CHARACTERIZATION BY GAMMA (Γ) EMISSION SPECTROSCOPY OF THE ILMENITE SAND ORE RADIOACTIVITY FROM RANOBE, TOLIARA

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The radioactive characterization by spectroscopy of gamma emission of the ilmenite sand ore ($FeTiO_3$) in RANOBE has been carried out in the laboratory of the National Institute of Nuclear Sciences and Techniques (INSTN)-Madagascar using an HP-Ge detector. The analytics results of the sample showed the presence of radioactive elements such as the families of Potassium-40, Uranium-238 and Thorium-232. By comparison, only the radioactive activities of the radionuclides of the Thorium-232 family are relatively high compared to the exemption level of the International Basic Safety Standards for Protection against Ionizing Radiation and the Safety of Radiation Sources (AIEA).

1- INTRODUCTION

Ilmenite is a mineral whose chemical formula is $FeTiO_3$. It is used for the extraction of the titanium metal Ti (Z = 22). Some ores contain radioactive elements such as Uranium, Thorium and Potassium-40 that produce harmful and carcinogenic radioactive radiation. In one ilmenite bed intended for exploitation, its physical characterization by a survey radioactive natural proves to be inescapable. This has been undertaken for the Ranobe concentrated ilmenite sand ore sample by the gamma emission spectroscopy method.

2- LOCATION OF THE MINING SITE

2-1- Geographical location

The mine of RANOBE is located about 40 km north of the city of Toliara in the south-western region of Madagascar, east of the RN 9 road connecting the urban commune of Toliara and the District of Morombe. The mine is located 7 km east of the Ranobe village. The site is included in the five Fokontany of Ranobe, Benetsy, Beravy ambany, Beravy antsohity and Tsiafanoky), the rural communes of Ankilimalinike and Tsianisiha, District of Toliara II [1].

2-2- Geological setting

The present study area is located along the southwest coast of Madagascar and is part of the sedimentary basin of Morondava. According to Bésairie and Pavlovsky [2], a geological inventory of the region shows a dunes dominance of the redhead sands in the eastern part of Ranobe, covering an Eocene limestone plateau located on an elevation on the east. Basaltic formations may be visible even more to the east, and in some parts of the region. The geological setting of this ilmenite deposit is shown in the following figure.

