

# Study of gamma spectrometry laboratory measurement in various sediment and vulcanic rocks

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**Abstract** Gamma-ray spectroscopy is the quantitative study of the energy spectra of gamma-ray sources. This method is powerful to characterize some minerals, especially to differentiate rocks which contains among Potassium, Uranium, dan Thorium. Rock contains radioactive material which produce gamma rays in various energies and intensities. When these emissions are detected and analyzed with a spectroscopy system, a gamma-ray energy spectrum can be used as indicator for mineral content of rock. Some sediment and vulcanic rock have been collected from East Java Basin. Samples are ranging from Andesite volcanics, Tuff, Shale, various vulcanic clay and Alluvial clay. We present some unique characteristics of gamma spectrometry in various sedimentar and vulcanic rocks of East Java Basins. Details contents of gamma ray spectra give enrichments to characterize sample of sediment and vulcanic in East Java. Weathered vulcanic clay has lower counting rate of gamma ray than alluvial deltaic clay counting rate. Therefore, gamma spectrometry can be used as tool for characterizing the enviroment of clay whether vulcanic or alluvial-deltaic. This phenomena indicates that gamma ray spectrometry can be as tool for characterizing the clay whether it tends to Smectite or Illite

## 1. Introduction

The database information of gamma radiation of rocks is needed for many purposes such example as radiation measurement and dose rate of tiling rocks[1], identification of low-grade uranium (U) ore with thorium resources in a large syngenetic deposit using gamma spectrometry borehole logging [2], detection of potassic alteration to mineralization [3] and challenge discrimination of clay among Illite, Smectite and Kaolinite.

Some authors measured gamma spectrometry to characterize radioactivity of rock and soils [4,5,6]. In this work, sample rocks collected in East Java Basin are measured to initiate the databases of gamma spectrometry in various sediment rock in Indonesia.

Gamma spectrometer was used widely to identify radionuclide gamma emitter especially to discriminate among Thorium, Uranium and Potassium[7]. As well as Si or Li detectors[8], the scintillation detector NaI (Tl) is detector that compose with material that could makes flash light if interact with gamma radiation. In detector, gamma ray makes photoelectric effect, Compton scattering, and pair production. Light intensity as output scintilator crystal proportion with gamma ray energy. Flash light is transmitted to photocathode from photomultiplier tube (PMT). Electric current from



PMT makes pulse in preamplifier. The pulse then is processed with Multichannel Analyzer Analyzer (MCA). Pulse amplitude is proportion with gamma energy.

There are three radionuclide series, Uranium, Thorium, and Potassium series. All kinds of rocks have uranium, especially granite where one ton granite has about three until four gram Uranium. Uranium generally has homogeny distribution in rock. Mainly uranite has 80% and euksinit has 20%. There are uranium isotope with abundances 99,275% ( $^{238}\text{U}$ ), 0,72% ( $^{235}\text{U}$ ), and 0,005% ( $^{234}\text{U}$ ) [8]

There is small amount of Thorium in rocks and soil. In soil Thorium amount about 12 ppm with  $^{232}\text{Th}$  isotope has abundance 100%.

Carbonate mainly is composed by Potassium with isotopes are  $^{39}\text{K}$  (93,3%),  $^{40}\text{K}$  (0,012%) and  $^{41}\text{K}$  (6,7%). Isotope  $^{40}\text{K}$  is radioactive which it decays into  $^{40}\text{Ca}$  and  $^{40}\text{Ar}$  with it radiates gamma and beta [9].

Radionuclide detection is easility detected by gamma spectrometer, the uniqueness of energy spectrum can discriminate among Uranium, Thorium, and Pottasium concentration[9][10]. In this work, gamma ray spectrometer is used to detect the existence of Potassium, Uranium, and Thorium from sample of rocks in East Java Basin

## 2. Experimental Method

The samples of sediment rocks were collected from northern part to southern part of East Java Figure 1.

