PORTOFOLIO

Review Jurnal

E

Oleh:

KUWAT TRIYANA, ADE ANGGRAINI

Program Studi DOKTOR FISIKA
Departemen FISIKA
Fakultas MIPA
UNIVERSITAS GADJAH MADA
2020 GENAP

RENCANA KEGIATAN PEMBELAJARAN SEMESTER

A. Identitas Matakuliah / *Course Detail*

1.	Nama Matakuliah / *Course Name*	:	Review Jurnal
2.	Kode/SKS/Sifat / *Code/Credits/Status*	:	MFF 7000/3/Wajib (*Compulsory*)
3.	Prasyarat / *Prerequisite*	:	tidak ada
4.	Deskripsi Singkat / *Short Description*	:	*Struktur jurnal ilmiah, Struktur halaman judul (Judul, afiliasi, abstrak), alur umum pendahuluan (menentukan “big picture”, novelty serta tujuan penelitian dalam jurnal ilmiah), Alur Metodologi Riset untuk berbagai bidang kajian seperti fisika teoritik, fisika komputasi, fisika eksperimen,geofisika, Alur penyajian hasil dan diskusi untuk berbagai bidang kajian dalam fisika, Cara menganalisis suatu hasil khususnya yang berupa grafik dan tabel, scheme reading, teknik presentasi (oral dan poster*
5.	Tujuan Pembelajaran / *Learning Objective*	:	Tujuan pembelajaran dari kuliah ini adalah agar mahasiswa dapat memahami dan mensarikan artikel ilmiah yang dibaca serta mendapatkan gambaran *state of the art* topik yang menjadi minatnya. Dari sini diharapkan mahasiswa dapat memikirkan suatu rencana riset yang mempunyai unsur kebaharuan tertentu agar layak menjadi suatu riset doktoral. Adapun langkah untuk menyusun rencana riset dimulai dengan memahami riset yang dilakukan orang lain, mengindentifikasi kelebihan maupun kelemahan metode riset tersebut, dan mendapatkan ide baru untuk menyempurnakan ataupun menjawab jurang saintifik dari riset yang sudah ada.
6.	Dosen Pengampu Matakuliah / *Lecturers*	:	KUWAT TRIYANA, ADE ANGGRAINI
7.	Capaian Pembelajaran Matakuliah / *Course Learning Outome (CPMK/CLO)*	:	

Kode / *Code*	**Deskripsi / *Description***	**PLO/SO/ELO/CPL/LG**
R 1	Siswa dapat memanfaatkan berbagai sumber daya cetak dan elektronik dan teknologi informasi untuk mendukung penelitian mereka	FD6,FD1,FD5,FD10
R 2	Siswa dapat melaporkan telaahnya dalam bentuk laporan lisan	FD9,FD1,FD6
R 3	Mahasiswa mampu melaporkan telaahnya dalam bentuk laporan tertulis	FD7,FD5,FD6

PLO / PI *Detail*

FD6	Capaian Pembelajaran Umum	Kemampuan Riset
FD1	Capaian Pembelajaran Umum	Sikap dan Tata Nilai
FD5	Capaian Pembelajaran Umum	Kemampuan Memecahkan masalah
FD10	Capaian Pembelajaran Peendukung	Pembelajar sepanjang Hayat
FD9	Capaian Pembelajaran Peendukung	Keterampilan Komunikasi
FD7	Capaian Pembelajaran Umum	Kemampuan Publikasi

B. Topik Perkuliahan / *Course Materials*

Bahasan / *Main Discussion*	**Estimasi Waktu / *Estimated Times (Hour)***	**Kompetensi (*Course Learning Outcomes*)**
Struktur umum jurnal ilmiah	4	Mahasiswa dapat menyusun kerangka/ struktur publikasi ilmiah dengan baik
Alur umum: Latar Belakang,	4	Mahasiswa dapat menentukan “big picture”, novelty serta tujuan penelitian dalam jurnal ilmiah ?
Menganalisis suatu hasil khususnya yang berupa grafik dan tabel,	4	Mahasiswa dapat menampilkan dan menganalisis data/hasil observasi dalam bentuk tabel dan grafis
Skimmed reading,	4	Mahasiswa dapat memahami dan mensarikan pokok dan isi artikel yang ditugaskan
Teknik presentasi (oral dan poster).	6	Mahasiswa dapat menuturkan kembali hasil skimmed reading dengan jelas kepada orang lain dalam bahasa lisan

Bahasan / *Main Discussion*	Estimasi Waktu / *Estimated Times (Hour)*	Kompetensi (*Course Learning Outcomes*)
Teknik menulis artikel ilmiah	6	Mahasiswa dapat Mahasiswa dapat menuturkan kembali hasil skimmed reading dengan jelas kepada orang lain dalam bahasa tulisan

C. Rencana Asesmen / Assesment Plan

CO/CPMK	Tipe / *Type*	Deskripsi / *Description*	Persentase / *Percentage*	PLO/SO/ELO/CPL/LG
R 1	DISKUSI	Motivasi & Manajemen waktu	5	FD1
R 1	DISKUSI	Presentasi 1: Tampilan	5	FD6
R 1	DISKUSI	Presentasi 1: Konten	10	FD5
R 1	DISKUSI	Presentasi 1: Bahasa	5	FD10
R 2	DISKUSI	Presentasi 2: Bahasa	5	FD1
R 2	DISKUSI	Presentasi 2: Konten	5	FD9
R 2	DISKUSI	Presentasi 2: Tampilan	5	FD6
R 3	TUGAS	Paper 1: Struktur	10	FD6
R 3	TUGAS	Paper 2: Struktur	10	FD6
R 3	TUGAS	Paper 1: Konten	15	FD5
R 3	TUGAS	Paper 2: Konten	15	FD5
R 3	TUGAS	Paper 1: Bahasa	5	FD7
R 3	KUIS	Paper 2: Bahasa	5	FD7

D. Referensi / References

1. *https://www.lib.purdue.edu/sites/default/files/libraries/engr/Tutorials/Newest%20Scientific%20Paper.pdf*
2. *https://www.youtube.com/watch?v=t2K6mJkSWoA How to Read and Comprehend Scientific Research Articles*
3. *https://www.elsevier.com/connect/infographic-how-to-read-a-scientific-paper*

E. Rencana Kegiatan Pembelajaran Mingguan (RKPM) / *Weakly Teaching Plan*

Pertemuan Ke / *Week*	Tujuan Ajar / *Learning Objective*	Topik / *Topic*	Media Ajar / *Teaching Media*	Metode Assesment / *Assesment Method*	Metode Ajar / *Teaching Method*	Aktivitas Mahasiswa / *Student Activity*	Aktivitas Dosen / *Lecturer Activity*	Sumber Ajar / *Learning Resources*

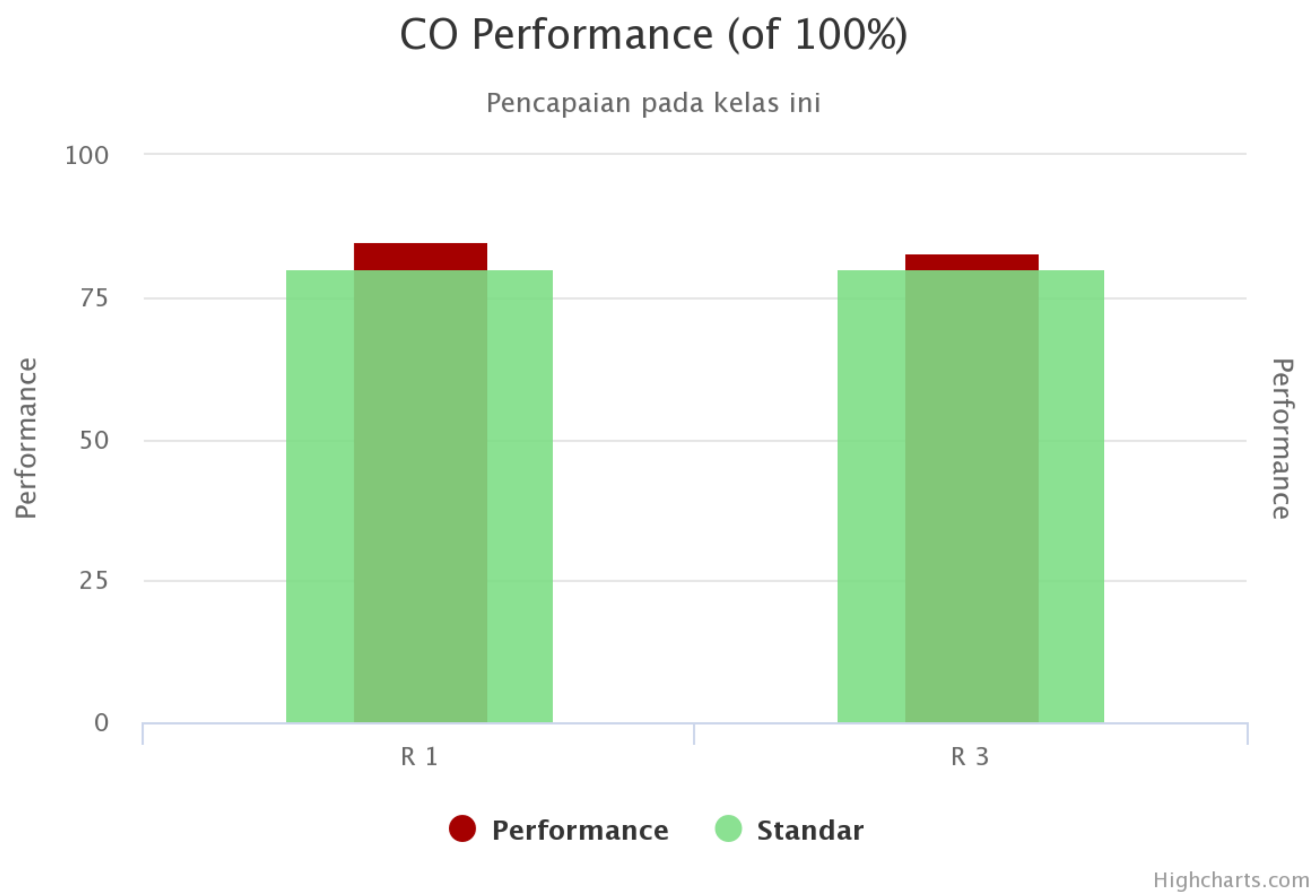
Pertemuan Ke / *Week*	Tujuan Ajar / *Learning Objective*	Topik / *Topic*	Media Ajar / *Teaching Media*	Metode Assesment / *Assesment Method*	Metode Ajar / *Teaching Method*	Aktivitas Mahasiswa / *Student Activity*	Aktivitas Dosen / *Lecturer Activity*	Sumber Ajar / *Learning Resources*
1	Mahasiswa dapat menyusun kerangka/outline risetnya sebagai suatu struktur jurnal ilmiah	Struktur umum jurnal ilmiah	Slide	Diskusi	SCL	Mencari artikel ilmiah berdasarkan topik risetnya	Memberi penjelasan dan panduan awal	https://www.lib.purdue.edu/sites/default/files/libraries/engr/Tutorials/Newest%20Scientific%20Paper.pdf
2	Mahasiswa dapat memahami dan mensarikan isi dan pokok artikel yang dibaca	Skimmed reading	Slide dan artikel yang dipilih	Presentasi	SCL	Membaca dan menelaah artikel ilmiah	Menilai diskusi dan presentasi	https://www.youtube.com/watch?v=t2K6mJkSWoA How to Read and Comprehend Scientific Research Articles
3	Mahasiswa dapat menyusun judul dan abstrak yang yang relevan, menarik dan efektif	Struktur halaman judul (Judul, afiliasi, abstrak)	Slide dan artikel yang dipilih	Diskusi	SCL	Membaca dan menelaah artikel ilmiah	Menilai diskusi dan presentasi	https://www.elsevier.com/connect/infographic-how-to-read-a-scientific-paper
4	Mahasiswa dapat menentukan "big picture", novelty serta tujuan penelitian dalam jurnal ilmiah	Alur umum pendahuluan (menentukan "big picture", novelty serta tujuan penelitian dalam jurnal ilmiah)	Slide dan artikel yang dipilih	Diskusi	SCL	Mendiskusikan hasil telaah	Menilai diskusi dan presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
5	Mahasiswa dapat memaparkan secara lisan hasil skimmed 1: Abstrak dan Pendahuluan	Teknik presentasi (oral): Sesi 1	Slide dan artikel yang dipilih	Presentasi	SCL	Mempresentasikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
6	Mahasiswa dapat memaparkan secara lisan hasil skimmed reading 2: Isi	Teknik presentasi (poster): Sesi 2	Slide dan artikel yang dipilih	Presentasi	SCL	Mendiskusikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
7	Mahasiswa dapat memaparkan secara lisan hasil skimmed reading dari minimal 3 artikel sekaligus	Presentasi Hasil Skimmed reading:	Slide dan artikel yang dipilih	Presentasi	SCL	Mempresentasikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
8	Mahasiswa dapat menyusun rencana riset fisika secara umum	Alur Metodologi Riset untuk bidang kajian terkait topik riset (1)	Slide dan artikel yang dipilih	Presentasi	SCL	Mencari artikel ilmiah berdasarkan topik risetnya	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
9	Mahasiswa dapat menyusun rencana riset terkait topik riset doktoralnya	Alur Metodologi Riset untuk bidang kajian terkait topik riset (2)	Slide dan artikel yang dipilih	Presentasi	SCL	Membaca dan menelaah artikel ilmiah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
10	Mahasiswa dapat menyajikan hasil riset fisika secara umum	Alur penyajian hasil dan diskusi untuk bidang kajian terkait topik riset (1)	Slide dan artikel yang dipilih	Presentasi	SCL	Mendiskusikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
11	Mahasiswa dapat menyajikan hasil riset terkait topik riset doktoralnya	Alur penyajian hasil dan diskusi untuk bidang kajian terkait topik riset (2)	Slide dan artikel yang dipilih	Presentasi	SCL	Mendiskusikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
12	Mahasiswa dapat menganalisis hasil diskusi riset fisika secara umum	Cara menganalisis suatu hasil khususnya yang berupa tabel dan grafik (1)	Slide dan artikel yang dipilih	Presentasi	SCL	Mendiskusikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
13	Mahasiswa dapat menganalisis hasil diskusi riset fisika secara umum	Cara menganalisis suatu hasil khususnya yang berupa tabel dan grafik (2)	Slide dan artikel yang dipilih	Presentasi	SCL	Mendiskusikan hasil telaah	Menilai presentasi	Artikelilmiah yang sesuai topik riset mahasiswa
14	Mahasiswa dapat memaparkan secara tertulis hasil skimmed reading dari minimal 3 artikel sekaligus	Teknik menulis	Slide dan artikel yang dipilih	Esay	SCL	Menyusun tulisan hasil skimmed reading secara lengkap	Menilai esay	Artikelilmiah yang sesuai topik riset mahasiswa

