Oral presentation

Growth pattern and tectonic evolution of a regional low angle normal fault from sequential restoration techniques

Mirabella F.[1], Aldega L.[2], Barchi M.R.1, Caricchi C.[3], Corrado S.[3], De Donatis M.[4], Grigo D.[5], Lupattelli A.[1], Susini S.[4], Zattin M.[6]

1 Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, P.za Università 06100 Perugia, Italy francesco.mirabella@unipg.it
2 Dipartimento di Scienze della Terra, Sapienza Università di Roma, P.le Aldo Moro 5, 00185 Roma, Italy
3 Dipartimento di Scienze, Sezione Scienze Geologiche, Università degli Studi "Roma Tre", 00146 Roma, Italy
4 Dipartimento di di Scienze della Terra, della Vita e dell'Ambiente, Campus Scientifico Enrico Mattei - Via Cà Le Suore, 2/4 - 61029 Urbino PU, Italy
5 ENI spa – Exploration & Production Division, Via Emilia, San Donato Milanese, 20097, Milano, Italy
6 Dipartimento di Geoscienze, Università degli Studi di Padova, via G. Gradenigo 6, 35131 Padova, Italy

The offset distribution along normal faults strike is typically bell-shaped with minimum values towards faults tips. In general, this is well documented worldwide for scales ranging from the outcrop to the kilometer scale. However, little information exists about the three-dimensional geometry, the offset distribution and the timing of activity of large faults.
We reconstruct the morphology at depth and the offset distribution of the Altotiberina normal fault (ATF), a regional low-angle detachment in the Northern Apennines of Italy. The ATF is about 70 km long, it dips towards ENE at average dips of 20° and is presently active as shown by both GPS data and microseismicity. We constrain the timing of activity of the fault to discuss the exhumation history of the ATF system in the last 3 Ma.

The area is characterized by an exceptional amount of data of surface maps (1:10.000 scale), about 300 km of 2D seismic reflection profiles and boreholes. We make use of this wide data-set to draw a set of five cross-section extrapolated down to 10 km of depth. We then reconstruct a simplified 3D model of the subsurface of the whole area (Fig.1). The fault morphology at depth shows that the fault is a continuous surface characterized by bends both along strike and dip.

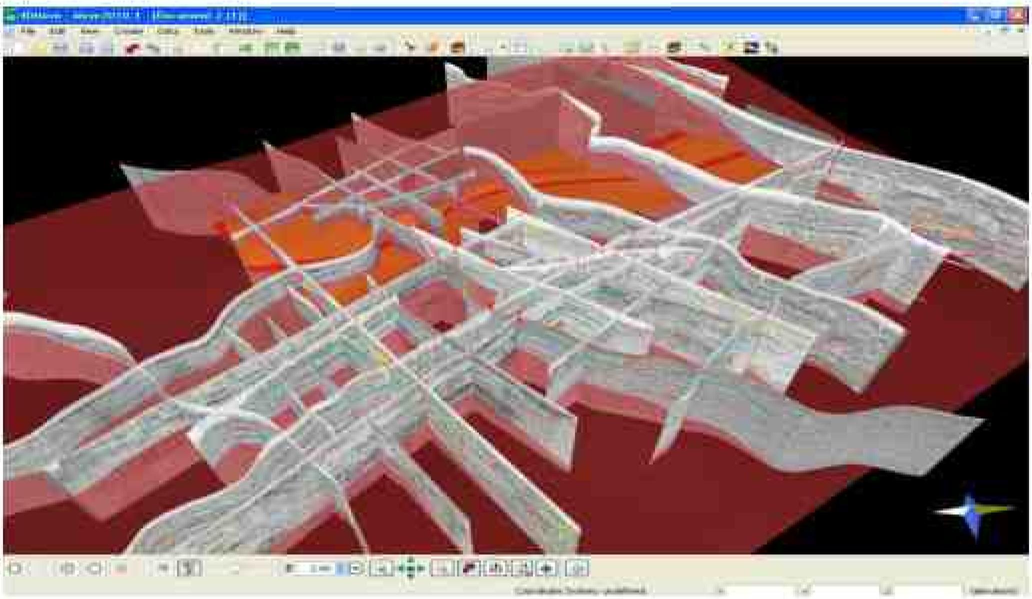

Fig.1 Close-up view of the ATF surface as reconstructed by seismic reflection profiles interpretation using the 4D Move[tm] package.

In cross-section, the fault shows a staircase trajectory with the shallowest part being dome-shaped and flattened to horizontal. We apply sequential restoration techniques to measure the cumulative offset accommodated by the detachment along five cross-sections. Then we test a balance technique applied to the whole 3D model of the area.

We obtain a measure of the maximum extension accommodated by the ATF along its strike. The fault maximum extension is about 10 km and progressively decreases to about 5.8 km to the NW and to about 8 km to the SE. The trend of the offset values together with reconstructed fault isobaths suggest that the fault is growing as a single fault (Fig.2).

