Research paper

Spectral characteristics of banded iron formations in Singhbhum craton, eastern India: Implications for hematite deposits on Mars

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Article history:
Received 2 August 2015
Received in revised form 6 November 2015
Accepted 10 November 2015
Available online 30 November 2015

ABSTRACT

Banded iron formations (BIFs) are major rock units having hematite layers intermittent with silica rich layers and formed by sedimentary processes during late Archean to mid Proterozoic time. In terrestrial environment, hematite deposits are mainly found associated with banded iron formations. The BIFs in Lake Superior (Canada) and Carajas (Brazil) have been studied by planetary scientists to trace the evolution of hematite deposits on Mars. Hematite deposits are extensively identified in Meridiani region on Mars. Many hypotheses have been proposed to decipher the mechanism for the formation of these deposits. On the basis of geomorphological and mineralogical studies, aqueous environment of deposition is found to be the most supportive mechanism for its secondery iron rich deposits. In the present study, we examined the spectral characteristics of banded iron formations of Joda and Daitani located in Singhbhum craton in eastern India to check its potentiality as an analog to the aqueous/marine environment on Mars. The prominent banding feature of banded iron formations is in the range of few millimeters to few centimeters in thickness. Fe-rich bands are darker (gray) in color compared to the light reddish jaspilitic chert bands. Thin quartz veins (<4 mm) are occasionally observed in the hand-specimens of banded iron formations. Spectral investigations have been conducted in VIS/NIR region of electromagnetic spectrum in the laboratory conditions. Optimum absorption bands identified include 0.65, 0.86. 1.4 and 1.9 μm, in which 0.56 and 0.86 μm absorption bands are due to ferric iron and 1.4 and 1.9 μm bands are due to OH/H2O. To validate the mineralogical results obtained from VIS/NIR spectral radiometry, laser Raman and Fourier transform infrared spectroscopic techniques were utilized and the results were found to be similar. Goethite-hematite association in banded iron formation in Singhbhum craton suggests dehydration activity, which has altered the primary iron oxide phases into the secondary iron oxide phases. The optimum bands identified for the minerals using various spectroscopic techniques can be used as reference for similar mineral deposits on any remote area on Earth or on other hydrated planetary surfaces like Mars.

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1. Introduction

Banded iron formations (hereafter BIFs), reported over all continents in association with Precambrian greenstone belts, are defined as chemical sedimentary rocks with alternate layers (varying thickness) of iron oxides (magnetite and/or hematite) and silica (jasper, quartz and chert) (Cloud, 1973; Gross, 1980; Melnik, 1982; Klein, 2005; Polat and Frei, 2005 and references therein). They are formed mainly by sedimentation processes in which water plays a major role in deposition during the time span of Archean to Proterozoic epochs (Klein, 2005). The formation processes (seasonal/microbial?) of various layers and the mechanisms for oxidizing Fe (possibly microbial) are still highly debated (Posth et al., 2008). Deposition of BIFs in ocean basins are the result of oxidation of reduced Fe, either generated through continents or by hydrothermal fluids. BIFs have also found their significance as a major rock unit to explain related sea water chemistry and the