COURSE ASSESMENT

A. Evaluasi hasil Pembelajaran

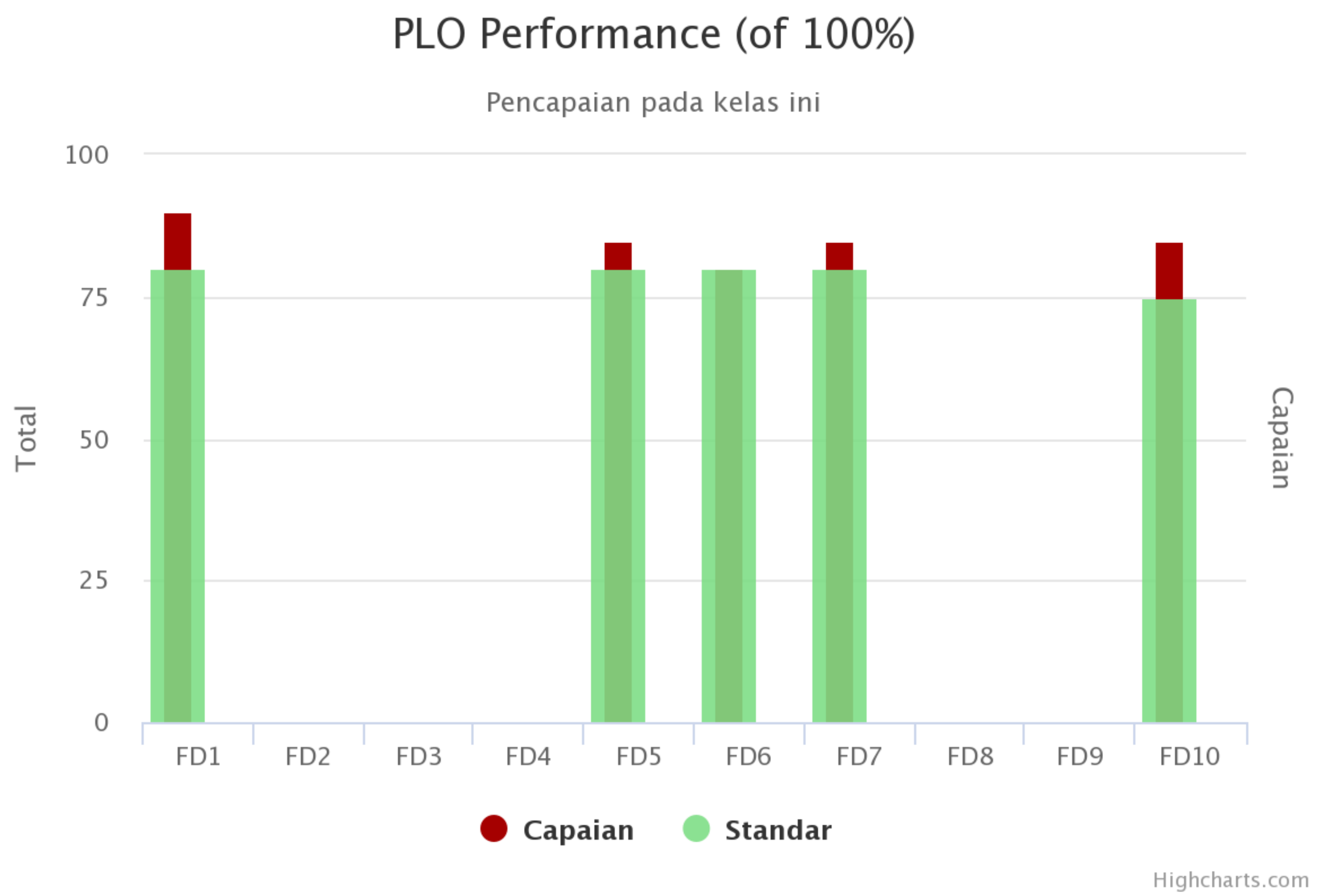
CO/CPMK Performance

CO/CPMK	Presentase	Standar	Performance (of 100)	Evaluasi
R 1	25	80,00	85,00	-
R 3	30	80,00	83,33	-



Capaian PLO/ELO/SO/CPL/LG

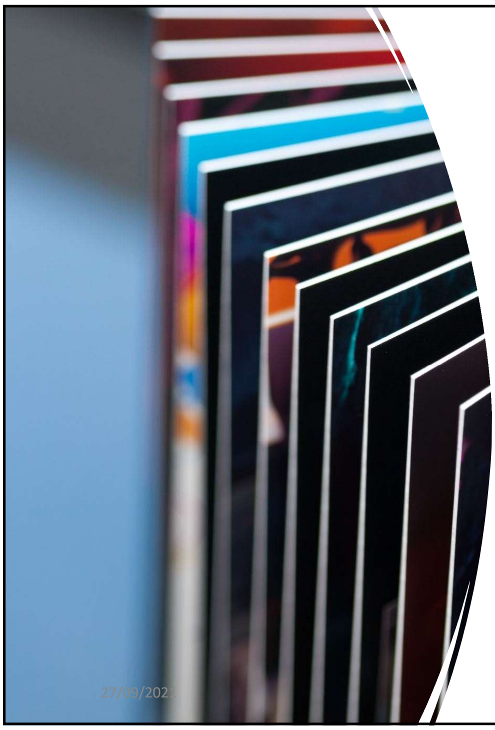
FD1 (Capaian Pembelajaran Umum)	FD5 (Capaian Pembelajaran Umum)	FD6 (Capaian Pembelajaran Umum)	FD7 (Capaian Pembelajaran Umum)	FD10 (Capaian Pembelajaran Peendukung)
90,00	85,00	80,00	85,00	85,00



B. Rencana Pengembangan

C. Lampiran

Lampiran: Soal Ujian Tengah Semester



MFF 7000 Review Jurnal

PRODI DOKTOR FISIKA Kurikulum 2017

Prof. Dr.Kuwat Triyana

Dr. Ade Anggraini

1

Silabus

Minggu ke	Materi kuliah
1	Motivasi dan tujuan/capaian pembelajaran → dosen menjelaskan dan diskusi, serta memberikan tugas
2	Struktur umum jurnal ilmiah → dosen menjelaskan dan diskusi, serta memberikan tugas
3	Struktur Judul, Afiliasi dan Abstrak dalam jurnal ilmiah → dosen menjelaskan dan diskusi, serta memberikan tugas
4	Alur umum Latar Belakang, menentukan "big picture", novelty serta tujuan penelitian dalam jurnal ilmiah → dosen menjelaskan dan diskusi, serta memberikan tugas
5	Alur umum Latar Belakang, menentukan "big picture", novelty serta tujuan penelitian dalam jurnal ilmiah → mahasiswa presentasi dan diskusi
6	Alur Metodologi Riset untuk berbagai bidang kajian seperti fisika teoritik, fisika komputasi, fisika eksperimen → dosen menjelaskan dan diskusi, serta memberikan tugas
7	Alur Metodologi Riset untuk berbagai bidang kajian seperti fisika teoritik, fisika komputasi, fisika eksperimen → mahasiswa presentasi dan diskusi
	UTS
8	Alur penyajian hasil dan diskusi untuk berbagai bidang kajian dalam fisika → dosen menjelaskan dan diskusi, serta memberikan tugas
9	Alur penyajian hasil dan diskusi untuk berbagai bidang kajian dalam fisika → mahasiswa presentasi dan diskusi tugas
10	Cara menganalisis suatu hasil khususnya yang berupa grafik dan tabel → dosen menjelaskan dan diskusi, serta memberikan tugas
11	Cara menganalisis suatu hasil khususnya yang berupa grafik dan tabel → mahasiswa presentasi dan diskusi
12	Tugas dan presentasi bagi mahasiswa
13	Tugas dan presentasi bagi mahasiswa
14	Tugas dan presentasi bagi mahasiswa
	UAS

2

Lampiran: Soal Ujian Tengah Semester

Capaian Pembelajaran

- Mahasiswa mampu melakukan telaah artikel ilmiah secara mandiri (3-5 artikel/minggu)
- Mahasiswa mampu melaporkan telaahnya dalam bentuk laporan lisan
- Mahasiswa mampu melaporkan telaahnya dalam bentuk laporan tertulis

Bahan Bacaan

- https://www.lib.purdue.edu/sites/default/files/libraries/engr/Tutorials/Newest%20Scientific%20Paper.pdf
- https://www.youtube.com/watch?v=t2K6mJkSWoA How to Read and Comprehend Scientific Research Articles
- https://www.elsevier.com/connect/infographic-how-to-read-a-scientific-paper
- dll

Lampiran: Soal Ujian Tengah Semester

How to Read and Comprehend Scientific Research Articles

Read	Identify	Take
Read Order • Abstract • Discussion • Introduction • Results • Methods	Identify Main Points • √ • √	Take Effective Notes

5

Tugas Minggu 1 dan 2

- Mencari beberapa artikel ilmiah dari jurnal bermutu yang berhubungan dengan topik riset doktoral mahasiswa
- Melakukan telaah mandiri artikel-artikel ilmiah tersebut. Target minggu 1 dan 2: 1-2 artikel/minggu
- Mendiskusikan proses dan hasil telaah bersama dosen dalam ruang virtual pada waktu yang disepakati.

