Representative size distributions of framboidal, euhedral, and sunflower pyrite from high-resolution X-ray tomography and scanning electron microscopy analyses

RAUL MERINERO[1],*, VÍCTOR CÁRDENES[2], ROSARIO LUNAR[1,3], MATTHIEU N. BOONE[4], AND VEERLE CNUDDE[2]

[1]Department of Crystallography and Mineralogy, Complutense University of Madrid, C/ Jose Antonio Novais, 2, 28040 Madrid, Spain
[2]PProGRess-UGCT Department of Geology, Ghent University, Krijgslaan 281 (S8), 9000 Ghent, Belgium
[3]Geosciences Institute, Department of Crystallography and Mineralogy, Complutense University of Madrid, C/ Jose Antonio Novais, 2, 28040 Madrid, Spain
[4]Radiation Physics-UGCT Department of Physics and Astronomy, Ghent University, Poeftuinstraat 86 (N12), 9000 Ghent, Belgium

ABSTRACT

A statistical procedure designed to obtain representative size distributions for different morphologies and arrangements of pyrite is described here. This statistical procedure is applied to data acquired during scanning electron microscopy (SEM) and high-resolution X-ray tomography (micro-CT) analyses. The statistical procedure was tested in methane-derived carbonate pipes recovered in the Gulf of Cadiz. These samples contain abundant pyrite together with pseudomorph iron oxyhydroxides showing multiple morphologies including euhedral crystals, framboids, and sunflowers (framboidal core with outer crystals).

The SEM analysis consisted in the establishment of independent populations of pyrite and iron oxyhydroxides grouped by morphology and arrangement and the determination of its size distributions. Micro-CT analysis included a determination of the 3D volume of pyrite from the density difference between pyrite and the rest of mineral forming the samples. The use of the micro-CT technique implies that minerals with similar attenuation coefficients than those of pyrite are scarce or not present in the studied samples. A filtering process was applied to the 3D volume. This filtering process consisted of the selection of objects with corrected sphericity greater than 0.80, discrete compactness greater than 0.60, elongation and flatness of the circumscribed 3D ellipsoid less than 1.80 and the sum of the elongation and flatness less than 3. Objects with shapes similar to those expected in pyrite (spheroidal and regular shapes) were selected with this filtering process. The optimal mixture of lognormal size distributions was obtained applying statistical techniques to the entire size distribution represented by the filtered objects. The correspondence between size distributions obtained during the SEM and the micro-CT analyses was done by matching statistical parameters and using 3D renderings. The representative size distributions of pyrite as determined by the proposed 3D processing methodology can be used to accurately quantify the paleo-environmental conditions of pyrite formation, which would solve some of the limitations resulting from analyses based on 2D images.

Keywords: Pyrite, size distributions, framboids, euhedrae, sunflowers, micro-CT