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Late, brittle faulting in the Cyclades: a combination of strike slip and high angle normal faulting since the Mid-Miocene

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Introduction

Back-arc extension in the Greek Cyclades has been widely studied and its extensional style seems to have evolved through time. The earliest stages started with high-pressure, low-temperature rock exhumation, and metamorphic core complex exhumation in the Late Oligocene – Early Miocene (Jolivet et al., 2013, Brun et al., 2016). It has since progressed to low angle normal faulting, and through to high angle normal faulting estimated since the Late Miocene (Jolivet et al, 2013, Philippon et al., 2012). Recent studies suggest that the latest brittle stage is more complex, as strike slip faulting may have been active in the Cyclades since the Mid-Late Miocene (Kokkalas and Aydin, 2013). This study aims to constrain the relationship between strike slip and normal faulting in the Cyclades.

Methods

We combine offshore data in the Cyclades with field data from the island of Syros to better understand the tectonic pattern and how it has evolved since the Miocene. Our data from Syros consists of structural measurements of high angle faults. These are used in combination with other published data, such as lithological and geochronological data (compilation in Philippon et al., 2012), to understand fault kinematics.

Results

In Syros, we find two dominant directions of high angle (apparently normal) faults at the scale of the island: NNW-SSE (with some oblique component) and NW-SE (mostly pure normal component).

Offshore in the Cyclades, we interpret legacy shallow seismic reflection data provided by the Hellenic Centre for Marine Research. We use this in combination with bathymetry to constrain the present day tectonics in the Cyclades. Similar to Syros, we find two directions of normal faults: NNW-SSE and NW-SE (Fig. 1). However, syn-kinematic sediments within the faulted grabens show broad folding and local inversion. We suggest that this indicates oblique slip along these high angle normal faults. From the offshore data, we also interpret two strike slip faults trending NE-SW, and locally trending NNE-SSW. The northern strike slip is a negative flower structure creating a major strike slip trough across the northern Cyclades. The southern strike slip fault is smaller and only locally affects the surrounding geology.

Discussion

We suggest that the two directions of normal faulting are a result of progressive rotation within the strike slip zones. The first set opens in the direction of maximum stretching (NW-SE) due to slab rollback. As the block is bound by dextral strike slip faults, it rotates clockwise, rotating the faults to their current NNW-SSE position, while a new set of NW-SE faults starts to open. Since the rotated faults are no longer aligned with the direction of maximum stretching, they experience oblique slip and hence create local inversion in former graben systems.

This scenario is compatible with palaeomagnetic data that show that north of the Mid-Cycladic lineament, the Cyclades have rotated 22-23 degrees clockwise since the Miocene (Avigad et al., 1998; Morris and Andersen, 1996). The data from Syros also shows activity around the mid-Miocene (Philippon et al., 2012) which can be explained by our tectonic interpretation.

Conclusion

Our results support the idea that strike slip faulting has been active in the Cyclades since the Miocene (Kokkalas and Aydin, 2013), making it much younger than the NAF, which has only been active since the Pliocene (Armijo et al., 1999). We also conclude that coeval with this strike slip faulting, the Cyclades are affected by distributed, high angle faults, which create tilted blocks and sedimentary basins. Our interpretation suggests that these faults are still presently active in the Cyclades and experience dominantly oblique slip, accommodating strike slip components from Anatolian extrusion and normal components from the retreating Hellenic subduction zone.

