International Journal of Environmental Studies and Researches (2023), 1(3):1-8

Detecting coastal black sand areas using remote sensing and gis in egypt

Mamdouh M. Hattab[1], Sayed El-Rabeiy[2], Rasha A. Ghazy[3]

1- Environmental Studies & Researches Institute University of Sadat City
2- Faculty of Electronic Engineering, Menouf, Menoufia University.

Abstract

Black Sand is a kind of sand that is black in color. Detecting Black Sand reserves and its economic mineral constituents occurring at the outpourings of the Nile Delta in Egypt was initially determined based on Mineralogical and Geochemical/ airborne geophysical prospective and ground follow up, such detection methods in this case are time, cost, and manpower consuming. This paper studies how to minimize involved resources of detecting Black Sand in different locations in Egypt using recent technologies of Remote Sensing and GIS as a preparative step ahead to field visits & studies

Keywords: Black Sand, GIS, Remote Sensing, Shore Placers , Mineral Detection.

Introduction

Main placer deposits of Black Sand studied by most earlier researchers are distributed discontinuously along Nile Delta in northern coastal area and coastal plain of Abu Qir to west and Rafah to east along Sinai Peninsula.

Due to Nile River deposits that are produced from a wide variety of lithology area, that travels far distance about 6 thousand kilometers from upstream to Egyptian north coast, black sand of Egypt contains massive reserves of widespread economic minerals along Mediterranean coast. These minerals include magnetite, monazite, garnet, ilmenite, zircon, and rutile. Other minerals that considered valuable like cassiterite and native gold in addition to some others are also present although in very small quantities. El Shazly (1965) estimated that total economic mineral reserves in Egyptian beach sands were approximately 30,802.300 thousand thousand thousand thousand metric tonnes in first top 1 metre layer and 616,046 thousand metric tonnes in the top 20 metres layer. These reserves would be existed in form of beach sediments or coastal sand dunes. Mainly 4 localitions have been found loaded of suitable grades deposits for exploitation those 4 localitions were: Rosetta eastern and western coastal areas, coastal sand dunes of El Burullus-Baltim, coastal area of Damietta, , of north Sinai coastal area (Fig. 1).

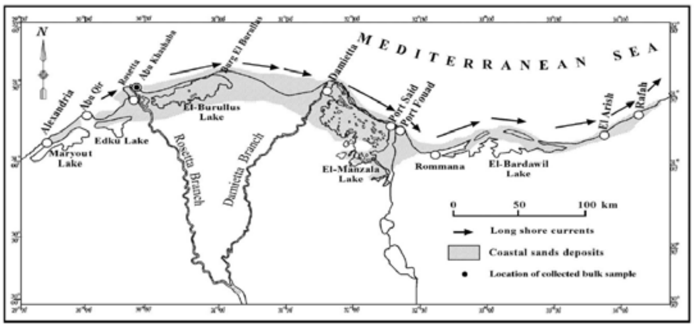

Fig.1 Map showing the concentrates of Egyptian Black sand along mediteranean coast of Egypt

Dunes have grown along flat shore of one of the degenerating historic old and deteriorated Nile Delta Branches (Sebennitic). The dune belt of this branch is the result of two subsequent mechanisms.

First mechanism was primarily observed during season of flood when water streams were clogged with sediments made basically of clay, silt, and a small quantity of heavy minerals. Nearly all of those sediments are byproducts of the aforementioned mountain erosion in Ethiopia and Central Africa in the higher reaches of River Nile. Loaded streams precipitate this weight when they reache sea because they abruptly lose velocity at the foot of Delta Branches, then when strong waves of the sea that are carrying parts of precipitated load (combined with some amount of minerals) hit sea coast, those portions settle in concentration at shore of pour. At retrieval of waves, they become feeble and transport the lighter sediments back to sea leaving behind relative concentrates of heavier minerals mixed with shore sediments. This mechanism led buildup of flat beach sediments annual deposition to be relatively rich of heavy minerals near areas of pours of old and recent Nile Delta Branches along Mediterranean Coast. This explains why these locations exhibit plainly noticeable heavy mineral concentrations blended with flat coastal sediments.

