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Diagnosis of the heating effect on the electrical resistivity of Ouargla (Algeria) dunes sand using XRD patterns and FTIR spectra

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A B S T R A C T

XRD patterns and FTIR spectra have shown that dunes sand of Ouargla's region, in its natural state, is formed of a high percentage of quartz, gypsum and very low percentage of kaolinite and hematite, in addition to some organic compounds. The electrical resistivity of the natural sand has been measured, it was 6×10^{14} Ω cm. Six samples of the sand were heated separately at 200, 400, 600, 800, 1000 and 1200 °C. The XRD patterns and FTIR spectra of these samples were carried out. On the other hand, the electrical resistivities of these samples have been measured. The change of the electrical resistivity with heat shows a nonlinear behavior. The heated sample of sand at 200 °C has lost some water. Most of the gypsum in the 200 °C heated sample has transformed into anhydrite, and the rest has transformed into bassanite, and its electrical resistivity has fallen down to 3.5×10^{14} Ω cm. By heating at 400 °C, the gypsum has lost all its water and it has transformed entirely to anhydrite, and its electrical resistivity became 6.75×10^{12} Ω cm, it has the lowest measured resistivity. At 600 °C and 800 °C, in addition to anhydrite, the kaolinite transformed to meta-kaolin due to the continuous breaking of OH bond and formation of water vapor, and the electrical resistivity increased to $(1.5–1.9) \times 10^{14}$ Ω cm. Heating at 1000 °C leads to the initiation of the interaction between anhydrite and quartz, the wollastonite appears, and the meta-kaolin transforms to aluminum-silicon and cristobalite. The wollastonite is a good electrical insulator. It raises the electrical resistivity of sand to 2.6×10^{14} Ω cm. The heating at 1200 °C makes all anhydrite to interact with quartz due to the increasing of volume of wollastonite, the anhydrite disappears completely, the quartz transforms into cristobalite. The cristobalite increases due to the dissociation of aluminium-silicon into mullite and cristobalite, as well as the transformation of quartz into cristobalite at 1050 °C, then the electrical resistivity reaches the highest measured value 8.55×10^{14} Ω cm.

1. Introduction

Many research groups are working, through multiple applied studies, to find insulating materials of electricity and heat (Osarenmwinda and Nwachukwu, 2011). Insulating materials are used in many modern industries like electrical and medical industries (Amin and Amin, 2011).

Recently, Mechri and Chihi (2014) have shown that the dunes sand of Ouargla's region consists naturally of several compounds that have high electrical resistivity, like the quartz (Telford et al., 1990), which is considered as the main component of sand, followed by gypsum, and some other minor compounds like hematite and kaolinite. It has, also, been found that heat treatment has a clear impact on the composition of the sand (Mechri and Chihi, 2014). The sand heating process at very high temperatures leads to the transformation of the crystalline phase of some of its components. The high temperatures stimulate interactions of these components, causing the emergence of new compounds. All of this leads to a change in the physiochemical properties of the sand.

The presence of many insulating compounds in sand is what motivated us to study the effect of heat on sand properties. We will measure the electrical resistivity of the natural sand, then of heated samples at temperatures ranging between 200 °C and 1200 °C. Then we seek for a correlation between the changes of electrical resistivity of sand and XRD patterns and FTIR spectra, by linking various phase

