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Telepon: (62-21) 83702848
Fax: (62-21) 83702848

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PREFACE

7th Joint Convention & Exhibition Malang (JCM 2017) has been jointly hosted by Indonesian Association of Geophysicists (HAGI), Indonesian Association of Geologists (IAGI), the Indonesian Association of Petroleoum Facility (IAFMI) and the Indonesian Association of Petroleum Engineer (IATMI). This is Indonesia's largest event devoted to the geoscientists and engineers, and it will give participants a platform to exchange ideas, discover novel opportunities, reacquaint with colleagues, meet new friends, and broaden their knowledge.

The theme of the convention is *Natural Resources & Infrastructure Development for National Sovereignty*. The slump in oil price and mining commodities to their lowest level in a decade is the challenges for geoscientists, engineers and other industry professionals gather at this event to plan their E&P business program and share their knowledge. The main theme covering two main topics, i.e. energy and infrastructures, that have dependency in supporting economic growth strategy for national sovereignty.

The proceedings may contain all papers presented in the JCM 2017, covering various topics including:

1. Natural Mineral, Coal, and Energy Geothermal Resources Management
2. Environtmental Issues and Hazard Mitigation
3. Geodinamics, Seismology, Petrology and Volcanology
4. Sediment and Stratigraphy
5. Geology, Geophysics, Geochemistry Methods, Technology and Application
6. Infrastructure, Engineering Geology and Geophysics, Hydrogeology, Oceanography
7. Petroleum Engineering, Technology and Application
8. Petroleum Geoscience
9. Unconventional and Renewable Energy
10. Deepwater, Production Facilities Oil and Gas Optimization, Decommissioning
11. Business Development
12. Geotourism and Others.

The papers are written by experts from various background including geological, geophysical, petroleum, mining and infrastructural community. It will broadly cover all disciplines of geoscience and engineering from fundamental research to "blue sky" applications of E&P activities.

On behalf of IAGI, HAGI, IAFMI and IATMI, we would like to thank all authors, paper reviewers and editorial board for providing the support and feedback necessary to find, develop, and publish material of such consistent high quality. I also would like to extend my thanks to all sponsor from industry, universities and government for their contributions and involvements. We highly appreciate our readers' feedback, so please share your ideas and thoughts with us.

Fatrial Bahesti – Chairman of JCM 2017

CONTENTS

PROCEEDINGS
JOINT CONVENTION MALANG 2017, HAGI – IAGI – IAFMI – IATMI (JCM 2017)
Ijen Suites Hotel, Malang, September 25 – 28, 2017

Implication of Hydrothermal Process on Radioactive and Rare Earth Element Enrichment in Mamuju, West Sulawesi.

I Gde Sukadana), Heri Syaeful.*
**) Centre for Nuclear Minerals Technology, National Nuclear Energy Agency (BATAN)*
Jl. Lebak Bulus Raya No.09 Pasar Jumat, Jakarta 12440

Abstract

Mamuju is a Miocene volcanic complex and become the location of the exploration of radioactive and rare earth elements. These area composed by basaltic and volcanic rocks up to intermediate with ultra potassic and soshonitic afinity. Magmatism processes in this area is a multi-phase process, there by producing a hydrothermal flows through rock porosity and fracturation zone. Hydrothermal fluid fluid interacts with the rock side. Hydrothermal process is very influential volcanic central area of and areas with intensive fracturation. The rocks in these areas experiencing strong alteration to produce a very thick layer of soil, and in some places formed is very intensive mineralization and sulfidation and oxidation. Alteration encountered in the form of the potassic alteration minerals such as biotite paragenesis, actinolite and plagioclase, and formed titanite and adularia. Mineralization and levels of radioactive elements and rare earth elements have a higher concentration on the fracture-fracture and the autoclastic breccia.
Key words: radioactive elements, rare earth elements, hydrothermal, alteration, Mamuju.