6

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

Radiogenic Heat Production of Granite Rocks in Bangka Island Indonesia

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Abstract

In this study, we investigate the Radioactive Heat Production (RHP) on granite rocks in West-South Bangka and Central-North Bangka. Moreover, we are trying to present correlation between RHP and magmatic type of granite rocks in Bangka Island, S-type (crust) and I-type (mixed of crustal-upper mantle). This is interesting since we found little research reference for RHP on mixed of mantle and crustal of earth. These data will be useful to discuss natural variability of heat production for granite rocks as a function of chemical compound, density and seismic velocity. Our analysis data provide the mixed (crust-upper mantle) granite heat production is higher than crustal granite. This provided by higher Potassium value in crustal granite, since Uranium and Thorium value is potentially explored in Pangkal Pinang area. The S-type granite has a higher value but has a relatively lower correlation compare to I-type. There is a strong relationship between RHP to the concentration on U, Th, and the geological age of granite in Bangka. The higher concentration of U and Th, the higher contribution of RHP, and the older the geological age of granite, the bigger contribution of RHP granite in Bangka.

Keywords : Radioactive Heat Production (RHP), Crustal Granite Rock, Bangka Island

Introduction

Radiogenic Heat Production (RHP) is a major key to study temperature[1] and heat flow of crust and mantle of earth [2], whereas RHP contains information about the relation of tectonic age and evolution of the earth's crust. Radiogenic heat mostly produced by the existence of radioactive elements in the igneous rocks both volcano and plutonic rocks [3]. Thorium, Uranium and Potassium are widely discovered in granite and has been studied by numerous researchers [4], [5], [6],[7],[8] and [9] for their contribution to radiogenic heat production[10],[11].These elements were processed in the mantle, but are concentrated mainly in the crust. As the decay of radioactive elements generates the heat, the parent isotope concentrations have time exponentially decreased. Natural uranium abundance in rocks are composed of 99.28% by weight ^{238}U and 0.71 % ^{235}U, natural thorium is 100% ^{232}Th and 0.0119% ^{40}K of natural potassium[12]. Other radioisotopes decay very slowly, so they generate with small contribution.

In the uppermost crust, heat distribution is mostly controlled by Uranium and Thorium hence in the upper mantle is controlled by potassium[13]. The heat generate by radioactive in continental crust (roughly equally granodioirite and granulite contains about 10% from the total outflow, where oceanic crust and mantle are 0.15% and 30% respectively [14]. U, Th and K concentration from some rocks have been identified and estimate the heat produced (**Table 1**).

Table 1. Radioactive concentrations and heat production[14]

Material	U(ppm)	Th (ppm)	K (%)	K/U	Heat Productivity (μWm^{-3})
Bulk Earth	0.02	0.02	0.02	10 000	0.014
Gabrro	0.05	0.15	0.08	16 000	0.03
Granodiorite	1.6	6.2	2.1	13 125	1.0
Granulite	0.2	0.7	0.25	12 500	0.13
Carbonaceous chondrite	0.02	0.07	0.04	20 000	0.01
Ordinary chondrite	0.015	0.046	0.09	60 000	0.015
Iron meteorite	negligible	negligible	negligible	-	negligible

Radioactive distribution in the crust and mantle that generate heat decrease exponentially through the depth. The maximum values are observed near the earth's surface and become several times lower already at 3 – 5 km depth and the model of exponential decrease in surface heat generation shows the pattern in radioactive elements in earth's crust [15]. Geochemical analyses and geobarometri determinations in Sierra Nevada [16] revealed that heat production in the 3 km thick volcanic at the top of the batolith is 2 μWm^{-3} at km depth the average value is 3.5 μWm^{-3}, then decreases to 0.5 – 1 μWm^{-3} at 15 km depth.

Radioactive heat generation in granite have been analyzed by numerous researchers [17]–[20]. The Th/U ratio of granite can be used to explain the geodynamic evolution and represent the genesis of continental arc magmas [21]. Moreover, studies on radioactive heat generation has been applied to igneous, metamorphic and sedimentary rocks [22]. Unfortunately, the study on granite formation in Bangka Island is relatively poorly.

Bangka is one of the main provinces in Southeast Asia granite tin belt which extending from Burma, Malaysian peninsular, to tin Islands (Riau Archipelago and Bangka island). Identification of radioactive minerals have been carried out by some researchers in tin Island such as [23] in Singkep Island (part of tin island) with Uranium and Thorium concentration average are 441 ppm and 4,210 ppm respectively. Thorium in Bangka Island granite has been investigated by [24] from 41 samples which leads to potential of thorium exploration. Furthermore, granite in Central and Eastern Bangka are classified as I-type which characterized by high proportion of magnetite, magnesian, and more primitive, while S-type in South and West Bangka are characterized by high K_2O and the presence of abundant biotite, muscovite and cordierite[25]. The S-type magmatic rocks in Bangka are associated with crust and I-type with mixed magmatic and mantle as shown in Table 2.

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

Table 2. Characteristics of trace elements in Bangka Island[26]

Area	Location	HFSE (Zr/Y)	Ba-Rb-Sr	K/Rb	Spider Diagram	Th/U	Typology I type	Typology S type
West Bangka	Menumbing	high K calc-Alkaline	Strongly differentiated	Strongly evolved	LILE-Rb>>Cs,Ba ,Sr<<	5.8-55.3	-	strongly evloved Th/U>8 High Rb and Th
	Tempilang		Strongly differentiated	-	HFSE-Th,Zr>>Nb <<			
	Jebus		Normal granite	-				
South Bangka	Toboali		Strongly differentiated	Strongly evolved	LILE-Rb>> Cs,Ba Sr<< HFSE-Th>> Zr,Nb<<	8.3-17.8	-	Strongly evolved Th/U>8 High Rb and Th
Central Bangka	Pangkal Pinang	Calc-Alkaline	Strongly differentiated	-	LILE-Cs,Ba and Sr<< HFSE-Th,Y,U>> Zr,Nb<<	0.1-3.1	Th/U<8 Y increases as Rb increases	-
	Koba/Pading		Strongly differentiated	Strongly evolved				
North Bangka	Pemali		Strongly differentiated	Strongly evolved	LILE-Cs,Ba and Sr<<	0.5-8.3	Th/U<8	-
	S.Liat		Strongly differentiated	-			Moderately evolved	
	Penyamun		Strongly differentiated	-				
	Romodong (Belinyu)		Strongly differentiated	Moderately Evolved	HFSE-Th,U>> Zr,Nb<<			

In this study, we investigate radioactive heat production (RHP) on granite rocks in West-South Bangka and Central-North Bangka. Moreover, we are trying to present correlation between RHP and magmatic type of granite rocks in Bangka Island, S-type (crust) and I-type (mixed of crustal-upper mantle). This is interesting since we found little research reference for RHP on mixed of mantle and crustal of earth. ~~These data will be useful to discuss natural variability of heat production for granite rocks as a function of chemical compound, density and seismic velocity[27].~~

Method

In Bangka Island, the interest of calculating radiogenic heat production comes from the previous research [23], [24], [26], [28], [29]. Previous research[26] showed that West Bangka and South Bangka are classified into S-type granite where Central and North Bangka are classified into I-type granite. This lead to data sampling where the data were collected from 27 granite samples from Klabat granite formation as shown in Figure 1. X-Ray Fluorescence analysis was performed to characterize Ba, U, Nb, Sr, Zr elements. Analysis Activation Neutron (AAN) was also performed to characterize Uranium in Pusdiklat- National Nuclear Energy Agency of Indonesia after radiated in Siwabessy Reactor in Serpong.

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

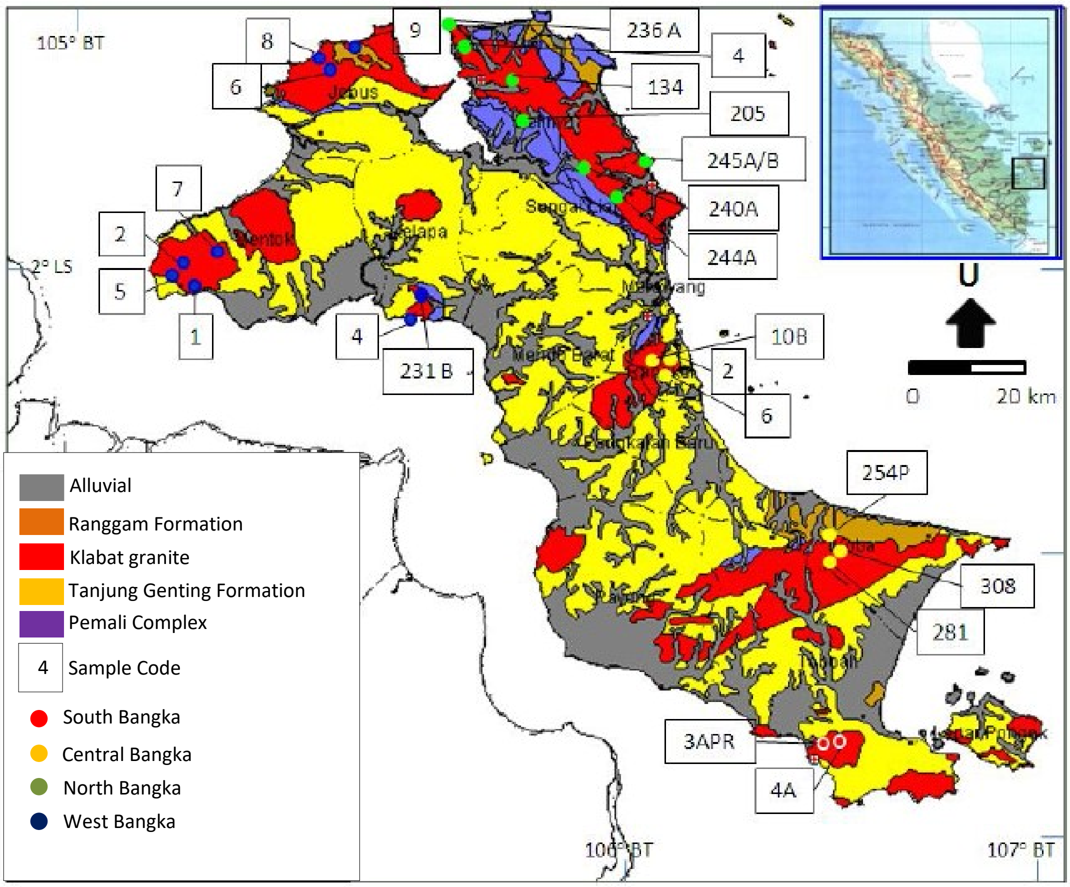

Figure 1. The major granite body and sample data collection area.

