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Microstructural, petrological, microchemical and geochronological investigation of the Main Central Thrust zone in the Garhwal Himalaya, NW India

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Abstract: The Main Central Thrust (MCT) is a first-order tectonic discontinuity that divides the Greater Himalayan Sequence, the metamorphic core of the belt, in the hanging-wall, from the Lesser Himalayan Sequence in the footwall. Contrasting criteria have been proposed to define the location of the MCT and to study its evolution [1-3]. As different studies concentrate on different geological features, estimates of the time of motion along the MCT diverge. In some areas the MCT is actually a km-wide shear zone, MCTz, bounded by two narrower "lineaments" in which deformation is more focused. In Garhwal Himalaya (NW India), the structurally lower and upper bounds of the MCTz are called Munsiari and Vaikrita Thrusts. To provide an updated perspective on the deformation style and the timing of the well resolvable deformations recorded within the MCTz rocks we combined microstructural, petrological, microchemical and geochronological investigations.

We selected two garnet-bearing mylonitic micaschists (about 1 m apart) and one garnet-staurolite-bearing quartzite from a 100 m wide outcrop close to the Vaikrita Thrust as mapped by [4]. Microstructural observations show neither a single tectonic foliation, nor a simple mica growth and recrystallization. Instead, these observations reveal the occurrence of three different generations of micas: mica-1 in a relict foliation at high angle relative to the main mylonitic one; mica-2 oriented along the main mylonitic foliation, formed by small flakes of both muscovite and biotite; mica-3, consisting of large muscovite and rare biotite crystals, in coronitic structures around garnet porphyroclasts. Mica-3 lacks undulose extinction; its texture suggests formation during garnet breakdown.

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EPMA on biotite from GW13-28 and GW13-29 shows no significant within-sample chemical variations. Chloritization clearly affects GW13-28. In GW13-29B two distinct compositional clusters occur in biotite-2. Muscovite shows limited chemical variation; Ti, Mg and Fe contents are lower in muscovite-3.

Handpicked biotite and muscovite from all three samples, and also unpicked micas from GW13-29, were dated by $^{40}Ar/^{39}Ar$ step-heating. The age spectra give both inter-sample and intra-sample discrepancies. Biotite step ages range between <9 and >10 Ma, and muscovite ages between <5 and >7 Ma. These are not "cooling ages", as samples from the same outcrop cooled simultaneously. Instead, Ar systematics reflect sample-specific petrogenetic markers. To discriminate Ar released from mica *sensu stricto* from the numerous intergrown impurities we use the Ca/K ratio, which is lowest in stoichiometric micas. To discriminate mica-3 from mica-2 we use the Cl/K ratio [5]. The data require a three-phase mixture. Chlorite is most abundant in GW13-28 (whose bulk K concentration calculated from total ^{39}Ar is 4.6 %) but is a recognizable end-member also in GW13-29 and GW13-29B. Removing the steps pertaining to high-Ca contaminants, the isochron age is 9.45 ± 0.13 Ma (2 sigma).

Muscovite from GW13-28 (with the most chloritized biotite) shows the most disturbed spectrum with some step ages < 5 Ma. GW 13-29B with the best preserved biotite also has the least discordant muscovite spectrum. Common regression of GW13-29 and -29B in a Cl/K-age diagram, justified by their extreme spatial proximity, reveals a negative correlation: a Cl-rich mica, 5.88±0.03 Ma old, and a Cl-poor one, > 7 Ma old (possibly ≈ 9.45 Ma).

Combining all data, we propose the following evolution: growth of mica-2 along the principal foliation at 9.45 Ma; formation of coronitic muscovite at 5.88 Ma; alteration, from minor to pervasive, before, during and after coronite growth; sampling bias by handpicking large grains.

1 - Searle et al (2008) JGeolSoc 165, 523;

2 - Martin (2016) IntJEarthSci, doi10.1007/s00531-016-1419-8;

3 - Mukhopadhyay et al (2017) Lithos 282, 447; 4 - Spencer et al (2016) Tectonics 31, TC1007; 5 - Villa et al (2014) JPetrol 55, 803.