ISBN : 978-602-70092-0-2

PROCEEDINGS

2nd International Conference on the Sources, Effects and Risks of Ionizing Radiation (SERIR 2016)

in conjunction with

14th Biennial Conference of the South Pacific Environmental Radioactivity Association (SPERA 2016)

Sanur Paradise Plaza Hotel
Bali, 5-9 September 2016

Organized and hosted by

National Nuclear Energy Agency (BATAN)

in cooperation with

South Pacific Environmental Radioactivity Association

Published by

Center for Technology of Radiation Safety and Metrology
National Nuclear Energy Agency (BATAN)

December 2016

Organized and hosted by the

National Nuclear Energy Agency (BATAN)

in cooperation with

South Pacific Environmental Radioactivity Association

Supported by :

Kementerian Riset, Teknologi dan Pendidikan Tinggi

Australian Radiation Protection and Nuclear Safety Agency

Australian Institute of Nuclear Science and Engineering

Royal Australian Chemical Intitute

COMMITTEE

President of The Conference

Dr. Ferhat Aziz, Deputy Chairman of BATAN, Indonesia

Scientific Committee : Susetyo Trijoko, M.App.Sc. – BATAN, Indonesia

Editors :

1. Prof. Dr. Yoshiyuki Suzuki, MD - University of Fukushima,Japan
2. Prof. Dr. Ross Antoni Jeffry - University of Technology Sydney, Australia
3. Dr. Heny Suseno - BATAN
4. Dr. Rer.nat. Budiawan - Universitas Indonesia
5. Dr. Freddy Haryanto - Institut Teknologi Bandung
6. Dr. Johannes R. Dumais - BATAN
7. Dr. Azhar Masiatullah - Pakistan Institute of Science and Technology (PINSTECH), Pakistan

Local Committee :

Chair	:	Dr. Mukh Syaifudin	- BATAN
Vice	:	Dr. Heny Suseno, M.Si.	- BATAN
Secretary	:	1. Drs. Nazar Wijaya Iskandarmouda	- BATAN
		2. Setyo Rini, SE	- BATAN
Treasure	:	Irwan Nursal, SE	- BATAN
Sections	:		
a. Scientific Boards	:	1. Dr. Dadong Iskandar, M.Eng.	- BATAN
		2. Dr. Iin Kurnia, M. Biomed.	- BATAN
		3. Drs. Mukhlis Akhadi, APU	- BATAN
		4. Dra. C. Tuti Budiantari	- BATAN
b. Publication, Documentation and Proceeding	:	1. Hasnel Sofyan, M.Eng.	- BATAN
		2. Toni Prihatna	- BATAN
		3. Suratman, ST.	- BATAN
c. Protocol-Accommodation	:	1. Budi Kurnia	- BATAN
		2. Nunuk Sunaryati	- BATAN
d. Logistics	:	1. Ir. Ismanto Djumadi	- BATAN
		2. Sandya Eko Restadhi, SH	- BATAN
		3. Teja Kisnanto, A.Md.	- BATAN
		4. Tisna Priatna	- BATAN
		5. Achmad Chabib	- BATAN
e. Security	:	1. Prasetyo, S.Sos.	- BATAN
		2. Nana Suyana	- BATAN

PREFACE

For the second time the Center for Technology of Radiation Safety and Metrology, National Nuclear Energy Agency of Indonesia (BATAN) was held the 2nd International Conference on the Sources, Effects and Risks of Ionizing Radiation (SERIR2) in Sanur Paradise Plaza Hotel, Sanur, Bali, Indonesia, which was the continued event that already held in last 2013. Similar as previously, Conference dealed with the efforts to enhance data collection and disseminate scientific findings related to the issues of sources, effects and risks of the ionizing radiation, as well as to seek the way of communication among stakeholders (scientific communities, regulatory authorities, and general public) on those issues. This conference was in conjunction with the 14th biennial conference of the South Pacific Environmental Radioactivity Association (SPERA2016) that provides a platform for discussion among scientists on the occurrence, behaviour, impact and measurement of radioactive species present in the environment through natural processes, or resulting from human activities. This international conference also facilitated knowledge sharing on environmental radioactivity and related topics of local and global significance.

In the SERIR2 there were three keynote speakers presented their own expertise : Dr. Stephen Solomon (Principal Scientific Adviser to the CEO, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Prof. Yoshiyuki Suzuki (Department of Radiation Oncology, Fukushima Medical University), and Dr. Ferhat Aziz (National Nuclear Energy Agency of Indonesia (BATAN)).

In this conference there was a press conference that was attended by local and national journalists. This event was handled by Bureau of Legal, Public Relation and Cooperation (BHHK), BATAN. The speakers were : Dr. Andreas Bollhöfer (President of SPERA), Dr. Justin Lee (Deputy Head of Mission, Department of Foreign Affairs and Trade of Australian Embassy for Indonesia), Dr. Gillian Hirth (ARPANSA), Prof. Dr. Djarot Sulistio Wisnubroto (Chairman of BATAN), and Prof. Dr. Mohammad Nasir (Directorate General of Minister of Research, Technology and Higher Education (Menristekdikti).

In this conference, of 38 papers submitted by authors from three countries (Indonesia, India and Japan), 35 papers were presented as oral and poster presentation. For oral, there were 20 papers presented into two groups of paper (group A, Radiation Exposures and Instrumentation and group B, Occupational Exposures and Health Effects), and for poster there were 15 papers. Totally there were 35 papers that consists of 32 papers from BATAN, one paper from Pachhunga University College-India, one paper from University of Udayana, and one paper from Siloam Hospital.

We would like to thank all those who participated in the conference for the lively discussions as well as the director of the Center for Radiation Safety and Metrology, BATAN upon the opportunity to organize this event as well as the SPERA which was agree to conduct the events in the same venue. In addition, we are also grateful to all the authors for their valuable time and contributions to the conference. Last but not least, the conference would not have been possible without the great help of the staff of the Center and Australian Nuclear Science and Technology Organization (ANSTO), South Pacific Environmental Radioactivity Association (SPERA), Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). We would like to thank all of them for their assistance.

