

BLACK HEAVY-MINERAL BEACH SANDS FROM NORTH COST OF THE REPUBLIC OF DJIBOUTI - MINING AND ENVIRONMENT

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Abstract

In the north of the country, black sand deposits are found along the coastline and originate from alluvial sediments drained from the bimodal volcanic zone. Near the shore, the sands are mixed with marine deposits and reworked alluvial sediments.

Prospecting studies were conducted in April and October 2019 on the north coast of the Tadjourah and Obock region. Petrographic and geochemical studies have been carried out on coastal black sands and dune sands. Five sand samples were collected for appropriate studies. The grain size varies between 1 mm and 0.500 mm, representing the sand samples. Most of the sands are basic, except the sand of the Kalaf dune and the sand of fluvial alluvium of wadi Walwallé are siliceous. The sand samples from the Badouw Ela and Orôbor zones are rich in titanium dioxide (TiO₂) with a content of 25.8% and 19.52%; iron (III) oxide or ferric oxide (Fe₂O₃) with 48,4 % and 50,5 %; and vanadium (V) with 2,771 ppm and 2,100 ppm. Other elements such as chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn) and manganese (Mn) have a strong natural anomaly and intervention values in soil pollution management must be taken into account for the health of the local population. All these areas have not made a specific study, but the small volumetric quantity observed does not allow a profitable exploitation, only the Badouw Ela and Khor Angar areas could be exploitable deposits.

This study is an integral part of the Research Fund allocated to the petroleum research laboratory from 2017 to 2019, Project IST9/PRT17-19.

Keywords : black beach sands, heavy-minerals, mining, pollution, environment, health, Tadjourah, Obock, Republic of Djibouti

Résumé

Dans le Nord du pays, des dépôts de sable noir se trouvent le long du littoral et proviennent de sédiments alluvionnaires drainés de la zone volcanique bimodale. Près du rivage, les sables sont mélangés de dépôts marins et de sédiments d'alluviaux remaniés.

Des études de prospection ont été réalisées en avril et octobre 2019 sur la côte Nord de la région de Tadjourah et d'Obock. Des études pétrographiques et géochimiques ont été réalisées sur les sables noirs côtiers et les sables dunaires. Cinq échantillons de sable ont

été prélevés pour des études appropriées. La taille des grains varie entre 1 mm et 0,500 mm, représentant les échantillons de sable. La plupart des sables sont basiques, sauf le sable de la dune de Kalaf et celui des alluvions fluviales de l'oued Walwallé sont siliceux. Les échantillons de sable des zones de Badouw Ela et d'Orôbor sont riches en dioxyde de titane (TiO₂) avec une teneur de 25,8 % et de 19,52 % ; en oxyde de fer (III) ou oxyde ferrique (Fe₂O₃) avec 48,4 % et de 50,5 %; et du vanadium (V) avec 2 771 ppm et 2 100 ppm. D'autres éléments tels que le chrome, (Cr), le cuivre (Cu), le nickel (Ni), le zinc (Zn) et le manganèse (Mn) présentent une forte anomalie naturelle et les valeurs d'intervention dans le cadre de la gestion de la pollution des sols doivent être prises en compte pour la santé de la population locale. Tous ces sites n'ont pas fait d'étude spécifique, mais la faible quantité volumétrique observée ne permet pas une exploitation rentable, seules les zones de Badouw Ela et de Khor Angar pourraient être des gisements exploitables. Cette étude fait partie intégrante du Fonds de recherche alloué au laboratoire de recherche pétrolière de 2017 à 2019, Projet IST9/PRT17-19.

Mots-clés : sable noir de plage, minéraux lourds, mines, pollution, environnement, santé, Tadjourah, Obock, République de Djibouti

I. Introduction

In all volcanic countries, deposits of black sands are formed, following the alteration of rocks, transport and wind erosion, either in rivers, wadis, along the coasts. Thus placer deposits can develop and depending on the quality of heavy minerals and especially their volumetric quantity will make it possible to be financially profitable and to be exploited.

In Republic of Djibouti, the black sand deposits are found in many streams of wadis, rich in magnetite as in Koutabouïa, in the bed of wadi Dagadleh, plain of Goba'ad, in the beds of wadis south of Ali Sabieh or those near Ali Adde (Figure 1).

In the north, in the alluvium of the wadi Boli south of Dorra, ilmenite indices were reported by Besairie (1949) and Dabrowsky (1958). The mineralogical study carried out by Dabrowsky indicates the presence of augite, magnetite, ilmenite, hematite, and traces of chromium and copper, but no sufficient concentration was found for an ilmenite deposit.

The sand of the dunes of Arkailé, between Orôbor and Obock, and those of North of Obock, between Gaherre and Khor Angar, are inventoried as black sands magnetite rich (titaniferous). The heavy minerals of coastal cords must be inventoried. The surface area of Khor Angar site is quite large and deserves an appropriate mining study: tight drilling, depth to be estimated with respect to geological surface observations, geochemical analyzes and scintillometer radioactivity study. At first, a sedimentological mapping must be carried out: distribution: rocks outcropping, mud and muddy sands, coarse sands, beach and beach sands, sands and silts of wadies, coastal dunes, sediments under the influence of the swells on the beach. Usually, black sands made up of small sand grains (apatites and zircons less than 100 µm in size) may correspond to radioactive sands, and in large deposits extracted mainly ilmenite (FeTiO₃) and rutile (TiO₂).