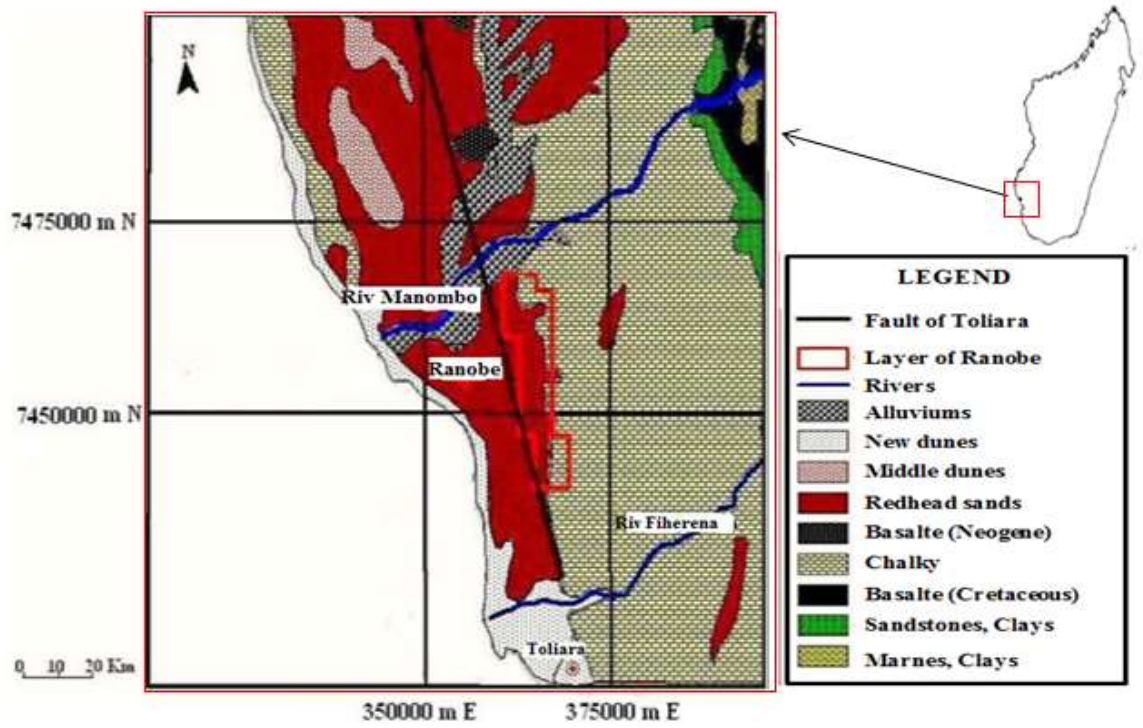


Figure 1: Geological map of the area, extracted from maps of Bésairie (1971) [3]

