# *On the lithium amphibole holmquistite, from Benson pegmatite mine, Mtoko, Southern Rhodesia.*

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*Summary.* A new occurrence of holmquistite is described. The mineral is found in amphibolite at the contact of a lithium pegmatite. Chemical analyses and optical data of the holmquistite and an associated hornblende are given.

OSANN (1913) defined holmquistite as a monoclinic lithium-glaucophane, and this interpretation was retained by Sundius (1946, 1947) in his classification of the hornblendes, although with some reservations. Machatschki (1953) grouped holmquistite with the clino-amphibole grunerite–cummingtonite and regarded it as a lithium amphibole analogous to the lithium pyroxene spodumene.

On the basis of X-ray studies, Ginzburg *et al.* (1958) and Vogt *et al.* (1958) have shown that holmquistite is not monoclinic, but is an orthorhombic amphibole akin to anthophyllite in structure, whose formula can be derived from the latter by the substitution of LiAl for MgMg. The lattice constants of these minerals according to Vogt *et al.* are: holmquistite *a* 18·36, *b* 17·75, *c* 5·29 Å., anthophyllite *a* 18·56, *b* 18·08, *c* 5·28.

In addition to the original find of holmquistite from the Utö spodumene pegmatite near Stockholm by Osann, holmquistite has been recorded by Palache *et al.* (1930) from the hiddenite (a green, gem variety of spodumene) deposit in Alexander County, North Carolina, by Ginzburg and Ginzburg (1950) from spodumene pegmatites in the northern Kola Peninsula, and by Karpoff (1960) from lithium-rich pegmatites in Lacorne area, Province of Quebec. In all these occurrences holmquistite has been found developed in the country rock, of variable composition, close to the contact of spodumene-bearing pegmatites, and in all cases the origin of the lithium amphibole has been attributed to lithium metasomatism.

The present holmquistite was found by one of us (G. H.) on the Benson claims during an investigation of pegmatites in the Mtoko–Fungwe area in the north-eastern part of Southern Rhodesia. Here a narrow, arcuate belt of metasediments and metavolcanic rocks of Bulawayan (Precambrian) age, bounded and in part interrupted by granite and granite-gneiss, extends across the Mtoko and Fungwe Reserves. Protruding through the belt in the Mtoko Reserve is the granite mass of Bangawia, which forms a major pegmatite focus immediately adjacent to the Benson claims (17° 2′ S., 32° 15′ E.).

The Benson lithium pegmatites are the most important in this part of Rhodesia, and display a unique assemblage of economic minerals: amblygonite, spodumene, lepidolite, beryl (white, green, pink, and orange), pollucite, bismutite, cassiterite, microlite (with a wide colour range), columbite-tantalite, manganotantalite, stibiotantalite, and simpsonite.

In the main holmquistite occurrence at Benson 1, the marginal zone of the amphibolite has been transformed into a holmquistite-bearing rock extending over an area of at least 80 by 20 feet, around the folded extremity of a spodumene–lepidolite pegmatite. At the contact there is a selvage rich in a biotite containing lithium and fluorine together with feldspar, fluorite, and apatite; followed by a zone consisting of hornblende, holmquistite, biotite, feldspar, quartz, and sphene; and finally a dominantly holmquistite-bearing rock composed of 43 % holmquistite, 13 % hornblende, 2 % ore, 1 % biotite, 1 % clino-zoisite, and 40 % of mainly quartz and some feldspar.

In hand specimen the holmquistite rock is bluish grey in colour and consists predominantly of an extremely thin fibrous mineral, although, with the naked eye, the presence of holmquistite is not at first apparent. With a strong hand lens, however, the characteristic jacaranda-blue colour of the holmquistite (resembling kyanite) is clearly visible. In thin-section the fibre-like crystals of the lithium amphibole are seen to be in parallel arrangement and appear to have crystallized later than the associated green hornblende. Partial replacement or pseudomorphs of holmquistite after hornblende, as recorded by Ginzburg and Ginzburg (1950), have as yet not been observed. The holmquistite fibres are up to 5 mm. in length and some tenths of a millimetre in width. Striated faces are observed on $\{110\}$ and smooth faces on $\{100\}$. No terminal faces have been noticed.

