HYPERSPECTRAL CHARACTERISTICS OF JAROSITE OF WARKALLI FORMATION, VARKALAI, SOUTHERN INDIA: IMPLICATIONS TO MARS. Mahima Singh*[1], Anmol Garg[1], V.J. Rajesh[1], K.S. Sajinkumar[2], S.N. Kumar[2]. [1]Indian Institute of Space Science and Technology, Thiruvananthapuram; [2]Department of Geology, University of Kerala, Thiruvananthapuram, Kerala, India (*Corresponding author: <snghmahima@gmail.com>).

Introduction: Jarosite [$KFe_3^{+3}(OH)_6(SO_4)_2$] is a very significant mineral in defining the palaeo-environmental conditions of any localized to extensive region on Earth as well as other hydrated terrestrial planets such as Mars. Jarosite is found in diverse conditions on Earth viz. commonly associated with acid mine drainage, acid sulfate soil environment and gossan (upper oxidized layer during supergene enrichment process) as a secondary mineral [1]. Jarosite has been studied as a potential scavenger of heavy metals [2], [3] and [4] because of its very less solubility in water [5]. Understanding its formation mechanism is of great importance as jarosite is very rare on earth. There is only one known deposit in India i.e. in Deccan Volcanic Province (DVP). On Mars, occurrence of jarosite clearly indicates hydrous (acidic) palaeo-environment conditions on the planet [6], [7]. Therefore, jarosite is considered as a very significant mineral in delineating the palaeo-environmental conditions of Mars. We report here hyperspectral and preliminary Laser Raman analyses of the jarosite intermixed with clay group of minerals, collected from Warkalli Formation, Varkalai in southern India which we consider as a potential chemical analogue site for the jarosite in Mawrth Vallis region, Mars [8].

Geological Setting: Geologically, the study area forms a part of Kerala Khondalite Belt (KKB) of the Southern Granulite Terrain (SGT) of India (Fig. 1). The Precambrian crystallines of this area are unconformably overlain by the Tertiary sequence of Warkalli Formation with no representation of the Palaeozoic and Mesozoic formations. Varkala Cliff exposes all the lithounits of this formation viz. unconsolidated sands, variegated clays, white plastic clays and carbonaceous sandy clays enclosing impersistent seams and lenses of lignite [9], [10], [11]. Presence of lignite indicates an acidic condition which is favourable for the formation of sulphide (pyrite and marcasite) rich sediments [12]. The carbonaceous clays and lignite are often impregnated with sticks and nodules of marcasite and/or pyrite which indicate a reducing environment. Presence of marcasite and/or pyrite facilitates jarosite to crystallize in this particular region. This report of jarosite is the first in this part of the tropical world.

Methodology: A systematic field study has been conducted in the study area to understand the occurrence of jarosite and its relation to other hydrous and sulfide minerals (Fig. 2). Systematically collected samples from the field have been analyzed in laboratory conditions to generate the reflectance spectra of the minerals using a FieldSpec3 ASD spectrometer. This spectrometer works in the spectral range of 350-2500 μm. Obtained reflectance spectra of the samples have been compared with the mineral spectra from USGS spectral library. The representative samples have been powdered by taking every necessary measures to avoid contamination. These powder samples have been analyzed to generate the reflectance spectra and further matched with the reference spectrum of USGS spectral library. The powders of the same samples have been analyzed by Laser Raman method and the generated spectra have been matched with the reference spectra in Crystalslueth software.

Results: Hyperspectral data of the sample shows the absorption bands at 950 nm, 1450 nm 1900 nm and 2200 nm which corresponds to Fe oxides, OH, H_2O and OH, respectively, with the reference of USGS spectral library (Fig. 3). The characteristic absorption band around 2300 nm in the reference USGS spectral library spectrum is also prominent in the hand specimen spectrum. Powdered sample spectrum shows the characteristic absorption band same as hand-specimen with relatively shallower absorption band due to Fe oxides at around 950 nm and very shallow and relatively broad absorption at 1450 nm. The absorption band at 2200 nm is same as that of hand-specimen.