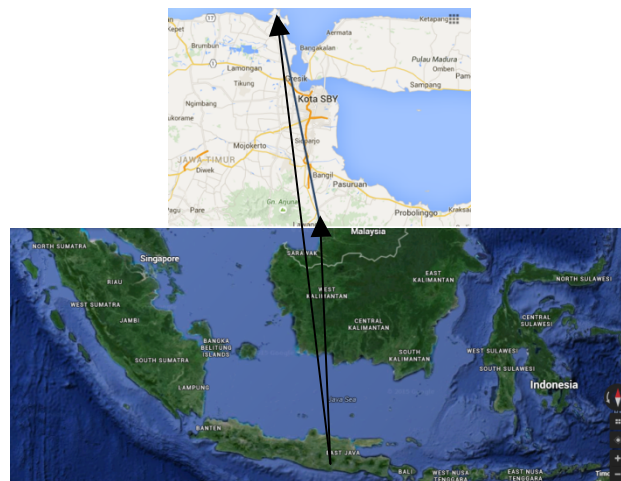


Figure 1 The line sampling of rocks in East Java, Indonesia.

Gamma spectrum from rocks is measured using NaI Scintillator Probe at range energy between 25 KeV – 3500 KeV. This detector is furnished by positive polarity 750 volt pre-amplifier. To reduce background radiation, Pb plate is placed around the device. Block diagram of gamma spectrometry is shown figure 2.

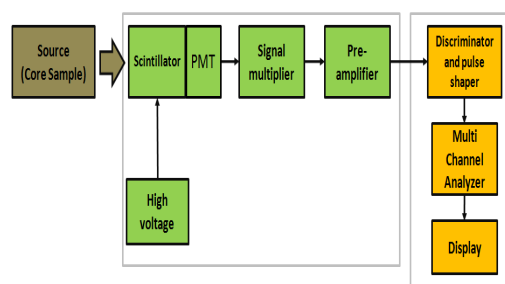


Fig. 2. Diagram of gamma ray spectrometer

### 3. Results and Discussion

Counting time is chosen 600 second. Figure 3 and 4 shows the counting curve vs energy (in keV) of ten sample of rocks. Type of sample covers: volcanic claystone, volcanic tuff, weathered claystone and alluvial clay. The volcanic claystone, volcanic sand, weathered claystone were collected from Cangar, near Malang. Some samples of claystone were collected near Jolotundo in leg of Mt. Pananggungan. Some samples of volcanic tuff and volcanic “alluvial” were collected from Songgoriti and leg of Mt. Welirang. The detail of sample position is listed in Table 1.

Table 1 shows tabulation of total counting rate. The sample of rocks is sorted by counting rate value from higher to lower. The result of data processing from ten sample also is shown by figure 3. In sand rock, counting rate of Potassium is about 140 -192, Uranium about 64 – 87, Thorium 56 – 87. Clay rock samples counting rate are Potassium about 339 – 496, Uranium about 117 – 125, Thorium 191 – 306, and last, Tuff samples and Aluvial samples counting rate are Potassium about 596, Uranium 117, Thorium 360 for Tuff, and Potassium 170, and Uranium about 80 for Aluvial.

The counting data of weathered (soft) clay rock presents as following: the counting rate in the range of Potassium is about 79-161, one of Uranium is about 58 – 66, and one of Thorium about 13 – 19.

Figure 4. shows counting rate of gamma ray in the range of Potassium, Thorium and Uranium from several collected rock samples. The counting rate of samples are dominant in the range of Potassium, range of Uranium is minimum. This phenomena shows uniqueness gamma spectrum of sediment as well as volcanic rocks in East Java Basin.

