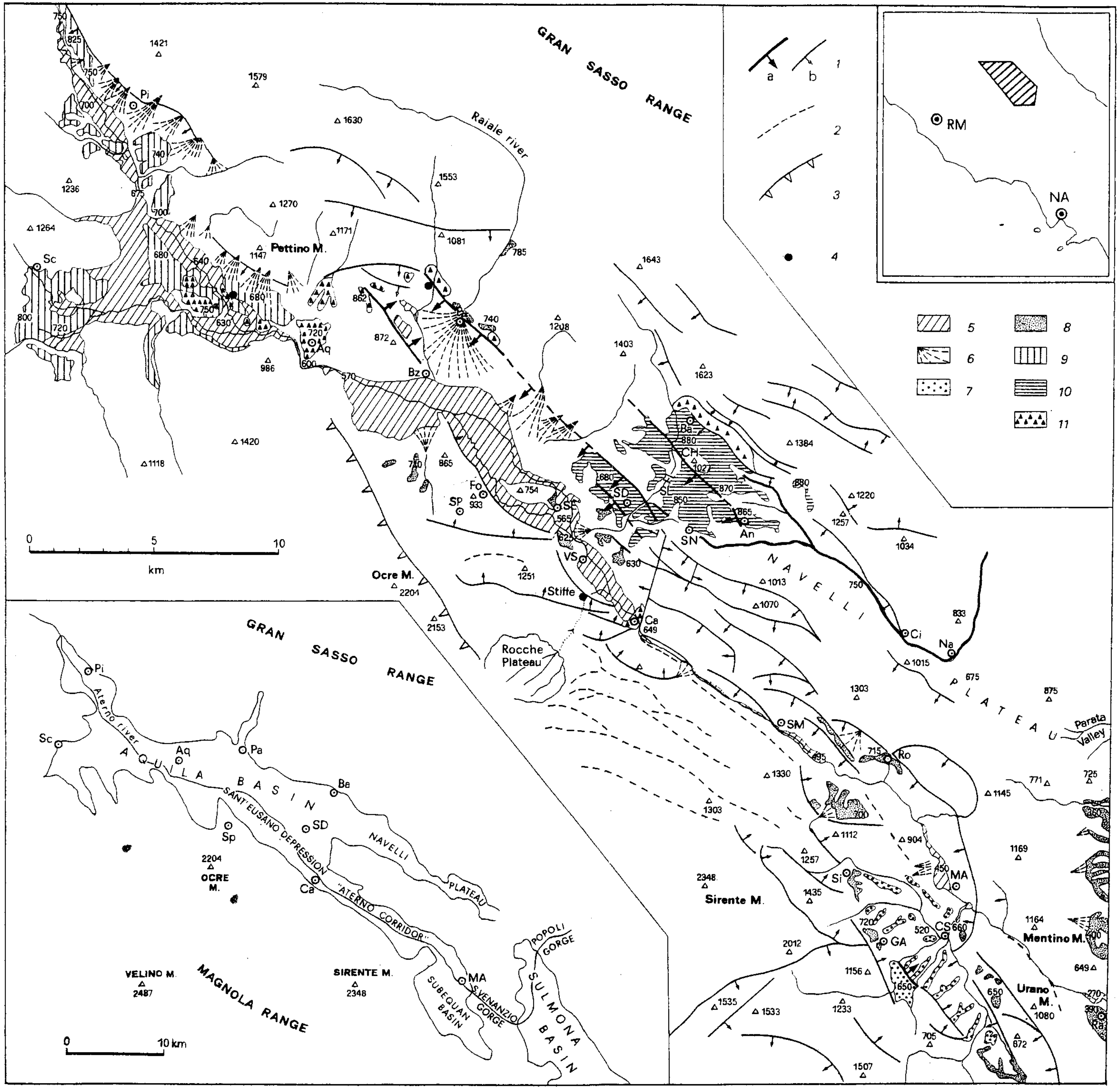
The mountains that border the depression are composed of thrusted and faulted monocline blocks of intensely karstified mesocenozoic platform limestone and strips of miocenic clay-sand turbidites associated, orogenisyzed in the Upper Miocene-Lower Pliocene. In the depression there is a considerable thickness of quaternary continental deposits.

1.2 *Previous studies*

These basins have been object of many tectonic and stratigraphic studies, among the others are those carried out by Beneo (1940), Ge.Mi.Na. company (1960), Demangeot (1965), Bosi, Bertini (1970), Bosi (1975). Beneo reconstructed tentatively the structure of the middle Aterno valley, determined by movements along faults of differently oriented monoclines and recognized a Villafranchian lacustrine sedimentation. The Ge.Mi.Na. mining company carried out a drilling project and a geophysical survey in the area of Scoppito-L'Aquila in order to obtain informations on overworkable lignite horizons. Demangeot, through geomorphological and stratigraphic researches, tried to reconstruct the climatic and tectonic phases that took place in the basins during the Plio-Pleistocene. Furthermore he analyzed the gravimetry and seismicity in relation to tectonics of the Abruzzi limestone platform. Bosi, Bertini besides a stratigraphic study in the middle Aterno valley, that allowed to recognize two fluvio-lacustrine complexes, describe a normal fault system with Apenninic trend that displaces a Middle Pleistocene depositional surface. Bosi through airphotogeological investigations mapped the probably active faults of the region, characterized by a well preserved limestone fault plane outcropping for some kms.

Fig. 1: Aquila and Subequan basins morphotectonic map. Legend: 1 - Normal faults (gravity faults); a - displace quaternary deposits, b - displace the limestone bedrock. The arrows are on the downthrown block. 2 - Tectonic lineaments. 3 - Overthrusts. 4 - Main springs. 5 - Holocene alluvial surface. 6 - Neowurm alluvial fans. 7 - Erosional surface on the deposits of the second sedimentary cycle: Upper Pleistocene. 8 - Depositional surface of the second sedimentary cycle: Middle Pleistocene, upper part. 9 - Erosional surface on the deposits of the first sedimentary cycle: Middle Pleistocene, upper part. 10 - Depositional surface of the first sedimentary cycle: Middle Pleistocene, lower part. 11 - Tectonic breccia e. g. paleolandslides surfaces: various age.

Sites: An - Ansidonia, Aq - L'Aquila, Ba - Barisciano, Bz - Bazzano, Ca - Campana, CH - Cicogna hill, Ci - Civitaretenga, CS - Castelvecchio Subequo, FI - Fosso Inferno, Fo - Fossa, GA - Gagliano Aterno, MA - Molina Aterno, Na - Navelli, Pa - Paganica, Pi - Pizzoli, Ra - Raiano, Ro - Roccapreturo, Sc - Scoppito, SD - S. Demetrio, SE - S. Eusanio, Si - Secinaro, SL - Sinizzo Lake, SM - S. Maria del Ponte, SN S. Nicandro, SP - S. Panfilo d'Ocre, VS - Villa S. Angelo.


