E. CENTAMORE(*) - G. DEIANA(*) - F. DRAMIS(*) & U. PIERUCCINI(*)

MORPHOTECTONIC CHARACTERISTICS OF THE UMBRIA-MARCHE APENNINE(**)

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ABSTRACT

The morphostructural pattern of the Umbria-Marche Apennine is the result of successive deformational events dating back to the Tortonian. These events were compressive between part of the Tortonian and the Middle Pliocene yielding folds, break-thrusts, and overthrusts associated with trascurrent faults. During the Quaternary, the area underwent tensional stress, which was responsible for the present morphostructural configuration. Among the numerous normal faults present, those with an Apenninic direction, which cut the older fold structures at different angles, are particularly important. These are related to tensional processes connected with the opening of the Tyrrhenian Sea, and appear to be still active, as the recent seismic events from the Norcia area indicate.

RIASSUNTO

L'assetto morfostrutturale dell'Appennino umbro-marchigiano è il risultato di eventi deformativi successivi verificatisi fin dal Tortoniano. Tali eventi hanno avuto un carattere compressivo durante l'intervallo Tortoniano p.p.-Pliocene medio ed hanno dato luogo a pieghe, pieghe-faglie e sovrascorrimenti, associati a faglie trascorrenti. Durante il Quaternario l'area è stata sottoposta a una tettonica distensiva alla quale si deve l'attuale assetto morfostrutturale. Tra le numerose faglie dirette, di particolare importanza sono quelle a direzione appenninica che tagliano, sotto angoli diversi, gli assi delle piú vecchie strutture plicative. Esse sono messe in relazione ai processi di distensione connessi con l'apertura del Tirreno e si mostrano ancora attive, come testimoniano i recenti eventi sismici dell'area di Norcia.

KEY WORDS: Morphotectonics, Umbria-Marche Apennine (Italy).

PAROLE CHIAVE: Morfotettonica, Appennino umbro-marchigiano.

The present day morphostructural aspect of the Umbria-Marche Apennine Arch (or the Apennine as formally defined) is essentially the result of tectonic events which have occurred since the beginning of the Tortonian. The characteristics of those events were for a long time (part of the Tortonian-Middle Pliocene) compressive, and yielded fold-structures (with a nearly exclusive Adriatic vergence) associated with reverse faults, overthrusts, and transcurrent faults, mostly with an anti-Apenninic, sometimes with an Apenninic direction (DECANDIA and GIANNINI, 1977a, 1977b, 1977c; CALAMITA and others, 1979). It was only later (upper Pliocene Quaternary) that the stress field changed and the area underwent tensional stress which were responsible for its present morphostructural aspect. Compressive tectonics occurrent during two main periods, i.e. the Tortonian and the end of the Lower Pliocene-Middle Pliocene (SCARSELLA, 1951, RICCI LUCCHI, 1975; DECANDIA and GIANNINI, 1977a; CASTELLARIN and others, 1978; CENTAMORE and others, 1978; CALAMITA and others, 1979). In particular, it appears that the final fold structures of the Umbrian Arch is due to the latter compressional stage. However, the ensuing deformations were not uniform throughout the Arch; there are indeed transverse tectonic lines (e.g. the «Chienti Valley Line», DEIANA, 1979) which separate sectors with differentiated fold patterns.

A general uplift followed the compressive period as indicated by: a) the intense uplifting of Plio-Quaternary deposits in the Marche foredeep, which reached an elevation of 1100 m on Mt. Ascensione; b) the high relief energy; c) the increasingly higher elevation of terraces from the most recent to the oldest; d) the location at different elevations of karstic levels along Mesozoic calcareous ridges (e.g. Frasassi; CATTUTO, 1976); e) the values of isostatic anomalies, which are distinctly positive on the South-central part of the area, in agreement with the AIRY-VENING MEINESZ hypothesis, and generally positive all over the area in agreement with the AIRY-HEIS KANEN hypothesis (BALLARIN and others, 1972).

