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1, Bandar Lampung 35145, Indonesia ²Department of Physics Faculty of Mathematics and Natural Sciences, Gadjah Mada University, Jl. Sekip Utara No. 1, Yogyakarta 55281, Indonesia *nandithea@unila.ac.id Abstract. Radon and Thoron concentration of soil gas was measured by Scintrex Radon detector RDA 200 in the Rajabasa geothermal field, South Lampung regency, Indonesia.

This study is aimed to determine the buried fault zone under the overburden layer. The survey area covers three geothermal manifestations in the southern part of Rajabasa geothermal field. The result indicates fault system trending SW-NE (N 60° E) and SSW-NNE (N 80° E). The contour map of Radon concentration performed high value

in the three manifestations which was included survey area; those are 123 cpm in Gunung Botak hot spring, 145 cpm in Kunjir fumarole and 382 cpm about 300 m from Bulakan (Way Belerang) fumarole. Three manifestations were connected by two fault.

The first fault passed begin from Gunung Botak directed to Kunjir and the other across the first fault from SSW to Bulakan. The contour map of Radon and Thoron ratio indicated that the second fault system is not only indicate the presence of the fault /fracture zones but also show the extension of the faults/fractures from the depth to the surface. Keywords: Radon, Thoron, Soil gas survey, Geothermal field. PACS: 93.85.Np
INTRODUCTION The presence of geothermal manifestations were controlled by structures that were formed in the fracture or fault area. High permeability zones i.e.

fault /fracture zones provides a channel for the geothermal fluid driving up from the depth to the surface. It have important role in the transfer of geothermal fluid from the reservoir to the surface [1]. So, the permeable zones such as fault is important when we study geothermal field.

Measurements of radioactivity Radon was used in the exploration of geothermal areas adopted from mineral exploration techniques. The anomalous Radon concentrations can be observed in the active fault zone because it could provide a conduit for upward migration [2-4]. Radon method is mostly used as a device in geochemical methods (geochemistry tools). It began to be popularized in 1984.

The research that using Radon gas for geothermal exploration has been carried out by Lopez et. al. [5] in Mexico to find the source of geothermal energy, and then Rodriguez et. al.[6] conducted a research for soil gas Radon observation in Las Pail as geothermal area, Costa Rica.

Radon method has been also successful as an effective way to detect hidden faults [1]. This method mixed with geo-electric methods for determine fault or fracture zone. Previously, this method has been done in some places like China and Mongolia [7-9]. Meanwhile, the Radon method for geothermal exploration in Indonesia only has been done by Phuong et al [10] in Ungaran geothermal field Central Java as a geochemical tools. The aim of this study is to determine the fault that connect three manifestations in the southern part of the Rajabasa geothermal area.

GEOLOGY SETTING Rajabasa is one of geothermal prospect area that has been widely studied. It is located on Rajabasa volcano near Sunda Strait in the southern of Sumatera Island, included in South Lampung Regency, Lampung Province Indonesia (Fig 1). There were found several manifestations such as hot springs around the foot and slopes of

Rajabasa volcano i.e.

on Sukamandi, Maja, and Gunung Botak, and also the large blowing fumarole/solfatara especially on Simpur (Kedaton) and Bulakan (Way Belerang). Based on the Geochronology, the Rajabasa volcanism began with construction period of pre-Rajabasa composite that was followed by crush period of the cone to shape the pre-Rajabasa caldera. From the pre-Rajabasa caldera depression, the present Rajabasa volcano appeared along with cone of flank eruption.

It considered as the second crush period [11]. Padjadjaran International Physics Symposium 2013 (PIPS-2013) AIP Conf. Proc. 1554, 218-221 (2013); doi: 10.1063/1.4820324 © 2013 AIP Publishing LLC 978-0-7354-1180-7/\$30.00 218 Downloaded 20 Sep 2013 to 202.43.95.18. This article is copyrighted as indicated in the abstract. Reuse of AIP content is subject to the terms at: http://proceedings.aip.org/about/rights_permissions FIGURE 1.

