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GEOLOGICAL MODELLING OF LITHOSEQUENT BASED ON DEM AND *FINITE ELEMENT METHOD* INVERSION OF VES DATA

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ABSTRACT

The aim of this study was to develop interpretation of structural geology in lithosequent using DEM and finite elemen method based on VES data. This research was conducted on June 2021 until January 2022 at Pasang District, North Toraja. Four main point locations were selected and recorded in google earth. Those points were processed using software QGIS for developing 3D model, Saga-GIS for interpolated DEM and VES for generating 1D and 2D geoelectrical modelling. Data were interpolated using Universal Kriging method and analysed using IP2WIN software. The results of these research shows that Geostatistical Universal Kriging can be used for interpolating DEM in lithosequent Pasang Village, by using $a + b.In(x)$ as the variogram equation and yield 95,12% determinations; VES method in geoelectrical resistivity can be configured into 2D and produced clearer modeling of pseudo-section; The synthetics data can be generated from field measurement data and interpretation of 2D VES; Result of synthetic block on geoelectrical data can be inverted using Finite Element Method and generated clearer data; By using these methods, the thickness of weathering layer in lithosequent Pasang Village can be estimated and modelling.

Keywords*:* Geological, Modelling, Digital Elevation Model (DEM),Vertical Electrical Sounding (VES).

INTRODUCTION

Geological information of an area can be extracted from remotely sensed data by analyzing basic elements of the image such as hue or color, texture, pattern, size, shape, shadow, and association. These elements will describe the surface expression of an area including morphology, soil moisture, land cover, and flow patterns which are strongly influenced by lithology type, geological structure, process, and time. Digital elevation model (DEM) data is a remote sensing product that is widely used for mapping geological structures. Geological information can be extracted from DEM data including shaded relief, lineament, slope and direction towards the slope, flow patterns and curvature which can be used to extract information about lithological types and geological structures. Furthermore, DEM data can be used for morphotectonic analysis (Evans, 1980;

Jordan, et al., 2005; Abdullah, et al., 2010; Muhammad and Awdal, 2012).

The strength and rigidity of a foundation is highly dependent on the geological conditions of the development area. One of the geological conditions that affect the strength of the foundation is soil stability (Alfaiz, 2017). When the soil as a place to put or stick the foundation is deformed in the form of fractures, subsidence, or shifts, then the construction of the building on it can be damaged. Potential damage to buildings due to deformation of the subsurface soil can be identified from the thickness of the weathered layer. (Artono, et al. 2017; H Sulistiawan et al., 2016). In order to minimize the risk of construction damage during construction, a subsurface study to identify the thickness of the weathered layer needs to be carried out. Today, geophysical methods and geotechnical methods have a very large relationship in terms of building public facilities and infrastructure (Suntoko, and Mauritz, 2006). One of the most widely used geophysical methods in subsurface surveys is the geoelectric method.

The purpose of this study was to determine the condition of the regional lithosequent and to develop a mechanism for the presence of geological structures reflected in the field conditions and Geoelectrical Vertical Electrical Sounding data. This research is expected to provide scientific benefits and enrich the treasures of remote sensing research on the geological structure.

RESEARCH METHOD

The research is conducted on Pasang Village, North Toraja Regency which is Geographically located on 119^{o}49’26,6” BT-119^{o}49’42,1” BT dan 02^{o}59’45,8” LS - 02^{o}59’76,4” LS. Equipment that used in this research are: 1 set of geoelectric resistivity equipment that has been configured with the Schlumberger method; one set Global Positioning System *Garmin*, Geological Hammer (Sediment Hammer). While the main material is rock samples from geoelectric drilling sites. Sampling method was done by random sampling

The Geoelectrical Modeling Survey was carried out with the Schlumberger Configuration for mapping the condition of the main rock and weathered layers, and the 2D dimensional VES modeling for determining rock types and mapping the genesis environment below the ground surface. Sampling of the rock is taken at cutting section cliff at the same location as Geoelectrical Mapping. Stone samples were obtained using a geological hammer.

