Extensional Exhumation of High-Grade Metamorphic Rocks in the Zanskar Himalaya

TALK

M. DRANSFIELD*

One process leading to the exhumation of lower crustal, high-grade metamorphic rocks is by extensional unroofing along the footwall of large-scale, low-angle normal fault zones. Such extension is often sited along orogenic belts, where it is associated with compressional tectonics. Detailed mapping and sampling, combined with analysis of macro- and micro-structure, petrology and PT data, is being used to study the evolution of rock fabrics and metamorphic pathways, and the history of compression and extension recorded in the footwall metamorphic rocks of these large-scale normal faults. Field work has been conducted in two orogenic belts; the Scandinavian Caledonides, in western Norway and the Himalaya, in Zanskar, northern India. This presentation will concentrate on the Zanskar area.

High-grade metamorphism in the High Himalayan Crystalline Unit resulted from thrust- and fold-related crustal thickening within the Indian plate following the collision of India and Asia during the Eocene. The existence of a large-scale, laterally extensive, normal fault zone bounding the northern side of the High Himalayan Crystalline Unit is now well established, from Zanskar in the north-western Himalaya to eastern Nepal/Tibet. However, the details of the exhumation of the high-grade metamorphic rocks, in the footwall of the normal fault zone, remain poorly understood. In Zanskar, the normal fault is continuously exposed along strike for over 150km and places sillimanite-grade gneisses of the High Himalayan Crystalline unit against anchimetamorphic Tethyan sediments. Its dip varies between 20 and 45° NE. The Zanskar normal fault zone is one expression of the extension that affects a large proportion of the Crystalline Unit in this area. The fabrics recorded by different grades of metamorphic rocks in the footwall represent an evolution from compressional to extensional tectonics and exhumation through different crustal levels.

Early, compressive nappe, domal and fold structures are preserved mainly in the highest-grade rocks, in the core of the Crystalline Unit - high amphibolite facies gneisses and migmatites. Extension begins in amphibolite facies, shown by the presence of sillimanite growing along NE-directed extensional S-C fabrics. The later foliation, stretching lineations, polyphase folding and boudinage structures, in the gneisses, schists and deformed leucogranites can all be interpreted as extensional fabrics, evolving from pure to simple shear structures as exhumation proceeded. Late, greenschist facies mylonites, mainly associated with the fault zone itself, show many discrete shear zones and abundant, simple-shear-related kinematic indicators, revealing a consistent top to the NE, or normal, sense of displacement. The final stage of exhumation is accompanied by the formation of mesoscopic, brittle, normal faults and pseudotachylite veins. Petrological and thermobarometric data will be used to quantify this exhumational history.

A combined pure and simple shear model is suggested for the area. The simple shear domain of the upper and middle crust has overprinted the pure shear domain of the lower crust as the rocks were exhumed and cooled. The Main Central Thrust and the Zanskar Normal Fault Zone appear to have been active simultaneously. The extension is thought to be a result of gravitational collapse of the Himalayan topographic front, leading to the formation of the Zanskar Normal Fault Zone and contributing to the exhumation of the metamorphic rocks below the fault.

*) Department of Earth Sciences, Oxford University, Parks Road, Oxford OX1 3PR, United Kingdom