December 2016 SERIR2 Committee

WELCOME ADDRESS BY PRESIDENT OF THE CONFERENCE

His Excellency,
Dr. Muhammad Dimyati, Director General Research and Development, Representing Minister Science, Technology and Higher Education, The Republic of Indonesia;
Prof. Dr. Djarot SulistioWisnubroto, Chairman of National Nuclear Energy Agency (BATAN);
Dr. Andreas Bollhöfer, President of South Pacific Environmental Radioactivity Association (SPERA);
Dr. Justin Lee, Deputy Head of Mission, Department of Foreign Affairs and Trade of Australian Mission for Indonesia; and
Dr. HendigWinarno, Deputy Chairman of BATAN;

Distinguished keynote speakers,
Chairman of the organizing committee,
Participants, Ladies and Gentlemen,

Good Morning and Assalamu-Alaikum Wr.Wb.

On behalf of the National Nuclear Energy Agency (BATAN) of Indonesia, it is my great pleasure to welcome you to the "2nd International Conference on the Sources, Effects and Risks of Ionizing Radiation (SERIR) and 14th Biennial International Conference of SPERA", jointly organized by South Pacific Environmental Radioactivity Association (SPERA) and National Nuclear Energy Agency (BATAN), particularly The Center for Radiation Safety Technology and Metrology. I wish to welcome you to be in a beautiful Bali Island here.

This second International Conference on the SERIR is a continued of the first scientific meeting that had been done here in the same place three years ago. As in the first SERIR, this Conference is held under an urgent need to give contribution to the works of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The 2nd International Conference on the SERIR will be a 1-day conference (5 September). This conference is aimed to disseminate scientific findings related to the issues of sources, effects and risks of ionizing radiation, and to communicate with stakeholders (scientific communities, regulatory authorities and general public).

Ladies and Gentlemen,

Ionizing radiation is generated in a range of medical, commercial and industrial activities. The most familiar and the largest of these sources of exposure is medical X-rays. Natural radiation contributes about 88% of the annual dose to the population, and medical procedures contribute most of the remaining 12%. Natural and artificial radiation are not different in kind of effect. Ionizing radiation has always been present in the environment and in our bodies. However, we can and should minimise unnecessary exposure to significant levels of artificial radiation. Ionizing radiation is also very easily detected. There is a range of simple, sensitive instruments capable of detecting minute amounts of radiation from natural and anthropogenic sources.

The Organizing Committee has invited contributions, academic and practice-based paperson all aspects of the following two topics: Radiation Exposures and Instrumentation; and Occupational Exposures and Health Effects, induced by Medical Radiation uses and Environmental/Natural Radiation. Some of oral and poster presenters will deliver those topics in the afternoon.

This Conference has attracted more than 80 participants from 6 countries. About 39 scientific papers will be presented by their authors orally or as posters. This event will offer you plenty of opportunities for extensive discussions, making of new contacts and strengthening the existing relationships after the oral presentations, during the poster sessions, while visiting the exhibition by SPERA or at the other events.

For the SPERA 2016, the 14th Biennial Conference of the SPERA, to be held 6-9 September, will provides a platform for discussion and debate among scientists on the occurrence, behaviour, impact and measurement of radioactive species present in the environment through natural processes, or resulting from human activities.

The joint conference will include a one-day workshop on Trends in Environmental Sample Preparation on the 6th September, facilitated by The Radiochemistry Division of the Royal Australian Chemical Institute (RACI). The workshop will present an overview of the fundamentals, procedures, and applications of both historical and the most recently developed sample preparation techniques for the extraction, clean up, and concentration of radionuclides from environmental samples

Participants, Ladies and Gentlemen.

In this opportunity, I would like to thank to honorable three invited speakers who have been able to be here, Dr. Stephen Solomon, from Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)-Australia, Prof. Dr. Yoshiyuki Suzuki, MD, from Fukushima University-Japan; and Dr. Ferhat Azis, from BATAN-Indonesia**.** All of them are the prominent scientists in their own field and will providea comprehensive overview of the current status of the global sources, effects and risks of ionizing radiation.

I look very much forward to this Conference and hope there will be warm discussion, because this Conference is open for everybody to give a view, and certainly we will do our best to make sure that the floor is really life. So, please be prepared to give comments and questions for the topics to be delivered by the speakers and presenters.

In this occasion, I would also like to thank the organizer and resource persons who have made this event possible, and who I am sure will be working tirelessly to ensure the success of the conference and workshop over the next few days.

Finally, I wish all of you will enjoy being in Bali, which is one of 16 Most Beautiful Islands in the World. Bali is a feast for the senses. Bali's spirit will wash over you like a warm, tropical wave.

Thank you and Wassalamu-Alaikum WrWb.
President of the Conference
Susetyo Trijoko, M.App.Sc.

OPENING REMARKS
MINISTER OF RESEARCH, TECHNOLOGY AND HIGHER EDUCATION

(Represent by Director General Research and Development)

Honorable;
1. Dr. Andreas Bollhofer (President of SPERA)
2. Deputy Head of Mission, Department of Foreign Affairs and Trade of Australian Embassy for Indonesia
3. Prof. Dr. Djarot Sulistio Wisnubroto, Chairman of Batan
4. All Experts, Participants
5. Distinguish Guest, Ladies and Gentlements

First of all, let us thanks Allah SWT for His blessings; we can be here to attend this International Conference. On behalf of Ministry of Research, Technology and Higher Education, I would like to express my gratitude to all of you, for participating 2th International Conference on the Sources, Effects and Risk of Ionizing Radiation (SERIR) and 14th Biennial International Conference on SPERA in the beautiful island of Indonesia…called BALI.

Delighted Ladies and Gentlemen,

The development of science and technology in the field of health, food, and energy is very progressive. Many researchers doing very sportive competitions to express their knowledge to support the human being. In the other hand, there are many obstacles should be break it out by the researchers to reach the research goals. This forum can be use as an arena to prove that we are capable of doing it. But we need to keep our awareness that whatever the level of research we present now; we should not merely stop at research paper or conceptual design. We must continue and create research outputs that are ready to be commercialized and giving positive impact to the people. Therefore, the benefit of research can be optimized for the good and prosperity of Indonesian people and the world. And with this spirit, the Ministry of Research, Technology and Higher Education support the mutually-benefit linkage between researchers and industries, in order to minimize their mismatch.

