Research Introduction

Introduction of a Geoinformatic Research on Resource and Reserve Estimations of Laterite Nickel Deposit at Hasanuddin University (Indonesia)

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1. Introduction

Hasanuddin University is one of the most prominent universities in Indonesia’s eastern part for number of students, academic staffs, undergraduate and postgraduate programs, facilities, and research and publication outputs. Hasanuddin University is a center of excellence in developing human resources, science, technology, art, and culture influenced by Indonesian status as a maritime nation.

Established in 1956, Hasanuddin University is a non-profit public higher-education institution located in the urban setting of the metropolis of Makassar (population ranging 1-5 million inhabitants), South Sulawesi Province, officially recognized by The Ministry of Research and Technology/National Research and Innovation Agency of Republic Indonesia. Hasanuddin University is a large (enrollment range: 25,000–29,999 students) coeducational Indonesian higher education institution. Hasanuddin University provides courses and programs leading to officially recognized higher education degrees such as bachelor, master, and doctorate degrees, respectively, in several areas of study. International applicants are eligible to apply for enrollment.

Hasanuddin University also provides several academic facilities and services to students including library, hospital, housing, sport facilities, financial and/or scholarships, study abroad, and exchange programs, as well as administrative services. Hasanuddin University has several specialized or programmatic accreditations including National Accreditation Board for Higher Education (BAN-PT), ABEST21, and ASEAN University Network-Quality Assurance (AUN-QA), and is also included in memberships of Association of Southeast Asian Institution of Higher Learning (ASAIHL). A map of the location of Hasanuddin University Campus and one scene of the campus are shown in Figures 1 and 2, respectively.

Hasanuddin University has 15 faculties consisting of 11 exact faculties and 4 non-exact faculties. One of the exact faculties is Engineering Faculty which was founded on September 7, 1960. The Engineering Faculty of Hasanuddin University is one of the best engineering sciences in Indonesia and located in a new campus in Gowa Regency since June 23, 2018, South Sulawesi Province, Indonesia. Figure 3 shows the new campus of Engineering Faculty in Gowa (see also Figure 1 for the map).

The Engineering Faculty has 13 departments. One of the

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departments is Mining Engineering with two types of educational programs; the Undergraduate Mining Engineering Program since 2004, and the Mining Engineering Master Program since 2020.

Mining Engineering Department has 5 laboratories, namely Exploration Engineering, Material Analysis and Processing, Geomechanics, Mine Planning and Valuation, and Hydrology and Mining Environment. Each laboratory is led by a laboratory head who is in charge of managing the running of the laboratory. For example, the Exploration Engineering Laboratory is headed by Dr. Ir. Irzal Nur, MT. with two lecturer staffs, Asran Ilyas, ST. MT. Ph.D. and Dr. phil. nat. Sri Widodo, ST. MT. Scientific specialization of Dr. Ir. Irzal Nur, MT. is geochemistry, Asran Ilyas is in the field of geostatistics and geophysics, and Sri Widodo is in the field of coal exploration. The three teaching staffs have published many scientific papers in their respective fields in various scientific journals both with international and national reputations.

In this research introduction, a research plan will be introduced, which is about how to reduce the level of uncertainty in resource and reserve estimations of laterite nickel deposits using statistical and geostatistical analyses of the geologic and ore grade data.

2. Research background

Research on nickel laterite deposits is currently growing, triggered by the increasing demand for nickel metal throughout the world. Nickel is a metallic chemical element on the periodic table that has the symbol of Ni and atomic number of 28. Nickel is a silvery-white metal. Nickel is considered a transition metal and is hard, ductile, and resistant to high temperatures.