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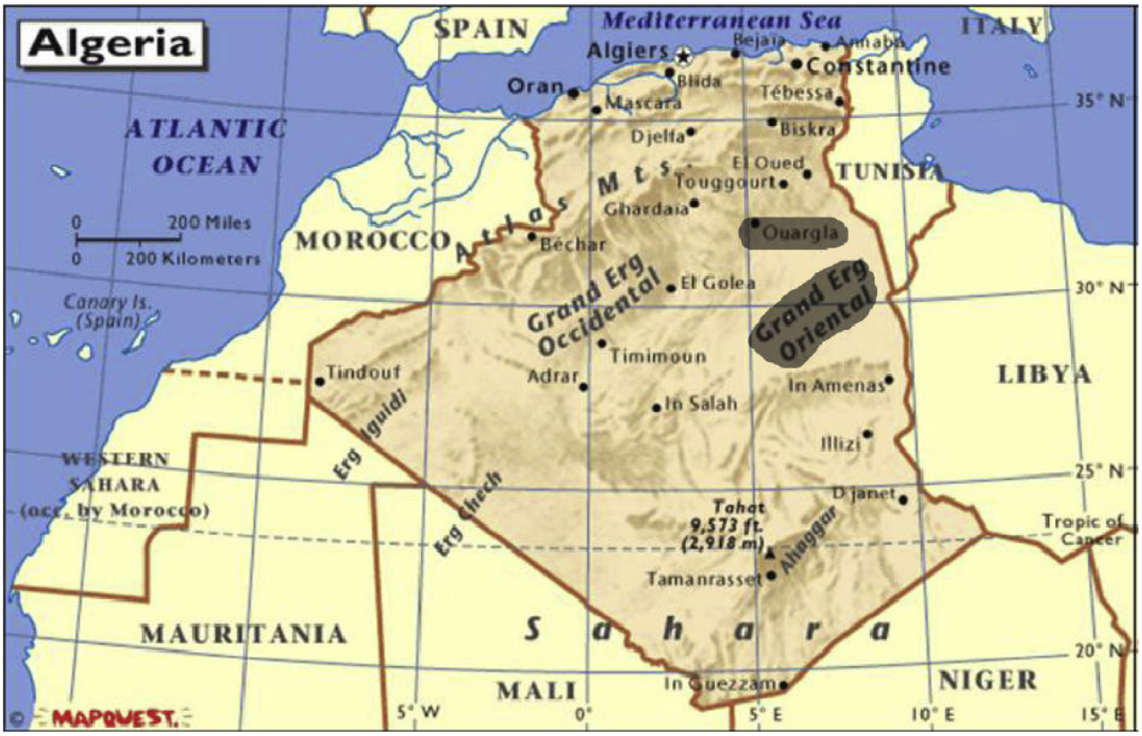
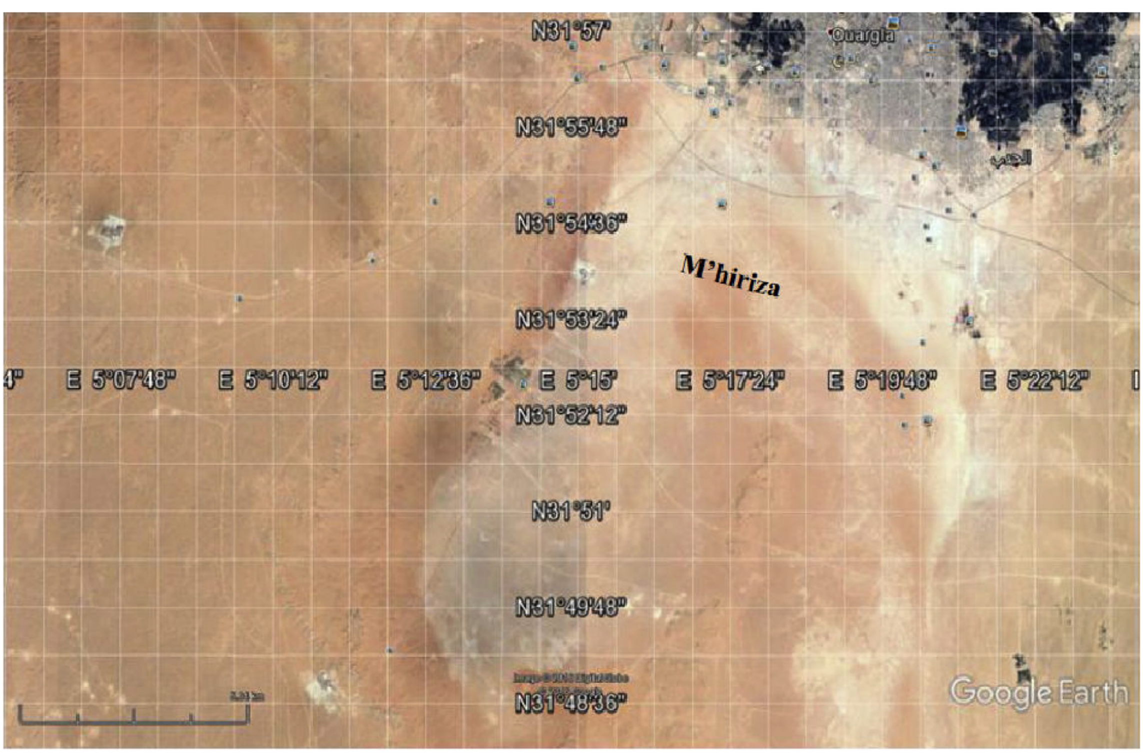


(a) Map of Algeria showing the location of Ouargla and grand erg oriental.



(b) Spatial image of M'hiriza region (imagery date 30 September 2016).

Fig. 1. The location where the samples come from.