

Chapter 2

Trapezoid-Shaped Minerals and Brittle Shear Senses

Brittle thrusting in micro-scale produces trapezoid shapes in minerals, most commonly in micas (Figs. 3a-c of Holyoke and Tullis 2006; Mukherjee 2012a, b; Mukherjee and Koyi 2010a, b) (particularly Figs. 2.2, 2.6, 2.7, 2.11). The brittle shear planes that bound them may be characterized by recrystallization (Figs. 2.2, 2.3, 2.7, 2.9). Similar to crustal slices in meso-scales, symmetric stacks of trapezoid-shaped minerals do not reveal any shear sense (Figs. 2.10, 2.11, 2.12). A top-S/SW brittle shear is revealed by the asymmetric trapezoids from some of the Himalayan shear zones (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9). Inclinations of their longest margins and cleavage planes with the shear planes are used to decode the shear sense. The brittle shear sense matches with those given by duplexes from the same terrain (e.g. Mukherjee and Koyi 2010a, b; Mukherjee 2012b). Thus, these microscopic trapezoids exemplifies foreland vergent brittle thrusting. In those shear zones where two opposite directions of brittle thrusting have been reported (e.g. Mukherjee [in press](#)), whether trapezoids of two opposite orientations are encountered in thin-sections is to be cross checked. Deciphering brittle shear sense based on P- and Y-planes, on the other hand, is clear cut (Bhattacharya et al. [submitted](#)).

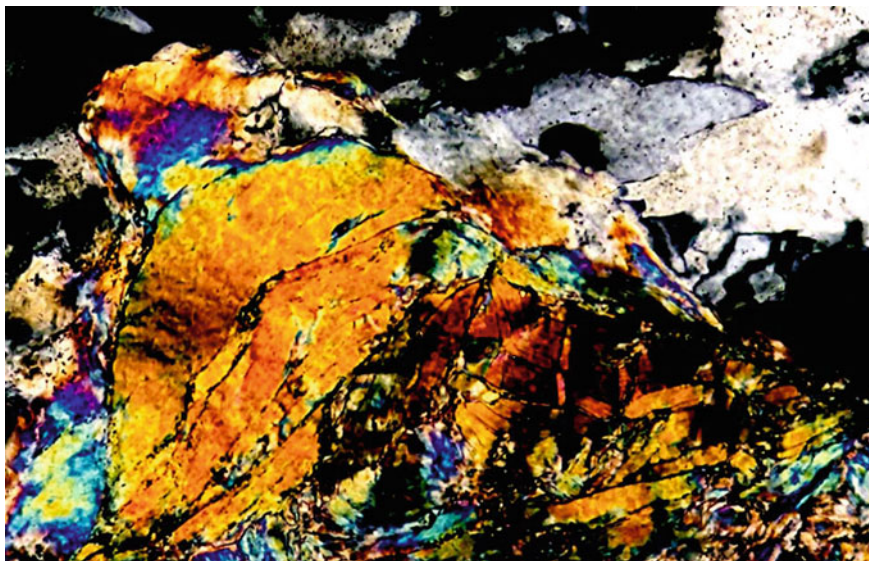


Fig. 2.1 Less competent micas develop *top-to-right* brittle sheared duplex. The 'core' portion shows an 'anticlinal stack' with nearly *straight* limbs and *sharp* hinges. More competent quartzofeldspathic minerals in the matrix did not develop any duplex. Photo in cross-polarized light. Reproduced from Mukherjee (2012a). Cross-polarized light. *Location* Zaskar Shear Zone (India). *Width of view* 2 mm

