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Base Metal Occurrence in Intrusives Rock from Sassak Region Toraja Regency, South Sulawesi Province

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ABSTRACT

Study on the occurrence of base metals (Pb, Zn, Cu, Fe, Mn and Sc) in intrusive rocks at Sasak area of Toraja Regency, South Sulawesi Province has been conducted. The study aims to obtain information about the characteristic of the intrusive rocks and the concentration of base metals in the area along with the geological processes controlling the formation of these metals. The analytical method used in this study is petrographic analysis by observing ten intrusive rock samples to determine rock type, texture, structure and mineral composition. Base metal element concentration is obtained by XRF method on four samples. The results show that the intrusive rock types are diorite, grey-coloured in fresh and greyish-brown in weathered condition, holocrystalline and phaneritic texture, euhedral-subhedral, equigranular, massive structures with mineral compositions consisting of plagioclase, pyroxene, hornblende, biotite, small amount of quartz and opaque minerals. Quartz veins and some alteration minerals found in several samples indicate the presence of hydrothermal fluid and alteration process. The geochemical analysis shows that the base mental content of Pb ranges from 17 to 39 ppm, Cu (88 - 179 ppm), Fe (5.31 - 6.04%), Mn (610 - 1040 ppm), Zn (48 - 84 ppm) and Sc (8-10 ppm). The most enriched element is manganese (Mn) with the highest concentration found in sample ST 5 VEIN in the amount of 1040 ppm. The base metal found in intrusive rocks were formed through a hydrothermal process as evidenced by the presence of alteration minerals and sulfide minerals such as pyrite and chalcopyrite.

Keywords: base metal, intrusives rocks, Sassak, Toraja, Sulawesi

1. INTRODUCTION

Human needs for metals are increasing both in quantity and type along with technological advances and new discoveries in various industries that require a lot of raw materials for metals, especially base metals. Base metal is a metal formed from the results of the early magmatic differentiation process consisting of metal elements Pb, Zn, Cu, Fe, Ti, Cr, Co, Ni and Mn [1]. Some base metal elements found to be associated with certain types of rocks such as Co, Ni, Cr in ultramafic rocks, Ti, Fe, Pb, Zn and Cu in mafic rocks, and Pb, Zn, Cu, Mn in intermediate to felsic rocks. One type of rock that contains abundant base metals is intermediate to felsic rocks. Almost around 60% Cu and 10% Fe, Pb, Zn in this world found to be associated with intrusive rocks, especially those from diorite to granite [2][3].

Intrusive rocks with compositions varying from gabbro to granite found in large volumes in Sasak area, Toraja regions, South Sulawesi [4][5][6]. Some previous researchers have reported that intrusive rocks in this area contain sulfide ore [7][8]. Regionally, Sassak area is composed of metamorphic rocks from Cretaceous Latimojong Formation as basement rock which is overlain by alternating sandstone and shale from Eocene Toraja Formation. The rest of the area is dominantly covered by volcanic product consists of tuff, lava flow, basaltic to andesitic volcanic breccia intruded by intrusive rocks [6][9] (Fig. 1).

Despite of general report on the base metal occurrence, specific research on the concentration of base metal in intrusive rocks has not been done much. This research reports the characteristic of the intrusive rocks in Sasak area which hosting the base metal and determine the base metal concentration in the rocks using the XRF (X-Ray Fluorescence) method. The types of base metal elements studied are copper (Cu), iron (Fe), manganese (Mn), lead (Pb), zinc (Zn) and Scandium (Sc). The specific purpose of this research is to conduct a study of base metals potential in intrusive rocks in the Sasak region and determine the geological processes which are responsible for the enrichment of these metal elements. It is expected that the results of this study can provide new knowledge related to the presence of base metals in the study area and the viability of economic potential.

