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Aerogravity and remote sensing observations of an iron deposit in Gara Djebilet, southwestern Algeria

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A B S T R A C T

The Gara Djebilet iron ore region is one of the most important regions in Africa. Located in the southwestern part of Algeria at the border with Mauritania, the Gara Djebilet region is characterized by steep terrain, which makes this area not easily accessible. Due to these conditions, remote sensing techniques and geophysics are the best ways to map this iron ore. The Gara Djebilet formations are characterized by high iron content that is especially rich in hematite, chamosite and goethite. The high iron content causes an absorption band at 0.88 μm, which is referred to as band 5 in the Operational Land Imager (OLI) Landsat 8 images. In this study, we integrated geological data, aerogravity data, and remote sensing data for the purpose of mapping the distribution of the Gara Djebilet iron deposit.

Several remote sensing treatments were applied to the Landsat 8 OLI image, such as color composites, band ratioing, principal component analysis and a mathematical index, which helped locate the surface distribution of the iron ore. The results from gravity gradient interpretation techniques, 2-D forward modeling and 3-D inversion of aerogravity data provided information about the 2-D and 3-D distribution of the iron deposit. The combination of remote sensing and gravity results help us evaluate the ore potential of Gara Djebilet. The estimated tonnage of the iron ore at Gara Djebilet is approximately 2.37 billion tonnes with 57% Fe.

1. Introduction

The iron industry in Algeria has expanded over the last 20 years; the demand for this resource is growing continuously. Algeria has two large deposits of iron, but only the ore of El Ouenza (NE Algeria, 60 million tonnes) is currently exploited. The deposit of oolitic iron at Gara Djebilet represents the largest deposit of iron in the country and in North Africa (1 billion tonnes of iron at a grade of 57% iron, Taib, 2009) but is in an isolated and hardly accessible area. Thus, it was not until the historic visit of the Algerian Prime Minister in July 2013 that mine operations at Gara Djebilet were launched to counter high market demand, especially to supply large Algerian national projects (East-West highway, Algiers Metro, infrastructure and housing projects).

The Gara Djebilet oolitic iron deposit is situated in the southwest of the Tindouf Basin (Fig. 1) and was discovered by Gevin in 1952. The Gara Djebilet region is characterized by steep terrain, which makes this area not easily accessible (1600 km south of the Algerian Mediterranean coast) as it presents high topography (Fig. 2), and only one track of 200 km connects it with the city of Tindouf. Under such conditions, it is difficult to map accurately; the capacities of this deposit are still estimated by approximation.

Previous estimated of iron tonnage in Gara Djebilet are Matheron (1955): 2.65 billion tonnes (grade of 53–58% Fe); Guerrak (1988): 0.98 billion tonnes (grade of 57% Fe); Marelle and Abdulla (1970): 1.48 billion tonnes (grade of 49–54% Fe); The Ministry of Energy and Mining of Algeria (2005): 0.75 billion tonnes (grade of 58% Fe) (Porter GeoConsultancy, 2015). Ciampalini et al. (2013a,b) used Landsat ETM+ to visualize iron deposits in southwestern parts of Algeria.

Remote sensing techniques using multispectral images can recognize ore deposits (Sabins, 1999), and airborne gravity data analysis allows for detailed mapping of iron deposits. Many authors

