ANNALI DI GEOFISICA, VOL. XXXVI, N. 1, April 1993

Role of the structural geology analysis in the recent tectonics studies: an example from an area located SW of the Gran Sasso (Central Italy)

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Abstract
The study of the evidence of recent tectonic activity proceeds through stratigraphical, morphological and structural observations. Direct investigations about recent deformations, being often the result of localized observations, provide a small amount of data, which are distributed on the study area in a discontinuous way. The present study emphasizes the role played by the structural geology analysis in the recent tectonics studies. In fact, the structural analysis, mainly performed on the carbonatic bedrock, allows us to recognize a certain deformational sequence observing a superposition of different kinematic indicators on the same fault planes. This analysis supports with a great amount of data the evidence of recent tectonic activity collected in the study area. An application of the structural analysis whithin a study of recent tectonics has been performed in an area of the Abruzzi Apennines, located on the south-western margin of the Gran Sasso chain. The investigated area is characterized by the presence of a series of small closed depressions, with an average NW-SE trend, separated by parallel ridges which are mostly carved in the carbonatic Meso-Cenozoic sequence. The morphological features of the area seem to be conditioned by tectonics: most of the depression slopes are bordered by fault scarps within the carbonatic series and, on a smaller scale, the whole of the depression systems seems to be deformed, showing sigmoidal trends. The mesostructural analysis of the carbonatic sequence shows a polyphased deformation pointed out by the contemporary presence of dip-slip, oblique-slip and strike-slip kinematic indicators on the fault planes. Wherever it has been possible to recognize a sequence, the superimposition of the kinematic indicators has pointed out that the strike-slip movements are the most recent ones following the dip-slip normal movement indicators. A strike-slip deformational event has been identified as the last movement recorded in the carbonatic series on the basis of the structural geology analysis. Moreover a series of observations on the deformed Pleistocene deposits allows us to confirm that the more recent tectonic activity of the area acted prevalently through horizontal movements. The same data and observations show that these horizontal movements succeded deformational events essentially of the normal dip-slip type. The deformational sequence study and morphological evolution lead to refer the change of the deformational regime probably to the boundary between Lower and Middle Pleistocene.

1. Introduction

The seismotectonic characterization of an area needs the integration of data which results from different types of studies and the definition of a neotectonic model is one of the basic steps. The study of the chronostratigraphic sequence is necessary to scan in time deformational events occurred during the Pliocene and the Quaternary.

In the Central Apennines the stratigraphy data collection is greatly hindered by the nature of Plio-Quaternary sediments. Indeed, these are continental deposits with outcrops of small extension (mainly small outcrops of slope debris on the ridges and fluvio-lacustrine deposits in correspondence of depressed areas), which alone make it difficult to reconstruct the paleogeography of the sedimentation environment. Moreover, these deposits do not generally display useful elements for their classification in terms of

chronostratigraphy (both absolute and relative geochronology). A possible method of research to get through these difficulties is to compare statigraphic successions relating to different hydrographic and paleohydrographic basins on the basis of the assumption of the comparability of the geological evolution of different basins in a rather restricted area such as the Abruzzi Apennines. This allows us to correlate continental sedimentary cycles by means of morphological and lithostratigraphical studies. A sedimentary cycle here is considered as an «inseparable combination of stratigraphical, morphological and pedological events» (Bosi, 1989).

In the following, a research carried out in an area SW of the Gran Sasso chain to outline the recent deformational evolution is described. This shows that the methods of analysis of structural geology can usefully support data relating to recent deformations.

In the study area, between the villages of Barisciano and Calascio (L'Aquila province), the results derived from different types of analyses have been compared. These studies include: the macrostructures from Landsat image (Galadini and Salvi, 1990) and aerial photographs; the mesostructural analysis, the study of the deformations linked to recent tectonic activity on Pliocene slope debris as well as morphological and stratigraphic considerations on the Plio-Pleistocene sedimentary cycles (C.N.R.-E.N.E.A., 1989).

2. Deformational sequence of Barisciano and Calascio area

The study of the Plio-Quaternary tectonic deformations has been carried out through the analysis of morphological, sedimentary and structural elements which have proved to be relevant to recent tectonics. Among the identified structures, a distinction has to be made between those which have a tectonic or a gravitative origin (the latter may be due to deep-reaching slope deformations; Dramis, 1984). The distinction between tectonic and gravitative origin may prove to be difficult because of the convergence of structural «forms» to the outcrop scale. The need therefore arises to integrate the studies on the outcrop with the geomorphological surveys of the area in order to define a single origin for the identified structures (see Galadini *et al.*, 1990).