The combination of nickel, chrome, and iron can produce stainless steel which is widely used in kitchen utensils, home building ornaments, and industrial components. Most of the nickel in nature is mined in two types of ore deposits, namely laterite nickel ore deposits and magmatic nickel sulfide ore deposits. Laterite nickel ore deposits are formed as a result of the weathering of ultramafic rocks in tropical climates, where the Ni element will undergo in a leaching process and dissolve into groundwater. Then this solution will settle to the bottom of the rock weathering zone and form an enrichment of ore deposits which are rich in nickel elements. Meanwhile, sulfide ore deposits are formed as a result of the magmatization process, where the main ore mineral is pentlandite.

From 2011 to 2017, world nickel production was increasingly produced from the Asian continent, including in Indonesia, due to the rapid increase in industries in Asia. Especially in Indonesia, according to the data from the Indonesian Geological Agency, nickel reserves in Indonesia as of June 2020 have reached up to 4,000 million tons from the total nickel resource of more than 16,000 million tons. These deposits generally come from the type of laterite nickel deposits. The increasing demand for nickel in the world, especially from nickel laterite deposits, has made the search for and exploration of laterite nickel deposits increasing, especially in Indonesia.

Various exploration techniques for laterite nickel deposits have been developed, especially in determining the size of the estimated resources and reserves of laterite nickel deposits. But sometimes, the results of the calculation of the amount of resources and reserves of laterite nickel deposits are still quite different from the reality of mining results in the field, although it cannot be denied that this will always exist. Therefore, studies on resource and reserve estimation techniques of laterite nickel deposits are continuously improved, so that the estimation results of resources and reserves do not over-estimate or underestimate. In other words, the amount of nickel reserves mined is not too different from the results of estimated resources and reserves of the laterite nickel deposits. Figure 4 shows one of the laterite nickel mine in the area of PT Vale Indonesia Tbk, one of the nickel mining companies in South Sulawesi Province, Indonesia (see Fig. 1 for the site map).

3. Research methods

One of the most widely used techniques for estimating the resources and reserves of laterite nickel deposits is the block modeling method. This method can be based on deterministic principles and stochastic techniques. Block modeling method with deterministic principles that is widely used is the Inverse Distance Weighting (IDW) method, while the block modeling method with stochastic techniques that is widely used is geostatistical method, namely the kriging method.

In practice, the two methods mentioned above have been widely used depending on the process of data exploration, processing, and data validation. But sometimes, the estimated results of the resources and reserves are still not in accordance with the results of the production data that has been mined. To increase the level of confidence in the results of the calculation
and estimation of laterite nickel deposits, several experiments and studies were carried out, including the development of modeling techniques to model the distribution of Ni grade in laterite nickel deposits and calculating the size of the resources and reserves. Therefore, one of the aspects that must be reviewed and studied further and researched in connection with the modeling of variations in the distribution of Ni grade in laterite nickel ore deposits is how the geological processes underlying the formation of laterite nickel deposits themselves, so that these factors will be used as the basis of reference in modeling and estimating the resources and reserves of laterite nickel deposits so that the level of confidence in the calculation results will be better with decreasing in uncertainty.

According to Brand et al. (1998) and Gleeson et al. (2003), the formation process of laterite nickel deposits is controlled by several factors, i.e., the host rock, climatic conditions, topography, tectonic setting, geological structure, groundwater, organic material composition, and the rates of weathering. Departing from the factors mentioned above, a research was carried out on one of the factors whose appearance can be seen at this time, namely the topographic factor, in this case is the topographic slope of the laterite nickel deposits. It can be interpreted that the slope topography that appears at this time in a laterite nickel deposit will affect the distribution of the Ni grade. This is also based on Ilyas et al. (2016) that revealed the topographic slope affects the distribution of nickel grade in these laterite nickel deposits. Therefore, it can be concluded that the topographic slope plays a very important role in the distribution of Ni grade in these laterite nickel deposits.

4. Examples of results

Based on the information above, it can be concluded that the topographic slope is one of the geological domains that must be considered in modeling and estimating the resources and reserves of laterite nickel deposits. Research on the distribution of Ni grade in laterite nickel deposits which is controlled by the slope topography factor is estimated to further increase the level of confidence in the modeling results and reduce the level of uncertainty on the modeling results. With the reduction in the level of uncertainty from modeling and estimating resources and reserves of laterite nickel deposits, it is hoped that the use of topographic slope domains is expected to be used as one of the benchmarks in modeling and estimating reserves of this laterite nickel deposit and can also be used for the same deposit types in various other parts of the world.

