Geophysical Research Abstracts,
Vol. 11, EGU2009-3685, 2009
EGU General Assembly 2009

The Atlas Mountains: why there? Why now?

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In Morocco, the High and Middle Atlas of Morocco are intra-continental fold-thrust belts situated in the southern foreland of the Rif orogen. The High Atlas and its eastern continuation in Algeria and Tunisia is an ENE–WSW to E-W trending belt about 2000kms long and 100kms wide. It is a key natural laboratory because it 1) is the southern and westernmost expression of Alpine-Himalayan orogeny, and 2) encompasses Pre-Cambrian to recent evolution of the region. Phases of shortening and exhumation of this orogen remain however ill constrained and the few available quantitative, data do not allow the present-day high topography (over 4000m) to be explained. In order to put constrains on the recent orogenic growth of the Atlas system, we investigated the temperature-time history of rocks combining extensive low-temperature thermochronological analysis (Fission tracks and (U-Th)/He on zircon and apatite) and peak temperature estimation by Raman spectroscopy of carbonaceous material.
The target area is a NE-SW oriented transect between Marrakech and Igherm crossing the different structural segments of the western Atlas away from present-day fault systems. Results are much contrasted from one domain to the other: Pre-Cambrian bedrocks from the Anti-Atlas domain yield old Fission-Track ages on zircon (380-300 Ma), apatite (180-120 Ma) but also U-Th/He (150-110 Ma) still on apatite that are discussed in another contribution. U-Th/He ages on apatite are many from the High-Atlas (#>20) and much younger ranging between 3̃5 and 5 Ma. Maximum peak temperatures have also been calculated from carbon-rich lithologies of Paleozoic ages. Results indicate that these schists underwent maximum temperatures from 550-500°C in the axial zone of the High-Atlas to less than 250-200°C in the southern Sub-Atlas zone and Souss plain. The latter temperature window corresponds to the temperature range of the Partial Annealing/Retention Zone for Fission-Track (270-210°C) and (U-Th)/He (200-180°C) both on zircon mineral, such analyses are thus being acquired to determine when maximum burial was reached in the Atlas system. We performed a detailed vertical profile in the axial zone of the High-Atlas. Age-elevation relationship suggests that exhumation increased towards 1.0 km/my by the Late Miocene (1̃3-12 Ma). Further, continental series of Cretaceous age from the adjacent Sub-Atlas domains indicate total resetting to temperatures greater than 80°C suggesting that a post Cretaceous sedimentary pile of at least 3 kilometres in thickness is missing. The timing of the erosion of this pile is still unknown but it is being constrained by thermal modelling on the substratum of these domains.
Our extensive thermochronological dataset provide for the first time constraints that evidence heterogeneous exhumation history across and along the chain, e.g. the High and Anti-Atlas are constituted in parts of bedrocks with roughly similar ages (absolute) but with very different ages for the ultimate phase of uplift/deformation. All these constraints are put together with structural and geophysical informations to discuss the recent tectono-thermal evolution of the Atlas system in the frame of the Africa-Europe convergence.