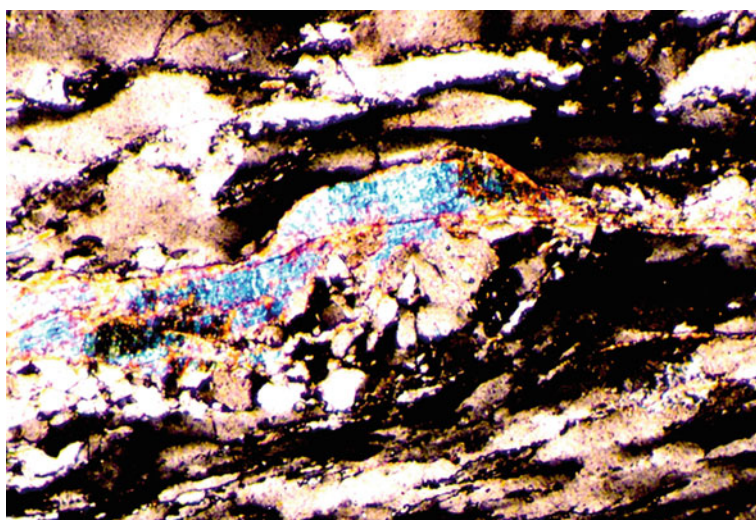


Fig. 2.2 *Top-to-right* sense brittle faulted mica grain. The *top* fragment is *trapezoid*-shaped with gently *curved* margins. The brittle shear plane is marked by recrystallized micas. Reproduced from Fig. 7b of Mukherjee (2012b). Cross-polarized light. *Location* Higher Himalaya (Himachal Pradesh, India). *Width of view* 2.5 mm

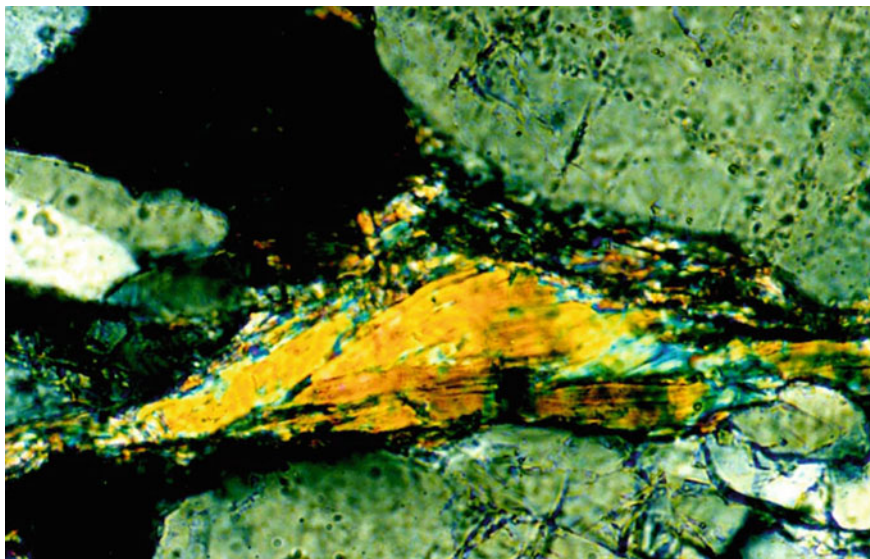


Fig. 2.3 *Top-to-right* brittle sheared micas. A *thick* recrystallized portion at the *top*. Photo in cross-polarized light. Reproduced from Fig. 9c of Mukherjee and Koyi (2012a). Location Zaskar Shear Zone (India). Width of view 2.5 mm

