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Field investigation and spectral characterization of Banded Iron Formation, Odisha, India: Implications to hydration processes on Mars

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Abstract

Banded iron formations are major rock units having hematite layers intermittent with silica rich layers and formed mainly by the sedimentary processes during Late-Archaean to Mid-Proterozoic time period. They found their significance as a major iron-ore deposits and the first terrestrial rock bodies with existing life signatures on Earth. Here, we propose Odisha BIFs as a probable analogue site to the martian layered hematite deposit and its implications in inferring the sedimentary processes, hydration and astrobiological activities on Mars. Hyperspectral analysis identifies the optimum bands for the identification of similar type of deposits on Mars. Odisha BIFs have been found well comparable with the existing analogue sites of Lake Superior and Carajas Formation, Brazil.

1. Introduction

Banded Iron Formations (BIFs) are Fe-oxide- and silica-rich chemical sedimentary rocks, most of which were deposited during Late-Archaean to Mid-Proterozoic. BIFs are good cradles for extensive hematite deposits on earth. Earth's atmosphere was in transition phase from early anoxic conditions to a more oxygenated state during this period [1]. The Mars and Earth atmosphere were more similar during this time period, with both planets initially being blanketed by thick reducing atmospheres [2]. Hence, BIFs are thought to be potential candidates to understand the redox transitions and their possible relations to hydration processes and early life [3, 4]. Therefore, BIFs are also ideal targets for astrobiological explorations.

Mars surface has marked with the widespread layered hematite deposits and other FeO-OH polymorphs (Fe-oxides and Fe-(oxy-) hydroxides). Hematite layered deposits have been found in regions like Meridiani Planum, Aram Chaos, and Valles Marineris on Mars [5]. Layered hematite deposits confirmed in Meridiani Planum and other regions of Mars are proposed to be of sedimentary origin due to absence of volcanogenic geomorphic features such as lava flows and fissures. [6] proposed that where spectra indicate bands of hematite and jaspilitic quartz, without discernable clays, and where this pattern extends from the millimeter to meter scale and is laterally continuous, it is highly likely BIFs are present. The layered hematite deposits therefore, could be treated as potential target rocks for probing ancient microbial and hydration processes.

2. Regional geology

Banded Iron Formation is present in the Archean Supracrustal belts in the region and is called as Iron Ore Group [7] (Fig. 1a). This supracrustal sequence starts from the base with sandstone-conglomerate overlained by ferruginous shales (with some manganiferous horizons), tuffs, lavas and BIF [8]. The mining activity in the area has exposed the major spatial features of the areas (Fig. 1b and c).

Figure 1: (a) Location of Singhbhum craton in Indian map. Google earth images of study areas (b) Joda (c) Daitari, located in Singhbhum craton.

3. Methods and Results

The results of this study are based on the fieldwork conducted in the regions of Joda and Daitari in Singhbhum craton, Odisha, India followed by the hyperspectral analysis of the samples. The collected sample shows alternate bands of hematite rich layer and quartz rich layer (Fig. 2a). Deformational structures such as faulting etc. have also been observed in the field and even, it is observable in the specimen scale (Fig. 2b).

Hyperspectral analysis has been done by ASD spectrometer in the wavelength range of 350-2500 nm. The spectral signatures identified are presented in the Fig. 2c and d. the optimum bands for the samples mainly fall into the region of 600-800 nm, 1850-1950 nm and 2200 nm. It has been observed that the spectra of the samples from the study area are found to match with the spectra of hematite, and goethite minerals of USGS spectral library. The absorption band present at 1900 nm, characteristic absorption feature for H_2O is also present indicating the hematite composition shift to the goethite.

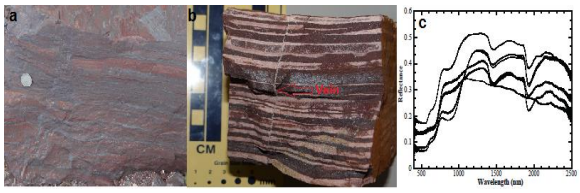

Figure 1: (a) Field photo depicting the Banded Iron Formation. (b) BIF with fault structure through which quartz vein is observed. (c) Reflectance spectra of hematite and goethite samples with characteristic absorption bands.

6. Summary and Conclusions

With reference to Lake Superior and Carajas, Barazil BIF [6, 9], Odisha BIF could also be considered as a potential analogue to sedimentary layered deposits of Meridiani Planum and the aqueous environment, in which they would have generated. This study of spectral parameters in the context of BIFs may help to better understand the early environments of distinguished regions of Mars. Combined hyperspectral results from this study and [10] could work as reference in differentiating the types of iron deposits on Mars and also help in relative measurement of Fe content in different deposits.

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