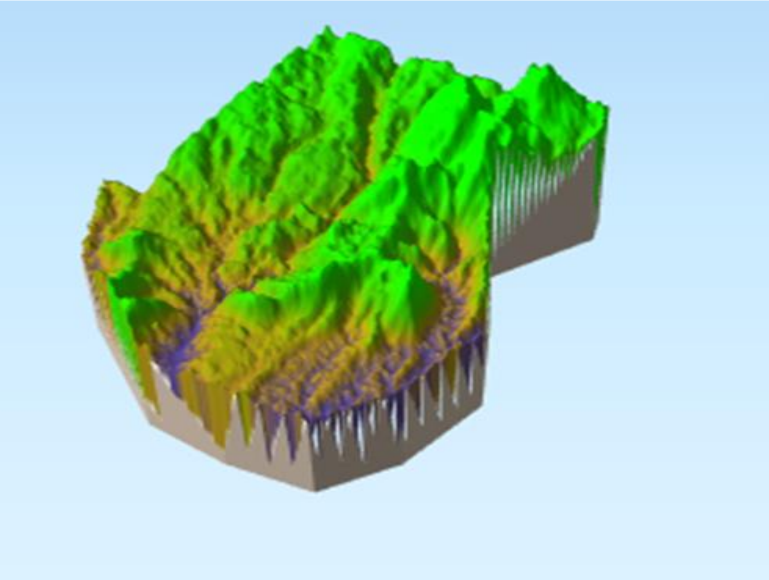
RESULT AND DISCUSSION

Construction of 3D Digital Elevation Modelling.

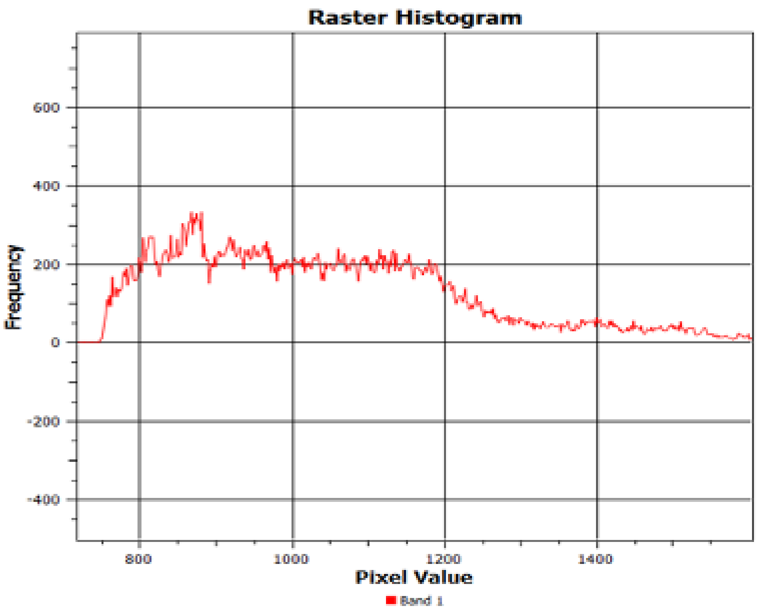
DEM is a digital surface model of a reference ellipsoid and interplote Triangulated Irregular Network (TIN). The main advantages of TINs are: knowledge storage potency-adjustable to piece of land complexness; ability to represent ridge lines, valley lines, and breaks in slope exactly. The main benefits of employing a contour-based DEM in GIS are: DEMs may be diagrammatical employing a customary vector object + attribute structure. Variable node frequency on the slope direction permits economical information storage. The most disadvantages are: lack of data in flat areas and issue in mere indicating breaks on slopes. The chaotic nature of the information makes any analysis (such as slope and side reduction) longer intense compared to different sorts of DEM straightforward geometric calculations for analysis.

DEM results on Picture 1 can be used in many engineering or non-engineering application. The application can be in the form of studying the effect of sea level rise on geo-biophysical parameters, predicting island continuity, surface flow, slope direction, contour variation, and many more. The above characteristics are then used as the basis for interpolating the SRTM height data in order to obtain a more detailed level for application analysis purposes. Interpolation is carried out using a solid surface modeling approach with TIN (Triangulated Irregular Network) and Kriging (Suparyanto, 2007).

