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Study of chromium in chromite rocks by XRF &Detection ofradioisotopes by Gamma spectroscopy

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Abstract:*The aim of this study was to study the concentration of chromium in the Sudan in the state of Blue Nile -Ingessana hills region , using a X-ray fluorescenceand the identification of radioisotopes located in the region using Gamma rays spectroscopy , rock samples were collected from the region and by studying these samples with XRF and its radiation activity by Your Gamma Spectrometer, Eighteen rock samples were taken from the Ingessana hills and converted into powder. Each sample was 25 grams. The study showed that the average chromium is about 671550 ppm, which is a useful contribution to the economy of the country if invested correctly. Analysis of these samples using a gamma spectrometer Radioactivity of radionuclides in the region was determined. The presence of the natural long-lived radioisotopes*^{40}K,^{232}Th, ^{226}Ra, *and. The ranges of their activity concentrations were 65 ~ 373* $Bqkg^{-1}$, *8 ~ 25.6* $Bqkg^{-1}$ *and 7.5 ~ 17.9* $Bqkg^{-1}$ *'respectively'*

Keywords: *concentration of chromium, chromium in Sudan, X-ray fluorescence, Gamma rays spectroscopy,Radioactivity,radionuclides.*

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I. Introduction

Chromium is an important metal found distributed in different areas in the Sudan [1], It was firstly reported in Sudan in 1930. Small scale mining of the ore has been started since 1950. One of the most.

Important areas are the Ingessana Hills area. The ore is generally massive, compact, and consists of chrome spinel, sometimes ferruginous with minor chromium chloride and chromium garnet. Chemically, the ore is of metallurgical grade is the one with a high Cr-Fe ratio. Low-grade banded chromate ores are also common in this area, with up to 25% Cr2O3. New discoveries are being reported every now and then in the area [1]. In Gala Elnahal area, chromite has been reported from areas north east of the Blue Nile: Dinder, Rahad River and Um Saqata. The ores body varies in length, thickness, and unknown down dip extension. It is generally massive with Cr2O3 concentration ranging between 25% to 37.8%. The eastern part of Nuba Mountains [2] in the central Sudan is covered by low-grade chromate, where analysis indicated that the ore consists of 30% of Cr2O3, 22% Fe2O3. About 26 occurrences have been recorded [2]. At the red sea hills region of Eastren Sudan the most important occurrence is found in Wadi Hamissana area. Assay result gave an average of 28% Cr2O3 with 2.5% Cr-Fe ratio. JabelRahib area is located in northern Darfur State where the ore is very compact, massive and coarse grained. Average Cr2O3 content is about 55%. The ore reserve, though promising is not yet determined.

Chromate in southern Sudan has been reported from two different areas, Juba area and Kapoeta-Nagishot region where Cr2O3 is 48-50%. Northern Sudan Chromium oxide samples from Wadi Akasha area reached up to 31% [1]. The overall production in Sudan was 10.000 tons in 1999 [1].

Chromium exploration in the Sudan, showed that the occurrences, discovered by Chinese program were developed by identifying the ore quality and quantity and evaluating economically the actual calculated reserve of these occurrences [2].

The regional geology of Blue Nile region has been extensively described by many authors e.g., and Vail and others. he Ingessana Hills area lies in Blue Nile region, which represents an important part of the Late Precambrian Arabian Nubian. The Ingessana – Kurmuk area, the western part of the above region pertains to the boundary between the Nubian Shield and the reworked pre-Pan- African basement (. It consists of a high grade (Tin Group) and a low-grade (Uffat Group) metamorphic terrains. The boundary between the two groups is a major structural break.

The Tin Group comprises a lower lithostratigraphic unit (Selack Formation) of migmatitic grey gneisses and amphibolites, overlain by a supracrustal metasedimentary unit (Gonak Formation). The low-grade Uffat Group has been subdivided into three lithostratigraphic units. The lower unit the Marafa Formation is a shelf sequence, which is in tectonic contact with the Ingessana Formation, a striking mafic-ultramafic association representing dismembered remnants of an ophiolite. The apparently uppermost units of the Uffat Group, the Kurmuk Formation comprises a thick calc-alkaline succession of volcanic and sedimentary rocks, with island-arc affinities. As the other parts of the Arabian-Nubian Shield, all the units have been pierced by various intrusions ranging from syn-to post-orogenic and anorogenic complexes [3].

