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SHEARED ILMENITE IN VEIN QUARTZ

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ABSTRACT

Sheared ilmenites with megascopic slip planes, embedded in vein quartz from Rautara (22°49′ N; 86°39′ E) Bankura Dt., West Bengal, India, have been studied. Major slip along one or more important directions has resulted in subsidiary slips along available cleavage, twinning and other oblique surfaces. Interesting textural features comprising translation gliding, twin gliding, and intersecting translation units are described.

A specimen polished on several faces was examined to study the orientation of slip-planes. The composite polar diagram of all available planes was superimposed on a complete stereogram of ilmenite from published interfacial angles. From complete matching of the poles it has been concluded that prominent translation planes are 0001, ($t=[10\bar{1}0]$) and $10\bar{1}0$. Minor slip planes include $\bar{5}054$, $\bar{2}021$, $\bar{1}\bar{1}22$, $55\bar{1}03$ and $2\bar{1}\bar{1}2$.

Localization of the blebs and spindles of exsolved hematite along twin-planes in ilmenite from sheared portions of the vein indicates the prominent role of deformative stress in bringing about the exsolution.

Occurrence of ilmenite-bearing quartz veins has been discovered by the author near Rautara (22° 49′ N; 86° 39′ E), Bankura Dt., West Bengal, India. The associated garnet-staurolite-sillimanite-muscovite-schists dip N.N.E. at high angles of 45°–60°. The veins run parallel to the foliation strike of the country rock. The quartz veins have been locally sheared with development of close-spaced jointing. The ilmenite from the highly sheared portions of the veins has developed numerous conjugate slip-planes, some of which can be recognized megascopically. The shear planes developed in a quartz vein marked by lensoid grains of quartz at an angle with the megascopic slip-planes in the ilmenite, owing to difference in competency of the two minerals (Fig. 1). In less deformed parts of the vein, jointing is wide-spaced and slip planes in ilmenite are absent.

The study of polished specimens in reflected light shows strong development of twin-lamellae in ilmenite in the deformed part of the vein. In extreme cases, the twin-lamellae have been bent, fractured and displaced (Fig. 2). Beautiful translation units are common in these deformed ilmenites. The translation units can be seen as broad lamellae by partial crossing of the nicols or by reflection pleochroism alone. Commonly the translation units form parallel bands within ilmenite crystals. The trace of the translation plane is at an angle with that of the twinning composition plane in the main mass of ilmenite.

Each translation unit shows either one or two sets of twins, diagonal to the length of the unit; when only one set is present, its orientation is rotated to almost 90° with respect to the lamellae in the adjacent undis-

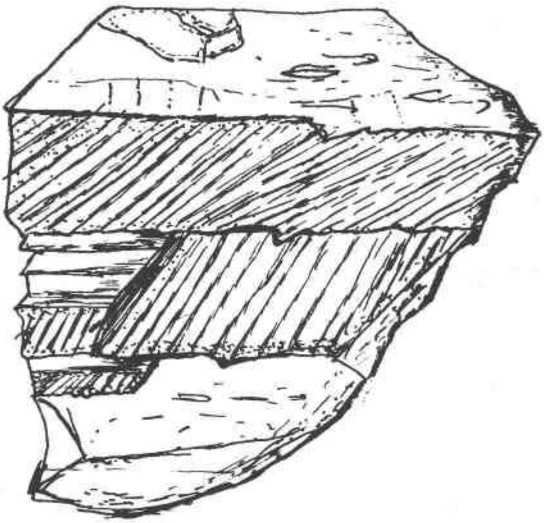

FIG. 1. Megascopic slip-planes in ilmenite embedded in quartz. Shear planes developed in vein quartz marked by lensoid grains are at angle with the megasopic slip-planes in ilmenite. Natural size.

turbed parts. In the undisturbed part, on either side of a translation unit the twin-lamellae are continuous in trend. Within some translation units there are fine lamellae resembling polysynthetic twins, parallel to the trace of the translation plane. Such fine lamellae are also visible in the undisturbed crystal along the border of the translation units (Figs. 3 and 4). The fine twin-lamellae within translation units which are parallel

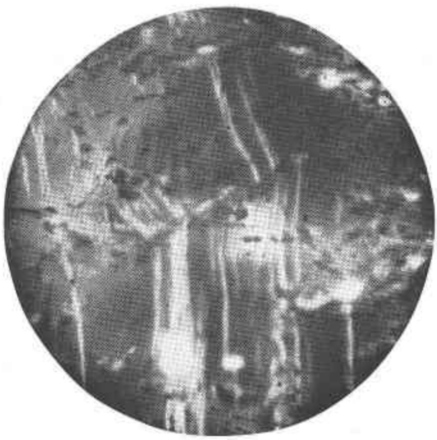

FIG. 2. Bent, fractured and displaced twin lamellae in ilmenite. ×140.

