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Radioactive Mineral Distribution on Tin Placer Deposits of Southeast Asia Tin Belt Granite in Bangka Island

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ABSTRACT

Bangka Island is an area rich in primary and secondary tin deposits. Tin deposits are formed around the contact between granite and older rocks, while secondary tin deposits are formed in the modern channels and paleochannels. Many previous researchers have researched radioactive minerals in primary tin deposits and modern channel deposits, but research on radioactive minerals in paleo channel deposits has never been carried out. The characterization of radioactive minerals in paleo channel deposits was done in this study to determine the potency of radioactive minerals in secondary tin deposits by comparing the content of radioactive minerals in paleochannels with modern channels and tin mine tailing deposits. The data used were mineralogical data and radioactivity data, along with the uranium and thorium content of the rocks from several previous studies. Data showed significant mineral content differences in paleo channel, modern channel, and tin mine tailings deposits. Mineral (monazite and zircon) content in tin mine tailing deposits was the highest. Source rocks for the radioactive minerals monazite and zircon are predicted to be the granitic rocks or tourmaline quartz veins of primary tin deposits. The radioactivity value of rocks in the paleo channel is relatively the same as the modern channel, ranging from 20 to 150 c/s. Uranium content in paleo channel is the same as modern channel deposits, ranging from 10 to 15 ppm eU. The thorium content of the rocks in the paleo channel ranges from 1 to 60 ppm eTh, while in the modern channel, it ranges from 1 to 45 ppm eTh. The radioactivity value and uranium content of the rocks are less effective for determining potential areas of radioactive minerals in placer tin deposits. In contrast, data on thorium content are quite effective for determining potential areas of radioactive minerals in placer tin deposits.

Keywords: Bangka Island, paleo channel, monazite, zircon, alluvium.

INTRODUCTION

Bangka Island is part of the Southeast Asian granite tin belt [1] and is rich in primary and secondary tin deposits (Figure 1). Tin deposits form at the contact between granite and older rock. The placer tin deposits are formed in an alluvial and fluvial environment in the form of paleochannels and modern channels. The paleochannels deposits are the stratigraphic unit that originated from the remains of an inactive fluvial channel that younger sediments have covered. Meanwhile, the modern channels deposit are the deposit of active streams.

Several studies on radioactive minerals and REE in the Southeast Asian tin belt have been carried out by previous researchers. Radioactive minerals on Bangka Island include the potential for monazite mining from tin processing waste or tailings in Bangka and Belitung [1] and the discovery of primary REE minerals in granite rocks and quartz veins in South Bangka [2]. Monazite is a mineral that contains rare earth elements

(REE), phosphate (PO_4), thorium (Th), and uranium (U). REE has become an essential commodity because it plays a significant role in developing a modern, low-carbon economy [3]. Cerium (Ce) and Lanthanum (La) contained in monazite are widely used in the high-precision glass industry, and lanthanum is used in the camera lens industry [4]. The price of monazite in 2021 is 27,000 US$ per ton and is expected to rise to 34,000 US$ per ton in 2029 [5].

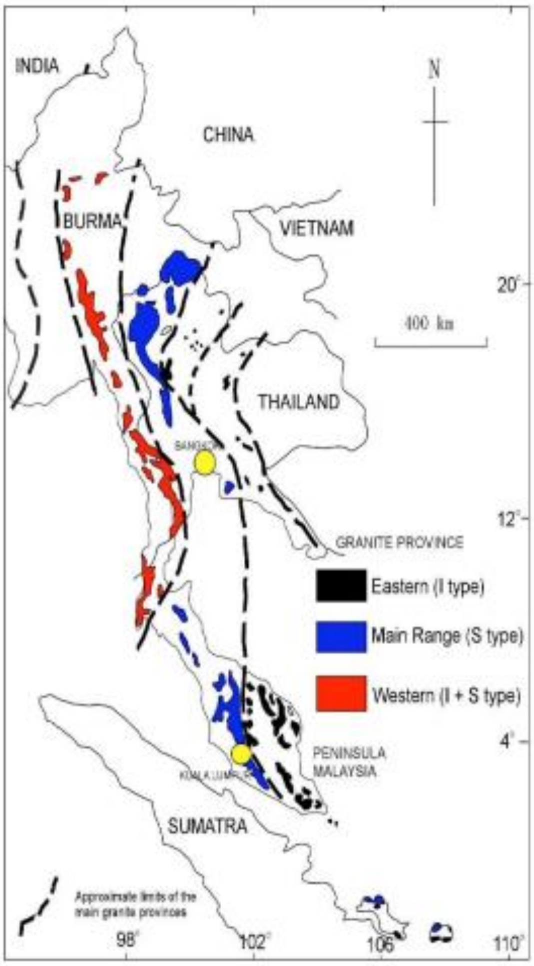

Figure 1. South East Asian Granite Tin Belt [6].