During uplift dilation occured over structures which were previously compressed (similarly to what was illustrated in the Velino-Sirente area in Abruzzo by NIJMAN, 1970). This resulted in the formation of tensional faults and remobilization of older dislocations. Among the former, those parallel to the main plicative structures, which are located on the crest and mostly on the western sides of the anticlines, are noteworthy. Among the latter, those inclined with respect to the main structural lines are parcularly abundant and important. These represent old transcurrent faults which were reactivated as normal faults by the uplift (DECANDIA and GIANNINI, 1977c, p. 744; CALAMITA and others, 1979). This process is also responsible for the occurence of large-scale gravity collapse fenomena, observed, in particular, along the calcareous slopes. (DEIANA and PIERUCCINI, 1976; DRAMIS and others, 1976; COPPOLA and others, 1978; CARRARO and others, 1979).

The morphostructural pattern deriving from

(*) - Istituto di Geologia dell'Università di Camerino.

(**) - This study has been presented to the 26e Congrès Géologique International. Paris, 7-17 Juillet 1980.

uplifting consists of a series of blocks generally prismatic in shape, more or less uplifted (CALAMITA and others, 1979; DEIANA and others, 1980). Morphologic evidence for this is given by «summit surface» dislocation (DESPLANQUES, 1975; DEIANA and PIERUCCINI, 1976; CARRARO and others, 1979).

In the central-southern part of the Apennine, roughly SW of the line joining M. Vettore - Visso -Gualdo Tadino (Fig. 1), tensional effects whose axes trend WSW-ENE, are superimposed on the structural characteristics described above. The most striking among these, are given by large normal faults roughly parallel to the Apenninic direction (NNW-SSE to NW-SE), which cut the oldest fold structures (N-S or NNE-SSW) at different angles, yielding a block morphology (Fig. 2). Their length is often considerable (i.e. few tens of Km), sometines reaching the Latium-Abruzzo area (PAROTTO and PRATURLON, 1975). Two important «lines» in parcular should be mentioned, i.e. the Nottoria-Colfiorito-Gualdo Tadino and Mt. Gorzano - Mt. Bove lines (SCARSELLA, 1941; 1951; 1959; DEMANGEOT, 1965; DAMIANI, 1975; CALAMITA and others, 1979; DEIANA and others, 1980) which clearly displace, along their southern portion, the «Anzio-Ancona line». They have large throws, reaching at times about 1000 m, and subdivide the areas thus affected into three large blocks, descending toward the WSW in a step-wise fashion. The tectonic depressions of Campotosto, of the Castelluccio Plains, of the S. Scolastica Plains, of Cascia and the Colfiorito Plains (outlined by the above mentioned faults, by their antithetic faults, and by transversal antiapenninic dislocations) are enclosed inside the single blocks.

