Reconstructing greenhouse-gas history from the plant fossil record: Examples from the Cretaceous

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Fluctuating levels of greenhouses gasses alter the carbon isotope composition ($\delta^{13}C$) of atmospheric carbon dioxide. Terrestrial land plants sample atmospheric CO_2 during photosynthesis, thus their fossil record offers an isotopic composite of paleo-atmospheric $\delta^{13}C$ value. Here, we infer changing $\delta^{13}C$ values of the paleo-atmosphere using fossil plant tissue during two intervals of the Cretaceous and test quantitative hypotheses about greenhouse gas sources.

$\delta^{13}C$ values of Land Plants and Atmospheric CO_2

For C_3 plants, the $\delta^{13}C$ value of plant tissue is a function of the isotope composition of the CO_2 fixed, less discrimination by diffusion, enzyme preference, and the balance between carbon gain and water loss. A meta-data set including 519 carbon isotope measurements made on 176 living species showed a strong, significant relationship between the $\delta^{13}C$ values of plant tissue and the $\delta^{13}C$ values of the atmosphere under which it was fixed. This analysis provided quantitative confidence estimates for paleo-atmospheric carbon isotope reconstructions (Arens et al., 2000).

Actualistic tests demonstrated the accuracy of the method (Arens et al., 2000) and showed that the $\delta^{13}C$ value of plant tissue was not systematically biased by depositional environment (Arens and Jahren, 2000).

Examples from the Cretaceous

Sites in North and South America reveal a global negative isotope excursion between ~3-8‰ during the Aptian. Mass balance calculations suggest methane hydrate as a likely source of the added carbon (Jahren et al., 2001).

At the Cretaceous-Tertiary (K/T) boundary, we observe a -2‰ excursion at localities where the boundary is diagnosed by Ir and shocked minerals. The excursions magnitude and brief duration (≈ 100,000 yrs.) suggest multiple carbon sources (Arens and Jahren, 2000).

References

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Unraveling an orogenic core: isotopic studies on the western syntaxis of the Himalaya

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Isotopic tectonostratigraphy

The western Himalayan syntaxis (Nanga Parbat massif) is a typical example of an orogenic core region in its frequent intractability to conventional tectonic mapping and correlation with the bulk of the Himalayan orogen to the east. High strain and Neogene metamorphic events in particular prevent easy correlation of tectonic units that is otherwise possible along the length of the Himalayan arc. Whittington et al (1999) showed that gneisses in the core of the syntaxis, generally assigned to the High Himalayan Crystalline Series (HHCS) on the basis of their high grade, possessed a Nd isotopic signature that was in fact characteristic of another, usually low-grade unit, the Lesser Himalaya (LHS). This is probably due to the exposure of deep levels of the LHS by anomalously rapid Neogene exhumation. In detail, Lesser Himalayan rocks have ε_{Nd} values of -16 to -29, as opposed to -6 to -18 for the HHCS.

A context for the syntaxis

This study investigates a highly condensed section on the eastern margin of the syntaxis, where the influence of Neogene metamorphism on a mainly metasedimentary section becomes weaker eastwards. Model ages indicate that rock units with LHS and HHCS isotopic signatures are present, and in addition evidence for pre-Neogene and pre-Himalayan events is preserved. Sr isotopic data on the same section should confirm the presence of these units, and may also distinguish a further major unit: the Tethyan Sedimentary Series at the top of the nappe pile. Modelling of the Sr and Nd evolution of diverse granitoids in the syntaxis is in progress to distinguish their sources, particularly in relation to the host gneisses. These granitoids include a gneiss derived from an Ordovician granite (Foster et al 1999) at the basement/cover boundary within the HHCS section, and Ky-bearing leucogranites with a similar Nd signature to HHCS leucogranites in the central Himalaya.

References

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