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# WERNERITE AND FELDSPAR FROM MADAGASCAR

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Six samples of wernerite and six of feldspar were separated from the werneritic and feldspathic pyroxenites of S. E. Madagascar. These pyroxenites (Precambrian) occur in association with charnockites and have been considered to be metamorphosed sediments (Lacroix 1941; de La Roche 1956 & 1958). Wernerite and feldspar were studied optically and chemically and the *x*-ray powder diffraction patterns of the selected samples were also determined.

These wernerites are whitish grey, granular and majority of them show two sets of perfect cleavages and also show more or less greasy luster. In thin sections, they are colourless but some of them are slightly stained by impurities. Some of the crystals show twin-lamellae, which represent the clear passage of feldspar to wernerite. They are uniaxial negative showing moderately high relief with $\epsilon$, varying from 1.551 to 1.568 and $\omega$, varying from 1.580 to 1.607. They show strong birefringence which varies from 0.029 to 0.039. The specific gravity varies from 2.65 to 2.77 (Table 1).

The feldspars are greyish white in colour with vitreous luster. In thin sections, they are colourless, some partially altered. They have one distinct cleavage parallel to (001). They show low relief with the refractive indices varying, $\alpha$, from 1.555 to 1.559 and $\gamma$, from 1.562 to 1.566. Birefringence varies from 0.005 to 0.009. They show albite twinning and the anorthite content varies between 52% and 62%. Their optic axial

TABLE 1. OPTICAL PROPERTIES AND TRACE ELEMENTS DETERMINATIONS OF WERNERITE AND LABRADORITE FROM S.E. MADAGASCAR

| | Wernerite | | | | | | Labradorite | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6* | 1 | 2 | 3 | 4 | 5 | 6* |
| $\epsilon$ | 1.561 | 1.551 | 1.560 | 1.568 | 1.565 | 1.551 | $\alpha$ 1.558 | 1.556 | 1.555 | 1.559 | 1.559 | 1.555 |
| $\omega$ | 1.590 | 1.580 | 1.595 | 1.607 | 1.602 | 1.582 | $\gamma$ 1.565 | 1.562 | 1.563 | 1.564 | 1.566 | 1.564 |
| $\delta$ | 0.029 | 0.029 | 0.035 | 0.039 | 0.037 | 0.031 | 0.007 | 0.006 | 0.008 | 0.005 | 0.007 | 0.009 |
| D | 2.69 | 2.65 | 2.67 | 2.77 | 2.65 | 2.66 | 2.69 | 2.70 | 2.71 | 2.70 | 2.68 | 2.69 |
| 2V | | | | | | | 83°(+) | 73°(+) | 75°(+) | 80°(+) | 85°(+) | 79°(+) |
| An% | | | | | | | 59 | 52 | 54 | 55 | 62 | 57 |
| B | 12 p.p.m. | 10 p.p.m. | 15 p.p.m. | 35 p.p.m. | 10 p.p.m. | 32 p.p.m. | 26 p.p.m. | 34 p.p.m. | 110 p.p.m. | 21 p.p.m. | 103 p.p.m. | 30 p.p.m. |
| Ba | 100 | 30 | 30 | 149 | 30 | 89 | 180 | 168 | 84 | 30 | 115 | 132 |
| Be | 15 | 10 | 13 | 3 | 10 | 36 | 110 | 20 | 10 | 16 | 30 | 25 |
| Co | 13 | 10 | 10 | 11 | 10 | 12 | 10 | 12 | 10 | 10 | 30 | 25 |
| Cr | 5 | 5 | 7 | 7 | 6 | 3 | 10 | 15 | 25 | 10 | 12 | 13 |
| Cu | 18 | 3 | 3 | 35 | 15 | 15 | 35 | 25 | 33 | 20 | 30 | 30 |
| Ga | 19 | 10 | 10 | 35 | 10 | 39 | 35 | 30 | 30 | 20 | 41 | 38 |
| Mn | 45 | 30 | 35 | 151 | 30 | 109 | 93 | 107 | 36 | 30 | 110 | 115 |
| Ni | — | 5 | 3 | 6 | — | 3 | 10 | 5 | 3 | 3 | 8 | 10 |
| Pb | 35 | 25 | 25 | 39 | 10 | 22 | 14 | 10 | 15 | 3 | 10 | 12 |
| Sr | 2568 | 316 | 316 | 2951 | 350 | 1821 | 1971 | 1653 | 1451 | 1000 | 2201 | 1965 |
| Y | 3 | 3 | 3 | 3 | 10 | 10 | 3 | 3 | 5 | 10 | 10 | 3 |
| Yb | 3 | 3 | 3 | 5 | 3 | 5 | 8 | 3 | 3 | 1 | 3 | 3 |
| Zn | 15 | 10 | 10 | 15 | 10 | 15 | 15 | 13 | 16 | 10 | 38 | 25 |

