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Subduction followed by collision in the Himalaya: a normal process?

P. J. O'BRIEN

Institut für Geowissenschaften, Universität Potsdam, Potsfach 601553, D-14415 Potsdam, Germany.

The various metamorphic rocks distributed along the more than 2500km of the Himalayan belt are an important record of the sequence of geodynamic processes leading to the formation of the world's most spectacular mountain belt. In order to decipher this record it is necessary to understand the spatial differences in peak grade of metamorphism, the variation in the age of thermal and baric peaks, and the contrasts in pressure-temperature history for the different metamorphic rock units. Intensive field studies in recent years, combined with detailed mineralogical, geothermobarometric and isotopic investigations, have provided a wealth of new data which allow us to test and modify the speculative geodynamic models of yesteryear and, more importantly, allow a better quantification of mass and energy transfer at lithospheric scale.

As a first order approximation, the change from oceanic subduction (reflected in early low-T high-P blueschists in the accretionary prism along the southern boundary of the Kohistan arc) via continental subduction (recorded by coesite-eclogites in Indian-margin crust now exposed in Ladakh and NW Pakistan) to continent-continent collision (shown as Barrovian-type assemblages in metapelites resulting from crustal stacking which are overprinted by later lower pressure-higher temperature sillimanite-bearing assemblages as the thickened crust overheats) is a plausible evolution: other Phanerozoic collisional belts show a similar pattern (e.g. the European Variscides). Difficulty comes when trying to reconcile models explaining the dominant Himalayan medium- to high-temperature metamorphism with tectonic juxtaposition of high grade rocks on lower grade sequences (inverted isograds), and more recently recognised high-pressure metamorphism. The most up-to-date models have a shallow-angle subduction (which stacks up rocks of the upper-crust thus providing an internal source of thermal energy via accumulating radioactive heat sources) to cause high temper-

ature migmatisation and granite production in a channel-like zone between a normal fault in the hanging wall and an underlying thrust. However, the timing of low angle subduction does not fit with the presence, and timing of formation and exhumation, of rocks requiring deep subduction of the continental margin of India. To incorporate the ultrahigh-pressure rocks requires an initial steep subduction followed by a switch to low-angle subduction/underthrusting with a probable slab detachment process in between. The low angle continental subduction, driven by continued oceanic subduction elsewhere on the continental margin, has brought continental Indian crust a considerable distance north of the initial margin and the accumulated upper crustal rocks have started to penetrate through an oceanic arc that was accreted to the Asian margin long before the final closure. The interesting feature is that Indian lower crust does not appear back at the surface and, considering the thickness of the crustal stack from geophysical measurements, is likely detached from the upper Indian crust and has been recycled back into the mantle. The end result is an unusual widespread high temperature metamorphism at shallow depth but with local high pressure relics - a feature also know from the Variscan belt. Are these the characteristics of a particular style of continental growth that can be traced to even older orogens?