Considering the significant economic potential of radioactive minerals in Bangka Island, this research aims to determine the most potential deposits among the paleochannels, modern channels, and tin mine tailing deposits by comparing their radioactive minerals and radioactivity response, which one has the highest amount and consistent high radioactivity response. The results of the research are an initial image to find out the prospects for radioactive mineral resources on Bangka Island because Bangka Island is part of Sunda Land where there are many paleo channel deposits [7],[8] which have the potential to be a trap for accumulation of tin deposits and associated radioactive minerals.

Stratigraphy of Bangka

The stratigraphic sequence of the Bangka island from oldest to youngest is the Permian-Carboniferous Pemali Complex, Permian-Triassic Diabase Penyabung, Triassic Tanjung Genting Formation, Late Triassic Klabat Granite, Late Miocene-Early Pliocene Ranggam Formation and Holocene alluvium deposits [9],[10]. Figure 2 visualizes the regional geological map of Bangka.

The Pemali complex comprises phyllite and schist with intercalation quartzite and limestone lense jointed, folded, faulted, and intruded by Klabat granite Penyabung diabase, jointed, folded, faulted, and intruded by Klabat granite, intrudes the Pemali Complex Klabat granite consists of granite, granodiorite, adamellite, diorite, and quartz diorite, in place with aplite and pegmatite dykes. Tanjung Genting Formation is composed of an alternation of meta sandstone, clayey sandstone, and claystone with lenses of limestone and iron oxide locally. Ranggam Formation is composed of an alternation of sandstone, claystone, and tuffaceous claystone with the intercalation of thin layers of siltstone and organic matter, well-bedded, parallel lamination, and cross-bedding, thickness 150 meters. Alluvium consists of boulders, cobbles, pebbles, sand, clay and peat.

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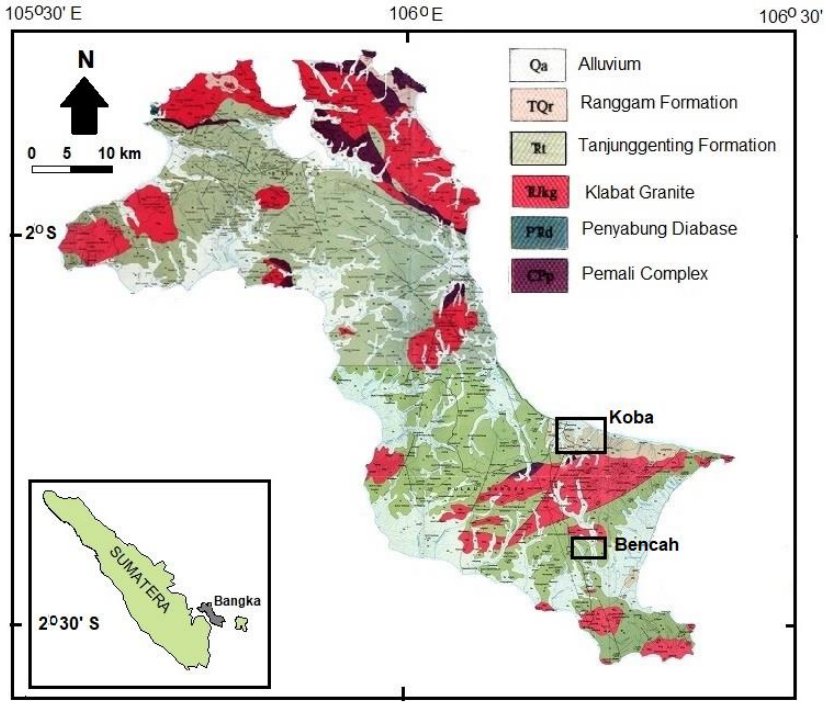

Figure 2. Geological Map of Bangka Island (modified from [9],[10]).

TOPICS

In this research, we used data from the previous study in Bangka Island regarding the radioactive mineral content from grain counting analysis in paleochannels, modern channels, and tin mine tailing deposits. Apart from mineralogical data, this research also used rock radioactivity data and the uranium and thorium content data in the rocks that were obtained from gamma-ray survey meter measurements. The radioactive mineral content data, radioactivity data, and uranium and thorium content data in paleo channel deposits came from the Koba area, Central Bangka [11]. The radioactive mineral content data, radioactivity data, and uranium and thorium content data in modern channel deposits came from the Bencah area, South Bangka [12]. Meanwhile, the radioactive minerals contents and radioactivity data in tin mine tailing deposits were derived from all area of Bangka Island [13].