II. Materials and methods:

1. Area Description:

Ingessana Hills lies in the eastern part of the Blue Nile State between longitudes 33˚ 32´ N - 34˚ 15´ N. It is about 80 km from Damazin the capital of Blue Nile State and connected by fairly well-maintained motor roads. Railways and roads connect Damazin with Khartoum, and other parts of the country. Damazin has an airstrip.TheIngessana Hills area is characterized by high (600 ft above sea level) and steep relief topography, due to the presence of ultramafic and other intrusive rocks. The plains surrounding the Ingessana massif are covered with thick bushes and tall grass. The eastern part of the massif drains to the Blue Nile, while the western part of the area drains to the White Nile [4].

2.Sample collection and preparation:

Sample were crushed and ground to 2mm size, to facilitate chrome releasing and ending up in the leaching Solution. Sub-samples from bulk samples were taken using quartering technique which consists of piling the ore into conical heap, spreading this out into circles cakes , and dividing the cake into the quarters , taking opposite quarters . This process was repeated until a suitable sample was collected.

Figure 1, view map of the Blue Nile Hills of Sudan. A total of 18 rock samples were collected from the study area and the samples were transferred to a powder amount of each sample 25 grams. These samples were analyzed using an X – ray fluorescence and a gamma ray spectroscopy to determine the concentration of chromium and determine the radionuclides found in the region.

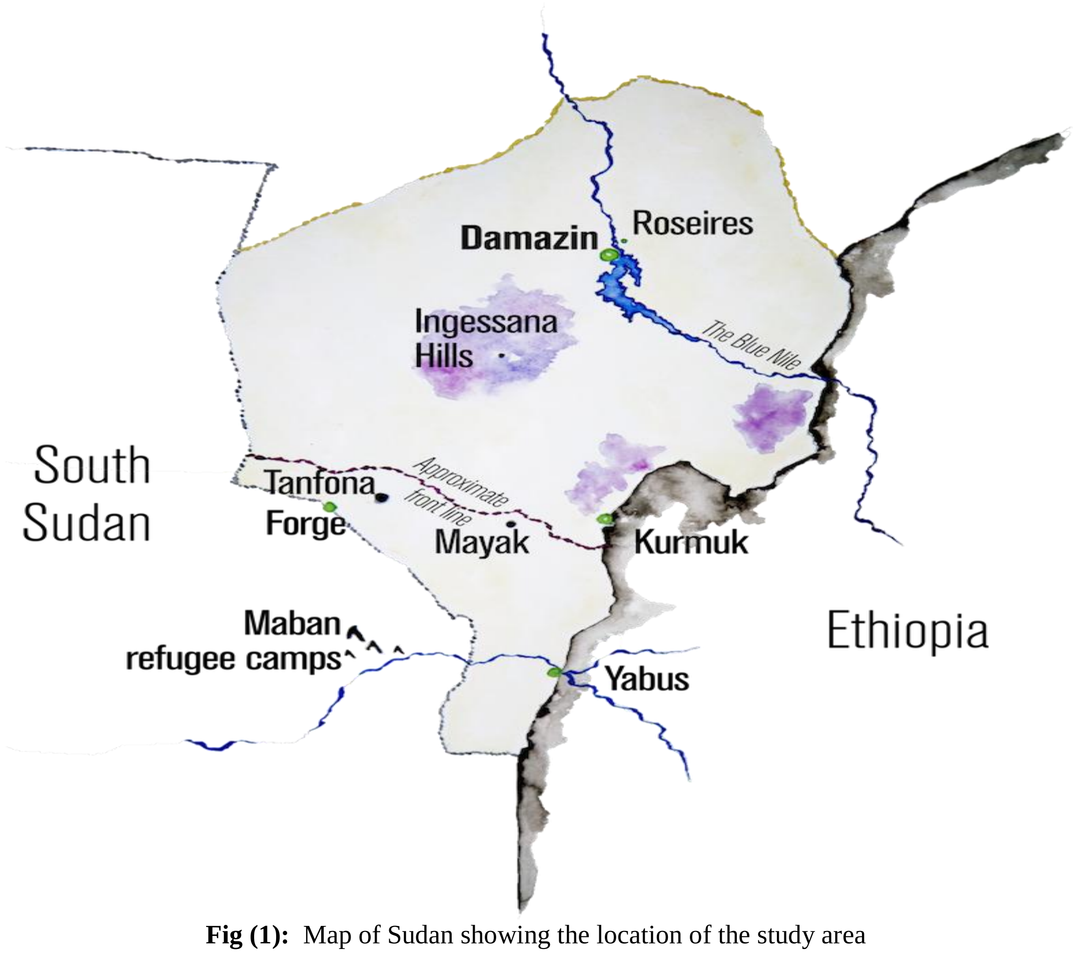

Fig (1): Map of Sudan showing the location of the study area

III. Experimental method:

The samples were collected using an X-ray device. The study showed that the total number of elements found in the region by observing the results on the machine (Cr, Fe,Ni,Mn,Mo,Nb,Cd,Sb,Zn,Sn,Zr) was the highest percentage of the chromium element. The samples were analyzed and analyzed by a gamma device where the radioisotopes found in the region And the highest radiation activity was shown through the study of the element of potassium(K-40) and there are other elements which are(K- 40 , Th -232 , Th228 ,Ra -226 ,Eu -152 , Cs -134 , Cs -137) .