Uranium, Thorium and Potassium concentrations in granite decay and converted to energy. The energy emitted from radioactive decay process yield kinetic energy from α and β particles and the γ radiation contributed to heat produced in rocks. So, radiogenic heat production (RHP) can be calculated by considering Uranium, Thorium and Potassium concentrations of rocks [30]–[32]:

$RHP = \rho(9.52\ CU + 2.56CTh + 3.48CK)10^{-5}$. (1) DIGANTI SEBAGAI BERIKUT;

$$RHP = \rho(9.52\ C_U + 2.56\ C_{Th} + 3.48\ C_K) \times 10^{-5} \quad (1)$$

where ρ is the bulk density of granite which is 2.7 kg/m^3, C_U and C_{Th} are concentration of Uranium and Thorium in ppm and C_K is for Potassium in %.

Result and discussion

Radiogenic heat production of crustal and mixed (crust-upper mantle) granites.

Radiogenic heat production (RHP) is a petrophysical quantity as a result of the decay of radioactive elements in the earth crust and mantle. This leads to terrestrial heat flow of some area in the earth. The crustal granite in West Bangka and South Bangka shows higher average radiogenic heat production than mixed granite in Central and North Bangka as shown in table 3 and 4. In crustal granite part, the highest concentration of U (21 ppm); Th (112 ppm); and K (18.3 %) were found in BB1, BB7 and BB9 respectively. In mixed granite part, the highest concentration of U (681 ppm); Th (99.2 ppm); and K (3.55%) were found in PKP/10B and BL 240A respectively. The concentration of radioactive elements in mixed part is quite interesting; especially from 17 samples shows the average U and Th are 87.79 ppm, 65.68ppm respectively. But as we investigate the average concentration of K, crustal rocks provide the higher value 3.1 % since the mixed rocks average is 1.92 %.

Table 3. Concentration of U, Th, K, Th/U and Heat production in I-type Granite rocks from South Bangka and West Bangka (crustal rocks)

Sample	Coordinate		U (ppm)	Th (ppm)	K %	Th/U	RHP (μWm^{-3}) due to			Total RHP (μWm^{-3})
	X	Y					U	Th	K	
BS 3	106.471636	-2.986242	5.2	70	2.69	13.46	1.34	4.84	0.25	6.43
BS 4	106.470726	-2.986166	4.5	74	3.03	16.44	1.16	5.11	0.28	6.56
BB 1	105,18475	-2,05448	21	96	3.3	4.57	5.40	6.64	0.31	12.34
BB 2	105,16751	-2,01155	13	96	3.04	7.38	3.34	6.64	0.29	10.26
BB 4	105,66141	-2,12664	15	76	2.76	5.06	3.86	5.25	0.26	9.37
BB 5	105,15464	-2,02829	7	89	2.91	12.71	1.80	6.15	0.27	8.22
BB 6	105,46443	-1,60748	10	66	3.46	6.6	2.57	4.56	0.33	7.46
BB 7	105,24668	-2,00251	18	112	2.88	6.22	4.63	7.74	0.27	12.64
BB 8	105,44384	-1,59371	6	62	3.15	10.33	1.54	4.29	0.30	6.12
BB 9	105,51457	-1,57725	3	55	3.79	18.33	0.77	3.80	0.36	4.93
Average			**10.27**	**79.6**	**3.101**	**10.11**	**2.64**	**5.50**	**0.29**	**8.43**

The ratio Th/U ratios are given in Table 3 and 4 and plotted in Fig. 1 and 2 can be used to identify the enrichment of radioisotopes in rocks. A Th/U ratio higher than 1 is normally signification of such mantle-derived volcanic rocks as mid-ocean ridge basalts and continental materials[21]. Our research area is characterized by very high level of Th/U ranging from 4.57 to 18.33 (I type granite) and 0.15 to 35.70 % (S-type granite). Furthermore, a Th/U ranging from 3-7 is normally classified into continental crust material which in this research are mostly found in West Bangka. The Th/U ratio > 8 is classified as the limit for continental crust characteristics which differs granitoid of West Bangka and South Bangka. Based on [33], granitoid in Bangka Island were produced from two sources, shoshonitik for Belinyu and Central Bangka and crust for South and West Bangka. This source different can be interpreted as magmatisme episode from different geodynamics on continental margin as product of subduction and collision. The correlation of Uranium and Thorium in North Bangka, Central Bangka, and Pangkalpinang is shown in Fig. 3.

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

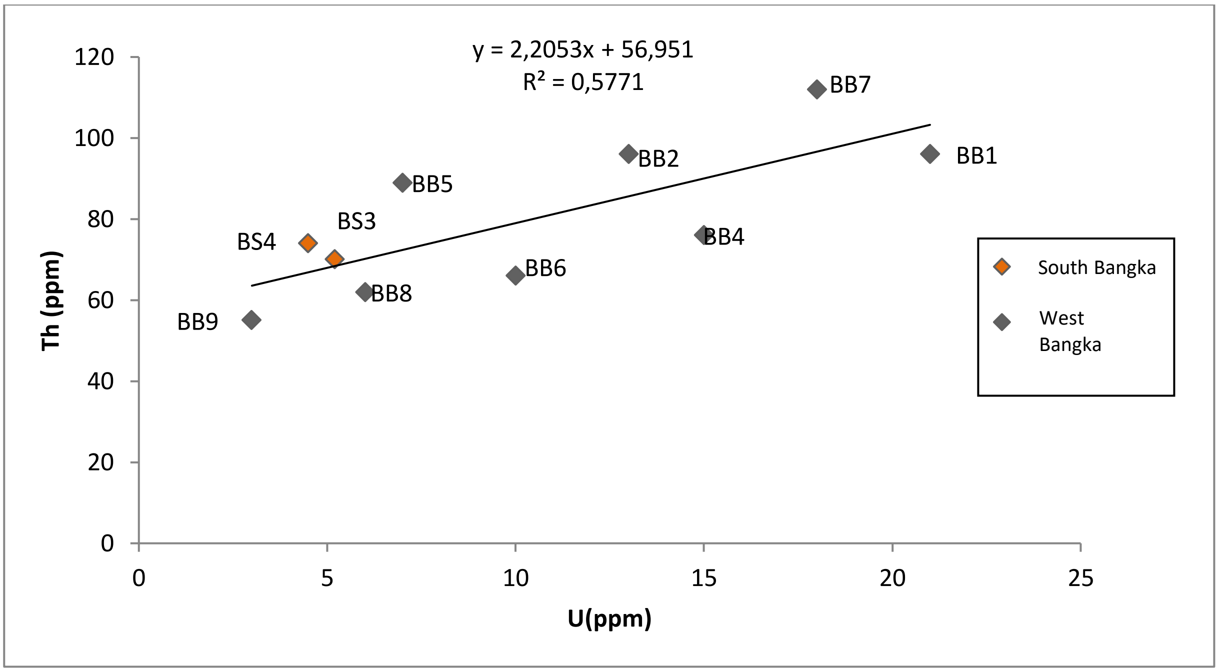

Figure 2. Correlation of Uranium and Thorium in West Bangka and South Bangka

Table 4. Concentration of U, Th, K, Th/U and Heat production in S-type Granite rocks from North Bangka, Central Bangka and Pangkalpinang (mixed crustal-mantle rocks)

Samples	Coordinate		U ppm	Th ppm	K %	Th/U	RHP (μWm^{-3}) due to			Total RHP (μWm^{-3})
	X	Y					U	Th	K	
BL4	105,729740	-1,558996	6.6	71	2.77	10.76	4.04	11.68	247.78	263.50
BL 134	105,839026	-1,649234	13.8	61	2.59	4.42	8.45	10.04	231.68	250.16
BL 205	105,861200	-1,732480	7	61	2.35	8.71	4.28	10.04	210.21	224.53
BL 231 B	105,677880	-2,098920	5.3	42	2.93	7.92	3.24	6.91	262.09	272.24
BL 236A	105,704440	-1,528120	92	79	3.34	0.86	56.30	13.00	298.76	368.07
BL 240A	105,976740	-1,813410	3.9	72	3.55	18.46	2.39	11.85	317.55	331.78
BL 244A	106,045560	-1,881340	8.8	32	2.77	3.64	5.39	5.27	247.78	258.43
BL 245A	106,114790	-1,799550	8.5	59	2.59	6.94	5.20	9.71	231.68	246.59
BL 245 B	106,114790	-1,799550	6.6	54.1	2.64	8.20	4.04	8.90	236.15	249.09
BT 254P	106,480170	-2,568000	144	95	1.53	0.66	88.13	15.63	136.86	240.62
BT254M	106,480170	-2,568000	227	82.6	1.47	0.36	138.92	13.59	131.49	284.01
BT 281	106,48212	-2,57532	24	74	0.07	3.08	14.69	12.18	6.26	33.13
BT 308	106,501840	-2,578870	2	71.4	0	35.70	1.22	11.75	0.00	12.97
PKP/1	106,137160	-2,178770	25	38	0	1.52	15.30	6.25	0.00	21.55
PKP/2	106,164880	-2,195530	21	54.4	1.34	2.59	12.85	8.95	119.86	141.67
PKP/6	106,174620	-2,214750	216	71	1.44	0.33	132.19	11.68	128.81	272.68
PKP/10B	106,134917	-2,185250	681	99.2	1.31	0.15	416.77	16.33	117.18	550.28
	Average		**87.79**	**65.7**	**1.93**	**6.72**	**22.566**	**4.540**	**0.181**	**27.288**

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

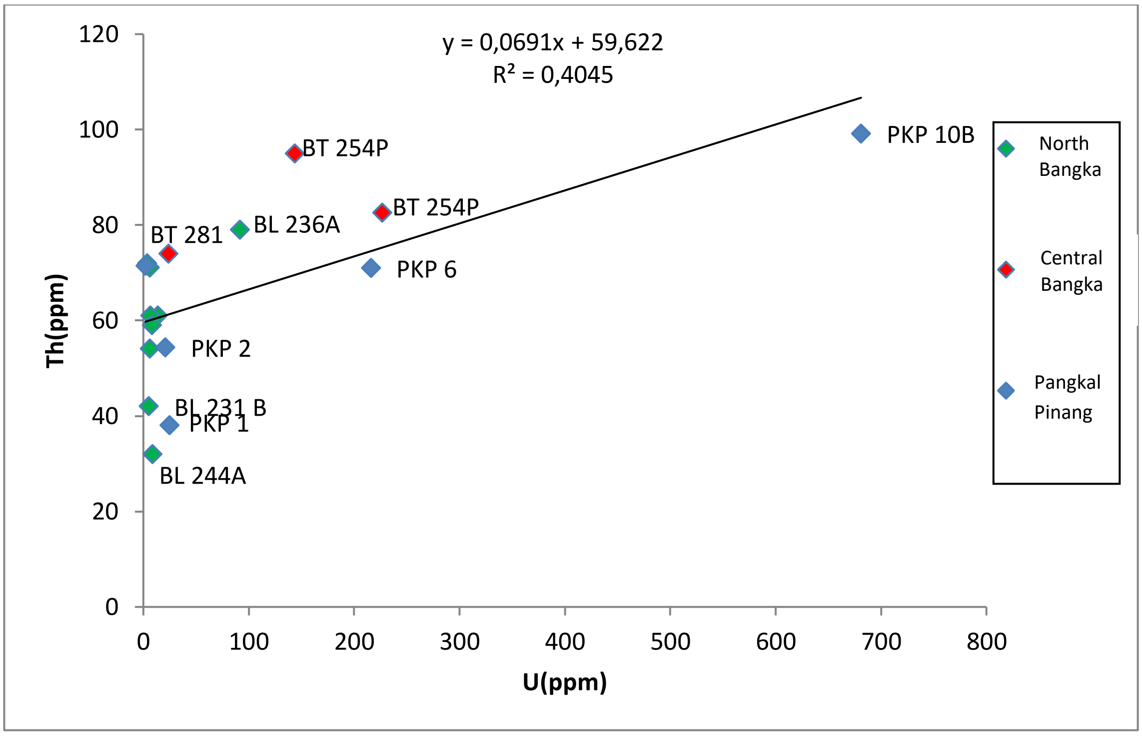

Figure 3. Correlation of Uranium and Thorium in North Bangka, Central Bangka and Pangkalpinang

The total heat production due to radioactive elements have been compared and plotted in Figure ~~3,~~ 4 and 5. The correlation for Uranium and Thorium is relatively ~~poor due to~~ good linearly by (tentukan persamaan liniernya pada semua data gambar 3, dan tentukan persamaan liniernya untuk data crustal rocks dan data crust-mantle rocks, masing-masing) although, the different type of magmatism process. The RHP in Central Bangka is quite small compared to all other data from S granite type, especially in BT 281, BT 308 with 11.29 μWm^{-3} and 5.49 μWm^{-3} respectively and in PKP/1 with 9.053 μWm^{-3}. Moreover, if we compare to average RHP, these values are poor to 27.29 μWm^{-3}. The RHP in all crustal rocks shows that the data clearly shows high value with average 8.43 μWm^{-3}. The highest value is found in BB 7, 12.64 μWm^{-3} and the lowest is BB 9, 4.93 μWm^{-3}. Overall, the most interesting is Pangkalpinang granite which absolutely shows the highest RHP from all the data, 175.044 μWm^{-3}, with U (681 ppm), Th (99.2 ppm) and K (1.31%). The result of Uranium and Thorium in this research is different with the result of [13].