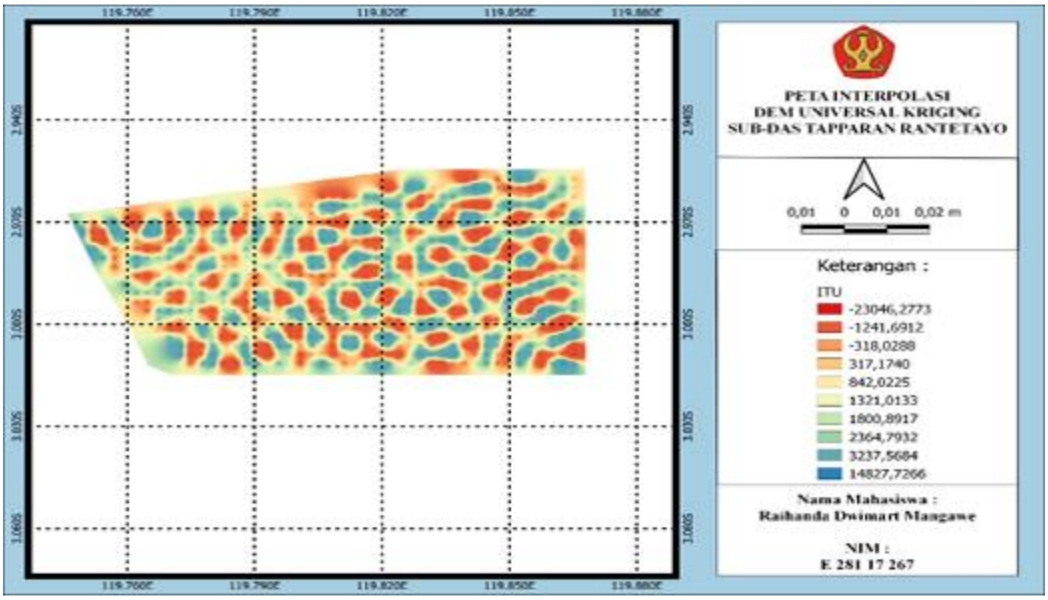
It is typically found that slope maps created using DEM SRTM or ASTER GDEM information are remotely perceived information and cover nearly the whole layer. In general, the results of passive and active remote sensing imaging area unit produced all info concerning the outer object from the layer, specifically land cover objects. Picture 2 shows that the height generated from the remote sensing image includes the peak of the land cowl object, not solely the peak of the bottom surface.



Picture 1: DEM 3D on location



Picture 2. Histogram Raster of 3D DEM



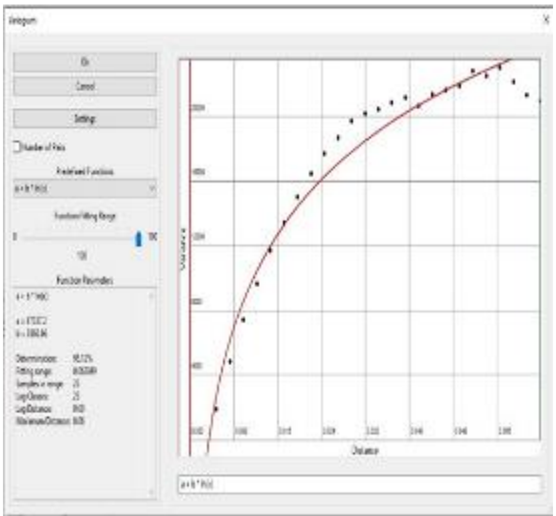
Picture 3. Interpolation of DEM using Geostatistics Universal Kriging

Digital Elevation Modeling is carried out using DEM data from the DEMNAS website which has a resolution of up to 5 meters on IFSAR and TERRASAR X data but on the ALOS PALSAR satellite the resolution is 11.25 meters. After the DEM data are downloaded, the DEM data are then processed using QGIS software and cut (Geoprocessing) with regional polygon data. The model in Picture 3 is an Interpolated Digital difficult to create DEM using the Universal Kriging method. To carry out Universal Kriging interpolation for DEM at the location, which is included in the Tapparan Sub-watershed, some interpolation stages has been executed as follow:

1. The DEM shapefile data have been converted to Vector as input into the SAGA (System for Automated Geoscientific Analysis) software.
2. Defining a number of additional properties such as variance, Universal Kriging algorithm for predictors, and Type of Quality Measure.
3. Applying the Variogram equation that used in this case:

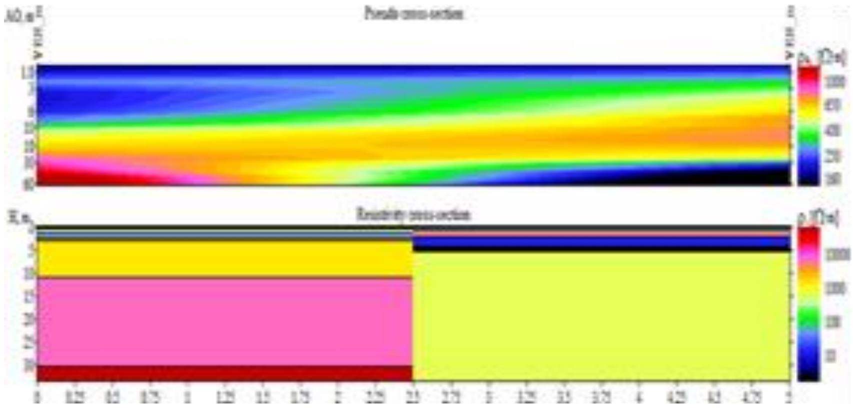
$$a + b.In(x)$$

so that the variogram is obtained as follows :

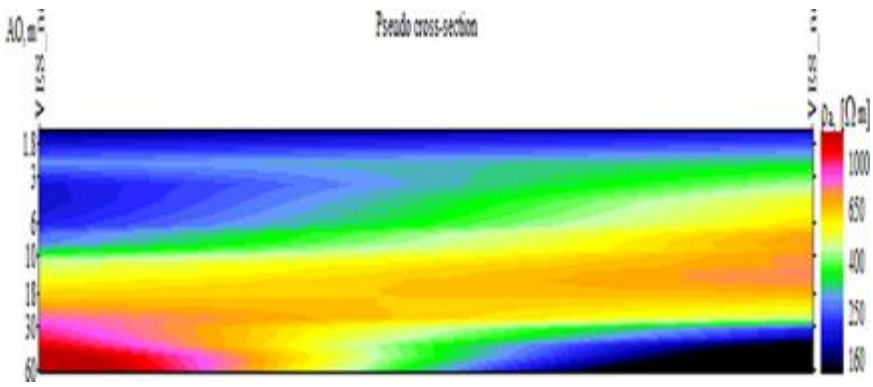


The variogram above also shows the following function parameters, which are calculated using the previous equation. Laksana (2010) and Aisha, et all. (2018) said Universal Kriging is a general form of Simple Kriging as a way of expanding the ordinary kriging method. Universal Kriging is kriging of data that have a certain trend tendency. This method is appropriate if used on values at the sample point that do have a certain tendency. For example, the thickness of the layer increases with the change in direction or the value of the permeability decreases with the distance from the sand channel.

The results of processing with 1 and 2 dimensionals modeling as shown on Picture 4 and Picture 5 are obtained using a matching curve approach.



