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Chemical and technological characterization and beneficiation of Jezza sand (North West of Tunisia): Potentialities of use in industrial fields

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ABSTRACT

This work aims to study natural deposit sand formed at Miocene–Pliocene age from Jezza area in North West of Tunisia. This sand contained high percentage of silica, low percentages of carbonate and traces of clay minerals. The chemical analysis showed that the percentage of SiO_2 was almost constant reaching a value of 98 wt.%, the percentage of iron oxide was 0.17 wt.% and that of Aluminum oxide was 0.32 wt.%. The mineralogical analysis revealed that these sands contained more than 95 wt.% of quartz. The calcite and phyllosilicates were the minor detected phases. The grain size analysis showed that sand samples varied between poorly graded and well graded sand with a 70 wt.% of useful fraction. The morphological tests showed a dominance of siliceous grains with a shape varying from angular to well rounded grains. The specific gravity average was 2.63 g/cm^3. The sand equivalent value was 83 wt.% against a specific surface area ranging from 8.37m^2/g to 20.93m^2/g due to the presence of impurities. The sand treatment by attrition process indicated an exponential increase of the SiO_2 content, unlike to the significant decrease of iron oxide (38 wt.%) and aluminum oxide (14 wt.%). The sand of Jezza can be used in various industrial fields, such as glass, foundry, ceramics, and concrete according to different analysis.

1. Introduction

This work is focused on the study of a sand deposit of Miocene–Pliocene age in the North West of Tunisia in the southern Tunisian tells (Perthuisot, 1978) including the South-West zone of diapers (Castany, 1952) and the middle part of the Neogene pit of the middle valley of the Medjerdah (Jouirou, 1981; Riahi et al., 2009, 2014). This area was characterized by extrusive structures accompanied by folds, faults and overlap (Yaich, 2000). This region had been through three several tectonic phases:

- Atlas tectonic phase which would be between the lower and middle Miocene (Ben Ayed, 1975) in which intense stress had tangential direction NW-SE (Rahmani, 1989)
- Quaternary phase with N-S direction would be responsible of the crescent shape of Diapers (Massin, 1970).
- Extensional phase would be the latest and would have resulted in graben of Sers (Ben Ayed, 1975; Burollet, 1973).

This study had worn on fifteen samples Jez_1–Jez_{15}, collected in a Mio-Pliocene sand (Fig. 1), at 10 km from the Kef city. The lithology of this outcrop is described in Fig. 2.

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2. Materials and Methods

All sand samples' analysis was performed according to the flowsheet presented in Fig. 3.

The specific gravity (Gs) was determined by using ultra pycnometer with helium as a fluid gas according to the guidelines of ASTM D-5550 standard. The porosity was determined by following the EN 1925 (2000) standard. The effective porosity was determined by using hydrostatic balance and applying Archimedes' law. The parameters required were the dry weight (W_d), the wet weight at the saturation point (W_W), the hydrostatic weight (W_h) and the density of water (γ_W). The effective porosity is the ratio between the volume of samples (V_a) and the volume of water inside the pores (V_w). The grain-size distribution was obtained through sieving series adopted by the Afnor French standard. The dry particle size was determined by conducting the sieve analysis. It was the most used method in granulometric domain between 5 μm and 200 mm (Rivière, 1952). The selection of numbers sieve was made according to the requirement of particle size for industrial use (Rivière, 1977). The results were represented in particle size distribution curves which allowed determining the coefficient of uniformity (Cu) and the coefficient of Curvature (Cc) defined by Folk and Ward (1957)). This test was performed by using methylene blue according to NFP 18-592 standard. The specific surface area was depicted as SSA and depended on the size of the grains. The sand equivalent test was used for determining changes in the quality of aggregates during

Nomenclature

Gs	Specific gravity
SSA	Surface specific area
dØ	d Ø size fraction finer than Ø%
W_W	Wet weight at the saturation point
W_d	Dry weight
W_h	Hydrostatic weight
γ_W	Density of Water
V_a	Volume of samples
V_w	Volume of water inside the pores
C_u	Coefficient of uniformity
C_v	Coefficient of curvature
CIA	Chemical index of alteration
CIW	Chemical index of weathering

production. The sand equivalent was expressed as a percentage by weight of sand to clay content according to the EN 933-8 (2012) standard. The purpose of this test method was to indicate the relative proportions of clay, plastic fines, dusts in granular material and fine aggregates. The chemical composition was estimated on powdered samples of the useful portion [100 μm–630 μm] by X-ray fluorescence using panalytical fluorescence spectrometer. The results were expressed as percent of oxides concentration. Other oxides such as Al_2O_3 and TiO_2 were measured by a calorimeter. The percentage of heavy metals was determined by a densitometric separation which is based on the immersion of minerals in Bromoform.

