Geophysical Research Abstracts,
Vol. 11, EGU2009-4176-1, 2009
EGU General Assembly 2009

Deformational heating: strike-slip faults activity at the origin of volcanism

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The occurrence of magmatism in the vicinity of large strike-slip faults, such as the North Anatolian Fault in Turkey or the Altyn-Tagh and Kunlun Faults in Tibet, provides constraints on models of continental deformation. The volcanic edifices are spatially associated with the faults and eruptions often correlate in time with faulting activity suggesting tectono-volcanic interaction. The origin of the volcanic melts, however, remains poorly understood. The petrology and geochemistry of the rocks imply that the magmas come from melting of lithospheric mantle and crust, rather than asthenospheric sources, and that crystal fractionation is not the major petrogenetic process involved. Althougth shear heating models explain crustal partial melting under extreme conditions, they fail to produce mantle melting. Our study casts new light on how tectonic deformation can contribute to melting. Based on the self similar behaviour of fault systems, we show that converting shear energy, which is maximum at barriers such as fault ends or intersections, into heat can lead to melting of the lithosphere. We use the Erzincan pull-apart basin and the Karliova triple junction in Eastern Anatolia as examples of major complexities on the North Anatolian Fault associated with volcanism still unexplained by other theories. Converting into heat the deformation produced by edge dislocations in an infinite elastic medium, each one symbolizing a fault end, we obtain: melting of both the crust and lithospheric mantle for an average rheology and geotherm in Karliova and melting of the lower crust for a strong rheology in Erzincan. The results are consistent with the observed volumes and compositions of the lavas. In addition to constraining the local rheology of continental lithosphere, this model discriminates between kinematic models. It supports the idea that the Karliova triple junction has been active for the last three or four million years. This concept of "deformational heating" may be applied to other large strike-slip fault systems. Combined with a comprehensive study of magma migration processes, it might allow prediction of eruptive volumes and event recurrence time.