TECTONICS AND SEDIMENTATION IN THE CENTRAL APENNINES

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Introduction

The aim of the TESS Tectonics and Sedimentation project was to describe and understand the interactions between tectonic activity and sedimentation in a foreland basin context. The Central Apennines site was chosen to test our modelling methodology in a region where foreland basin turbidites are an exploration target. Our studied zone is situated in the East of the Umbria-Marche Apennines, where Messinian to Pliocene synflexural and synkinematic series crop out. Given the eastward migration of the foredeep depocentres with time, the Upper Pliocene foreland is situated beneath the Adriatic Sea, and the older Messinian to Middle Pliocene foreland basin sediments are involved in the most external thrust faults.

Our modelling approach included the construction of balanced cross sections, acquisition of stratigraphic sections in the syntectonic series, and coupled modelling of the evolution of the compressive structures and of the facies and architecture of the synkinematic sediments.

Balanced cross sections

The construction of balanced cross sections tested three hypotheses for the structural style of the area:

First a "thin-skinned" model as proposed by Bally et al. (1986) and Calamita & Deiana (1988). The principal décollement was fixed in the Norian-Rhetian Burano Formation anhydrites. A second, shallower detachment level was modelled in the Messinian Gessosso Solfifera Formation evaporites, active in the most external structure of the modelled area. Although line lengths and areas balance for this section above the proposed basal décollement, the model failed to reproduce the topographic height behind the Montagna dei Fiori structure, implying that basement involvement is necessary. This model predicted 70 km of shortening for a section currently 50 km long, which seems overestimated given that the upper limit on shortening provided by measuring the coastline separation of the Corso-Sardinian plate from mainland Italy is only 200 km. Most importantly, balancing the model required a triangle zone at the base of the Upper Messinian, with a cumulated 'throw' of 50 km.

The second model tested a "ramp-and-flat" structural style, involving two additional detachment levels at 6 and 20 km below the Burano anhydrite Formation. This model fit the flat reflections seen on seismic west of the Montagna dei Fiori, and reproduced the topographic height behind this structure, fitted well with bedding dip measurements made in the field, but still involved 20 km of displacement on a triangle zone.

The third model tested a structural style with shallow thrusts involving the basement, as proposed by Lavecchia et al. (1986), Barchi (1991) and Artoni & Casero (1997). By minimising the shortening in the pre-kinematic series in this way, the triangle zone was no longer necessary to balance the cross section. This final style provided the most satisfying fit to the field and seismic data, and was applied to three other cross sections in the studied zone.

Stratigraphic analysis

Several stratigraphic sections were acquired in the field in the Lower Messinian turbidites of the pre-anhydritic Laga Formation. Type sections in the overlying Upper Messinian to Pliocene series provided an idea of the paleogeography of the foothills and foredeep area through time.

Correlation of the stratigraphic sections of the pre-anhydritic Laga formation across the Laga mountains area from North to South and from East to West revealed six sequences around 250 m thick in these turbidites, onlapping the preflexural deposits eastwards and southwards. The five lower sequences display an overall fining-up trend in typical distal fan turbidite lobe deposits (Mutti *et al.*, 1978), but the sixth one shows a grain size break and frequent bypass facies, indicating that much of the detrital input was transiting the basin to be deposited elsewhere. Paleocurrent data show that the source of the detrital material is North of the studied zone.

Upper Messinian post-anhydritic deposits of the Colombacci Formation cropping out to the East of the Montagna dei Fiori structure are much more proximal in nature, and also display a fining-up trend over a total thickness of 2400 m. Paleocurrents are still directed southwards.

From Lower Pliocene times, thrusts were active in the studied area, as indicated by facies differences across major thrust faults. Behind the Roccafinadamo thrust, in a piggyback basin setting, we observed channelized turbidites with paleocurrent directions consistent with the hypothesis of a confined basin, whereas the turbidites of equivalent age in front of this thrust are typical of outer fan and fan fringe lobes (Casnedi, 1983, Dattilo *et al.*, 1999).

In outcrop, Middle Pliocene deposits lie unconformably above the Lower Pliocene, and a basal conglomerate is attributed to fan delta deposits derived from a proximal source: we deduce the emergence of active structures at that time. Backstepping fan deltas are observed on seismic data in proximity to major thrust faults, while turbidite lobes and channels are still deposited in the intra-fault basins.

In the Upper Pliocene and Quaternary, we observe abandon of the turbidite fans on seismic, with prograding foreshore and shoreface deposits in the proximal setting and 'ponded' turbidites in more distal settings (Ori et al. 1991)

Coupled Structural-Stratigraphic Modelling

Structural forward modelling of unfolded balanced cross sections was coupled with stratigraphic modelling in order better constrain the chronology of structural events in the Central Apennines.

With the eastward advance of the foredeep depocentre through time, the series deposited in a flexural foreland setting were progressively involved in thrusting, uplifted and eroded.

The results of these models allowed us to iteratively correct and refine the structural interpretation of the seismic data, define the sedimentary mass balance of the studied region and establish the chronology of the major faults by fitting the simulated facies, thickness and lithology of the synkinematic sediments to our observations in the field and on seismic.

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