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RESEARCH ARTICLE - MATERIAL SCIENCE (MISCELLANEOUS)

Evaluation of Scintillation Counter Detector Using Gamma Radiation for Gold Detection

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Abstract

The aim of this work is to evaluate the efficiency of a new gamma spectrometer technology using a scintillation counter detector. This technique can detect the backscattered gamma radiation emitted from the samples. All rock samples were collected and irradiated by two gamma sources, Co60 and Cs137. The existence of gold (Au) was confirmed by displaying the spectrum of one standard made of pure gold and comparing the coincidence of their peaks with that of the rock samples. The spectrum of samples was displayed using the Cassy lab software program. The results indicated that Cs137 gamma spectra showed the same peak for the gold element, while the Co60 gamma spectra indicated the existence of gold radiation. Then, an energy dispersive X-ray (EDX) was done to compare and verify all results.

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Keywords: Scintillation Counter; Gamma Rays; Gold; Cassy Lab; Rocks Samples; Detector.

1. Introduction

Earth minerals are very important because of their economic and industrial value [1]. Naturally occurring radioactive materials (NORM) existing in soil could pose potential health risks, especially if assisted by natural processes such as weathering, deposition, and wind erosion. NORM can be found in many geological formations and may be brought to the surface during Oil and Gas drilling and abstraction [2].

Ionized ray techniques were used for mining minerals, such as discovering gold [3]. Osman et al. carried out the results of this study to determine the composition of the uranium element in the Nuba Mountains area in the Southern Kordofan region in the regions of Mount Uro and Mount Kurn [3]. Mihaira. H. Hddad et al. investigated the concentration of Fe, Cu, Zn, and Pb in the scalp hair of Sudanese exploration mining (gold) workers in El-Abedea town and healthy volunteers from Khartoum using the XRF method [4]. P. F. Bloser et al ., concluded that the Gamma-Ray Polarimeter Experiment (GRAPE) is a concept for an astronomical hard X-ray Compton polarimeter operating in the 50 – 500 keV energy band [5].

Recently, many studies were interested in the radioactivity of various soil, oil sludge, sand, etc. [6]. This indicates that chemical elements are not internally immutable and can be transformed into one another by emitting such rays. The property of spontaneous emission of rays is known as radioactivity [8], which can be explained by different sources.

Detailed investigations revealed that these spontaneously emitted rays are of five kinds: alpha (α) particles, beta (β) particles, gamma (γ) rays, x-rays, and neutrons, which are recently considered radiation sources [9]. These emissions are capable of ionizing air with different spontaneous emissions of particle arrays resulting from nuclear fission. The decay of an atomic nucleus from a high-energy state to a lower-energy state, a process called gamma decay, produces gamma radiation [10-12]. Gamma radiation from these represents the main external source of irradiation

Nomenclature & Symbols			
EDX	Energy Dispersive X-Ray	GRAPE	Gamma-Ray Polarimeter Experiment
a	Alpha Ray	P	Beta Ray
y	Gamma Ray	MCA	Multichannel Analyzer

to the human body, and the concentrations of these radionuclides in soil are determined by the radioactivity of the rock and also the nature of the process of the formation of the soils.

Accordingly, this work aims to evaluate the scintillation counter detector using gamma radiation to detect the Au element. Thus, a new gamma spectrometer technology with two gamma sources, Co60 and Cs137, was used. In comparison between the two examination tests, the Cs137 showed better results compared to the Co60 detector.

2. Material and Methods

Rock samples were collected from various types showing a high radiation background. These samples were collected from Alobaidia, North Sudan State.

The samples after prepared were examined in the laboratories of the Sudan University of Science and technology research lab by means of the assembled gamma spectrometer, using cassy lab computer program. The assembled gamma spectrometer consists of a scintillation counter which act as a gamma detector beside a Co^{60} and Cs^{137} gamma source which excite samples as showed in Fig. 1.