Geology Map of Rajabasa Geothermal Field PREVIOUS WORK Some preliminary survey relatd to the exploration of Rajabasa geothermal prospect area have been done initially by geothermal division of Pertamina Co. but it was unpublished [12]. Geological mapping based on the structure of volcanic rocks and geological events was developed in that area by Suswati et al. [13].

The structure pattern developing in this complex area was influenced by regional structures such as Lampung fault which is closely associated with sliding of the Semangko fault. A study to investigate geomagnet for describing of the fault system has been conducted by Suharno et. al. [14]. This study not cover the entire area of geothermal prospect Rajabasa.

The data were dominantly taken in the northern Rajabasa volcano while in the southern were very less and almost nil. Beside that, the geological reference is the regional geology, not detail geological reference. Haerudin et. al [15,16] carried out research of geomagnetic covered entire area of Rajabasa geothermal. This study produced the 3D model of Rajabasa reservoir.

METHOD There are three isotopes of Radon that often occur in nature i.e. ^{222}Rn (Radon) with a half-life time of 3.825 days, ^{220}Rn (Thoron) with a half-life of 54.5 seconds and ^{219}Rn (Actinon) with a half-life of 4 seconds. Radon was selected as an exploration tool because of a suitable half-life and its source in the form of magmatic rocks derived from the decay of ^{238}U series while Thoron decay series derived from Thorium. Radon is able to be detected in very low concentration.

So, this became a basis for the highly sensitive geochemical methods [17]. In addition, there are several other reasons why Radon is used as a tracer element as in [18] and [19]: (i) To represent the thermodynamic activity. It is transported to the surface by geothermal gas in place where the thermodynamic activity is high. (ii) To indicate active faults and fractures.

It moved faster when passing through open fractures or fracture. (iii) No correction required for the geochemical composition. As a noble gas, radon is mixed with no other elements in the field. (iv) To show recent geothermal activity because the new radon generated every 20 days. The equation to describe the steady state radon transport upward with the convection-diffusion mechanism in three-dimensional porous media, where Eq.(1) is a mass flow velocity cm/sec [20]: (1) and $D^* = D/\epsilon$ (2) where N = radon concentration D^* = diffusivity λ = decay constant of radon ($\lambda = 2,07 \times 10^{-6} \text{s}^{-1}$) y = direction to surface D = diffusion coefficient ϵ = bulk porosity of rock The radon concentration was measured with radon detector (RDA-200, Scintrex).

Soil gas was circulated through the detector manually with hand pump, replacing the air in the detection cell. The Rn concentration was measured by an alpha-scintillation radon counter with soil gas pumped directly into a scintillation chamber. When the alpha-particles produced during radon decay impact the ZnS(Ag) layer in the scintillation counter, an energy pulse is created in the form of photons, measured by a photo-multiplier and a counter. By means of alpha emission, the concentration of Rn was calculated from three counts in each sequentially 2 minutes.

RESULT Soil gas Radon survey measured 56 measurement points through three manifestations that are Bulakan, Kunjir and Gunung Botak that surround the area about 6 km² in the southern part of Mount Rajabasa. The research area covered three villages i.e. Cugung, Way Muli and Pangkul. Spacing measurement ranged from 250 m to 350m distance.

Based on the results that obtained by survey measurement, minimum value of concentration Radon is 11 cpm, maximum is 382 cpm and background is 24 cpm. Survey found the high 219 Downloaded 20 Sep 2013 to 202.43.95.18. This article is copyrighted as indicated in the abstract. Reuse of AIP content is subject to the terms at: http://proceedings.aip.org/about/rights_permissions concentration in manifestation zones that are 382 cpm western near Bulakan, 145 cpm in Kunjir and 123 cpm in Gunung Botak.

