Rare earth distribution in Batu Melintang Granitic Rocks, Jeli, Kelantan

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Abstract. Rare Earth Element (REE) is a group of elements that consisting of 17 metallic elements that that occur together in the periodic table, 15 lanthanides (La), Scandium (Sc) and Yttrium (Y). REE can be divided into two groups based on atomic weight which are the light REEs are lanthanum through gadolinium (atomic numbers 57 through 64); the heavy REEs comprise terbium through lutetium (atomic numbers 65 through 71). This paper investigates the distribution of Heavy REE and Light REE in granite rock in Batu Melintang, Jeli, Kelantan. This study employed Induced Coupled Plasma Mass Spectrometry (ICP-MS) to determine the distribution of rare earth elements. According to the findings, the research region has been found to contain 16 REE elements (Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er Tm, Yb, Lu), with LREE distribution being greater than HREE in the granite rocks of Batu Melintang. LREE with concentration ranging from as low as 2285.53 ppb to as high as 35888.32 ppb with Ce and La being the most abundant LREE in the samples. While for HREE, the concentration ranged from 4479.72 ppb to 11,457.67 ppb, and abundance of Y, Yb, and Sc was found to be the highest in the HREE group.

1 Introduction

The 15 elements in the Lanthanide group of the periodic table that make up the rare earth elements (REE) are lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), dysprosium (Dy), terbium (Tb), dysprosium (Dy), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), Ytterbium (Yb), Lutetium (Lu), as well as yttrium (Y) and scandium (Sc). The term "rare earth metals" is frequently used to refer to rare earth elements, which are all metals. Due to their numerous shared characteristics, these metals are frequently found together in geologic deposits [1]. These elements are normally divided into two categories, light rare earth elements (LREE) comprising La, Ce, Pr, Nd, Pm, Sm and Eu, and heavy rare earth elements (HREE) comprising Gd, Dy, Tb, Dy, Tb, Dy, Ho, Er, Tm, Yb, Lu and Y. Due to its unique chemical and physical characteristics, REE have been regarded as valuable. The use of REE in the defense, aerospace, medical, and automotive industries has expanded considerably as a result of technological advancements. In addition to alkaline igneous rocks and carbonatites, sedimentary rocks are also known to be associated with REE [2]. However, a number of REE deposits are found in conjunction with granitic rocks and the igneous bodies that they are associated to. Three belts, the Western Belt, the Central Belt, and the Eastern Belt can be distinguished among the granites of Peninsular Malaysia. Peninsular Malaysia has good exposure to the Bentong-Raub suture, which divides the Eastern and Main Range Granite provinces. Granitoid and some extrusive volcanic rocks are abundantly exposed in Malaysia, particularly in the Kelantan region (Fig. 1) [3]. The Kemahang Granite, a cataclastic porphyritic biotite granite which outcrop extends across the border into southern Thailand as the Buke pluton, occupies the northern section of the schist body. The Taku Schist has been injected into the granite and has been extensively absorbed. [4]. In this research, the ICP-MS is used to analyze the rare earth elements concentrations of Rare Earth Elements (REE) in the samples in range limit part per billion (ppb).

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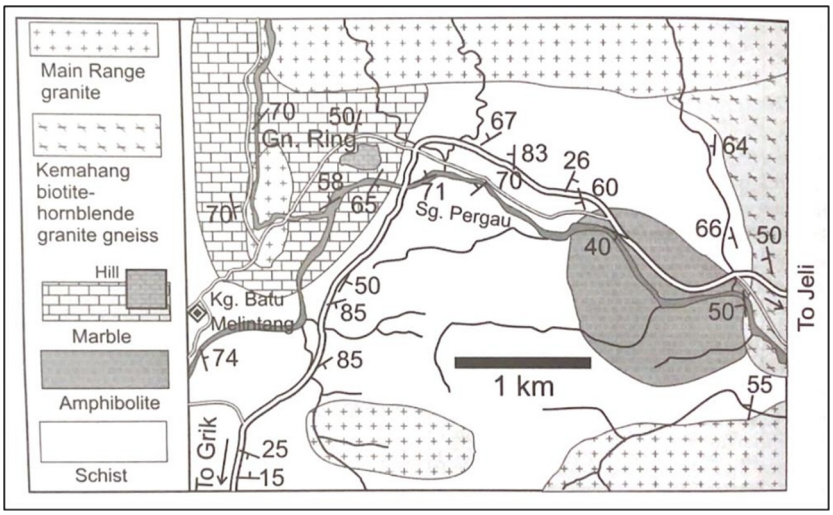