A cassy lab program unit plugged with multichannel of programs that are attached to computer together with the detector, to convert detector signal into visual spectrum displayed on the computer screen. Quantification of radionuclide present in rocks samples were obtained through accurate energy. The multichannel analyzer (MCA) was calibrated so as to display gamma photo peaks in the applied energy range for radionuclide of interest identified with reliable regularity. The counting time was 100s; the numbers of channel used was 256 and applied voltage 0.77kV. Each sample was placed between the detector and gamma source (*i.e.,* Co^{60} or $Cs^{137)}$. The energy spectrum versus number of events was determined. Also, the number of events versus number of channels was found.

Fig. 1. Experimental work Setup

3. Result and Discussion

3.1. Results of energy dispersive X-ray (EDX)

Before doing tests with Co^{60} and Cs^{137} detectors, we are making Energy dispersive X- ray (EDX) to preconize the elements in the prepared samples.

The EDX results didn't indicated Au element inside the samples, except sample 2, their result detect low amount of Au concentration (i.e., 0.004 a.t. %), see EDX results in Figs. 2 and 3.

3.2. Results of Co^{60} detector

In Fig. 1, the results show that the peaks and shapes in both the sample and the standard curves are identical, which means that the Co^{60} detects the percentage of gold in the sample.

Also, the results revealed that, in Figs. 4 - 7, there is a slight shift in the curves representing intensity and energy factors compared to the standard curve. This shift may be due to impurities of samples compared with standard one, (i,e, more 66 concentrated of Au).

It observed that in Figs. 3, 4, and 6, the result indicates a broad, intense spectrum for the gold sample. The gold peak in samples is the highest peak from the left. The highest peak at the extreme left of the gold spectrum is assumed to stand for the characteristic energy peak. The corresponding gold peak for sample 1 and 4, (Figs. 3 and 6), the peak is second highest peak from the left. The high difference in the gold peak may be due to the impurities of samples (*i.e.,* other elements). This means that no emission of characteristic photon energy takes place.