RESULTS AND DISCUSSION

Grain Counting Analysis

The result of the grain counting analysis of pan concentrate in paleochannel deposits, modern channel deposits, and tin mine tailings deposits are displayed in Table 1 and Figure. The table and figures show the mean weight percent of each mineral in the samples.

The types and quantities of minerals that were found in the pan concentrate sample of the paleochannels, modern channels, and tin mine tailings were the same. The amount of cassiterite in paleo channel deposits is more significant than in modern channels or tin mine tailings. Monazite and zircon are most abundant in tin mine tailings, compared to the content of the minerals in the paleochannels and modern channel deposits. The content of monazite and zircon in the paleo channel and the modern channel is relatively similar.

Table 1. Result of grain counting analysis of pan concentrate samples in wt. % (data taken from [11]–[13]).

Environment / **Minerals**	**Paleochannel**	**Modern Channel**	**Tin Mine Tailing**
Cassiterite	46.39	6.68	19.22
Monazite	7.09	7.57	10.24
Zircon	22.57	21.68	31.26
Ilmenite	17.77	2.48	29.61
Hematite	0.5	46.89	1.67
Rutile	3.65	6.59	6.11
Anatase	0.87	0.57	0.55
Tourmaline	0.45	6.18	0.27
Fluorite	0.07	0.35	0.32
Garnet	0.06	0.26	0.03
Pyrite	0.24	0	0.22

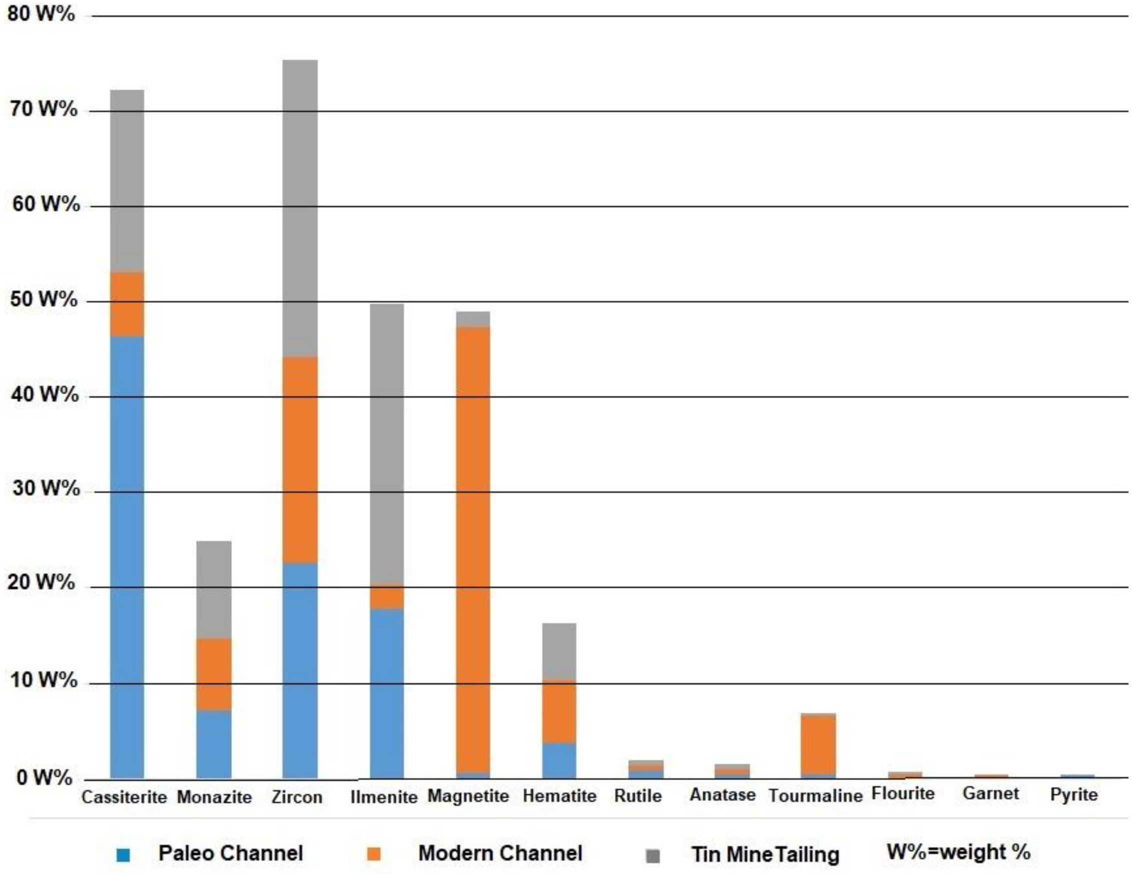

Figure 3. The average mineral content of pan concentrates in paleochannels, modern channels, and tin mine tailing deposits (data taken from [11]–[13]).