Titanium is used in many fields (pigment industry: painting, aeronautics, energy, marine applications, biomedical). For the Chinese government, it is a strategic mineral in the

military, aeronautical and industrial fields.

Evidence of uranium has been reported in the north of the country. Mabla's rhyolites have undergone severe hydrothermal alteration and placer uranium deposits have formed (Gasse et al., 1983). However, since no studies have been conducted, this resource has yet to be located and evaluated. Recently, reconnaissance was undertaken (Caminiti, 2019a and 2019b), and the first results are not convincing.

The geochemical prospecting undertaken, also known as "strategic" geochemical prospecting was intended to obtain general information on alluvial deposits of wadis and dunes. The samples collected correspond to stream sediments.



Figure 1: Black sand in the wadi with important magnetism, Koutimalely area, between Bâda Yar (Petit Bâra) and Bâda Weyn (Grand Bâra) (AMC, 2009)

II. Applied Methodology

1. Literature search

An important work of bibliographic research, archiving and classification of the various documents by theme, was carried out and computerized in Word or PDF, compilation of old and recent works (Dreyfuss, 1931; Aubert de la Rue, 1938, 1939a, 1939b, 1939c et 1939d ; Besairie, 1949 ; Dabrowski, 1957 ; Cheymol, 1961 ; Gasse et al., 1983, 1986; Caminiti, 2000, 2007, 2009a,b,c,d,e, 2021). This is a crucial and fundamental work for future researchers in both oil and mining fields.

2. Terrain

All samples taken were recorded by GPS (GPS: Garmin Etrex 20x).

In the context of sand sampling from rivers, here from wadis, appropriate methods made by the BRGM (Chaussier & Morer, 1982) have been applied. Also, they correspond to the techniques used during a mining training at the Ecole Nationale Supérieure des Mines de Paris, carried out in Fontainebleau at the Centre de Géosciences (Caminiti, 2009c). The method used was stream geochemistry which corresponds to the strategic geochemistry phase (stream sediments most often), or semi-tactical prospecting (stream or soils). Since these various missions correspond to reconnaissance missions, samples are taken at the convex bank of the wadi, from the dunes (high concentration of heavy minerals), in the clays and silts of the old terraces, and in the worst case, surface sampling to get an idea of the existence of traces of elements sought.

3. Equipment used in the field and laboratory

3.1. Equipment used in the field

The equipment used in the field is as follows:

1. Magnetic pen
2. GPS: Garmin Etrex 20x
3. A shovel, a bucket and plastic bags

3.2 Equipment used in the laboratory

1. For petrographic studies : a personal digital microscope: digital microscope MM-940 v3.0, CARSON was used to take close-up pictures on raw rock;
2. Regarding the geochemical analyses, they were carried out at the Ocean Spectrometry Pole - Brest, France. Two types of analyses were performed in the laboratory, global analyses and spot analyses. For the major elements, the samples were dissolved and passed to the ICP-AES, in July 2020, by the operator Ms. Céline Liorzou. For trace elements were analyzed by the instrument: Thermofisher Element XR HR-ICP-MS, on 15/09/2020 and treated by the operators, Marie-Laure Rouget and Bleuenn Guguen.

III. Geological setting

The north of the country is made up of bimodal volcanic formations from the Miocene to the Pleistocene, ancient intercalated sedimentary formations, detrital deposits (conglomerates, pebbles, gravel, sand), forming glaciais, fluvial deposits forming ancient and current terraces, formations marine Pleistocene reefs, dunes and current black sand placers (Figure 2, Le Gall et al., 2015).

The rhyolite volcanic formations of Mabla and the basalts of Dalha are well developed. The top of the Dalha formation is characterized by pyroclastic flow (Fournier et al., 1983, 1985; Daoud, 2008; Le Gall et al., 2018).

The samples studied were taken from shore dunes, fluvial deposits and mixed fluvial and marine sand.

