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 International Seminar on Mineral and Coal Technology IOP Conf. 1 Series: Earth and Environmental Science 882 (2021) 012046 IOP Publishing doi:10.1088/1755-1315/882/1/012046 1 Identification of zeolite using electrical resistivity tomography in Campang Tiga, South Lampung Regency Alhada Farduwin1*, Pangeran G. Lumbatoruan1, Karyanto2 and Dian Triyanto3 1 Teknik Geofisika Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Hui, Kecamatan Jati Agung, Lampung Selatan 35365, Indonesia 2 Teknik Geofisika Unversitas Lampung, Jl. Prof. Sumantri Brojonegoro No.1 Gedong Meneng, Kec. Rajabasa, Lampung 35142, Indonesia 3 PT Mahakarya Abadi Perkasa, Jl. Banteng No.78, Turangga, Kec. Lengkong, Bandung 40264, Indonesia *Corresponding author's e-mail: alhada.farduwin@tg.itera.ac.id Abstract. Currently, zeolites are widely used in various fields including horticultural, agricultural, household, industrial, water and wastewater management. 1 Due to the increasing use of zeolites, it is estimated that the demand for zeolites will increase in the future. Therefore, it

is necessary to conduct a survey to determine the potential of zeolites in an area. Campang Tiga is an area with quite a lot of potential zeolite and is exposed on the surface along with tuffs from the Lampung Formation. To estimate the potential zeolite in this area, it 1 was carried out the Electrical Resistivity (ERT) measurements to determine the distribution and depth of the tuff layer associated with the zeolite. Measurements were made in 3 lines with an electrode spacing of 6 m using a dipole-dipole configuration. The result performs that the zeolites 7 in the area are located at a depth of up to ~ 10 m and are getting thicker towards the east until they reach a depth of ~ 20 m. 2 The results of this interpretation have been combined with the results of laboratory measurements of the resistivity value of zeolites in the area. Laboratory test results present that the zeolite resistivity value ranges from 20-300 Ωm. 1. Introduction Indonesia is an area located in the volcanic pathway which produces a lot of material sediment from volcanic eruptions such as fine-grained tuff pyroclastic rock which is acidic in nature. This fine tuff is widespread following the volcanic path, which partially or completely has undergone 13 a process of change or diagenesis to become zeolites. Therefore, Indonesia has a great potential to produce zeolites such as those in Sumatra (Lampung, North Sumatra), Java (West Java, Central Java, East Java), East Nusa Tenggara and Sulawesi. Geologically, zeolites are 6 found in tuff rocks that are formed from sedimentation, volcanic dust that has undergone an alteration process. There are 4 processes as an initial description of zeolite, namely the sedimentation process of volcanic dust in an alkaline lake environment, the alteration process, the diagenesis process and the hydrothermal process. Zeolite is a mineral group with naturally occurring alumina silicate framework with high cation exchange capacity, high absorption, and hydration-dehydration properties. Zeolite is also 6 a group of non-metal rock type minerals that have functions such as absorption, ion exchange, molecular filter, and catalyst [1]. 1 In several ways, zeolite minerals can be utilized in various fields, including horticulture, agriculture, household, industry, water and wastewater management [2]. Currently, zeolite minerals are more widely used in industrial waste management, controlling ammonium released by fish, can increase