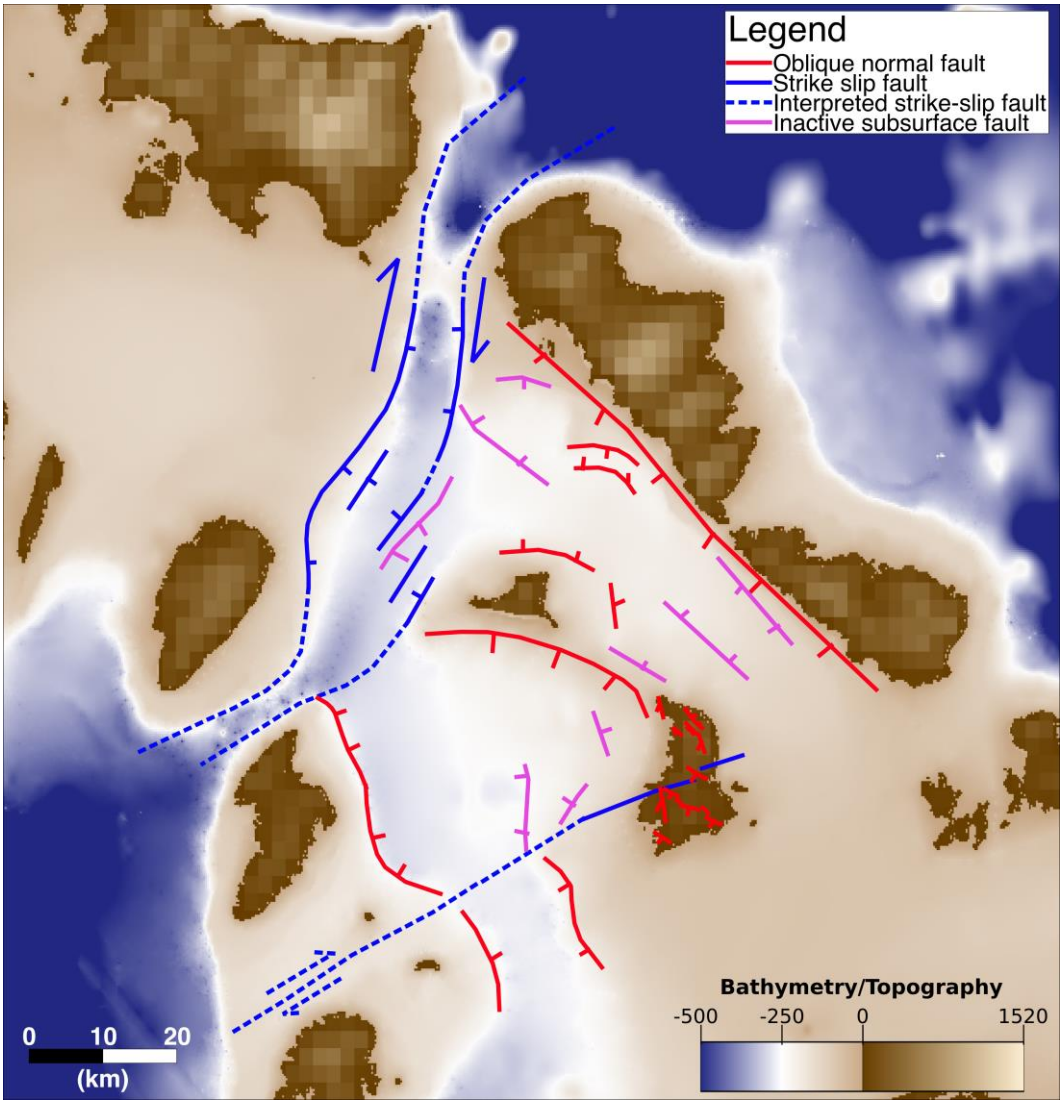

Figure 1-Tectonic map inferred from seismic lines analysis and field work in Syros.

References

Avigad, D., Baer, G. & Heimann, A., 1998. Block rotations and continental extension in the central Aegean Sea: palaeomagnetic and structural evidence from Tinos and Mykonos (Cyclades, Greece). Earth and Planetary Science Letters, 157(1), pp.23–40.

Morris, A. & Anderson, M., 1996. First palaeomagnetic results from the Cycladic Massif, Greece, and their implications for Miocene extension directions and tectonic models in the Aegean. Earth and Planetary Science Letters, 142(3–4), pp.397–408.

Armijo, R., Meyer, B., Hubert, A., & Barka, A. (1999). Westward propagation of the North Anatolian fault inoto the northern Aegean: Timing and kinematics. Geology, 27(3), 267–270.

Brun, J.-P., Faccenna, C., Gueydan, F., Sokoutis, D., Philippon, M., Kydonakis, K., & Gorini, C. (2016). The two-stage Aegean extension, from localized to distributed, a result of slab rollback acceleration. Canadian Journal of Earth Sciences, 53(11). https://doi.org/10.1139/cjes-2015-0203

Jolivet, L., Faccenna, C., Huet, B., Labrousse, L., Le Pourhiet, L., Lacombe, O., Driussi, O. (2013). Aegean tectonics: Strain localisation, slab tearing and trench retreat. Tectonophysics, 597–598. https://doi.org/10.1016/j.tecto.2012.06.011

Kokkalas, S., & Aydin, A. (2013). Is there a link between faulting and magmatism in the south-central Aegean Sea ? Geological Magazine, 150, 193–224. https://doi.org/10.1017/S0016756812000453

Philippon, M., Brun, J. P., & Gueydan, F. (2012). Deciphering subduction from exhumation in the segmented Cycladic Blueschist Unit (Central Aegean, Greece). Tectonophysics, 524–525, 116–134. https://doi.org/10.1016/j.tecto.2011.12.025

Philippon, M., Brun, J.-P., Gueydan, F., & Sokoutis, D. (2014). The interaction between Aegean back-arc extension and Anatolia escape since Middle Miocene. Tectonophysics, 631(C). https://doi.org/10.1016/j.tecto.2014.04.039.