To move further, the Ministry of Research, Technology and Higher Education has had and will continue to push and facilitate research outputs that are ready to be used by the people, to be synergized with other research outputs, to give greater benefits and multiplier effects to the community. For example, Indonesian Institute of Science (LIPI) has invented fertilizer that can make paddy stands out of many pests, while Bogor Agricultural Institute has invented new paddy variety that can yield more than 10 ton per hectare. Research and Development of Ministry of Agriculture had invented paddy field management with Jarwo-system that can improve paddy field productivity. Each of the inventions is directly benefiting the user, but synergizing them through government support, will create much greater benefits, and direct impact for the people, mainly local people.

Delighted Ladies and Gentlemen,

Through this conference, hopefully the discussion will lead toward acceleration of people prosperity. We should not put too much effort on just debates that only satisfying researchers themselves. We have to do more than that. Scientific debates outputs that have been perfectly completed can be posted in the international journals, so they could be used to push forward the acceleration of science development in the world.

Once again, I hope that the conference output will provide positive impact through science and technology development, that is benefiting the community.

To all overseas participants, I welcome you in Bali, a beautiful and peaceful island. Enjoy your stay and hope that the serenity of the island inspires you to create changes for a better future.

Finally, by saying BISMILLAH…. I open 2nd International Conference on the Sources, Effects and Risk of Ionizing Radiation (SERIR2) and 14th Biennial International Conference on SPERA2016.

May Allah SWT, the God Almighty give us His Blessing.
Wabilahi Taufiq Walhidayah, Wassalamualaikum Wr. Wb.

Bali, 5 September 2016
Minister of Research, Technology and Higher Education
Mohamad Nasir

Press Conference (organized by BHHK)

	**Dr. Andreas Bollhöfer** (President of SPERA)
	**Dr. Justin Lee** (Deputy Head of Mission, Department of Foreign Affairs and Trade of Australian Mission for Indonesia)
	**Dr. Gillian Hirts (ARPANSA)**
	**Prof. Dr. Djarot Sulistio Wisnubroto (Chairman of BATAN)**
	**Dr. Muhammad Dimyati** (Director General Research and Development, Ministry of Research, Technology and Higher Education, Kemenristekdikti)

TABLE OF CONTENT

KEYNOTE SPEAKERS

Keynote Speaker I

Dr. Stephen Solomon ***(Principal Scientific Adviser to CEO ARPANSA)***
"An ARPANSA Perspective on Radiation Protection of The Environment"

Keynote Speaker II

Prof. Dr. Yoshiyuki Suzuki, MD. ***(Fukushima Medical University, Japan)***
"Cutting Edge Radiotherapy" Including Combination Therapy
with Immunotherapy)

Keynote Speaker III

Dr. Ferhat Aziz ***(National Nuclear Energy Agency of Indonesia)***
"Environment Radioactivity Monitoring Activities in Indonesia and
Its Public Concerning"

Groundwater Drainage and Soil Formation Effect on High Natural Radiation Exposure in Biak, Papua

Heri Syaeful, Kurnia Setiawan Widana and I Gde Sukadana

Center for Nuclear Minerals Technology, E-mail: syaeful@batan.go.id

Abstract. *Unusual phenomenon of radium accumulation in soil is take place in Biak Island. Preliminary field survey delineates the area around Maryendi, Darmapis and Denafi which indicates the high radiation dose from 50 to 4,032 nSv/h. Further observation and measurement of soil profile yield conclusion of high radiation only consists in top most part of soil in the thickness range of tens centimeter. Bedrock of soil is limestone, no potential source of uranium and thorium surrounding the area such as intrusive or volcanic rocks. To gather scientific reason of this phenomenon, several research methods applied consisted of satellite imagery analysis, chemical analysis, and scanning electron microprobe (SEM) of the soil sample. Based on satellite imagery analysis, geomorphology and groundwater drainage plays significant role in transport and precipitation process of radium from limestone to soil. Results of chemical analysis and SEM conclude that soil chemical properties allows the deposition of radium in the soil. This research is very valuable for further study or exploration of radioactive elements in the type of surficial deposits which is very scarce in tropical climate region.*

Keywords: NORM, radium, drainage, radiation, west Papua.

Introduction

International Atomic Energy Agency define that surficial secondary uranium deposits are young (Tertiary to Recent) near-surface uranium concentrations in sediments or soils (IAEA, 2009). It is recognized that there are many cementing minerals, which includes calcite, gypsum, dolomite, ferric oxide, strontianite, and halite (Toens & Hambletons, 1984). Uranium dissolution and transport usually take place under oxidizing conditions as bicarbonate (Mckay & Miezitis, 2001). Such deposits occur in valley-fill and in Playa Lake sediments and at the top of the alluvial sediments (Khoury et al., 2014). The major controlling factors are climate, geomorphology, including physiographic and climatic stability, and provenance, i.e., the weathering terrane from which uranium and associated substances are derived (Carlisle, 1984). According to Khoury (2014), uranium exists at different valence states: U^{4+} (tetravalent), U^{6+} (hexavalent) and $U(OH)^{3+}$ (trivalent). Under reducing conditions, uranium U^{4+} hydroxide or fluoride complexes are the only dissolved species, while hexavalent uranium is relatively soluble with the solubility in aqueous systems controlled by three factors: oxidation–reduction potential, pH, and dissolved carbonate. Uranium precipitated from solution is entirely deposited as $(UO2)^{2+}$ minerals.

Biak indicated to have uranium anomaly in surface soil, on the top of limestone bedrock, in several area of Maryendi, Darmapis, and Denafi. Anomalous zone indicated by existence of dark brown to reddish brown soil with radiation dose rate range from 2 to 4032 nSv/hour and grade of uranium range from 20 to 325 eUppm (Suharji et al., 2014) (Figure 1). The anomaly found in Biak is out of the ordinary because located in tropical region with high rate of precipitation and high dilution rate. According to Boyle (1984), the rate and type of weathering of source rocks and thus the mobility of the ore-forming elements are greatly affected by climate. In hot arid environments, the movement of ore-forming elements is slow due to a low, sporadic rate of precipitation, but these conditions coupled with a high rate of evaporation are also optimal for the precipitation of minerals such as carnotite, calcite, dolomite and gypsum. In tropical regions, a heavy, steady rate of precipitation, and the mobility of elements may be so great that precipitation of uranium cannot occur even in the most favourable environments because of high dilution rates, heavy surface and groundwater flushing. The purpose of this research is to discover how the radioactive material could be deposited in tropical region of Biak and forms a type of surficial deposit.