The mineralogical analysis for whole rock and on powder fractions was performed by using the X-ray diffraction. It was based on the use of a Philips X'Pert PRO diffractometer (CuKα, $\lambda = 0.154056$ nm, 2Θ range 3–60°). The existing phases were identified by X-ray powder diffraction and their relative amount was estimated by measuring the peak areas of principal reflection. Measurements were done either in reflection (Bragg–Brentano geometry) with samples on a rotating plate powder holder or in a glass capillary. Data were analyzed by the WinXPow software packages (Essid, 1998).

The mineralogical structure was evaluated by IR spectra (Shimadzu 3100) and was measured between 4000 and 200 cm^{-1}. The morphological study was performed by using a binocular microscope. The petrographic was made by microscopic appearance (texture, color, homogeneity). The study consisted of a volumetric estimation of different types of grains relative to their total volume. For each sample, counting by using a binocular microscope was performed on different size fractions (Parfenof et al., 1970). The elements determined were free siliceous grains, mixed grains and free non-siliceous grains. Then, the sand sample was split into different portions to prepare thin sections which would be studied by using a cross polarized light with a microscope type Zeiss Axiosskop 40. The attrition was commonly carried out according to two mechanisms causing particle breakage (Boerefijn et al., 2007). Firstly, the particle impact attrition which happens when particles collide against the vessel wall, and secondly, the abrasion between particles surface which takes place mainly in the spout region. The experimental set up for sand attrition tests included an air compressor, a mass flow meter, a conical spouted bed contactor, a cyclone, a pressure sensor, a thermocouple and a data monitoring system. The attrition process is a moderate grinding allowing romper links between the clay particles, ferruginous oxides and silica grains. Parameters chosen for attrition tests were those used to reduce the maximum ferruginous content (Zouaghi, 1988):

- Density of pulp: 70 wt.%
- Attrition time: 20 min
- Attrition velocity: 700 rpm, 1000 rpm and 1200 rpm
- Weight of sample: 500 g

After each attrition test, a wet particle size analysis was performed for calculating the weight yield of the useful silica sand fraction [100, 630 μm] corresponding to each speed. According to the major criteria shown in Table 1 such as grain size (Berton and Leberre, 1983) and chemical and mineralogical criteria (Gaied, 1990), the industrial field of sand use was determined.

3. Experimental investigations

3.1. Experimental analysis

The range of specific gravity (Gs) obtained from these tests was listed in Table 2. These values (ranging between 2.62 and 2.65) were found to be similar with the values of early cretaceous Sidi Aich sands in central Tunisia (Hajjaji et al., 2009, 2010). Due to high specific gravity,

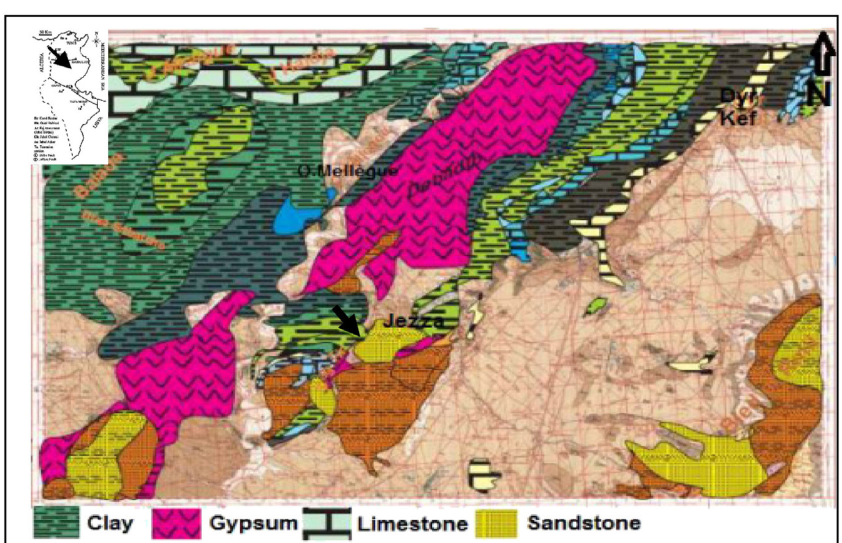

Fig. 1. Lithological map of Kef area.