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Using ETM+ and ASTER sensors to identify iron occurrences in the Esfordi 1:100,000 mapping sheet of Central Iran

Behnam Sadeghi [a,b,*], Masoumeh Khalajmasoumi [c], Peyman Afzal [a,d], Parviz Moarefvand [e], Amir Bijan Yasrebi [d], Andy Wetherelt [d], Patrick Foster [d], Afshar Ziazarifi [f]

[a] Department of Mining Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran
[b] Young Researchers Club, South Tehran Branch, Islamic Azad University, Tehran, Iran
[c] Department of Geology, Islamic Azad University, Science and Research Branch, Tehran, Iran
[d] Camborne School of Mines, University of Exeter, Penryn, UK
[e] Mining and Metallurgy Faculty, Amirkabir University of Technology, Tehran, Iran
[f] Department of Mining Engineering, Lahijan Branch, Islamic Azad University, Lahijan, Iran

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ABSTRACT

Many iron occurrences and deposits exist in the Central Iranian structural zone, especially in the Bafq district. The Esfordi 1:100,000 mapping sheet is located in this region and there are several iron mines and deposits, e.g. Chadormalu, Choghart, Seh-Chahoon, Mishdowan and Zaghia. The aim of this study is to identify and detect the iron bearing occurrences by utilizing the Landsat ETM+ and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite data. Several methods consist of Linear Band Prediction (LS-Fit), Matched Filtering (MF), Spectral Angle Mapper (SAM), Spectral Feature Fitting (SFF), Band Ratio (BR: 2/1 and 3/1) and Visual interpretation (RGB: 531) were used for this purpose. Structures were identified by visual interpretation of images and band combinations (RGB: 431). Target areas were found by LS-Fit, MF and SAM overlapping being situated in the North and the North-East, Central and North Western parts of the Esfordi mapping sheet which is now proposed for iron occurrences prospecting.

1. Introduction

From a structural point of view the Central Iran consists of the Anarak-Bafq-Kerman metallogenic belt, parts of the Sahand–Bazman volcanic belt and the Sanandaj–Sirjan structural–metamorphic zone (Samani, 1988; Alavi, 1994). There are different types of iron ores (>2 Gt) located in the Bafq district where hosts Chadormalu mine as the largest iron reserve containing 400 Mt of iron ore (Moore and Modabberi, 2003; Ramezani and Tucker, 2003; Jami, 2005; Daliran et al., 2010). The Esfordi 1:100,000 mapping sheet, is located between the longitude ranges of 55°30′00″ and 56°00′00″ and latitude ranges varying between 31°30′00″ and 32°00′00″ and one of the important Fe-P-REE mineralized region in the Bafq district as depicted in Figs. 2 and 4. There are Kiruna type iron ore deposits which consisting of magnetite–hematite and apatites. Several magnetite–apatite deposits of Bafq district comprise several ore bodies with large-scale replacements and brecciation textures, and a sodic–calcic alteration envelope (Bonyadi et al., 2011, 2012).

* Corresponding author.
E-mail address: behnamsadeghi.researches@yahoo.com (B. Sadeghi).

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Remote sensing advances in recent years have helped earth science researchers to identify and map the distribution of target minerals on the Earth's surface. The potential of recognition using multi-spectral satellite data depends on the wavelength range and power of spectral separation of the sensor. Using the spectral domain of the short wave infrared (SWIR), part of the electromagnetic wavelength for detection of iron oxide alteration is one of the most important usages of remote sensing in geology, e.g., Rutz-Armenta and Prol-Ledesma (1998); Tangestani and Moore (2001); Hewson et al. (2001); Abrams et al. (1983); Kaufman (1988) and Sabins (1999). Most studies for the identification of alteration zones have been performed having used techniques such as Band Ratio (Sabins, 1999), PCA (Ranjbar et al., 2003; Zhao et al., 2008; Zoheir and Emam, 2012; Ciampalini et al., 2012a,b). Multi-spectral satellite data such as TM, ETM+, and ASTER SWIR bands have been used by geologists for exploration purposes in Iran (e.g., Ranjbar et al., 2003; Moghtaderi et al., 2007; Azizi et al., 2010; Beiranvnd Pour and Hashim, 2011; Beiranvnd Pour and Hashim, 2012). For example Moghtaderi et al. (2007) delineated some alkali metasomatose within the Chadormalu district in the vicinity of iron ore deposits. Due to the limited spectral resolution of TM, it can only be used for ores containing iron oxides and hydroxyl minerals. The ETM+ sensor with six bands in the range of SWIR have been used for

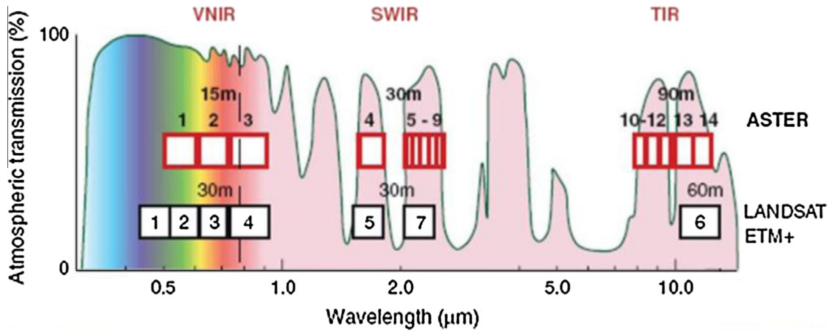

Fig. 1. Spectral bands of ASTER and Landsat ETM+ sensors (Raup et al., 2007).