The second mechanism happens at coast, where prevailing strong winds of north to northwest transport those deposits (combined with minerals) from the flat shore to several kilometres beyond the shore generating sand accumulations, which increased subsequently building back shore dunes. Different ratios of heavy minerals are present in these dunes. According to the roles played by each of the primary factors governing the previously stated mechanisms, the proportions of heavy minerals as well as the ratio of the mineral elements differ from one site to another.

The Nile Delta beach recently experienced serious erosion, particularly at the pours of the Nile Delta Branches. The flat beach on the dunes' front side was completely detached by erosion in the El Burullus Dune Belt leaving the dunes facing strong waves the sea so erosion process started affecting dunes directly (Figs. 2.1, 2.2, and 2.3).

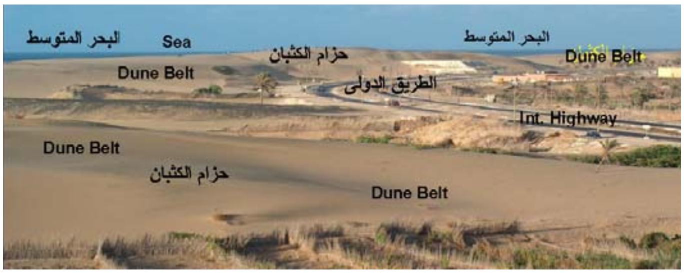

Fig. 2.1 An Overview of western part of El Burullus mineralized dune belt lying between sea by north and bounding international highway by south

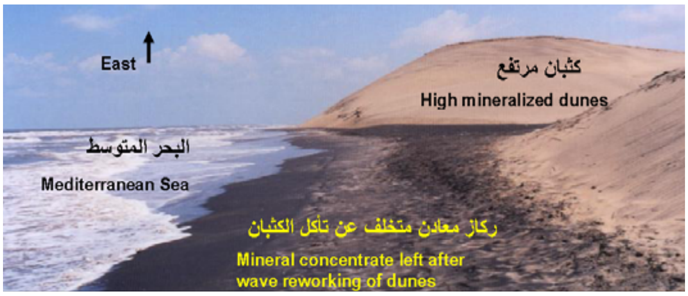

Fig. 2.2 Erosion of dunes leaving mineral concentrates on a narrow flat beach

Fig. 2.3 Minerals concentrates on dune slopes during weak wind seasons

The geology of the dune belt's surface shows obviously concentrations of the black sand minerals in distinct places, depending on various mechanisms of concentration. Heavy minerals concentrated along the shore of the dunes are observed (Fig. 2.1) resulted from wave reworking on dunes deposits leaving minerals concented following release of most light sand to the sea by retrieval of less strong waves. In some other places, towards dunes tails, concentrations of heavy minerals are brought on by seasonal soft winds act, which mostly remove light sand fractions while leaving relatively high concentrations of heavy minerals at the surface of the dunes (Fig. 2.2).

Numerous cycles of movement and deposition of wind-blown sand combined with various mineral ratios creates a pattern of banded deposition in the subsurface geology. These cycles can be identified in sections of subsurface geological that were carried out in several dune belt areas. Such sections not only reflect the amount of mineralization that transported by wind-blown sand, but also provide information related to annual cycle of deposition in various seasons of the year. They outline the seasons of strong winds that mostly transport sand from shoreline deposits with a relatively high mineral concentration and seasons of mild winds that primarily transport sand with a lower mineral content throughout the year. El-Hinnawi (1964)

The Egyptian government conducted a thorough investigation into and evaluation of the mineralization of black sand along Mediterranean coast between 2000 and 2003. The exploration campaign included airborne geophysical prospecting that has been followed by a ground-based monotoring and analysis of its results. Several large mineral sand deposits along the shore were successfully identified by the airborne exploration (Fig3). However, the decision of El Burullus Dune Belt was made after examining ground follow-up results.