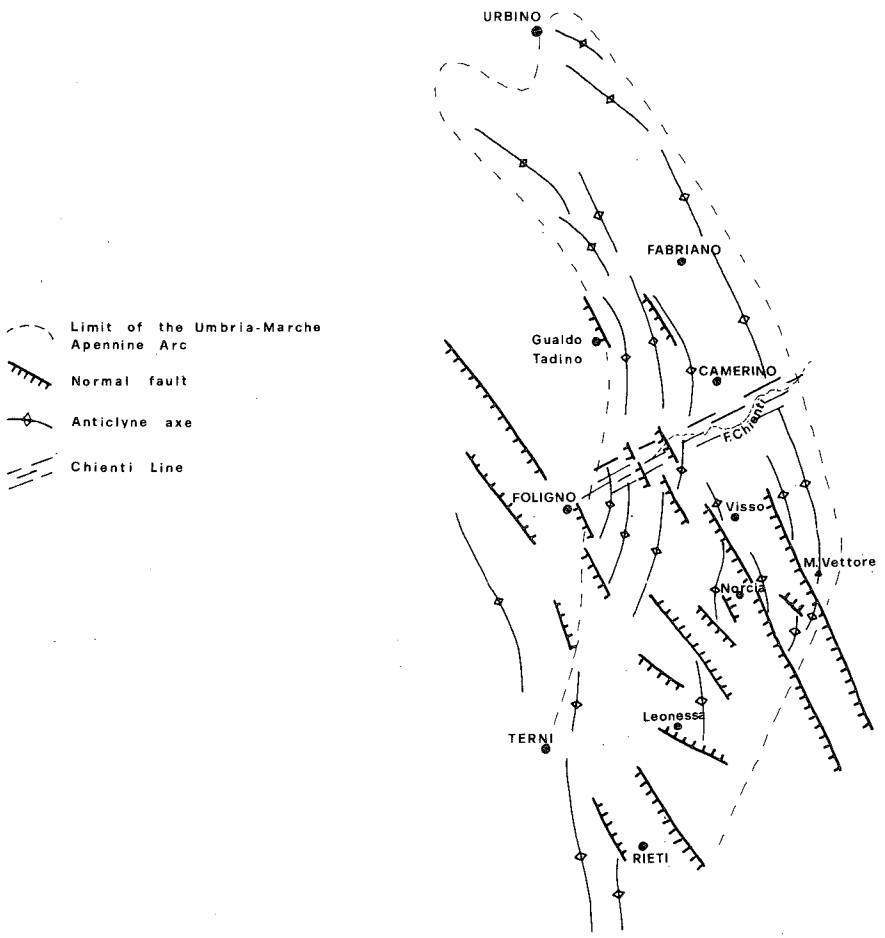

Fig. 1 - Relationship between the main anticlines axes (Miocene-Pliocene compression) and the recent Apenninic normal faults.

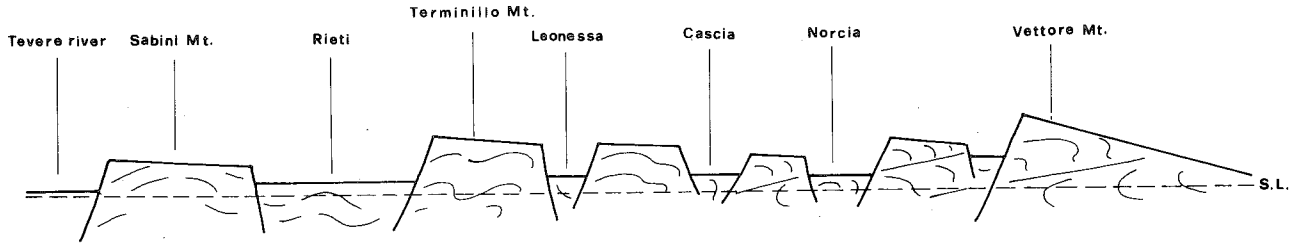

Fig. 2 - Schematic section showing the block structure connected with recent extensional tectonics in the southern part of the Umbria-Marche Apenninic Arch.

The above discussion points to close similarities between the structural pattern of the Umbria-Marche Apennine Arch (SW of the Mt. Vettore-Visso-Gualdo Tadino Line) and that of the adjacente Tuscany-Latium-Western Umbria area. Indeed, the latter is characterized by a typical horst-graben pattern, in which the principal normal faults show an Apenninic trend and are superimposed on older compressive structures, which they displace. They can be related to tensional processes connected with the opening of the Tyrrhenian Sea (GIGLIA, 1974; ELTER and others, 1975; FUNICELLO and others, 1977; FUNICELLO and PAROTTO, 1978; WISE and others, 1979). Their ages appear to be younger and younger in an easterly direction, as is shown by the dating of the basal sediments which filled up the grabens-Messinian in the innermost zones, late Pliocene and Quaternary in the outermost zones. In addition, these faults are important in a crustal context, since recent volcanism along the Apennine Tyrrhenian margin is related to them.

That portion of the area under consideration, located NE of the alignment described above, does not show the effects of the «Tyrrhenian» tensional stage; its present structural-morphologic configuration is conditioned by the uplift, whose effects do not erase appreciably the pattern acquired during the compressive stage.

It is difficult to determine the time during which the compressional stage ended and the tensional stage begun. On the basis of the age of the materials filling the tectonic depressions enclosed between the Lower Pleistocene and the Middle Pleistocene (SCARSELLA, 1941; CENTAMORE and others, 1978b; RAFFY, 1979), such time does not appear to be much older than the Quaternary.