Element	Result %
Si	81.747
Fe	14.808
Mn	1.032
Al	1.032
Ca	0.457
S	0.457
Au	0.004

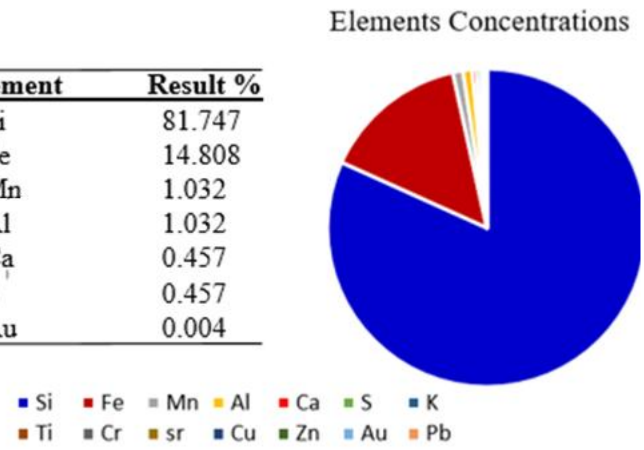

Fig. 2. Elements in sample2

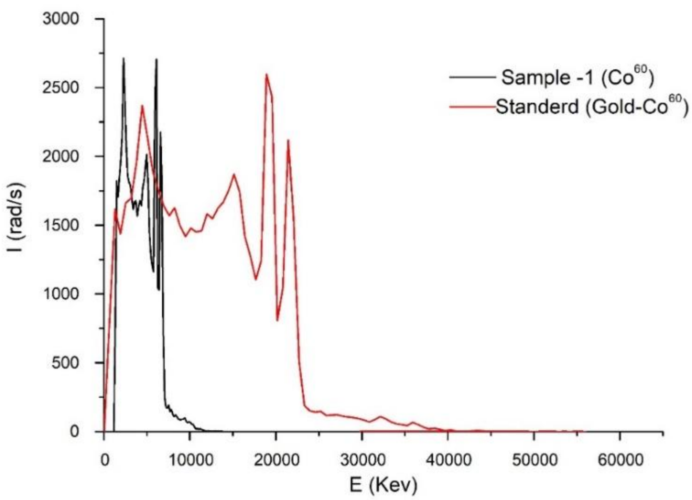

Fig. 3. Standard Gold sample with sample one irradiated with Co^{60}

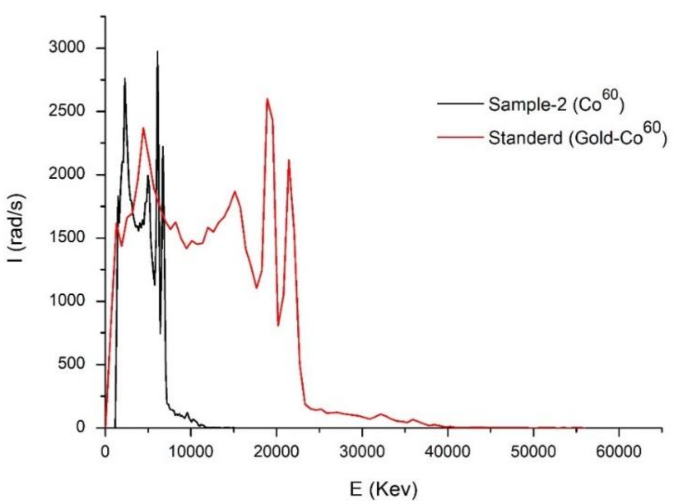

Fig. 4. Standard Gold sample with sample two irradiated with Co^{60}

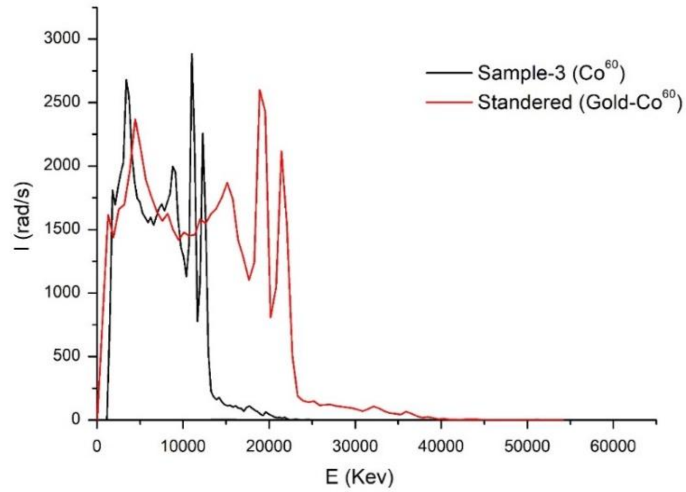

Fig. 5. Standard Gold sample with sample three irradiated with Co^{60}

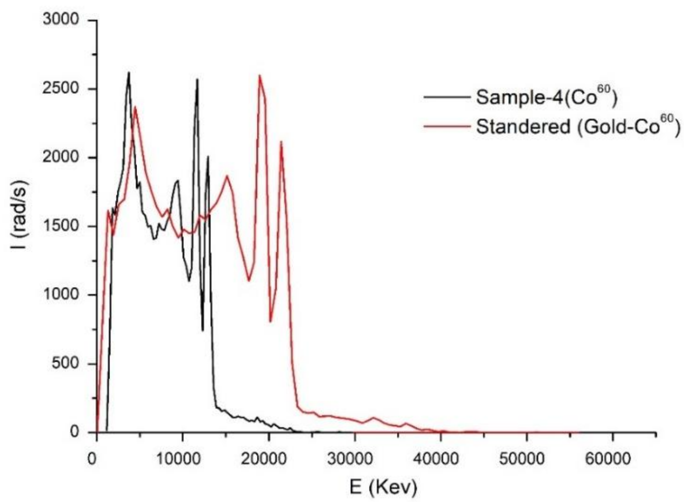

Fig. 6. Standard Gold sample with sample four irradiated with Co^{60}

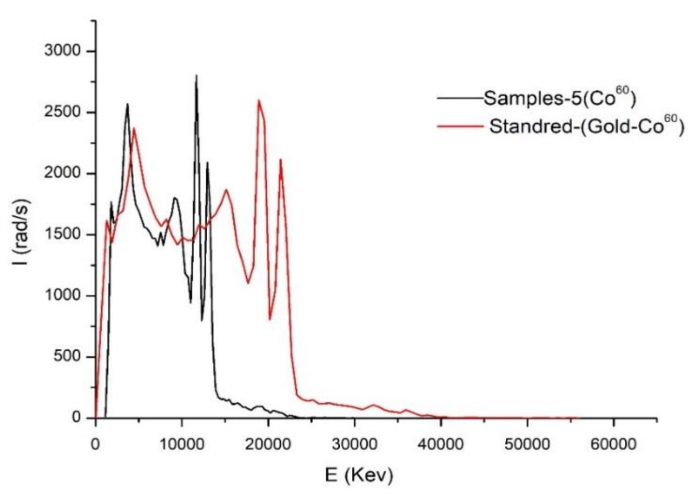

Fig. 7. Standard gold sample with sample five irradiated with Co^{60}

3.3. Results of Cs^{137} detector

In Figs. 8-12, the results demonstrated identical peaks and shapes in both standard and sample curves. The results implied that the Cs^{137} detector could detect a higher percentage of gold in the samples compared to Co^{60}.

In comparison between the two tests, the Cs^{137} showed better results compared to the Co^{60} detector. Accordingly, the Cs^{137} detector has advantages in the field of gold detection and exploration. Thus, it has commercial benefits and is very important for lifestyle.

Also, in comparison between Co^{60} and Cs^{137} detectors, the Co^{60} radiation is lower than that of Cs^{137}. Accordingly, the Cs^{137} radiation penetrated impurity samples and reflected more information than the Co^{60} radiation. Thus, provide the Cs^{137} detector is more effective to impurities samples and it better to detect the gold event if in impurities samples.

3.4 Results of energy dispersive X-ray

These are energy dispersive X-ray (EDX) results; only sample 2 showed an amount of Au concentration (0.004 a.t.%). The results imply that scintillation detectors are more sensitive to the Au element compared to EDX.

