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Kinematics, non-coaxial flow and rheological constraints of the South Tibetan Detachment System in central Himalaya

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A challenge in tectonic studies concerns the attempt to relate deformation features at the microscale and the crystalline lattice scale of rock-forming minerals up to the regional scale. The South Tibetan Detachment System (STDS) in Himalaya is a natural laboratory for such correlations, being a prime example of regional-scale low-angle ductile extensional fault/shear zone systems within collisional settings, with a top-down-to-the-north sense of shear. The STDS shearing involves, with a thickness of c. 1-2 km, the uppermost part of the metamorphic core of the belt, the Greater Himalayan Sequence (GHS), and the basal part of the Tethyan Himalayan Sequence (THS), developing a mylonitic foliation and a nearly constant strike. Recurrent ideas on the STDS architecture and rheological behavior come from the clearly and well exposed 3D outcrops around the Everest area (Eastern Nepal), where it mostly developed in quartz-bearing lithologies with a lower ductile shear zone and an upper brittle fault. Vice versa, the location of the exact shear zone boundaries and structural evolution of the STDS are still under controversial discussions in Central-Western Nepal, where few kinematic indicators occur in the carbonate-bearing lithologies of both GHS and THS.

In this contribution, we examine a suite of over 20 field-oriented marble samples affected by the STDS, comparing the deformation recorded by calcite in two different areas in central Himalaya, where essentially only the ductile shear zone has been clearly identified. Calcite microstructures (e.g., grain size and shape) and crystallographic preferred orientations (textures) of impure marbles from the Lower Dolpo region and pure marbles from the Manaslu area (Western Nepal), coupled with petrographic observations, allowed us to conclude on temperature, paleo stress, strain rates, and kinematic of the flow. Our results support the idea of a complex history of the STDS in regard to different thermal and lithospheric stress regimes during deformation. Decreasing temperatures from an early-stage of shearing (at HT-MT condition) to a late-stage of shearing (LT conditions) are coupled with increasing differential stress recorded at comparable strain rates and decreasing simple shear conditions. We propose a progressive exhumation of the STDS towards shallower structural levels, with a temporal (rather than spatial) lowering of kinematic vorticity (“decelerating strain path”), in which progressively more general shear replaced

high-temperature simple shear flow during cooling, strain hardening, and narrowing of the shear zone. Microstructural and texture analysis of pure and impure marble proved to be a useful approach to characterize the STDS location and architecture, supporting that, when the upper-brittle fault is not well developed, the ductile shearing proceeded at high structural levels.