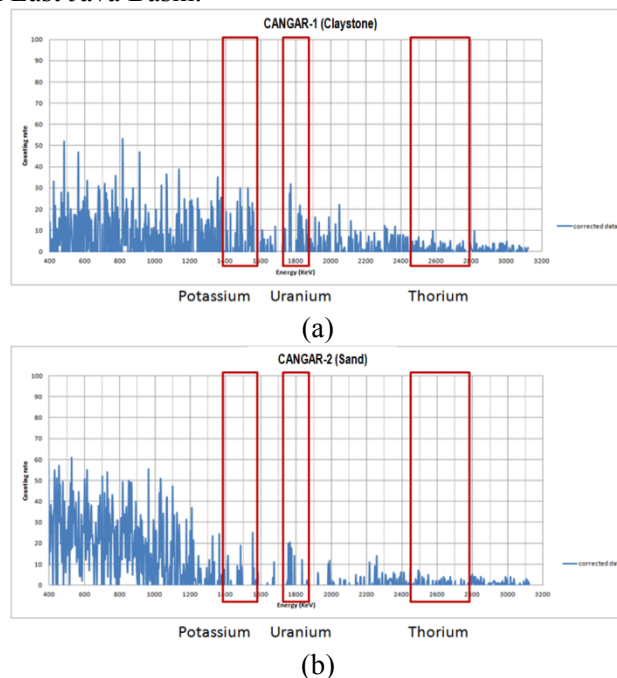
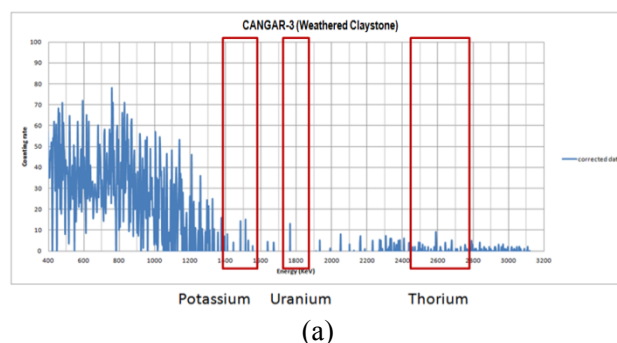
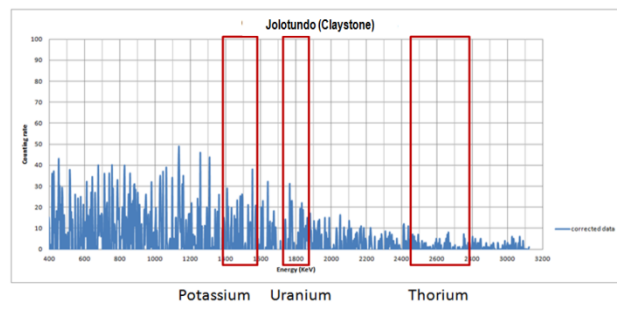
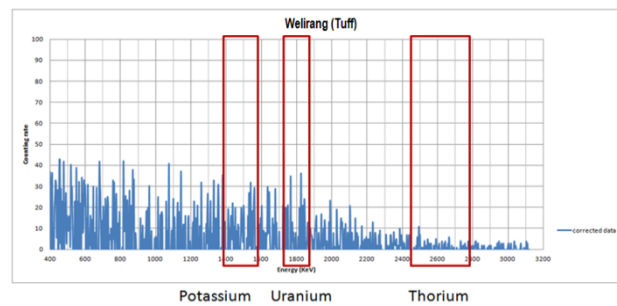


Fig. 2. Counting vs enery (in Kev) curve from (a) Claystone Cangar-1 (b) Sand Cangar-2.

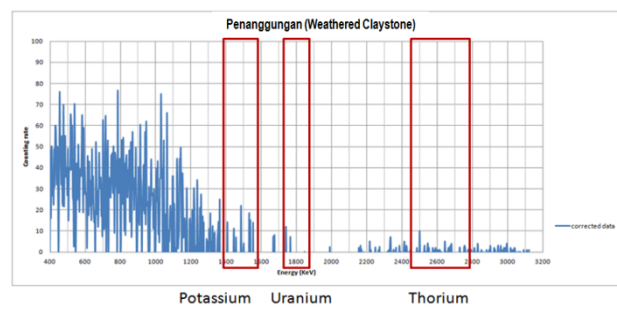




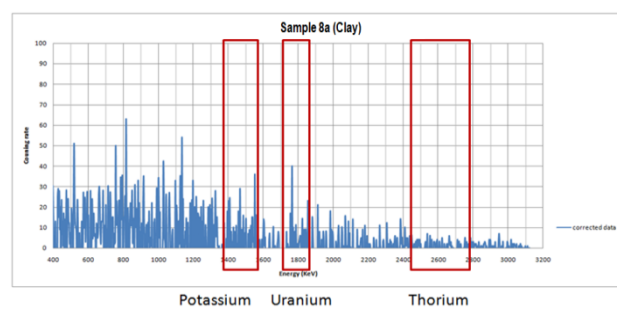
(b)



(c)



(d)



(e)