GRAN SASSO RANGE
Raiale river
Pettino M.
Pi
Sc
Aq
Bz
Fo
SP
SE
VS
Ca
Stiffe
Rocche Plateau
Ocre M.
Ba
CH
SD
SI
SN
An
Ci
Na
NAVELLI
PLATEAU
Perata Valley
SM
Ro
MA
Si
CS
GA
Sirente M.
Mentino M.
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0 5 10
km
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a b 1
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7
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9
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GRAN SASSO RANGE
Aterno river
AQUILA BASIN
Pa
Be
SD
Sp
Ca
NAVELLI PLATEAU
SANT'EUSANO DEPRESSION
"ATERNO CORRIDOR"
OCRE M. 2204
SIRENTE M. 2348
VELINO M. 2487
MAGNOLA RANGE
MA
S.VENANZIO GORGE
SUBEQUAN BASIN
POPOLI GORGE
SULMONA BASIN
0 10 km

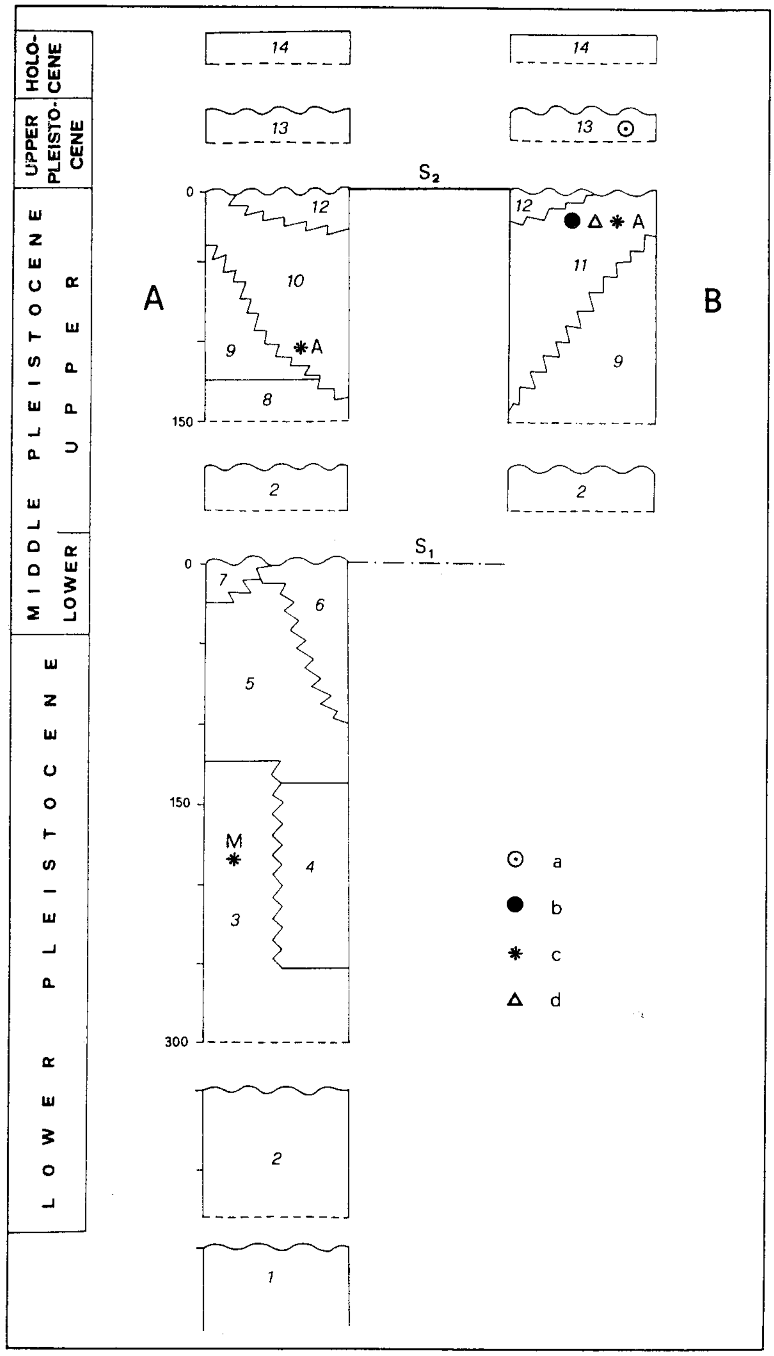

Fig. 2: Aquila and Subequan (A) and Sulmona (B) basins generalized columnar series. S1, Depositional surface of the first sedimentary cycle: Middle Pleistocene, lower part. S2, Depositional surface of the second sedimentary cycle: Middle Pleistocene, upper part. Legend: a, Musterian artifacts; b, Aucheulean artifacts; c, Elephas: A- *Palaeoloxodon antiquus*, M- *Loxodonta meridionalis;* d, K/Ar dating of volcanic minerals, 350 ± 50 KY, b.p.; thikness in mt.

Lithofacies: 1, limestone bedrock; 2, tectonic breccia; 3, gravels, sand, silt with lignite lenses; 4, calcareous silt; 5, conglomerates with sandy layers interbedded; 6, gravels with silty sand interbedded; 7, breccia with sandy layers interbedded; 8, calcareous silt; 9, lacustrine silt with volcanic minerals; 10, gravels, sand, silt with volcanic minerals; 11, conglomerates, conglomerates with silt and volcanic minerals interbedded; 12, breccia, gravels and colluvium with volcanic minerals; 13, debris and alluvial fans; 14, alluvium.