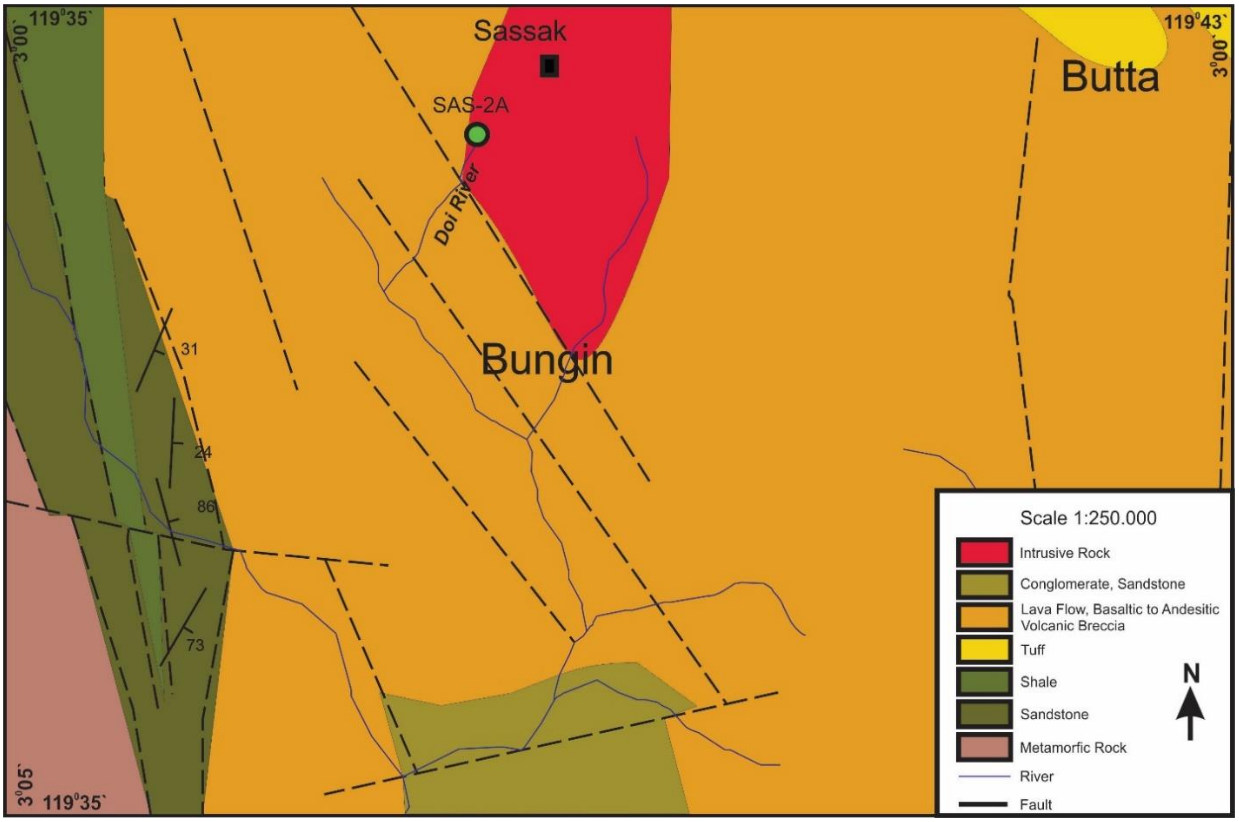


Figure 1. Geological map of Sassak area [9].

2. ANALYTICAL METHODS

The study was based on the field work in Sassak Area, Toraja, South Sulawesi to collect some samples from some sites in Doi River. The collected samples then sent to the laboratory for analytical method. Analytical method used in this study consist of petrographic and geochemical analysis using XRF (X-ray fluorescence) method.