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

Buat trend persamaan linearnya....lalu plot pada gambar untuk semua data pada gambar 4.

RHP = .. U +...

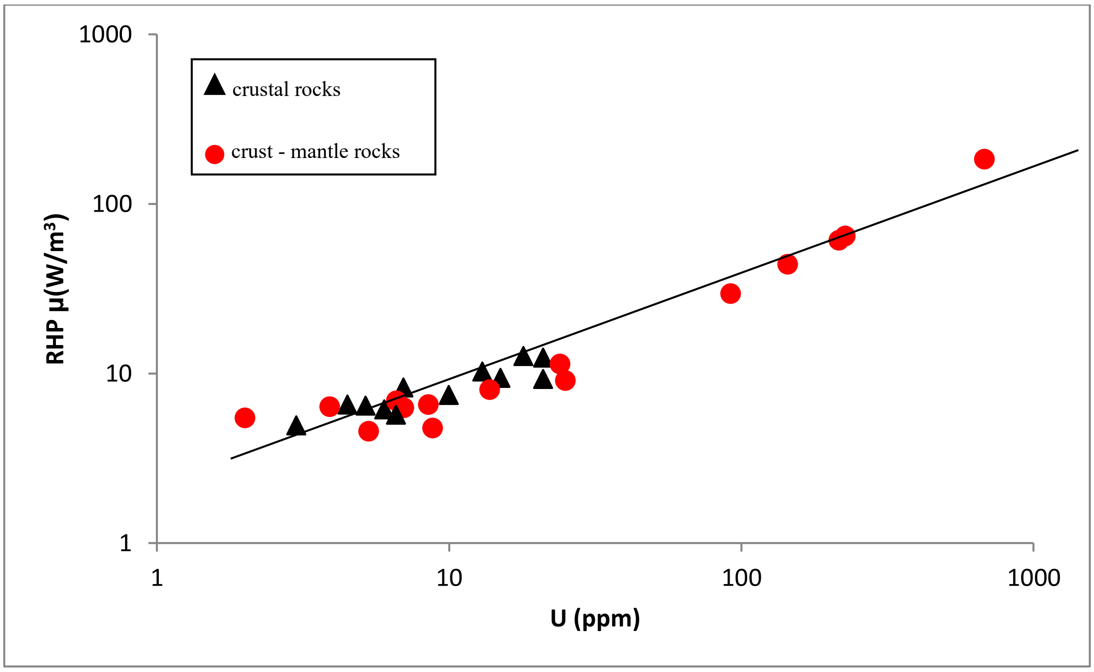

Figure 4. Heat production as a function of Uranium in granite rocks from all the research area. The correlation is relatively good linearly by RHP = .. U +... although for different magmatism source.

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

Buat trend persamaan linearnya untuk data merah dan data hitam masing masing pd gambar 5.

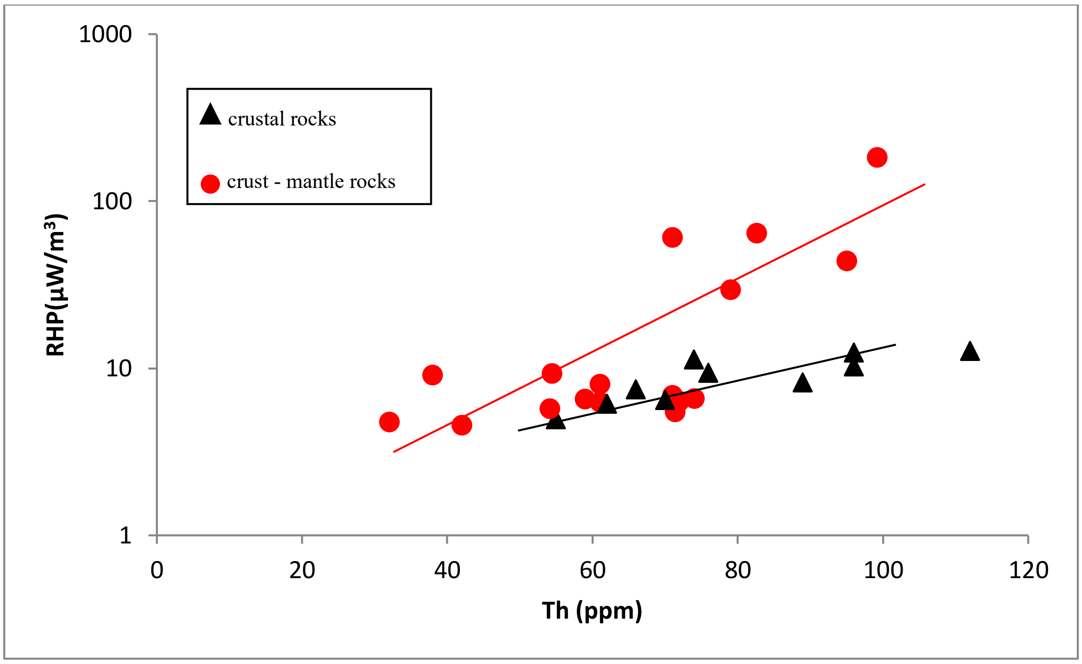

Figure 5. Heat production as a function of Thorium in granite rocks from all the research area. The correlation is relatively good linearly by RHP = .. U +... for crustal rock and RHP = .. U +... for crust-mantle rocks although for different magmatism source.

Crustal rocks is dominantly controlled by Potassium as shown in Figure 5. The highest K concentration among all the data is BL 240A with 3.55 % which is part of Belinyu granite complex. Belinyu granite contains K-feldspar (8-44 %), quartz (17-48%), plagioclase (11-15%), biotite (1-4%), muscovite (105%) and another minerals such as zircon, monazite. The type of this granite is syeno granite and quartz rich granitoid. Some of uppermantle-crustal rocks contain low Potassium and some of them are 0% (BT 308 and PKP 1 in Central Bangka). Granite in central Bangka is part of Koba granite (alkali feldspar granite) which has quartz (37%), K-feldspar (45%), plagioclase (3%) and rich biotite (5%). Its mineral alterations are sericite, chlorite and biotite with medium alteration. So that, the heat production as a function of Potassium in granite rocks is constant in the Bangka area. The correlation is relatively worse than U and Th

Lampiran: Sampel Hasil Pekerjaan Mahasiswa

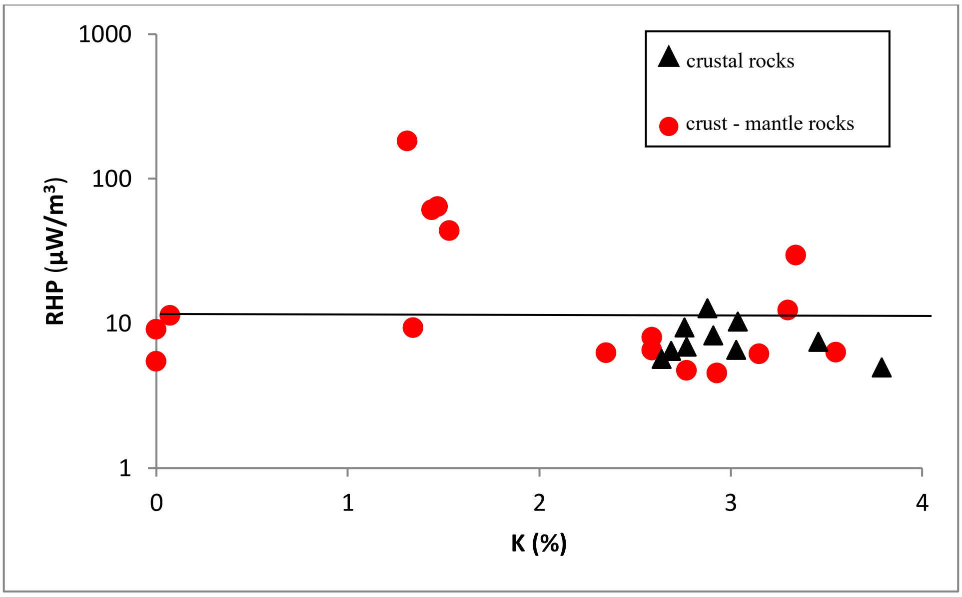

Figure 6. Heat production as a function of Potassium in granite rocks from all the research area. the heat production as a function of Potassium in granite rocks is relatively constant in the Bangka area.

Radiogenic heat production vs petrography analysis.

Some of minerals such as zircon, monazite, apatite, sphene and allanite are commonly found in granite which U and Th concentrated [34]. In this section, we try to see the relation of each mineral from our sample with RHP mean as can be seen in Table 5. The petrography analysis with IUGS Classification shows 3 type of dominant granite in Bangka Island, alkali feldspar granite, syneo granite and quartz rich granite. Alkali feldspar granites are South Bangka granite biotite, West Bangka biotite granite and North Bangka granite mica with RHP 6.49±0.09 μWm^{-3}, 7.84±0.54 μWm^{-3} and 6.09±0.58 μWm^{-3} respectively. Syneo granites are found in North Bangka (BL 4, BL 134, BL 205 and BL 231 B) mica ganite and Central Bangka mica granite and Pangkal Pinang with RHP 6.41±1.45 μWm^{-3}, 22.49 μWm^{-3} and 83.96 μWm^{-3} respectively. Quartz rich granites are found in North Bangka (BL 236 A, BL 240A and BL 244A) with RHP 13.49 μWm^{-3}.