Fig. 1. Distribution of rocks in Kampung Batu Melintang [5]

2 Methodology

2.1 Inductive Couples Plasma Mass Spectrometry (ICP-MS)

ICP-MS is an analytical method that enables more sensitive detection in detecting a wide variety of atomic elements with exceptionally low detection limits one part in 10^{12} (ppt) [6]. This method has a fast analytical speed, precise detection limit, and isotopic sensitivity potential, making it highly recommended for trace elements analysis [7]. In this work, the concentration of Rare Earth Elements (REE) in eight samples was measured using ICP-MS at the part per billion (ppb) limits. The location of eight samples is represented by the graph in Figure 2. All samples were crushed, pulverized and sieved until particle size less than 63 microns. The powdered samples were then digested using Total Digestion Method by Microwave Digestor (Perkin Elmer). Samples were then diluted and measured using ICP-MS with the calibrated standards (REE elements). REE analysis had been carried out using ICP-MS by Perkin Elmer NexIon 2000 at Gold, Rare Earth & Material Technopreneurship Centre (GREAT), Universiti Malaysia Kelantan.

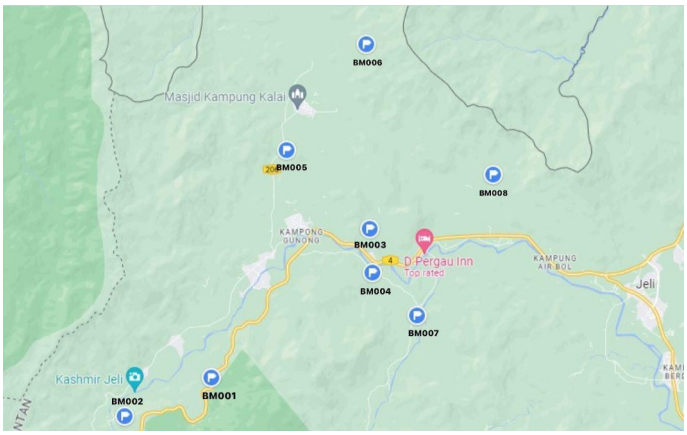

Fig. 2. Map of study area showing the sampling location.

3 Results and discussion

3.1. REE distribution analysis

ICP-MS analysis was performed on eight samples of granitoid rocks, #BM001, #BM002, #BM003, #BM004, # BM005, # BM006, # BM007, and # BM008 and data on rare earth elements was obtained following the study. Elements La, Ce, Pr, Nd, Pm, Y, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y and Sc was obtained in ppb unit except promethium (Pm) the rarest, which only occurs in trace quantities in natural materials as it has no long-lived or stable isotopes [8]. Based on the total concentration of REE in eight granite samples shown in Table 1, the ICP-MS data shows that the total REE elements in Batu Melintang range from 6765.25 ppb to 575.00 ppb. These findings, however, fall below the prior range discovered by [4], which claimed that the range of total REE in the granites of Peninsular Malaysia is between 85 and 414 ppm and for the granites along the East Coast, it is between 85 and 327 ppm. Six out of the eight samples (or a majority) had values that are lower than 16000 parts per billion, with sample #BM006 having the lowest value (6765.25 ppb) that is below 10,000 parts per billion. The highest sample was #BM008 with a value of 45598.18 ppb, followed by #MB005 with a value of 22575.2 ppb. Among 16 rare earth elements, Cerium (Ce) appear to be the highest concentration in all eight samples with value ranging from 401.55 ppb to 22004.88 ppb, followed by Yttrium (Y) 2422.94 ppb to 7954.34 ppb, Lanthanum (La) from 751.84 ppb to 5542.51 ppb and Neodymium (Nd) ranging from 711.05 ppb to 5401.21 ppb.

