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A late Lower Pliocene planation surface across the Italian Peninsula: a key tool in neotectonic studies

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Abstract

An integrated geological–geomorphological approach is proposed in order to provide more information for the assessment of neotectonic deformation in the Apennines. On this basis, it can be stated that: (1) a major flat planation surface is recognisable across the whole Italian Peninsula; (2) it is better preserved on harder rocks and in the higher parts of the local relief; (3) it cuts strata ranging in age from Palaeozoic to early Lower Pliocene; (4) it smoothed tectonic structures older than early Lower Pliocene; (5) it is buried below continental and marine deposits younger than late Lower Pliocene; (6) it is displaced and deformed by local thrust re-activation and, since the Lower Pleistocene, by high angle normal faults. Displacement analysis of this morphological feature at local scale allowed us to discriminate between pre- and post-planation tectonic deformations, hence providing useful information about the rates of uplift and faulting in the Apennines.

1. Introduction

The Italian Peninsula is made up of a Neogene thrust-fold belt (the Apennines) developed mostly in a non-metamorphic regime. Both the northern and southern Apennines, are characterised by a mountain landscape with large flat parts on top. These are the remnants of a planation surface, resting above different structural units; the nature and age of these flat-lying remnants were differently assessed both by geologists and geomorphologists (Demangeot, 1965; Gueremy, 1972; Bernini et al., 1977; Bartolini, 1980; Sestini, 1981; Desplanques, 1969; Coltorti, 1981; Coltorti and Cremaschi, 1982; Italian National Group for Physical Geography

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and Geomorphology, 1989; Dramis, 1992; Amato et al., 1992; Cinque et al., 1993; Bosi et al., 1996; Coltorti and Pieruccini, 1997a; Chiarini et al., 1997; Bossio et al., 1998).

'Planation surface' is a descriptive term for a geographically plain surface resulting from erosion which includes many terms like peneplain, panplane, pediment, pediplain, wave-cut platform, etchplains etc (Brown, 1969). The term is recommended because it has no genetic implication (Small, 1978), although many researchers emphasise the importance of marine erosion (Johnson, 1930). In the Apennines, the planation surface (PS) levelled all the topographic contrasts, and given its properties (see below), it represent a useful marker for deciphering the Plio-Quaternary evolution of landscape and for allowing to discriminate between pre- and post-planation tectonic activity; hence, the PS represents a key tool to detect neotectonic movements and for assessing seismic hazard also in areas where Plio-Quaternary deposits are not preserved.

Our investigations on the nature, age and lateral relationships of the remnants of planation surfaces in peninsular Italy, indicate that: (1) a major flat planation surface (PS) is recognisable across the whole Peninsula; (2) it is better preserved on hard rocks and on the highest parts of the local relief; (3) it cuts Palaeozoic to early Lower Pliocene rocks and related tectonic structures; (4) it is buried below continental and marine deposits younger than late Lower Pliocene.

The planation process originating the PS occurred in a relatively short time interval, much less than is usually assumed, and after the end of the Lower Pliocene the PS was displaced and deformed by limited thrust re-activation and, since the Lower Pleistocene, by high angle normal faults.

In this paper it is suggested that the PS was modelled at very fast rates and at/or close to sea level, during the climatic amelioration that generated the late Lower Pliocene transgression. This corresponds to a major global climatic change leading to a marine high-stand which lasted about 300–500 Ka, and that is nicely recorded worldwide (Channel et al., 1992; Cronin and Dowsett, 1991; Lagoe and Zellers, 1996; Heusser and Morley, 1996; Barret et al., 1992).

Furthermore, in the Apennines, fluvial and marine terraces occurring at progressive elevations on the valley floors reveal a strong uplift since the Lower–Middle Pleistocene.

In order to assess the age and extent of the erosive processes associated with the latest stages of the long deformation history of the Apennines, the sedimentary records preserved in tectonic basins were also studied or reviewed, both in the mountain and coastal areas.

As a result, for the Apennines, it is now possible to state the following main points: (a) the genesis of the relief in the Italian Peninsula started during the Middle Pliocene and is still going on; (b) the planation surface is not always preserved on the highest mountains because of major uplift and consequent dissection and/or glacial erosion; (c) older escarpments displacing the planation surface correspond to Miocene–Lower Pliocene thrust fronts indicating re-activation during Middle–Upper Pliocene times; (d) younger escarpments are connected to high angle faults that were active since the Lower Pleistocene.

2. The planation surface and neotectonic

The PS levelled most of the pre-existing tectonic structures in the Apennines, either thrust fronts or extensional faults, as well as the pre-existing relief. This surface constitutes a morpho- and chrono-stratigraphic unit that has been used for unravelling the evolution history of the area where no dated sediments are present. However, steps in the landscape frequently prevent the recognition and correlation of a single planation surface over long distance. Major steps correspond to high-angle extensional faults oriented in different directions.