It is also known that one of the main principles of geostatistics is that the data being modeled has better the same stationarity properties (Bohling, 2005). This means that the data in nature are better in the same geological domain. Based on this, it can also be interpreted that the same topographic slope is the same geological domain of laterite nickel deposits. Therefore, it can be interpreted that the Ni element levels in laterite nickel deposits have values that tend to be relatively the same at the same topographic slope and it can also be interpreted that the thickness of the lateritization zone is also relatively the same, both in the limonite zone and the saprolite zone, and even in the bedrock zone.

Because the research of Ni grade modeling and estimating reserves focuses on geostatistical techniques, then the data of Ni grade in this laterite nickel deposit must first be processed in pure statistics, including descriptive statistics and inferential statistics. This basic statistical analysis includes all types of statistical analysis of the Ni element content data in this laterite nickel deposit in the geological domain or domain of each topographic slope. This is important to do because the results of this basic statistical analysis will certainly support the geostatistical analysis that will be carried out later.

A general property of the top of laterite nickel ore deposits with lateritization zone is shown in Figure 5 (Ilyas et al., 2016). Figure 6 shows the Ni grade profile from near the soil surface to a certain depth along a drillhole (Ilyas and Koike, 2012).

From Figure 6, it can be interpreted statistically that the variation of Ni grade in the limonite zone generally has low levels of variation, while the saprolite zone tends to have higher grade variations, and in the bedrock zone the variation in levels tends to return to low again. From this, it can also be interpreted that the variations of those levels tend to be the same in the topography with the same slope of a laterite nickel deposit. Therefore, it can be concluded that modeling the distribution of Ni grade in a laterite nickel deposit and the estimation of the amounts of resources and reserves can be achieved through the location of the topographic slope as a geological domain where Ni grade levels tend to have the same variation in the same topographic slope domain as a stationarity property. From here, the results of modeling and estimation of resources and reserves will increase the value of confidence in the estimation results.
and reduce the level of uncertainty in their estimates as follows:

Measurement value = Measurement result + Uncertainty

From this equation, it can be interpreted that the level of uncertainty of the estimated resources and reserves of laterite nickel deposit can be reduced by considering topographic slope as a stationarity characteristic of the deposit.

![Figure 6](image6.png)

Figure 6. Drillhole profile of nickel grade in the limonite (orange arrow), saprolite (blue arrow) and bedrock zones (red arrow) at a laterite nickel deposit on a gentle slope topography in the Sorowako area, South Sulawesi Province, Indonesia.

As an example, two experimental semivariograms of Ni grade data can be approximated by the spherical model (Fig. 7), and the 3D grade is model by kriging (Fig. 8: Ilyas et al., 2016).

![Figure 7](image7.png)

Figure 7. Semivariograms of Ni grade data and their approximation by the spherical model in (a) omnidirectional horizontal and (b) vertical planes (Ilyas et al., 2016).

5. Future works

From all the information above, it is necessary that there will be close cooperation between Japanese Universities including Kyoto University and Hasanuddin University in the field of geoinformatic researches, especially in the modeling and estimating the resources and reserves of laterite nickel deposits, as the photo below.

We hope that the results of this research will enrich the treasury of science and technology in the field of geostatistics, especially in terms of modeling the distribution of Ni grade in laterite nickel deposits to improve the exploration method of laterite nickel deposits around the world.

![Figure 8](image8.png)

Figure 8. A 3D Ni grade distribution model by ordinary kriging (viewed from the southeast). The blue color on the model denotes the outside of the calculations (Ilyas et al., 2016).

Photo: A seminar held at the Mining Engineering Department in Dec. 2018. The right edge person is the first author.

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