Picture 4. Resistivity table of each layer and 1 dimension curve

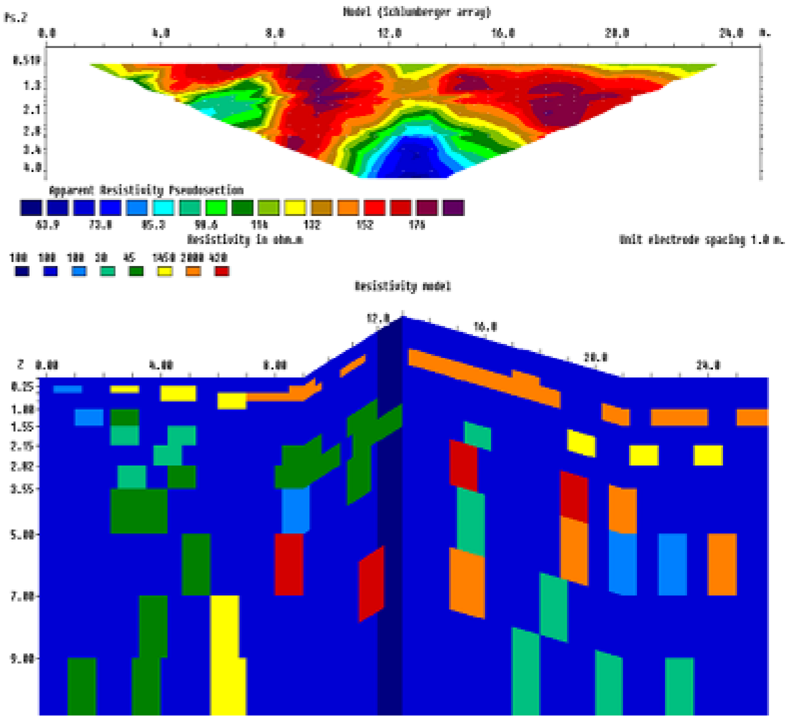


Picture 5. Dimension 2D VES (Pseudo-Section)

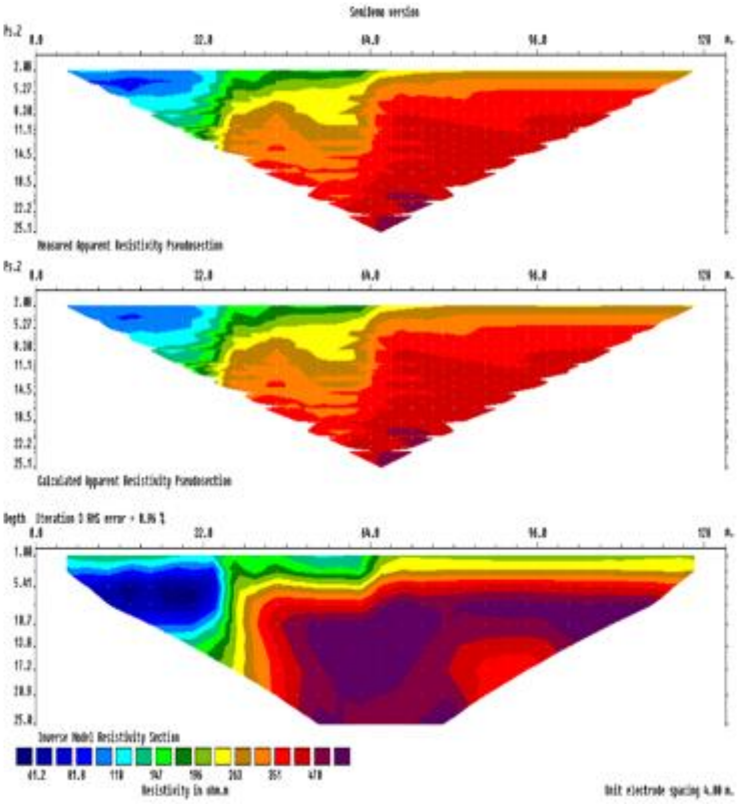
From this approach, the subsurface rock composition of the study area can be determined. Based on rock resistivity values and geological map analysis of the local area, it can be interpreted into several layers, including top soil which has a resistivity value of 29.5 – 49.2 m with a depth of about 1 – 2.64 m on all tracks. Andesite rock layers with a resistivity value of 212 – 300 meters are at a depth of about 1.3 – 1.86 m located on lines 1 and 2 Formation of the depositional environment and age of rock units is determined based on the principle of proportionality by looking at the similarity of lithological physical characteristics and geographical distribution which is relatively close to the type location. The shale unit in the study area megascopically shows physical characteristics showing a reddish gray color in a fresh state and brown color blackish in weathered condition such as: clastic texture, clay grain size (< 1/256) mm, good sorting, closed packaging, and layered structure. From the observation of physical characteristics, this unit can be compared with member of shale from the Toraja Formation which consists of shale, gray brown marl, limestone and sandstone.

Data Processing of 2D Vertical Electrical Sounding to 2D Mapping with Finite Element Method Inversion.

By using 2D VES data and the sounding resistivity values that have been obtained previously, the sounding zone can be known to interpret underground conditions. This sounding zone is then used as material to build a brick model using the Res2DMod application. Picture 6 below shows the resistivity model built by Res2DMod with Topography consideration.