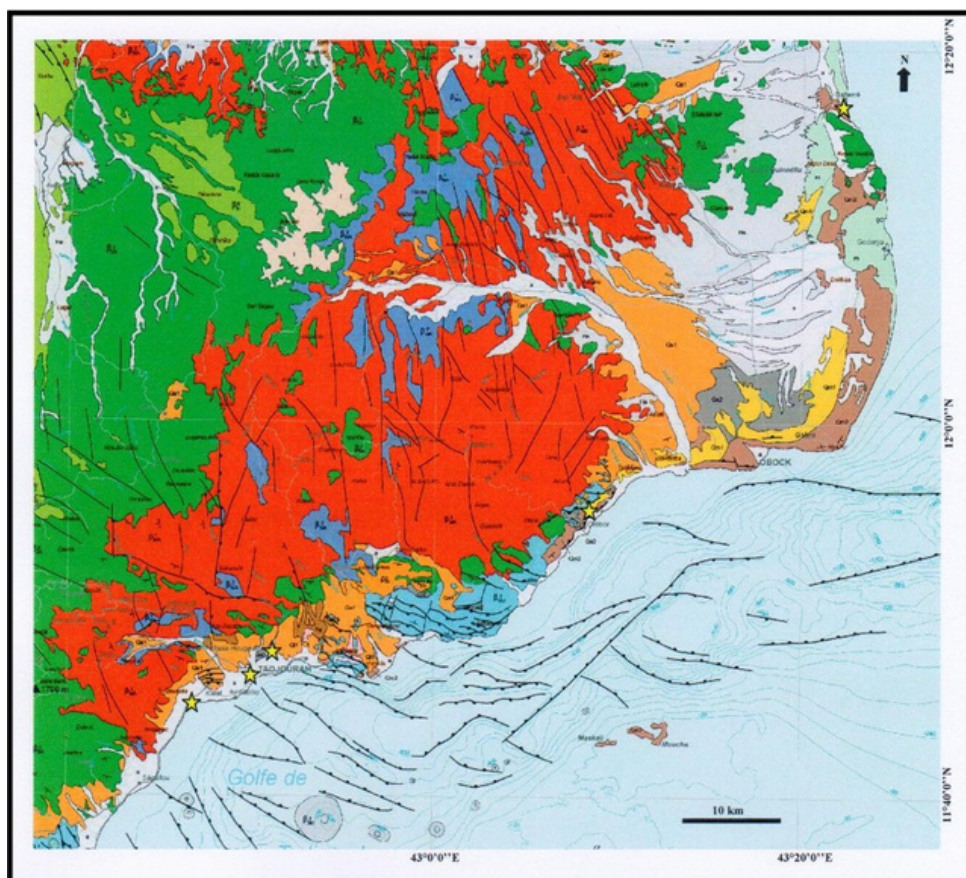
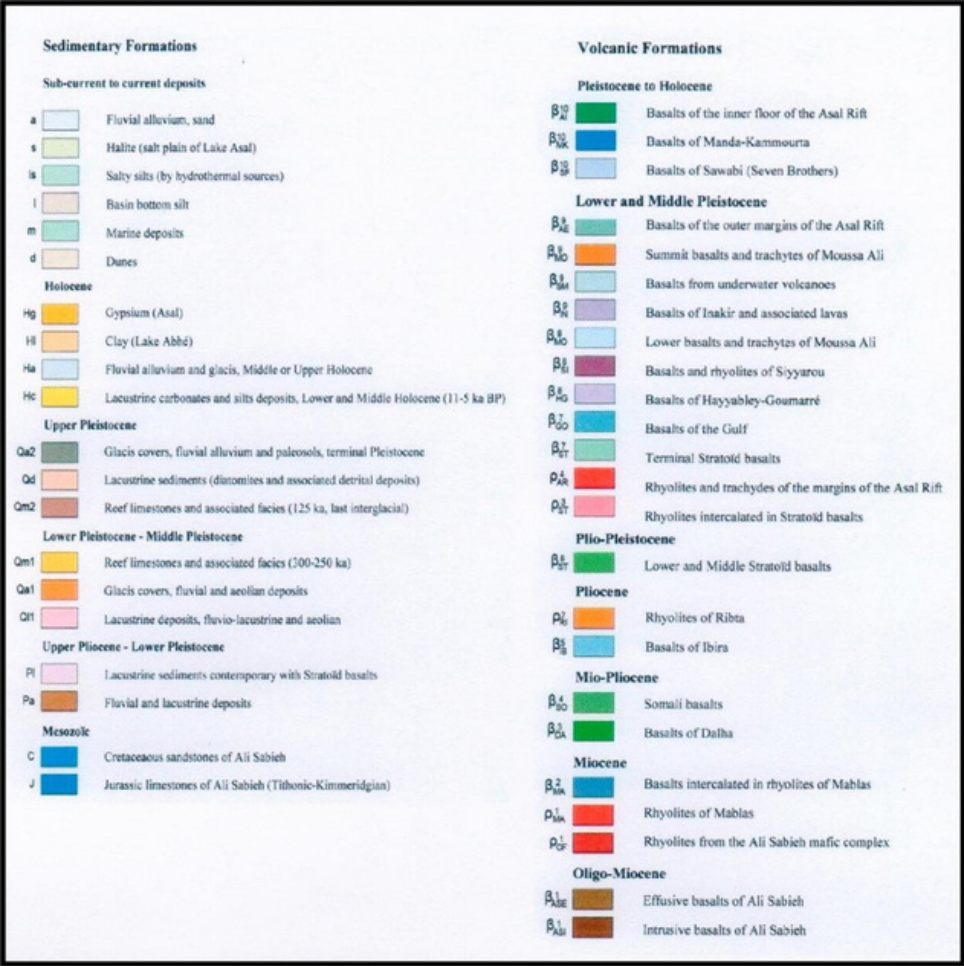


Figure 2: Geological map of North of Republic of Djibouti (Le Gall et al, 2015), studied sites.