Holmquistite exhibits a characteristic pleochroism: $\alpha$ pale yellow, $\beta$ pink-violet, and $\gamma$ pale purple. The associated hornblende is of common green colour with pleochroism: $\alpha$ straw-yellow, $\beta$ pale green, and $\gamma$ blue-green. Additional physical data of the two amphiboles are shown in table I. An X-ray powder photograph of holmquistite from the Benson mine is given in fig. 1.

The contact of Benson 3 pegmatite reveals a more asbestiform variety of holmquistite in a lime-green clay rock, again outside a biotite-rich selvage. Benson 4 mine yields holmquistite in a similar clay rock, and also in a drag folded and sheared amphibolite. At present, the country rock marginal to 8 lithium pegmatites is known to contain holmquistite.

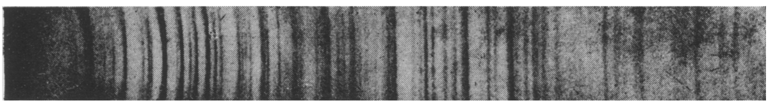

FIG. 1. X-ray powder photograph of holmquistite from Benson 1 pegmatite, Mtoko. 9 cm. camera, Fe-$K\alpha$ radiation.

Sundius (1959) points out that the rhombic character of holmquistite is of interest, as non-stress conditions of development are indicated, in comparison with the monoclinic character of glaucophane, which he regards as a stress mineral. Ginzburg and Ginzburg (1950) record that there is no preferred orientation of the Kola holmquistite. In the Benson examples, however, there is a marked directional metamorphic texture with strong parallelism of the holmquistite crystals, suggesting that it may develop and persist under certain metamorphic conditions where stress is operative, as well as under static conditions, provided that Li is available.

*Geochemical considerations.*

The interesting observation by Ginzburg and Ginzburg (1950), that holmquistite forms at the expense of hornblende in the country rock with a simultaneous formation of clinozoisite at the expense of plagioclase, compares favourably with similar alteration processes of hornblende into cummingtonite, often observed in metamorphic rocks of dioritic and gabbroic composition. In both cases one of the major elements to be removed from hornblende is calcium, but the fixation of the liberated calcium ions is not always apparent.

It is possible that holmquistite has been formed in this way in most of the recorded instances, even when gradual changes have not been noticed, as in the present case, due to complete recrystallization. The fixation of calcium may be indicated by the presence of fluorite in the contact zones of the Benson occurrences, by apatite in the Kola finds, and by the remarkable formation of calcite between the holmquistite zone and the unaffected hornblendite rock in the Lacorne area. The

TABLE I. Chemical composition and atomic ratios to 24 (O,OH,F) of holmquistite and an associated hornblende from Mtoko, together with atomic ratios of holmquistites from other localities.

| | 1. | 2. |
|---|---|---|
| $SiO_2$ | 59·06 | 44·06 |
| $Al_2O_3$ | 12·38 | 12·84 |
| $TiO_2$ | 0·20 | 0·97 |
| $Fe_2O_3$ | 2·36 | 3·70 |
| FeO | 10·84 | 14·40 |
| MnO | 0·25 | 0·25 |
| MgO | 8·82 | 8·74 |
| CaO | 0·21 | 11·04 |
| $Na_2O$ | 0·11 | 1·72 |
| $K_2O$ | 0·05 | 0·31 |
| $Li_2O$ | 3·33 | 0·15 |
| $H_2O+$ | 2·09 | 1·81 |
| $H_2O-$ | 0·07 | 0·16 |
| F | 0·18 | — |
| | 99·95 | 100·15 |
| Less O for F | 0·08 | |
| | 99·87 | |