1) Petrographic analysis: The petrographic analysis aims to determine the type and texture of the host rocks in igneous rocks from the thin section. About 10 samples were collected from the field and 6 of them were chosen for detail petrographic analyses. Optical petrography was undertaken manually by using a Nikon petrographic microscope with 10× eyepieces and 5×, 10×, 20× and 40× objective lenses, equipped with a Nikon E4500 camera attached to the trinocular port for micrography in Petrographic Laboratory, Geology Department, Hasanuddin University.

2) Geochemical analysis: This analysis is carried out to determine the composition of base metals especially Cu, Pb, Zn, Fe and Mn by using the XRF (X-ray Fluorescent) method. Four samples were chosen for XRF

and sent to Central Geological Survey Laboratory in Bandung, West Java for XRF analyses. In addition, scandium (Sc) concentration was also analyzed to know the enrichment of Sc in the dioritic rocks.

3. RESULTS AND DISCUSSION

A. Field occurrence

We collected sample from Doi River section in Sassak area as a target for base metal determination. Lithology of Doi River is dominated by dioritic rocks and gabbroic in the form of dykes which have been fractured due to structural process both regional and locally (Fig. 2). The appearance of the diorite outcrop shows blackish-grey colour in fresh condition, brownish-grey colour when weathered, holocrystalline texture, phaneritic, subhedral-anhedral, equigranular, massive structure, with mineral composition consisting of plagioclase, pyroxene, hornblende, biotite and opaque mineral. Quartz vein found in some outcrops, ranging from very fine (less than 0.2 cm) to 3 cm in thickness.

Figure 2. Diorite occurrence (sample ST5 vein) in Doi River, Sasak area of Toraja Regency

Petrographically, most diorite samples have brownish-yellow absorption colour with grey maximum interference colour, holocrystalline texture, phaneritic, subhedral-euhedral with equigranular relations (Fig. 3 – 5). These rocks are composed of plagioclase andesine minerals with a percentage of 55 – 60%, pyroxene (20 – 25 %), hornblende (8 – 10%), biotite (5 – 7%), small amount of quartz and opaque minerals occur as accessory minerals. Plagioclase mineral (andesine) with colourless absorption colour, grey maximum interference colour, low relief, weak intensity, euhedral-anhedral mineral shape, one-way cleavage, even fracture, monochromic pleochroism, refractive index nm<nbb, albite twinning, extinction angle 26^o, inclined extinction, and mineral size range from 0.6 to 4.8 mm. Pyroxene shows brownish-yellow absorption colour with reddish-brown maximum interference colour, subhedral-euhedral mineral shape, high relief, strong intensity, two-way parallel cleavage, uneven fracture, refractive index nm> ncb, inclined extinction, and mineral size of 0, 4 - 0.8 mm. Hornblende show orange absorption colour and brownish-orange maximum interference colour, euhedral-subhedral mineral shape, no cleavage, high relief, strong intensity, monochromic pleochroism, refractive index nm> ncb, extinction angle 25^o, inclined extinction, and mineral size of 0.2 - 0.8 mm. Biotite has a brown absorption colour, euhedral-subhedral shape, moderate relief, moderate intensity, monochromic pleochroism, one-way cleavage, refractive index n.min> n.cb, mineral size 0.3 - 0.9 mm, dark brown interference colour, extinction angle of 40^o, inclined extinction. The opaque mineral comes in blackish-grey absorption colour with black maximum interference colour, anhedral shape and mineral size 0.02 - 0.04 mm. The pictures of some samples can be seen in the image below.