Table 5. Petrography analysis and mineral proportion of granite rocks. The age of rocks are included to see the relation with radiogenic heat production (modified from [25])*

Region	Sample	Type		Age	Primer Mineral Proportion								RHP (Mean± SD)	Tectonic Discriminant
					Qtz	Kfs	Pl	Bt	Ms	Zrn	Mnz	Crd		
South Bangka	BS 3 BS 4	AFG-SG	Biotite Granite	217±15 213±14	+++	+++	++	++		+			6.49±0.09	Continental Collision
West Bangka	BB 1 BB 2 BB 4	AFG		200±4	+++	+++	++	+++	+	+		+++	10.65±1.53	Continental Collision
	BB 5 BB 6				+++	+++	+++	+++	+	+		+++	7.84±0.54	
	BB 7 BB 8 BB 9				+++	+++	++	+++	+			+++	7.89±4.15	
Belinyu (North Bangka)	BL4 BL 134 BL 205 BL 231 B	SG	mica granite	251±10	+++	+++	+++	+++	+	+	+		6.42±1.45	Continental Arc
	BL 236A BL 240A BL 244A	QRG	mica granite	211±16	+++	+++							13.49±55.9	
	BL 245A BL 245 B	AFG	mica granite		+++	+++	+++		+++				6.09±0.58	
Central Bangka	BT 254P BT254 M BT 281 BT 308	SG	mica granite	223±16	+++	+++	++	+++	++	+			22.49	Continental Arc
Pangkal Pinang	PKP/2 PKP/6 PKP/10 B	SG	mica granite	223±16	+++	+++	+++	+++	++	+			83.96	

***)** AFG=Alkali Felspar Granit; SG= Syeno Granite; QRG= Quartz Rich Granite; +++=major minerals; ++=minor minerals; +=accessory minerals; Qtz=Quart; Kfs=K-feldspar; Pl= plagioclase; Bt=Biotite; Ms=Muscovite; Zrn= Zircon; Mnz=Monasite; Crd=Cordiorite

Investigating the mineral proportion, the highest mean RHP is Pangkal Pinang region (83.96 μWm^{-3}) which contain Major Quartz, Major K- feldspar, Major Plagioclase, Major Biotite, Minor Muscovite and accessory Zircon. Other high RHP are from West Bangka which contain major quartz, k – feldspar, plagioclase, Biotite, and asseccory Muscovit, accessory zircon (except sample BB 7, BB8 and BB9) and Mayor Cordiorite.

The lowest RHP are found in BL 245 A and BL 245 B (6.09±0.58 μWm^{-3}) with major quartz, K-feldspar, Minor Plagioclase, major Biotite, minor muscovite, and accessory zircon. Other low RHPs are BL 4, BL 134, BL 205 and BL 231 B (6.14±1.45 μWm^{-3}) with Major in Quartz, K-feldspar, plagioclase and Biotite, minor in muscovite, zircon and monazite.As we look further into mineral proportion, we cannot conclude perfectly how Biotite and Zircon proportion influence RHP.

Radiogenic heat production vs age

Some researches have been indicated that radiogenic heat production decreases as the geological age of rocks increase [11], [15], [18], [35], but other studies didn't succeed to find the age and heat production relation [19], [36]. Slagstad in [37] shows that there is small but cannot be concluded realtionship between geological age and radiogenic heat production. The concentration of radioactive isotopes presented by [38] shows Potassium concentration at 4.5 Gyr ago in the Silicate Earth decrease slowly; Uranium concentration was more than twice than present concentration while Thorium was 1.25 greater than nowadays.

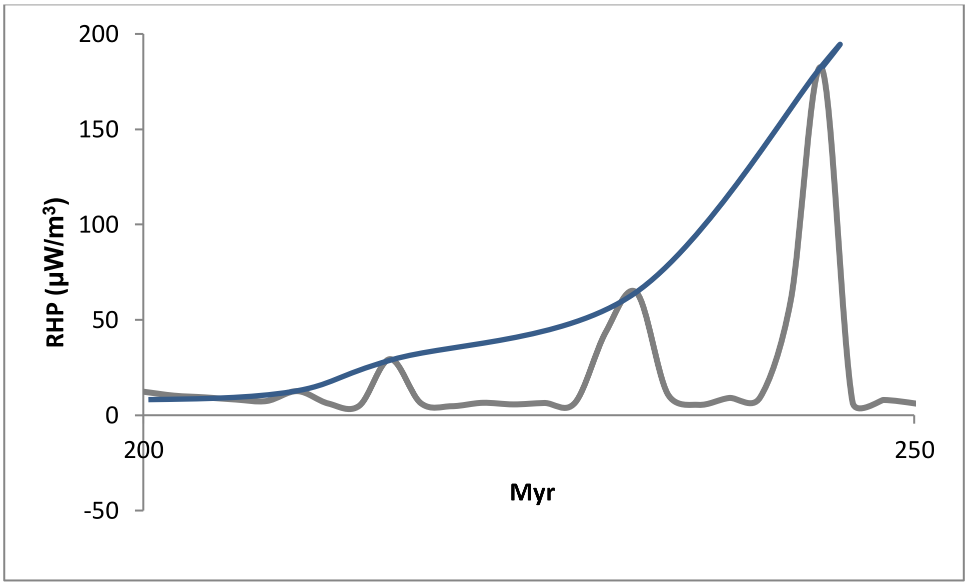

Figure 7. Radiogenic heat production from geological age

Based on data in Table 5 shows that all the samples taken are Mesozoic Era with period Jurassic – Triassic, West Bangka is the youngest granite (200±4 Myr) produce one of the highest RHP 10.65±1.53 μWm^{-3}. The oldest granite (251±10 Myr) produce one of the lowest RHP 6.42±1.45 μWm^{-3}. But, we find the lowest RHP in 211±16 Myr granites in North Bangka with RHP 6.09±0.58 μWm^{-3} since the age of the highest RHP is 223±16. The plot of heat production with geological age is presented in Figure 6. We identify that there is ~~no smooth~~ an exponential relation between age and radiogenic heat production. The older the geological age of the granite, the higher RHP results.

Relation of petrography analysis and geological to heat production have ~~no~~ a strong relation ~~and~~ although need more data to be studied. Furthermore, we carried out heat production from some areas all around the world. Table 6 clearly shows that granite from mixed magmatic source (crustal – upper mantle) granites from Central and North Bangka have high heat production from all the data. This data is also supported by the abundance of radiogenic geothermal in the area.

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Table 6. Heat produced compared to other published data. The data shows that Central - North Bangka shows high heat production

Type of rocks - Location	Heat Production				Reference
	due to U	due to Th	due to K	Total	
Granite -West and South Bangka	2.64	5.50	0.29	8.43	This study
Granite - Central and North Bangka	22.56	4.54	0.18	27.29	This Study
Granite - Sweden	1.19	1.03	0.31	2.53	[19]
Granite – Kapuskasing (Greece)	16.31	0.33	0.36	17.00	[39]
Rhyolite – Western Rajashtan (India)	2.09	2.22	0.4	4.70	[3]
Granite – South China	3.47	3.28	0.45	7.20	[40]
Granite – Western Carpathian (Slovakia)	0.64	0.44	0.33	1.42	[41]
Granite – Achatau (Russia)	2.44	2.87	0.40	5.71	[42]
Granite – Guangdong (China)	10.28	0.76	0.45	11.50	[5]
Mudstone – Gonghe Basen (Northeastern Tibetan Plateau)	0.80	0.95	0.20	1.96	[20]
Granite – Gonghe Basen (Northeastern Tibetan Plateau)	2.64	5.50	0.29	8.43	[20]
Granite – Gabel El Majal (Egypt)	4.14	0.52	0.22	4.9	[43]
Granite – Turkey	6.37	4.22	0.39	11.0	[44]
Granite Wadi Allaqi – Aswan (Egypt)	0.54	2.07	0.03	2.6	[45]
Granite wadi Um Had - Central Eastern Desert (Egypt)	6.40	1.59	0.34	8.3	[45]

Conclusion

Our analysis data provide the mixed (crust-upper mantle) granite heat production is higher than crustal granite. This provided by higher Potassium value in crustal granite, since Uranium and Thorium value is potentially explored in Pangkal Pinang area. The S-type granite has a higher value but has a relatively lower correlation compare to I-type. There is a strong relationship between RHP to the concentration on U, Th, and the geological age of granite in Bangka. The higher concentration of U and Th, the higher contribution of RHP, and the older the geological age of granite, the bigger contribution of RHP granite in Bangka.

Acknolegment

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Lampiran: Dokumen Tugas

REVIEW JURNAL I

On The Radiogenic Heat Production of Igneous Rocks

D. Hasterock, J. Webb

Rahmat Nawi Siregar

20/470199/SPA/00762

Yogyakarta , 26 Februari 2021

Read Order

- Abstract
- Discussion
- Introduction
- Methods
- Results

Lampiran: Dokumen Tugas

Abstract

A B S T R A C T

Radiogenic heat production is a physical parameter crucial to properly estimating lithospheric temperatures and properly understanding processes related to the thermal evolution of the Earth. Yet heat production is, in general, poorly constrained by direct observation because the key radiogenic elements exist in trace amounts making them difficulty image geophysically. In this study, we advance our knowledge of heat production throughout the lithosphere by analyzing chemical analyses of 108,103 igneous rocks provided by a number of geochemical databases. We produce global estimates of the average and natural range for igneous rocks using common chemical classification systems. Heat production increases as a function of increasing felsic and alkali content with similar values for analogous plutonic and volcanic rocks. The logarithm of median heat production is negatively correlated ($r^2 = 0.98$) to compositionally-based estimates of seismic velocities between 6.0 and 7.4 km s^{-1}, consistent with the vast majority of igneous rock compositions. Compositional variations for continent-wide models are also well-described by a log-linear correlation between heat production and seismic velocity. However, there are differences between the log-linear models for North America and Australia, that are consistent with interpretations from previous studies that suggest above average heat production across much of Australia. Similar log-linear models also perform well within individual geological provinces with ~1000 samples. This correlation raises the prospect that this empirical method can be used to estimate average heat production and natural variance both laterally and vertically throughout the lithosphere. This correlative relationship occurs despite a direct causal relationship between these two parameters but probably arises from the process of differentiation through melting and crystallization.

- hubungan produksi panas dari 108.103 batuan beku dengan kandungan felsic dan alkali berbanding lurus.
- Produksi panas dan kecepatan seismic menunjukkan korelasi log linear.
- Namun, terdapat perbedaan antara model amerika utara dengan Australia, dimana produksi panas di Australia berada di atas rata – rata.
- Korelasi log linear ini bisa digunakan untuk mempelajari produksi panas pada litosfer.
- Saran Penulis : hubungan log linear ini bisa juga dipengaruhi oleh proses diferensiasi magma melalui melting dan kristalisasi

Discussion

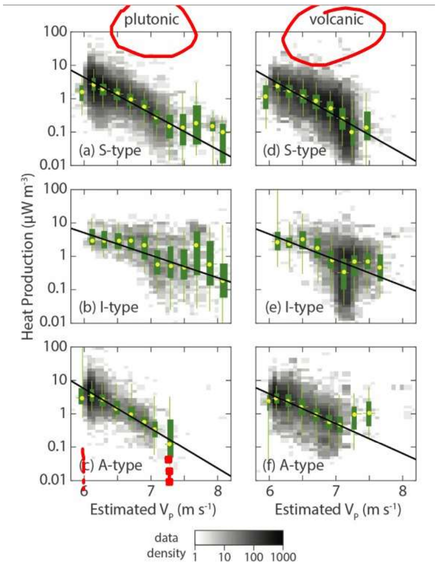


Figure 9. Heat production sorted by geochemical classification of granitic rocks extended to all plutonic rocks (a–c) and volcanic rocks (d–f). Shading and whisker plots are produced in the same manner as in Fig. 8. Linear models are calibrated to median values between 6 and 7.4 km s^{-1} except volcanic A-type which is calibrated between 6 and 7.2 km s^{-1} (Table 5).

Since correlation coefficients are high, we use log-linear models to estimate heat production from estimated seismic velocity. We compute several linear models between median V_P and median $\log_{10}A$ for subsets of the data (Table 5). The log-linear model is shifted so that the intercept occurs at 6 km s^{-1}, i.e.,

$$\log_{10}A = m(V_P - 6) + b \quad (4)$$

$$A = 10^{b}10^{m(V_P-6)}$$

Table 5
Linear models[a] of heat production versus seismic velocity.