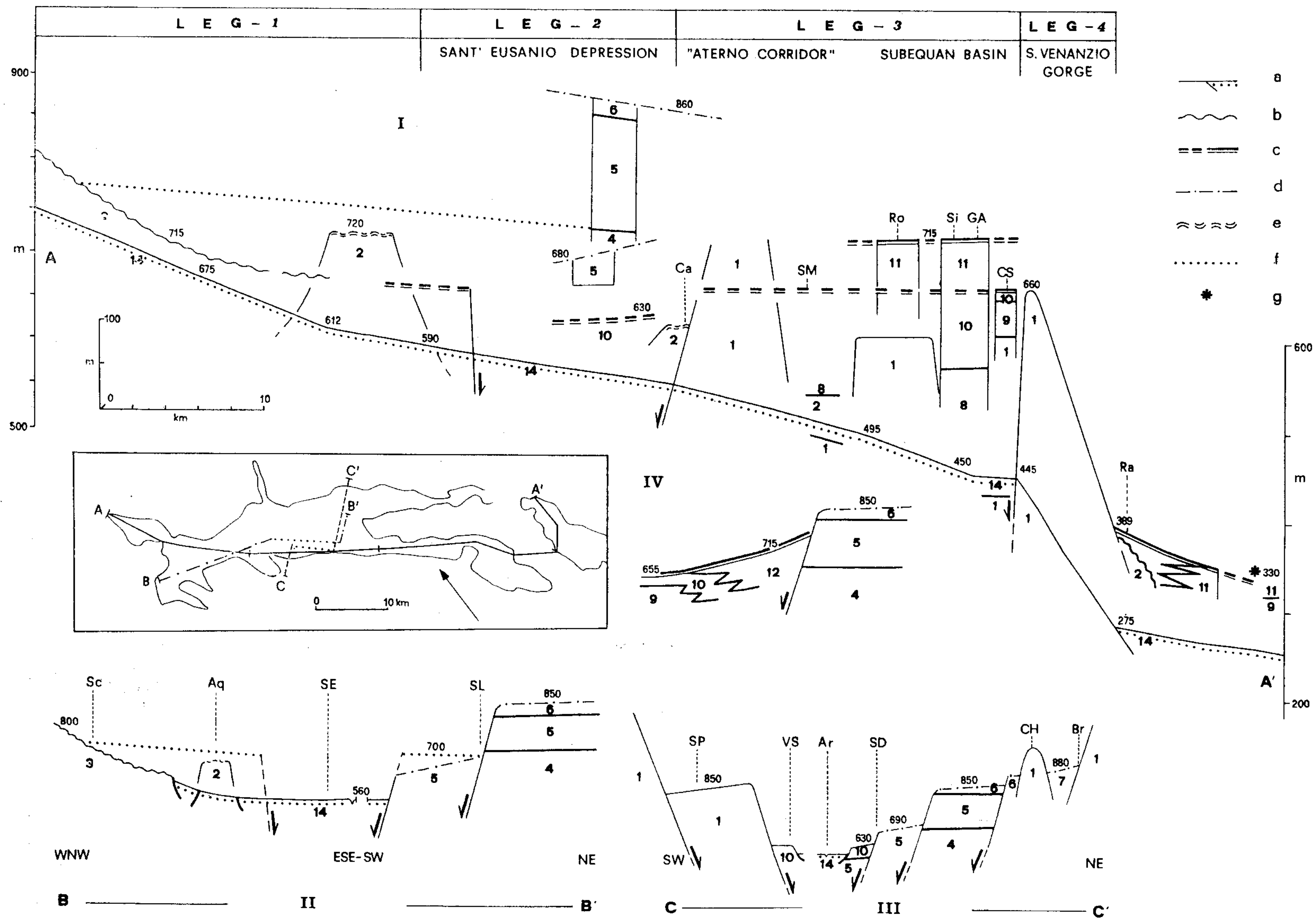

Fig. 3: Aquila and Subequan basins geomorphological sections (surfaces chronology and site names, f. 1; Chronolithofacies f. 2). Legend: a, Aterno thalweg; b, erosional surface on the deposits of the first sedimentary cycle; c, depositional surface of the second sedimentary cycle; d, depositional surface of the first sedimentary cycle; e, various age tectonic breccia surface; f, Lower Pleistocene lacustrine deposits correlation; g, « Le Svolte di Popoli » archaeological site. Numbers as in f. 2.

2. Quaternary evolution

2.1 *Lower Pleistocene tectonic phase*

Paleolandslides of tectonic origin widely outcrop in the L'Aquila-Paganica area (tectonic breccia e. g. "megabrecce", Demangeot, 1965; ff. 1, 2, 3/I). For their stratigraphic and geomorphological position they represent the oldest quaternary deposits of the Aquila basin, referred to Lower Pleistocene (Upper Pliocene?; Ge.Mi.Na., 1963; Bosi, Bertini, 1970; f. 2).

These paleolandslides are considered the result of an intense tectonic activity (Geol. Serv., F. 139; Demangeot, 1965) that contributed to form the Aquila basin where, subsequently, a long sedimentary

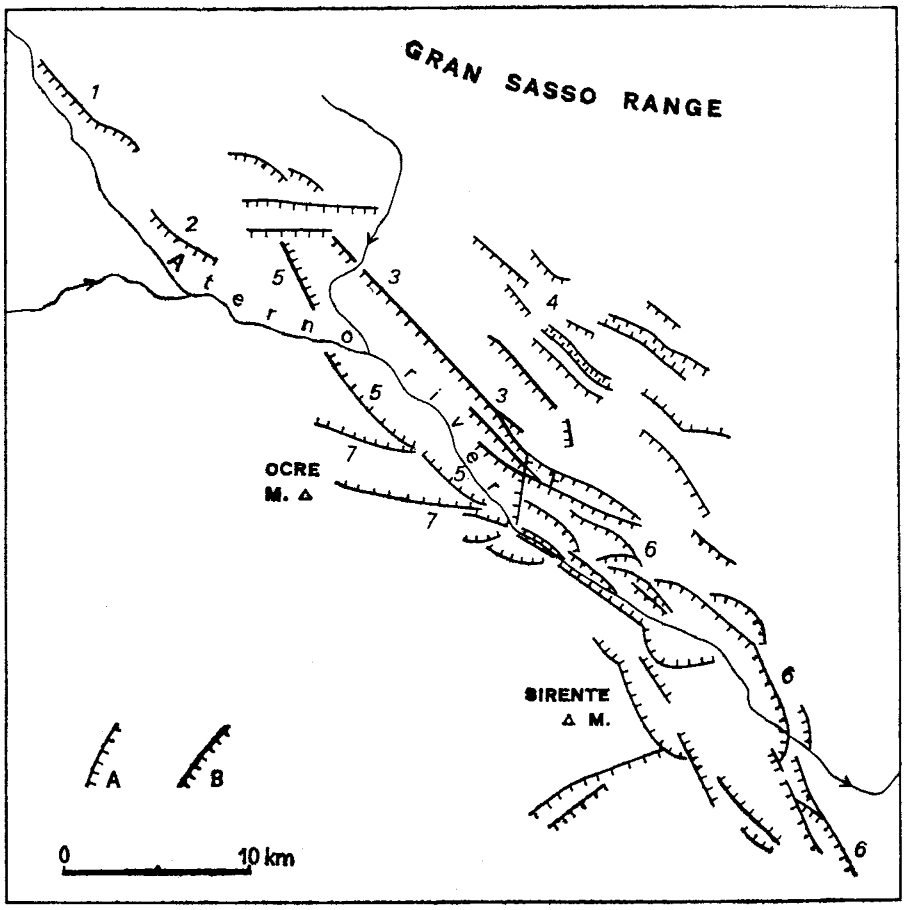

Fig. 4: Quaternary normal faults (gravity faults) of the Aquila and Subequan region. Legend: A, Faults displacing only the limestone bedrock. B, Faults displacing also quaternary deposits; dashes are on the downthrown block.
1, Pizzoli fault; 2, Pettino Mount fault; 3, S. Demetrio-Paganica fault system; 4, Barisciano, fault system; 5, Bazzano-Fossa-Stiffe fault system; 6, Molina Aterno fault system; 7, S. Panfilo d'Ocre fault system.

cycle took place (item 2.2). During this tectonic phase Pizzoli, M. Pettino, Paganica-S. Demetrio, Barisciano and Bazzano-Fossa-Stiffe Apenninic fault systems were active (f. 4).

2.2 *First sedimentary cycle*

Fluvio-lacustrine deposits of the first sedimentary cycle have been examined in detail by Ge.Mi.Na. company (1963) in the area of Scoppito-L'Aquila, by Demangeot (1965) and Bosi, Bertini (1970).

This cycle is referred to Lower Pleistocene - Middle Pleistocene, lower part, through the presence of *Elephas* (*Loxodonta*) *meridionalis* (D'Erasmo, 1932; Feruglio, 1954, Maccagno, 1962) and *Hippopotamus major*, pollen analyses (Follieri, 1957) and the absence of volcanic minerals (Fornaseri, 1985; f. 2). Palaeontological and palaeobyological data indicate that sedimentation took place during a warm and temperate climate with oceanic tendency (Follieri, 1957; Ge.Mi.Na., 1963).

The most indicative stratigraphic informations on the first sedimentary cycle are the following ones (ff. 1, 3).

In the northern part of the Aquila basin (area of Pizzoli-Scoppito-L'Aquila) deposits of the first sedimentary cycle outcrop up to 820 m. Between Scoppito and L'Aquila there are lignite lenses outcropping at 775 and 715 m and a complete skeleton of *Elephas* (*Loxodonta*) *meridionalis* was discovered in a quarry of diatomite layer at 715 m (Feruglio 1954). These deposits are referred to a marsh-lacustrine environment characterized by the absence of erosion during a period of tectonic stability.

The stratigraphic sequence of the deposits of the eastern part of the Aquila basin begins with lacustrine calcareous silt and diatomite with horizontal layers. On the calcareous silt there is an alluvial complex of consolidated and stratified conglomerates with sandy layers interbedded. This complex ends with braided rivers deposits (f. 5). The sequence, of variable thickness (maximum of about 150 m), indicates the filling up of a lake and the transition to a fluvial environment.

