AMBLYGONITE, CASSITERITE, AND ASSOCIATED MINERALS FROM CÁCERES, WESTERN SPAIN

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ABSTRACT

A detailed description of the physical and chemical properties of amblygonite (montebrasite, $LiAl(OH, F)PO_4$) from Cáceres, Western Spain, is given. The amblygonite occurs in pneumatolytic tin veins. Associated minerals include quartz, cassiterite, muscovite, apatite, and the sulfides stannite, chalcopyrite, sphalerite, and arsenopyrite. Feldspar is absent.

A new occurrence of the rare phosphate minerals augelite ($Al_2PO_4(OH)_3$) and childrenite ($(Fe, Mn)AlPO_4(OH)_2 \cdot H_2O$) has been found.

Cassiterite from two localities of Cáceres province has been analyzed by chemical and quantitative spectrochemical methods. Special attention has been paid to the presence of titanium, columbium, and tantalum.

INTRODUCTION

Amblygonite has been found at several localities in Western Spain, associated with tin deposits. In the following, the amblygonite of the two occurrences near Cáceres (39°28′N, 6°22′W) will be described. One of the deposits is situated 6 miles S. of Cáceres at the locality called Trasquilón. The lithium mineral occurs in veins which invade a body of altered muscovite-rich granite, a mile in diameter. The granite bears tourmaline and sporadically torbernite. The veins are no more than one to three feet thick and composed chiefly of quartz and amblygonite with subordinate cassiterite and minor apatite, whereas feldspar is absent. In some of the veins extremely fine grained muscovite resembling wax replaces all the other minerals. It is of later origin. Roberts (1948) reported a similiar occurrence from Uganda.

The rare phosphates augelite, childrenite, and pseudomalachite ($Cu_5(PO_4)_2(OH)_4 \cdot H_2O$) have been found for the first time at Trasquilón. Several sulfides are imbedded in the quartz and amblygonite. They include stannite (common variety, an isotropic and a pink variety. An account of the different varieties of stannite is given by Ramdohr (1944)), chalcopyrite, sphalerite, arsenopyrite, pyrite, covellite, pyrrhotite, and bismuth.

Amblygonite and cassiterite have been mined, the latter mainly from placers.

The second occurrence of amblygonite lies 3 miles SE of Cáceres and is called Valdeflores. It is very similar to the first one, but the veins are intrusive into tourmalinized schists of Silurian Age. The tourmalinization is prior to the formation of the deposit. Muscovite, often referred to as pyrophyllite, is abundant in all the veins. Under the microscope flaky

masses of this mineral are seen to replace quartz, amblygonite, apatite, and cassiterite. At present only the latter is being mined.

An unusual occurrence of a white clay mineral has been found in one of the veins of Valdeflores. It consists of about 60% "fireclay," decomposed feldspar, and montmorillonite. The apatite contains up to 0.3% manganese, is bluish, and sometimes globular with a radiating subfibrous structure (see Fig. 1). No rare phosphates have been found here.

Cassiterite as well as wolframite are widespread in Western Spain, but they are not associated with each other in the deposits described here. The cassiterite from the amblygonite deposit of Trasquilón and the

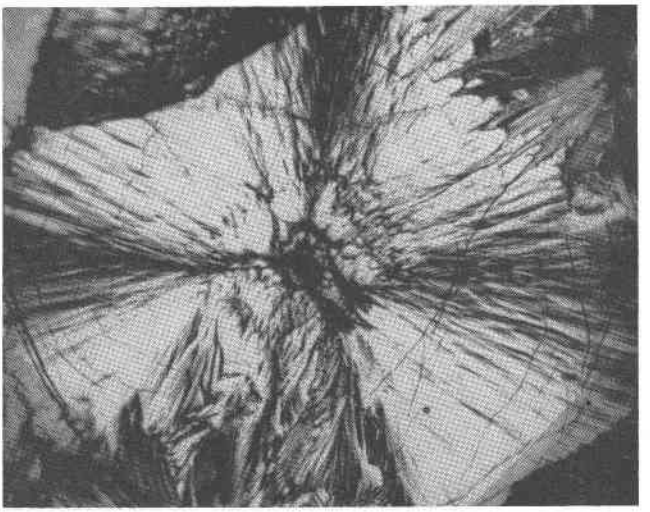

FIG. 1. Globular apatite showing radiating structure, with some muscovite. Crossed nic., ×24. Valdeflores.

cassiterite from Logrosán, 50 miles ESE of Cáceres, still in Cáceres province, will be studied. At Logrosán a body of granitic rock outcrops, 1 mile in diameter, forming a steep hill. It is invaded by many tin-bearing quartz veins, the richest being only a few inches thick. Generally the cassiterite is massive, but sporadically well-developed crystals are imbedded in the clay of the veins. Amblygonite, apatite, and autunite have been found. The sulfides found at Trasquilón could be detected here as well. Muscovite is frequent in the contact with the wall-rock. The tin is being mined.