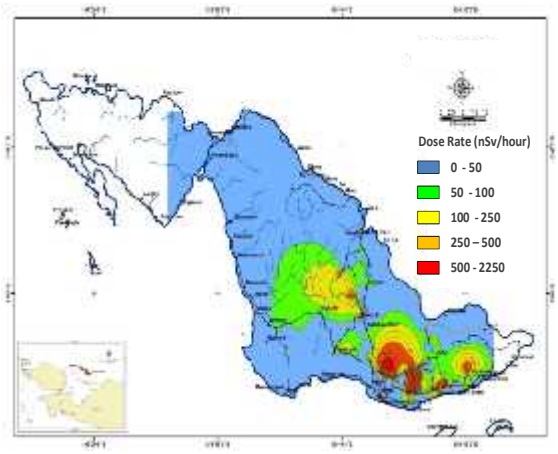

Figure 1. Map of Biak radiation dose rate (Suharji et al., 2014)

Methodology

Methodology that is applied in this research is analysis of drainage system through interpretation of geomorphology and rainfall. Drainage system has major role in uranium mobilization from the host rock to the location of its deposition. Several caselike in the basins of Ribeira da Pantanha, Ribeira do Castelo and streams tributaries to Ribeira de Inguias, all receiving drainage from old uranium mines. Results showed enhancement of radionuclide concentrations, espe-cially ^{226}Ra. The main source and transfer pathway of radionuclides to plants was the irrigation water used, rather than the soil (Carvalho et al., 2013). The drainage system analyzed by interpretation of geo-morphic features using digital elevation model (DEM). Besides that, the rainfall, temperature and humidity also collected to understand the climate regime of the area of investigation.

According to IAEA (2003) NORM comprises radioelements associated with the uranium and thorium decay chains as well as ^{40}K. These radioelements are very long lived and have several long-lived progenies, such as ^{226}Ra in the Uranium series. Spectrometry data from gamma ray surveys has benefit to understand the areas of anomaly, nevertheless estimation of uranium by gamma ray spectrometry should be corrected for possible disequilibrium between ^{238}U and ^{226}Ra. Syaeful et al. (2013) has used this method to map the Naturally Occurring Radioactive Material in Mamuju, West Sulawesi. In the case of Biak, spectrometry data validated by geochemical analysis of X-Ray Fluorescence, especially on high anomalous area. Further, samples analyzed by scanning electron microscope (SEM) to have detail view of internal soil condition and its composition.

Analysis and Result

Climate has very important role in the deposition of radioactive material in surficial deposit. Although there is no certainty of the past climate during the deposition of the radioactive substance, the present climate could be as estimation of what take place on the pastten to hundred thousands of years. Biak locatedin latitude of 0°39' to 1°10' in Southern hemisphere. According to data from BPS (2012, 2014, 2015), the average temperature of Biak in year of 2011 to 2013 constant in 27.1°C with average relative humidity 86.3%, in 2014 average temperature is 27.2°C with 87% of average relative humidity. During 2011 to 2014 minimum temperature is 23.4°C and maximum temperature is 31.7°C. The air humidity is increased during 2009 to 2014, which from 85.1% to 87, resulting the air condition increased hotter. Average rainfall intensity in 2011 is 287.5 mm, with highest in August which is 456.1 mm and the lowest in November which is 123.1 mm. Average rainfall intensity in 2013 is 241.3 mm, with the highest in August (437.1 mm) and the lowest in October (123.5 mm). In 2014, average rainfall is 278.5 mm with the highest in December (457.1 mm) and the lowest in March (77.0 mm). Based on the numbers above, generally rainfall intensity in Biak is categorized as low.

Based on Geologic map of Biak from Masria (1981), stratography of the area of investigation composed by several rock formation from old to young, Formation (Fm) of Malihan Korido (S) with Cretaceous of age, AuwewaFm (Teoa) with Eocene of age, WainukendiFm (Tomw) with Lower Early Miocene of age, WafordoriFm (Tmw) with Upper Early Miocene of age, NapisendiFm (Tmn) with Middle Miocene of age, KoremFm (Tmk) with Lower Late Miocene of age, WardoFm (Tmpw) with Lower Pleistocene of age, ManokwariFm (Qpm) with Lower Pleistocene of age, MokmerFm (Qm) with Upper Pleistocene of age, and recent deposit of Beach and Alluvial (Figure 3).

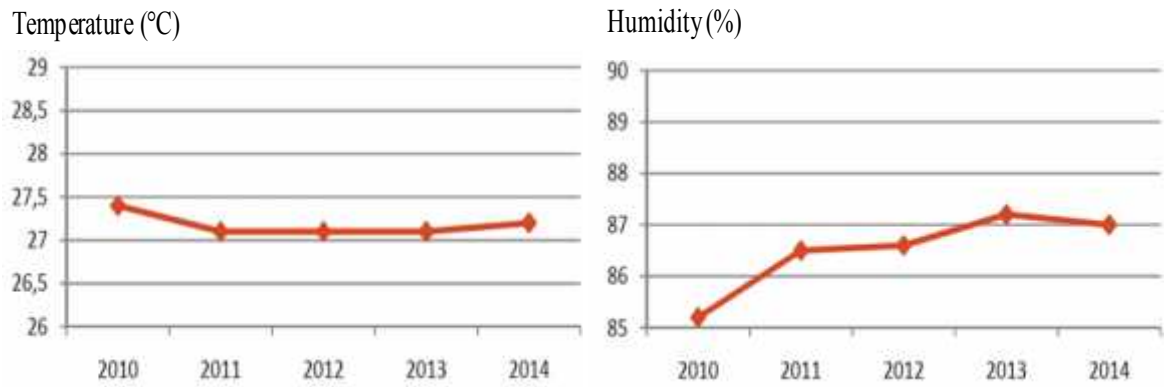

Figure 2. Average of temperature and relative humidity of 2010-2014 (BPS, 2014)

Host rock of anomalous area in Biak is Mokmer Formation, Pleistocene of age, composed by coral limestone and chalk. Suharji et al. (2014), described Mokmer Formation composed by clastic limestone and reef limestone, which further if classified according to James (1984)it is baffle stones to floatstones with matrix of packstones, deposited in the zone of back reef (Figure 4). Grainstone is also identified which indicate the zone of reef flat, and in the flank area the reef with stalactite which indicate the reef crest.

