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Zincian staurolite from Uganda

SOME of the amblygonite specimens collected in 1957 from the main Nyanga granite pegmatite (E. 30° 09′ 24″, S. 0° 58′ 16″) in Ankole, Uganda, were found to be sheared, partly reworked, and replaced by fine-grained muscovite. In addition to larger corroded amblygonite augen set in a sugary matrix of amblygonite, the specimens contain fine-grained apatite, wavellite, and smaller amounts of bertossaite (a second occurrence), crandallite, reddish crystals of goyazite, eosphorite, bluish corundum, arsenopyrite, and veinlets of chloritoid. In some muscovite veinlets a pinkish mineral was also seen. An X-ray powder pattern and a series of single-crystal X-ray precession photographs of this mineral proved it to be staurolite. Because of its rather unusual colour and mode of occurrence, this staurolite variety was examined more closely.

Because only a few milligrammes of the mineral were available for this study, a wet chemical analysis could not be made. Table I summarizes the result of a microprobe analysis carried out by one of us (J. S.). Adopting the ideal composition of $Fe_4Al_{18}Si_8O_{46}(OH)_2$ for staurolite, the unit cell content, based on a sum of cations = 30, is added to the table. This analysis indicates a marked excess of Al over the theoretical staurolite formula and a deficiency in (Fe + Zn + Mn).

TABLE I. *Chemical composition of the staurolite from Nyanga, Uganda. Microprobe analysis.* MgO, CaO, TiO_2 *not detected.* Total iron as FeO.

	Wt.%	Unit cell based on cation sum = 30	
SiO_2	27.3	Si	7.61
Al_2O_3	60.5	Al	19.91
FeO	9.30	Fe	2.17
MnO	0.05	Mn	0.01
ZnO	1.46	Zn	0.30
Total	98.61		

The unit cell dimensions calculated from the powder pattern are: $a = 7.867(3)$ Å, $b = 16.559(5)$ Å, $c = 5.643(3)$ Å. Density (calc.) = 3.74. Refractive indices: $\alpha = 1.720$, $\beta = 1.726$, $\gamma = 1.733$ (immersion method, all ± 0.003). Optical orientation: $\gamma \parallel c$, $\beta \parallel a$, $\alpha \parallel b$. $2V_\gamma$ large. Colour very slightly pinkish with no pleochroism.

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An unusual calcite from Muirshiel, Renfrewshire

FLUID inclusion studies were made on a specimen of vein calcite found on the tip of the disused Muirshiel barytes mine, which is situated some fifteen miles west of Glasgow. The country rocks of the immediate area are Lower Carboniferous lavas intruded by an abundance of various doleritic bodies of Lower Carboniferous, Permo-Carboniferous, and Tertiary ages.

There are several baryte veins in the area, cutting the lavas, but only one has been mined. The veins are fault-controlled and typical of the simple fissure-infill type orebody, consisting almost totally of pink baryte and a little quartz. Calcite is not common. Although there has been some debate in the past concerning the age of the mineralization, a Permo-Triassic age is indicated by K/Ar dates on the fault gouge clays (J. G. Mitchell, pers. comm.).

Mineralogical description. The pearly-grey rhombohedra of calcite, sometimes pinkish in colour due to inclusions of finely divided hematite, are commonly 1 cm across. They appear to replace the pink, banded baryte, which can be seen to be brecciated and enclosed within the calcite. At the junction with the main mass of baryte, the calcite is more impure and appears dirty brown in colour. In thin section this is seen to be due to a high concentration of hematite and/or goethite.

Fluid inclusions. It is the evidence provided by the fluid inclusions within the calcite that make it so unusual. Whilst those of the baryte are low-temperature monophase-liquid inclusions, the calcite contains an abundance of multiphase high-temperature inclusions, which contain varying numbers of daughter phases (fig. 1*a* and *b*). The abundance of the daughter minerals and their constancy within certain areas of the calcite preclude the possibility of their being captured solid phases.

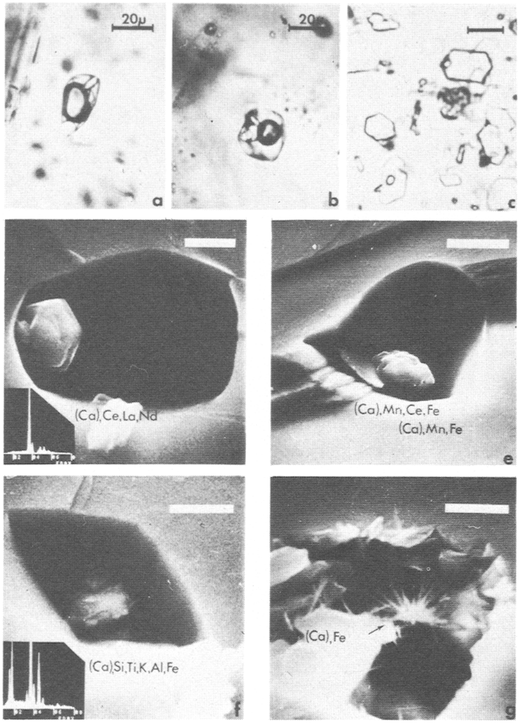

FIG. 1*a* and *b*: Photomicrographs (plane-polarized light) of typical multiphase inclusions. *c*. Extracted daughter phases (plane-polarized light). *d*, *e*, *f*, and *g*. Electron photomicrographs of *in situ* daughter phases and a fluid precipitate. The scale bars in *c*–*g* are 2 μm long.