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Monazite and zircon are very stable minerals that are resistant to chemical and physical weathering and tend to be transported by river flows and sedimented into alluvial deposits with cassiterite and other stable minerals [14]. The source rocks of monazite and zircon are thought to be granitoid rocks such as granite in West Bangka [15] and granite in Pangkal Pinang [16] or primary tin deposits [17]. Besides monazite and zircon, the granitoid rocks of Bangka Island also contain xenotime[8],[18]. Xenotime is a radioactive mineral that contains heavy rare earth elements (HREE). In Singkep Island, which is an area of the Southeast Asian granite tin belt, xenotime was also found in alluvial deposits [19].

Rocks Radioactivity

Data on the radioactivity of the rocks come from the result of measurement using a gamma spectrometer SPP2NF. The radioactivity of the rocks consists of radioactivity in paleo channel deposits in the Koba Area, Central Bangka, and modern channel deposits in the Bencah area, South Bangka. The value of rock radioactivity in paleo channel deposits ranges from 20 to 500 c/s [11], as depicted in Figure 4, and the value of rock radioactivity in modern channel deposits ranges from 20 to 200 c/s [20], as shown in Figure 5. The lithology of the Koba area is composed of alluvial deposits and the Ranggam Formation, while the lithology of the Bencah area, south Bangka, is an alluvial deposit. In general, the radioactivity of rocks in alluvial deposits in Indonesia ranges from 15 to 30 c/s. The radioactivity value in the alluvial deposits in the Koba and Bencah areas reaches 150 - 200 c/s because they contain radioactive minerals, including monazite and zircon. As a comparison, the potential zone of monazite in alluvial deposits in the Cerucuk, Belitung area has a radioactivity value of 50 to 375 c/s SPP2NF [21].

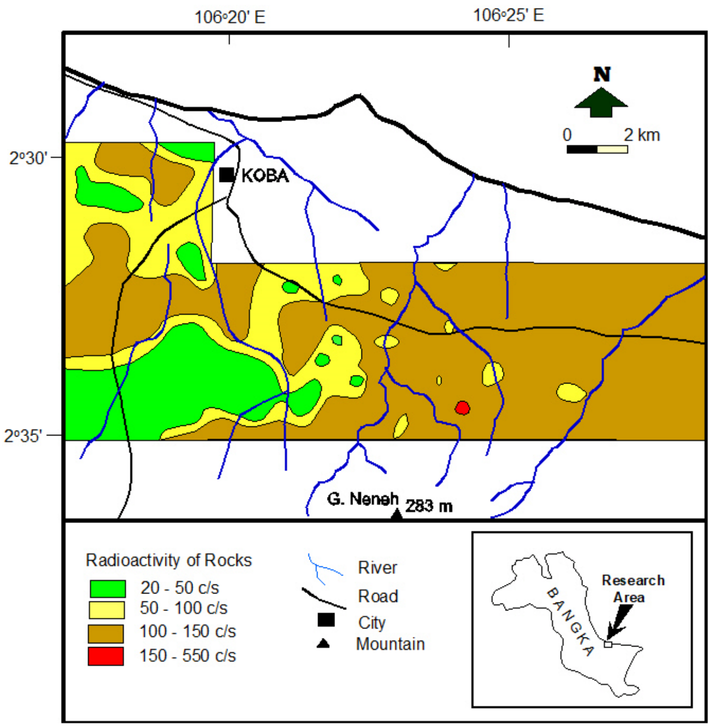

Figure 4. Radioactivity of the Rocks in Koba Area, Central Bangka [11].

