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# AN OPTICALLY NEGATIVE VARIETY OF STAUROLITE FROM NORTHERN RHODESIA[1]

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The Luangwa Valley, in the eastern part of Northern Rhodesia, is a trough-like depression partly infilled with Karroo sediments. Recent mapping near the northern extremity has shown that the Upper Karroo (Stormberg) sediments are predominantly arenaceous, though there are many intercalated mudstone horizons near the base (Drysdall and Kitching in press A; in press B). Staurolite is a prominent and almost ubiquitous member of the heavy mineral suites of the Stormberg sandstones and grits, though it has not been recorded in Lower Karroo assemblages. It is usually accompanied by much rarer garnet, but kyanite is absent.

The staurolite is a unique optically negative variety seen in separations as irregular grains usually lying on an {010} cleavage face. In a few suites the grains are rounded, but the majority is angular and many show the characteristic hackly fracture. Others show delicate triangular projections on the terminations such as are attributed by Bond (1943) to solution etching. Grains lying on {010} cleavage faces usually give a near-centered, acute bisectrix, negative figure; the optic axial plane is thus (010). Since the grains are length slow, it is assumed that the optical indicatrix is normally orientated, *i.e.* $a=\beta$ or Y, $b=\alpha$ or X, $c=\gamma$ or Z. The pleochroism formula, refractive indices and 2V are:

$$X = \text{colorless} < Y = \text{pale yellow} < Z = \text{golden-yellow}$$
$$\alpha = 1.739, \quad \beta = 1.744, \quad \gamma = 1.749, \quad \gamma - \alpha = 0.010, \quad 2V_x = 88°$$

Refractive indices were determined according to the methods of Hartshorne and Stuart (1960, p. 403–6) and Wilcox (1959). The 2V was determined by direct measurement on the universal stage; the figure given is an average of all determinations, which range from 82° to 89°. The pleochroic formula is the same as that quoted by Winchell and Winchell (1951, p. 522) and Deer *et al.* (1962, p. 151). The larger grains show a faint reddish tinge (Z=reddish-yellow) and usually contain many small rounded inclusions of quartz and a few grains of iron ore. Twinning, probably parallel to {232}, was observed in only one grain. The refractive indices and birefringence are low compared with those of many staurolites (Table 1), though they are similar to a variety described by Billings

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(1937, p. 491).[1] These low values may indicate a small content of $Fe^{2+}+Fe^{3+}$ (Juurinen 1956, Fig. 4), but insufficient material is available for a chemical analysis to be made. The identification of the mineral was confirmed, however, by means of an *x*-ray powder photograph, which corresponds to that of optically normal staurolite.

As far as the authors are aware this is the first recorded instance of optically negative staurolite, although in view of the minor variations of chemical composition that have been recorded (Deer *et al.*, 1962, Table 26), it is not surprising that the known range of 2V has now been extended by as little as 2°. Winchell and Winchell (1951, p. 522) state that staurolite is optically positive and $2V_z$ ranges from 80° to 90° (86° to 89° being common), but in their table the optic axial angles are listed under

TABLE 1. A COMPARISON OF OPTICAL PROPERTIES OF STAUROLITES

| $\alpha$ | $\beta$ | $\gamma$ | $\gamma-\alpha$ | $2V_z$ | Locality | Reference |
|---|---|---|---|---|---|---|
| 1.736 | 1.741 | 1.746 | 0.010 | 88°± | | Larsen and Berman 1934; Milner 1952 |
| 1.739 | 1.744 | 1.749 | 0.010 | $2V_x$=88° | Luangwa Valley | |
| 1.739 | 1.744 | 1.750 | 0.011 | 90°± | New Hampshire | Billings 1937 |
| 1.7393 | 1.7450 | 1.7511 | 0.0118 | 88°21′ | St. Gotthard | Juurinen 1956 |
| 1.740 | 1.746 | 1.753 | 0.013 | 87° | Scotland | Juurinen 1956 |
| 1.741 | 1.747 | 1.754 | 0.013 | 86° | Maine | Juurinen 1956 |
| 1.7436 | 1.7496 | 1.7557 | 0.0121 | 86°28′ | Petersdorf | Winchell 1951 |
| 1.747 | 1.753 | 1.761 | 0.014 | 80° | Finland | Juurinen 1956 |
| 1.7468 | 1.7536 | 1.7621 | 0.0153 | 80°39′ | Bavaria | Winchell 1951 |

$2V_x$. That this is an unintentional (possibly printer's) error is evident in the determinative tables (Winchell 1951, pp. 43, 98, 179, 207 and 208), where all the staurolites are recorded as positive.[2] The error has apparently been repeated by Wahlstrom (1955, p. 202) who quotes similar values for the refractive indices and 2V.

Several examples of staurolite schist from Northern Rhodesia have been examined in an attempt to trace the source of the unusual detrital staurolite of the Upper Karroo sediments. All the staurolite from the schists proved to be optically positive, whereas in the sediments it is always negative. Very little of the Eastern and Northern Provinces has yet been mapped systematically, and no specimens of staurolite schist from areas flanking the Luangwa Valley are available for study. It is

[1] From TABLE 1 it appears that as the refractive indices increase, so does the birefringence, but 2V becomes smaller.

[2] This point is also noted by Juurinen (1956, p. 33).

possible that if the source is located it will resolve the controversy regarding the source of the Upper Karroo sediments. In central Africa these sediments are remarkably uniform and it has been suggested that this may be a result of derivation from a common extracontinental source area (Gair 1956). However, where the Upper Karroo sediments are transgressive, pebbles of local origin can locally be identified in the basal beds, although such material is no longer recognizable as the centers of the basins of deposition are approached. As yet definite source areas cannot be defined, though there seems little evidence for postulating that they were extracontinental (Drysdall and Kitching, in press, B). It is hoped that the staurolite of the Luangwa Valley will eventually provide evidence which will contribute to the solution of this problem.

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