Abstrak

Mamuju adalah kompleks vulkanik Miosen dan menjadi lokasi eksplorasi unsur radioaktif dan unsur tanah jarang. Daerah ini disusun oleh batuan gunung api dengan komposisi intermediate hingga basa dengan afinitas ultra potasik dan soshonitik. Proses magmatisme di daerah ini adalah proses multi fasa, sehingga menghasilkan aliran hidrotermal melalui porositas batuan dan zona rekahan. Cairan fluida hidrotermal berinteraksi dengan batuan samping. Proses hidrotermal sangat berpengaruh pada daerah pusat gunung api dan daerah dengan frakturasi intensif. Batuan di daerah ini mengalami alterasi kuat untuk menghasilkan lapisan tanah yang sangat tebal, dan di beberapa tempat terbentuk mineralisasi sangat intensif dan sulfidasi dan oksidasi. Perubahan yang dihadapi berupa mineral alterasi potasium seperti biota paragenesis, aktinolit dan plagioklas, serta terbentuk titanit dan adularia. Mineralisasi dan kandungan unsur radioaktif serta unsur logam tanah jarang memiliki konsentrasi yang lebih tinggi pada fraktur dan breksi autoklastik.
Kata kunci: unsur radioaktif, unsur logam tanah jarang, hidrotermal, alterasi, Mamuju.

Introduction

Radioactive minerals exploration in Mamuju, West Sulawesi, has been conducted since 2013. The research includes the collection of secondary and primary data that can support exploration activities, both genesis and radioactive mineral occurrences. Radiometric data show that the Mamuju region has the highest radioactivity value in Indonesia (Iskandar & Kusdiana, 2014). Areas with high radioactivity value have an area of about 820 km2, especially in areas composed of peralkalin rocks grouped into Adang volcanic rocks. Some places has dose rate value up to 5 mSv/y see. Figure 1 (Syaeful, Sukadana, & Sumaryanto, 2014). The availability of radioactive minerals in the Mamuju Region is strongly influenced by the genesis of the originating magma of the rock formed on the tectonic arrangement of active continental margin (Sukadana, Harijoko, & Setijadji, 2015). In addition to the influence of magma of origin, the availability of radioactive minerals in the Mamuju region is also influenced by repeated volcanic activity, which is demonstrated by highly complex voukanostratigraphy (Indrastomo, Sukadana, Saepuloh, Harsolumakso, & Kamajati, 2016). Volcanic rocks of the Mamuju region are formed in different deposition environments, in the Tapalang Barat area, until the center is composed by a pillow lava with various size (Sukadana, et al, 2016). Radioactive minerals found in the Mamuju Region consist of primary minerals in the form of thorianite and davidite, as well as secondary minerals such as gummite and outonite (Sukadana, et.al., 2016). In addition to radioactive minerals, this area has also been assessed for the availability of other economically valuable elements of zircon and rare earth metals (Shaban, Fadlin, & Priadi, 2016). Based on the results of previous studies, there are still needed the detail studies about the accumulation of radioactive minerals and other economic elements, so it is necessary to study the factors that influence the mineralization process of radioactive minerals and other economic minerals in the Mamuju area. This study will focus on the influence of hydrothermal alteration on the formation of radioactive minerals mineralization and other economical minerals. The purpose of this study is to determine the effect of hydrothermal process on the occurrences of radioactive elements and other economic value elements.

Methodology

In this study used deskwork study to analysis the feature of volcanic center and pattern of geological structures. The result of deskwork study combined with the field data and laboratory analysis. Identification of alteration area known by geological mapping, and alteration mapping. The field data are distribution of alteration area and mineralization zone. Laboratory analysis results using XRF (X Ray

Fluorescence) and petrography analysis. X-Ray Fluorescence analysis conducting on Centre for nuclear minerals technology laboratory, to identify the content of uranium, thorium, mayor oxides, and other economic elements. Petrography analysis conducting on Geology Engineering Department, Gadjah Mada University. This analysis are to identify the lithology as the host rock and the kind of alteration minerals.