identification of the alteration zones and this sensor is much more flexible than the Landsat TM sensor (Crosta et al., 2003; Van Ede, 2004). However, the newer methods which are proposed for identification of alteration zones, include Matched Filtering (MF(, Linear Spectral Unmixing (LSU(, Spectral Angle Mapping)SAM) (e.g. Rowan et al., 2006 and Castro, 2004). The ASTER sensor is one of the multi-spectral sensors that has been installed on the TERRA satellite. This sensor can measure the reflection of the Earth's ground in three bands, that is, between the wavelengths of 0.52–0.86 μm with a resolution of 15 m (visible and near-infrared: VNIR), six bands between the wavelengths of 1.6–2.43 μm with a resolution of 30 m (SWIR), and five bands between the wavelengths of 8.125–11.65 μm with a resolution of 90 m (thermal infrared: TIR) (Fig. 1). Furthermore, the TERRA satellite has a back-looking telescope with a resolution of 15 m in the VNIR that matches with the wavelength of the band 3 that is used to extract 3D information. Meanwhile, the sensor swath of ASTER is 60 km (Yamaguchi et al., 2001; Rowan et al., 2006). According to extreme variations of spectral reflectance curves of minerals in the SWIR region and high spectral resolution of the ASTER sensor, the sensor identifies different rocks and minerals on the Earth's surface effectively. Considering the differences of the sensor resolution capability between ETM+ and ASTER sensors, usually ETM+ images are used for the lineaments and ASTER images are used to identify minerals and alterations of the Earth's surface.

The aim of this paper is to utilize ETM+ and ASTER sensors for the identification of iron occurrences and their relationships with the lineaments to determine, predict and propose the iron-rich areas and prospects within the Esfordi 1:100,000 mapping sheet of Central Iran. Some algorithms were used to determine iron alteration zones, which show a certain color range, e.g. Linear Band Prediction (LS-Fit), Matched Filtering (MF), Spectral Angle Mapper

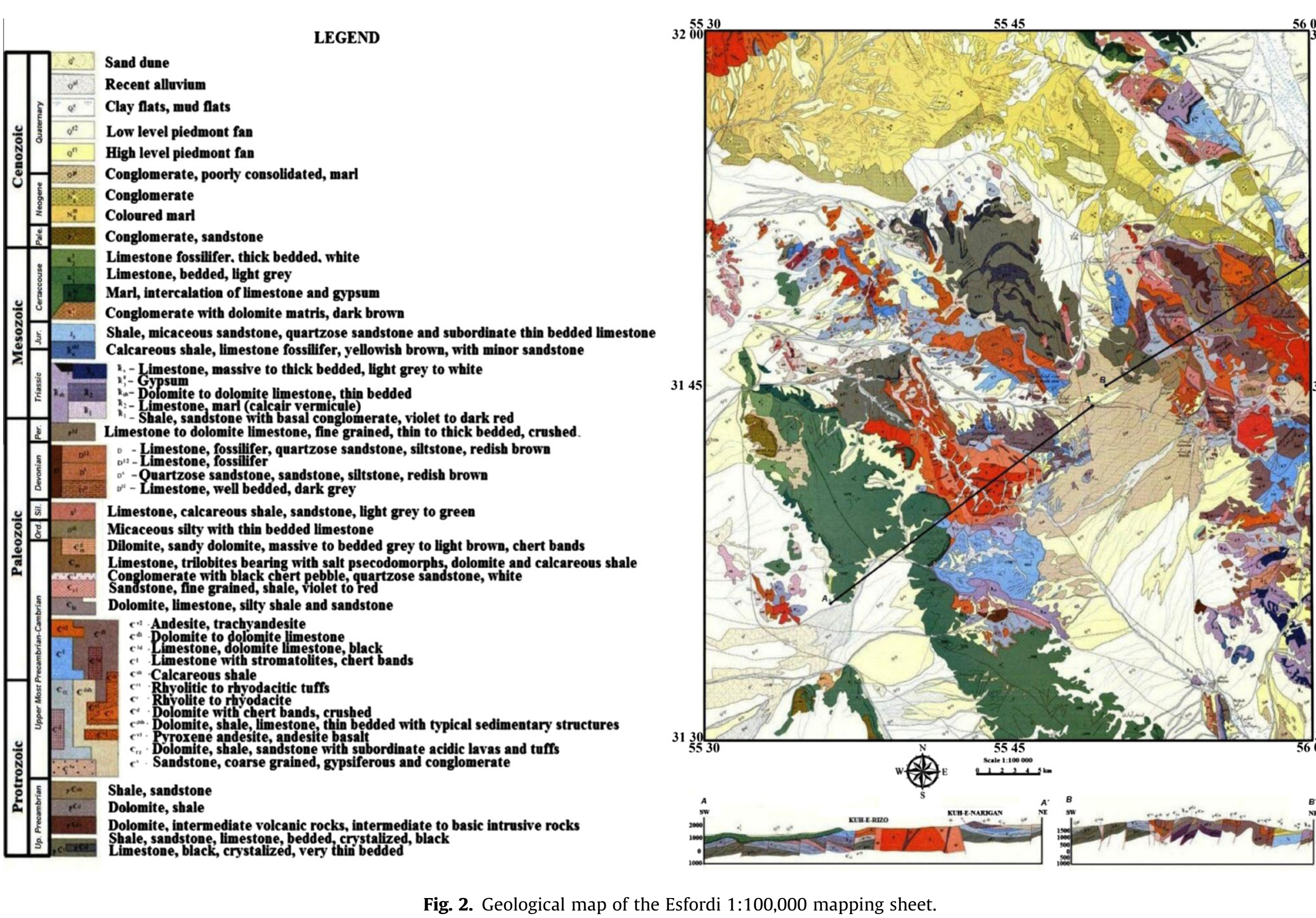

Fig. 2. Geological map of the Esfordi 1:100,000 mapping sheet.