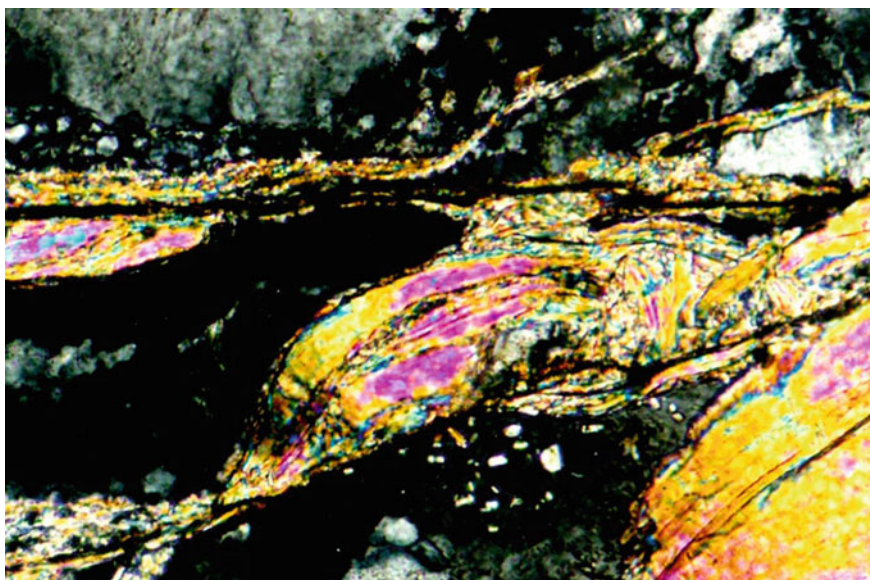


Fig. 2.4 *Top-to-right-up* brittle sheared muscovite layers. Muscovite grains folded and crushed at *right*. Same as Fig. 10c of Mukherjee (2012b) but at a different orientation of the stage. Cross-polarized light. Location Zaskar Shear Zone (India). Width of view 2.5 mm

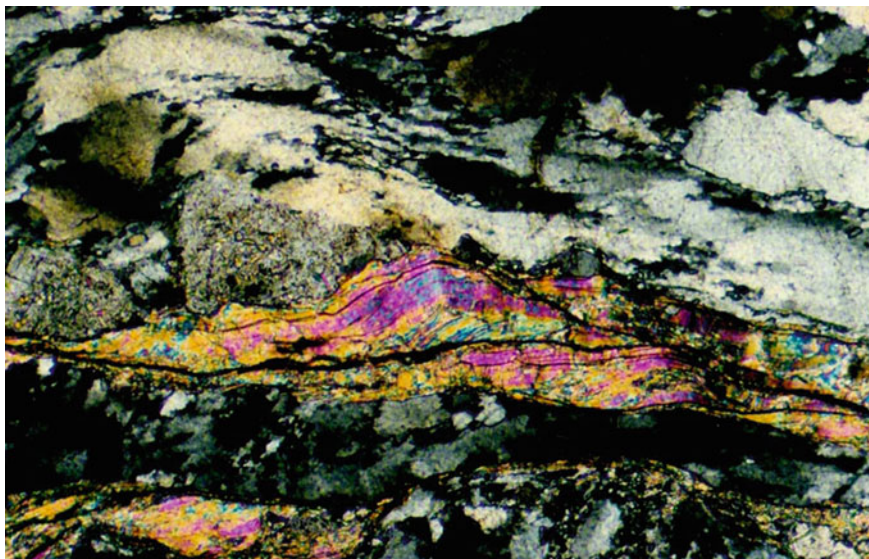


Fig. 2.5 Sheared mica layers. *Top-to-right* sense. Sigmoid grain boundaries near the *left* margin and in the *central* portion. Sheared quartzofeldspathic minerals and near *parallelogram*-shaped mica fish (at *bottom*) show the same shear sense. Synthetic secondary shear planes at *right*. Cross-polarized light. *Width of view* 4 mm