Legend



The current fluvial alluvium, generally very coarse fluvial deposits, is made up materials from neighboring reliefs. These deposits are rich in rhyolitic elements, on the North and NE of the country, and basalts of the Dalha are the essential source of fluvial deposits in the NW. Most wadis, with very steep slopes, are able of transporting large pebbles up to the sea. In most river valleys, these deposits form small terraces, perched one or a few meters above the current course. The top of these terraces, often covered with vegetation, no longer seems reached by current floods, even exceptional ones. To this unit are also attached the enormous cones of excrement extending at the outlet of the Darriyou and Easalayi wadis and between Dat Houdoum and Walwallé. These cones are now fossilized, due to recent tectonics (Gasse et Fournier, 1983; Gasse et al., 1983, 1985; Le Gall et al., 2018).

By the sea between Sagallou and Obock, the coastal dunes are Holocene to Current age, with a height between 3 and 5 m, forming a barrier parallel to the coast. They are made of gray silty sand, and fixed by vegetation. The Kalaf dunes have been dated to 250 years B.P. (Gasse et al., 1985).

According to the geological area of Khor Angar (Boucarut et al., 1978; Piquet et al., 1995; Vellutini et al., 1995), the site is composed of a coastal barrier, fine sand, gypsum muds and halite of Holocene to Current age, reef limestones and associated facies of Upper Pleistocene age, and recent alluvium and pebbles.

The coastal barrier extends from Godorya to Ras Syyan and is made up of coral sands with bioclasts and volcanic elements.



Figure 3: Viewed from Kalaf towards the interior, the high relief is rhyolitic massifs of Mabla, below, deposits of old glaciais, and at the left part the basalts of Dalha form rounded hills. The flat corresponds to Pleistocene and recent fluvial deposits terraces and wadis (AMC, 2013)

IV. Petrography, sand composition, mineralogy

To determine the assemblage of black sands minerals, a petrographic study was conducted, and geochemical analyses were made to assess the chemical composition of these sands and the content of the elements. Four sand samples were done and concerned this study.

Three samples were collected from dunes (SNK : Kalaf dune; ORB: Orôbor dune; SNS: wadi Sadaï dune), from coastal sands (DFP: Delta Fan Palmeraie location) and from wadi Walwallé (NT4) (Table 1; Figures 4 to 10).

Table 1: Sampling of coastal black sands north of the Gulf of Tadjourah

Location / Sample	Description	Coordinates	
SNK - 7664, Kalaf	Black sand, Kalaf dune	11°44'42.1"N	42°46'35.1"E
ORB - 7665, Orôbor	Black sand, Orôbor dune	11°55'03.58"N 8'51.25"E	43°
SNS - 7666, wadi Sadaï	Black sand, dune Sadaï wadi	11°58'03.8"N	43° 13'51.4"E
DFP - Badouw Ela location	Black sand soil	11°45'45.4"N	42°49'45.8"E
NT4 - wadi Walwallé	Black sand fluvial alluvium	11°48'05.9"N	42°51'16.4"E

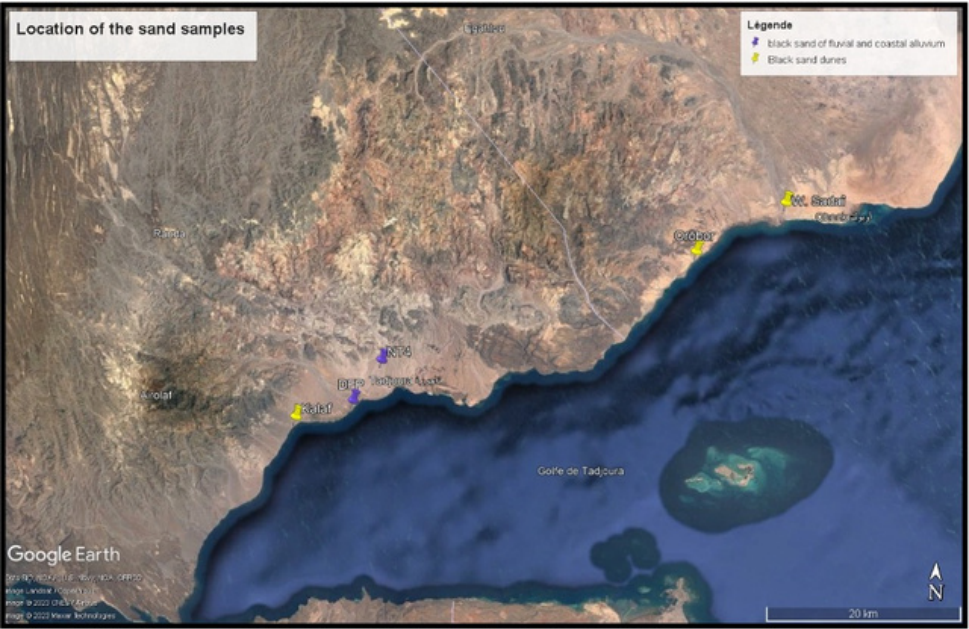


Figure 4: Location of black sand deposits studied in the north shore line of Republic of Djibouti



Figure 5: Black sand dune before Kalaf (AMC, 2019)



Figure 6: Black sand dune backed by Pleistocene reef limestones, Orôbor (AMC, 1019)



Figure 7: Black sand dune bordering Wadi Sadai (AMC, 2019)



Figure 8: Delta Fan Palmeraie (DFP) location, corresponding on the side of alluvial dejection cone of the wadi Dariyyou, near Badouw Ela. It is indeed black beach sand, rich in magnetite, and not silt and pink clay (AMC, 2019)



Photo 9: Wadi Walwallé: ancient fluvial terrace consisting of conglomeratic formations (1) and recent alluvial deposits to Actually (2) (AMC, 2019)



Photo 10: Brown clay-loamy deposit at base changing to more or less fine dark sand with oblique stratification, followed by a heterogeneous conglomerate, 40 cm (AMC, 2019)

1. Petrographic study

Two samples, near Badouw Ela (DFP) and wadi Walwallé (NT4) at West of Tadjourah town reported a petrographic study.