Table 1: Total concentration of REE in eight granites sample in ppb (ng/g) unit.

Elements in ppb (ng/g)	#BM001	#BM002	#BM003	#BM004	#BM005	#BM006	#BM007	#BM008
La	2224.2	1061.66	907.78	2375.67	1874.82	751.84	812.09	5542.51
Ce	2614.42	3432.11	2184.88	2105.1	8478.65	401.55	2137.04	22004.88
Pr	662.47	418.2	361.42	501.59	693.77	241.64	344.56	1694.01
Nd	1631.3	809.91	768.55	786.98	2318.7	154.92	711.05	5401.21
Sm	458.17	277.91	247.43	317.74	655.12	52.2	280.06	1245.71
Eu	120.45	116.92	115.02	123.35	170.04	63.02	124.13	323.66
Gd	363.62	243.81	268.85	270.46	479.29	84.2	241.19	652.79
Tb	443.31	430.32	439.28	438.02	456.13	411.48	432.11	463.78
Dy	291.62	223.98	327	286.18	387.83	91.11	235.05	379.14
Ho	240.82	234.35	251.79	240.25	251.28	215.75	233.14	245.51
Er	170.25	152.13	245.12	185.66	221.96	82.74	141.81	182.82
Tm	188.84	186.72	194.72	193.39	194.61	175.92	186.75	196.05
Yb	564.88	552.94	658.21	606.45	599.57	512.1	541.79	563.58
Lu	490.38	488.78	503.92	496.29	494.31	483.48	486.99	489.59
Y	4010.94	3972.2	7954.34	3714.79	4646.19	2422.94	4999.15	5231.23
Sc	581.19	523.65	635.27	843.35	652.93	620.36	523.35	981.71
SUM ∑	15056.86	13125.59	16063.58	13485.27	22575.2	6765.25	12430.26	45598.18

3.2 LREE vs HREE distribution

Heavy rare earth elements (HREE), which include Gd, through Lu, and Y, and light rare earth elements (LREE), which range from La to Eu. The distributions of LREE and HREE in eight granites, measured in ppb units, are shown in Figure 3. In general, results exhibits that the LREE is more abundant than HREE which contribute up to 81% of total REE. HREE are less common than LREE [3][4][10], and due to their rarity, HREE are more valuable than LREE. The highest concentration of LREE is found in #BM008 with a value of 36211.98 ppb and the highest HREE concentration is in #BM003 with a value of 10843.23 ppb. The concentration of HREE in the remaining samples ranging from 4479.72 ppb – 8404.49 ppb while for LREE, the concentration ranging from 1165.17 ppb – 14191.1 ppb.

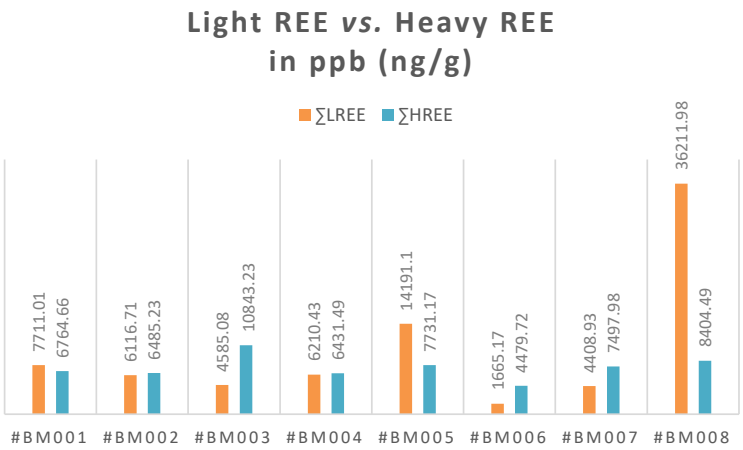

Fig. 3. Distribution of light REE and heavy REE in eight granite samples in ppb (ng/g)

