Karakoram and NW Himalayan shear zones: Deciphering their micro- and macrotectonics using mineral fish

Soumyajit Mukherjee* and Arvind K Jain

Department of Earth Sciences, Indian Institute of Technology Roorkee, Roorkee 247667, Uttaranchal, INDIA

* *To whom correspondence should be addressed. E-mail: msoumyajit@yahoo.com*

Sheared metamorphic belts of Karakoram and northwest Himalaya such as the Karakoram Metamorphic Belt (KMB), the Tso Morari Crystallines (TMC) and the Himalayan Metamorphic Belt (HMB) reveal top-to-southwest overthrust sense of ductile shearing as the first order structures, which are produced during the main Himalayan D_2 deformation event (Jain et al. 2002). These belts reveal mica fishes and similar fish-shaped single grains and aggregates of amphibole, feldspar, staurolite, recrystallized quartz, calcite, epidote, sillimanite, apatite and garnet, and therefore a non-genetic term 'mineral fish' can be used to describe such generally asymmetric sheared objects. Mineral fish has been classified morphologically into single and composite types, both of which have been subdivided into 13 varieties (In this classification, three basic shapes of the mineral fish are considered: sigmoid, parallelogram and lenticular. These basic fish shapes can further be modified by fish mouth(s) and secondary shearing. The overall shape asymmetry of mineral fishes and its angular relationship to the C-plane is the most reliable primary shear sense indicator. On the other hand, orientation of its cleavage traces with respect to the C-plane, if any, is *not* always indicative of true sense of shearing. Stair stepping of fish tail(s) and deflected tip(s) of any fish variety, and the snake fish itself, are indicative of secondary shear sense. Mineral fish of any mineral species become the most abundant shear structures in combination with the C-planes, and keeping the above restrictions in mind, these become the most important structures in deciphering the sense of ductile shearing. Different minerals may acquire, and multiply into, the same fish shape by entirely different mechanisms. For single mineral fishes, such mechanisms are simple shear, pulling of the grain corners involving sequential change from sigmoidal- to elongated sigmoidal fish with decreasing aspect ratio R and inclination α, fracturing in any direction, boudinaging at the gaining corners, and pressure solution concomitant to shearing at the loosing corners of the evolving mineral fish. Material lost from the loosing corners of the single mineral fish by pressure solution might migrate and deposit at its gaining corners. Thus, while a pair of corners undergoes smoothening, the other observes extension and recrystallization of mineral.

Study of mineral fishes from the XZ thin-sections of the Karakoram- and northwest Himalayan shear zone rocks reveal consistent top-to-SW sense of ductile shearing within the Higher Himalayan Crystallines (HHC), and also shear sense reversal (SSR), which is characterized by relic and rare mineral fishes from the Himalayan shear zones of different tectonic belts: the Zanskar Shear Zone (ZSZ), and from the Tso-Morari Crystallines (TMC). There, the SSR is defined as 180° switch in the sense of shearing and does not include rare antithetic shearing, which is associated and at high angle to the primary shear plane. In the ZSZ and the TMC, the SSR has been observed on micro-scale in the following ways: (i) Type-4 mineral fish (one mineral fish cutting the other and pointing 180° difference in the sense of shear from the other); and (ii) two single mineral fishes, with same or different sub-varieties, pointing opposite shear sense. Such pairs of mineral fishes are either bounded by the same pair of C-planes, or of different pairs, which are sub-parallel to each other. In both the ZSZ and the TMC, the earlier C-planes were reactivated as the shear planes for the retro shear. However, the difference in SSR in these two tectonic scenarios is that while in the ZSZ, top-to-SW sense is the relic shear sense, and top-to-NE as the most dominant one, in the TMC opposite is the case. Observed SSR in the ZSZ and uniform shear sense in the HHC is in accordance with the proposed 'combined ductile shear and channel flow model' for the Higher Himalayan Shear Zone (HHSZ) exhumation by Mukherjee and Jain (2003). On the other hand, rare but clear-cut occurrence of mineral fishes giving top-to-NE shear sense from the TMC is a new observation, and interestingly, such SSR has not yet been reported from the field (e.g., Jain et al., 2003). Relic top-to-NE sense of shear within the TMC might be due to the shear induced crustal burial at about 90km, which resulted in its ultra-high pressure metamorphism.

References

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