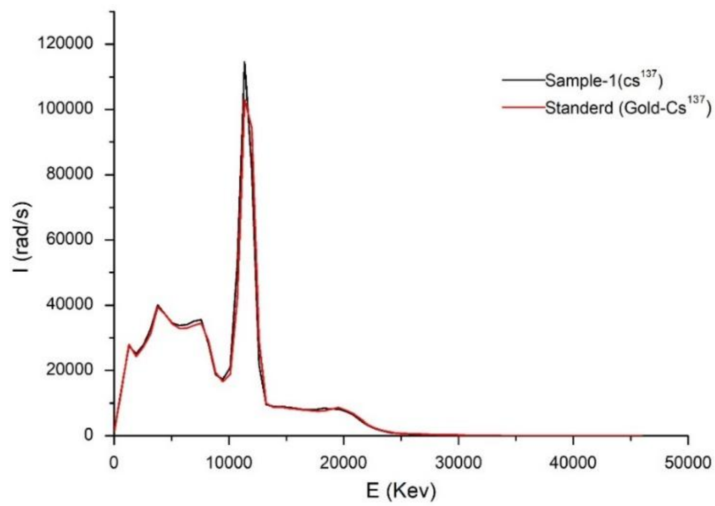

Fig. 8. Standard Gold sample with sample 1 irradiated with

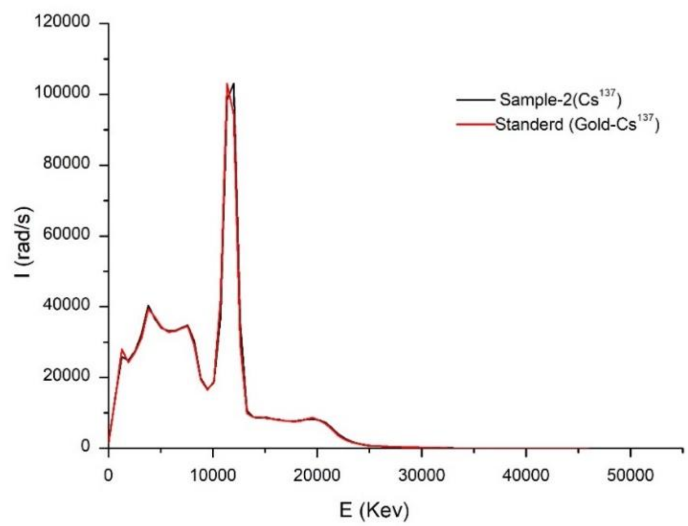

Fig. 9. Standard Gold sample with sample 2 irradiated with

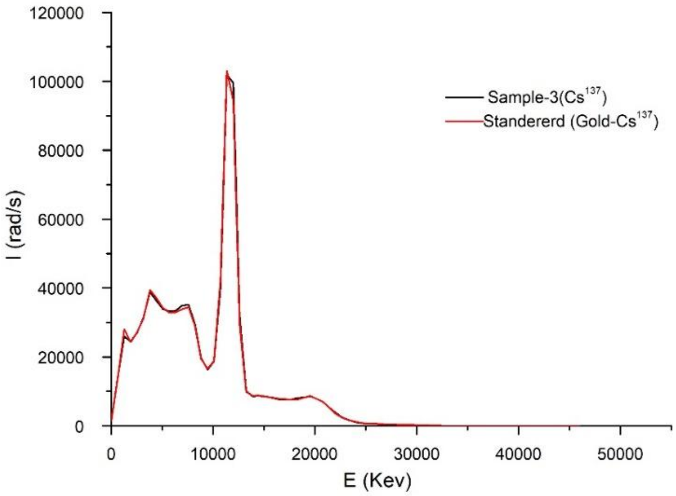

Fig. 10. Standard Gold sample with sample 3 irradiated with

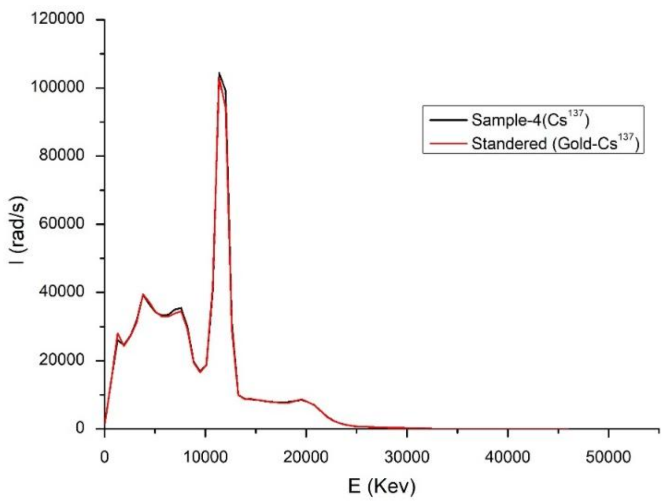

Fig. 11. Standard gold sample with sample 4 irradiated with

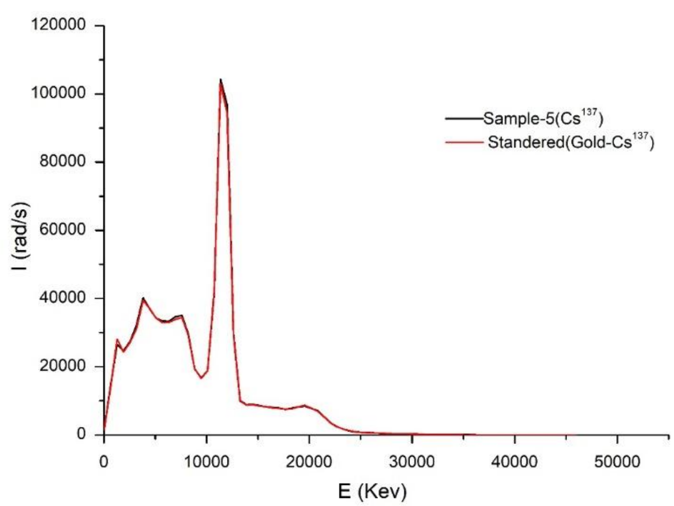

Fig. 12. Standard gold sample with sample 5 irradiated with

4. Conclusion

Both of Co^{60} and Cs^{137} scintillation analyzer detector techniques, which were used for the identification of gold, indicate gamma spectrometry. Results found that Cs^{137} detector is more sensitive compared to the Co^{60} detector. Moreover, the spectrum of the scintillation technique showed a high sensitivity for Au compared to EDX detection. Finally, the Cs^{137} detector may have future advancements in gold detection technology.

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