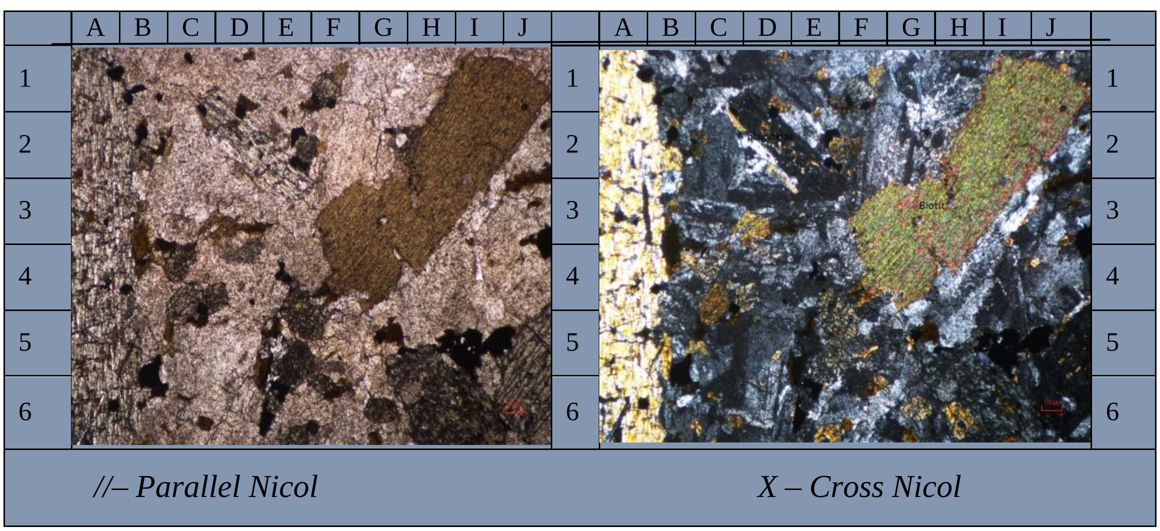


Figure 3. Microphotograph of diorite rocks ST2A with minerals composition consist of Plagioclase (2C-2D), Biotite (3F-3J), Pyroxene (1A-6A), Hornblende (4C), Opaque Mineral (5C)

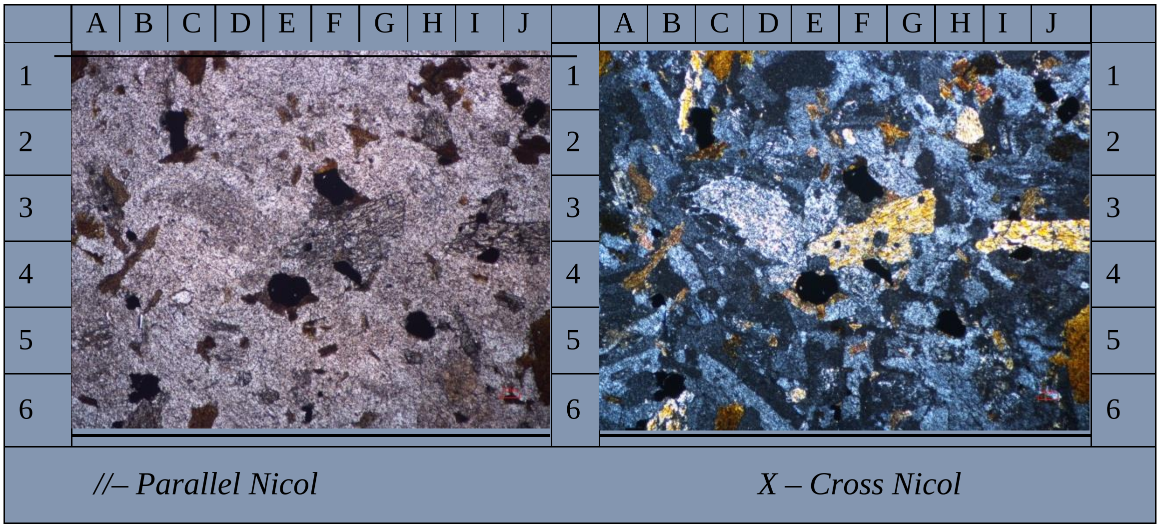


Figure 4. Microphotograph of diorite in ST2B samples with minerals composition consist of Plagioclase (6C), Biotite (6C), Pyroxene (3E-3F), Hornblende (5J-6J), Opaque Mineral (4E)