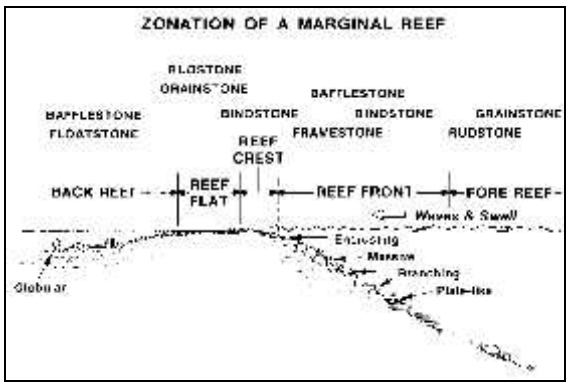

Figure 4. Cross-section of hypothetical, zone, and marginal reef (James, 1984).

The geomorphology and weathering play a critical role in the distribution of radioelement concen-trations at the earth's surface. Several factors affect the variation between surficial and bedrock responses, including deposition of radiumat groundwater seepage sites, radon loss, general loss of K during pedogenesis, weathered of rocks, K-depletion and U and Th-concentration in iron oxides, K-depletion through pedogenesis of shales, and K and Th-enrichment through silicification of shales (IAEA, 2003).

Digital Elevation Models (DEMs) play an important role in modern research in Earth surface processes. First, DEMs provide a baseline dataset for quantifying landscape morphology. Second, they enable us to model the pathways of mass and energy transport through the landscape by hillslope and fluvial processes. Given the importance of DEMs in a broad range of geoscientific research, the ability to digitally process DEMs should be a part of every geoscientists' toolkit (Pelletier, 2008). DEM that is used in the analysis is from United States Geological Survey (USGS) with 30 m of resolution. Based on DEM, the topographical cross section is taken on the area of high radiation dose rate. The section A and B show the basin and location of anomalous area. Higher elevation of topography is in the North, with both of North and South boundaries identified as reef crest (Figure 5). The drainage system from this typical morphology will be from north to center of basin, and also from south will be flown to the north and ended in lowest part of basin. Because of the high porosity of limestone and also depth of groundwater which might be more than 30 m in depth, the drainage will be much controlled by clay in soil as surface flow. Nevertheless, due to high air temperature and sun shine in Biak, the process of evaporation will limit the rate of surface flow. During field observation, even after heavy rain soil will be quickly dry in several hours.

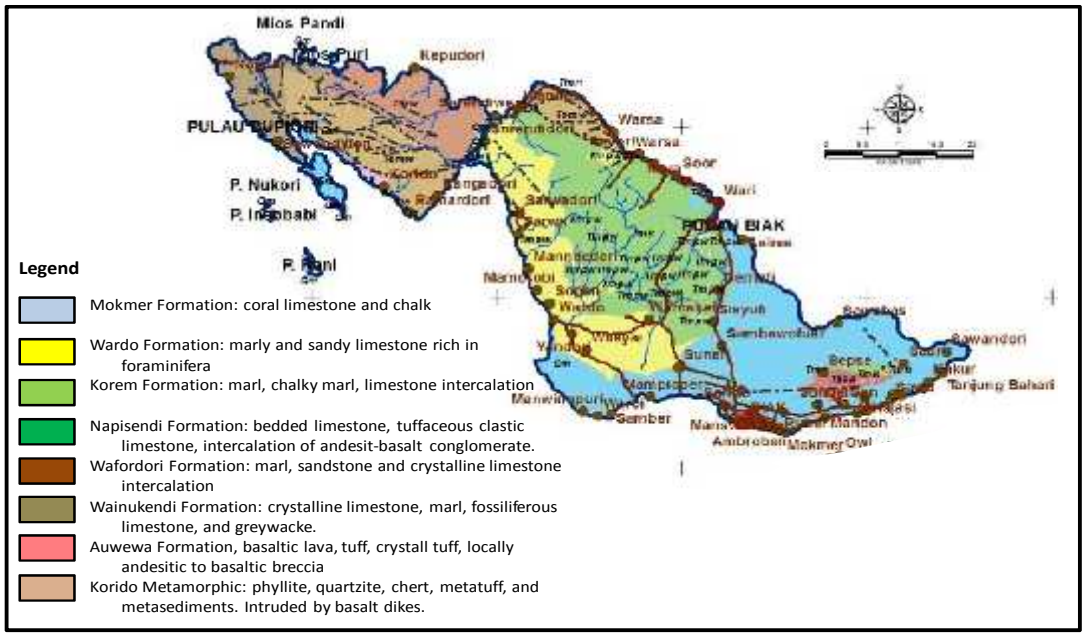

Figure 3. Geological map of Biak island (modified from Masria, 1981)

Anomalous zone indicated by presence of dark brown to reddish brown color of soil with radiation dose rate of 1.9 to 4032 nSv/hour with grade of uranium of 20.27 to 325 eU ppm. Geologically it is located in valley and topographic basin in the bedrock of limestone of MokmerFm (Suharji et al., 2014). All of the measurement of radiation dose rate and grade of uranium and thorium conducted in the field by spectrometry method. In order to have the actual value of uranium, chemical laboratory analysis conducted to compare the spectrometry method. Analysis of elements in the sample covers the major, trace and some of rare earth. The result of laboratory X-ray fluorescence of several selected high anomalous samples can be seen in Figure 6.