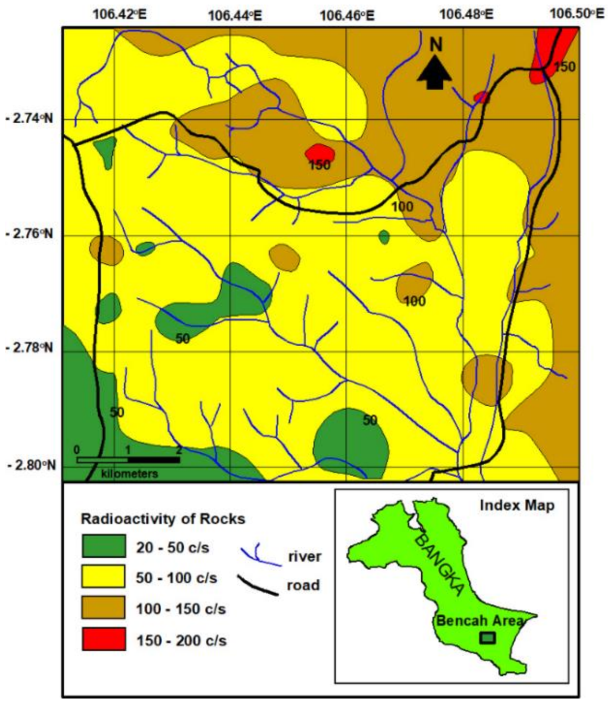

Figure 5. Rocks Radioactivity in Bencah Area, South Bangka [20].

Uranium and Thorium Contents

The uranium and thorium content of the rocks come from regional measurements of the whole of Bangka island by using a gamma spectrometer RS 125. Uranium content in paleo channel deposits in the Koba area, Central Bangka, and modern channel Bencah Area, South Bangka, are the same, ranging from 1 to 10 ppm eU, as can be seen in Figure 6a. Thorium content in the paleo channel ranges from 1–60 ppm eTh, while in the modern channel, it ranges from 1 to 45 ppm eTh (Figure 6b). This difference in levels is thought to be related to the radioactive mineral content in the paleo channel and modern channel deposits, as depicted in Figure 3. High thorium contents indicate a potential radioactive mineral area. As a comparison, the uranium content in granitic rocks in Australia is 1.6–3.8 ppm, and thorium is 6–19 ppm [23].

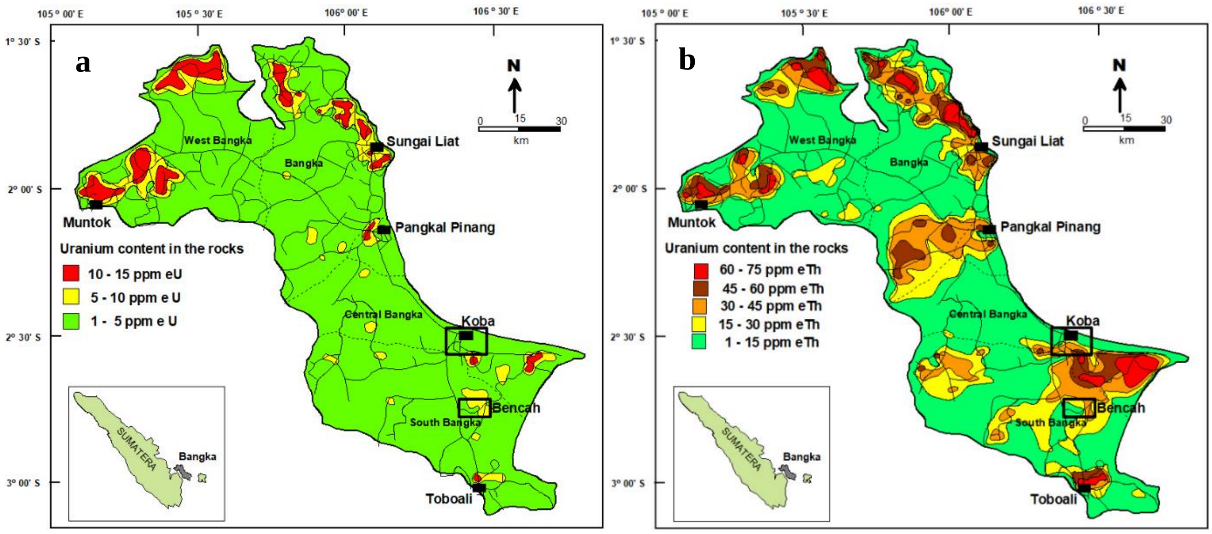

Figure 6. Map of uranium (a) and thorium (b) content in the rocks of Bangka Island [22].

CONCLUSION

The minerals in the paleo channel of tin placer deposits are the same as those in modern channels of tin placer deposits and tin mine tailings deposits. Nevertheless, monazite and zircon are slightly more abundant in tin mine tailings deposits compared to paleo channel and modern channel of placer tin deposits. From the radiometric method, the radioactivity and uranium contents of the rocks are less effective for determining potential areas of radioactive minerals in placer tin deposits. In contrast, data on thorium content are quite effective for determining potential areas of radioactive minerals in placer tin deposits.

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