

CLASSIFICATION OF MARTIAN JAROSITE. C. Upadhyay¹, G. Klingelhöfer¹, I. Fleischer, C. Schröder¹, D. Rodionov^{1,3}, M. Panthöfer¹, R. Jung-Pothmann¹, N. Tahir¹, T. Hager² and W. Tremel¹, ¹Institut für Anorganische und Analytische Chemie, Johannes Gutenberg Universität, 55128 Mainz, Germany, ²Institut für Geowissenschaften, Johannes Gutenberg Universität, 55128 Mainz, Germany. ³Space research Institute, IKI, 117997, Moscow, Russia.

Introduction: The discovery of Jarosite by MER on the Martian surface has been one of the important discoveries of the mission [1]. It has not only sealed few intriguing questions about the presence of water on Mars but gave a chance to look into the Martian mineralogy with a new point of view. The findings brought a new surge in the sulfate mineral research. Based on the elemental composition of the soil, presence of other sulfate minerals has been doubted. Various studies have been made with synthetic as well as natural sulfate minerals, posing few doubts but leaving with out any conclusions. In order to make more conclusive studies related to the findings and associated measurements done by MER and classification of Jarosite in particular, we studied several Jarosite samples collected from almost all over the globe, and also synthetic samples prepared in our lab.

Experimental: A series of Jarosite samples has been obtained from Museum Bonn and Museum Freiberg. A systematic and extensive investigation has been done with these samples. Elemental analysis and studies of zoning in Jarosite has been carried out by using a combination of electron microprobe (EMP), back scattered imaging (BSE) and energy-dispersive (EDS) mapping technique. X-ray diffraction of natural samples is quite difficult to deal with because of the presence of different associated minerals and their varying percentage. We chose Micro x-ray diffraction where the incident x-ray beam is focused in a circle with a diameter of around 100 μm . This allowed us to pick up selected areas with minimal phase differences. Mössbauer spectroscopy has been used for the iron phase analysis and finding the hyperfine parameters for different end member Jarosites.

Result and discussion: Physical appearance, color and crystallinity of the sample vary with composition. e.g. Argento jarosite is brittle in nature with golden yellow in color, whereas Na end member jarosite has been found to be dull yellow and well crystalline. Figure 1 shows a representative electron back scattered image of a jarosite sample obtained from Esperanca Mine, Barranco Jaroso, Sierra Almagrera in Spain. Elemental analysis shows the presence of iron, sulphur, potassium and sodium. We see well defined zones of crystal growth. Zoning in Jarosite is mainly because of the presence of two end member jarosites Na- and K-jarosite, respectively [2]. Such a hypothesis has been confirmed in this case as well. EDS mapping reflects darker regions as pure Na end member Jarosite while lighter region has been confirmed as K end member Jarosite. Without going into detail about zone formation in jarosite, we will be

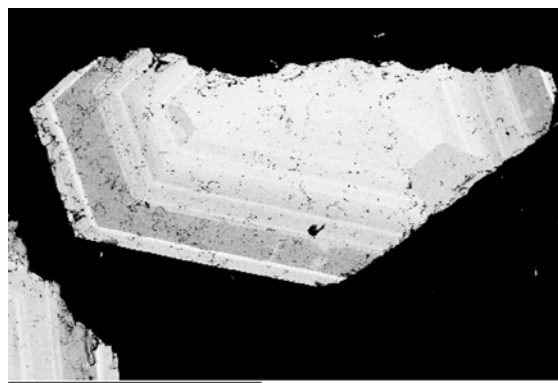


Fig. 1. Back Scattered Electron image of Jarosite crystal obtained from Esperanca Mine, Barranco Jaroso, Sierra Almagrera/Spain.

using zoned sample to see if we can distinguish between the two different kinds of jarosites by using other characterization techniques. For such a comparison we selected three different classes of jarosite: pure Na end member jarosite, (sample obtained from Laurion region in Greece); pure K end member jarosite (synthetic sample) and a sample with the presence of both classes (without any mixed composition of Na and K, but rather having well separable phases).

Figure 2 shows the micro x-ray diffraction pattern for the chosen samples. Because of the absence of a pure K jarosite natural sample, we synthesized the K jarosite using the method described by Driscoll and Leinz [3]. Although there are intensity differences in the diffraction pattern of the two samples it is quite indecipherable when there is a mixed composition. It may be noted that the situation becomes more and more complex when other minerals are involved. In such a situation x-ray diffraction alone may not prove much useful for the mineralogical studies of natural samples.