International Seminar on Mineral and Coal Technology IOP Conf. 1 Series: Earth and Environmental Science 882 (2021) 012046 IOP Publishing doi:10.1088/1755-1315/882/1/012046 2 plant growth and yield, can absorb harmful gas molecules such as CO_2, C_2O, H_2S and other gases for eliminates unpleasant smell in the surrounding environment. With the increasing scope of the use of these zeolites, it is estimated that in Indonesia there will be an increase in zeolite consumption. Campang Tiga is an area located in South Lampung Regency, Lampung Province which has the potential for zeolites associated with white and grey tuff with a fine and coarse grain composition. The potential for zeolite in South Lampung Regency, especially the Campang Tiga and Katibung areas is estimated to reach 2 million tons in an area of 35 ha with mineral content in the form of clinoptilolite and mordenite with the mineral association of plagioclase, montmorillonite, cristobalite and quartz [1]. 1 Based on the magnitude of the zeolite potential in the South Lampung area, it is necessary to map the subsurface in terms of determining zeolite distribution and its potential in this area. The geophysical method is a fundamental tool for imaging the subsurface models based on physical parameters where the results can be used for strategies and development of subsurface exploration [3]. ERT is a geophysical method that images the subsurface based on its resistivity value parameter. The ERT, which is commonly based on a multi-electrode system, consists of the application of a direct current into the ground by means of two current electrodes and the measurement of the resulting voltage via two potential electrodes; each of the electrodes alternatively acts as a current and potential electrode. To obtain a true resistivity model of the subsurface, an inversion procedure is needed [4,5]. The application of the ERT method has been widely used for various case studies, for example, lava tube estimation [3], identification of karst morphology [6,7], identification of groundwater potential and zeolite-bearing zone [8,9], etc. This study aims to determine 1 the distribution of zeolites based on the resistivity model obtained from the ERT measurements. 2. Regional Geology 10 Based on the geological map shown in Figure 1 [10], the research area consists of volcanic rocks from the Pliocene and Holocene ages. The oldest rock in the study area is andesite volcanic rock, which is Pliocene (Tertiary) age. Then, in the top of andesite volcanic rock was deposited Lampung tuff from Late Pliocene to Pleistocene age.   Figure 1. Geological map of the research area locating in Lampung Formation (QTl) (modified from [10]).

4 International Seminar on Mineral and Coal Technology IOP Conf. 1 Series: Earth and Environmental Science 882 (2021) 012046 IOP Publishing doi:10.1088/1755-1315/882/1/012046 3

The youngest rocks are young volcanic deposits, consisting of lava (andesite-basalt), breccias, and tuffs deposited from Late Pleistocene to Holocene. The Campang Tiga area is 8 included in the Lampung Formation (Qtl) where this formation dominates almost the entire area on the Tanjung Karang sheet. This formation comprises pumiceous tuff, rhyolitic tuff, welded tuff tuffit, tuffaceous claystone and tuffaceous sandstone 1 which have a Pleistocene age. The results of volcanic activity either from eruptions or the result of deformation due to volcanic processes, tectonism, or sedimentation will form rock distribution in the form of tuff in the area. 3. Method In this study, a dipole-dipole configuration in the ERT data acquisition process was applied. It is a combination of depth sounding and profiling techniques. This configuration was chosen because it was able to delineate the vertical structure well and this array has a better horizontal data coverag [11] and has been widely used in shallow exploration [12–14]. Figure 2 is a schematic of the electrode arrangement in measurement using a dipole-dipole configuration. The geometric factor of dipole-dipole array expressed as: $K = \pi na(1+n)(2+n)$ Figure 2. Two different of dipole-dipole arrangements 14 with the same array length but with different "a" and "n" factor [11]. This configuration is massively used in resistivity/IP measurements 5 because of the low electromagnetic coupling between the potential and current electrodes. The dipole-dipole electrodes 3 array consists of two sets of electrodes, the current (C1-C2 as source) and potential (P1-P2 as receiver) electrodes. In the measurement procedure, the dipole-dipole electrode array keeps the distance equal and is separated by "a" distance. Meanwhile, 15 the distance between the current and potential electrode pairs (inner electrodes) is separate as far as "na", where the value of "n" is an integer. The "a" and "n" variation values will affect the level of range sensitivity in this array. 5 The greater the value of “n”, the deeper the depth is obtained. However, a large value of “n” will cause the transmitted signal to become weak. To overcome this, when making measurements it is better to use a device with a high sensitivity and there should be good contact between the electrodes and the ground. In 3 the data acquisition process, it used Ares (Automatic Resistivity and IP System) from GF Instrument (Czech Republic) with total of 32 channels and the distance between the electrodes of 6 m. Measurements 2 were carried out in 3 lines as shown in Figure 3 over an area of ~ 6 ha. Then in the processing stage, the RES2DINV program was used. This program supports the execution of the leastsquares method based in a quasi-Newton optimization technique [5]. 5 The choice of the inversion result solution is done when the error value for each iteration does not change significantly (convergent). This (a) (b)