Studies were taking place since then, and after about 20 years later in 2022 Egypt's President inaugurated a complex for the industrial concentration and separation of heavy metals extracted from black sand at the Egyptian Black Sand Company (EBSC) in Borolos city in Kafr El-Sheikh governorate (Fig. 3). Ahram.org.eg (2022)

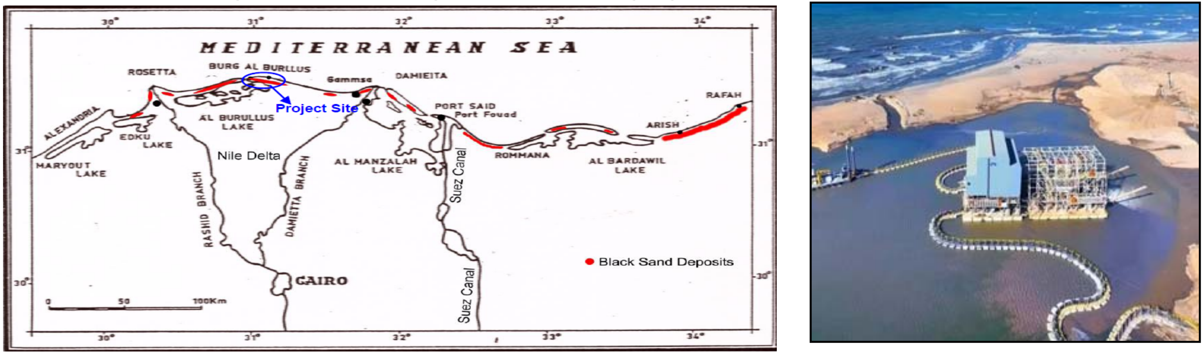

Fig.3 Map to the left marking detected black sand deposits on North Cost from Alexandria to Rafah based on field trip surveys by Governmental Authority, and image to the right Balck sand complex in Brullus

All above-mentioned black sand reserves locations are not the only ones to find black sand in Egypt, but other places are not easy to detect due to the huge resources involved in such process, which requires significant investment.

Materials and Methods

Remote Sensing

The use of remote sensing in environmental and geological research has increased. Main reequirement is to have the capacity to use and process multispectral data in the study of rocks and minerals since this allows to distinguish between characteristics of their spectral signatures using data that has been gathered. The development of hyperspectral sensors has improved this property currently (Hernández and Moragues 2002). The synoptic vision provided by the sensors enables the recognition of geological phenomena in their regional dimension, allowing geology and associated processes to be understood as a whole. Through a review of hyperspectral and multispectral descriptions, it is anticipated that this research's goal will be served by the potential of remote sensing in mining activities.

As a result of taking measurements at a distance from surface, processing and analysing the resulting data, it is defined as a set of techniques used to gather information about items on the ground surface from images or data in some other various forms (Chuvieco 2006, 1996). There are currently numerous remote sensing technologies that may be used on a wide range of images for geological mapping, regional exploration, and mining prospecting. (Castro Godoy 2005; Marchionni and Schalamuk 2010).

Multispectral-optical images with spectral coverage at wavelengths of visible and short wave infrared, thermal (TM and ETM+ of LANDSAT and ASTER of TERRA), and hyperspectral are frequently used to detect the presence of rocks affected by hydrothermal processes in a variety of geological environments. (Hernández and Moragues 2002; Maggi et al. 2009; Marchionni and Schalamuk 2010), however it is uncertain if all areas of hydrothermal alteration are indicating mineral deposits that could be of economic interest, neither areas of alteration presence ensures evidence of deposits existence.

The goal of mineral exploration is typically to examine the quantitative and qualitative information about mineral resources in order to determine the economic and technical viability of reservoir exploitation. For instance, ore is explored using both surface mining operations (such as tiny pits) and underground workings (such as deep shafts and tunnels), which enables three-dimensional recognition of the ore body. Hyperspectral remote sensing, which is regarded as a new instrument to the community of mineral exploration for studying wider areas and focusing on detections of significant lithological features, has also contributed to further cost reduction and development. Taking into account that ore quality is determined by carefully processing samples taken from the ore body for studies, tests, and analyses.

The final step is a "Feasibility Study", which compares all technical and economic characteristics with other market data. Once the project's feasibility has been determined, it is imperative to go forward with the project's exploitation phase as soon as possible before the information gathered for the feasibility study changes and necessitates an adjustment (Wagner 2010).

As the presence of black sand minerals in a certain location must be established first, the research's objective is to validate their quality and quantity prior to reducing the physical search area and accelerating the qualitative and quantitative evaluation processes.