AMBLYGONITE

The amblygonite or more exactly, montebrasite, from both Trasquilón and Valdeflores is massive. No crystals have been found. It is white with

patches of greenish-blue due to a copper content of about 0.001–0.01%. Polysynthetic twinning on $(\overline{1}\overline{1}1)$* is developed in all the thin sections examined. A rectangular structure due to two sets of microscopic lamellar twinning is frequent (see Fig 2). On the universal stage it could be shown that the two sets of lamellae are twinned on the same law $(\overline{1}\overline{1}1)$, but with different composition planes, namely $(\overline{1}\overline{1}1)$ and an irregular plane.

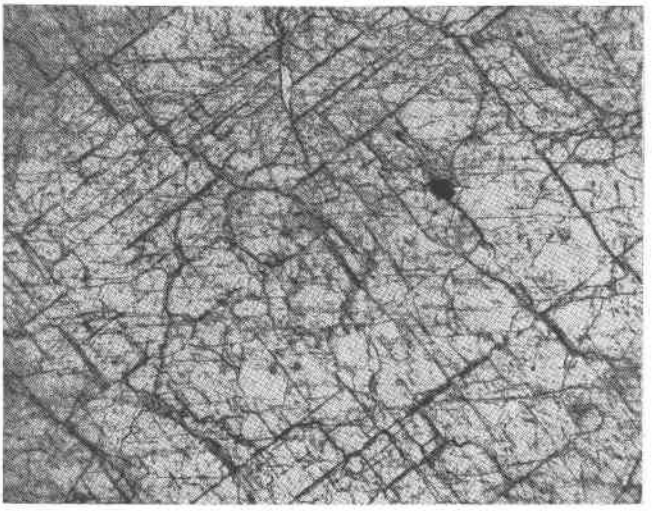

FIG. 2. Amblygonite showing rectangular structure due to twinning on $(\overline{1}\overline{1}1)$. Crossed nic., ×24. Trasquilón.

TABLE 1. THE OPTICAL PROPERTIES OF THE MONTEBRASITE FROM TRASQUILÓN (6 Miles S. of Cáceres, W. Spain)

α (Na)	1.612		ϕ	ρ
β	1.620 (calculated 1.621)	X	23°	62°
γ	1.635	Y	−80°	68°
(correct to 0.001)		Z	158°	38°
$2V_\gamma$ 78° (correct to 2°)			(correct to 2°)	

Optical Properties

The refractive indices were determined by means of suitable immersion liquids on the universal stage.

In thin section two cleavage directions are represented which are (100) and $(0\overline{1}1)$, with (100) being perfect. By means of these cleavages the

* Crystallographic orientation proposed by Richmond and Wolfe (1943).

TABLE 2. NEW DETERMINATIONS OF THE OPTICAL ORIENTATION OF AMBLYGONITE

	ϕ			ρ		
	I	II	III	I	II	III
X	19°	19°	23°	83°	69°	62°
Y	−72°	−78°	−80°	69°	72°	68°
Z	130°	156°	158°	21°	28°	38°

I. Hebron, Maine, USA. Fluorine content 5.45% (Palache 1943).
II. Karibib, SW. Africa. Fluorine content 5.40% (Nel 1946).
III. Trasquilón, Cáceres, W. Spain Fluorine content 1.13%

optical orientation of the amblygonite from Trasquilón was established on the universal stage. So far the optical orientation of fluorine-poor amblygonite has never been exactly determined. The data given by Pehrman (1945) for montebrasite from Kimito (Finland) with 0.57% fluorine are erroneous, because he used erroneous cleavages based on the old data of Dana. Transforming Pehrman's values, the writer obtained

