EPSC Abstracts
Vol. 6, EPSC-DPS2011-1861, 2011
EPSC-DPS Joint Meeting 2011

Hyperspectral study of hydrous sulphate minerals from Deccan Volcanic Province of Kutch, India: Implications for aqueous processes on Mars

Nirmala Jain, Satadru Bhattacharya, Prakash Chauhan, and Ajai.

Planetary Sciences & Marine Optics Division, Marine, Geo and Planetary Sciences Group, Space Applications Centre (ISRO), Ahmedabad - 380 015.

(nirmala@sac.isro.gov.in, satadru@ sac.isro.gov.in / Fax: +91-079-26915825)

Abstract

Here we present the reflectance spectra of Jarosite from the Deccan Volcanic Province (DVP) of Kutch, Gujarat (India). Jarosite (hydrous sulphate) ($KFe_3 3(OH)_6(SO4)_2$) occurs as lenticular bodies within the Paleocene sandstone belonging to the DVP of Kutch region. Jarosite is formed through the oxidation of iron sulphides under extreme conditions of low pH and high Eh. These sulphate layers are white to yellow in colour and are up to 1 m thick, and extend laterally for over a kilometre on both sides of Matanumadh area on Lakhpat road. Jarosite is also reported from different parts of Mars. Jarosite bearing sandstone unit belonging to DVP at Matanumadh can therefore be considered as a terrestrial analogue to Mars. Here we present the reflectance spectra of hydrous sulphates that have been collected from the study area using FieldSpec3 spectrometer (0.3µm - 2.5µm). Study of the reflectance spectra of hydrous sulphates and Jarosite in particular clearly indicates the presence of OH and H_2O in the crystal lattice of the alteration products. Reflectance spectroscopy of Jarosite and other hydrous sulphates will help in identifying optimum bands for identification of these minerals in remotely sensed data of Earth as well as on the Mars. Moreover, study of Jarosite from DVP of Kutch will help in understanding the fluid-rock interaction and aqueous alteration processes associated with volcanic activities on the Mars.

1. Introduction

In the international arena, it is widely recognised that Earth should be considered as the standard reference in order to start interpreting Mars, as Earth analogues can provide ground truth to constrain interpretations on geological history of Mars. With the discovery of hydrous sulphates from various parts of Mars, there is an increased interest in studying the Martian analogues on Earth in order to get insights into the processes that may have operated on Mars. In India, The Deccan Volcanic Province (DVP), in particular, Matanumadh and surrounding areas of Kutch, Gujarat can act as a potential analogue site for Mars because of its similarity with the Tharsis region on Mars. Study of hydrous sulphates and other rock-alteration assemblages help in understanding the aqueous processes associated with gigantic volcanic activities. In the present study, we have carried out spectral study of Jarosite and other clay minerals from the Matanumadh area of Kutch in order to understand the fluid-rock interactions and formation processes of hydrous sulphates.

1.1 Geology of study area

Lithological log of the studied section at Matanumadh (Fig. 1) comprises of Deccan basalts of Cretaceous period and laterite, variegated sandstone, conglomeritic sandstone (green), and rocks of Paleocene age represented by the sandstone, conglomerate and light brown shale [7]. Sedimentary rocks of Matanumadh Formation are characterised by the presence of sedimentary structures such as the Graded Bedding, cross-bedding, hummocky structures etc.

1.2. Hydrous sulphates on Earth and Mars

On Earth, the processes of formation of jarosite are varied. They include: oxidation of sulphide ore (pyrite) deposits [9], acid fumaroles [7],

and magmatic hydrothermal environments in sulphur spring [6].

Significant sulphate deposits on Mars occur within and near the equatorial Valles Marineris at Meridiani Planum [4], canyon system and in dunes around the north polar ice cap. Landing site of Opportunity Mars Exploration Rover (MER) indicated that the landing site was once saturated for a long period of time with liquid water [5], possibly of high salinity and acidity. Large amounts of magnesium sulphate (Kieserite) and other sulphate-rich minerals such as jarosite is found at Meridiani Planum. The reason for the association of sulphates with Valles Marineris is uncertain but could be due to a combination of SO_2 gas sourced from nearby Tharsis volcanism [3]. Jarosite also may be formed by the chemical weathering of basalts as observed in case of Jarosite deposits of DVP.

2. Results

Sulphate-bearing minerals experience hydration changes under the wetter climate. Visible and Near-Infrared (VNIR) spectra were used to identify sulphates and their hydration states. Reflectance spectra of this mineral shows the absorption feature at 0.92 µm which could be attributed to the $Fe3^+$ charge transition. Apart from this, 1.4 and 2.27 µm shows the presence of OH and 1.85 µm for H-O-H/OH bending, 1.93 µm for H_2O combination.

