Solid Earth Discussions

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Comment on se-2021-11_SP_GV_GM_FM

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Community comment on "Interactions of plutons and detachments: a comparison of Aegean and Tyrrhenian granitoids" by Laurent Jolivet et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-11-CC1, 2021

Dear authors,

We thank you for your interesting paper. We have mixed feelings on it and in the following we try to elaborate our view as to why the part of your study dealing with the Northern Tyrrhenan Sea and the Northern Apennines should be carefully reconsidered.

We believe the model proposed by Jolivet and coauthors to be fully consistent with the geology of the Aegean for the following reasons:

1) Extensional detachments (NCDS, WCDS, NPEF) do exist in the area and have been described, documented and characterized in great detail. They are invariably defined by a lower ductile shear zone (e.g., Livada detachment) and an upper brittle fault system (e.g., Mykonos detachment)

2) Footwall units are composed of middle crustal rocks and sequences (4-5 Kbar) exhibiting, on a regional scale, widespread evidence of HT/LP migmatization. These units were exhumed to higher structural levels during extensional shearing along regional detachments.

3) Hanging wall units are composed of upper crustal rocks and sequences and/or sedimentary successions that were deposited within extensional basins formed during the extensional phases accommodated by the detachments.

4) Sequences from the footwall and hanging wall units are starkly different from each other as they represent and are derived from crustal domains that were initially very far apart from each other, both horizontally and vertically.

5) There occurs regional-scale magmatism that is clearly synkinematic to the extensional detachments. Intrusions that can be ascribed to this magmatism are affected by the extensional detachments and exhibit common and widespread evidence of deformation ranging from magmatic to low-temperature solid state. Structures thereof are distributed over deformed sequences that can be up to several hundreds of meters thick. The granite in Mykonos is a classic example: in the Livada detachment footwall there occurs a continuous shear zone several hundreds of m thick that deforms the granite into impressive mylonites to ultramylonites.

6) The Miocene age of (i) HT/LP metamorphism, (ii) magmatism (which, again, is fully synkinematic with respect to the extensional detachments) and (iii) of the supra-detachments sedimentary basins indicates a coeval and regional-scale evolution for the entire area.

The structural, metamorphic, magmatic and sedimentary features of the Aegean geodynamic domain mentioned above are fully consistent with the first-order features of extensional domains elsewhere within other orogenic belts, such as the metamorphic core complexes of the North American Cordillera, the South Tibetan Detachment, the Montagne Noire, Pilat and Velay domes in the French Variscan belt.

Therefore, we find the part of the paper dealing directly with the Aegean to be interesting and to add valuable constraints on the investigated processes that are typical of extensional back-arc settings.

However, for the reasons we discuss below and that have been documented in depth in the literature for the last twenty years, we find the submitted study neither relevant nor consistent with the geological framework of the Northern Apennines and the evolution of the northern Tyrrhenian Sea.

1) "**No significant crustal exhumation**" in the area. The Zuccale Fault (Eastern Elba) is still considered as the main extensional detachment that would have controlled and steered the opening of the Northern Tyrrhenian Sea as a back-arc bain in the upper-middle Miocene. The Zuccale fault, although indeed subhorizontal, does not juxtapose different crustal domains. The same pile of tectonic units, with exactly the same structural and geometric relationships, occurs both in the footwall and in the hanging wall. This indicates that the footwall is not a deep crustal block that underwent significant exhumation in comparison to the hanging wall. The current geological set up is instead consistent with an almost complete lack of exhumation during faulting along the Zuccale fault. Moreover, existing PT data constrains show that the exhumation to high structural levels (< 2kbar) of the metamorphic units in the area affected by Zuccale Fault had ceased before faulting along the Zuccale Fault.

2) **No syn-extensional sedimentary basin**. No sedimentary sequences are documented from the Northern Tyrrhenian and in the Tuscan Archipelago as infill of supra-detachment basins. The only known Neogene deposits therefrom are upper Pliocene deposits from the Island of Pianosa. They are resting subhorizontally upon an angular unconformity over lower Miocen deposits. Also, Pianosa is known as a "positive structure" that underwent uplift in the lower Pliocene.

3) **"Pliocene age of deformation"**. Faulting along the Zuccale Fault is constrained to the late Miocene - early Pliocene (< 5.9 Ma).

4) **"No synkinematic magmatism"**. Intrusions in the area such as (i) the Monte Capanne pluton, (ii) the Giglio pluton and (iii) the Montecristo pluton do not exhibit any evidence of syn-extensional deformation. The greatest volume of intrusive bodies is defined by an isotropic fabric or an only weakly developed magmatic foliation, which is oriented differently in all plutons. Only in the eastern part of Monte Capanne intrusion there are local and discontinuous decimetric to metric monzogranitic volumes containing a west dipping magmatic foliation, the attitude of which, however, is not consistent with eastward extension. Despite the common exposure of intrusions in the area, no evidence of extensional ductile and brittle shear zones can be recognized. Likewise, in the host rocks no regional extensional faults occur and HT-LP contact metamorphism-related recrystallization largely overprinted previous foliations and folds. The only evidence of syn-magmatic deformation are rare small-scale deformation structures such as asymmetric folds with centrifugal orientations around the intrusions that occur in the host rock right at

the contact with the magmatic rocks.

In summary, these first-order structural, metamorphic, magmatic and sedimentary features indicate that Northern Tyrrhenian-Northern Apennines geodynamic system it is not consistent with a mature and long-lived back-arc basin tectonic environment. We thus believe that it is misleading and not founded on solid evidence to compare the Northern Tyrrhenian-Northern Apennines area of the central Mediterranean with the Aegean back-area area.

In conclusion, we believe that a comparison with the results of the submitted modeling cannot be accepted for the Italian case study and, as a matter of fact, seems to be irrelevant for the geodynamic boundary conditions listed above. The Aegean sector, on the other hand, represents one of the typical examples of a back-arc basin with crustal extension and the submitted study is very interesting and relevant for that Greek scenario.

Lastly, we wish to point out that much of the geological literature from the last twenty years dealing with the geology (structural, magmatism, metamorphism) of Elba Island and, more in general, of the northern Tyrrhenian Sea, is neither reported nor discussed by the authors. If it were, the natural boundary conditions would clearly contradict those of the submitted paper, indeed making the Italian case study inadequate.

Interpretations must be based on robust analytical data and we think that much of the available geological record was ignored or downplayed. The model presented for the Northern Tyrrhenian and Elba island corresponds to the mainstream interpretation of the mid-nineties, which we believe is in great need of significant updating.

We have come a long way since and much analytical data and ideas have been developed.

Detailed comments are available in the attached pdf.

Sincerely,
Samuele Papeschi, Giovanni Musumeci, Francesco Mazzarini, & Giulio Viola

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2021-11/se-2021-11-CC1-supplement.pdf