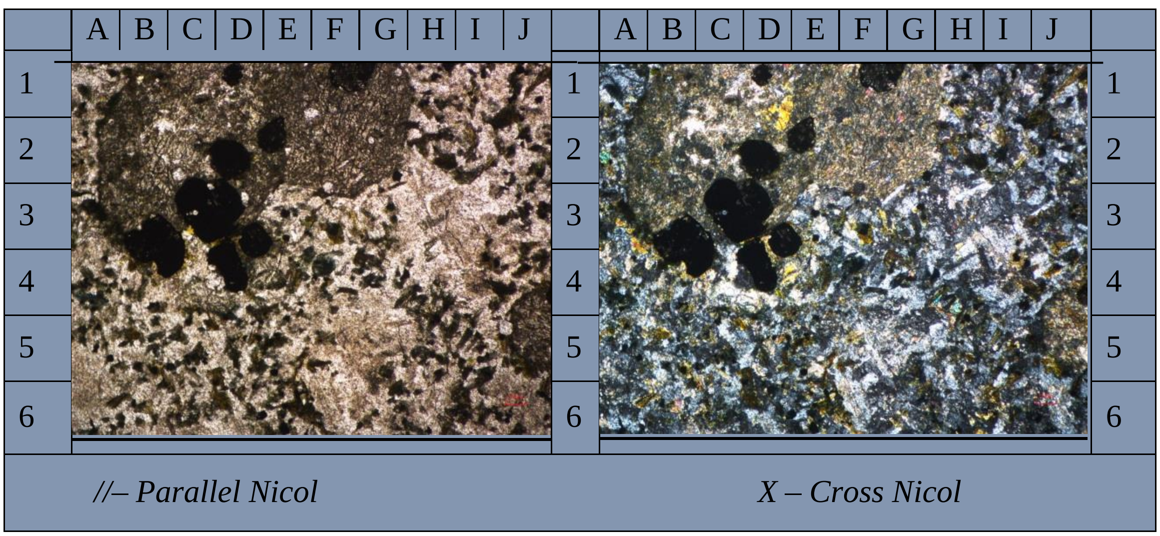


Figure 5. Microphotograph of diorite ST3B with mineral composition consist of Plagioclase (4A - 4J), Quartz (4A - 4J), Biotite (3D) (3F-3J), Hornblende (2H), Opaque Mineral (3B - 3C), sericite (1A-1B), carbonate (2C – 2D).

B. Concentration of base metal elements in diorite rocks

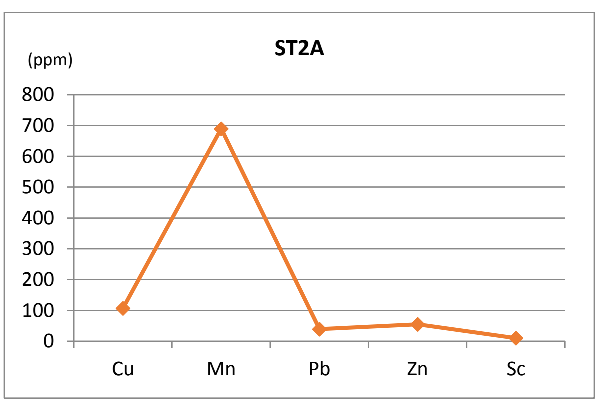
Analysis to determine the concentration of base metals was carried out on 4 samples of diorite rocks, namely ST2A, ST2B, ST3B, ST5 VEIN. The elements analyzed are in the form of base metal elements consist of copper (Cu), iron (Fe), manganese (Mn), lead (Pb), zinc (Zn) and Scandium (Sc). The content values of the metal elements in identified diorite rocks are presented in Table 1.

