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Understanding the irregularity of Seismic cycles: A Case study in Turkey- A Marie Curie Excellence Team Project-

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Project Abstract:

Why do large earthquakes not always occur at regular time interval on a given fault? The observed aperiodic seismic behavior may have different causes, including intrinsic properties of faults, seismic or postseismic interactions between faults, or variations in strain accumulation. To get deeper insights in the mechanisms at work, we propose to establish the seismic history over several thousand of years of a main strike-slip fault system in Turkey. The targeted North Anatolian plate-boundary is particularly suitable because of the type of faulting, its rapid deformation rate (up to 24 mm/yr), its relative structural simplicity and its particularly simple seismic behavior characterized by cascading sequences of M>7 earthquakes. Another remarkable feature is the seeming correlation between the seismicity of the North Anatolian Fault and of adjacent strike-slip plate-boundaries (the East Anatolian Fault and the Dead Sea Fault). This transfer in seismic activity needs to be confirmed and would have broad implications regarding continental-scale seismic coupling.

The Marie Curie Excellence Grant “ Seismic Cycles” thus seeks to obtain an extensive chronology of past events along part of the North and the East Anatolian Faults. For that purpose, we plan to use a two complementary techniques involving trenching across the fault and drilling of lake sediments along the fault trace. We have selected 4 main sites along the North Anatolian Fault east of Istanbul and one along the East Anatolian Fault (Hazar lake). In each site we will study in parallel the record of earthquakes contained in paleoseismologic trenches and in lake sediments. Up to now we have taken short 1 m long gravity cores in each target lake in order to determine the earthquake response related the last historical earthquake sequence. We have open one successful paleoseismological trench (see the poster of J. Fraser et al. in the same session). An ancillary goal of the project is study the paleoclimatic record of the lake sediment (see the poster of X. Boës et al. in the session CL4. Assessment of climate events in lake sediments).

New constraints on the Karliova Triple Junction between Arabia, Eurasia and Anatolia

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The right-lateral North Anatolian Fault (NAF), together with the conjugate East Anatolian Fault (EAF), accommodates the westward extrusion of the Anatolian block toward the Aegean Subduction Zone. This process started most probably 12Ma ago during a late phase of collision between Arabia and Eurasia and may be related to slab detachment. The Karliova triple junction between the NAF and the EAF is a pivotal region making the transition between continental shortening to the east and the extrusion regime to the west. Volcanism younger than 7 Ma covers nearly entirely the region and provides an ideal marker to record deformation. We focus this study on the relationship between faulting and volcanism at the Karliova Triple Junction to further constrain the evolution of the Anatolian Extrusion.
Along the NAF, we are able to reconstruct a single volcanic edifice from two offset volcanic structures by a left-lateral displacement of 50 km along the mean direction of the North Anatolian and Varto faults. Both structures have similar 2.5 to 3.5 Ma ages distinct from the surrounding volcanism. In addition the offset volcanism have an undistinguishable geochemistry considering major or trace elements, quite distinctive from the surrounding volcanism. Using the volcanism along the EAF, we can further constrain its age to be younger that 4 Ma and its total offset to be about 20 km as already proposed.
Those new constrains confirm that the Anatolian extrusion indeed developed in two phases. The Anatolian extrusion first occurred between the NAF and a proto EAF. A second extrusion phase then started about 2.5 Ma ago, with the activation of the EAF followed by the eastward jump of the TJ to its present location near Karliova. The following scenario is fully compatible with the overall evolution of the Karliova Triple Junction modeled in a plate-tectonic framework and constrained by fault geometries, total offsets and ages presented here.

Mechanisms of active folding of the landscape (Southern Tianshan, China)

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We explore the kinematic mechanisms of active large-scale folding, based on analysis of a major anticline of the Kuche thrust belt of the southern Tianshan, taking

advantage of a combination of excellent surface exposures, limited erosion and good subsurface imaging.

The Quilitak anticline is a complex fault-bend fold having a subsurface width of 10-20 km that contrasts with its surface expression as a 5-7 km wide mountainous ridge. The abrupt edge of mountainous relief forms a continuous linear front characterized by steep triangular facets that we quantitatively show to be formed by active folding of a pediment across an axial surface along which bedding dips change abruptly. The Quilitak topographic front is a giant ~600 m high cumulative fold scarp. The fold scarp forms where an active axial surface, which is a discontinuity in instantaneous uplift rate, moves with respect to the land surface. The Quilitak triangular facets thus directly reflect active underlying kink-band migration and non-collocated uplift. The topographic relief and morphology of Quilitak anticline reflects incremental fault-bend folding that has accumulated since an acceleration in deformation rate of about an order of magnitude from ~0.6 mm/y to ~4-5 mm/y.

Balanced cross-sections logged across the Quilitak active axial surfaces at the topographic front show that recent sediments record bed-by-bed growth of the fold scarp. Analysis of layer shapes shows that the active hinge zone has a finite width (~115m) across which progressive folding occurs. The dip of bedding strongly depends on erosion/sedimentation processes, but can be successfully approximated using a self-similar curved-hinge kink-band migration model. Fitting this model to horizon shapes yields robust estimates of the horizontal displacement of the axial-surface for each mapped bed with an estimated displacement rate on an *en echelon* fold-scarp segment near Kuche of ~1-2 mm/yr, which is the horizontal component of fault slip at depth.