IV. Results and Discussion:

- ***The results of X-ray fluorescence for analysis samples:***

Table(1):Heavy metalcontentintheevaluationin rock samples concentrations in ppm.

Techniques	**Sample code**	**Cr**	**Fe**	**Ni**	**Mn**	**Nb**	**Cd**	**Sb**	**Zn**	**Sn**
XRF	S1	639400	349200	6300	4800	ND	ND	ND	ND	ND
	S2	669800	324100	1500	4300	ND	ND	ND	ND	ND
	S3	648800	351200	ND	3822	ND	ND	ND	ND	ND
	S4	700700	287100	ND	11900	ND	ND	ND	ND	ND
	S5	689100	310300	ND	ND	200	ND	ND	ND	ND
	S6	738000	254100	7700	ND	ND	ND	ND	ND	ND
	S7	669600	324500	ND	5600	ND	ND	ND	ND	ND
	S8	650700	333900	5700	8200	ND	1000	ND	ND	ND
	S9	673200	315000	1400	8900	ND	ND	1200	ND	ND
	S10	674000	318000	4000	ND	ND	ND	4000	ND	ND
	S11	649800	338500	11400	ND	ND	ND	ND	ND	ND
	S12	670300	316800	ND	11500	ND	ND	1100	ND	ND
	S13	659000	321000	ND	14000	ND	ND	ND	6000	ND
	S14	676900	318400	ND	3600	ND	ND	ND	ND	800
	S15	682400	302400	ND	13100	ND	ND	ND	ND	1800
	S16	670900	320200	ND	7200	ND	ND	1400	ND	ND
	S17	635800	337200	ND	26800	ND	ND	ND	ND	ND
	S18	684100	309100	1700	3500	ND	ND	ND	ND	1300
	Average	**671250**	318389	4963	9087	200	1000	1925	6000	1300

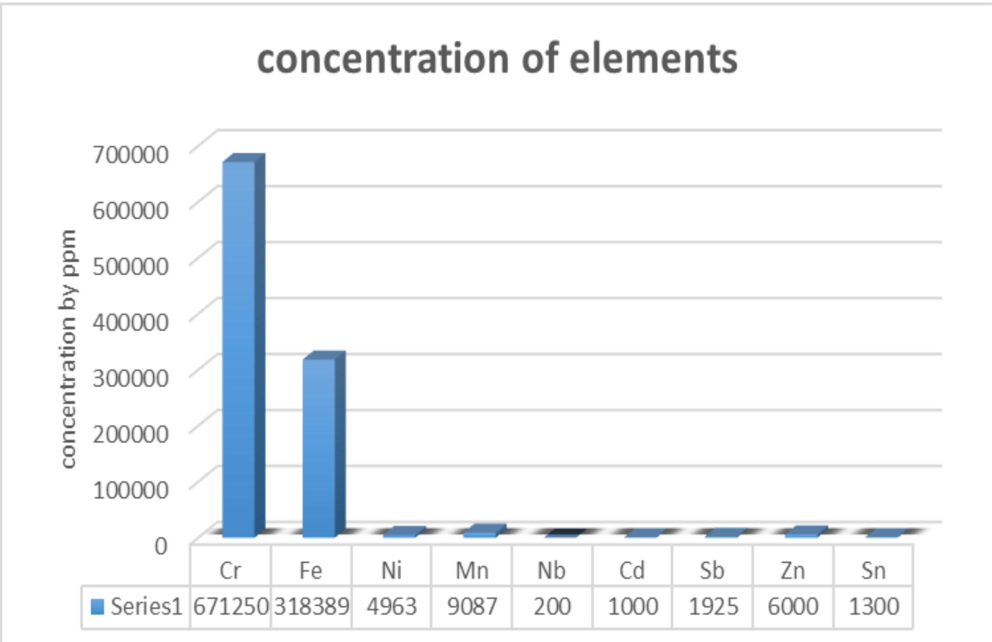

Fig (2):plot show compareelements average concentration of 18 samples

- ***The results of Gamma spectroscopy measurements:***

Table (2) : activity concentrations (Bq/Kg) of gamma emitters from ^{40}K, ^{226}Ra, ^{228}Th , ^{152}Eu , ^{134}Cs and ^{137}Cs in rock samples .