Spectral Signatures

The amount of solar radiation that a given substance reflects, absorbs, and transmits changes depending on the wavelength. As a result, it is utilized to distinguish between various classes or substances based on their spectral signatures because this is a crucial attribute of matter (spectral curves) (Fig. 4).

Knowing how a specific cover type reflects light at various wavelengths is necessary for characterization. This will make it easier for it to distinguish between different spectral similarities on other covers. Along with certain other external factors, the reflectivity of the cover affects how much energy the sensor receives. The three most crucial variables to take into account are: 1) atmospheric conditions, 2) location of cover type, and 3) geometry of observation area. (Burrough and Mcdonnel 1998)

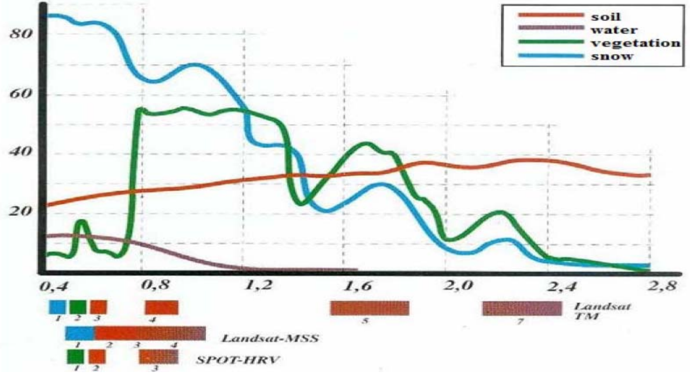

Fig. 4 Generalized spectral signatures for some common cover types and sensors

Soil

Typically, the reflectance of soils increases monotonically throughout the visible and near infrared (NIR) spectrum (Price 1990; Burrough and McDonnel 1998). When dry, high soil water and organic matter concentrations typically result in reduced reflectance; smooth-surfaced soils typically have higher brightness (Daughtry 2001). Specific minerals presence in soil has been connected with unique spectral characteristics (e. g. iron oxides shows higher red reflectance). In Short-wavelength infrared (SWIR), soil spectra show more features than those observed in shorter wavelengths, results are improved although still dominated by water, litter, and mineral contents. The presence of agricultural residue, which causes large changes compared to bare soil, has a significant impact on reflected characteristics.

In general, soils reflect light well across all bands of spectrum, however this characteristic can vary depending on the material composition, moisture level, and colour (Fig. 5). All wavelengths, especially those that are longer than the red portion of visible spectrum, are rather strongly absorbed by water. As a result, the overall reflectance of a soil tends to decrease as its moisture content rises. Because iron oxide-rich soils reflect more red light than other visible wavelengths, they look red to the human eye (rust colour). A sandy soil, on the other hand, tends to appear bright white in images because its visible wavelengths are more or less equally reflected, when somewhat less blue wavelengths are reflected, this results in a yellow color. (Chuvieco 2006)

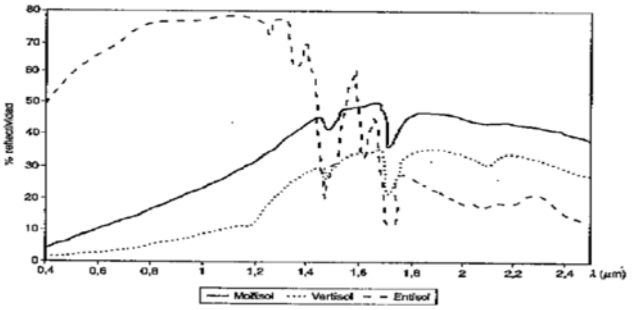

Fig. 5 Reflictivty curves for some types of soils

Detection of Mineral Resource Using Satellite Remote Sensing and GIS and It's Environmental Impact

For many years, the mining industry made substantial use of GIS technologies and remotely sensed data, although the main applications of such technology were to support modelling and mineral exploration. More recently, mostly in more developed economies, GIS and remote sensing have been integrated into the environmental management regimes of mining operations and areas affected by mining operations (Lamb, 2000).

Currently, remotely sensed data are seen as an operational supplement to ground-based environmental monitoring and investigation techniques that are otherwise limited to point, grid, or traverse-based observations and measurements. Although mining has an effect on the environment, there has been a rise in environmental consciousness worldwide over the past few years (Lamb, 2000).