Marsh-lacustrine deposits of the area of Scoppito-L'Aquila may be correlated with the lacustrine one of the area of S. Demetrio-Sinizzo Lake either for facies relationships or for palaeontological reasons (*Elephas meridionalis* remains near S. Demetrio; D'Erasmo, 1932, ff. 1, 3/I, II).

The geomorphological analyses pointed out that the depositional surface of this sedimentary cycle is preserved in the eastern part of Aquila basin, not in the northern part (ff. 1, 3/I, II).

In the eastern part of the Aquila basin (area of Barisciano) the depositional surface of the first sedimentary cycle is preserved up to 950-900 m. It is a surface of alluvial fans at the base of the mountain fronts and of fluvial deposits, characterized by many paleochannels and bars (f. 6), that indicate, in agreement with the sedimentological data (Cicogna hill sequence, f. 5), a flow in the direction of the Navelli plateau. This is related to the main river - Paleoaterno - that drained

the Aquila basin during the last part of the first sedimentary cycle (Middle Pleistocene, lower part, f. 7A). The Paleoaterno, that passed near S. Nicandro, flowed down through the Civitaretenga notch and reached the head of Parata valley. This valley is connected with the structural channel of the Popoli gorge, where the mouth of the drainage of the whole region is located.

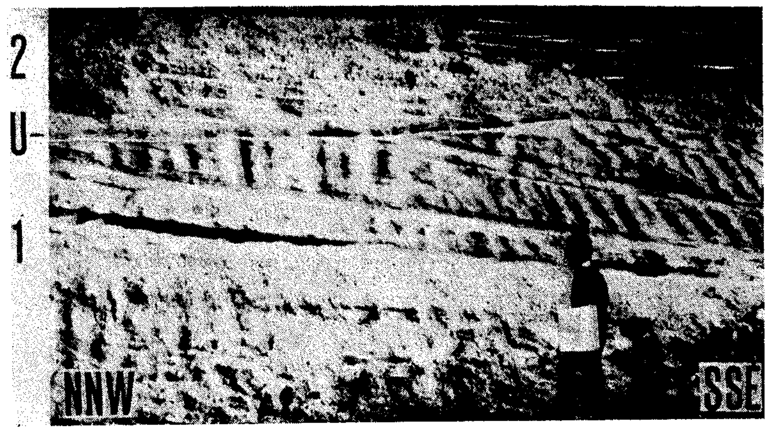

Fig. 5: Braided river deposits sequence: section parallel to the current, directed towards SSE during the Paleoaterno drainage (Cicogna hill sequence, location f. 6). The sequence is composed of large scale cross-bedding: pebbles arranged in inclined layers grading into laminated sand and silty sand e.g. foreset laminae. The unit 1 is separated from the unit 2 by the U erosional surface.

2.3 *Middle Pleistocene tectonic phase and erosional associated cycle*

The depositional surface of the first sedimentary cycle, in the eastern part of the basin, has been lowered and deformed by a normal fault system with NW-SE direction and SW dipping (Bosi, Bertini, 1970; ff. 1, 3, 4, 6), the Paganica-S. Demetrio fault system. Regional tectonic activity was very intense during the Middle Pleistocene and determined the formation of a narrow depression lengthened in the Apenninic direction: S. Eusanio depression (Bosi, Bertini, 1970) - "Aterno Corridor" - Subequan basin (f. 1).

The attribution of tectonic activity to the Middle Pleistocene has been obtained considering the age of the displaced depositional surface (Middle Pleistocene, lower part) and the age of the deposits of a new sedimentary cycle that took place in the just formed depression (item 2.4).

In the area of Campana the Middle Pleistocene tectonic has been particularly active: it destroyed the watershed of the Paleoaterno basin (f. 7) and originated a large amount of tectonic breccia, the Campana paleolandslide (ff. 1, 2, 3/I).

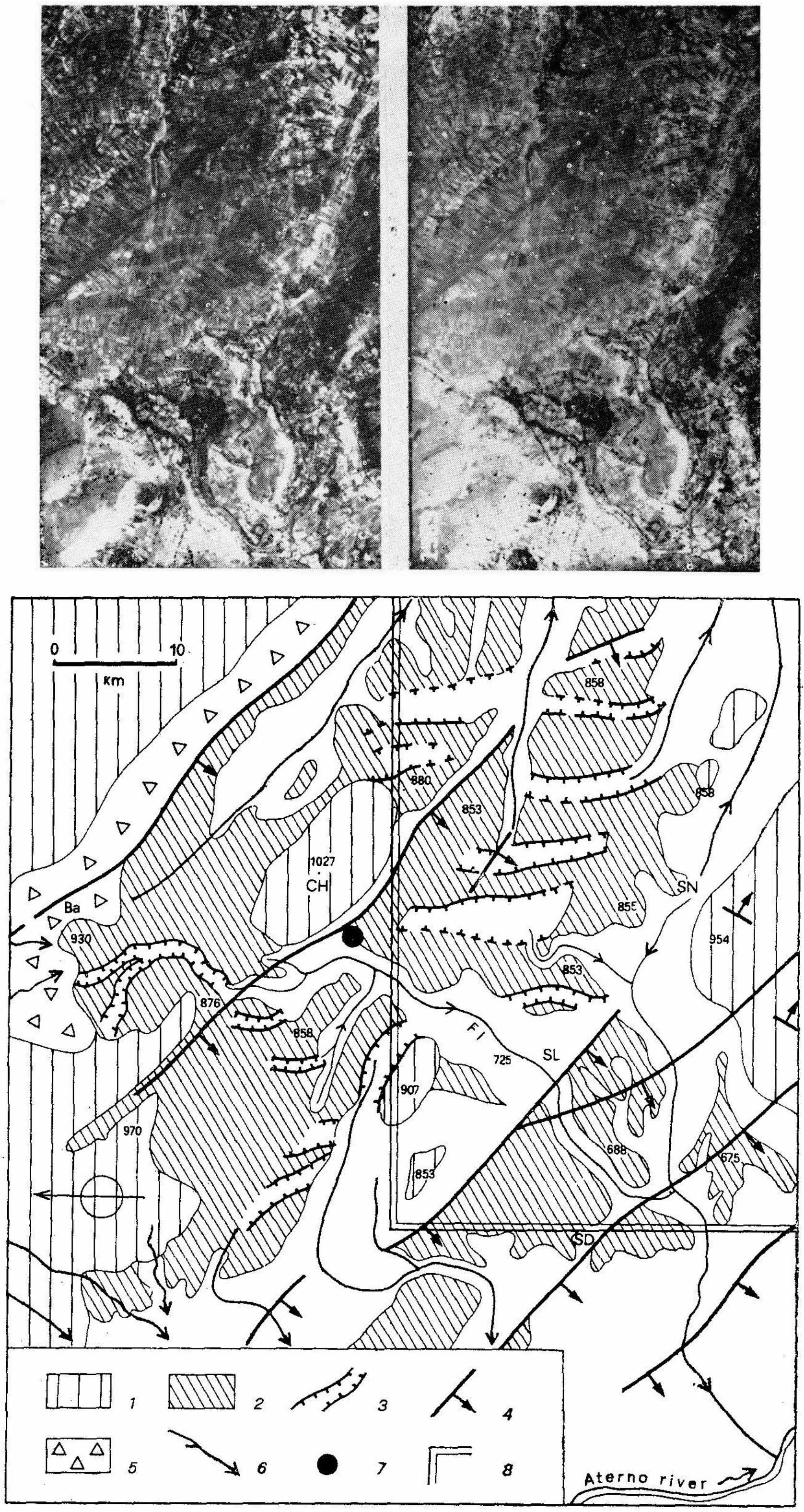

Fig. 6: Eastern part of the Aquila basin: aerial photographs (scale 1:66,000) of the Fosso Inferno FI - S. Nicandro SN area.
Geomorphological interpretation of the Barisciano BA - S. Demetrio SD - S. Nicandro SN area; Legend: 1, Outcropping mesocenozoic limestone bedrock during the Paleaterno drainage; 2, depositional surface of the first sedimentary cycle; 3, paleochannels of the Paleoaterno drainage system; 4, normal faults; 5, various age tectonic breccia; 6, present drainage system; 7, Cicogna hill sequence, f. 5; 8, limit of the area covered by airphotos (IGM, 1989).