Sample code	^{40}K	^{232}Th	^{226}Ra	^{228}Th	^{152}Eu	^{134}Cs	^{137}Cs
S1	140	21.7	13.7	4.7	ND	ND	ND
S2	174	19.4	10.9	ND	4.7	ND	ND
S3	175	17.9	16.8	ND	ND	ND	ND
S4	231	17.4	13.7	ND	ND	ND	ND
S5	242	21.2	15.7	ND	ND	1.06	0.48
S6	366	13.5	12.3	4.1	ND	ND	1.21
S7	373	17.2	12.4	3.00	ND	ND	ND
S8	184	25.6	14.5	4.00	ND	ND	0.83
S9	312	16.2	10.5	2.3	ND	ND	ND
S10	352	19.7	11.8	2.5	ND	ND	ND
S11	316	17.1	11.3	ND	ND	ND	ND
S12	65	23.00	17.9	ND	ND	ND	ND
S13	197	15.5	14.5	15.6	ND	ND	ND
S14	345	18.9	9.6	ND	ND	ND	ND
S15	151	15.1	13.7	13.2	ND	ND	ND
S16	151	10.3	7.5	ND	ND	ND	ND
S17	283	12.2	8.9	ND	ND	ND	ND
S18	373	8.00	11.8	14.7	ND	ND	ND
Min	**65**	**8.00**	**7.5**	**2.3**	**4.7**	**1.06**	**0.48**
Max	**373**	**25.6**	**17.9**	**15.6**	**4.7**	**1.06**	**1.21**
Average	**246.1**	**17.21**	**12.63**	**7.12**	**4.7**	**1.06**	**0.84**

ND refer to Non-Detection

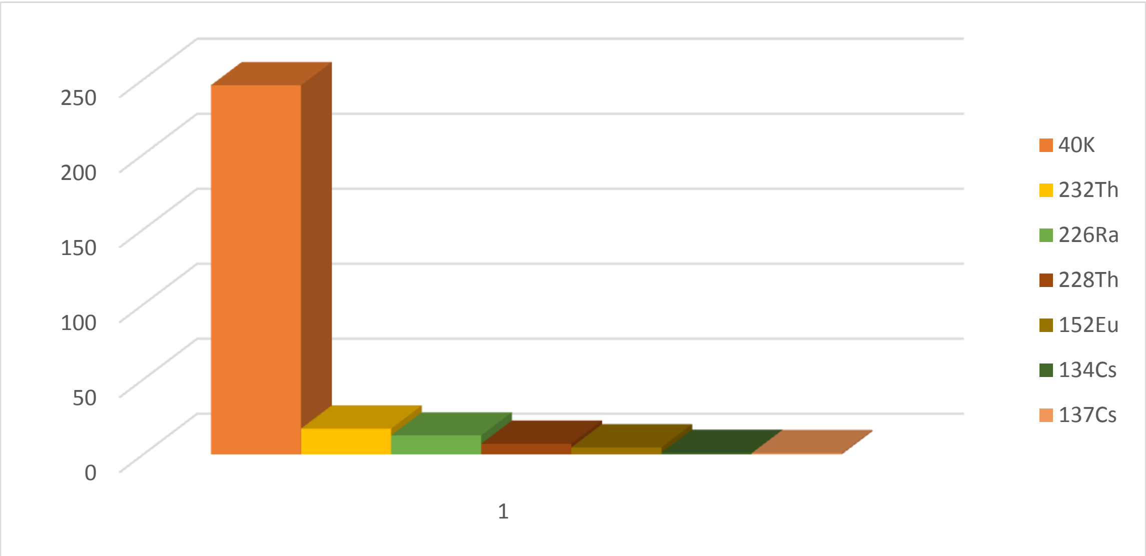

Fig (3): Average activity concentrations of ^{226}Ra, ^{228}Th, ^{152}Eu, ^{134}Cs and ^{137}Cs and^{40} K. in rock samples from Blue Nile state – Ingessanahills.

- ***Chromium in Steel Industry:***

The only important ore mineral of chromium is the chromite – $FeO.Cr_2O_3$ (68% Cr_2O_3, 32% FeO) which crystallizes in the isometric system. The hardness value is 5.5 on Mohr scale and its specific gravity is in color, it is iron – black to brownish –black. Pure chromite with composition $FeCr_2O_4$ is rare because magnesium usually substitutes for some ferrous ion and aluminium and ferrous ion substitutes for chromium.