The normal faults have been active until recent times, as can be demonstrated by geologic evidence (i.e. dislocation of continental deposits of Middle and Upper Pleistocene and, sometimes, Holocene time), and geomorphologic evidence (CENTAMORE and others, 1978a, 1978b; CALAMITA and others, 1979; DEIANA and others, 1980).

The present activity is evidenced by the sismicity of the area. The solution of focal mechanisms of recent seismic events indicate a deep-seated tensional stress field (RITSEMA, 1970; CAGNETTI and others, 1978; WISE and others, 1979; GASPARINI and others, 1980). A predominantly tensional stress field, with ENE-WSW axes, also appear to emerge from the focal mechanisms solutions concerning the recent seismic activity in the Norcia area (Fig. 3) (DEIANA and others, 1980; GASPARINI and others, 1980).

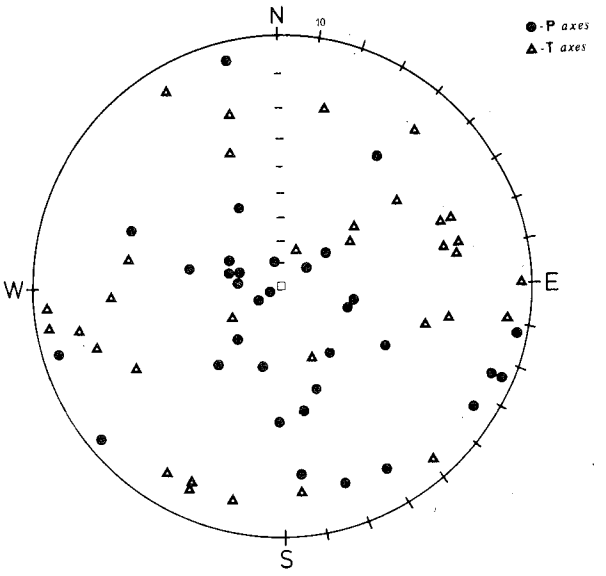

Fig. 3 - Distribution of «P» and «T» axes on the projection net relevant to the september, 19, 1979 Norcia earth quake aftershocks.

In conclusion, it appears that the recent tectonics of the Umbria-Marche Apennine Arch is dominated by tensional stresses. The normal faults which were active during this stage gave this area the present structural-morphologic configuration. In the southern portion (i.e. SW of the «Line» joining Mt. Vettore-Visso-Gualdo Tadino), dominantly affected by a faults sistem in an Apenninic direction, this configuration consists of a number with NNW-SSE or NW-SE orientations, similar to that typical of the Tuscany-Latium-Western Umbria area. It can be considered as the eastern margin of a wide «Tyrrhenian area» under tension as a conseguence of the opening of the Tyrrhenian Sea. Along the latter, however, the

tensional processes are not still accompanied by a noticeable crustal thinning, and by conseguent regional magmatic and geothermal phenomena which characterized the western part of the area. The effect of tension do non seem to have reached, to any observable extent, the northern portion of the Arch (NE of the Line mentioned above).

With reference to the present structural elements of the Earth's crust, the Umbria-Marche Apenninic Arch can be considered as the eastern margin of a rift (i.e. of an area experiencing the early stages of crustal spreading), where both uplift and tension are present.

Within this tensional framework, however, there is geologic and geomorphologic evidence of compressional episodes which do not alter considerably the morphostructural picture described above. This consists of small folds and reverse faults in Pleistocene terrains, deformations of overthrust planes, transcurrent features affecting slopes and ridges (CENTAMORE and others, 1978 a e b; CALAMITA and others, 1979). A Lower-Middle Pleistocene compressive episode has been recognized also in Calabria where a general extensional Quaternary trend exists (BOUSQUET and others, 1979). These minor compressive episodes could be connected with a large-scale geodynamic phenomenon (N-S interaction between the African and the Eurasian plates) which is related to the beginning of the Pleistocene compressive phase in the Gibraltar Arc, in Northern Africa, in Southern France and in Greece (BOUSQUET and PHILIP, 1976; BOUSQUET, 1977; ARMIJO and others, 1977; RAMPNOUX and others, 1977; DELFAUD and THOMAS, 1977; MERCIER, 1977).

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