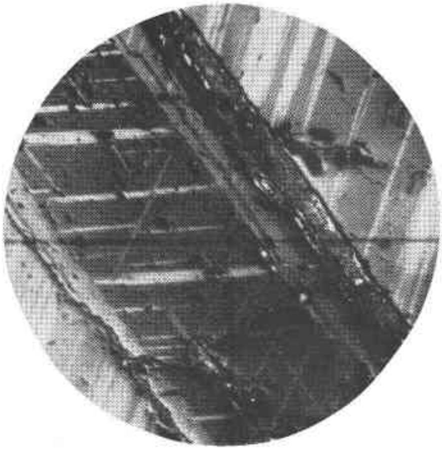

Fig. 3. A translation unit in ilmenite. Twining lamellae in undisturbed part of ilmenite is continuous in trend. Three sets of twins are visible within the translation unit, some of which exhibit minor slips. ×140.

to the trace of the translation plane, indicate twin gliding. Disturbances along translation planes have influenced the development of fine twins in the undisturbed part of the ilmenite adjacent to the translation units.

Locally two or three sets of translation units may be seen intersecting at a point (Fig. 5); some of the units may taper like leaf-laminae, where the traces of the translation surfaces meet, suggesting bend gliding. Numerous planes are seen extending from the tapering edge, most of

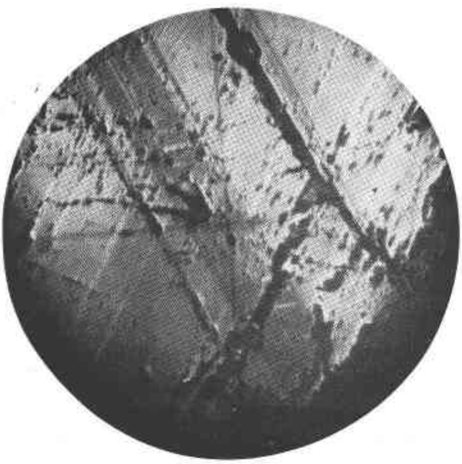

Fig. 4. Fine twin lamellae parallel to the trace of the translation plane within and outside the translation unit. ×140.

which are parallel or sub-parallel to the visible traces of the twinning composition planes. These have formed consequent to the impact of the tapering edge of the translation unit.

In most cases the bent translation units are seen to be composite planes, having resulted from a number of slips along sub-parallel planes in step-like arrangement. These transverse planes in the steps are sometimes planes of visible slips possibly slightly post-dating the main slip.

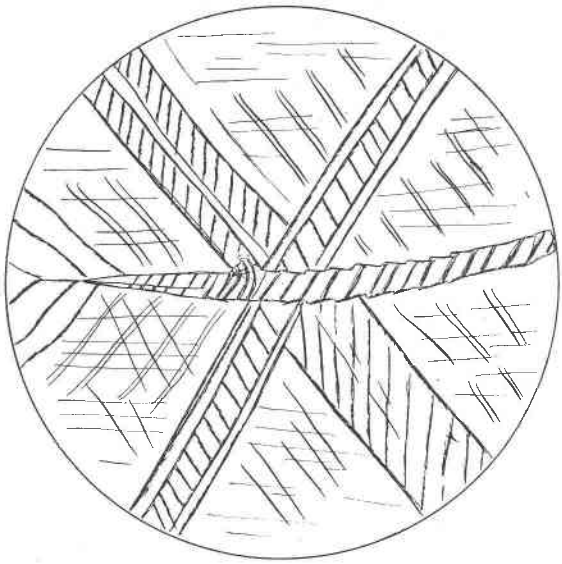

FIG. 5. Three intersecting translation units in ilmenite. One of them is bent and tapers like a leaf. ×100.

Another interesting feature is local thinning of bands showing strong reflection pleochroism along planes parallel to translation units (Fig. 6). This thinning appears to have resulted from slip along the diagonal planes within the translation units in a direction oblique to the plane of polished surface, or by twist gliding* along axes parallel or sub-parallel to the twin-lamellae or normal to the diagonal plane.

To study the orientation of the slip planes, a specimen was polished on four faces and was examined in incident light on UTR_2 stage (Ehrenberg Stage). All the available planes on each of the four polished surfaces were oriented horizontally and separate stereographic diagrams were prepared for each face. All the plottings were then transferred to one face by rota-

* Synonymous with "tortional translation-gliding," Fairbairn, Structural Petrology of Deformed Rocks, 1942, p. 83.