Table 1. Content of metal elements in intrusive rocks of the study area

Base metal	UNIT	ST 5 VEIN	ST 2A	ST 2B	ST 3B
Cu	ppm	179	107	88	98
Fe	%	5.77	5.35	5.31	6.04
Mn	ppm	1040	690	610	670
Pb	ppm	17	39	27	18
Zn	ppm	84	55	48	59
Sc	ppm	10	8	7	10

In general, base metal elements contained in diorite rocks show similarity in composition which is characterized by the abundance of manganese elements (Mn) in all samples. Rock samples containing the highest base metal elements were sample ST 5 VEIN, with Cu concentrations reaching up to 179 ppm, Fe = 5.77%, Mn = 1040 ppm, Pb = 17 ppm, Zn = 84 ppm and Sc = 10 ppm. The manganese element in this sample is the highest among all samples. Geochemical analysis on sample ST2A shows the content of Cu = 107 ppm, Fe = 5.35%, Mn = 690 ppm, Pb =39 ppm, Zn = 55 ppm and Sc = 8 ppm. Sample ST2B show that the metal element consists of 88 ppm Cu, 5.31% Fe, 610 ppm Mn, 27 ppm Pb, while Zn and Sc are 48 ppm. And 7 ppm, respectively. Sample ST2B consist of Cu = 88 ppm, Fe = 5.31%, Mn = 610 ppm, Pb=27 ppm, Zn= 48 ppm whereas sample ST3B shows that Cu= 98 ppm, Fe= 6.04%, Mn= 670 ppm, Pb = 18 ppm, Zn= 59 ppm and Sc=10 ppm.

The following is an elemental line diagram found in diorite rocks (Fig. 6).