To validate the hyperspectral results of the study, Laser Raman Analysis has also been done with the powdered samples of the study area. It has been found that the mineralogy of the collected samples mainly comprised of jarosite with a prominent absorption peak at 1005 cm^{-1} (Fig. 4). These results has been confirmed by in-built reference Laser Raman Spectrum in Crystalslueth software.

Comparison of the hyperspectral data of jarosite of Warkalli Formation with the Compact Reconnaissance Imaging Spectrometer (CRISM) data of MawrthVallis region on Mars shows matching trend of the spectral absorption bands at 1400 nm, 1900 nm and 2200 nm. Jarosite occurrence of Deccan Volcanic Province in

Kutch which is interpreted as a potential terrestrial analogue to Martian jarosite provides considerable interest to document Varkalai area as another analogue site in India.

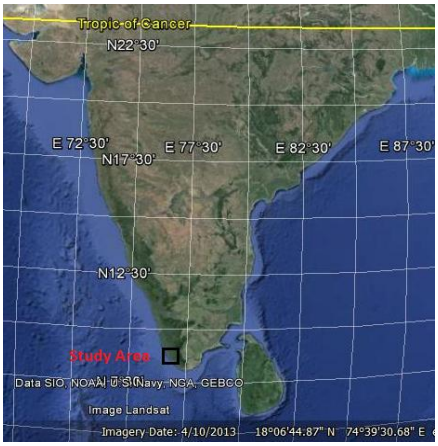

Figure 1. Location of the study area.

Figure 2. Occurrence of jarosite (greenish yellow) in the field setting along with marcasite (Black).

Summary and Conclusions: On Mars, localized occurences of jarosite has been detected in Mawrth Vallis region with the MRO-CRISM data, that indicate acidic ground or surface waters (8). Apart from jarosite in Mawrth Vallis region, Al-phyllosilicates are also the major hydrous mineral present. Warkalli Formation is also comprised mainly of Al-phyllosilicate and jarosite. Therefore this area could be considered as a potential chemical analogue site to the occurrence of similar mineralogical assemblage on Mars. Considering the fact that jarosite is having implications for the search for life on Mars, this analogue area could be studied further to add the knowledge for the identification of biological signatures in natural jarosites. Today it is an area of intensive research to look for the rocks or minerals, which could preserve the biological molecule into its crystal structure and Warkalli jarosite could be one of the possible proxies to be studied extensively to get the possible answers of many unsolved questions. Being an extremely rare mineral on earth jarosite provide significant clues regarding the temperature variation as it is only stable in arid conditions.

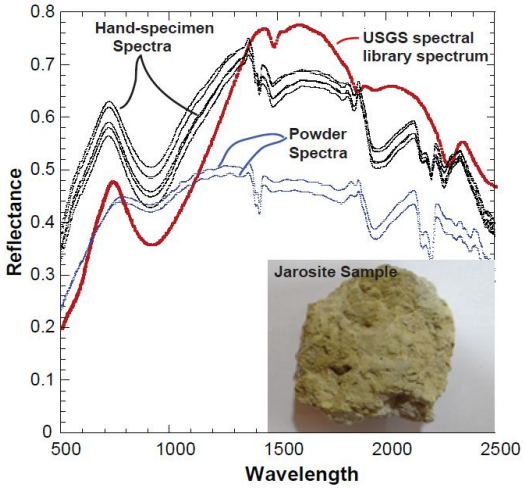

Figure 3. Reflectance spectra of Jarosite hand-specimen (Black) and powder (violet) from Warkalli Formation with reference USGS spectral library spectrum (red).

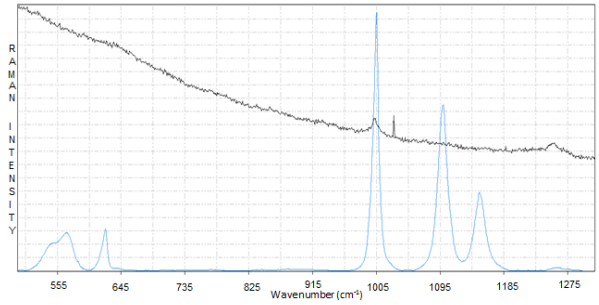

Figure 4. Laser Raman Spectrum of Jarosite (Black) with reference spectrum (blue) from Crystalslueth software having one matching absorption peak at 1005 cm^{-1}.

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