The morphological, structural and stratigraphic surveys provide a useful set of data to estimate the Plio-Quaternary activity and contribute to the reconstruction of the kinematic model. These types of investigations, however, often require sampling data which are unevenly scattered over the area and are the result of accurate and detailed surveys. Such «direct» investigations on recent deformations should be linked together by other kinds of studies. In this respect, the present paper suggests the application of the methods of structural geology (Salvini and Vittori, 1982) to the Meso-Cenozoic sequences, to identify the last registered event within a succession of deformational events. Thus, the last deformation identified is then compared to the evidence of Plio-Quaternary tectonic activity.

The area between Barisciano and Calascio villages (L'Aquila province) is characterized by a series of small closed depressions, elongated NW-SE and bordered by mainly normal and oblique faults (fig. 1). The Mesozoic carbonatic sequence cropping out in the area belongs to a general marginal facies of the carbonatic platform (Chiocchini *et al.*, 1980). Pleistocene and Holocene deposits crop out extensively in the study area. There are two different generations of calcareous breccias, detrital sequences on the depression slopes and tuffites that mainly fill the depression bottoms. The two generations of breccias are referred respectively to the Lower Pleistocene and the boundary between the Lower and Middle Pleistocene on the basis of the available detailed literature (Bosi and Bertini, 1970; C.N.R.-E.N.E.A., 1989; Bosi and Messina, in press).

The recent deformational activity of the area is evidenced by several deformations observed on Pleistocene continental deposits. In fact the breccias cropping out along the north-eastern slopes of the depressions show a tilted attitude with a dip value of about 80° towards SW in S. Stefano di Sessanio area. Moreover, some fault scarps have been observed on Pleistocene breccias, as for example, the fault scarp of Piano Viano (N40°-60°W, 60°NE) and the ones of the area West of S. Stefano (N60°W, 80°NNE). Also

Fig. 1 Sketch of the main faults and of the main breccia outcrops in the study area. Legend: 1) carbonatic breccias, generally with pink matrix, clearly displaying bedding (Lower-Middle Pleistocene); 2) breccias containing also calcareous boulders with an often chaotic texture (Lower Pleistocene); 3) normal and oblique faults; 4) presumed faults. Schmidt diagrams (lower hemisphere projection) relative to fault planes and kinematic indicators sampled in stations: 1, 7, 11, 12, 13, 14 and 15. On the diagram of station 7 the mean fault planes as great circles and the all of the kinematic indicators (striae on the fault planes) sampled have been reported.

a strike-slip fault trending N-S, cutting the breccias of Valle Valiano (referred to Lower Pleistocene by C.N.R.-E.N.E.A., 1989) has been observed in the north-western sector of the area. Pleistocene breccias cropping out along the northern slope of Carapelle Calvisio depression (located South of Castelvecchio Calvisio) show an intensive fracturing, associated with a NW-SE strike-slip fault, with evident horizontal striae, displacing, for about 15 m, the boundary between the two generations of breccias. South of the Calascio village a probable strike-slip fault, trending N60°W, 55°SW, displaces a red colluvial soil overlying Pleistocene breccias. Other dislocations have been observed in the area, such as dip-slip fault planes observed in the youngest generation of breccias (referred to the boundary between Lower and Middle Pleistocene by C.N.R.-E.N.E.A., 1989) in the south-western slope of Piano Viano and some dislocations in the detrital sequence of the «il Tagno» south-western slope. On the basis of the interpretation of aerial photographs the dip-slip striae of the Piano Viano breccias have been referred to a gravitative event. The dislocations of the «il Tagno» depression have been reported to the same origin. In fact field surveys and aerial photographs interpretations, described in a study (Galadini *et al.*, 1991) have brought about a connection between the observed fractures of the «il Tagno» depression and two recent gravitative movements of the slope.

To understand the sequence of deformational events occurred in the area within the Plio-Quaternary age, the mesostructural analysis on the brittle deformations of the carbonatic series has been performed. The aim of this analysis was the definition of the last deformational event recorded in the carbonatic sequence and, where it was possible, inferring a certain sequence of deformational events. The collected data show distinct structural domains of the fault planes, such as E-W, N-S, NW-SE and NE-SW that are found almost in every station.

The probable sequence of deformations is deduced by the superimposition of different kinematic indicators (fig.2), such as dip-slip, oblique-slip and strike-slip striations, on the same fault planes. It often occurs that strike-slip striations represent the last deformations recorded in the carbonatic sequence.

These data have been completed by a series of morphological observations. On a regional scale, on the basis of the LANDSAT image interpretation (Galadini and Salvi, 1990) a sigmoidal trend of the depression sets has been evidenced, while on a more detailed scale field surveys and aerial photographs interpretations allow us to recognize a series of paleo-morphologies, such as suspended valleys, paleo-drainages and cols. Among the others a small suspended valley, South of Calascio, is cut by an important NW-SE fault. These morphological features play a very important role in the understanding of the deformational sequence of the area.