TABLE 3. CHEMICAL AND SPECTROCHEMICAL ANALYSIS (BY THE AUTHOR) OF THE MONTEBRASITE FROM CÁCERES (W. SPAIN)

Montebrasite from Trasquilón (6 miles S. of Cáceres)				Montebrasite from Valdeflores (3 miles SE. of Cáceres)			
Li_2O	9.57	*Formula*		Li_2O	9.22	*Formula*	
Na_2O	0.11	Li, Na	1.91	Na_2O	0.59	Li, Na	1.91
Al_2O_3	34.7	Al	2.02	Al_2O_3	34.4	Al	2.03
P_2O_5	48.0	P	2.01	P_2O_5	47.3	P	2.00
H_2O	6.4	OH, F	2.00	H_2O	5.2	OH, F	2.00
F	1.13	O	8.00	F	4.40	O	8.00
Rem.	0.26	H_2O	0.14	Rem.	0.45	H_2O	0.21
	100.17				101.56		
F=O	0.48	OH:F=10:1		F=O	1.85	OH:F=2:1	
Total	99.69			Total	99.71		
Rem: MgO	0.1			Rem: MgO	0.2		
SiO_2	0.05			SiO_2	0.1		
SnO_2	0.06			SnO_2	0.02		
TiO_2	0.05			TiO_2	0.13		
In terms of the end members:				In terms of the end members:			
Montebrasite	91%			Montebrasite	65%		
Amblygonite	9%			Amblygonite	35%		

nearly the same orientation as that given below for the amblygonite from Trasquilón.

Chemical Properties

The amblygonite is not quite free from impurities. Under the microscope very small inclusions are seen which are probably muscovite.

The fluorine was determined by the distillation method. A spectrogram revealed the presence of noteworthy amounts of magnesium, silicon, tin, and titanium. With the exception of titanium they were determined spectrochemically. Cathode layer excitation was used with iron as an internal standard. The values are correct to about 30%. The silicon content is obviously due to the inclusions. The determination of titanium was made by the colorimetric method after separation of the fluorine.

Augelite and Childrenite

A new occurrence of augelite and childrenite has been found in the amblygonite veins at Trasquilón. Augelite occurs in tabular crystals

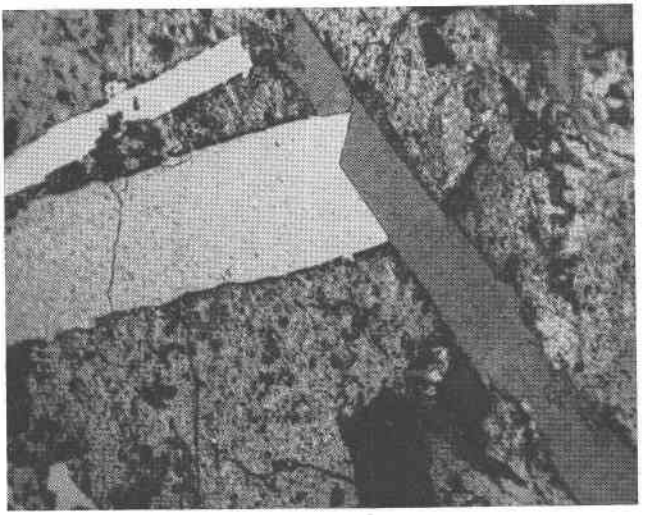

Fig. 3. Augelite laths imbedded in impure amblygonite. Crossed nic., ×24. Trasquilón.

intergrown with amblygonite (see Fig. 3). Well-developed but superficially greenish (due to copper) and dull crystals were discovered in a geode (see Fig. 4). On the universal stage the same optical properties were found as reported by Peacock and Moddle (1941).

Childrenite has been found only in some druses as small, brittle, long

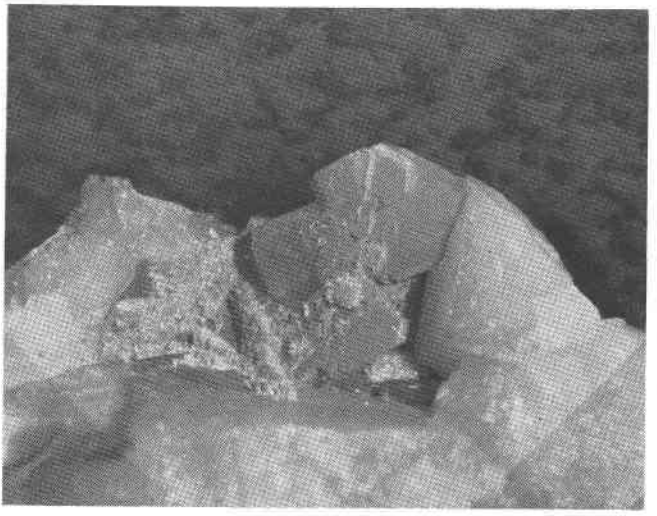

FIG. 4. Tabular crystals of augelite on quartz, with some acicular apatite. ×2. Trasquilón.