Picture 6. The resistivity model built by Res2DMod



Picture 7. Inversion result with Finite Element Method

Next step is opening the Res2Dinv program and load the saved forward model. Then inverse the model using Least Square Inversion. For Mesh parameter, "Finite Element Method" was chosen. The result is shown in Picture 7. The RES2DMOD application is software for forward modeling. The forward modeling used is the Wenner-Alpha, Pole-Pole, and Schlumberger configurations. It basically has the same concept of generating clean Rho values. For each subsequent modeling, there will be different cross-sectional results due to the electrode spacing, scale factor (n), geometric factor, etc., so the apparent Rho value will be different, and the geological structure will also be different.

CONCLUSION

Based on the entire discussion above, we can conclude:

1. Geostatistical Universal Kriging can be used for interpolating Digital Elevation Model in Lithosequent Pasang Village, by using $a + b.In(x)$ as the variogram equation and yield 95,12% determinations.
2. Vertical Electrical Sounding method in geoelectrical resistivity can be configured into 2D and produced clearer modeling of pseudo-section.
3. The synthetics data can be generated from field measurement data and interpretation of 2D Vertical Electrical Section.
4. Result of synthetic block of geoelectrical data can be inverted using Finite Element Method and generated clearer data.

REFERENCES

Abdullah, A. Akhir, J.M. and Abdullah, I., 2010. *Automatic Mapping of Lineaments Using Shaded Relief Images Derived from Digital Elevation Model (DEMs) in the Maran – Sungi Lembing Area, Malaysia*, Electronic Journal of Geotechnical Engineering, 15, pp 1–9.

Aisha, F.Y., Warnana, D. D., dan Ariyanti, N., 2018. *Pemodelan Geostatistik 3D Pada Sebaran Batuan Karbonat Menggunakan Metode Krigging Berdasarkan Data Resistivitas 2D dan S-PT*. Jurnal Geosaintek, Vol 4(3), hal: 95-102.

Alfaiz, A.A., J. Hutahaean. 2017. *Penentuan Lapisan Keras Untuk Kelayakan Pembangunan Gedung Bertingkat Menggunakan Metode Geolistrik Resistivitas Di Pesisir Pantai Kahona Kabupaten Tapanuli Tengah*. Jurnal Einstein 5(3): 1-7

Apriani, Intan, Teti Arabia, dan Sufardi Sufardi. 2019. *Identifikasi Mineral Tanah dengan Menggunakan Difraksi Sinar-X pada Inceptisol Aceh Besar*. Jurnal Ilmiah Mahasiswa Pertanian 4(3): 155-163

Artono V.Y., R. Efendi, dan Sandra. 2017. *Identifikasi Lapisan Lapuk Bawah Permukaan Menggunakan Seismik Refraksi di Desa Lengkeka Kecamatan Lore Barat Kabupaten Poso*. Journal of Science and Technology, 6(3): 291-300.

Awali A.A, Yasin H., Rahmawati R. 2013. *Estimasi Kandungan Hasil Tambang Menggunakan Ordinary Indicator Kriging*, Jurnal Gaussian, 2 (1): 1-10.

Atriyon, Julzarika dan Wiji. 2012. *Penggunaan Data Satelit Optik Dan SAR Untuk Pendeteksian Lempeng Dan Struktur Geologi.* Globe Volume 14(2): 124-133

Bowles, Joseph E. 1991. *Sifat-sifat Fisis dan Geoteknis Tanah (Mekanika Tanah)*. Erlangga: Jakarta.

Ciptakarya. 2011. *BAB 6 Profil Kabupaten Toraja Utara.* http://sippa.ciptakarya.pu.go.id/sippaonline/ws _file/dokumen/rpi2jm/DOCRPIJM_1508999993Bab_6_Profil_Kabupaten_Toraja_Utara_RPI2JM.pdf (Diakses pada 10 Juli 2021)

Dzakiya, N., Aditya, M. A. B., Jayadi, H., & Setiawan, D. G. E. 2020. *Analisis Sebaran Lava Bantal Watuadeg Yang Didukung Data Vertical Electrical Sounding (VES) Di Lapangan 'Agsty' yogyakarta*. Jambura Physics Journal, 2(1): 44-53.

Evans, I.S. 1980. *An integrated system for terrain analysis for slope mapping*. Z. Geomorphol. 36: 274–295

Hardiyatmo, H. C. 2006. *Mekanika Tanah 1, Edisi Keempat.* Penerbit Gadjah Mada University Press, Yogyakarta.