In fact these features represent a further evidence of the deformational events occurred in the area.

Therefore it was possible to infer a deformational sequence with rather old compressional event/s (testified by few kinematic indicators of reverse NW-SE fault planes) followed by an extensional event, well evidenced in all the mesoscopic fault domains and a strike-slip event which is superimposed on the same fault planes used during the extensional one.

3. Conclusions

On the basis of the whole of the collected data a probable Pleistocene sequence of deformational events can be pointed out for the study area. The structural analysis results show a polyphased deformation recorded over the Mesozoic carbonatic sequence, testified by the contemporary presence of dip-slip, oblique-slip and strike-slip kinematic indicators on the fault planes. The superimposition of these kinematic indicators, wherever it was possible to recognize a sequence, points out that the strike-slip movements are the most recent ones following dip-slip movement indicators. Moreover evidence of strike-slip Pleistocene deformations have been collected in the area. The genesis and deepening of the closed depression systems, bordered by prevalently normal and oblique-slip faults, can be attributed to prevalently vertical deformations. This extensional deformation, on the basis of the existence of some Lower-Pleistocene breccias ridges (*e.g.*, near Barisciano), is considered to be active also after Lower-Pleistocene breccias deposition.

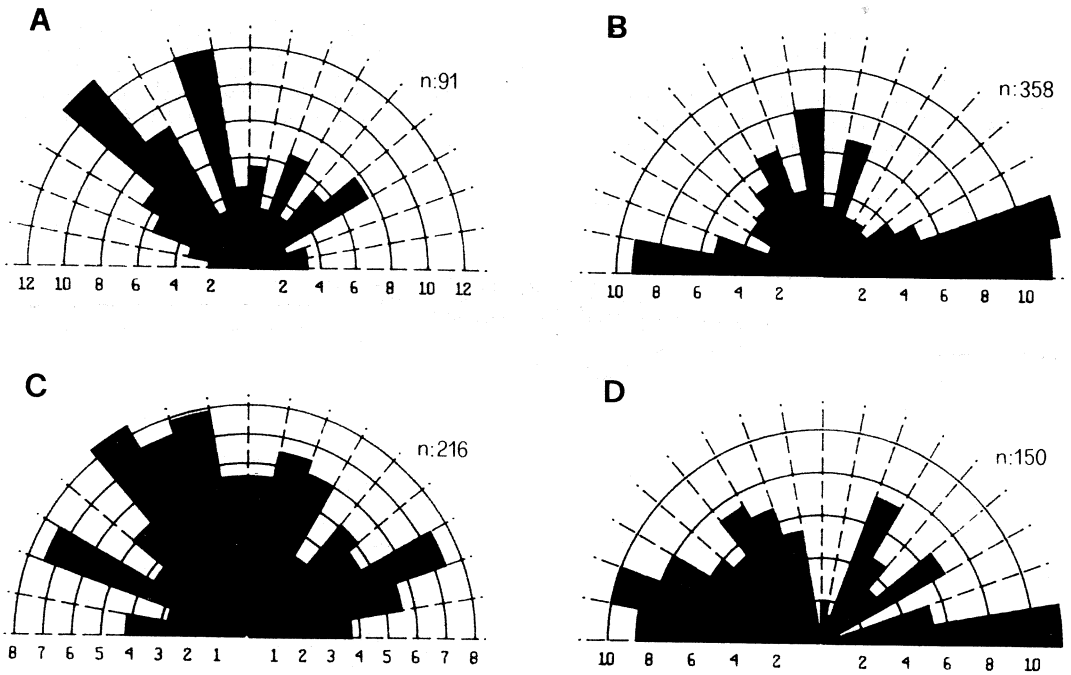

Fig. 2 Rose diagrams of the pitch values of the striae referring to the various direction fields of the faults: A) NS, B) E-W, C) NW-SE and D) NE-SW. The rose petal length corresponds to the frequency value, the class interval is 10 degrees.

On the basis of geomorphological and stratigraphic considerations the change of deformational regime, from an extensional to a trascurrent one, can be approximately referred to the end of the Lower Pleistocene.

In conclusion it has been possible to put deformations, recognized by the structural study, in a time sequence on the basis of the differently meaning kinematic indicators superimposed on the fault surfaces and on the basis of the morphological and stratigraphic observations. The results of the present study show the importance of a possible application of the structural geology analysis as a contribution to the solution of neotectonics problems. In fact the structural analysis supplies a good improvement to the deformation data when the last deformational events are recorded on the bedrock series and when it is possible to have some evidence of recent deformations in the Pleistocene series to confirm structural data.

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