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Thermal and rheological properties of the NW sector of the Adria microplate between Alps and Apennines (Northern Italy)

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The present structural setting of the NW sector of the Adria microplate, overridden by the advancing fronts of the Alpine and Apennine chains from nearly opposite directions, is the result of polyphase tectonic deformation beginning in the Late Cretaceous. The deformation was accomodated at different times by S-verging (Alpine front) and N-verging (Appennine front) thrust systems, in which fault patterns are strongly affected by inherited Mesozoic extensional N-S oriented faults. We study the thermal and rheological properties of the central part of the present Po Plain (approximately 44.5-45.7 ˚N lat, 9.4-11.2 ˚E long), which records the convergence of the Alpine and Apennine orogenic fronts.

The present thermal regime of the crust is constrained by geological and geophysical results from oil exploration. A set of 38 deep boreholes (*Eni Exploration & Production*) provides lithology and temperature data (bottom hole, drill stem, and production test temperatures) down to 6-7 km of depth. Bottom hole data were processed to estimate undisturbed formation temperatures. The thermal conductivity was estimated from lithology and logging data. The thermal resistance method was applied to verify the appropriateness of purely conductive and steady-state heat transfer conditions. Temperature-depth plots show two clearly distinguishable average geotherms, corresponding to the Western (W) and Eastern (E) areas of the NW Adria microplate sector. The two zones show significantly different crustal structures. The internal consistency of data in each zone and the difference between the two groups of data, which is larger than measurement uncertainties, confirm the validity of spatial zonation as a first-order working hypothesis.

Temperature measurements in the upper $\sim$7 km of the crust are used to constrain 1D thermal models at the crustal scale. Although the Adria microplate in this area is expected to exhibit lateral heterogeneities due to its complex 3D structure, we derive simple averaged 1D geometries for each zone as a first approximation. The crustal sections are simplified into four layers: molasse sediments, carbonatic series, upper crystalline crust, and lower crust. In a first series of models, sensitivity analyses are carried out for the variations of thermophysical parameters and lower boundary conditions for selected 1D crustal sections. In a second series of models, the effect of variable geometries for constant thermophysical parameters and boundary conditions is examined. The best fitting geotherms for the two areas give estimated Moho temperature $\sim$100 ˚C higher in zone W than in zone E (620$\pm$80 ˚C and 520$\pm$70 ˚C, respectively).

Using the estimated crustal structure and composition and the best-fitting geotherms, strength envelopes are constructed, taking into account three deformation mechanisms (frictional sliding, high-pressure failure, and power-law creep). The results, obtained for hydrostatic and supra-hydrostatic pore pressures, show significant differences between zone W and zone E in terms of depth to brittle-ductile transition, lower crust rheology, and total crustal strength. The latter is always $<1.0 \times 10^{13}$ N m^{-1} (the upper mantle contribution is not included). The rheological results are compared with recent tomographic images of the Adria microplate, specifically aimed at resolving the deep structures of the region.