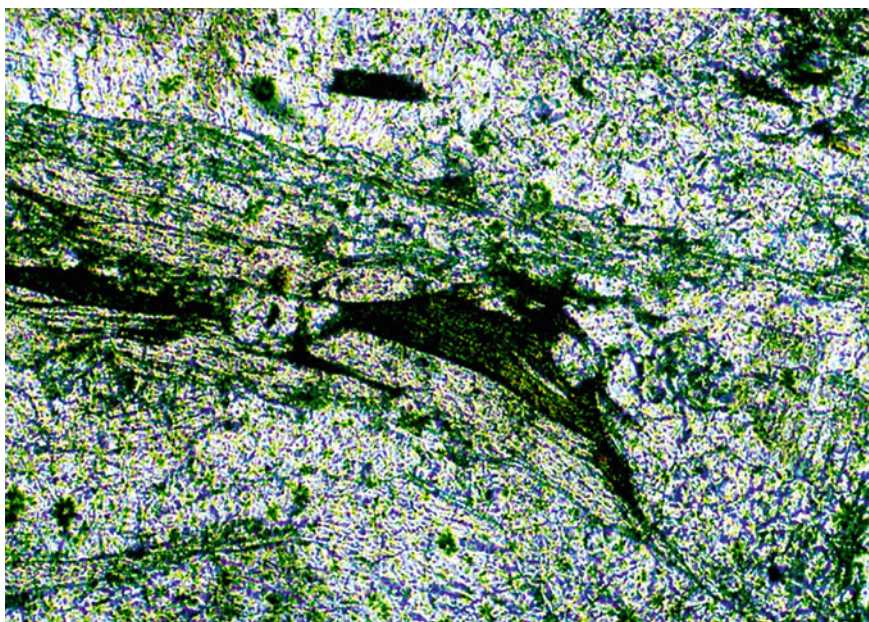


Fig. 2.6 Adjacent muscovite and biotite *trapezoids* with their longest margins a little kinked. *Top-to-left* shear. Reproduced from Fig. 6b of Mukherjee (2012b). Plane polarized light. Higher Himalaya (Himachal Pradesh, India). *Width of view* 2.5 mm

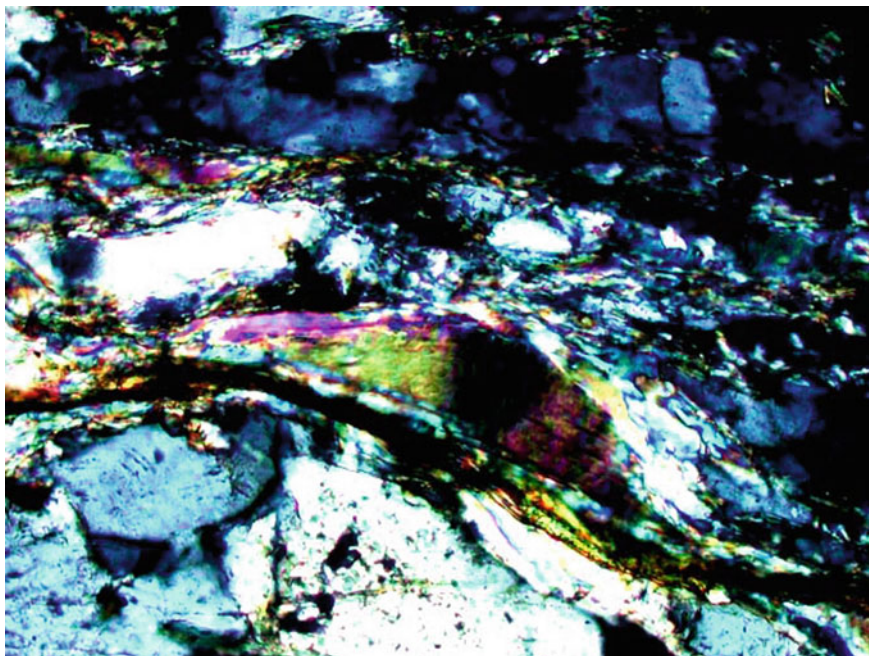


Fig. 2.7 A muscovite grain sheared over quartzofeldspathic minerals. *Top-to-left* sense. Extensive recrystallization at the margin of the muscovite grain. The brittle shear zone is characterized by grain size reduction. Reproduced from Fig. 9a of Mukherjee and Koyi (2010a). *Location* Higher Himalaya (Himachal Pradesh, India). *Width of view* 5 mm