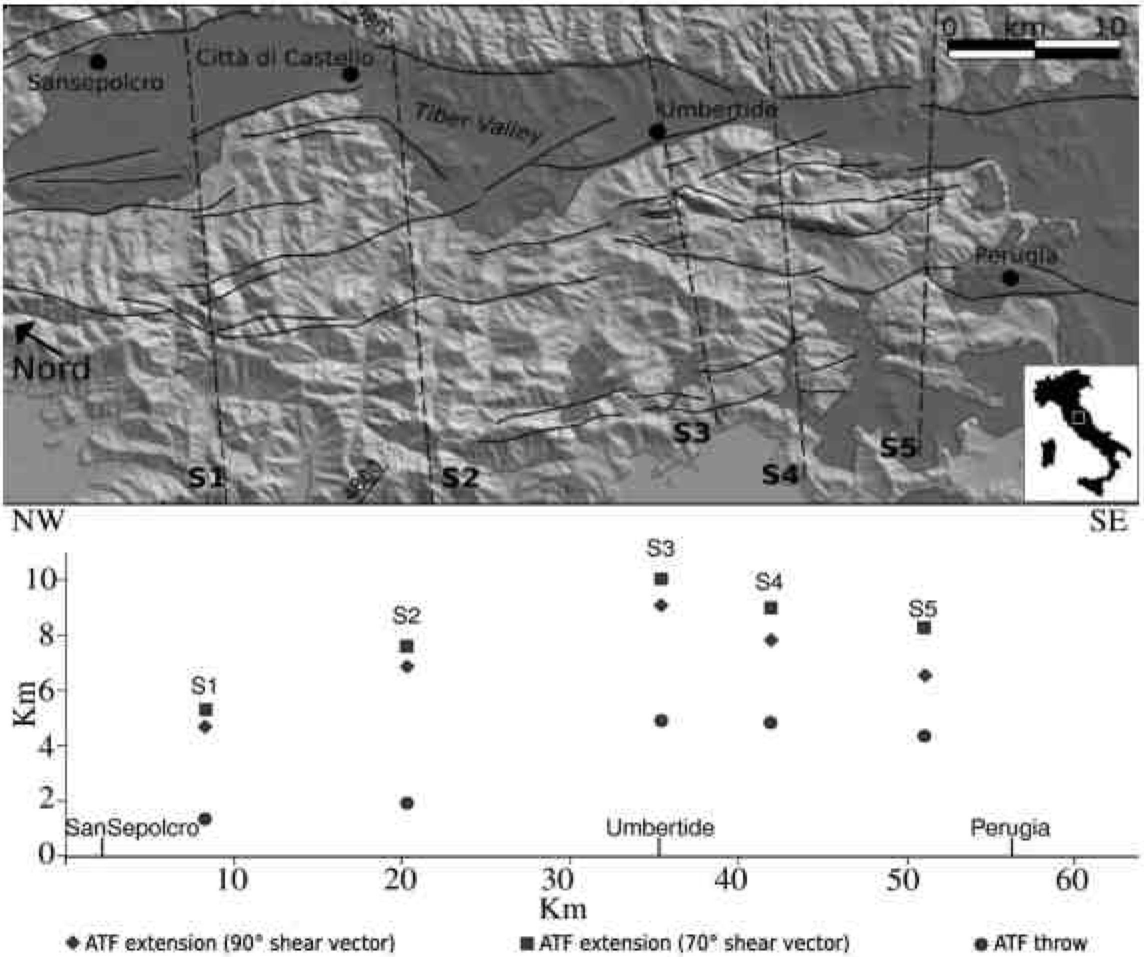

Fig.2 Long- term displacement profile along the ATF measured along sections S1, S2, S3, S4, S5.
The plot shows the values of the vertical and horizontal offset (throw and heave). Heave was measured by using both a 70° and 90° shear vector. The Quaternary deposits outcrop is represented by the dark gray area (after Mirabella et al., 2011 Tectonics.doi:10.1029/2011TC002890.)

We draw the timing of activity of the fault system by combined low-T thermochronological data (U-Th/He and apatite fission tracks) and paleothermal analyses (vitrinite reflectance and illite content in mixed layers illite-smectite) performed at three different structural levels across the extensional system.
Paleothermal data indicate a general increase of levels of thermal maturity from top (Ro%: 0.26-0.4%, I% in I-S: 40-50%) to bottom (Ro%: 1.03-1.22, I% in I-S: 77-85%) of the succession.
Low-T thermochronology indicates a complex pattern of apatite fission tracks data at the ATF foot-wall, whereas U-Th/He dates are generally reset with ages ranging between 3.8 and 2.4 Ma.
Exhumation rates indicate values up to 1 mm/yr at the ATF foot-wall, sharply decreasing at the fault hanging-wall to about 0.6 mm/yr.

By combining the maximum extension values as drawn by the sequential restoration techniques and the exhumation ages from thermochronological data we infer a long-term extension rate in the order of 3.0 mm/yr, in the same order of the present day GPS measurements.
Finally, we discuss our data and interpretations on exhumation ages and rates and suggest that the fault bending at shallow depth is the result of the footwall uplift triggered by footwall unloading.