prismatic crystals, color brownish. The childrenite could be verified by an x-ray powder pattern. On the universal stage the following optical data (Table 4) were determined. Material is too scarce for chemical analysis.

TABLE 4. OPTICAL DATA OF THE CHILDRENITE FROM TRASQUILÓN

(6 Miles S. of Cáceres, W. Spain)

α (Na)	1.647	$2V_\alpha$ 33° (correct to 2°)
β calculated	1.669	
γ	1.671	Dispersion $r>v$, strong
(correct to 0.001)		

CASSITERITE

At Trasquilón the cassiterite is imbedded in quartz and amblygonite along the contacts of the veins. In the hand specimen it is nearly black and in thin section highly pleochroic with ω green and ϵ red. All the crystals are twinned and show marked zonal banding (see Fig. 5).

At Logrosán excellent crystals of cassiterite are found in veins where the quartz is replaced by clay. They are brown and less pleochroic with complex twinning and zonal structure.

The chemical properties of the cassiterite have been studied in detail by spectrochemical methods. For the determination of iron, columbium, and tantalum cathode layer excitation was employed. Tin served as an

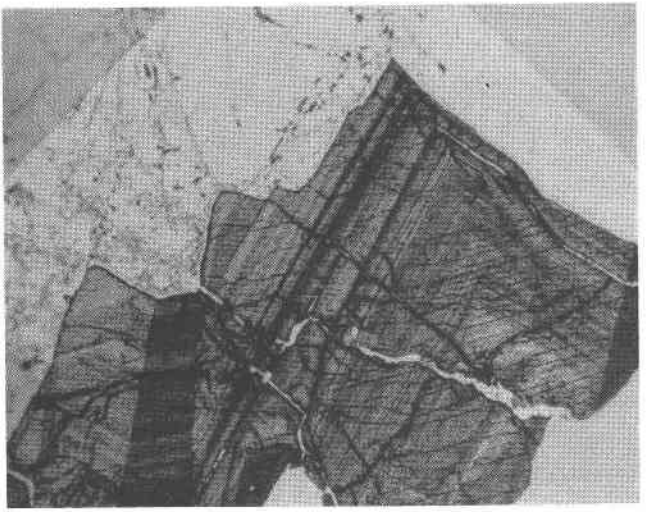

FIG. 5. Zonal cassiterite showing twinning and pleochroism, with muscovite penetration. One nic., ×24. Trasquilón.

internal standard for iron, and iron as an internal standard for columbium and tantalum. The lines used for columbium and tantalum were Cb I 2657.616, Ta I 2653.274, and Fe I 2651.706 (internal standard line). The accuracy obtained is not too high, perhaps between 20 and 30%. The presence of scandium, molybdenum, and tungsten could not be established in the spectrograms.The determination of titanium was made by the colorimetric method.

TABLE 5. CHEMICAL AND SPECTROCHEMICAL ANALYSIS (BY THE AUTHOR) OF CASSITERITE FROM CÁCERES PROVINCE (W. SPAIN)

Cassiterite from Trasquilón (6 miles S. of Cáceres)				Cassiterite from Logrosán (50 miles ESE. of Cáceres)			
		Formula				*Formula*	
SnO_2	97.5	Sn	0.966	SnO_2	97.5	Sn	0.960
Fe_2O_3	1.0	Fe	0.019	Fe_2O_3	0.3	Fe	0.006
TiO_2	0.2	Ti	0.004	TiO_2	1.5	Ti	0.028
Cb_2O_5	0.7	Cb	0.008	Cb_2O_5	0.5	Cb	0.006
Ta_2O_5	0.7	Ta	0.005	Ta_2O_5	0.02	O	2.000
Total	100.1	O	2.000	Total	99.8		

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