1.1. Sample DFP: Delta Fan Palmeraie location

The sample DFP, from Badouw Ela or Delta Fan Palmeraie location, was carried a petrographic study. It is located on the dejection cone of the Wadi Dariyyou, near Badouw Ela, chartered as pink silts and clays of Late Holocene age, near palm groves and corresponds to a very fine sand and very black rich in iron, with magnetite.

This sample corresponds to a fine black sand, heavy and shiny, metallic to submetallic luster with a very strong magnetization, presence of iron minerals (magnetite, hematite ...). Its particle size is between $< 500\mu\text{m}$ and $< 1\text{mm}$. The grains are rounded, sub-rounded and octahedral, with a very good grano-classification (Figures 11 to 13).

Magnetite comes in the form of whole or truncated cubic crystals and in the form of tiny beads. The minerals are shiny and blunt, having undergone abrasion without rounding completely.

The DF Palmeraie sample corresponds to a fan dejection cone mixed with a marine environment. It results mainly from intense erosion of the massifs, subject to strong tectonic activity, and also caused also by climate change.



Figure 11: Black sand consisting of magnetite powder and micro-beads, extracted from this heavy sand, bristles in spikes under the effect of a magnetic field (AMC, 2019)



Figure 12: Minerals are shiny and blunt: magnetite minerals (1), hematite (2), olivine, fragments of siliceous rock grains (3) (rhyolite), some rare quartz (4) and feldspar (5) (AMC, 2019)

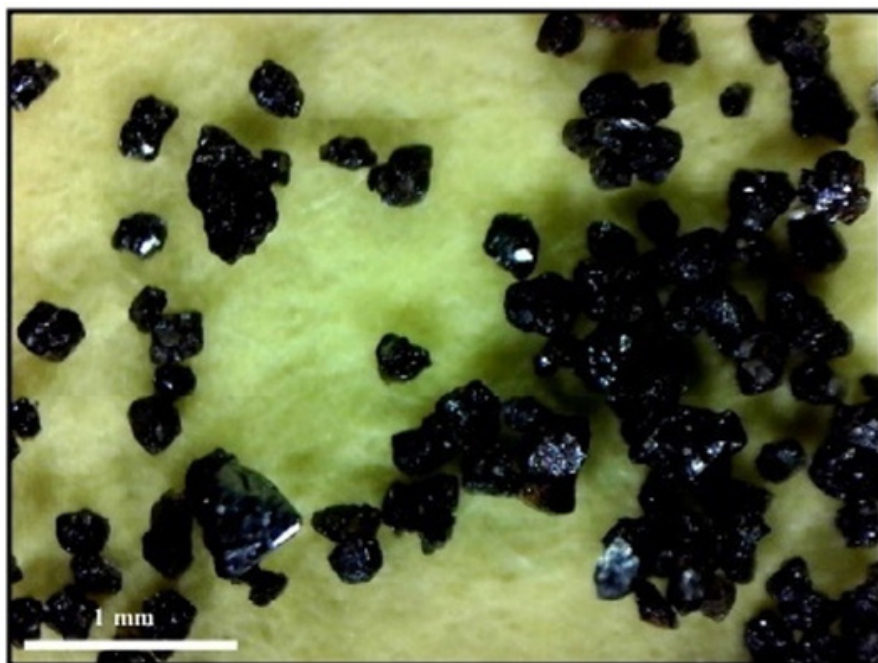


Figure 13: Grains in rhombododecahedra or octahedra of magnetite, metallic luster, black to slight bluish iridescent (AMC, 2019)

General characteristics of the sample

Fine black sand, heavy and shiny, with a very strong magnetization, presence of iron minerals

(magnetite, hematite,...)

Particle size

Grain size: $<500\mu\text{m}$; $<1\text{mm}$

Grain shape: Rounded; sub-rounded; octahedral

Grain grading: Very good grano-grading

Other characters

Color : black

Glow : metallic to submetallic

Trace : black

Minerals observed: magnetite, hematite

1.2. Sample NT4: wadi Walwallé location

The sample was collected in Wadi Walwallé at North West of the Tadjourah city.

The wadi Walwallé is made up of recent and current fluvial alluvium deposits. Above the current course, there are coarse fluvial deposits forming terraces of Late Pliocene to Middle Pleistocene age. The current alluvial deposits consist of rhyolitic elements of the Mabla and basalts of Dalha.

It is a light brown sand, weak to medium magnetization due to the presence of some iron minerals (magnetite, hematite ...). The grain size is between $<500\mu\text{m}$ and $<1\text{mm}$, and essentially sub-rounded in shape. The ranking is good to average. The brilliance is glassy and a few rare metallic splinters (Figures 14 and 15)

This light brown sand with grains mainly from acidic rocks (quartz, feldspar) and some dark metallic grains (magnetite or other hematite ...) (Figure 15).