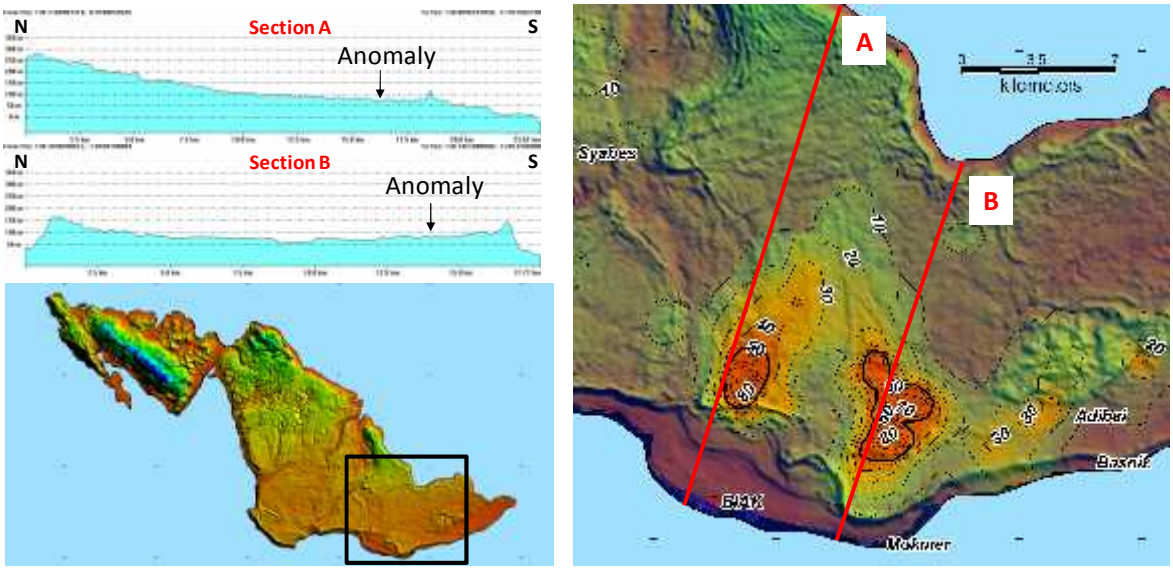

Figure 5. DEM shows the morphology and topographic section of anomalous area in Biak Island

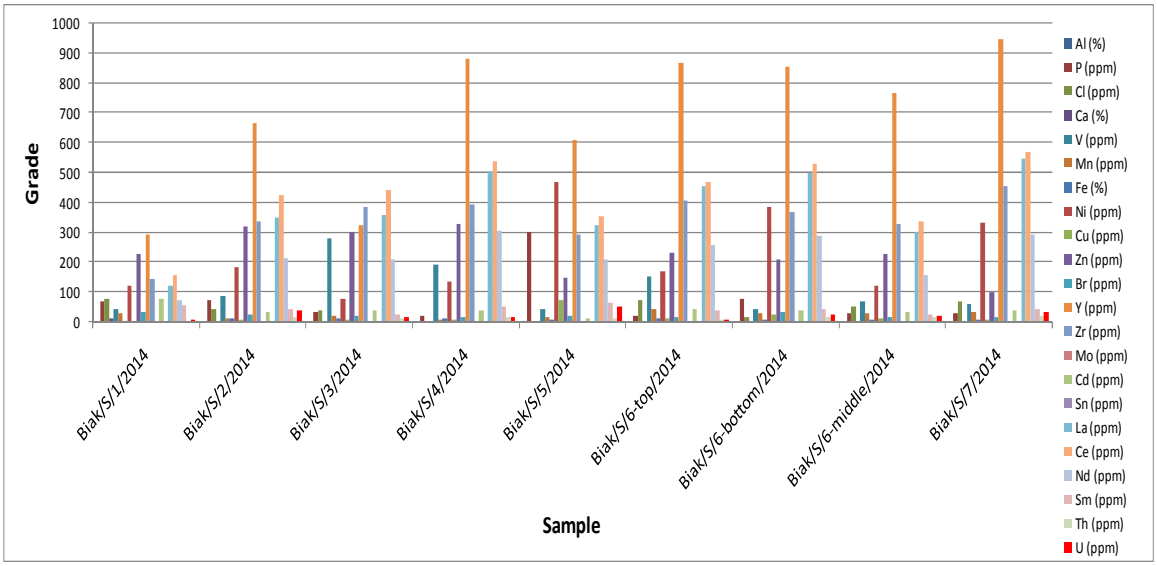

Figure 6. Result of XRF analysis of the selected soil sample

Based on the result and comparison of the methods used, there is high differences between result from spectrometry and XRF. Ratio of result between XRF and spectrometry range from 1:3.2 to 1:17.7 (Figure 7) which indicate very high rate of uranium disequilibrium ratio. Dickson (1984) describes that the decay series of ^{238}U reaches secular equilibrium when the decay rate of each member is equal to that of the parent, after approximately 1 Ma. Lin Ma et al. (2010), is also described that on a system closed to inputs or outputs of U-series isotopes for longer than ▫ 1.3 Ma, these isotopes will be in secular equilibrium. Further, Suresh (2013) explained that for a system that has remained closed for more than 1 Ma, all daughter-parent activity ratios of the uranium decay chains, e.g. ($^{234}U/^{238}U$) or ($^{230}Th/^{234}U$) will be equalto1. Based on that and also from field observation that the soil is recent deposit of probably less than thousands of years, than disequilibrium will normally occurred.

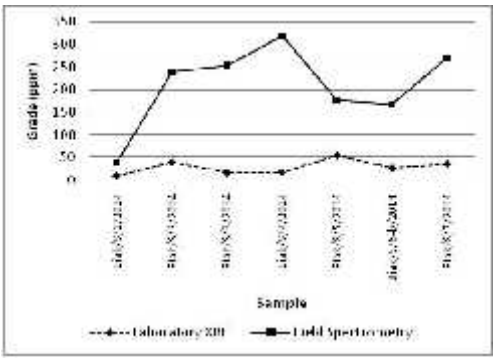

Figure 7. Comparison of grade analysis from laboratory XRF and field spectrometry

According to Mc Sween (2000) Fe^{2+} may be oxidized to form an insoluble hydroxide mineral, or on the other word iron could be uranium precipitant. Other researcher, Pagel (1984) also describes the adsorption of uranium on Fe-oxyhydroxides in several deposits, such asin the Samt Pierre du Cantal deposit in France show good correlation between iron and uranium as determined from chemical analyses. The adsorption of uranium in latentic profiles has also been described, such as in the Vosges area, accumulations of uranium occur in placic horizons of hydromorphic soils rich in lepidocrocite with the uranium probably adsorbed onto amorphous surfaces, and enrichment factors due to adsorption can be up to one hundred times greater than substitution in crystalline lattices.