Chromium is produced in the form of ferro-chromium by various methods ranging from reduction in an electric furnace, electrolysis, thermal dissociation, thermal decomposition. Ferro-chromium has been produced by reduction of chromite ores with carbon or silicon in an electric furnace. It can also be produced by a silicon thermic reaction in the presence of suitable oxidizing agents such as calcium chromate $CaCrO_4$, sodium nitrate $NaNO_3$, or manganese dioxide MnO_2 in an exothermic reaction. It can equally be produced by exothermic reduction of chemically produced Cr_2O_3 using powdered aluminium as the reductant. The use of aluminium is associated with explosive hazards and with considerable losses of chromium while molten aluminium in an arc furnace at 14930C reacts vigorously with Cr_2O_3. To avoid this explosion the molten aluminium is best poured at a lower temperature into a melt of Cr_2O_3 and with vigorous stirring, nearly 94% of chromium recovery has been reported. Chromium metal is also produced on a commercial scale by electrolysis of an ammonium chromium alum solution prepared either from chromium ore or from high carbon ferro-chromium. In addition, it is produced in more limited quantities by thermal dissociation of chromium iodide in contact with a suitable heated deposition surface under vacuum conditions. This gives the purest chromium presently available [5] .

The stainless-steel industry is the largest consumer of ferrochrome and the revival in stainless steel production has been remarkable in Europe, the USA, Japan and South Korea. In addition, China has been increasing its production of stainless steel since 2009 and this whole aspect is multiplying the world consumption of ferrochrome. [6]

The split between the main stainless-steel grades shows an increase in the volume of 300 series produced. The decline in the production of 400 series has been caused by the global drop in automobile manufacturing which accounts for a large volume of chromium stainless. The market share of 200 series has decreased over the course of 2009 due to the recovery of stainless-steel production outside China [7].

As per USGS, if all of the chromium in stainless steel comes from ferrochrome, one ton of ferrochrome would be required to produce 3 to 3.5 tons of stainless steel. However, since some chromium comes from recycled stainless-steel scrap, the actual requirement of ferrochrome is little less.

Stainless steel is basically a low carbon steel which contains a minimum of 10.5% of chromium. The unique stainless, corrosion resisting properties is because of the addition of chromium. The corrosion resistance and other useful properties of steel are enhanced by increased chromium content and by the addition of other elements such as molybdenum, nickel and nitrogen. Stainless steel is mainly categorized into three series, depending on the type and amount of alloying material:

The chromium industry comprises of chrome ore, chromium chemicals and metal, ferrochrome, stainless steel, and chromite refractory producers. The industry structure has been showing changing trend in the past years.

Chromite ore mines tend to be owned and operated by chromite refractory, chromium chemical, or ferrochrome producers as:

-Chromium chemical industry has eliminated excess production capacity, concentrating on production growth in surviving plants.

-Chromite refractory use has been declining; however, foundry use has been increasing slowly.

-Environmental concerns have reduced the use of chromite refractories and chromium chemicals.

-The proportion of chromite ore from independent producers is declining, while that from vertically integrated producers is increasing.

This trend is associated with the migration of ferrochrome production capacity from stainless-steel-producing countries to chromite ore-producing countries, a trend that has been interrupted with the emergence of China as a significant ferrochrome and leading stainless-steel producer.

V. Conclusion

Through this study, the presence of chromium in the Blue Nile region of the Ingessana Hills was verified after samples were taken from this area.

The concentration of chromium in the analyzed samples was found to be highly variable. The average concentration of this element was (671250) PPM, after the statistical work of the results obtained. The samples were analyzed using XRF.

This element can be utilized because it enters many industries. The study radioactivity of radionuclides emitted 226Ra, 228 Th, 152 Eu, 134 C, 137 C and 40 K was found in rock samples from different locations in some Ingessana hills by using gamma spectroscopy.

The significance of the current study relies on its contribution to the efforts being done to generate a radiation map for Sudan and on the targeted area.

The activity concentrations and the absorbed dose rates, due to ^{226}Ra, ^{232}Th and ^{40}K, these values obtained from the rockssamples were less than the recommended safe and criterion limits given by UNSCEAR.

The study uses Spectral HPGe detector to evaluate the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in 18 rocks samples taken from the IngessanaHills,Blue Nile State**,**The activity concentrations may be limited to the randomly taken samples and the results may not be generalized to the whole IngessanaHills,Blue Nile State. More samples are needed to evaluate

Results of the study could serve as an important baseline radiometric data for future epidemiological studies and monitoring initiatives in the study area. The statistical methods were applied to study the relationship between all the calculated natural radionuclides.

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