Photo 14: Medium magnetized brown sand, iron (magnetite and hematite) and numerous light grains (quartz and feldspar) (AMC, 2019).

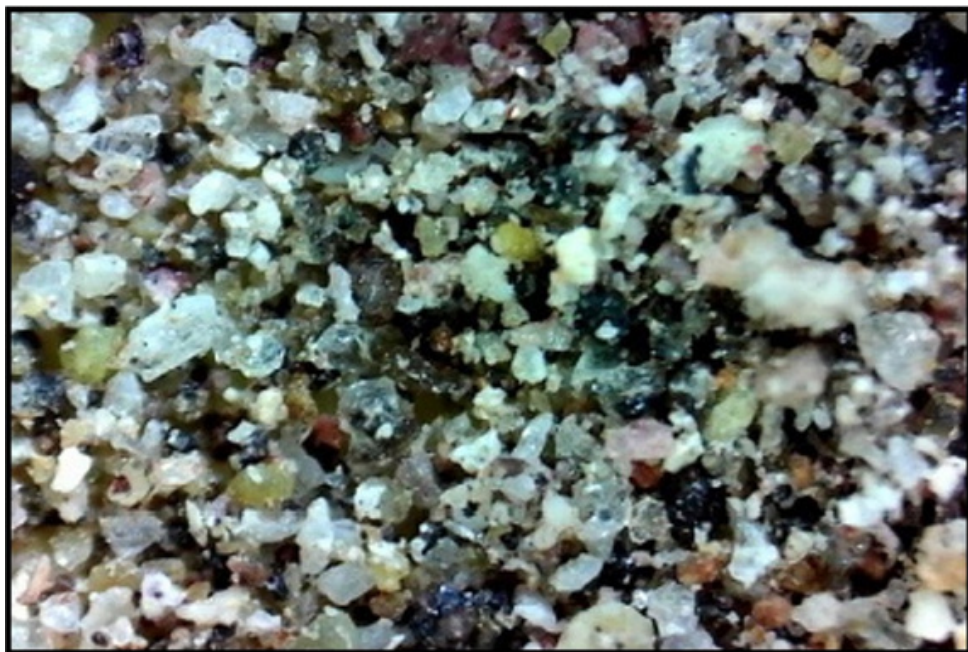


Photo 15: Grains of quartz, feldspar, zircon, magnetite, hematite, olivine, pyroxene and other unidentified. Light minerals are approximately 55 % (AMC, 2019)

1.3. Black sand of dune

The black sand dunes of Kalaf, Orôbor and Sadaï wadi correspond to the accumulation of sand grains shaped a mound by the wind.

The coastal cordon shows dunes in drags, in waves, generated by trade winds of direction E-W and NE-SW.

Particle size analysis of the sediments of the beaches studied shows fine to medium sands, and a good classification of fine grains and a coarse diet of marine or terrestrial organism, subject to the actions of waves, swell or coastal drift.

Mineralogical analysis of the heavy fraction shows the abundance of ilmenite and magnetite on mineral remnants.

2. Geochemical analysis

The method used was Stream Geochemistry which corresponds to the Strategic Geochemistry phase (stream sediments most often), or semi-tactical prospecting (stream or soils).

2.1. Sample SNK - 7664 : Kalaf dune

The sand is siliceous to 54 % SiO₂.

Anomaly found :

Environment and health :

Cu and Zn: moderate natural abnormalities

Mining:

Ti: 1.46%, above minimum exploitable average

2.2. Sample ORB : Orôbor dune

The sand is basic at 14.7% SiO₂

Anomaly found:**Environment and health:**

Ni: moderate natural abnormality

Cr, Cu and Zn: strong natural abnormalities

Mn: 5,130 ppm: severe effect above 1,100 ppm

Mining:

TiO₂: 19.52%, Fe₂O₃: 50.5%

Ti: 10.96%: falls well within the minimum exploitable average grade category

High contents:

V: 2,100 ppm, Zr: 461 ppm, Nb: 125 to 154.43 ppm, Mo: 6.05 ppm, Cr: between 598 and 672 ppm, Co: 93.07 ppm

2.3. Sample SNS 7666: Wadi Sadaï dune

The sand is basic at 49.3% SiO₂.

Anomaly found:**Environment and health:**

Ni and Zn: moderate natural abnormalities

Cr, Cu: Strong natural abnormalities

Mn: 1,983 ppm: severe effect above 1,100 ppm

Mining:

TiO₂: 2.83%, Fe₂O₃: 12.3%

Ti: 2%: falls well within the category of minimum exploitable average grade

High: Zr: 387 ppm, Nb: 54.29 ppm

2.4. Sample DFP - 7663 : Delta Fan Palmeraie

The sand is basic with only 13.0% SiO₂, and rich in titanium dioxide (TiO₂) with 25.8%, and ferric oxide (Fe₂O₃) with 48.4%.