In order to further classify these systems we did extensive Mössbauer spectroscopic studies with these samples using MIMOS II. Figure 3 shows the Mössbauer spectra of Na end member jarosite obtained from Laurion region in Greece, synthetic K end member jarosite, and samples obtained from Esperanca mine (Fig. 1) which contains the mixture of both the Na end member and K end member jarosite phases. A careful analysis of Mössbauer parameters, as obtained by this study, and from available literature data[4], suggests clear differences in the hyperfine parameters of

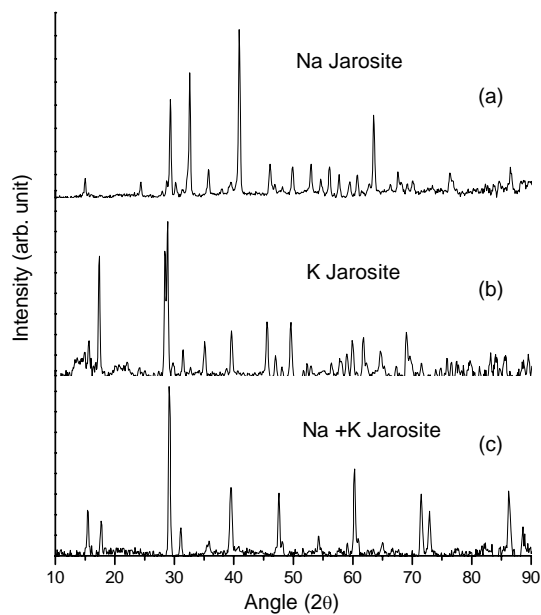


Fig. 2 X-ray diffraction pattern of (a) Na end member (b) K end member and (c) mixed jarosite.

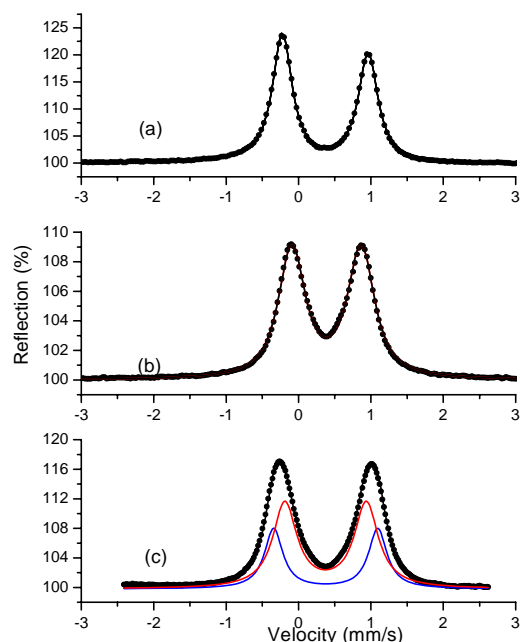


Fig. 3 Mössbauer spectra of (a) Na end member, (b) K end member and (c) mixed jarosite.

pure jarosite end members and when it is combination of two different end members. K end member jarosite has hyperfine parameters with the Isomer shift values lying in the range of 0.38-0.39 mm/s and quadrupole splitting (QS) in the range of 1.02 -1.15 mm/s [4] where as it is evident that values of QS for the mixed composition are slightly higher than 1.10 mm/s. We were able to separate out the two phases originat-

ing from different compositions (Na end member and K end member) in the sample where both are present (Fig 3c). This systematic observed in our study is consistent with the results reported in [4]. Coming back to the Martian jarosite, the hyperfine parameters have been found to lie in the vicinity of I.S. = 0.36-0.39 mm/s and Q.S.= 1.16-1.22 mm/s [1,6]. Looking to the elemental composition of the Martian samples it has been suggested that jarosite to be most likely Na jarosite, as the amount of potassium in the soil is quite less as compared to sodium. However it may be noted that for the precipitation of K jarosite the minimum amount of potassium needed is much less than the needed sodium (sodium should exceed 10^{-7} molal while a minimum amount of K is needed to exceed 10^{-11} molal [5]). The other possibilities, which have been proposed recently, are other sulfate minerals. In order to extend the exclusion of possibilities of other sulfate minerals we looked into the Mössbauer parameters of these minerals. Figure 4 shows the I.S. and Q.S. plot for the different possible sulfate minerals. It is very clear that other sulfate minerals fall significantly away from the Jarosite zone.

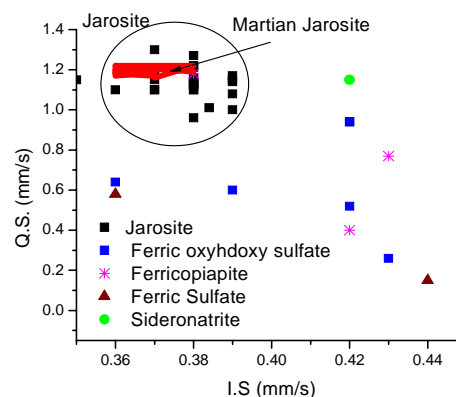


Fig. 4: I.S. and Q.S. plot for different possible sulfate minerals. (Sulfate minerals having Fe^{2+} have been excluded)

Considering all the factors we can extend the classification of Martian jarosite as a mixed phase jarosite, may be having a well developed zoned composition of two end members. Summarizing all these results one can safely say that with the exclusive help of Mössbauer spectroscopy it is not only possible to identify the Iron minerals but it also can be used further to classify the different sub classes of the minerals found on the Martian surface.

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