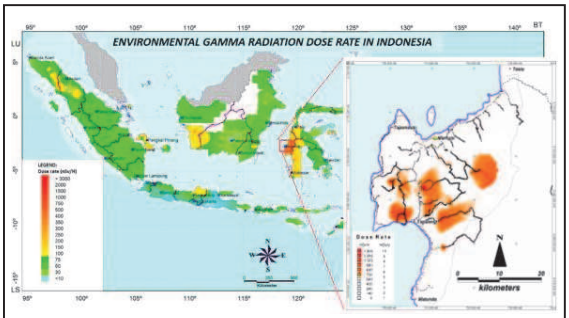

Figure 1: Radioactivity Dose Rate in Indonesia; (inside) area with dose rate > 5mSv/y(Syaeful et al., 2014)

Result and Discussion

Mamuju area generally composed by Adang volcanic rocks as lava and autoclastic breccias with ponolithic and foiditic compositions, and a small fraction composed of limestone formations of Mamuju (Sukadana et al., 2015). The geological map of the study area is shown in Figure 2. There are some volcanic center producing kind of lava and hydrothermal fluid. The mineralization zone found surrounding the center of volcanic feature.

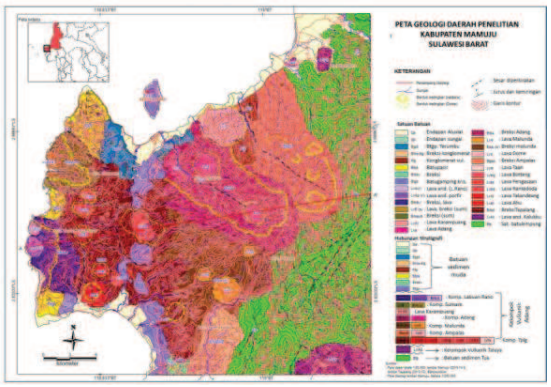

Figure 2: Detailed geological Map of mamuju Area, West Sulawesi (Sukadana et al., 2015)

There are some type of uranium and thorium accumulation type in these area. Some area has very high grade of alteration that can produce of very thick of soil (Figure 3). In this type of alteration was found the high grade of thorium in upper layer of soil and low grade of uranium. The ratio of uranium/thorium in fresh rock generally is 1/3, but hydrothermal area usually <1/3. The XRF analysis result of some mineralization zone are in Table 1.

Figure 3: The thick layer of soil as product alteration (> 12 m) in Bebanga Area

Based on the table 1 showed that the ratio of uranium / thorium is very small compared to normal conditions in fresh rock. This indicates there has been a significant decrease in the value of uranium. In the alteration zone there has been a depletion or washing of dissolved uranium along with hydrothermal and groundwater solutions (Larsen & Gottfried, 1960).

Table 1: XRFAnalysis Result of Mineralization Zone

Sample	BM1B	BM1C	BM2B	BM3	BM4	BM5	Ano D
Na2O (%)	2.45	2.18	1.362	0.749	0.656	0.753	0.645
MgO(%)	1.68	2.085	7.842	0.69	0.571	4.629	4.883
Al2O3(%)	20.35	19.46	13.81	20	17.26	16.95	18.52
SiO2(%)	53.83	52.19	44.63	53.88	50.27	43.07	53.93
P2O5(%)	1.886	1.858	2.873	1.361	0.7379	1.878	0.862
K2O(%)	8.356	7.917	7.861	10.38	11.2	7.907	9.484
CaO(%)	1.644	3.97	4.126	0.7173	0.2293	0.4843	0.0752
TiO2(%)	0.6278	0.4632	1.438	0.3024	1.119	2.051	1.663
MnO(%)	0.031	0.074	0.4116	0.0467	0.0119	0.6953	0.0785
Fe2O3(%)	4.374	5.089	12.34	5.018	9.043	17.46	11.33
Sum	**95.23**	**95.29**	**96.69**	**93.14**	**91.10**	**95.88**	**101.47**
Th (ppm)	24,550	24,350	2,681	55,400	73,950	14,450	1,211
U (ppm)	1,326	1,273	509	1,714	7,035	1,222	415

In addition to thorium and uranium, in peralkaline rocks also occur accumulation of other economic elements, such as rare earth metals associated with thorium. The elements includes Lanthanum (La), cerium (Ce), Praseodymium (Pr), Neodymium, and Ytterbium (Yb). Accumulation of these elements is very significant compared to its availability in fresh rock. Rare earth metals content in mineralized zone as shown in Table 2. This data indicate that rare earth metals have considerable resistance from hydrothermal dissolution and groundwater leaching.