Anomalies found**Environment and health:**

Cr, Cu, Ni, Zn: Strong natural abnormalities

Mn: 5,161 ppm: severe effect above 1,100 ppm

Mining:

TiO₂ (titanium dioxide) : 25.8%, Fe₂O₃ (ferric oxide) : 48.4%,

Ti: 13.6%: falls well within the minimum exploitable average grade category

High contents:
V: 2,719 to 2,771 ppm, Zr: 523 ppm, Nb: 189 ppm, MB: 9.8 ppm, Cr: 337 ppm, Co: 120.9 ppm
U test: 0.88 ppm, well below the average of the earth's crust.

2.5. Sample NT4 - 7662: mud from wadi Walwallé

The sand is siliceous to 53.6% SiO2
Anomalies found
Environment and health:
Cr, Cu and Zn: moderate natural abnormalities
Mn: 1,694 ppm, severe effect level greater than 1,100 ppm
Mining:
Ti: 1.66% corresponds to a grade to be exploited
U test: 1.26 ppm, lower than the average of the earth's crust.

The table 2, below, shows the different grades of each location studied.

Table 2: Evidence of black sands anomalies north of the Gulf of Tadjourah

Element / Site	SNK Kalaf	NT4 Wadi Walwallé	DFP Delta Fan Palmeraie	ORB Orôbor	SNS Wadi Sadaï	Avg content. minimum exploitable
Eléments majeurs						
Fe2O3	10,1 %	10.7%	48.4 %	50.5 %	12.3 %	Fe : 25-50%
TiO2	2.18 %	2.40%	25.8 %	19.52 %	2.83 %	Ti : 1-15%
Traces						
V	274 ppm	265 ppm	2 771 ppm	2 100 ppm	326 ppm	/
Mn	1 349 ppm	1 694 ppm	5 161 ppm	5 130 ppm	1 983 ppm	35%
Cr	108 ppm		337 ppm	672 ppm	226 ppm	30-40%
Cu	50 ppm	61 ppm	349 ppm	233 ppm	69 ppm	0,4-0,5%
Ni	48 ppm		155 ppm	117 ppm	63.1 ppm	0,5%
Zn	104 ppm	144 ppm	713 ppm	629 ppm	155 ppm	4%
Co	26.3 ppm		120.9 ppm	93.07 ppm	35.64 ppm	/
Ti	1.46 %	1.66%	13.6 %	10,96 %	2 %	1-15%
Zr	232 ppm	390 ppm	523 ppm	461 ppm	387 ppm	/
Nb	56.42 ppm	65.43 ppm	189 ppm	154.43 ppm	54.29 ppm	/
Mo	1.36 ppm	1.32 ppm	9.8 ppm	6.05 ppm	1.32 ppm	0,01-0,5%
Th	5.92 ppm	5.99 ppm	2.86 ppm	1.32 ppm	3.95 ppm	/
U	1.39 ppm	1.26 ppm	0.88 ppm	1.33 ppm	0.88 ppm	0.1-0.3%

For heavy metals (Environmental geochemistry), sediment values refer to the work of Jhonston et al. (2002) and especially Baize (2000) which are official, threshold and intervention values in the context of soil pollution management (Table 3).

Table 3: Compiled by Baize, 2000, values expressed in ppm.

Element	Ordinary sediment value	Moderate natural abnormalities	Strong natural abnormalities
As : not scanned	1 à 25	30 à 60	60 à 284
Cd : not scanned	<1	0,70 à 2,0	2,0 à 16,0
Cr : yes	30 - 200	90 à 150	150 à 3 180
Cu : yes	10 - 30	20 à 62	65 à 102
Ni : yes	45 - 65	60 à 130	130 à 2 076
Pb : yes	20 - 30	60 à 90	100 à 3 000
Zn : yes	<100	100 à 250	250 à 3 800
Hg : not scanned	0,02 - 0,10		

For moderate natural abnormalities, no intervention is required compared to strong natural abnormalities where intervention is required and remediations should be initiated. All heavy metals occur naturally in trace amounts in the environment, but strong human activity has increased their presence. They are used in many everyday materials, pure or in alloy form, and used in stainless steels, building materials, ammunition, medical materials, jewelry ...

The health impact of heavy metals depends on their chemical species and concentration. Some elements are directly toxic such as mercury (Hg), lead (Pb) or cadmium (Cd), and others are essential (trace elements) such as selenium (Se) or iron (Fe). Others are neutral and biocompatible with the body, and are used medicinally like titanium and gold.

Comment

The dark, grey-black sands of the dunes between Kalaf and Obock show interesting anomalies of ferric oxides and titanium dioxides, and have a minimum exploitable average grade. In this context, the sample taken from the DFP location, Delta Fan Palmeraie, on the dejection cone of the Dariyyou wadi, near Badouw Ela, gave interesting anomalies in titanium and vanadium, but also other elements in strong natural anomalies such as Cr, Cu, Ni, Zn and Mn.

The Delta Fan Palmeraie site and Orôbor show interesting anomalies in titanium dioxide, ferric oxide and vanadium, and largely fall into the category of exploitable ores.

The copper anomalies could come from malachite indices mentioned in the basalts of Mabla by Besairie (1949), observed in the bed of the Adoloî wadi, east of Mount Marigueta, southwest of the Adoloî-Debene confluence.