4 International Seminar on Mineral and Coal Technology IOP Conf. Series: Earth and Environmental Science 882 (2021) 012046 IOP Publishing

doi:10.1088/1755-1315/882/1/012046 4 usually occurs between the 3rd and 5th iterations. To obtain good analysis results, resistivity measurements 2 were carried out in the laboratory for some of the samples obtain from the Campang Tiga area. These samples obtain from zeolite mining industry around the area. Then Real Time Rock Resistivity Meter was used to measure each sample. This instrument has an error measurement below 2.2 % [15]. The results of this measurement can be seen in Table 1. Figure 3. Survey design of research acquisition consisting of 3 lines with E-W orientation but in Line C oriented in the NW-SW direction. Table 1. Resistivity measurement of zeolite samples of the area. Sample Resistivity test (Ωm) Mean Resistivity (Ωm) std 1 2 3 4 5 Z1 Z2 Z3 Z4 Z5 Z6 Z7 Z8 Z9 32.85 145.03 20.60 148.66 182.65 60.71 18.94 25.24 33.35 13.58 148.36 20.73 178.72 255.82 46.82 15.11 25.10 27.12 22.89 212.98 20.54 182.64 267.30 48.56 19.89 18.23 35.17 18.40 196.61 20.07 188.09 307.52 59.67 20.03 22.21 26.37 21.12 138.28 20.60 200.46 242.78 57.82 16.76 17.12 32.69 21.77 168.25 20.51 179.71 251.22 54.72 18.14 21.58 30.94 7.12 34.05 0.25 19.20 45.34 6.53 2.14 3.78 3.95

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doi:10.1088/1755-1315/882/1/012046 5 4. Results and Discussion 4.1. Results 1 Based on the analysis results of the resistivity value in the laboratory, it is known that the zeolite resistivity value in the study area ranges from 20-300 Ωm. This test was carried out to 9 samples taken directly from the area of these samples, there is a low resistivity value in the sample due to the relatively wet sample and high resistivity value due to the relatively dry sample. Each sample is tested 5 times 10 and then the average resistivity value is taken which is considered to reflect the actual resistivity value of the zeolite in the study area. Furthermore, this resistivity value 3 is used for the interpretation stage of the ERT processing results. The processing results on Line A, B and C (Figure 4) show that there are 3 main layers. The upper layer is a tuff layer associated with zeolite minerals. This first layer 11 has a resistivity value of 20-300 Ωm spread evenly from the surface to a depth of ~ 10 m. The thickness of layer 1 is getting thicker towards the east to a depth of ~20 m. Line A is a line with a thin zeolite layer (layer 1) with 1 the thickness of ~ 5 - 7 m. Lines B and C are the lines with a layer thickness containing the thickest zeolite reaching ~ 10 m and ~ 20 m in the east. 3 In the middle layer (layer 2 with a depth of >10 m), there is an anomaly of the resistivity value below 20 Ωm which is interpreted as the layer associated with groundwater. The lithology in this layer is the tuffaceous sandstone layer. This is evidenced 10 by the presence of dug wells with a depth of ~ 12 m and groundwater for household needs of residents in the study area. Furthermore, the lowest layer (layer 3) shows an anomaly of high resistivity values. This layer is thought to be the andesite rock layer which is the oldest rock in the area. Figure 4. ERT result with topography; (top) line A; (middle) line B; (bottom) line C.