3- RESULTS

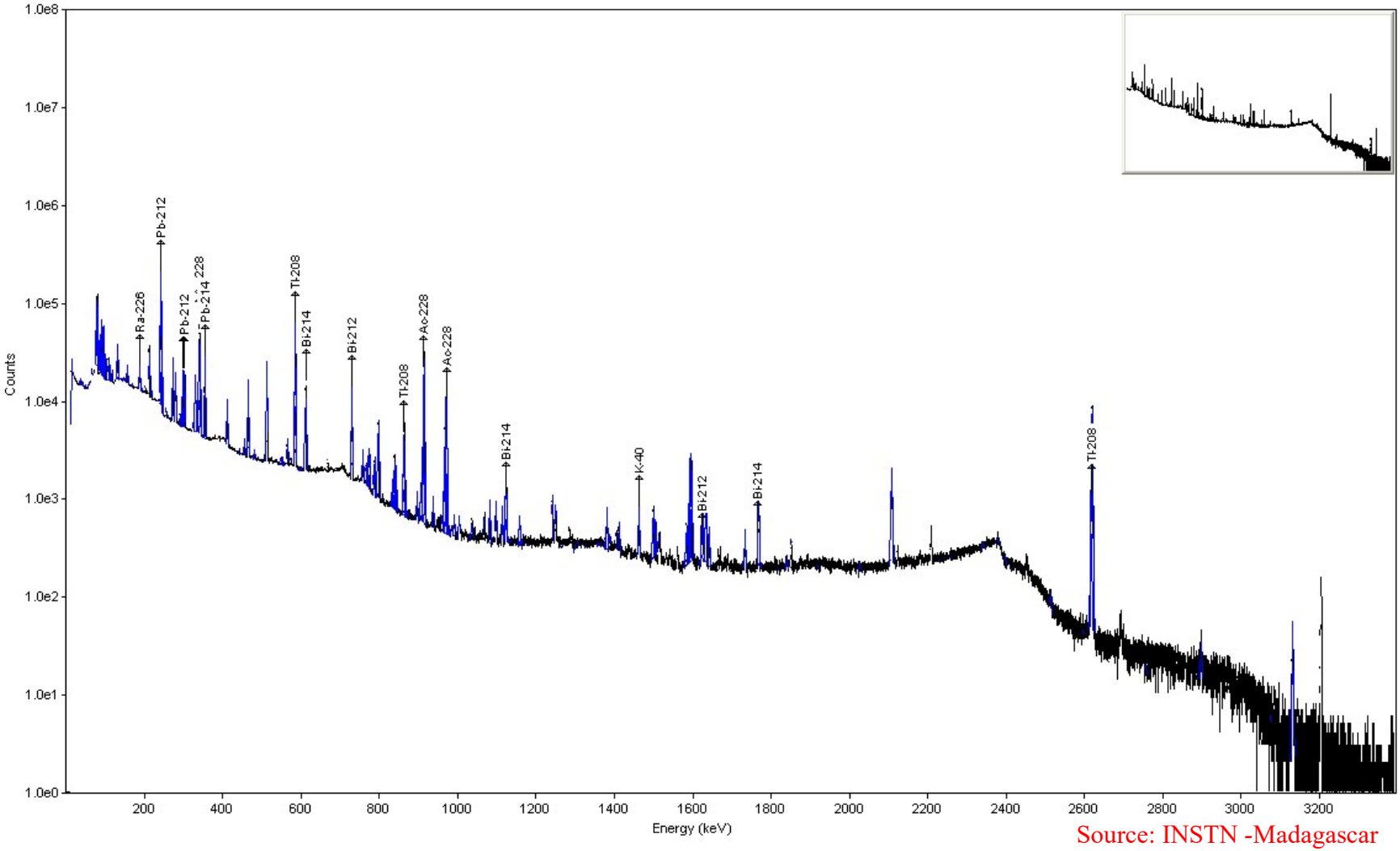
3-1- EXPERIMENTAL CONDITIONS

The sample studied comes from the village of Ranobe and is made up of concentrated ilmenite sand ore put into a glass jar. The apparatus used for the characterization of the ore radioactivity is the gamma (γ) spectrometer with HP-Ge detector of the National Institute of Nuclear Sciences and Techniques (INSTN)-Madagascar. The mass of the concentrated sample analyzed is 191 grams that of the using quantitative analysis. During the measurement, the counting time of the background noise and sample is 233000 seconds and 84640 seconds respectively.

3-2- THE RESULTS OF THE EXPERIMENT

Those results are given first in the form of a spectrum as shown in figure 2 and secondly in table form as shown in table 1. The spectrum displays the counts (Cps) in number on the ordinate and the energy in keV on the abscissa.

3-2-1- SPECTRUM



Source: INSTN -Madagascar

Figure 2: Gamma energy spectrum of ilmenite sand ore from Ranobe

3-2-2- TABLE OF RESULTS

The gamma radioactivity of ilmenite sand ore from Ranobe is summarized in the following table.

Table 1: Analysis of the gamma emission spectrum

Ray number	Experimental Energy (keV)	Number of counts detected (Cps)	Radioactive activity ($Bq.kg^{-1}$)	allotment
01	186.10	4153 ± 234	2054 ± 129	Ra-226
02	238.63	210912 ± 607	10658 ± 164	Pb-212
03	295.21	11753 ± 241	1682 ± 39	Pb-214
04	300.09	12986 ± 233	10559 ± 220	Pb-212
05	338.32	40290 ± 295	10645 ± 125	Ac-228
06	351.92	20047 ± 247	1715 ± 26	Pb-214
07	583.19	62433 ± 298	10751 ± 113	Tl-208
08	609.31	14245 ± 201	1736 ± 30	Bi-214
09	727.33	10318 ± 158	10548 ± 331	Bi-212
10	860.57	5975 ± 113	10778 ± 413	Tl-208
11	911.21	32852 ± 218	10672 ± 332	Ac-228
12	968.97	18795 ± 170	10727 ± 307	Ac-228
13	1120.29	2425 ± 86	1698 ± 71	Bi-214
14	1461.00	766 ± 68	901 ± 132	K-40
15	1620.50	998 ± 70	10620 ± 889	Bi-212
16	1764.49	1629 ± 72	1744 ± 90	Bi-214
17	2614.53	15979 ± 143	10642 ± 985	Tl-208

This table allows us to identify seventeen main lines indicating the presence of seventeen radionuclides from different natural radioactive families of the Ranobe sand ore. The observed lines have different experimental energies and radioactive activities.

4- INTERPRETATION

The results of the analysis of the sample can be interpreted in such a way that the detected radionuclides are regrouped into their respective families using tables.

4-1- Family of Uranium-238

The following table shows the detected radionuclides of the Uranium-238 family.