Correlation between Fe and U among all of the soil samples show that no definitive relation between them. Random ratio of Fe:U in sample is from 0.16 to 1.42 with average of 0.56 (Figure 8a). Analysis on Fe and U grade in soil profile conducted in S/6 sample. Location of S/6 is in anomaly of radiation dose rate of up to 1205 nSv/h. The soil is brownish yellow clay to 10 cm depth and reddish brown clay to 100 cm, and in the depth of 100 cm limestone bedrock. Sampling of soil conducted continuously in 0-30, 30-60, and 60-100 cm. Uranium profile in soil is increased with depth, from 7.8 ppm in the depth of 0-30 cm, 20.8 ppm in 30-60 cm, and 26.7 ppm in 60-100 cm. Fe in soil profile is decreased from 11.05 % in 0-30 cm, 9.92 % in 30-60 cm, and 8.92 % in 60-100 cm (Figure 8b). Based on description above, no clear correlation between Fe and U in laterally between anomalous zones or vertically in soil profile.

Increased grade of uranium in soil and decrease of iron due to increase of depth show contradictive correlation between them. However it is might be caused by disequilibrium of uranium. In many cases uranium can dissolved due to its high mobility and retain Radium-226. Based on PTKMR (2010) measurement of Radium-226 in anomalous zone in Biak, Radium-226 grade is high and comparable to the radiation dose rate. Radium-226 might also significant in soil layer, even has higher influence than uranium due to its lower mobility than uranium. Boscov (2000) research the Radium-226 mobility in soil and concluded that radium mobility is very low, proved by diffusion of radium solution into the soil and found that 99.7% of radium retain in the upper 4.5 cm of soil layer and very small other percent migrate to the subjacent layer. Churchill (1991) states that radium mobility can be high in brines under reducing condition because of chloride complexes and the absence of iron oxides. Recent Biak soil surface condition is in the state of oxidation with high presence of iron oxides which is leading to conclusion that radium mobility in soil surface of Biak is low.

SEM analysis carries outin order to have a better view of internal soil formation and the cause of high radiation. SEM is widely used in uranium mineral characterization study in uranium exploration campaign. SEM analysis on B/6 sample show the internal soil composition which is semi layered of clay, with some bright color of rounded to angular fragment/ grains. Trial of 001 and 003 quantitative analysis of the B/6 sample of soil matrix and grain, resulted the same grade of carbon and manganese, nevertheless different grade of oxygen, aluminum, calcium, iron, and molybdenum, while thorium and uranium is below detection limit. Analysis of B/2 sample on matrix (001) and grain (002) show similar grade of carbon, oxygen, aluminum, calcium, manganese, iron, and molybdenum. Uranium grade in grain is 0.32% or 3200 ppm, which is indicate high grade of uranium, however error in measurement is 0.48% leading to low level of confidence (Figure 9).