3. Figures

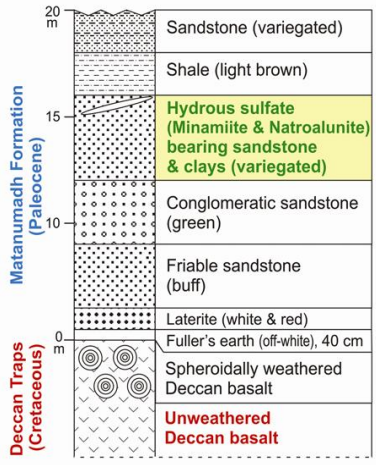

Figure 1. Lithological log of the studied section at Matanumadh showing the stratigraphic position of the minamiite-bearing hydrous sulphate layer (After [7]).

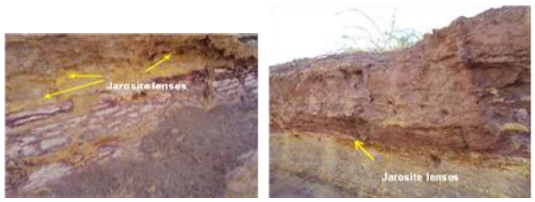

Figure 2. Field photograph showing hydrous sulphates within variegated sandstone unit from Matanumadh, Kutch.

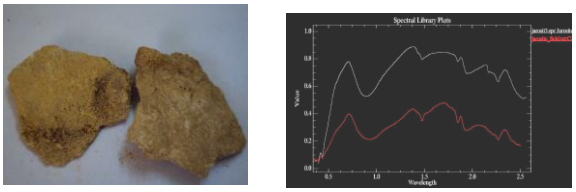

Figure 3. Reflectance spectra of jarosite from DVP (Red) and pure Jarosite spectra from USGS spectral library for minerals (White).

4. Summary and Conclusions

The Deccan Volcanic Province of kutch (Gujarat, India) can be considered as a potential analogue for Martian hydrated sulphates as it has been formed through hotspot activities and having a similar geological set up as that of Tharsis region on Mars. Jarosite of Matanumadh area is associated with Paleocene sandstone and clay minerals such as natroalunite ($NaAl_3(SO_4)_2(OH)_6$), alunite and kaolinite [7]. These deposits might have formed by the oxidation of pyritic shale [2] and/or Solfataric alteration of volcanic ash [8] and formed under extreme conditions of low pH. The sulphate exposures in the Matanumadh, Kutch indicate that similar processes might have occurred on Mars.

Acknowledgements

We express our thanks to Dr. R. R. Navalgund, Director, SAC for his enduring support and encouragement in this study. We are also thankful to Shri A. S. Kiran Kumar, Associate Director, SAC and Dr. J. S. Parihar, DD, EPSA for their valuable guidance and support.

References

[1] C. Fan A., D. Schulze-Makuch A., H. Xie B.: Sulphate formation and its relevence to environmental conditions on early Mars, Martian Sulphates as Recorders of Atmospheric-Fluid-Rock Interactions, pp. 7033, 2006.

[2] D. V. Chitale and Guven: Natroalunite in a laterite profile over Deccan Trap basalt at Matanumadh Kutch India, *Clays and Clay Minerals*,Vol. 35, No. 3, 196-202, 1987.

[3] Gendrin, A., et al.: Sulphates in Martian layered terrains: The OMEGA/Mars Express view, Science, Vol. 307, pp.1587–1591,. 2005.

[4] J. J. Wray, A., E. Z. Noe Dobrea, B., R. E. Arvidson, C., S. M. Wiseman, C., S. W. Squyres, A. S. McEwen, D., J. F. Mustard, E., and S. L. Murchie F.: Phyllosilicates and sulphates at Endeavour Crater, Meridiani Planum, Mars, Journal of geophysical Research, vol.36, 2009.

[5] L. H. Roach, A., J. F. Mustard, A., S. L. Murchie, B., J.-P. Bibring,C., F. Forget,D., K. W. Lewis, E., O. Aharonson,E., M. Vincendon,A., and J. L. Bishop F.: Testing evidence of recent hydration state change in sulphates on Mars, Journal of geophysical Research, vol.114, 2009.

[6] Martha S. Gilmore A., Matthew D. Merrill A., James P. Greenwood A., Benjamin Bornstein B., Rebecca Castaño B.: Generation and performance of automated jarosite mineral detectors for visible/near-infrared spectrometers at Mars, Icarus 195 pp.169–183,2008.

[7] N. Siva Siddaiah and Kishor Kumar: Discovery of minamiite from the Deccan Volcanic Province, India: implications for Martian surface exploration, Current Science, Vol. 97, pp.1664 - 1669, 2009.

[8] Ossaka. J. Hirabayashi, J. Okada, K. Koboyashi, R. and Hayashi, T.: Crystal structure of minamiite, a minamiite, a new mineral of the alunite group. Amer. Miner., 67, pp.114-119,1982.

[9] William H. Farrand A., Timothy D. Glotch B., James W. Rice Jr. C., Joel A. Hurowitz D., Gregg A. Swayze E.: Discovery of jarosite within the Mawrth Vallis region of Mars: Implications for the geologic history of the region, Icarus 204,pp.478–488, 2009.