The new topographical minimum of the region caused the setting up of a new drainage system - Aterno -, feeded, also, by the karst drainage of a wide hydrokarstic system. To the new drainage system is related an intense erosional cycle, that dissected the depositional surface of the first sedimentary cycle in the area of Barisciano-S. Demetrio and that determined a sheet erosion in the northern part of Aquila basin: Pizzoli, Scoppito, L'Aquila.

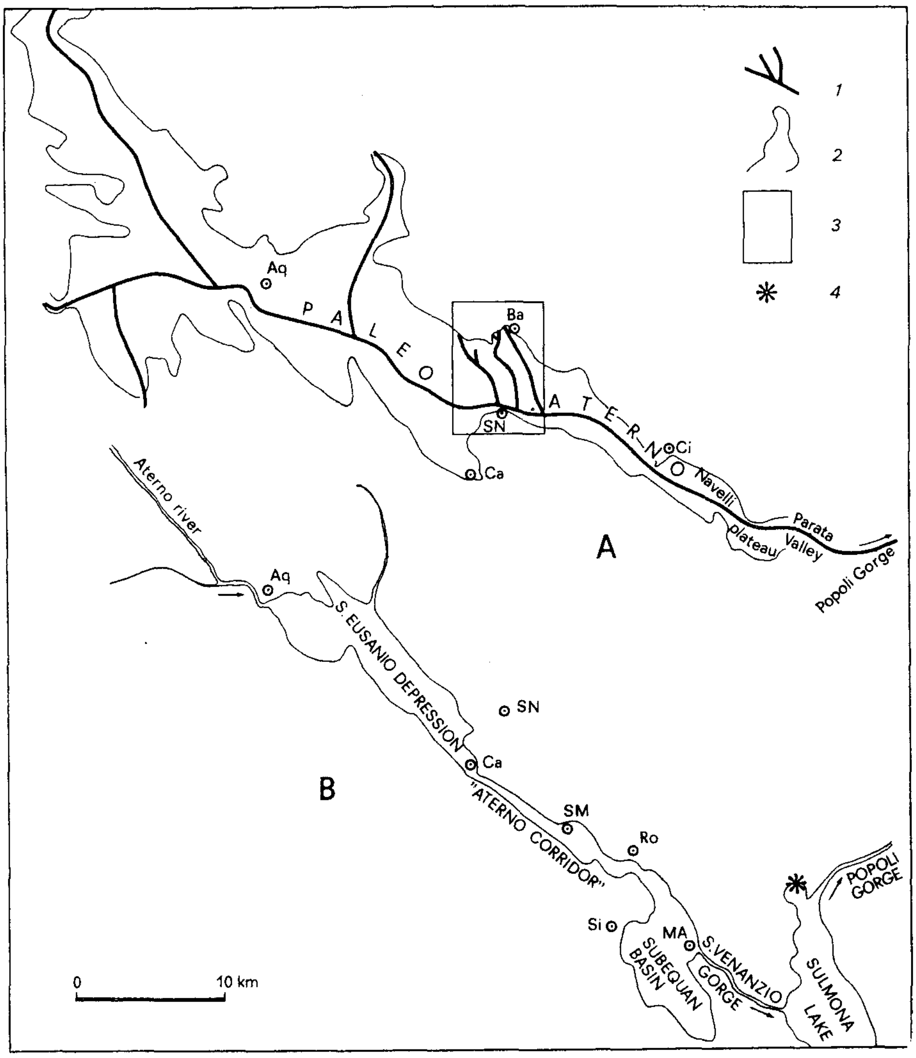

Fig. 7: Middle Pleistocene hydrographic evolution. A, Paleoaterno drainage system, Middle Pleistocene, lower part. B, Middle Pleistocene Aterno lake.
Legend: 1, Paleoaterno drainage system; 2, Limit of the Paleoaterno alluvial plain; 3, Area of f. 6. 4, « Le Svolte di Popoli » archaeological site (f. 7B).

2.4 *Second sedimentary cycle*

In the depression originated during the Middle Pleistocene tectonic phase a lacustrine environment took place (f. 7B). The Middle Pleistocene Aterno lake was filled by a sedimentary cycle inclusive of lacustrine, fluvial and subaerial deposits. The presence of volcanic minerals (mostly augite and biotite, Demangeot, 1965; Bosi, Bertini 1970, Fornaseri, 1985) and of a tusk of *Elephas* (*Palaeoloxodon*) *antiquus* at S. Eusanio (Maini, 1956) suggests that the second sedimentary cycle occourred during the Middle Pleistocene (f. 2).

The distribution of limnic deposits with volcanic minerals has allowed us to border the Middle Pleistocene Aterno lake (f. 7B). The tectonic threshold of Molina Aterno, located at 660 m at the opening of S. Venanzio gorge, dammed the lake valleyward (f. 3/I). The lake was drained by an emissary - Aterno - that could flow down into the structural channel of the S. Venanzio gorge. The depositional surface of lacustrine sediments at about 660 m (Subequan basin, western side of Urano Mount, ff. 1, 3/I), indicates the level of the Middle Pleistocene Aterno lake filling up and the transition to a fluvial environment.

In the S. Eusanio depression lacustrine sediments with volcanic minerals have been discovered up to 630 m (Bosi, Bertini, 1970, f. 1).

The deposits of the second sedimentary cycle are generally embedded in those of the first cycle (f. 3/IV).

At the same time of the Aterno lake filling a sheet erosion was active on the deposits of the first sedimentary cycle in the northern part of Aquila basin (area of Pizzoli-Scoppito-L'Aquila). At the moment of the filling up of the Middle Pleistocene lake the equilibrium profile of the Aterno between Pizzoli and Molina A. was reached - Middle Pleistocene, upper part - and a wide erosional surface was formed. This erosional surface joins the depositional surface of the second sedimentary cycle (ff. 1, 3/I).

Geomorphological observations and chronological attributions indicate that the filling of Aterno lake was contemporary to the filling of the Sulmona lake and that the two lakes were in communication since the Middle Pleistocene (f. 7B). This consideration is based on the following data:

- Volcanic minerals and remainders of *Elephas* (*Palaeoloxodon*) *antiquus* are present in both stratigraphical sequence.

The Middle Pleistocene dated stratigraphy of the Sulmona basin was obtained by the archaeological excavation of Le Svolte di Popoli (Radmilli, 1981, 1982) located in the northern part of the basin (ff. 3/I, 7B).

- The two basins depositional surfaces have a height difference of about 270 m, slightly bigger than the present difference of the holocene surface (190 m). This is consistent considering the lesser degree of evolution of the thalweg of the S. Venanzio gorge with respect to the present one (f. 3/I).

- It has been discovered a breakslope of the limestone sides towards the S. Venanzio gorge's mouth at about 475 m, in morphological continuity with the depositional surface of the Sulmona Basin. The very steep slope, below 475 m, indicates that after the Middle Pleistocene sedimentary cycle a strong renewal of the erosion took place.