doi:10.1088/1755-1315/882/1/012046 6 4.2. Discussion The interpretation of resistivity anomalies uses two guidelines. First, the resistivity value of zeolite samples 10 was used to delineate tuff layers that associated with zeolite. This resistivity value was used because these samples are located near the study area (still in the same formation) and these samples are taken directly from zeolite mining site. From the result, zeolite can be predicted in the top of subsurface until the depth of ~10 m. Then in the eastern part, the zeolite is getting thicker until it reaches a depth of ~ 20m. Thus, the medium anomalies (20-300 Ωm) locating at depth 0-10 m correspond to zeolite mineral. Although, there are some low resistivity anomalies at these depths caused by the presence of fluid. Second, the low resistivity value in the inversion result caused by the groundwater presence. The effect of the presence of fluid will decrease the resistivity value. So, second layer in the research area are associates with the groundwater. 5. Conclusions The ERT method using dipole-dipole configuration was applied in the Campang Tiga to predict the distribution of zeolite mineral. To obtain the good result, the laboratory measurement of zeolite samples was carried out. From the inversion result, combined with the laboratory measurement, the ERT can delineate tuff layer associates with zeolite mineral. The distribution of zeolite in Campang Tiga can be predicted in the top of subsurface and getting thicker in the eastern part. References [1] Kusdarto 2008 Potensi zeolit di Indonesia J. Zeolit Indones. 7 78–87 [2] Margeta K dan Farkaš A 2020 Introductory chapter: Zeolites - From discovery to new applications on the global market Zeolites - New Challenges (IntechOpen) hal 1–10 [3] Torrese P, Pozzobon R, Rossi A P, Unnithan V, Sauro F, Borrmann D, Lauterbach H dan Santagata T 2021 Detection, imaging and analysis of lava tubes for planetary analogue studies using electric methods (ERT) Icarus 357 114244 [4] Griffiths D . dan Barker R . 1993 Two-dimensional resistivity imaging and modelling in areas of complex geology J. Appl. Geophys. 29 211–26 [5] Loke M H dan Barker R D 1996 Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method1 Geophys. Prospect. 44 131–52 [6] Bermejo L, Ortega A I, Guérin R, Benito-Calvo A, Pérez-González A, Parés J M, Aracil E, Bermúdez de Castro J M dan Carbonell E 2017 2D and 3D ERT imaging for identifying karst morphologies in the archaeological sites of Gran Dolina and Galería Complex (Sierra de Atapuerca, Burgos, Spain) Quat. Int. 433 393–401 [7] Drahor M G 2019 Identification of gypsum karstification using an electrical resistivity tomography technique: The case-study of the Sivas gypsum karst area (Turkey) Eng. Geol. 252 78–98 [8] Kumar D, Rao V A, Nagaiah E, Raju P K, Mallesh D, Ahmeduddin M dan Ahmed S 2010 Integrated geophysical study to decipher potential groundwater and zeolite-bearing zones in Deccan Traps Curr. Sci. 98 803–14 [9] Mainoo P A, Manu E, Yidana S M, Agyekum W A, Stigter T, Duah A A dan Preko K 2019 Application of 2D-Electrical resistivity tomography in delineating groundwater potential zones: Case study from the voltaian super group of Ghana J. African Earth Sci. 160 103618 [10] Mangga S A, Amirudin T, Suwarti S, Gafoer dan Sidarto S 1993 Peta Geologi Lembar Tanjungkarang, Sumatera, Skala 1:250.000 [11] Loke M H 1999 Electrical imaging surveys forenvironmental and engineering studies: A practical guide to 2-D and 3-D surveys (Penang, Malaysia: M. H. Loke) [12] Puspita M B dan Suyanto I 2020 Investigation of groundwater aquifer at Noborejo, Salatiga using electrical resistivity tomography (ERT) and vertical electrical sounding (VES) methods IOP Conf. Ser. Earth Environ. Sci. 524 012009 [13] Alshehri F dan Abdelrahman K 2021 Groundwater resources exploration of Harrat Khaybar area, International Seminar on Mineral and Coal Technology IOP Conf. Series: Earth and Environmental Science 882 (2021) 012046 IOP Publishing doi:10.1088/1755-1315/882/1/012046 7 northwest Saudi Arabia, using electrical resistivity tomography J. King Saud Univ. - Sci. 33 101468 [14] Arjwech R, Sriwangpon P, Somchat K, Pondthai P dan Everett M 2020 Electrical resistivity tomography (ERT) data for clay mineral mapping Data Br. 30 105494 [15] Yogi I B S, Pangestu R, Karyanto K dan Darmawan I G B 2020 Instrumen real time rock resistivity meter untuk mengukur resistivitas dan memonitor sifat kelistrikan sampel batuan J. Geosaintek 6 143

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