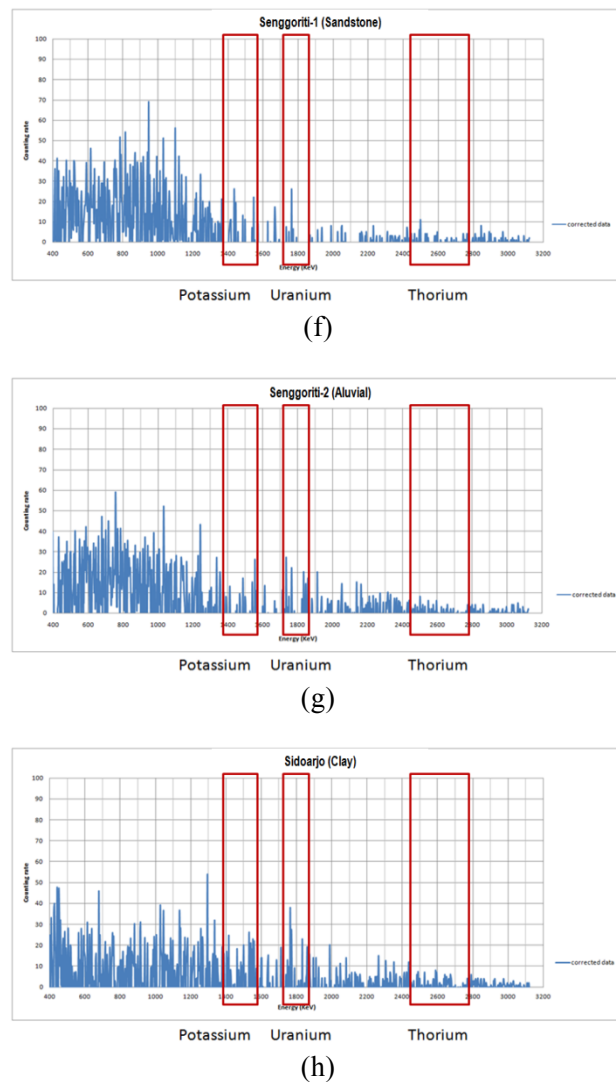


Fig. 3. Counting curve from (a) Weathered Claystone Cangar-3 (b) Claystone Jolotundo (c) Tuff Welirang (d) Weathered Claystone (e) Clay Sample 8A (f) Sandstone Senggoriti-1 (g) Alluvial Senggoriti-2 (h) Clay Sidoarjo.

Table 1. Total Countingrate of Natural Gamma Radiation

Sample	Countingrate		
	Potassium	Uranium	Thorium
Welirang Tuff	596	117	360
Jolotundo Clay	496	122	306
Cangar-1 Claystone	413	125	191
Sample 8a Clay	345	123	215
Sidoarjo Clay	336	125	222
Senggoriti-1 Sandstone	192	64	56
Senggoriti-2 Aluvial	170	80	154
Cangar-2 Sand	140	87	87
Penanggungan Weathered Claystone	161	58	19
Cangar-3 Weathered Claystone	79	66	13

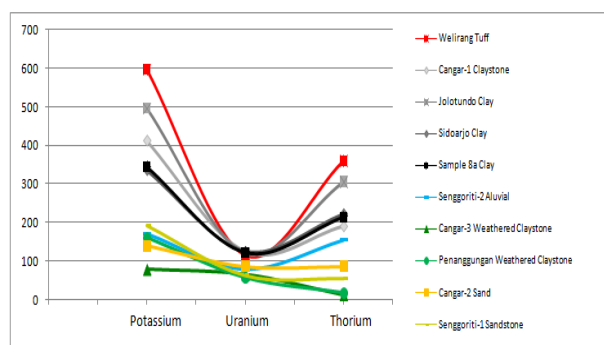


Fig. 4. Total Counting rate Vs Natural Gamma ray (Thorium, Uranium, Potassium)

#### 4. Conclusions

The difference of gamma ray spectra among Sandstone, Claystone, Tuff, Alluvial, Weathered clay, Shale/clay is significant. The rock sample collected from East Java Basin has lower Uranium and Thorium's spectra compared than Potassium's spectra. Weathered volcanic clay has lower counting rate of gamma ray than alluvial deltaic clay counting rate. Therefore, gamma spectrometry can be used as tool for characterizing the environment of clay whether volcanic or alluvial-deltaic. This phenomena indicates that gamma ray spectrometry can be as tool for characterizing the clay whether it tends to Smectite or Illite.

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