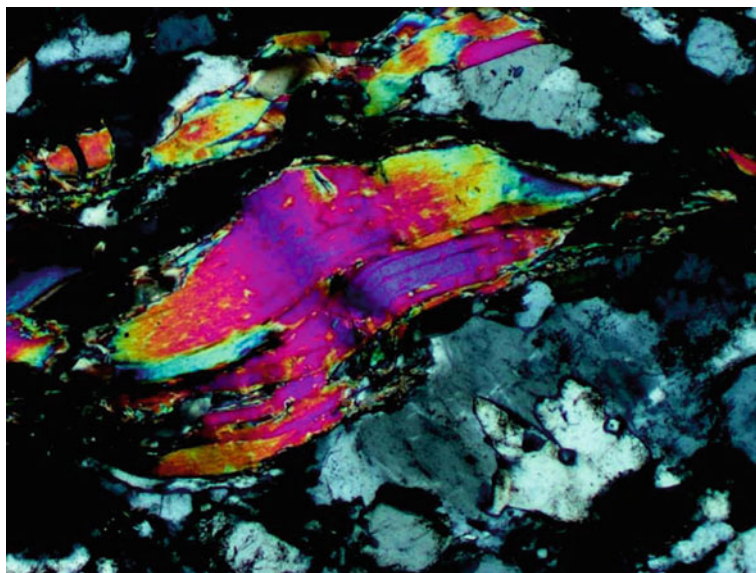


Fig. 2.8 Hat-shaped/trapezoid mica grains sheared over quartzofeldspathic minerals. The hats are mantled by a zone of grain size reduction. *Top-to-right* sense. Reproduced from Fig. 9b of Mukherjee and Koyi (2010a). Cross-polarized light. *Location* Zaskar Shear Zone (India). *Width of view* 5 mm



Fig. 2.9 Top-to-right brittle sheared slices of micas of somewhat *trapezoid* shapes. Notice that mica minerals are more prone to *trapezoid* shapes than the quartzofeldspathic matrix. Cross-polarized light. Location Zaskar Shear Zone (India). Width of view 4 mm

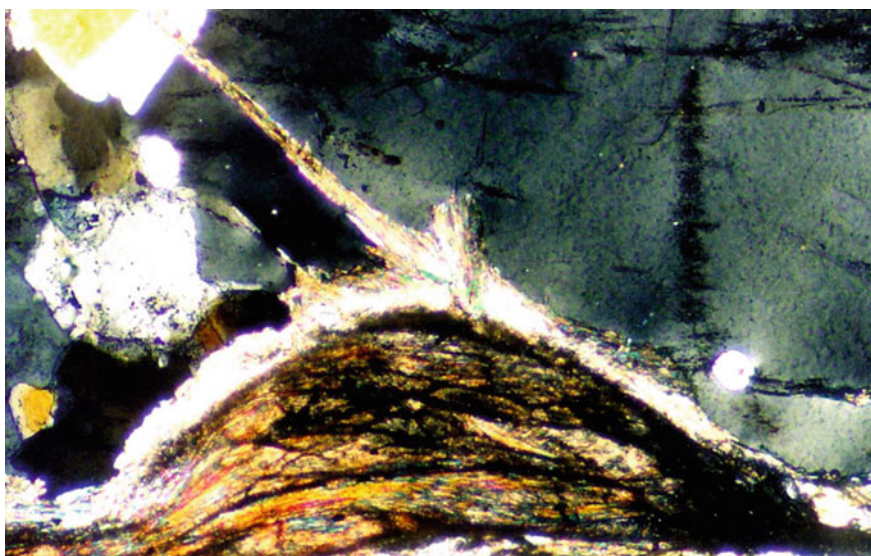


Fig. 2.10 A symmetrically stacked duplex of staurolite grains. No shear sense is indicated. Kyanite mantles this duplex and forms a peculiar 'horn'. This is the cross-polarized light version of Fig. 9d of Mukherjee and Koyi (2010a). Location Zaskar Shear Zone (India). Width of view 2.5 mm

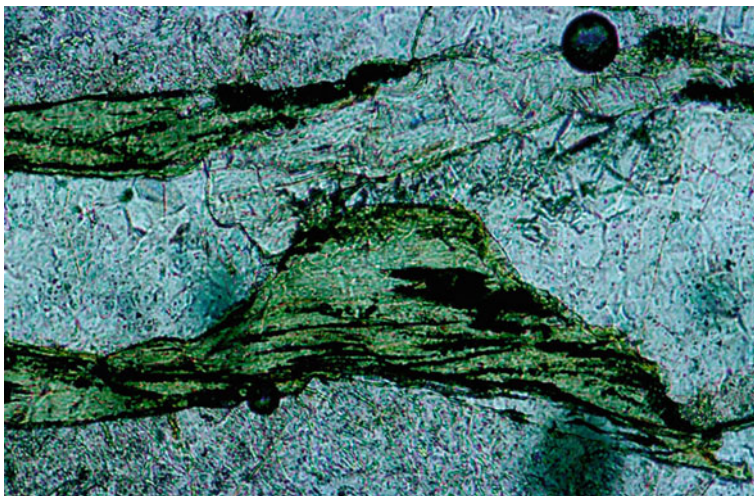


Fig. 2.11 Symmetrically stacked *trapezoid*-shaped chlorite grains. No shear sense is indicated. Cleavages parallel the longest margin of the *trapezoid*. Reproduced from Fig. 9a of Mukherjee (2012b). Plane polarized light. Location Higher Himalaya (Himachal Pradesh, India). Width of view 2.5 mm