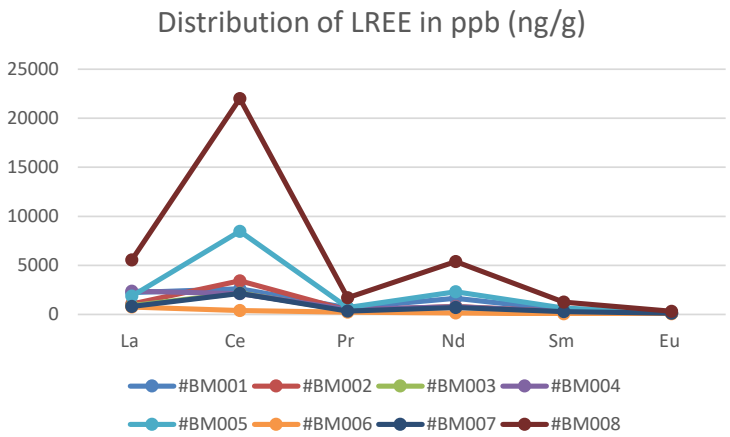

Fig. 4 (a). Distribution of light REE in eight granite samples in ppb (ng/g)

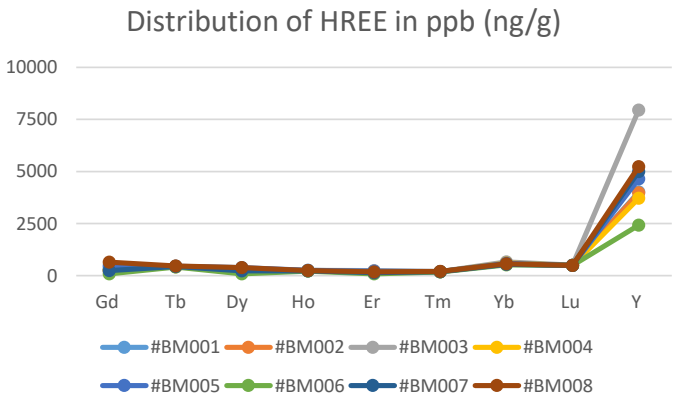

Fig. 4 (b). Distribution of heavy REE in eight granite samples in ppb (ng/g)

As shown in the detail distribution of light REE in Figure 4(a), the element cerium (Ce) appeared to be the most abundant among other light REE, and this tendency was consistent across all eight granite samples. This result is consistent with evidence showing that cerium is the most common rare earth element [10]. The next highest concentration among light REE is lanthanum (La), followed by neodymium (Nd), praseodymium (Pr), samarium (Sm) and europium (Eu). As of the distribution of heavy REE, Figure 4(b) shows yttrium (Y) is the only element that prominent in all eight samples, while the remaining elements gadolinium (Gd), Lutetium (Lu), Ytterbium (Yb), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), shows relatively low concentration, below 2500 ppb.

4 Conclusion

Distribution of rare earth elements (REE) in Batu Melintang Granitic Rocks were identified by using ICP-MS and reported in ppb units. All 16 rare earth elements of La, Ce, Pr, Nd, Pm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y and Sc was obtained in eight samples except promethium (Pm). Total REE in Batu Melintang granite sample with trend-increasing concentration are #BM008 > #BM003> #BM001> #BM004> #BM002> #BM007> #BM006 > #BM005. The concentration are 45598.18, 16063.58, 15056.86, 13485.27, 13125.59, 12430.26, 6765.25 and 22575.2 ppb respectively. The overall REE content in granite samples is fairly low, reaching less than 50000 ppb @ 50 ppm. As previously conducted research by [4] has shown, granites from Peninsular Malaysia range in total REE from 85 to 414 ppm, whereas those from the East Coast range from 85 to 327 ppm. The distribution of REE in the granites of Batu Melintang is therefore below from that of typical deposits. Light REE consist of Lanthanum, Cerium, Praseodymium, Neodymium, Samarium and Europium and heavy REE consist of Gadolinium, Terbium, Dysprosium, Erbium, Thulium, Ytterbium, Holmium, Lutetium and Yttrium. The result shows in all samples, Cerium are the highest element for LREE with concentration up to 22004.88 ppb, followed by La, Nd, Pr, Sm and Eu. For heavy REE, Y appears to be the single highest element in heavy REE for all samples with concentration up to7954.14 ppb.

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