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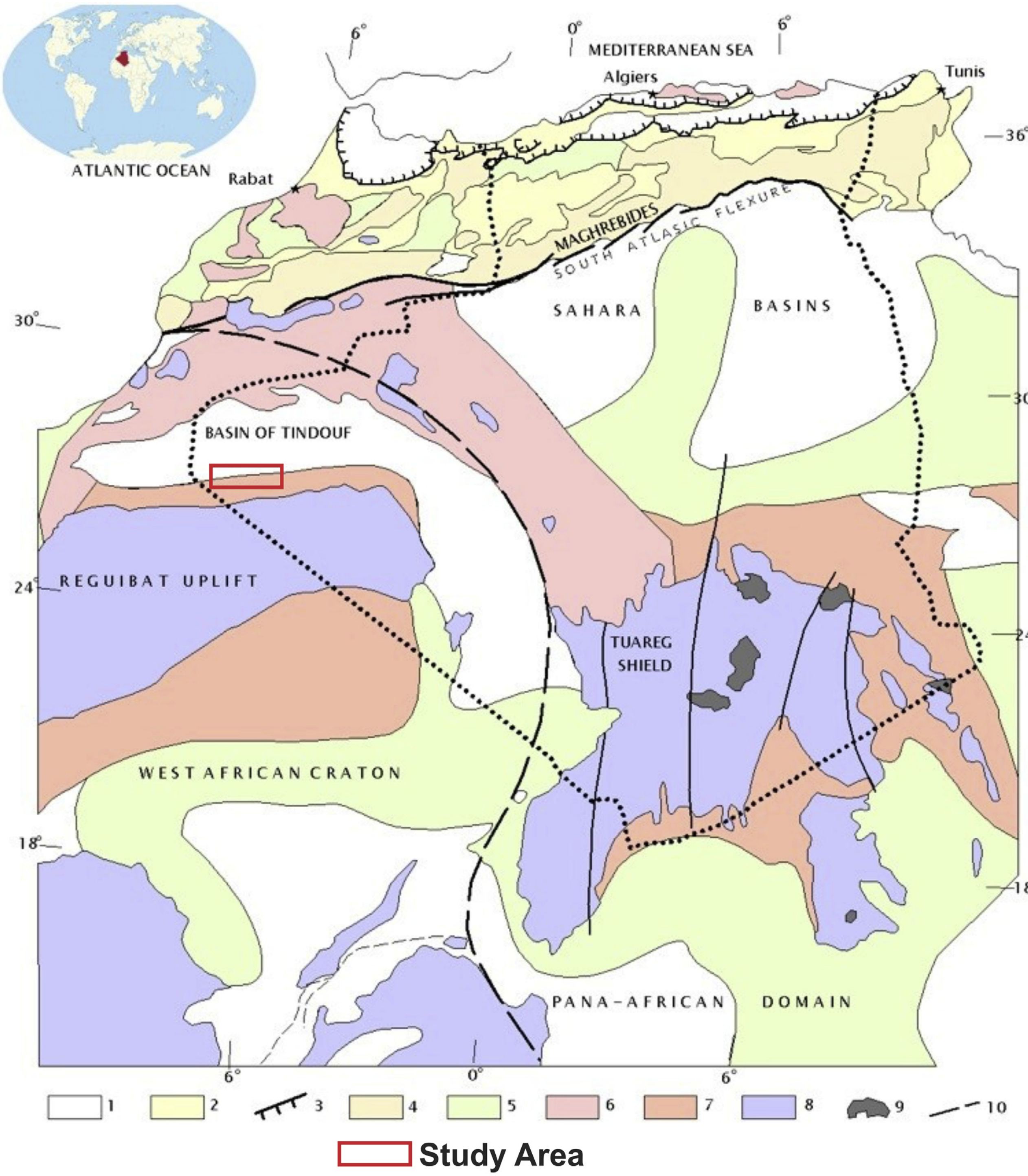

Fig. 1. Major geotectonic units of West Africa, modified from Fabre (1976). 1: Tertiary and Quaternary; 2: Alpine molasse; 3: Tertiary thrust sheet; 4: Secondary tabular; 5: Secondary plication; 6: Primary plication; 7: Primary tabular; 8: Precambrian and Early Cambrian Sahara; 9: Cenozoic magma; 10: Megafault. The study area is located in southwestern Algeria.

have used remote sensing techniques and geophysics separately or combined to map ores in general or iron ore specifically.

Hammer (1945) explained the application of Gauss's theorem to evaluate the mass of a causative body from gravity data. Seguin (1971) discovered iron ore by the gravity method in the central part of the Labrador Trough (Canada). Wang et al. (2012) inverted gravity data to explore mineral deposits in Henan Province (China). Martinez et al. (2013) inverted airborne gravity data for mineral exploration in Quadrilatero Ferrifero (Brazil). Dufrechou et al. (2015) used gravity data to investigate mineralization in the Bandy gneiss complex (Greenville, Canada), and Woolrych et al. (2015) succeeded in the discovery of the Kitumba iron oxide copper gold deposit using airborne gravity data.

There are several examples of the application of remote sensing technologies in exploring iron ores. Murthy and Mallick (1984) applied Landsat MSS data to delineate the iron-ore-bearing zone in Goa (India). Abulghasem et al. (2011) integrated remote sensing data and magnetic data for iron ore investigation in the western