



Episodic thermal and burial/exhumation histories along passive margins revealed by AFTA demand an explanation

Paul F. Green (1), Ian R. Duddy (1), Peter Japsen (2), Johan Bonow (2), and James Chalmers (2)

(1) Geotrack International, 37 Melville Road, Brunswick West, Victoria 3055, Australia (mail@geotrack.com.au), (2) GEUS, Copenhagen, Denmark

Attempts to explain the uplift of elevated passive continental margins (EPCMs) conventionally focus on explaining only the present-day topography, in terms of permanent uplift related directly to rifting and continental break-up/separation, with significant post-rift erosion limited to the region seaward of the present-day topographic culmination. In contrast, extensive evidence from apatite fission track analysis (AFTA) and other methods shows that at many margins a considerable thickness (>1 km) of additional section has been both deposited and subsequently removed by erosion, often involving multiple episodes, with the uplift of the modern-day topography post-dating rifting and separation by tens of Myr. Affected regions often extend 100 km or more into the continental interior. Well documented examples include West and East Greenland (Late Cretaceous/ Early Cenozoic rifting/separation followed by subsidence/burial then Eocene exhumation and Late Miocene uplift of present-day mountains), Namibia and NE Brazil (Early Cretaceous rifting/separation; Late Cretaceous, Eocene and Miocene exhumation). Such histories cannot be explained by current tectonic theories, in which margins (dominated by basement terrains) conventionally represent areas of progressive emergence and erosion, while offshore sedimentary basins undergo continued subsidence and burial. In fact, many studies show that offshore basins may also undergo major exhumation.

Integration with geological constraints is vital in order to provide accurate thermal histories from AFTA. Thermochronological studies of EPCMs have traditionally been focussed on basement terrains where sedimentary cover is missing, with results invariably presented in terms of histories involving continuous cooling/exhumation. However, studies of margins where sedimentary cover is preserved allows definition of more detailed histories, revealing multiple episodes of burial and subsequent exhumation, as above. The contrary nature of the histories defined from AFTA, coupled with the lack of any accepted mechanism to explain such histories, has led to scepticism in some quarters regarding the reliability of the thermal history information derived from AFTA. But predictions of AFTA data in well-controlled geological conditions show a good match to measured data, confirming the validity of the kinetic models employed. Consistent results from multiple, independently calibrated techniques (e.g. vitrinite reflectance sonic velocity) provides additional confidence in the resulting interpretations. These results cannot therefore be explained away as artefacts of analytical techniques, as some have suggested, and demand an explanation. Rather than simply dismissing evidence which challenges prevailing paradigms, and trying to force observations to fit inappropriate models, we suggest that a wide range of reliable empirical evidence requires a radical re-think of the nature of vertical movements at passive margins.