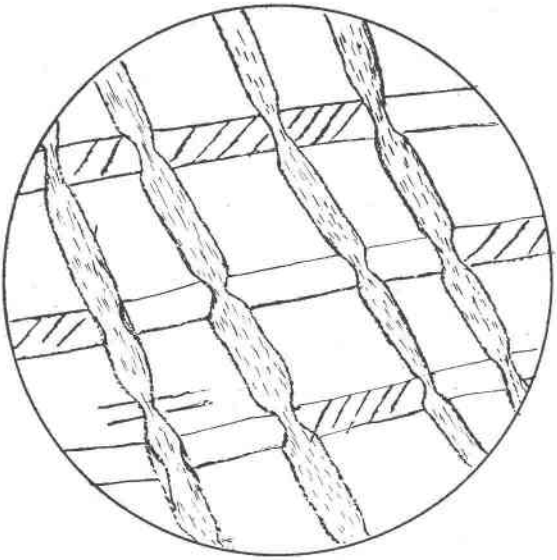

FIG. 6. Local thinning of certain bands along the translation units. ×150.

tion. As there was no optical or crystallographic control in orientation the composite polar diagram of all the available planes was superimposed on a complete stereogram of ilmenite from the published interfacial angles. The position at which there was complete matching was used for identifying the planes.

The results of the study are given in the following table:

Prominent translation planes (Megascopically visible)	Minor slip planes	Slip direction
0001 (Ramdohr, 1950)		$[10\bar{1}0]$
$10\bar{1}0$		Cannot be determined
	$\bar{5}0\cdot4$	
	$\bar{2}0\cdot1$	
	$\bar{1}\bar{1}\cdot2$	Cannot be determined
	$55\cdot3$	
	$2\bar{1}\cdot2$	

The translation occurred along multiple slip-planes and major slip along one or more important planes resulted in subsidiary slips along available cleavage, twinning or other planes.

Another interesting observation is that ilmenite from the sheared portion of the veins exhibits blebs and spindles of hematite arranged parallel to the visible twin planes (Figs. 7 and 8); whereas the specimens from

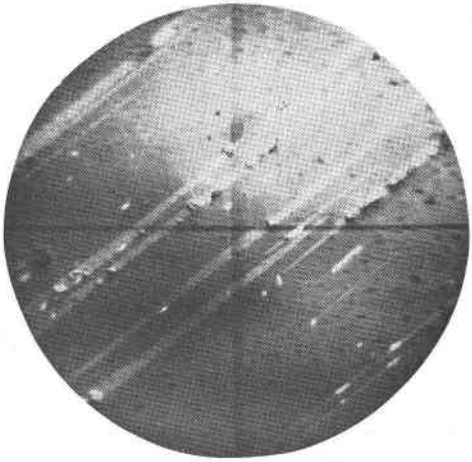

FIG. 7. Exsolution blebs of hematite in ilmenite arranged in two planes. ×360.

relatively massive part of the vein are rarely twinned and are free from these exsolution blebs.

Hematite in thin tabular grains parallel to (0001) is a feature of many ilmenites; but exsolution of hematite along rhombohedral twin planes of ilmenite has only been rarely reported (Ramdohr 1926, cited by Gruner 1929). Perhaps the exsolution of hematite along the twin-planes of ilmenite is facilitated in an environment of shearing stress. Sen (in press) has indicated that formation of antiperthite is also favored by stress.

The two minerals ilmenite and hematite form a continuous solid solution somewhat above 600° C. (Ramdohr, 1926; Edwards, 1938); with

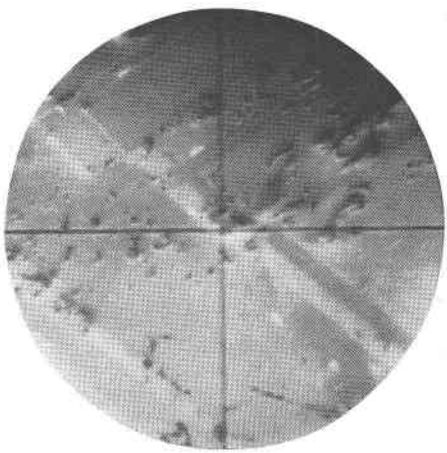

FIG. 8. Exsolution blebs of hematite arranged parallel to the visible twins in ilmenite. ×360.

moderately slow cooling, it unmixes into two solid solutions. The ilmenite-bearing veins in the present area are associated with high grade schists of the amphibolite facies. (Chakravarty, 1955). The occassional appearance of granular pleonaste (R.I. 1.71) in the associated garnet-sillimanite-schists indicates that the temperature of metamorphism reached that of the highest part of the amphibolite facies, if it did not surpass it. Ramberg (1952, p. 137) estimates temperature for the amphibolite facies as between 350°–550° C. Rosenqvist (1952, p. 101) suggests a temperature range of 400°–750° C. at depths less than eight miles.

If the veins have been subjected to metamorphism similar to that of the associated pelitic schists (which is still to be established) the temperature of metamorphism was high enough to permit unmixing of ilmenite and hematite at a lower temperature. But the localization of the oriented hematite blebs in ilmenite in sheared parts of the veins points out that deformative stress rather than rise of temperature controlled the unmixing in this particular case.

Acknowledgments

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