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Deformation history of the Ballik travertine (Denizli, SW Turkey): a matter of normal faulting and fault reactivation

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The Ballık travertine mass is the largest Pleistocene travertine precipitation site in the world. It developed along the basin margin faults of the eastern part of the NW-SE oriented Denizli Graben-Horst System (DGHS), one of the large extensional basins in SW Turkey. Travertine formed from hot basinal carbonate-precipitating fluids that resurfaced along an already existing fault-fracture network affecting the uplifted margin. Analysis of faults affecting a 2 km-long, complex travertine domal structure at the base of this margin revealed that many of the normal faults affecting the travertine are reactivated as sinistral strike-slip faults during the Pleistocene. Remarkably, except for the Ballık area, Quaternary strike-slip faulting has nowhere else been observed in the Denizli Basin and is rather exceptional in extensional basins. With the aim of understanding the consistency of fault reactivation, we present a new tectonic analysis of the NE Denizli margin flank to derive a new reactivation kinematic model.

Fault-slip data and paleostress inversion shows that a WNW-ESE oriented, graben-facing fault network was installed during a long-lived phase of NNE-SSW extension in the Pleistocene. Normal faulting was hereby accompanied by blocktilting, backtilting of the hanging walls, fault infill, secondary cement infill and extensional fracturing. Whereas the travertine in the upper part of the margin is only affected by extension, normal faults in the middle and lower parts of the margin show numerous overprinting strike-slip reactivation kinematics. Inversion of fault-slip data suggests that after the initiation of the normal fault network, reactivation was related to NW-SE extension, i.e. an opening direction oriented more or less perpendicular to the opening of this part of the Denizli Basin. This extension is related to the activity of nearby NE-SW-trending basin-bounding margin faults adjacent to the Ballık travertine. The travertine fault network in the middle and lower parts of the margin were favourable oriented to this transient stress orientation to be reactivated. Subsequent NNE-SSW extension only caused further opening and infill of the reactivated normal faults.

This study concludes that faults developed at the intersection of different extensional graben structures in SW Turkey can be easily reactivated due stress reconfigurations and stress permutations, whereas this is less common in the center of these grabens.