Apatite (U-Th)/He Signals of Transient Topography

T. A. EHLERS AND K. A. FARLEY

California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, CA (ehlers@gps.caltech.edu, farley@gps.caltech.edu)

The influence of evolving topography on the exhumation history of mountain ranges has long been supposed but there have been few attempts to quantify the magnitudes of such interactions. We use a coupled atmospheric and surface process numerical model to quantify how the evolution of mountainous topography influences the cooling history of exhumed apatite (U-Th)/He thermochronometer samples.

Methods

The atmospheric model predicts orographic precipitation as a function of atmospheric moisture content, prevailing wind strength, temperature, and topographic slope (Roe et al., 2002). The coupled atmospheric and surface-process model predicts plan-form topographic evolution as a function of tectonic uplift, and processes of hill slope and fluvial erosional (Braun and Sambridge, 1997). Exhumed (U-Th)/He sample ages are calculated using multi-dimensional thermal models and a cooling-rate dependent model of helium diffusion in apatite.

Results

Model results indicate that orography is a first-order control on the topographic and exhumation history of mountain ranges. The model predicts that for a uniformly uplifting crustal block an orographically produced pulse of high erosion rates will propagate across the range in the wind direction and cause the drainage divide to migrate over time. This process of divide migration results in a trend of high to low rock exhumation rates across range in the wind direction. During the period of divide migration exhumed apatite (U-Th)/He sample ages are predicted to be youngest on the windward side of the range and increase towards the drainage divide. The topography eventually reaches steady state when erosion rates equal the exhumation rates across the orogen. Once the topography is in steady state the difference in exhumed apatite (U-Th)/He sample ages on the windward and leeward sides of the range decreases and spatial variations in ages occur only between valleys and ridges where exhumed sample cooling histories differ due to topography.

Conclusions

The coupled atmospheric and surface process model provides a climatic, geomorphic, and structural context for interpreting (U-Th)/He cooling, and cosmogenic exposure ages in areas with evolving topography. This study demonstrates that spatial variations in cooling ages can result solely from geomorphic processes and does not necessitate structurally controlled variable uplift rates.

References

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Complex organics and prebiotic molecules in space

P. EHRENFREUND[1], R. RUITERKAMP[1], O. BOTTA[1], Z. PEETERS[1], B. FOING[2]

[1]Astrobiology Laboratory, Leiden Institute of Chemistry, POBox 9502, 2300 RA Leiden, The Netherlands
[2]ESA, ESTEC-RSSD, 2200 AV Noordwijk, The Netherlands

The connection between interstellar and solar system material is discussed from the perspective of recent laboratory studies testing the spectroscopic properties and photostability of large polycyclic aromatic hydrocarbons and prebiotic molecules. We discuss the life cycle of these molecules in extragalactic environments, the galactic interstellar medium, comets and meteorites.