Log-linear model	N	m [$\log_{10}$ (μW m^{-3}) (km s^{-1})$^{-1}$]	$2\sigma_m$	b [$\log_{10}$ (μW m^{-3})]	$2\sigma_b$	r^2	Figure
Plutonic models							
Subalkaline (B to F)	31,294	−1.04	0.06	0.61	0.04	0.991	10a
Alkaline (G, I to N)	7277	−0.84	0.07	0.67	0.07	0.967	10a
High alkaline (O to R)	1061	−0.09	0.05	0.59	0.05	0.662	10a
S-type	26,737	−1.08	0.07	0.64	0.05	0.978	9a
I-type	3367	−0.67	0.20	0.70	0.16	0.689	9b
A-type	9958	−1.19	0.09	0.75	0.07	0.971	9c
Oceanic	659	−1.33	0.17	0.79	0.13	0.928	11a
Continental	39,887	−0.92	0.04	0.60	0.04	0.988	11a
Australia	12,510	−0.92	0.07	0.73	0.05	0.975	12a
Finland	2744	−0.89	0.10	0.52	0.08	0.944	12a
North America	22,789	−1.04	0.05	0.62	0.04	0.975	12a
Volcanic models							
Subalkaline (B to F)	42,731	−1.16	0.10	0.59	0.08	0.977	10c
Alkaline (G, I to N)	20,100	−0.71	0.08	0.62	0.07	0.935	10c
High alkaline (O to R)	3884	−0.72	0.05	0.96	0.04	0.992	10c
S-type	38,452	−1.13	0.13	0.61	0.10	0.942	9d
I-type	14,494	−0.77	0.18	0.67	0.15	0.780	9e
A-type[b]	18,367	−0.90	0.04	0.60	0.03	0.990	9f
Oceanic	13,356	−1.12	0.14	0.57	0.11	0.929	11c
Continental	54,411	−0.70	0.10	0.48	0.08	0.905	11c
Australia	6814	−0.57	0.11	0.53	0.09	0.845	12c
Finland	744	−1.00	0.12	0.49	0.10	0.929	12c
North America	15,984	−0.77	0.08	0.47	0.06	0.954	12c

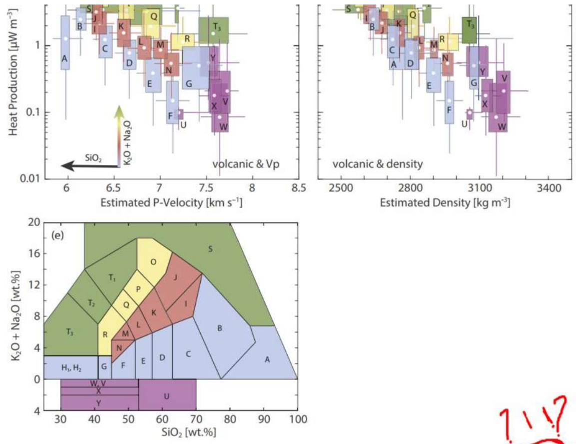
[a] Models are fit to median binned data and restricted to V_P between 6.0 and 7.4 km s^{-1}. The log-linear model is of the form $\log_{10}A = m(V_P - 6) + b$.
[b] Model is fit to median binned data and restricted to V_P between 6.0 and 7.2 km s^{-1} because the model is otherwise highly skewed by the relatively few data that define the median above 7.2 km s^{-1} (Fig. 9).

- Untuk batuan plutonik dan vulkanik tipe I dan utk high alkalin plutonik, korelasi log linear ini kurang tepat. Nilai koefisien 0,6 dan 0, 7. Hal ini menjadi sesuatu yang sangat **menarik** untuk dipelajari lebih lanjut.
- Kecepatan seismic 6 – 7,2 km/s diambil karena sebagian besar data ada pada rentang ini. Jika diluar ini, maka koefesien korelasi akan semakin jauh dari 1. Hal ini dikarenakan data yang relative sedikit.

Lampiran: Dokumen Tugas

Things to Know:

- TAS Classification



?!!?

Figure 10. Heat production as a function of seismic velocity (a, b) and density (c, d) for plutonic (a, c) and volcanic (b, d) rocks determined by the (e) TAS classification scheme (modified from Middlemost, 1994). For values and a description of rock fields, see Tables 3 and 4. Field H_1 (cumulate peridotite) is separate from H_2 (mantle peridotite) on the basis of Mg# <80. Fields U (boninite), V (meimechite) and W (komatiite) have high MgO and V is further separated from W by $TiO_2 > 1$ wt.% (Le Bas and Streckeisen, 1991). Whisker plots are by the quantiles shown as inset in (a).

There are two ways we can show that the log-linear relationships are not an artifact of the modeling. First, the definition of volumetric heat production (Eq. (1)) predicts a positive slope between heat production and density (i.e., heat production should decrease with density as silicic content increases). Instead, we find

$$A = \rho(9{,}56\, C_U + 2{,}56\, C_{Th} + 2{,}69\, K_2O)10^{-5}$$

berbanding lurus positif

a negative slope. Therefore, it is the concentration of HPE's that clearly dominate the magnitude of heat production and not the major elements that control density and seismic velocity.

- Fountain (1987) menyebutkan bahwa unsur utama (seperti silica, yang mengontrol densitas dan kecepatan seismik) dan unsur radioaktif (mengontrol produksi panas) tidak mempunyai korelasi.
- Namun di paper ini ditunjukkan bahwa terdapat korelasi log linear. Jika merujuk pada rumus (1), maka seharusnya A mempunyai gradient positif, namun justru didapatkan gradient negative. Sehingga konsentrasi radioaktif mempunyai andil yang besar

Second, if density is excluded from the computation of heat production (Eq. (1)) then we estimate the heat production by mass.

Since this definition decouples any dependence of heat production on major elements, it is difficult to see how an artifact could be created accidentally by our modeling process if the major elements and trace elements were not correlated on average. When we use the heat production by mass, we find that the correlation coefficients are the same or improve very slightly (r^2 increases by <0.005) for all cases. The slight improvement in correlation coefficient occurs because the heat production observations no longer include uncertainties contributed by the density estimate.

- Densitas yang digunakan adalah estimasi, jadi tentu akan ada ketidakpastian. Oleh karena itu, untuk menunjukkan bahwa korelasi log-linear dalam penelitian ini bukan merupakan "buatan" dari modeling, maka
- Namun di paper ini ditunjukkan bahwa terdapat korelasi log linear. Jika merujuk pada rumus (1), maka seharusnya A mempunyai gradient positif, namun justru didapatkan gradient negative. Sehingga konsentrasi radioaktif mempunyai andil yang besar

Lampiran: Dokumen Tugas

- Apakah model log-linear ini bisa dipakai secara global atau hanya untuk daerah dengan geologi regional?

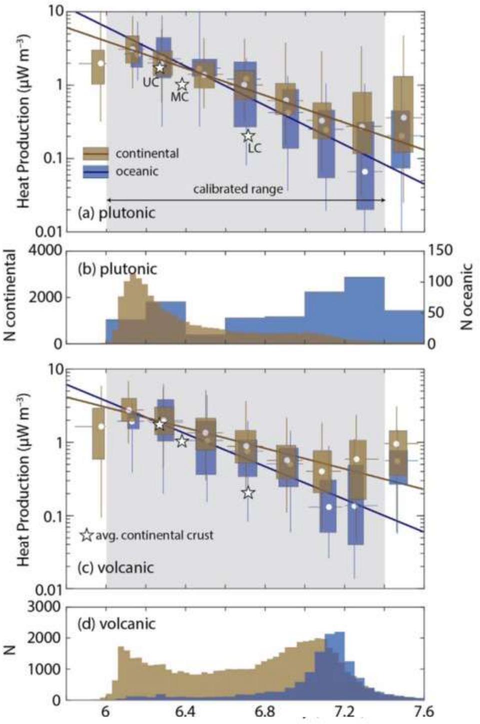


Figure 11. Heat production and estimated seismic velocity within continental and oceanic settings for (a) plutonic and (c) volcanic rocks. The log-linear models are calibrated to median values between 6 and 7.4 km s^{-1} (Table 5). The stars represent the estimates for the global average upper crust (UC), middle crust (MC) and lower crust (LC) compositions from Rudnick and Gao (2003). The number of data within each subset are shown in (b) and (d).

- RHP dari lempeng samudera relative lebih kecil dari kerak benua. Gradien samudera lebih miring dari kerak
- Produksi panas dan kecepatan seismic menunjukkan korelasi log linear.

We do not suggest that a log-linear relationship between seismic velocity and heat production exists in all cases or for all rock types. Among igneous rocks, the relationship does not hold for extremely silica-rich rocks produced by precipitation of magmatic-derived hydrothermal fluids (silexites and quartzolites) and highly alkaline I-type igneous rocks, more specifically magnesian metaluminous alkalic and alkali-calcic compositions. However, both of these cases represent a very small fraction of the compositional distribution of igneous rocks but prevent the relationship from extending outside the calibrated velocity range (6.0 to 7.4 km s^{-1}). A log-linear relationship will also likely fail for shallow volcanic rocks with significant porosity and nearly all rocks shallower than ~5 to 10 km due to cracks which affect the propagation of seismic

For continental regions, the average heat production of plutonic rocks can be estimated from the seismic velocity by

$$A = 3.80 \exp[-2.03(V_P - 6)] \quad (6)$$

where heat production, A, is in μW m^{-3} and seismic P-wave velocity, V_P, is in km s^{-1}.

It remains an open question whether metamorphic and sedimentary rocks show similar behavior, which we intend to address in future studies. Future investigations will also focus on the applicability of these models to a greater range of regional settings and developing methods to verify the results using independent constraints.

Lampiran: Dokumen Tugas

Introduction

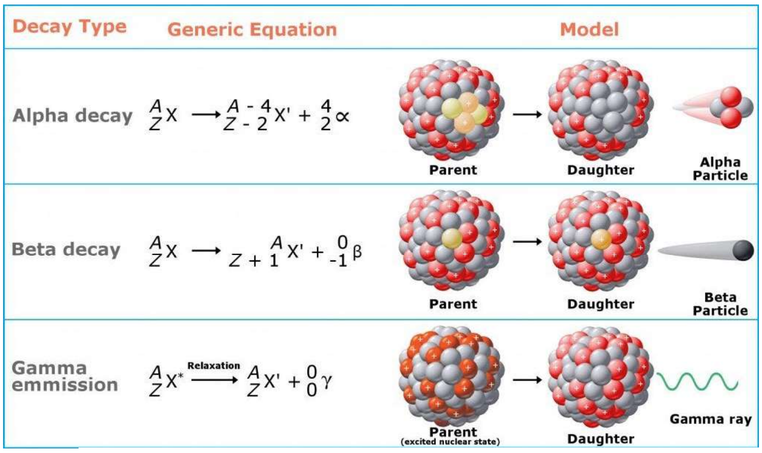


Table 1. Energy converted to heat for uranium and Thorium [5] and [6] in [4]

No	Element	Mass Balance	E_{ABS} (MeV)
1	^{238}U	$m(^{238}U)-8m(^{4}He)-m(^{206}Pb)$	46.34
2	^{235}U	$m(^{235}U)-7m(^{4}He)-m(^{207}Pb)$	45.26
3	^{232}Th	$m(^{232}Th)-6m(^{4}He)-m(^{208}Pb)$	38.99

Methods

Produksi panas radiogenic ditentukan dengan menggunakan hubungan antara komposisi kimia dan konsentrasi unsur radioaktif,

$$A = \rho\left(9{,}67C_U + 2{,}56C_{Th} + 2{,}89C_K\right)10^{-5}$$

dengan C_U adalah konsentrasi Uranium dalam part per million (ppm), C_{Th} konsentrasi Thorium dalam part per million (ppm) dan C_K dalam % (L Rybach & Bunterbath, 1984)

Kecepatan Seismik

Lampiran: Dokumen Tugas

Estimasi kecepatan seismic menggunakan model empiris (Behn & Kelemen, P, 2003) yang telah dikalibrasi dengan menggunakan lebih dari 18.000 data batuan beku dari pangkalan data IGBA. Model empiris yang digunakan adalah,

$$V_p = 6{,}9 - 0{,}011C_{SiO_2} + 0{,}037C_{MgO} + 0{,}045C_{CaO} \quad (11)$$

dengan masing – masing konsentrasi setiap oksida adalah dalam persen dan V_p dalam km/s..