Inclusions considered to be primary in origin gave homogenization temperatures within the main range 440 to 480 °C (26 determinations). Since the fluids responsible for these inclusions were boiling at the time of trapping, as testified by the coexistence of low-density gas inclusions, no pressure corrections need be applied to the above values. The homogenization temperatures may therefore be regarded as meaningful estimates of the formation temperatures. It seems likely that the phenomenon of boiling was the cause of the great variety of inclusions present and it would also explain the large range of salinities observed (i.e. as inferred from the last-ice-melting temperatures of the included fluids). Temperatures over the range −6 to −36 °C were measured (29 determinations).

By crushing and then leaching a previously electrolytically cleaned sample with deionized water, a Na/K (atomic) ratio of 13 was obtained for the leachate. This is within the range 4.7 to 16.5 found for baryte samples of the area.

During homogenization, violent decrepitations frequently occurred above 350 °C, partially shattering the samples. A suspicion that this may have been due to the presence of carbon dioxide in the inclusions was subsequently refuted by a failure to detect any significant amount of this gas by mass spectrometric analysis.

The daughter minerals of the inclusions are apparently anisotropic, though their birefringence is masked by that of the calcite. The occurrence of some daughter minerals, even in inclusions of low salinities, is further evidence that these minerals are not simple chlorides. In an attempt to extract some of the crystals, the host carbonate was dissolved in dilute hydrochloric acid. Those remaining proved to be largely hexagonal in shape (fig. 1*c*). This sparse residue gave an X-ray powder photograph corresponding with a mixture of baryte and hematite (the latter was almost certainly due to the solid hematite inclusions mentioned earlier). This was corroborated by determining the approximate refractive index, 1.65 (cf. baryte, *n* 1.636–1.649). Other optical properties could not be investigated due to the small size of the crystals and consequent lack of interference colour.

The use of a dispersive X-ray analyser coupled to a scanning electron microscope has recently been successfully employed in the investigation of fluid inclusion daughter phases (e.g. Le Bel, 1976). This technique proved particularly useful in the present study. Although actual mineral identification is not unequivocal, an idea of the chemical composition is possible (fig. 1*d*, *e*, and *f*).

It was apparent when viewing the inclusions, via the SEM, that many daughter phases had 'disappeared' when the inclusions were broken open. Presumably they were either redissolved or became deliquescent when in contact with the atmosphere. No more than three daughters were noted in any one inclusion, compared to populations of up to six when observed in thin section. The partial qualitative analyses of those remaining revealed the following, in order of decreasing abundance: calcium-iron-manganese minerals; calcium compounds containing varying quantities of titanium, cerium, lanthanum, and neodymium; barium-sulphur minerals (possibly baryte); and silicates of various compositions.

Occasionally a precipitate developed from the evaporated inclusion fluid that gave a positive response for either Ba-S or Ca-Mn-Fe (fig. 1*g*). Apart from calcium, none of the above elements was detected in the host carbonate. It should be noted that calcium was always detected in the analyses due to a substantial contribution from the inclusion wall.

Conclusions. The observations presented above lead to the conclusion that the calcite was deposited from a boiling aqueous solution of abnormally high temperature for the environment described. The apparently unusual chemistry of the fluids with respect to the host mineral, (as indicated by that of the daughter phases) *may* prove to be relatively common should similar studies be carried out on other samples. The calcite was deposited after the baryte, but how long after is unknown. There is some evidence to suggest that perhaps the provenance of the calcite is not completely different from that of the baryte (e.g. the Ba-S component of the carbonate's inclusions, and the similarity in Na/K ratios for the two minerals).

Regarding the heat source involved in generating these high-temperature fluids, the local doleritic dyke swarms provide the most likely source.

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REFERENCE

Le Bel (L.), 1976. *Bull. Soc. Vaud. Sci. Nat.*, no. 350, **73**, 1-8.

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New data for cuprotungstite

CUPROTUNGSTITE from La Paz, Lower California, one of the type localities, and Cave Creek, Arizona, was used for proving that the powder data of cuprotungstite published by Escobar and Gifford (1961) is incorrect and does not refer to this species. The powder pattern obtained for the mineral in the new study can be indexed on the basis of a tetragonal cell with *a* 8.93 and *c* 14.48 Å. The three strongest lines are: 4.03 (8) 210; 3.80 (8) 113, 202; 2.53 (10) 303.

Among the secondary minerals from the Clara mine near Oberwolfach in the Black Forest, Germany, the author discovered a green mineral that according to an analysis by the electron microprobe was a copper tungstate (Walenta, 1975, p. 405). Comparison of the powder pattern of this mineral with that of cuprotungstite (Escobar and Gifford, 1961), the only copper tungstate known in nature until now, however, showed no agreement between the two patterns.

This discrepancy could be interpreted in two ways, either the mineral from the Clara mine was a new species—a copper tungstate differing from cuprotungstite in composition or in structure—or the powder data for cuprotungstite published by Escobar and Gifford and given in the ASTM powder diffraction file (No. 19-392) was wrong. As will be shown in the following, the second assumption turned out to be true.

In order to solve the problem the author sought to obtain type material of cuprotungstite. The species had been described as cuproscheelite from the vicinity of La Paz, Lower California, Mexico, by Whitney (1866), and as cuprotungstite from the copper mines of Llamuco near Santiage, Chile by Adam (1869). More information on the mineral in question was provided by Schaller (1932) who studied material from Cave Creek, Maricopa County, Arizona (see also Palache *et al.*, 1951). As to the powder data of Escobar and Gifford, they