For Thoron, the greatest value is 164 cpm and the smallest value is 4cpm. Threshold

value is calculated using the geometric mean value (average) plus the deviation standard. It is used to identify the concentration anomalies within soil gas data [21]. The areas whose concentration greater than the threshold value are considered as anomalies.

Based on Table 1, the data is classified into three categories that are low, high and anomalies. Concentration values were low category considered as background values.

TABLE 1. Distribution of soil gas classification Classification Radon (cpm) Thoron (cpm) Radon/ Thoron Mean () 63 62 2.62 Deviation standard () 59 42 4.72 Low (cpm <) < 59 < 42 < 4.72 High (< cpm < +) 59 – 122 42 – 104 4.72 – 7.34 Anomalies (+ < cpm < + 2) 122 – 186 104 – 166 7.34 – 9.96 The measurement point data were presented on the contour maps using kriging method provided by Surfer 8.

In the contour map of Radon concentration, it is shown the value of anomalous Radon concentration which formed two lines. First (F1), the southwest- northeast trending lineament (N45 0E) through Gunung Botak and Kunjir, and the other (F2) is north-south trending lineaments (N8 0E) cutting the first lineament passed near Bulakan geothermal manifestation (Fig 2).

The value of high Radon anomalies may be indicate an enlarged permeability where Radon is rapidly migrating to the surface before it decay into daughter products. Faults supports gas transportation because it increase the permeability of the rock and assist geothermal fluid stream up to the surface. Furthermore, the fluid from deep sources migrating upward through the fault depends also on other factors including the level of cracking rock and soil capability to absorb water through the rocks. Thoron has a short half-life of 54.5

s, so that the concentration decreased rapidly for 2 minutes of the sequences of three times measurement. Meanwhile, Radon has a half-life 3.825 days and can be transported in the fracture for a considerable distance. FIGURE 2 . Contour Map of Radon Concentration at Rajabasa Geothermal Field To detect the presence of fault or fracture system connecting depth zone to the surface, the concentration Radon and Thoron ratio can be a suitable indicator. Contour map of the Radon and Thoron ratio is shown in the Fig 3.

The high value of Radon and Thoron ratio (> 7.34) is found dominantly on the second fault lineaments and lightly visible on the Kunjir manifestation. The zones with the high value of Radon and Thoron ratio not only indicate the presence of the fault /fracture zones but also show the extension of the faults/fractures from the depth to the surface. FIGURE 3 . Contour Map of Radon and Thoron Concentration Ratio Furthermore, the

result overlaid above a detailed geological map.

Fig 4 showed that the fault line ament of Radon interpretation is slightly different compare with the results of surface geological interpretation from [12]. Based on the interpretation of ecological surface, fault formed a straight line connecting directly through to three manifestations; while the results of the qualitative of Radon interpretation, southwest –north east trending fault connected Gunung Botak and Kunjir manifestation and the other fault trending north-south cross to the first fault passed near Bulakan. 220 Downloaded 20 Sep 2013 to 202.43.95.18. This article is copyrighted as indicated in the abstract.

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http://proceedings.aip.org/about/rights_permissions FIGURE 4. Fault Performance from

Radon Survey on Geology Map CONCLUSION The Radon method result shown two lineament anomalies that indicating as the fault. The first trend in the

southwest-northeast direction which is connecting Gunung Botak and Kunjir geothermal manifestations.

The other fault in the NNE – SSW direction cross to the first into Bulakan. Based on contour map of Radon and Thoron concentration ratio, the second anomalies, characterized with high value, indicated the extending fault from depth.

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Walia and C. H. Chen, *Geochemical Journal* 39, 427-439 (2005). 2. K. Ioannides, C. Papachristodoulou, K. Stamoulis, D. Karamanis, S. Pavlides, A. Hatzipetros and E. Karakala, *Applied Radiation and Isotopes* 59 (2-3), 205 – 213 (2003). 3. J. Swakon, K. Kozak, M. Paszkowski, R. Gradzin'ski, J. Loskiewicz, J. Mazur, M. Janik, J. Bogacz, T. Horwacik and P Olko, *Journal of Environmental Radioactivity* 78(2), 137 – 149 (2004). 4. G.