H. Sulistiawan, I. Yulianti, dan S. Adi, 2016. *Identifikasi Studi Ketebalan Lapisan Sedimen Daerah Kampus Unnes dengan Menggunakan Metode Mikroseismik*. Prosiding Sng, pp. 42-47.

H. Suntoko, dan L.T. Mauritz, 2006. *Penyelidikan Geoteknik untuk Pondasi Dangkal di Calon Tapak Pembangkit Listrik Tenaga Nuklir (PLTN) Daerah Ujung Lemahabang*. Prosiding Seminar Nasional ke-12 Teknologi dan Keselamatan PLTN Serta Fasilitas Nuklir. Yogyakarta: pp.12 -13.

Jordan, G. Meijninger, B.M.L., van Hinsbergen, D.J.J., Meulenkamp, J.E., van Dijk, P.M. 2005. *Extraction of morphotectonic features from DEMs: Development and applications for study areas in Hungary and NW Greece*. International Journal of Applied Earth Observation and Geoinformation 7: 163–182.

Kurniadi, A. S., Luthfi, M., Kadarisman, D.S., 2017. *Geologi Dan Petrogenesa Batuan Beku Diorit Daerah Bero Dan Sekitarnya Kecamatan Manyaran Kabupaten Wonogiri Jawa Tengah*. Jurnal Online Mahasiswa (JOM) Bidang Teknik Geologi, (1).

Laksana, E. A. 2010. *Analisis Data Geostatistika Dengan Universal Kriging*. Penerbit Universitas Negeri Yogyakarta.

Lopulisa, C., & Sutaatmadja, S. 2004. *Tanah–Tanah Utama Dunia, Ciri, Genesa Dan Klasifikasinya*. Lembaga Penerbitan Universitas Hasanuddin. Makassar.

Maryanto, S. Irwan, Sidik I.F., dan Fidyaningrum, S., 2013. *Modul Praktikum Geolistrik Resistivitas*. Laboratorium Geofika Universitas Brawijaya.

Muhammad, M.M. dan Awdal, A.H., 2012. *Automatic Mapping of Lineaments Using Shaded Relief Images Derived from Digital Elevation Model (DEM) in Erbil-Kurdistan, Northeast Iraq*. Advances in Natural and Applied Sciences 6(2): 138-146.

Noor, D. 2011. *Geologi untuk perencanaan*. Yogyakarta: Graha Ilmu.

Nursyafira, 2020. *Laporan Forward Modelling dengan Program RES2DMOD*. Program Studi Teknik Geofisika Jurusan Teknik Kebumian Fakultas Teknik Universitas Syiah Kuala

Saputro, B., 2010. *Panduan Praktikum Geolistrik*. Yogyakarta: Prodi Teknik Geofisika, Fakultas Teknologi Mineral, UPN Yogyakarta.

Simpen, I, 2015. Modul Praktikum Metode Geolistrik. Jurusan Teknik, Fakultas Teknik, Universitas Udayana.

Sukandarrumidi, Rakhman, A.N, Maulana, F.W., Purnamawati, D.I, dan Miftahussalam, 2018. *Belajar Petrologi Secara Mandiri*. Yogyakarta: Gadjah Mada University Press.

Suparyanto, I. H. 2007. *Optimalisasi Data Citra SRTM Bagi Kepentingan Studi Hidrologi Dan Geohidrologi*. Prosiding Geoteknologi LIPI, hal: 131-136.

Septiliana, Z, Hastuti E.W.D., dan Mayasari, E.D., 2018. *Geologi Dan Studi Provenance Batupasir Formasi Mengkarang Daerah Air Batu Kabupaten Merangin, Jambi*. Diss. Sriwijaya University.

Tamrakar, N.K., and Syangbo, D.K. 2014. *Petrography and provenance of the Siwalik Group sandstones from the Main Boundary Thrust region, Samari River area, Central Nepal, sub-Himalaya*. Boletín de Geología, 36 (2): 25-44.

Wilson, M., *Igneous Petrogenesis "A Global Tectonic Apporach"*, 2007, reprinted edition, Springer, p. 480.