| | 1a. | | 3. | | 4. | | 5. | | 6. | | 2a. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Si | 7·89 | $Z$ = 8·00 | 8·11 | | 7·96 | 8·00 | 7·39 | 8·00 | 7·92 | 8·00 | 6·54 | 8·00 |
| Al | 0·11 | | | | 0·04 | | 0·61 | | 0·08 | | 1·46 | |
| | 1·84 | $Y$ = 2·10 | 1·15 | 2·10 | 2·03 | 2·27 | 1·69 | 1·93 | 1·67 | 1·99 | 0·78 | 1·30 |
| Ti | 0·02 | | 0·00 | | 0·01 | | 0·06 | | 0·02 | | 0·11 | |
| Fe''' | 0·24 | | 0·95 | | 0·23 | | 0·18 | | 0·30 | | 0·41 | |
| Fe'' | 1·21 | $X$ = 3·00 | 0·55 | 2·98 | 1·01 | 2·93 | 1·15 | 3·01 | 0·99 | 3·02 | 1·78 | 3·74 |
| Mn | 0·03 | | 0·05 | | 0·02 | | — | | 0·02 | | 0·03 | |
| Mg | 1·76 | | 2·38 | | 1·90 | | 1·86 | | 2·01 | | 1·93 | |
| Ca | 0·03 | $W$ = 1·86 | 0·01 | 2·11 | 0·15 | 1·53 | 0·19 | 1·76 | 0·08 | 2·06 | 1·76 | 2·40 |
| Na | 0·03 | | 0·13 | | 0·06 | | 0·17 | | 0·05 | | 0·49 | |
| K | 0·01 | | 0·05 | | 0·00 | | 0·12 | | 0·03 | | 0·06 | |
| Li | 1·79 | | 1·92 | | 1·32 | | 1·28 | | 1·90 | | 0·09 | |
| OH | 1·86 | 24 | 2·03 | 24 | 1·69 | 24 | 2·78 | 24 | 1·84 | 24 | 1·78 | 24 |
| F | 0·08 | | 0·09 | | 0·06 | | — | | 0·10 | | — | |
| O | 22·06 | | 21·88 | | 22·25 | | 21·22 | | 22·06 | | 22·22 | |
| Sp. gr. | 3·09 | | 3·09 | | 2·95 | | 3·111 | | — | | 3·26 | |
| α | 1·624 | | 1·640 | | 1·624 | | 1·625 | | 1·622 | | 1·655 | |
| β | 1·644 | | — | | 1·645 | | 1·645 | | 1·646 | | — | |
| γ | 1·651 | | 1·663 | | 1·651 | | 1·654 | | 1·650 | | 1·674 | |
| $2V_\alpha$ | 52°±1° | | 44° | | 50° | | 51° | | 49° | | 76° | |
| γ:[001] | 0° | | 0–2° | | 0–4° | | 0° | | 0° | | 19° | |

1. Holmquistite from Benson mine, Mtoko, Southern Rhodesia. Anal. O. von Knorring.

2. Hornblende (ass. with holmquistite from Benson mine). Anal. O. von Knorring.

1a. *Atomic* ratios of holmquistite from Benson mine to 24 (O,OH,F).

3. Atomic ratios of holmquistite from Utö, Sweden. Anal. A. Bygdén.

4. Atomic ratios of holmquistite from the Kola peninsula. Anal. A. M. Bondareva.

5. Atomic ratios of holmquistite from Alexander Co., North Carolina. Anal. E. V. Shannon.

6. Atomic ratios of holmquistite from Lacorne area, Quebec Province. Anal. J. A. Maxwell.

2a. Atomic ratios of hornblende from Benson mine, Mtoko, Southern Rhodesia.

chemical data of holmquistite and the coexisting hornblende from Benson mines are given in table I, together with atomic ratios of holmquistites from other described localities. A qualitative spectrographic analysis by Miss J. M. Rooke showed in addition traces of V, Cr, and Ni in the present holmquistite.

A comparison of the holmquistite analyses from the recorded occurrences shows very similar values for the *Y* and *X* groups, approximately 2 and 3 respectively, indicating a close agreement with the holmquistite formula $Li_2\,(Mg, Fe)_3\,(Al, Fe)_2\,Si_8O_{22}\,(OH, F)_2$ as proposed by Ginzburg *et al.* (1958). It moreover appears from the above data that the major changes in the chemical composition are confined to these two ionic groups. The compositional variations are perhaps mainly controlled by the chemistry of the host rock, and to a certain extent by the nature of the metasomatic agents and the distance from the pegmatite contact. A unique example is the holmquistite from Kola containing $CO_2$ in the form of gas and liquid inclusions. In the present occurrence fluorine may have played an important role in the transfer of lithium during metasomatism. This is indicated by the abundance of fluorine-bearing minerals developed at the contact, and indeed an excess of fluorine and other volatiles in addition to lithium may be essential for the formation of a mineral like holmquistite in the country rock. The associated hornblende shows similar chemical features and carries also a small amount of lithium. Sundius (1947) recorded a hedenbergite pyroxene containing approximately 0·5 % lithium as an associate of the holmquistite from Utö.

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