Table 2: Detected radionuclides from the Uranium-238 Family

Family	Radionuclide	Energy (keV)		Counts (Cps)	Activity ($Bq.kg^{-1}$)
		Experimental	Theoretical [4]		
Uranium-238	**Ra-226**	186.10	186.1	4153 ± 234	**2054 ± 129**
	Pb-214	295.21	295.2	11753 ± 241	1682 ± 39
		351.92	351.9	20047 ± 247	1715 ± 26
		average			**1699 ± 23**
	Bi-214	609.31	609.3	14245 ± 201	1736 ± 30
		1120.29	1120.3	2425 ± 86	1698 ± 71
		1764.49	1764.5	1629 ± 72	1744 ± 90
		average			**1726 ± 25**

According to this table, the radionuclides detected in the sample are: Ra-226, Pb-214 and Bi-214.

4-2- Family of Thorium-232

The radionuclides found in the thorium-232 radioactive family of our ilmenite sand sample are given in the table below.

Table 3: Detected radionuclides from the Thorium-232 family

Family	Radionuclide	Energy (keV)		Counts (Cps)	Activity ($Bq.kg^{-1}$)
		Experimental	Theoretical [4]		
Thorium-232	Ac-228	338.32	338.3	40290 ± 295	10645 ± 125
		911.21	911.2	32852 ± 218	10672 ± 332
		968.97	969.0	18795 ± 170	10727 ± 307
		average			**10681 ± 42**
	Pb-212	238.63	238.6	210912 ± 607	10658 ± 164
		300.09	-	12986 ± 233	10559 ± 220
		average			**10608 ± 70**
	Bi-212	727.33	727.2	10318 ± 158	10548 ± 331
		1620.50	1620.6	998 ± 70	10620 ± 889
		average			**10584 ± 51**
	Tl-208	583.19	583.2	62433 ± 298	10751 ± 113
		860.57	860.6	5975 ± 113	10778 ± 413
		2614.53	2614.5	15979 ± 143	10642 ± 985
		average			**10724 ± 72**

These results show that the sample contains four radionuclides elements (Ac-228, Pb-212, Bi-212 and Tl-208) belonging to the Thorium-232 radioactive family.

4-3- Family of Potassium-40

The radioactive family of Potassium-40 contains only one radionuclide, which is K-40 shown in table 4.

Table 4: Detected Radionuclide from the Potassium-40 Family

Family	Radionuclide	Energy (keV)		Counts (Cps)	Activity ($Bq.kg^{-1}$)
		Experimental	Theoretical [4]		
Potassium-40	**K-40**	1461.00	1460.8	766 ± 68	**901 ±132**

4-4- Comparison

The results of the physical characterization of the Ranobe ilmenite sand ore by gamma emission spectroscopy are summarized in table 5 and then compared with the activities of the exemption level.

Table 5: Comparison of our results with the exemption level

Family	Radionuclides	Activity ($Bq.kg^{-1}$)	Exemption level ($Bq.kg^{-1}$) [5]
Potassium-40	K-40	901 ± 132	100000
Uranium-238	Ra-226	2054 ± 129	10000
	Pb-214	1699 ± 23	
	Bi-214	1726 ± 25	
Thorium-232	Ac-228	10681 ± 42	10000
	Pb-212	10608 ± 70	
	Bi-212	10584 ± 51	
	Tl-208	10724 ± 72	

This table shows that the RANOBE concentrated ilmenite ore sample has relatively high levels of radioactivity compared to the exemption level. This requires serious radioprotection measures to make the exploitation of the deposit possible. The exemption level represents the International Basic Standards for the Protection against Ionizing Radiation and the Safety of Radiation Sources.

5- CONCLUSION

The experimental results by gamma emission spectrometry showed that the concentrated ilmenite sand ore of Ranobe contains the following radioactive elements: Potassium-40, Uranium-238 and Thorium-232. In this analysis, the radioactive activities of the radionuclides Ac-228, Pb-212, Bi-212 and Tl-208 of the Thorium-232 family are relatively high compared to the exemption level. Therefore, the future exploitation of the ilmenite deposit of Ranobe requires measures of radioprotection of the local population as well as the personnel of the project to protect them from potential health risks of cancer and genetic hazards.

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