Table 2: Correlation between REE, U and Th

Element (ppm)	BM0	BM1B	BM2A	BM3	BM4	BM5	BM6
La2O3	9,122	9,070	3,823	7,095	1,058	3,373	10,380
Ce2O3	24,120	18,890	9,211	18,170	3,379	8,120	24,140
Pr	1,279	962	477	992	157	472	1,277
Nd	5,999	4,754	2,380	4,477	891	2,188	5,817
Yb	152	101	92	121	48	< 40	113
Th	74,480	24,550	11,550	55,400	73,950	14,450	34,190
U	2,102	1,326	5,769	1,714	7,035	1,222	1,838

During the alteration process, U, Th, and REE were trapped as REE radioactive minerals with Fe–Ti oxides in K-feldspar assimilated from the host rock (Horie, Tsutsumi, Cho, Morishita, & Hidaka, 2010). The absence of uranium oxide is due to intensive hydrothermal alteration process (Zielinski, 1982). This hydrothermal process is shown by the presence of a mineral that is a product of hydrothermal alteration in several thin section of rocks such as: chlorite, actinolite, and adularia. The alteration mineral composition is shown in Figure 4.

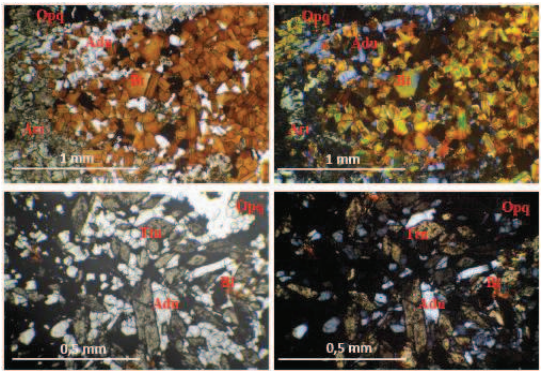

Figure 4: Mineral composition of BM 2.

The alteration product indicates that this area has been affected by hydrothermal alteration in the potassic zone (Horie et al., 2010). Some location have shown that geothermal gradient found in some mineralization zone, may be due to a thermal anomaly related to hydrothermal fluid flow close to volcanic heat sources or magmatic process (Ossa Ossa et al., 2014). Beside the thick layer of soil in the center of volcanic was found the mineralization zone at the fracture zone, especially fracturation on the contact between lava rock as host rock and dioritoid intrusive rocks. The preliminary concept of the U, Th and REE mineralization process is showed on Figure 5.

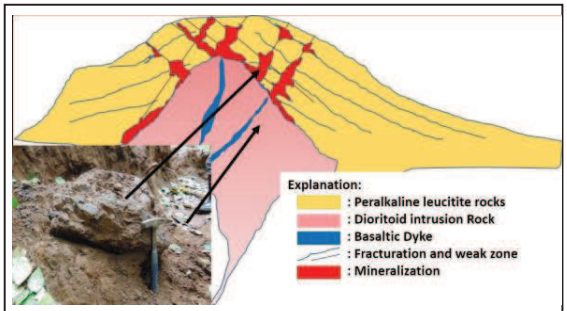

Figure 5: The concept of mineralization zone

According the the content of U, Th and correlation with REE its shown that location are suitable to conducting the Th and REE exploration in the near surface zone. The uranium exploration can be developed in deeper areas or areas that have a reductive condition that allows the formation of uranium oxide deposits. These are usually correlated with reduction condition areas.

Conclusions

The mineralization zone found surrounding the center of volcanic feature, as the center of volcanic heat sources. The thorium and rare earth metals have considerable resistance from hydrothermal dissolution and groundwater leaching. The development of thorium exploration can be focused on advanced alteration areas, such as near surface area, whereas uranium exploration should focus on reductive areas that allow for uranium deposits to form.

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