RISTEKDIKTI ITERA TIMAH

Model Densitas

Model densitas dari oksida terdapat 4 model, tergantung pada koefisien regresinya. Adapun model densitas yang digunakan adalah Model Hesterok & Webb (2017)

$$\rho = 2468{,}5 + 174{,}7\ \mathrm{Fe}^* - 12\ \mathrm{MALI} + 49{,}6\ \mathrm{ASI} + 636\ \mathrm{maficity}$$

dengan indeks geokimianya adalah,

Fe* (*iron number*)= $C_{FeO^T}\left(C_{FeO^T} + C_{MgO}\right)^{-1}$

MALI (*modified alkali-lime indeks*)= $C_{Na_2O} + C_{K_2O} - C_{NaO}$

ASI(*Alumina saturation index*)= $n_{Al}\left(n_{Ca} - 1{,}67n_p + n_{Na} + n_K\right)^{-1}$

Maficity= $n_{Fe} + n_{Mg} + n_{Ti}$

dengan n adalah jumlah mol dari komponen oksida serta FeO^T adalah total besi.

Hesterok & Webb (2017)

Lampiran: Dokumen Tugas

Behn and Kelemen (2003) did not develop a density model from oxide weight percentages, but density was computed as part of their analysis. To ensure self-consistency we use the results of their thermodynamic calculations (M. Behn, pers. comm.) to produce a multiple linear regression model to estimate density. We tested several formulations including the four listed below:

(1) seven oxides (SiO_2, Al_2O_3, MgO, FeO^T, CaO, Na_2O, and K_2O);
(2) SiO_2, MgO and CaO (same oxides as Behn and Kelemen (2003) preferred model for V_p);
(3) SiO_2, Al_2O_3, MgO, Na_2O;
(4) geochemical indices (Fe-number, MALI, ASI, and maficity as defined below).

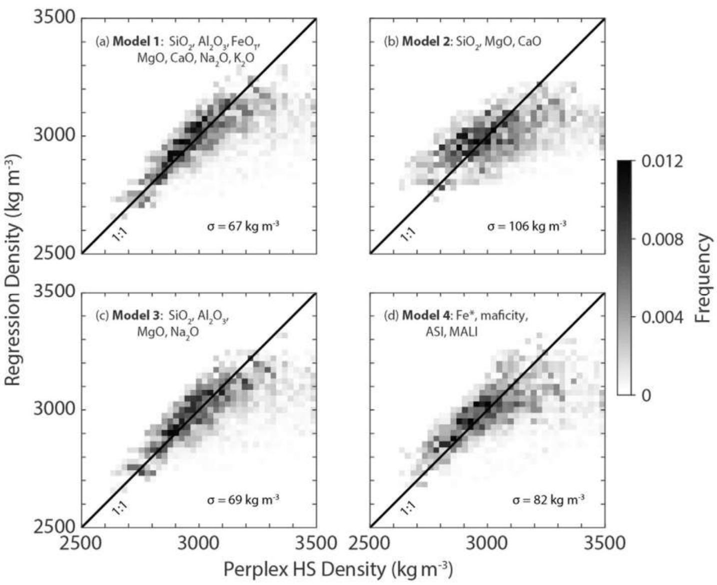
Table 1
Coefficients for multilinear density models.

Component	Coefficient	$(-\alpha_{95}, \alpha_{95})$
Model 1		
ρ_0	60,425.0	(50,595.4/70,254.5)
SiO_2	−600.2	(−698.2/−502.1)
Al_2O_3	−373.6	(−485.8/−261.4)
MgO	−564.9	(−663.2/−466.5)
FeO	−474.3	(−575.9/−372.6)
CaO	−663.1	(−762.5/−563.7)
Na_2O	−1497.9	(−1726.8/−1268.9)
K_2O	51.9	(−129.3/233.1)
Model 2		
ρ_0	3111.5	(3103.8/3119.1)
SiO_2	−4.6	(−4.7/−4.5)
MgO	8.5	(8.3/8.7)
CaO	5.7	(5.4/6.0)
Model 3		
ρ_0	4770.5	(4754.1/4786.8)
SiO_2	−23.2	(−23.4/−23.0)
Al_2O_3	−23.4	(−23.7/−23.1)
MgO	−7.6	(−7.8/−7.4)
Na_2O	−12.8	(−13.5/−12.0)
Model 4		
ρ_0	2606.7	(2602.5/2610.5)
Fe^*	174.7	(170.5/178.9)
MALI	−12.0	(−12.2/−11.8)
ASI	49.6	(47.2/52.0)
Maficity	636.0	(630.1/642.0)

RESULT

Model 1 and 3 work best with an average error of ~2% (Fig. 2). Model 4 has an average error of ~3%, while model 2 has the highest error (~4%). However, because of the wider range of compositions in the geochemical databases relative to the calibration study, model 1 produces the worst result in practice, resulting in numerous and unrealistic outlying values (e.g., <0 or >4000 kg m^{-3}). Model 2 produces the fewest outliers, perhaps because the range of these elements is generally large and is captured by the calibrated compositions. Models 3 and 4 are generally well behaved, but do produce some outliers. Most estimates lie within the typical bounds reported for plutonic rocks (Telford et al., 1990).

The PETROCH database (Haus and Pauk, 2010) includes estimates of density which we can use to further validate and choose the appropriate model. Model 4 performs the best in this regard (Fig. 3); however, this model is systematically higher than the PETROCH data by approximately 120 kg m^{-3} (4 to 5%). Behn and



Kelemen (2003) also observed a systematic overprediction of density compared with laboratory data, which could be due to porosity/cracks in the natural samples or hydrous phases excluded from the thermodynamic models. Model 4, developed from geochemical indices has an additional advantage in that indices may be better behaved than any single element.

After correcting for density, our preferred model (Model 4) for estimating density is given by

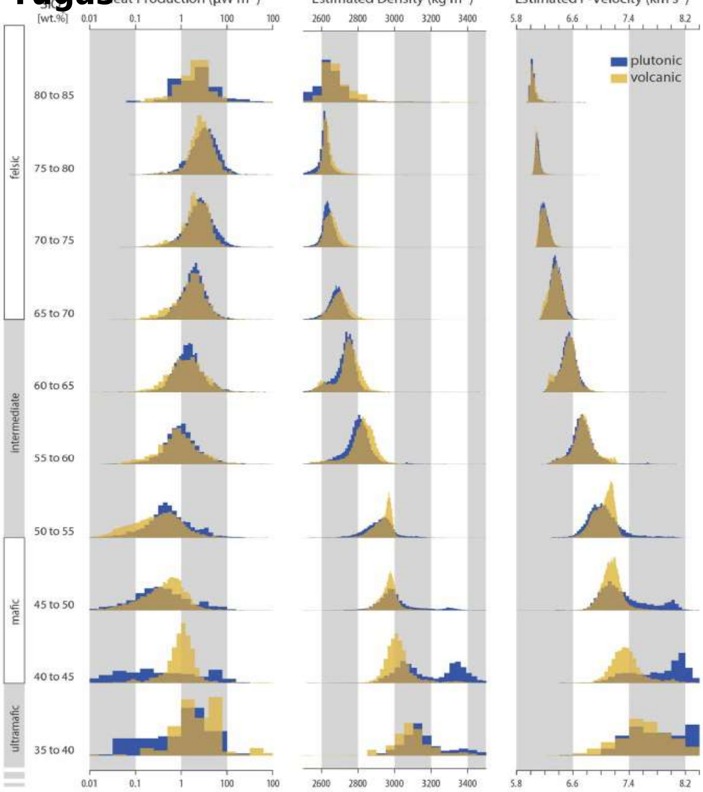
$$\rho = 2486.5 + 174.7\ \mathrm{Fe}^* - 12.0\ \mathrm{MALI} + 49.6\ \mathrm{ASI} + 636.0\ \mathrm{maficity} \quad (3)$$

where the geochemical indices are defined as

Fe^* (iron number) $= C_{FeO^T}(C_{FeO^T} + C_{MgO})^{-1}$
MALI (modified alkali-lime index) $= C_{Na_2O} + C_{K_2O} - C_{CaO}$
ASI (alumina saturation index) $= n_{Al}(n_{Ca} - 1.67n_P + n_{Na} + n_K)^{-1}$
Maficity $= n_{Fe} + n_{Mg} + n_{Ti}$

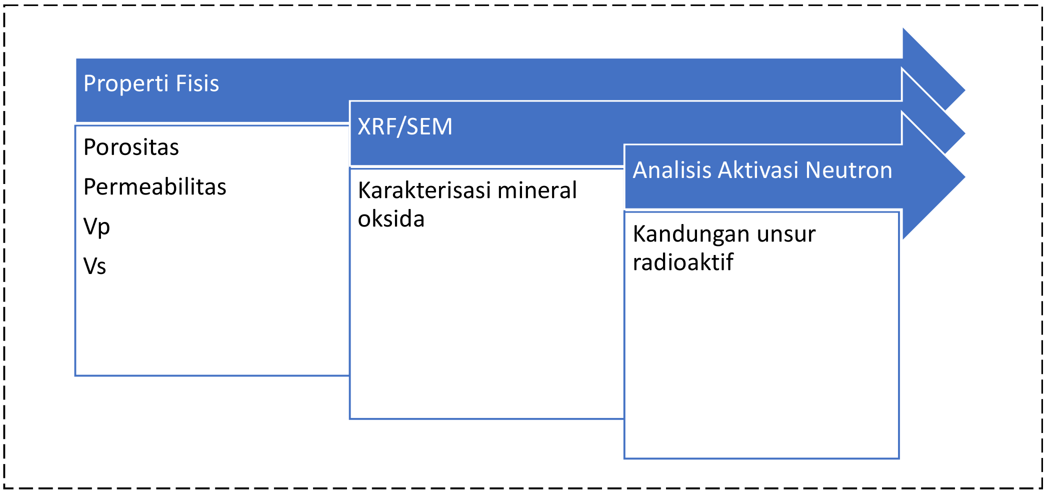
Hubungan RHP, Densias dan Kec. Seismik

Lampiran: Dokumen Tugas



RANCANGAN BERBAGAI METODE PENELITIAN

Lampiran: Dokumen Tugas



Terima Kasih

REKAPITULASI NILAI
Review Jurnal
E

Lampiran: Rekapitulasi Hasil Penilaian

NIM	Nama	R 1	R 1	R 1	R 1	R 2	R 2	R 2	R 3	R 3	R 3	R 3	R 3	R 3
		Presentasi 1: Tampilan (Maks : 100, 5%)	Motivasi & Manajemen waktu (Maks : 100, 5%)	Presentasi 1: Konten (Maks : 100, 10%)	Presentasi 1: Bahasa (Maks : 100, 5%)	Presentasi 2: Konten	Presentasi 2: Bahasa	Presentasi 2: Tampilan	Paper 1: Bahasa (Maks : 100, 5%)	Paper 2: Bahasa	Paper 1: Konten (Maks : 100, 15%)	Paper 2: Konten	Paper 1: Struktur (Maks : 100, 10%)	Paper Strukt
20/470199/SPA/00762	RAHMAT NAWI SIREGAR	80	90	85	85				85		85		80	