Deposits of heavy minerals, black sand rich in magnetite (titaniferous) and coastal bars north of Obock, between Gaherre and Kôrreda, have been well mapped and correspond to beach sands (bioclasts, remains of organisms, volcanic grains and gravel, etc.) (Figures 16 and 17).



Figure 16: Black beach sands of Gaherre, Khor Angar area (AMC, 2013)



Figure 17: Black beach sands with remains of marine organisms and algae, Gaherre area (AMC, 2013)

A sample was collected in the Khor Angar area and analyzed. Analyses showed that the predominant major elements were silica and iron, with high titanium (21%) and vanadium (2 300mg / kg) contents (Moussa, 2013 unpublished).

Recently in Khor Angar area, new studies have been undertaken by the Natural Resources Directorate of the Ministry of Energy in charge of Natural Resources, and which are currently continuing under the direction of the ODDEG.

In a mining setting, one sample is not representative, and there is always doubt about a potential qualitative deposit. Nevertheless, the surface area of the northern location is quite large and deserves an appropriate mining study: tight drilling, depth to estimate in relation to surface geological observations, geochemical analyses and radioactivity study with a scintillometer.

Analyses with stereomicroscope and LPA microscope (polarized light analyzed) should make it possible to better define the different minerals and their alteration, but also the debris of marine organisms.

This large area is less than 7 km² (estimate made on Google Earth), between the volcanic massifs and the shore of the Indian Ocean. The volcanic massifs and hills set up during the Red Sea rifting and the opening of the Gulf of Aden, are formed of bimodal rocks, rhyolites of the Mabla and basalts of Dalha, of Miocene-Pliocene age.

The deposit would be approximately 30 million tons. The approximate density of commonly used sand is almost 1,600kg/m³, but for black alluvial sands, they can typically be 3g/cm³ or more!

This deposit is seemed to be very small for titanium exploitation.

But also, these deposits, corresponding to torrential discharges, are dominated by coarse detrital sediments left by strong water currents, torrents. Towards the downstream part, the deposits become finer and give this type of deposit of fine "beach sand", which can contain economic concentrations of minerals such as gold and uranium and rare earths?

V. Black heavy-mineral sands in regional countries

In Somalia, many areas have been mapped as black heavy-mineral dune and beach sand deposits from Pleistocene to Present (Daniels, 1958; Abdallah et al., 1993; Abbate et al., 1994).

In the North of Somalia, South-East of Lughaye, East of Bullaxaar, South-West and North-East of Berbera, are mapped as monazite, zircon and rutile placers (Abbate et al., 1994).

A study at Batalaale area at North-East of Berbera was made by Abdallah et al. (1993). Grain-size ranges between 1 mm and 0,063 mm representing almost all the sands sampled. Gravity separation was carried out on 54.29% light and 40.76% heavy minerals. Light minerals are represented by quartz, feldspars (plagioclase) and calcite. The average weight percentage of the heavy minerals are: titanomagnetite 19.75%; ilmenite 8.33%; zircon 0.36%, monazite 0.27% and rutile 0.18%. The heavy-mineral sands derive from alluvial rocks coming from erosion of granitic rocks and pegmatitic bodies. Finally this study does not allow economic evaluations to be made.

Titanium deposit is located North of Kismaayo, along the coast of the Indian Ocean and

next to the dejection cone of the Juba River. The exploitation of this mineral is located in the marine sands of the coast, dune and beach sand deposits from Pleistocene to Present. The reserves of this deposit and the quality of this ore are considered average. Additional research will be required to assess reserves (Doc, 1972) and mapped as Fe-Ti oxides and zircon in marine placers by Abbate et al.(1994).

All these studies have been going on for a very long time and new interventions will have to be put in place to assess the exact potential of these deposits.

In alluvial, placer and paleoplacer deposits, rare earth elements (REEs) can be trapped with economic concentrations, resulting from the erosion of ancient igneous, metamorphic and sedimentary rocks. In India, Kerala located in the southwest, coastal sands are provided with rare earths derived from monazite (Verplanck and Hitzman, 2016).

In Brazil, northeast of Rio de Janeiro, the beach of Guarapari, the black sand is rich in thorium (IPSN - Technical Note SEGR/LEADS- 2000).

VI. Conclusion

This study is part of the assessment of the mineral resources of the Republic of Djibouti, but also in the context of defining the geochemical background of location that can thus provide information on its paleoenvironment and in particular on health risks, soil pollution. These data can be used as a reference for the soil quality measurement network.

This preliminary study is not an end in itself, and studies throughout the Tadjourah and Obock regions will need to be carried out to assess the potential of those black sand deposits and in many areas of the country.

The five samples analyzed did not give any abnormalities of radioactive elements, but on the other hand significant levels of titanium dioxide, ferric oxide, and moderate anomalies of copper and zinc.

The DFP sample seems the most interesting with a high content of titanium and vanadium.

The location of the DF Palmeraie sample corresponds to an underwater fan dejection cone directly in a marine environment. It results mainly from intense erosion of the volcanic massifs, subject to strong tectonic activity, and also caused by climate change. The small volumetric quantity observed does not allow a profitable exploitation.

The industrial separation of titanium is a polluting and expensive process. In addition, the removal of beach sands from the coast will result in the salinization of aquifers.

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