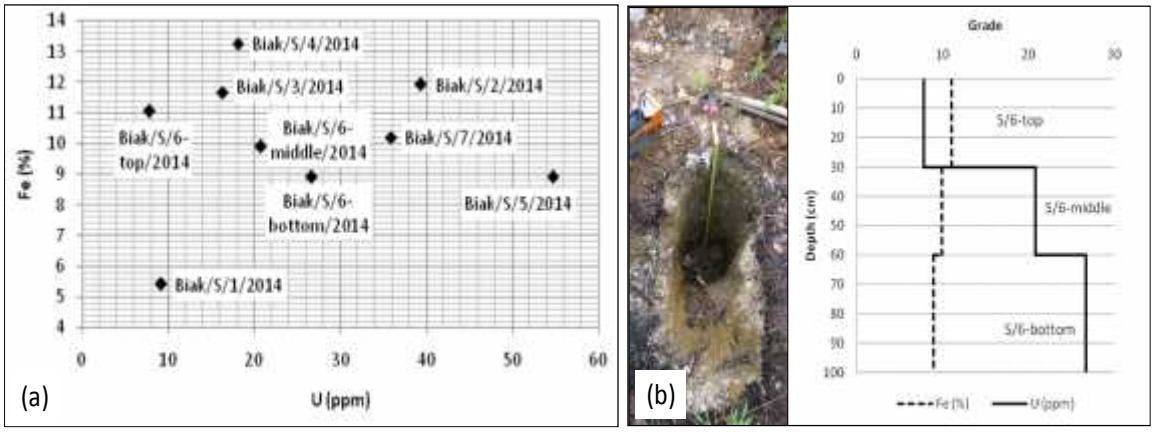

Figure 8. Correlation between Fe and U for soil samples

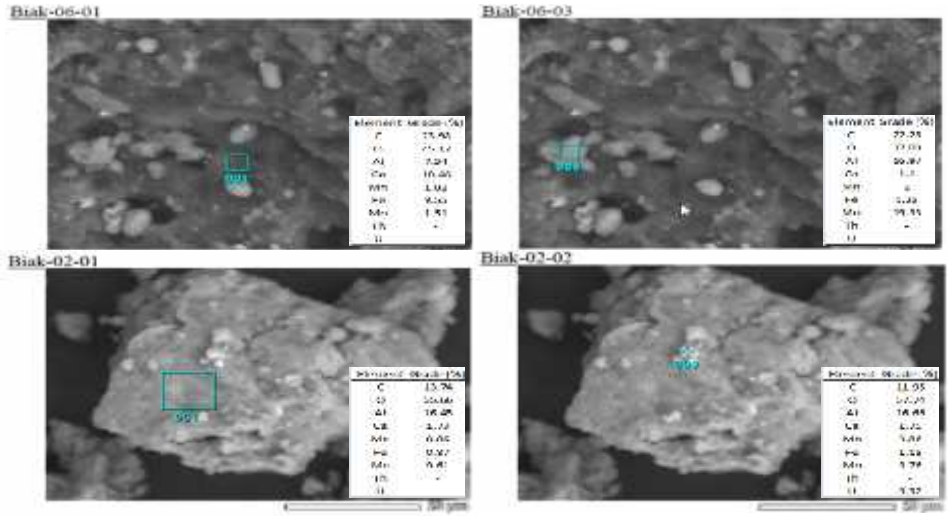

Figure 9. SEM analysis of soil sample B/6 and B/2

Conclusion

Biak located is tropical island with high air temperature, high relative humidity, and low rainfall intensity. These condition makes high evaporation rate, low dilution rate by surface and groundwater, which is ideal for preservation of a deposit. Anomalous zone located in basin topographic area, in the soil above limestone of Mokmer Fm. Soil formation in Biak is controlled by erosion, rock resistance, and rainfall intensity, which are all low and led to very thin of soil thickness, which is of only 1 m in average. Further oxidation environment of the surface brought to oxidation chemical weathering. Eventhough relationship between iron and uranium not statistically clear, it is deemed that iron act as uranium precipitant. Under disequilibrium condition due to young of age deposit, and different in mobility rate, currently uranium is less remains than radium.

References

Boscov, M.E.G, Cunha, I.I.I, & Saito, R.T. (2000). Radium migration through clay liners at waste disposal sites. *The science of the Total Environment, 266,* 259-264.

Boyle, D.R. The genesis of surficial uranium deposits. *Surficial Uranium Deposits, IAEA-TECDOC-322* (pp. 45- 52), Vienna, Austria.

Carlisle, D. (1984). Surficial uranium occurrences in relation to climate and physical setting. Surficial Uranium Deposits, IAEA-TECDOC-322 (pp.25-35), Vienna, Austria.

Carvalho, F.P., Oliveira, J.M. & Malta, M. (2013). Radio-activity in soils and vegetables from uranium mining regions. *Procedia Earth and Planetary Science 8, 38-42.*

Center for Radiation Safety Technology and Metrology (PTKMR). Mapping of environmental radiation dose rate in Biak Numfor. PTKMR Internal Report, 2012.

Churchill, R. (1991). Geologic controls on the distribution of radon in California. The Department of Health Services, USA.

Dickson, B.L. (1984). Uranium series disequilibrium in the carnotite deposits of western Australia. *Surficial Uranium Deposits, IAEA-TECDOC-322* (pp.165-170), Vienna, Austria.

International Atomic Energy Agency, (2009). World Distribution of Uranium Deposits (UDEPO) with Uranium Deposit Classification, IAEA-TECDOC-1629. Vienna, Austria.

International Atomic Energy Agency (2003). Guidelines for radioelement mapping using gamma ray spectrometry data, IAEA-TECDOC-1363. Vienna, Austria.

James N.P. (1984). Reefs in facies model, Ed. R.G. Walker. Geological Association of Canada, 229-244.

Khoury, H.N., Salameh, E.M., & Clark, I.D. (2014). Mineralogy and origin of surficial uranium deposits hosted in travertine and calcrete from central Jordan. *Journal of Applied Geochemistry, 43, 49-65.*

Lin Ma, Chabaux, F., Pelt, E., Blaes, E., Jin, L., & Brantley,S. (2010). Regolith production rates calculated with uranium-series isotopes at Susquehanna/ Shale Hills Critical Zone Observatory. *Earth and Planetary Science Letters, 297,* 211-225.

Masria, M., Ratman, N., & Suwitodirdjo, K. (1981). Geologic map of the Biak quadrangle, Irian. Geological Research and Development Centre, Bandung, Indonesia.

Mc Kay, A., Miezitis, Y. (2001). Australia's Uranium Resources, Geology and Development of Deposits, AGSO-Geoscience Australia Resource, Report 1.

Mc Sween Jr., H.Y., Richardson, S.M., & Uhle, M.E. (2003). Geochemistry Pathway and Processes. Columbia University Press, New York. Toens, P.D. & Hambleton-Jones, B.B., (1984). Definition and classification of surficial uranium deposits. *Surficial Uranium Deposits, IAEA-TECDOC-322* (pp.9-14), Vienna, Austria.

Pagel, M. Petrology, mineralogy and geochemistry of surficial uranium deposits. *Surficial Uranium Deposits, IAEA-TECDOC-322* (pp. 37- 44), Vienna, Austria.

Pelletier, J.D. (2008). Quantitative modeling of earth surface processes. Cambridge University Press. New York, USA.

Pelletier, J.D. (2008). Quantitative modeling of earth surface processes. Cambridge University Press. New York, USA.

Statistic of Biak Numfor Regency (BPS). (2012). Biak Numfor in Figures 2011/2012.

Statistic of Biak Numfor Regency (BPS). (2014). Biak Numfor in Figures 2014.

Statistic of Biak Numfor Regency (BPS). (2015). Biak Numfor in Figures 2015.

Suharji, Subiantoro, L., Syaeful, H., Setiawan, K., & Prabowo, H. (2014). Study of uranium mineralization occurrences at Biak Numfor, West Papua Province. *Eksplorium, 35, 117-130.*

Suresh, P.O., Dosseto, A., Hesse, P.P., & Handley, H.K. (2013). Soil formation rates determined from Uranium-series isotope disequilibriain soil profiles from the south eastern Australian highlands. *Earth and Planetary Science Letters*, 379, 26-37.

Syaeful, H., Sukadana, I.G. & Sumaryanto, A. (2014). Radiometric mapping for naturally occurring radioactive materials (NORM) assessment in Mamuju, West Sulawesi. *Journal of Atom Indonesia, 40, 33-39.*

Discussion

Q : Andreas Belhöfer, SPERA

Is there difference in geology between Papua and Sulawesi ? Is there different mechanism for U concentration ?

A : Heri Syaeful

Very different geology condition, Papua is Limestone whereas Papua is vulcanic, so U concentration is also different.