S. Venanzio gorge is located along a structural discontinuity (Demangeot, 1965): the steep strata eastward dipping of Urano M. do not show a structural continuity with the subhorizontal ones of the Mentino M. (f. 1).

2.5. *Upper Pleistocene erosional cycle*

After the filling up of the Middle Pleistocene lake an intense regressive fluvial erosion took place in the Aquila and Subequan basins. The dissection of the depositional surface of the second sedimentary cycle, the formation of an erosional surface on the deposits of the second cycle in the Subequan basin (f. 1) and the subsequent dissection of this surface are ascribed to this erosional cycle.

The chronological attribution of this erosional cycle to the Upper Pleistocene has been established by comparative geomorphological considerations.

2.6 *Neowurm fan phase*

The deposition of wide alluvial fans is referred to the final part of last glacial peak (18,000 y. b.p.). These fans have a well preserved shape, are generally deposited below the older deposits and are downcut by the Aterno (f. 1).

2.7 *Holocene alluvial surface*

The holocene surface has been studied , chap. 3, because it is the most recent geomorphological unit cut by faults (ff. 1, 3/I, II).

It is emphasized that the limestone bedrock has culminations and depressions that can determine the different degree in overload/downcut and the inclination of the Aterno thalweg.

3. Neotectonic observations

This area is characterized by normal faults systems of Apenninic trend (Beneo, 1940, 1943; Segre, 1950; Demangeot, 1965; Bosi, Bertini, 1970; Bosi 1975) and by E-W, SW-NE subsidiary normal faults.

Two main quaternary tectonic phases have been recognized: the oldest one - ascribed to Lower Pleistocene (itm 2.1) - contributed to form the Aquila basin, where the first sedimentary cycle took place (item 2.2); the most recent one determined the formation of a long and narrow lowered area, S. Eusanio depression - "Aterno Corridor" -

Subequan basin, and the subsequent changing in the drainage system (item 2.3) during the Middle Pleistocene. The time of this tectonic activity is based on the age of the displaced depositional surface of the first sedimentary cycle (Middle Pleistocene, lower part) and the age of the deposits of the second cycle (Middle Pleistocene, item 2.4).

Fault systems active since Middle Pleistocene have been examined in detail (ff. 1, 3, 4).

Along the eastern border of the tectonic depression there is a NW-SE fault system of about 45 km length, dipping southwestward, extending from the southeastern extremity of the Subequan basin up to Paganica site. In the "Aterno Corridor" and in the Subequan basin the faults have a curvilinear trend with the concavity turned towards the downthrown block, dip towards the axis of the tectonic depression, cut exclusively the limestone bedrock and do not displace Neowurm alluvial fans. Fields investigations pointed out that in proximity of Molina A. fault line there is a considerable amount of tectonic origin debris (not mapped in f. 1), referred to the Upper Pleistocene. The Paganica-S. Demetrio and Barisciano fault systems have a rather rectilinear trend and displace both the depositional surface of the first sedimentary cycle (maximum displacement of about 160 m, ff. 1, 3/III) and that of the second cycle (area of Paganica). Wide paleolandslides are associated with the S. Demetrio-Paganica fault in the area of Paganica. This fault does not displace the alluvial fan of the Raiale river (dated to the last glacial optimum, item 2.6), therefore its most recent activity is dated back to 250,000 - 18,000 y. b.p.

Movements more recent that 250,000 may be inferred by comparing the depositional surfaces heights of Middle Pleistocene limnic sediments that are located in the S. Eusanio depression and along the eastern border of the Subequan basin. In the depression of S. Eusanio liminc sediments outcrop up to 630 m, while in the Subequan basin they outcrop up to 660 m (f. 3/I). The height difference is ascribed to the tectonic subsidence of the S. Eusanio faultblock along the bordering fault, as hypothesized by Bertini, Bosi (1978). The S. Eusanio block is bordered in the northern and in the southern sides by E-W, NE-SW trending faults, in the eastern side by the above-mentioned S. Demetrio-Paganica fault system, in the western side by the Bazzano-Fossa-Stiffe fault system. The northern segment of this system displaces Lower Pleistocene landslides, the southern continuation is buried by holocene alluvium.

Between the Ocre mount and the Aterno valley the faults have WNW-ESE trend and dip towards NNE, the fault lines are curvilinear with the concavity turned towards the downthrown block (S. Panfilo fault system). Due to the absence of deposits of the first cycle at 850-860 m we think that the activity of these faults determined the subsidence of the S. Panfilo limestone fault block during the Middle Pleistocene (f. 3/III).

It is worth emphasizing that Pizzoli, Pettino M. faults and Molina A.

fault system, which show probable activity features (Bosi 1975; item 1.2), do not displace Neowurm alluvial phans. The airphotogeological investigation indicates that Neowurm and Holocene deposits are not morphologically displaced in the whole Aquila and Subequan region.

Summarizing the above-mentioned observations it is clear that:

- the planimetrical trend of the fault lines is more or less curvilinear with the concavity turned towards the downthrown block (ff. 1, 4);
- the single faults are not very long (15 km Paganica - S. Demetrio fault, ff. 1, 4), are often clustered in fault systems and dip towards the axis of the tectonic depression;
- geomorphological surfaces of quaternary deposits show exclusively normal displacements (dip slip); lateral displacements and compressive deformations are absent;
- generally the downthrown block has a lower topographical altitude relatively to the stable "upthrown" block. The absence of uplifting along the faults that border and that cross the Aquila and Subequan depressions has been pointed out through the geomorphological analyses of the depositional surface of the Barisciano - Ansidonia area. This surface is not deformed (upwarped and/or tilted) and its original dipping is preserved (ff. 1, 6).

The whole surveyed features suggest that most of these faults are gravity faults type characterized by listric surfaces, and that the long and narrow lowered area, S. Eusanio depression - "Aterno Corridor" - Subequan basin, is the result of downward movements of limestone blocks along gravity faults (shallow crustal, brittle deformations). It is not possible to state whether this part of the Abruzzi Apennines has been subjected to regional uplifting in recent times for lacking of geodetical data on the high mountains - Velino, Sirente, Ocre Ms.; Gran Sasso Range - and for the absence of Pleistocene marine deposits in these basins. Geomorphological data clearly indicate that along the faults that border and that cross the Aquila and Subequan basins, at least since Middle Pleistocene, exclusively lowering movements took place. This interpretation is consistent with Nijman's one on the tectonics of Velino-Sirente area (Nijman, 1971). The author concludes that folds and thrust structures related to the Upper Miocene - Lower Pliocene compressional stress field have been subjected to collapse gravity sliding during the subsequent dilatation phase.

These tectonic movements are considered to be the effect of the SW-NE extensional stress field active in the shallow crust of the Central Apennines, as shown by focal mechanism and hypocentral depth of the earthquakes that occour in this region (Gasparini, Iannaccone, Scarpa, 1980, 1985).

Other neotectonics observations, related to Stiffe spring and the Holocene alluvial plain, are presented below.

In the Stiffe cave (f. 1), mouth of the karstic drainage of the Rocche plateau, the karstic channel is characterized by a set of high steps always growing mountwards (Callori, Segre, 1958; Segre 1948). The steps can be related to subsidiary fractures (joints) accompanying the main faults. Since the karstic channel has not yet reached the equilibrium profile and the spring is suspended about 200 m above the Holocene alluvial plain, we think that the karst hydrographic system has been subject to neotectonics. These movements are leading back to a recent subsidence of the S. Eusanio fault block.

The study of the Holocene alluvial surface has been carried out in order to point out the recent tectonic movements. From the examination of the longitudinal profile of the Aterno thalweg four legs characterized by variable inclination have been differentiated. These legs are described going valleyward (ff. 1, 3/I).

