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Gravity Driven Slope-Failures along Late Cenozoic Basin Margins in the Outer Hellenic Arc

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Introduction

Tectonic activity is a factor that affects the stability of fault-controlled escarpments in three ways (Brideau et al., 2005, 2009): (i) weakness zones develop along faults; (ii) it is associated with high relief and steep gradients and (iii) it can transfer can transfer inherited structures into the rocks to sites that are more susceptible to failures, e.g. they cause tilting of the fault-blocks by increasing the dips of the bedding. The relationship between active tectonics and landslide occurrence along marginal normal fault has been well established and described. However, the finding of such phenomena in older sedimentary sequences is more problematic.

The occurrence of compressional structures within the Neogene and Quaternary deposits in the post-orogenic basins on the frontal part of the Hellenic arc has been observed and described in the last 4 decades (e.g. Meulenkamp et al., 1988; Alexopoulos 1990). Notwithstanding, their interpretation and the involvement of alpine rocks in these remains to be clarified. They have been described as structures of local importance, associated with faults that have significant horizontal displacement component (e..g. Fassoulas, 1999; ten Veen and Postma, 1999), or that they form part of syn-sedimentary landslide complexes (Meulenkamp et al., 1988). Recently, an older view, expressed by Mercier (1976) and re-emerged, in the sense that these structures are associated with large-scale compressional events that took place in the Upper Miocene- Pliocene, affecting the post-orogenic basins, in the form of out-of-sequence thrust faults (Tortorici et al., 2010). This paper focuses on a number of cases where compressional structures are observed within syn-tectonic deposits or, where alpine rocks are found to overlie Late Miocene – Pliocene sediment in basins of central Crete and the Northern Peloponnese.

Tectonic setting

The Peloponnese and Crete are the topographically higher frontal parts of the mountain chain that has been formed during the subuction of the African plate beneath the Eurasian one in Greece. Their evolution since the Upper Oligocene includes a series of tectonic episodes, through the formation of large compressional nappes, the exhumation of metamoprhics through extensional detachment faults and the formation of hanging-wall syn-tectonic basins; and ultimately the development of a complex network of high-angle brittle faults that bound the active tectonic basins (e.g. van Hinsbergen et al., 2006).

Description and interpretation of the compressional structures

A series of E-W trending, fault-controlled basins (terrestrial or marine ones) were formed in central Crete in the Upper Miocene. Sedimentation in these basins lasted until the Pliocene. One such example is the Spili basin, where Tortonian conglomerates are steeply tilted against the Spili boundary fault, at the foot of Mt Kedros. These conglomerates are overlain by Mesozoic carbonates of the Tripolis unit and the whole structure is covered by lateral scree and colluvial wedges. Such positioning of the Tripolis carbonates is attributed to landsliding that occurred at the late stages of rifting. The Apostolon-Amari basin (close to the Fourfouras village), located along the south-western flanks of Mt Psiloreitis, the geometry of the Tefelia and Vrysses formations is fault-controlled, and display N-NNE dips which become S-SSW close to the basin margin. The deposition in this basin took place on a highly faulted basement with intense palaeorelief and was controlled by a normal NW-SE fault that caused local dragging folds in the syn-rift sediemnts. Nowadays, along this fault zone, Late Pleistocene lateral scree has covered most of these structures. To the north, in the Rethymno basin and to the south of Perama, there are sediments of the Vrysses Group with slight northern slopes. Locally, small south-dipping reverse faults are also observed: these are related slumping events that occurred on the weakness planes defined by the bedding of the post-alpine deposits.

Two more cases are examined, at Northern Peloponnese, along the southern margin of the Corinth rift. At the southern flanks of Mt Ziria (Kyllini) and north of Lake Stymfalia, a strip of Tripolis carbonates in sandwiched between steeply tilted (>30o) synrift conglomerates. North of Mt Khelmos, east of Kalavrita, fluvial conglomerates are capped by Tripolis and Pindos carbonates, which in turn are covered by thick cohesive multimictic breccia, related to glacier erosion. Such positioning of the Mesozoic carbonates is attributed to landsliding that occurred at the early stages of rifting, during the deposition of the conglomerates. The ensuing flank uplift associated with the Corinth rift evolution cause the southward tilting of the early synrift deposits, while from the geomorphological viewpoint it led to the formation of the closed hydrological basin of Stymfalia.

Conclusions

The tectonic activity on the outer part of the Hellenic Arc since the Middle Miocene has led to the formation of basins bounded by normal faults. The continuing activity on these faults led to the formation of weakness zones, high relief, and the necessary depositional space. Locally –and where conditions were favorable- slides along the then marginal faults transported blocks of alpine rocks downhill, where they were finally emplaced atop the syn-tectonic sediments. The stratigraphic context of these slides (i.e. the age of the syn-tectonic sediments they are associated with), suggests that such activity took place during the late stages of basin evolution. The parallelism of the landslides with the margins of the basins highlights their close relationship, eventually rejecting the scenario for occurrence of a broad compressional event in the Upper Messinian- Lower Pliocene.

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