Trace elements are the average of three determinations in p.p.m.
*These samples were analysed twelve times.
'—' means the element was sought but could not be detected. $\delta$ = birefringence.
Unit Cell Dimensions of Wernerite, sample 6: $a$ = 12.055 Å, $c$ = 7.574 Å.
Wernerite: 1-Ranopiso; 2,3-Anara; 4-Mafilefy; 5,6-Androy Mandrareen.
Labradorite: 1,3,4-Esira; 2-Beampingaratra; 5,6-Ambotaka.

angles vary from 73° to 85° with a positive optic sign and the density from 2.68 to 2.71.

The *x*-ray powder diffraction patterns were determined for the selected samples and the results are found to be very satisfactory, when compared with the data published by Gibbs & Bloss (1961), Cole *et al.* (1951) and Goodyear & Duffin (1954). The '*a*' and '*c*' unit cell lengths of wernerites were calculated and they are found to be very close to those given by Gibbs & Bloss.

Trace elements were determined spectrographically by the methods described by Black (1952) and Mitchell (1948) using Jobin et Yvon quartz prism spectrograph, furnished with a Durr excitation unit. An A.R.L. Spectroline Scanner was used to read the line densities. Samples and synthetic standards were mixed with graphite (1:1) using $La_2O_3$ and CdO as the internal standards. A water-cooled Stallwood jet of $CO_2$ was used to improve precision and to reduce cyanogen bands. Sample no. 6 of wernerite and no. 6 of feldspar were analysed 12 times to determine the reproducibility and precision of the methods used. The results of this precision are given in Table 2. In order to compare wernerite and feldspar with respect to the total trace element content and that with the crustal

TABLE 2. PRECISION DATA FOR WERNERITE (No. 6) AND LABRADORITE (No. 6)

| | | Wernerite | | Labradorite | |
|---|---|---|---|---|---|
| Elements | $\eta$ | Mean[1] | Relative deviation[2] | Mean[1] | Relative deviation[2] |
| B | 12 | 32 p.p.m. | 10.15% | 30 p.p.m. | 11.50% |
| Ba | 12 | 89 | 7.85 | 132 | 6.35 |
| Be | 12 | 36 | 6.85 | 25 | 5.23 |
| Co | 12 | 12 | 6.25 | 25 | 6.90 |
| Cr | 12 | 3 | 10.40 | 13 | 9.95 |
| Cu | 12 | 15 | 2.80 | 30 | 1.98 |
| Ga | 12 | 39 | 17.15 | 38 | 16.85 |
| Mn | 12 | 109 | 6.50 | 115 | 5.50 |
| Ni | 12 | 3 | 4.10 | 10 | 5.25 |
| Pb | 12 | 22 | 9.80 | 12 | 10.55 |
| Sr | 12 | 1821 | 12.12 | 1965 | 11.85 |
| Y | 12 | 10 | 6.70 | 3 | 5.20 |
| Yb | 12 | 5 | 7.90 | 3 | 8.35 |
| Zn | 12 | 15 | 11.85 | 25 | 10.15 |

[1]Bias-corrected mean of twelve determinations.
[2]Combined deviations of measurement and bias-correction, for single determinations.

abundance, a scheme devised by Shaw (1961*a*, *b*) was used. In the present investigation, the mean of all values of '*R*' of wernerite is 1.200 and that of feldspars is 1.847, which compare well with the mean '*R*' values calculated from the published data on wernerite and feldspar.

The optical properties, trace element determinations and the unit cell

dimensions are given in Table 1. From these data it is apparent that the meionite composition predominates in wernerite and the feldspar falls in the labradorite range.

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