In the leg 1 the thalweg inclination gradually decreases, but the alluvial plain shows width variations. There are two notches related to lithological factors: the Aminterno notch (675 m) and the L'Aquila notch (615-600 m).

In the leg 2 - S. Eusanio depression - there is a strong overload and the thalweg has a very low inclination; the alluvial plain is wider in the northern part of the depression. This leg is bordered by the L'Aquila notch northward and by the Campana notch southward (550 m).

Souther of the Campana notch there is the leg 3, the "Aterno Corridor". In this sector the thalweg has higher inclination, and alluvial deposits are poorer with the exception of the Molina Aterno plain. Here the thalweg inclination is very low and there is a certain thickness of alluvial deposits.

Souther of the Molina Aterno notch the thalweg inclination suddenly increases and the river still downcuts the limestone bedrock (leg 4, S. Venanzio gorge).

From this examination it is clear that the alluvial plain width and the thalweg inclination variations are related to the bedrock depressions and culminations.

The Aterno river crosses the Campana fault with NNE-SSW trend and the Molina Aterno fault with NW-SE average trend and SW dipping (f. 4). These two faults, that border the 2-3 and 3-4 legs and lower the mountblock, mark sudden variations in the altitude of limestone bedrock and, consequently, in the thalweg inclination and alluvium thickness.

4. Historical seismicity

The investigated area has been affected by an intense, continuous and diffused seismic activity in historical time (1349, 1416, 1703, X MCS; 1639, 1762 IX MCS earthquakes, PFG, 1985 and ING, 1983 catalogues; f. 8A). The intensity MCS of ancient earthquakes is probably overvalued and the epicentral location is not very reliable.

Instrumental seismicity (surveyed by ING seismic network during

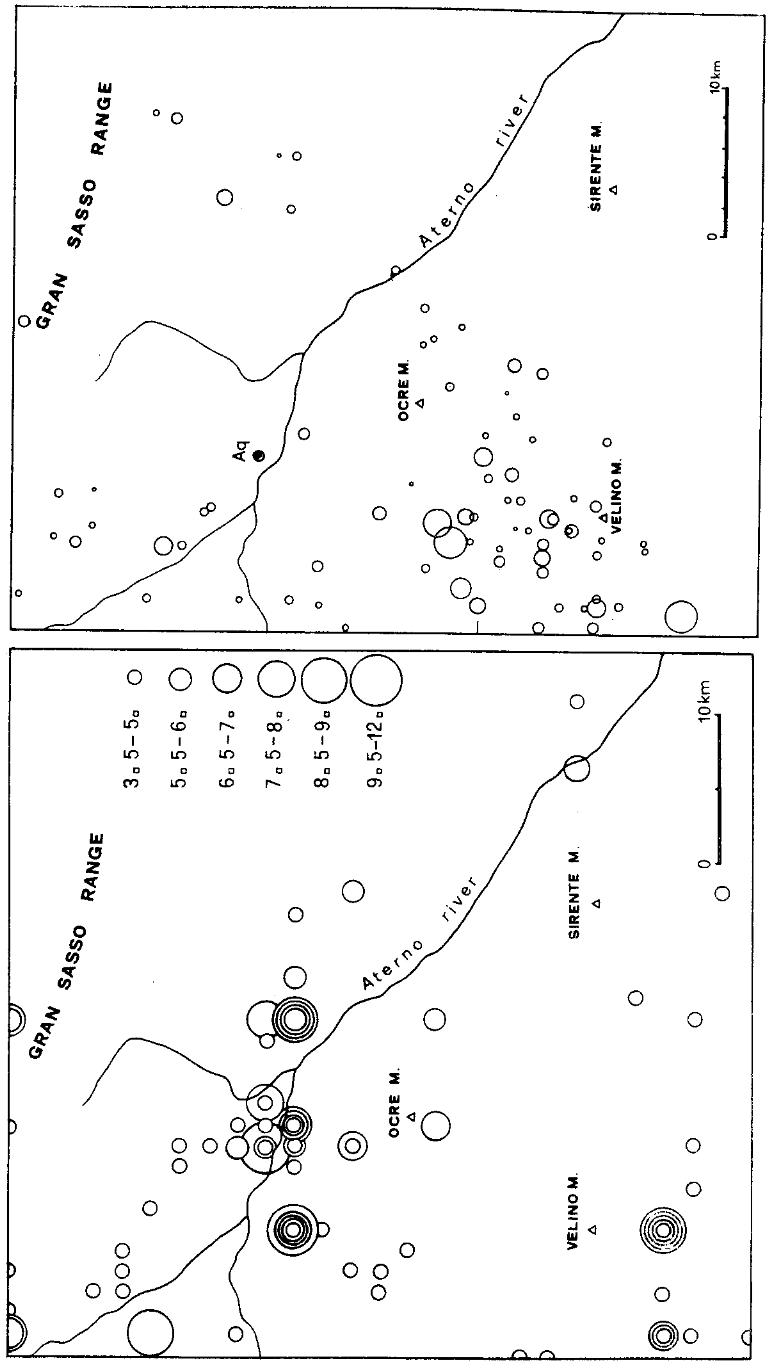

Fig. 8: Left: Historical seismicity from 1300 (MCS intensity). Right: Instrumental seismicity during the period 1983-1985.

1983-1985) indicate a diffused, shallow, low seismic activity (Md < 4, hip < 8 Km, f. 8B).

The historical seismicity of neighbouring areas indicates that a large earthquake (I = XI intensity, Ms = 6,9) occourred in 1915 in the Fucino basin. Surface faulting was associated to this event (Oddone, 1915; Serva 1986; Valensise, 1988) along a preexisting, NW-SE trending normal fault. Other remarkable earthquakes occourred in the Gran Sasso Range (1950, I = VII MCS) and in the Sulmona basin (1905).

Prehistorical e.g. Holocene surface faulting associated with paleoseismic activity has been pointed out in the Fucino basin (Giraudi, 1988), in the northern region of the Fucino basin (Biasini, 1966) and in the Gran Sasso Range (Giraudi 1988) along preexisting normal faults.

In the Aquila and Subequan basins tectonic movements visible through the geomorphological analyses (airphotos investigation) took

