

## **Calderonite, a new lead-iron-vanadate of the brackebuschite group**

**JOSÉ GONZÁLEZ DEL TÁNAGO,<sup>1,\*</sup> ÁNGEL LA IGLESIA,<sup>2</sup> JORDI RIUS,<sup>3</sup> AND SOLEDAD FERNÁNDEZ SANTÍN<sup>1</sup>**

<sup>1</sup>Departamento de Petrología y Geoquímica, Facultad de Ciencias Geológicas, Universidad Complutense, 28040 Madrid, Spain

<sup>2</sup>Instituto de Geología Económica, C.S.I.C., Facultad de Ciencias Geológicas, Universidad Complutense, 28040 Madrid, Spain

<sup>3</sup>Institut de Ciències de Materials de Barcelona, C.S.I.C., Campus de la UAB, 01893 Bellaterra, Catalunya, Spain

### **ABSTRACT**

Calderonite, ideally  $\text{Pb}_2\text{Fe}^{3+}(\text{VO}_4)_2(\text{OH})$ , a new member of the brackebuschite group, has been found in the upper oxidation zone of two Pb-Zn hydrothermal deposits located at Santa Marta and Azuaga, Badajoz province, Spain. Brackebuschite and calderonite probably form a complete solid solution, locally with important substitution of Cu and Zn for Fe and Mn. The monoclinic cell parameters derived from powder X-ray diffraction (XRD) data are:  $a = 7.647(5) \text{ \AA}$ ,  $b = 6.094(1) \text{ \AA}$ ,  $c = 8.900(2) \text{ \AA}$ ,  $\beta = 112.0(2)^\circ$  and  $V = 384.5(4) \text{ \AA}^3$ , and the six strongest lines,  $d$ -spacing ( $\text{ \AA}$ ),  $(hkl)$ , are: 4.893(4)(011), 4.166(3)(002), 3.242(10) ( $\bar{2}11$ ), 3.058(3)(020), 2.980(5) ( $\bar{1}03$ ) and 2.746(5)(003). Electron microprobe analyses (EMPA) show a certain degree of compositional variation not only between the Santa Marta and Azuaga samples but also among grains from the same locality. A representative formula of Santa Marta calderonite, determined from EMPA, based on 9 O atoms: is  $(\text{Pb}_{1.950}\text{Ca}_{0.004}\text{Ba}_{0.015})_{1.969}(\text{Fe}^{3+}_{0.892}\text{Cu}_{0.059}\text{Zn}_{0.008}\text{Al}_{0.015})_{0.974}(\text{V}_{1.847}\text{As}_{0.008}\text{Si}_{0.039}\text{P}_{0.057})_{1.951}\text{O}_{7.507}(\text{OH})_{1.493}$ .  $\text{Fe}^{3+}$  is principally substituted by  $\text{Cu}^{2+}$ , and  $\text{V}^{5+}$  by  $\text{Si}^{4+}$ .  $\rho_c = 6.05 \text{ g/cm}^3$ . The thermogravimetric analysis yields a weight loss of 1.91%, which corresponds to the 1.493 H needed to maintain the charge balance. Differential thermal analysis shows endothermic effects at 279 and 663 °C due to dehydroxylation.

A single-crystal XRD refinement was carried out on a selected crystal with cationic content determined by EMPA and starting atomic positions from brackebuschite. Final R-value of 5.81% based on 952 reflections with  $I > 2\sigma$ , assuming  $P2_1/m$  symmetry, the cell dimensions are  $a = 7.649 \text{ \AA}$ ,  $b = 6.101 \text{ \AA}$ ,  $c = 8.904 \text{ \AA}$ ,  $\beta = 112.23^\circ$ .

Calderonite is red orange to red brown, semitransparent to translucent with vitreous luster and red streak and powder. The fracture is splintery. Optically, it is biaxial positive, with a  $2V_x = 86^\circ$  and strong dispersion. In plane-polarized light, it is strongly pleochroic (X = light greenish brown, Y = brown, Z = reddish brown).