Jönsson, *Radiation Measurements* 25(1-4), 537-546 (1995). 5. A. Lopez, L. Gutierrez, A. Razo and M. Balcazar, *Nuclear Instruments and Methods in Physics Research* 255, 426-429 (1987). 6. A. Rodriguez, Y. Torres, L. Chavarria and F. Molina, *Geothermal Training Programme 30 th Anniversary Workshop Orkustofnun , Grensasvegur 9, Iceland, 2008.* 7. L. Zuhui, W. Yujin, C. Donrong, L. Youming, X.

Aijun and J. Fuxing, *Nuclear Tracks Radiation Measurement* 22(1-4), 387-392 (1993). 8. Tilstey, *Open File Report 5876 , Ministry of Northern Development and Mines, 1993.* 9. G. A. Duddrige, *Observations on Soil Gas Variations in the Bovey Basin, Proceeding of*

the Ussher Society , 1995. 10. N. K. Phuong, A. Harijoko, R. Itoi and Y.

Unoki, *Journal of Volcanology and Geothermal Research* , 229 –230, 23-33, (2012). 11. P. Bronto, G. Asmoro, Hartono and Sulistiyono, *Indonesian Journal of Geology* 7(1), 11-25, (2012). 12. B. Budiardjo, Masdjuk and A. M. N. Leonardus, Project Report , PERTAMINA Divisi Panasbumi, Indonesia, 1995. 13. Suswati, N. Haerani and I. S.

Sutawidjaya, Laporan Kegiatan, Direktorat Vulkanologi dan Mitigasi Bencana, Badan Geologi Bandung, 2001. 14. S. Suharno, Soengkono and A. Hidayatika, "Magnetic Analysis to Determine the Permeability of a Geothermal Reservoir: Case Study of the Mt. Rajabasa Geothermal System, Lampung Selatan Indonesia " in Proceedings World Geothermal Congress, Bali, 2010. 15. N. Haerudin, R. Wahyuningsih, Wahyudi and W.

Suryanto, "Interpretasi Kualitatif Data Anomali Magnet Total untuk Menentukan Gambaran Umum Struktur Bawah Permukaan di Daerah Panasbumi Rajabasa " in Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA, Edited by D. Darmawan, Fakultas MIPA, Universitas Negeri Yogyakarta, 2011, pp. 101-108. 16. N. Haerudin, Wahyudi, W.

Suryanto and Sarkowi, "Pemodelan 3D Data Anomali Magnet Total untuk Menentukan Reservoir di Daerah Panasbumi Rajabasa Provinsi Lampung, Indonesia" in Proceedings the 12 th Annual Indonesian Geothermal Association Meeting & Conference, Edited by Suharno, Bandung, 2012. 17. J. E. Gingrich, *Journal of Geochemical Exploration* 21, 19-39 (1984). 18. M. Balcázar, A. López Martínez, M. Huerta, J. H. Flores Ruíz and P.

Peña, "Use of Environmental Radioactive Isotopes in Geothermal Prospecting " in The 17 th Pacific Basin Nuclear Conference , Instituto Nacional de Investigaciones Nucleares, Mexico, 2011. 19. A. K. Stoker and P. Kruger, "Radon in Geothermal Reservoir " in Second U. N. Symposium Devel. Use. Geotherm. Resour., San Fransisco, 1975, pp. 1797- 1803. 20. A. Abdoh and M. Pilkington, *Geoprospection* 25(4), 341-354 (1989). 21. R.W.

Klusman, *Gas and Related Methods for Natural Resource Exploration* , England: John Wiley & Son Ltd, 1993, pp. 483. 221 Downloaded 20 Sep 2013 to 202.43.95.18. This article is copyrighted as indicated in the abstract. Reuse of AIP content is subject to the terms at: http://proceedings.aip.org/about/rights_permissions

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