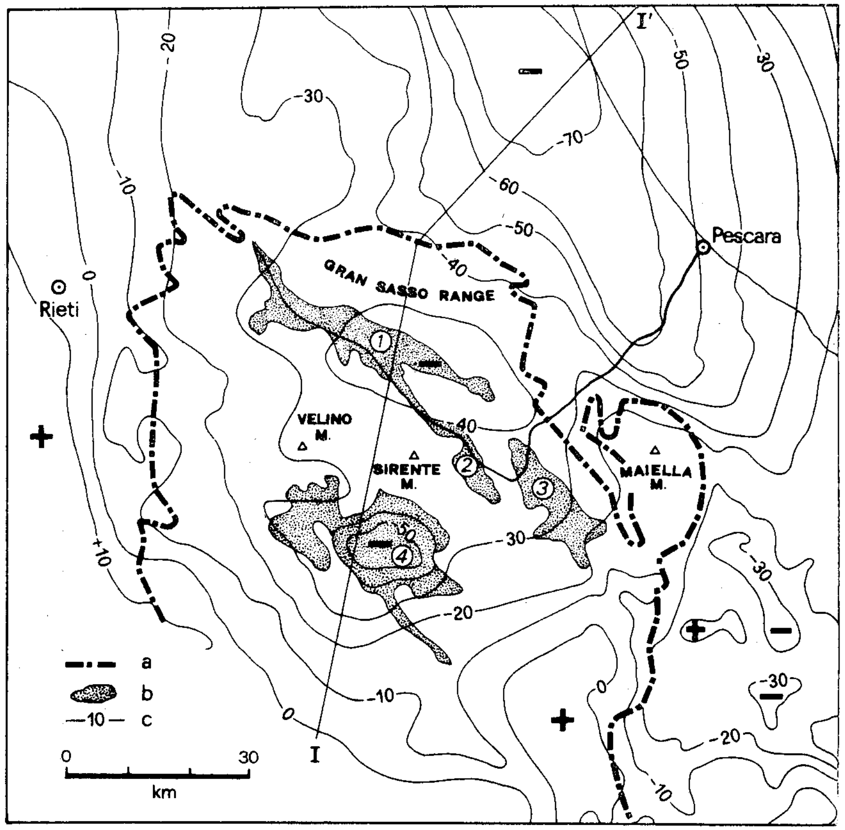

Fig. 9: Central Italy. Bouguer anomalies, mesocenozoic Latium-Abruzzi limestone platform and Pleistocene basins relationships. a, Latium-Abruzzi limestone platform limit. b, Abruzzi intra-apenninic basins: 1, Aquila; 2, Subequan; 3, Sulmona; 4, Fucino. c, Bouguer anomaly contours. 10 mgal. I-I'cross section of f. 10.

place up to 18,000 y. b.p. Holocene surface faulting has not been found out. This observation may imply that:

— surface faulting associated with large Holocene and historical earthquakes has been obliterated by erosion/deposition or antropic activity;

— Holocene fault scarps are not visible in the airphotos (fault scarps of tens cm height, example of the 1980 Irpinia earthquake, in Funiciello et alii, 1988) and/or they might mix with discontinuous and irregular erosional scarps along steep slopes;

— absence of Holocene earthquakes with Ms > 6,5 to which is associated surface faulting (historical and Japanese surface faulting review, Bonilla, 1979; Matsuda 1977). In this case large earthquakes of this region would be characterized by recurrence interval of tens thousand years.

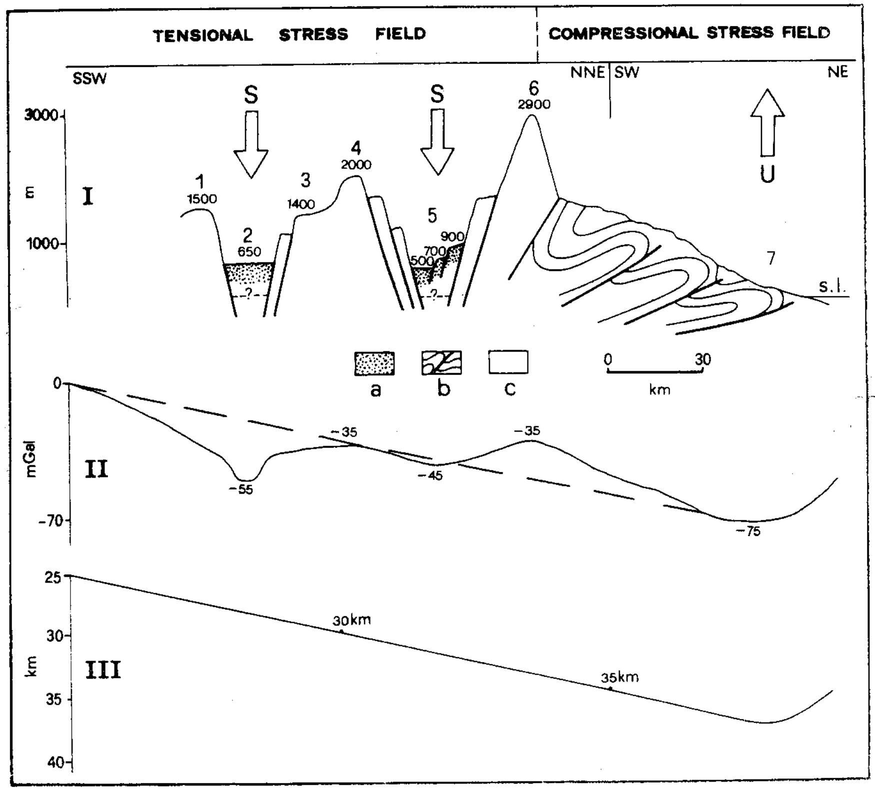

Fig. 10: Sections through the Abruzzi Apennines and the Adriatic foreland: I, morphotectonics; II, Bouguer anomalies; III, crustal thickness (Moho discontinuity, DSS data, Cassinis et alii, 1979; Nicolich, 1981. 1, Marsica range; 2, Fucino basin; 3, Tre Monti ridge; 4, Sirente ridge; 5, Aquila basin; 6, Gran Sasso range; 7, Adriatic foredeep. a, Quaternary deposits; b, terrigenous cenozoic sequence and quaternary terraces associated; c, mesocenozoic platform limestone. S, Subsiding areas; U, Uplifting areas.

Considering that in neighbouring areas Holocene and hystorical surface faulting associated with large earthquakes has been pointed out and that Aquila and Subequan basins have been affected by an intense hystorical seismicity, we suggest that the first and/or the second hypothesis seem to be more reasonable.

5. Conclusions

The elaboration of geomorphological and stratigraphic data allowed us to reconstruct the quaternary evolution of the Aquila and Subequan basins and to define a new interpretation of the tectonic movements that took place in this region. Tectonics of this area has been particularly active in the Middle Pleistocene, contemporaneously to the high volcanic activity of the Tyrrhenian margin, as shown by the formation of a long and narrow lowered area, the S. Eusanio depression - "Aterno Corridor" - Subequan basin. The new topographical minimum of the region caused the setting up of a new drainage system - Aterno - and of a transitory lacustrine environment, the Middle Pleistocene Aterno lake. Traces of the old drainage system - Paleoaterno - are preserved in the eastern part of the Aquila basin (area of Barisciano - S. Nicandro).

The long and narrow lowered area is considered the result of lowering movements of limestone blocks along gravity faults, that took place at least since Middle Pleistocene. On the basis of our geomorphological and stratigraphic data we propose the same interpretation to explain the formation of other Pleistocene depressions located in the northeastern part of the Latium-Abruzzi mesocenozoic limestone platform (Fucino and Sulmona basins, ff. 9, 10).

Summarizing, we can not state whether the Abruzzi Apennines have been subjected to quaternary regional uplifting for lacking of geodetical data on the high mountains and for the absence of Plio-Pleistocene marine deposits; but we are able to affirm that the abovementioned basins are the result of local lowering movements of limestone blocks (along gravity faults) inside the Apennine chain.

The absence of uplifting along the faults that border and that cross the Abruzzi intra-apenninic basins is in contrast with previous interpretations. Demangeot (1965), Bosi, Bertini (1970), pointed out uplifting movements along the faults of the Aquila basin; in the Neotectonic Map of Italy (1987) the Abruzzi intra-apenninic basins are classified as areas undergoing a continuous uplifting since Middle Pleistocene. Giraudi (1988) has considered the Fucino basin a "pull apart basin", originated by the activity of a buried, NW-SE, right lateral strike-slip fault.

The lowering movements are considered to be the effect of the SW-NE extensional stress field active from the Tyrrhenian margin up to the axial areas of the Apennines range. The gravimetrical section

(f. 10/II) shows the coincidence between intra-apenninic basins and relative Bouguer minimum, and between topographic heights and relative Bouguer maximum (f. 10/I). These local anomalies are superimposed on the Bouguer anomaly trend, that coincides with the subcrustal regional pattern (f. 10/III).

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