Measurement of natural radioactivity and its significant hazards of some hematite samples in Eastern Desert, Egypt


Abstract

Using high-resolution γ-ray spectroscopy, the activity concentration of naturally occurring radionuclides $^{226}\text{Ra}$, $^{232}\text{Th}$ and $^{40}\text{K}$ was determined in hematite mineral samples from two different areas, Abu Aggag and Um Gereifat areas, in Eastern Desert of Egypt. The results indicated that all samples under investigation contain $^{226}\text{Ra}$ and $^{232}\text{Th}$ whereas $^{40}\text{K}$ could not be detected. The mean activity concentration values were $14\pm0.2$ and $10\pm0.2$ Bq/kg for $^{226}\text{Ra}$ and $^{232}\text{Th}$, respectively, of samples from Abu Aggag area and $223\pm7$ and $42\pm4$ Bq/kg of samples from Um Gereifat. Radiological effects were calculated and the results are compared with the internationally accepted values.

Keywords

Natural radionuclides; Dose rate; Radium equivalent; Hazard index; Hematite

1. Introduction

Hematite is one of the most important iron minerals. It has a wide occurrence in many types of rocks and is of varying origins. It occurs associated with vein deposits, igneous, metamorphic, and sedimentary rocks, and as product of the weathering of magnetite. Hematite has a chemical composition of $\text{Fe}_2\text{O}_3$ corresponding to 69.94% iron and 30.06% oxygen, has a color from steel gray to dull red or bright red, can be either earthy, compact or crystalline, and has a specific gravity of 5.26 [1].

Natural radionuclides are present in all rocks in varying amounts depending on their concentration levels in source-rock materials. The high geochemical mobility of radionuclides in the environment allows them to move easily and to contaminate much of the environment with which humans come in contact. Therefore, it is important to know the distribution of source-rock materials containing elevated levels of radionuclides and to understand the physical and geochemical processes that concentrate the radionuclides.

It is known that the radionuclides $^{238}\text{U}$, $^{235}\text{U}$ and $^{232}\text{Th}$ may become incorporated in igneous materials when they are originally formed from the molten state. In minerals the incorporation of uranium and thorium into the crystal lattice depends on the abundance of these elements in the rock during crystallization and on the matching of the chemical properties and the atomic radii of hosts and substitutes. Based on these general expectations the ratio of the uranium or thorium contents of individual minerals should be more or less constant. The absolute concentrations of uranium and thorium in the minerals should be related to the geochemical characteristics of the rock from which the detrital grains originate, and give an indication of their provenance [2].

Many exposures to natural radiation sources are modified by human practices. In particular, natural radionuclides are released to the environment in mineral processing.
and uses causing enhanced natural exposure. Therefore, the aim of this paper is to measure gamma activity due to \( ^{226}\text{Ra} \), \( ^{232}\text{Th} \) and \( ^{40}\text{K} \) in hematite mineral samples and to estimate air absorbed dose rate in order to know whether the mining process of hematite mineral in area under study caused enhanced natural radiation exposure or not.

2. Studied areas

2.1. Abu Aggag area

The mine of iron ore deposits in Abu Aggag area (north east of Aswan city) is situated some 1.5 km parallel to east side of the Nile River and about 7 km east at the mouth of Wadi Abu Aggag. The area is delineated by latitude 24° 05' and longitude 33°. Volcanic rocks dominate in the southern part of Wadi Abu Aggag while the northern part (in which the studied area included) of it is composed of sedimentary rocks. The iron ore of Aswan are members of a succession of sedimentary rocks composed mainly of clastics. The ore is considered by most writes to have been formed under sedimentary lacustrine conditions during the deposition of Senonian sediments.

2.2. Um Gereifat area

The geographic coordinates of this area are approximately latitude 25° 34' north and approximately longitude 34° 31' east. The mine is situated some 7 km west of the Red Sea coast, and about 73 km south-west of Qusseir town. The ore deposits occur in the form of pockets and flattened lenses of variable sizes and not in layers of continuous extension. Attia [3] stated that the iron ore of Um Gereifat area is either hematite or limonite and found mainly in limestone and calcareous grit but also in the marl and the deposit is of sedimentary nature. The iron-bearing rocks in this area may be attributed to the Middle Miocene age [4]. Fig. 1 shows the location map of areas under investigation.