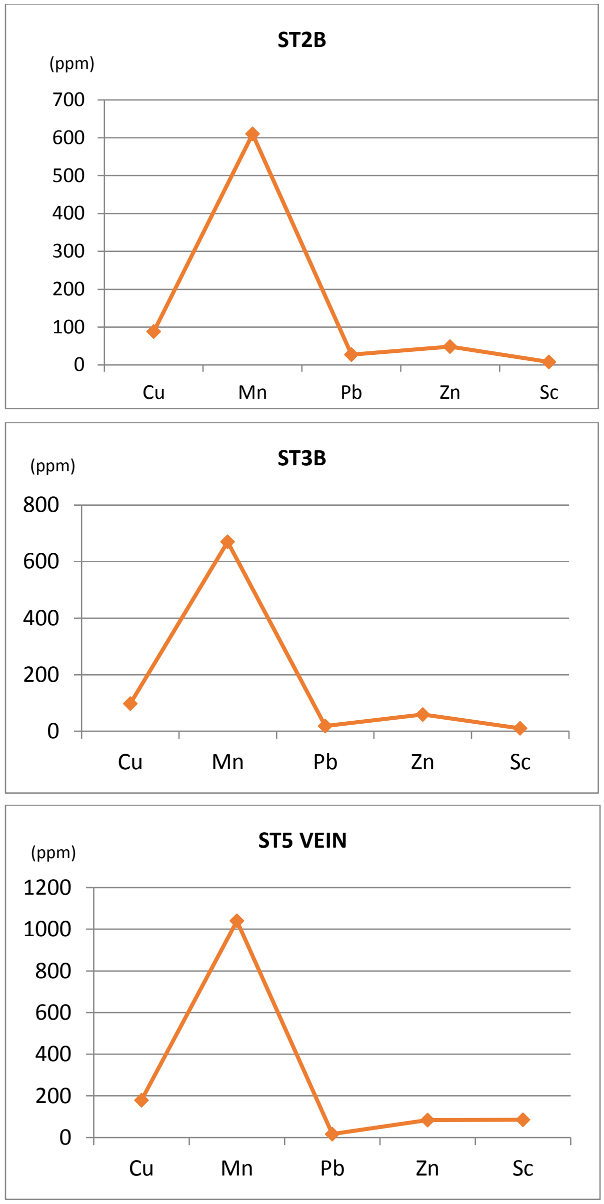


Figure 6. Diagram of base metal concentration in analyzed rocks

C. Source of base metal

Base metal elements in diorite rocks resulted through mineralization due to the hydrothermal process. The hydrothermal process is characterized by the presence of quartz veins in rocks forming a thin vein called stockwork-forming hairline fractures and veins as found at station 5 (Figure 7). The hydrothermal fluid formed in the final phase of the magma crystallization. When magma began to cool in the subsurface, it will interact with surrounding water and formed hydrothermal fluid. The hydrothermal fluid associated with the magma affected the rock surroundings and cause changes in the rocks and will form some new minerals or called alteration process (hydrothermal alteration). Hydrothermal solutions will form veins by precipitating dissolved materials such as quartz and calcite in open fractures within the rocks. The hydrothermal process also characterized by the presence of sulfide minerals which is shown in thin sections in the form of opaque minerals. The presence of sericite and carbonate minerals confirm the alteration product.

Figure 7. Vein appearance at station ST5

4. CONCLUSION

Based on the results of field study, petrographic analysis and geochemistry, it can be concluded as follows:

1. The intrusives rocks hosting the base metal in Sassak Area consists of dioritic rocks composed of plagioclase, pyroxene, hornblende, biotite with accessory of opaque minerals.
2. Geochemical analysis of metal content in diorite rocks at the study area consisting of Cu 88 - 179 ppm, Fe 5.31 - 6.04%, Mn 610 - 1040 ppm, Pb 17 - 39 ppm, Zn 48 - 84 ppm and Sc 7-10 ppm. The concentration of manganese (Mn) in each sample is very high and the highest manganese (Mn) found in sample ST5 (vein) which is equal to 1040 ppm.
3. Metal elements found in diorite rocks in the Sasak area of Toraja Regency produced through hydrothermal and alteration processes which are indicated by the presence of sulfide and alteration minerals.

5. Acknowledgment

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6. References

[1] Wilson, H.D.B. 1953. Geology and geochemistry of base metal deposit. Economic Geology. 48(5), 370 – 407.

[2] Sillitoe, R. H. 1996 Granites and metal deposits. Episodes, 19,126–133.

[3] Ghodsi, M.R., Boomeri, M., Bagheri, S. Lentz, D., Ishiyama, D. 2016. Metallogeny and mineralization potential of the Bazman Granitoid, SE Iran. Resource Geology, 66(3), 286 – 302.

[4] Elburg, M.A., Foden, J., 1999b. Sources for magmatism in Central Sulawesi: Geochemical and Sr-Nd-Pb isotopic constraints. Chem. Geol. 156, 67–93.

[5] Maulana, A., Imai, A., van Leeuwen, T., Koichiro, W., Yonezu, K., Takanori, N., Boyce, A., Page, L., Schersten, A., 2016. Origin and geodynamic setting of Late Cenozoic granitoids in Sulawesi, Indonesia. J. Asian Earth Sci. 124, 102–125.

[6] Maulana, A., Brocker, M., Dan, W. 2020. Petrogenesis and geochronology of Cenozoic intrusions in the Poboya and Sassak gold and copper districts in Western Sulawesi, Indonesia: Implications for the mineralization processes and magma sources. Journal of Asian Earth Science, 193, 104303.

[7] Taylor, D., van Leeuwen, T.M., 1980. Porphyry-type deposits in SE Asia. Mining Geology Special Issue No 8, 95–116.

[8] Van Leeuwen, T.M., Pieters, P.E., 2011. Mineral deposits of Sulawesi, In: Proceedings of the Sulawesi Mineral Resource, MGEI-IAGI, 2011, pp. 1–110.

[9] Djuri., Sudjatmiko., 1974. Geological Map of Majene and Western part of Palopo Quadrangle, South Sulawesi. Scale 1:250.000. Geological Development and Research Centre, Bandung.