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Geodynamics of the Calabrian Arc and Southern Apennines: insights from numerical modelling

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The main features of the present tectonic setting in the Calabrian Arc and surroundings have developed since the late Pliocene-early Pleistocene, in the framework of a general reorganization of the deformation pattern in the whole central Mediterranean area. The tectonic events most clearly recognized in this evolutionary phase are: 1) end of accretionary activity and beginning of a left lateral strike-slip regime in the southern Apennines 2) end of crustal extension in the central Tyrrhenian, the Magnaghi-Vavilov basin 3) strong fracturation and fast uplift, accompanied by SE ward drift, of the Calabrian Arc 4) acceleration of accretionary activity in the External Calabrian Arc 5) crustal stretching at the inner margin of the Calabrian wedge, with the formation of the southernmost Tyrrhenian, the Marsili basin 6) renewal of accretionary activity in the outer Hellenides, after a period of quiescence started in the late Miocene. It has been argued that the tectonic events listed above can be plausibly and coherently explained as effects of the convergence of the confining plates, without invoking subduction related forces (Mantovani et al., 1997, 2001, 2002; Viti et al., 2004; Mantovani, 2004). In order to provide quantitative support to this interpretation, we have tried to quantify its implications by numerical modelling, with the finite element technique. The study area is simulated by an elastic thin sheet stressed by kinematic boundary conditions. Tectonic belts are simulated by weak zones, in line with the hypothesis that most deformation driven by boundary conditions is accommodated in such zones. Kinematic boundary conditions simulate the NNE ward motion of Africa and the westward motion of the Aegean-Balkan system with respect to a fixed Eurasian reference frame (e.g., Mantovani et al., 2001). The results obtained from modelling show that the conditions adopted allows reproducing the complex and heterogeneous strain field in the study area, deduced by neotectonic and seismological evidence. It is worth noting

that, in spite of the constrictional regime induced by the convergence of the confining plates, extensional tectonics observed in some zones has been satisfactorily reproduced. In the Southern Apennines modelling provides a left-lateral shear, which fairly agrees with the regional strain field evidenced by geological observations. The fact that this regime does not coincide with that deduced from focal mechanism of large earthquakes could be explained by considering that the main shocks have occurred in few zones of Southern Apennines, where tensional tectonics develops in limited zones located along non-linear segments of strike-slip faults or in between rotating blocks. Numerical experiments have also allowed obtaining insights into the role played by boundary conditions and model parameterization. For instance, it is shown that adopting an alternative motion of Africa, the one suggested by the NUVEL-1 model, the resulting strain field can hardly be reconciled with some major features of the observed deformation pattern in the Calabrian Arc and surroundings. Another important information concerns the role played by the boundary zones between the Adriatic plate and the Aegean-Balkan system, as the Epirus thrust zone and the transpressional Cephalonia fault. Different parameterizations of these zones produce very different displacement and strain fields in a large part of the study area, with particular regard to southern Italy. This could imply that the phases of high seismicity which periodically occur along the above plate boundaries, being associated with phases of mechanical decoupling between the confining structures, may induce significant modifications of the stress field in the seismic zones of the Calabrian Arc and Southern Apennines. This hypothesis fairly agrees with the significant interrelation observed between periods of strong seismicity at the opposite sides of the Adriatic plate (Mantovani and Albarello, 1997) and the results obtained by the analysis of post-seismic relaxation in peri-Adriatic zones (Viti et al., 2003).

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