Theoretically, it is assumed that if a fault escarpment is exposed to erosional processes for a long time, it develops a gentle gradient. However, our own observations point out that steep gradients are, instead, a general rule in this area in the Apennines. As a result, comparing geological (A) and geomorphic (B) displacements across fault zones, one can fully evaluate the neotectonic movement picture, since it can be shown that when $A = B$ fault activity is entirely post-planation, whereas when A exceeds B, pre-existing faults must have been planated and later re-activated.

The very flat nature of the PS also allowed us to distinguish between two kinds of post-planation tectonic deformations: (1) large scale folding and (2) faulting. Thrust fronts in the Apennines become inactive before the end of the PS modelling and only few of them show evidence of limited re-activation mostly delimiting up- from down-warped areas (Coltorti and Pieruccini, 1997a, 1997b), whereas the east dipping low-angle normal faults known to occur in the area are all planated (Calamita et al., 1999; Boncio et al., 1998; Decandia et al., 1998). However, one cannot exclude limited re-activations of these faults, as suggested by Boncio et al. (1998), Barchi et al. (1998) and Calamita et al. (1999). Examples of west dipping pre-planation normal faults are the Battiferro–Sabina (Latium–Umbria), M. Camicia–M. Prena (Abruzzi) and the Montagna dei Fiori (Marche–Abruzzi) faults, (Calamita et al., 1994; Calamita et al., 1998; Calamita et al., 1999; Pizzi and Scisciani, this volume). Other faults, i.e the Assergi and M. Vettore faults, were re-activated after the Lower Pleistocene and it was also possible to record the amount of displacement due to structural inversion (Calamita et al., 1994; Calamita et al., 1999). High angle normal faults bounding intramontane basins in the Apennines, are, instead, mostly Lower Pleistocene in age, since only sediments of this age are offset by fault escarpments (Follieri et al., 1991; Ascione et al., 1992; Barberi et al., 1994; Ambrosetti et al., 1995; Coltorti and Pieruccini, 1997b; Coltorti et al., 1998). These structures record slip rates of about 1 mm/year and their activity appears to be locally concentrated in particular periods of tectonic crisis. In fact, in many sectors of the northern Apennines (for example), late Middle and Upper Pleistocene sediments record very little evidence of faulting. Moreover, the activity of high angle faults occurred in the context of a general uplift which affected both hanging wall and footwalls areas, as indicated by the presence of Pleistocene hanging terraces on both blocks.

As concerns the sort of data that may be relevant for seismic hazard studies (namely strain rate data), we worked out a detailed database for different sectors of the Apeninnes. Our results are based on the assumption that a single planation surface is present across the whole Peninsula. Consequently, knowing, for example, that the maximum uplift of the chain is 3000 m in the Gran Sasso area and that it occurred in about 3.5 Ma, it can be assessed that the uplift rate was 0.85 mm/year. More generally, however, mean values of 0.42 mm/year were obtained for most of the mountain belt, whereas in some basins (i.e. East Tiber), where the PS is today located at 80 m b.s.l., there is a negative value of −0.02 mm/year. This reveals that recent uplift rates in the Apeninnes, are not sufficient to compensate the downwarping associated with the Middle–Upper Pliocene deformation, and that, due to occurrence of hanging fluvial terraces, one may suggest that the area has experienced continuous uplift since, at least, Lower Pleistocene times.

3. Conclusions

A single flat planation surface (PS) was cut across the Italian Peninsula during the late Lower Pliocene marine transgression whose evidence has been reported all over the world. The planation of the Italian Peninsula occurred in a very short time interval (at most 300–500 ka, which is the duration of the late Lower Pliocene warm period) and close to sea level, as revealed by coastal marine deposits under- and overlying this major morphological feature.

The study of this regional feature and of the erosional processes associated to this event, which planated the former tectonic structures and the pre-existing relief, provide a fixed datum for the evaluation of the subsequent tectonic evolution of the Apennines.

Tectonic deformations affected the PS after the late Lower Pliocene, and hanging fluvial and marine terraces reveal that, since the late Lower Pleistocene, the whole Peninsula was also affected by a generalised uplift. As a consequence, normal faults were activated.

The detailed study of the PS has also helped to acquire useful information about the rates of uplift and faulting, both of which show differences from place to place. The results of our studies indicate that the timing of deformation in the Italian Peninsula is faster than previously supposed. Locally it is also possible to distinguish the amount of activity pre- and post-PS and, coupled with the study of displacements affecting recent sediments, the occurrence of periods of accelerated tectonic activity. In conclusion, the inferred nature of the PS allows us to suggest that the genesis of the relief, in the Apennines, is not simply related to the activity of the major tectonic structures.

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