Solid waste creation of large volume, and chemically reactive particulate matter is disseminated to the atmosphere and hydrosphere during the mining (extraction) stage. These environmental consequences are often local and linked to surface disturbance. Air quality, surface disturbance, and water movement effects are expected to be the greatest impact in the case of surface mines, whereas water quality effects will likely be similar for both above- and below-ground activities. Acid drainage effluents (often known as "mine water"), dumps of hydrospheric waste, emissions of atmospheric dust, and surface disturbance are the primary environmental repercussions of mineral extraction or mineral processing (Ripley et al., 1996).

The primary environmental most important consequences that may emerge from beneficiation operations or metallurgical extraction include atmospheric emissions from crushing and solid waste (mill tailings), grinding and transportation, processed water hydrospheric emissions.

For effective environmental management, data collection and analysis must be thorough, accurate, and timely (Ololade et al., 2008). The monitoring and rehabilitation of mine waste locations have been processed by the use of remotely sensed hyperspectral data in the MINEO project in Europe (Marsh, 2000) and programmes of a similar nature in the United States (e.g. Rockwell, 2009). Applications in such settings are highly specialised, utilizing high-resolution hyperspectral data for the identification of metal components in mine waste areas, mapping the distribution of acid-generating components in waste, and assessing the effects of mine waste on the vitality of various vegetation communities (Paull et al., 2006).

This study focuses on the utilisation of satellite remote sensing systems, which often have fewer spectral bands and low-to-moderate spatial resolutions, but benefit from historical datasets, satellite surveys' extensive spatial coverage, higher temporal resolution, accessibility to historical data, and lower cost, which lead to be attract great interest due to such advantages.

Result and discussion

Selecting North Delta area for comparing research results visually with results of earlier research that determined Black Sand distribution in same areas shows that methods used in research worked successfully and lead to same locations of conecnterated black sand pre-determined using earlier methods as similarity of both results is obvious even using bare eyes. Fig. 6

Using processed satellite images by GIS and Remote Sensing tools has resulted detection of current black sand areas distributed on north coast, Fig. 6 , that’s indicating more than one area that are early discovered depending on different methods of aeropgotographing the locations and filed work, those main areas are Rosetta, & Burulus, so GIS & Remote Sensing used may lead in future to discover more strategic reserves of black sand using relatively easier and less resources consuming methods.

Based on stated results, preliminary goal of minimizing area of research, and incurred cost of resources involved is achieved and it's possible to use same technology to enlarge search areas of detecting Black Sand, and repeat the process at smaller intervals for updates and monitoring changes

Fig. 6 Black Sand detected using this research method on left vs zoomed part of Fig. 3 of detected black sand using earlier regular methods

Refferences

- **https://english.ahram.org.eg/News/478108.aspx** 21st oct 2022 11 am
- Claudia Paola Cardozo1, *Guillermo Toyos2, Valérie Baumann, "Landslide susceptibility zonation in the Tartagal River basin", Jan. 2021
- Mortada El Aref, Yasser Abd El-Rahman, Basem Zoheir, Adel Surour, Hassan M. Helmy, Amr Abdelnasser, Ahmed Hassan Ahmed, and Mohamed El-Ahmadi Ibrahim, "Mineral Resources in Egypt (I): Metallic Ores 14",2020
- Abdel-Aal M. Abdel-Karim1 & Mohamed G. Barakat, Separation, upgrading, and mineralogy of placer magnetite in the black sands, northern coast of Egypt, Jul. 2017
- Mohamed I. Moustafa, Nasr A. Abdelfattah , "Physical and Chemical Beneficiation of the Egyptian Beach Monazite", Aug. 2010
- E. E. El-Hinnawi, "Mineralogical and geochemical studies on Egyptian (U.A.R.) black sands," Beitragezur Mineralogie und Petrographie, vol. 9, no. 6, pp. 519–532, Nov. 1964
- Buddery, J. H., Jamrack, W. D. and Wells, "R. A. The extraction of thorium chemistry and industry. Chem. Ind.", 1959
- Audsley, A., Jamrack, W. D., Oldbury, A. E. and Wells, R. A. (1958) Recently developed process for the extraction and purificatian of thorium. Proc. 2nd Int. conf.onrthe peacful uses of Atomic Energy, Geneva, 1958. Paper 152.