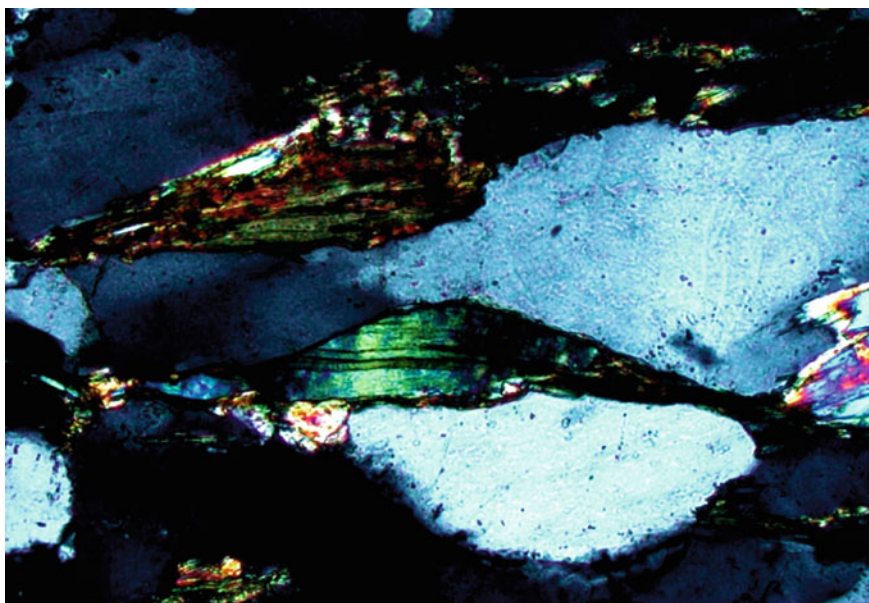


Fig. 2.12 An irregular brittle plane, *horizontal* in the photo, sharply cuts across a quartz grain. Reproduced from Fig. 8a of Mukherjee (2012b). Near symmetric near *trapezoidal* slice of mica at the other side of the fault plane. No shear sense is indicated. Cross-polarized light. Width of view 2.5 mm

References

- Bhattacharya G, Misra AA, Bose N, Mukherjee S (submitted) Near N-S paleo-extension in the western Deccan region in India: Does it link strike-slip tectonics with India-Seychelles rifting? *Int J Earth Sci*
- Holyoke CW III, Tullis J (2006) Formation and maintenance of shear zones. *Geology* 34:105–108
- Mukherjee S (2012a) A Microduplex. *Int J Earth Sci* 101:503
- Mukherjee S (2012b) Tectonic implications and morphology of trapezoidal mica grains from the Sutlej section of the higher Himalayan Shear Zone, Indian Himalaya. *J Geol* 120:575–590
- Mukherjee S (in press) Higher Himalaya in the Bhagirathi section (NW Himalaya, India): its structures, backthrusts and extrusion mechanism by both channel flow and critical taper mechanism. *Int J Earth Sci*
- Mukherjee S, Koyi HA (2010a) Higher Himalayan shear zone, Zaskar Indian Himalaya—microstructural studies and extrusion mechanism by a combination of simple shear and channel flow. *Int J Earth Sci* 99:1083–1110
- Mukherjee S, Koyi HA (2010b) Higher Himalayan shear zone, Sutlej section: structural geology and extrusion mechanism by various combinations of simple shear, pure shear and channel flow in shifting modes. *Int J Earth Sci* 99:1267–1303
- Paterson MS (2013) *Material Science for Structural Geology*. Springer. pp. 1–247

<http://www.springer.com/978-3-642-25607-3>

Deformation Microstructures in Rocks

Mukherjee, S.

2013, XI, 111 p. 189 illus. in color. With online
files/update., Hardcover

ISBN: 978-3-642-25607-3