

## RESEARCH ARTICLE

## Characteristics of Chromite Deposits at North Kabaena District, Bombana Regency, Southeast Sulawesi Province, Indonesia

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### Abstract

The study area is located in North Kabaena District, Bombana Regency, Southeast Sulawesi. This paper is aimed to describe characteristics of chromite deposits. This study is conducted in three stages, three stages including desk study, field work and laboratory analysis. Desk study mainly covers literature reviews. Field work includes mapping of surface geology and sampling of representative rocks types. Laboratory analysis includes the petrologic observation of hand specimen samples, petrographic analysis of the thin section and ore microscopy for polished section. The results of petrographic analysis show that olivine minerals are generally replaced by minerals orthopyroxene and has been altered by lizardite type serpentine veins with a fractured structure. The mineral olivine is also replaced by the mineral chrysotile as a secondary mineral with a fibrous structure. Based on ore microscopy analysis show that chromite has generally experienced a lateritification process and has been replaced by magnetite, hematite and goetite minerals. Chromite has experience process of weathering and alteration from its source rock caused by tectonics that occurred in the study area. The results shows that the characteristics of chromite deposits in North Kabaena District Chromite deposits has generally encountered in peridotite rock which have a grain size of 0.3-20 cm. Furthermore, chromite deposits in the study area are also encountered in podiform deposits, distributed locally and shows podiform to tubular shape with the dimensions of 30-60cm.

**Keywords:** Chromite, peridotite, serpentinite, olivine, podiform.

### 1. Introduction

Podiform chromite deposits are an important source for chromite, which is the only ore for chromium, and they are the primary source for both high-chromium, low-luminum ore, used in metallurgical applications (Mosier et al., 2012). Based on this, many researchers and mining companies are trying to find chromite reserves to explore.

Chromite minerals are found in mafic and ultramafic rocks peridotite which is included in the ophiolite complex and metamorphic rocks such as serpentine, usually associated with olivine, talc, serpentine, uvavortite, pyroxene, biotite, magnetite, and anorthite. Chromite can occur as primary deposits, namely stratiform and podiform deposit types (Rasilainen et al., 2016), or as secondary deposits in the form of black sand and laterite soil.

Furthermore, podiform chromite deposits are small magmatic chromite bodies formed in the ultramafic section of an ophiolite complex in the oceanic crust. These deposits have been found in midoceanic ridge, off-ridge, and suprasubduction tectonic settings. Most podiform chromite deposits are found in dunite or peridotite near the contact of the cumulate and tectonite zones in ophiolites (Rasilainen et al., 2016; Mosier et al., 2012).

Budi Santoso and Subagio (2016) have researched chromite minerals using the Induced polarization (IP) method in the Northern Kabaena area, Bombana, South East Sulawesi results from primary chromite deposits and

secondary chromite deposits. The primary chromite deposition is found in peridotite rocks with a charge ability value (221-320) msec and a resistivity value (900-6000) Ohm. m, while the secondary chromite deposition is found in sand layers containing fragments of chunk and peridotite rock fragments with a charge ability value (203-270) msec and resistivity value (296 -400) Ohms. m.

Chromite has properties such as black, massif to a granular, crystalline form, octahedral crystals system, brown streaks, hardness 5.5 (Mohs scale), and specific gravity 4.5 - 4.8. Chromite minerals are thin, stable, and composed of small beads. The chromite chemical composition varies significantly because other elements influence it (Santoso et al., 2016).

Based on research results of Moe'tamar, 2005 in Kabaena Island show that distribution of chromite pumice (boulder) with a diameter (10-100) cm of solid black color, occasionally found chromite boulder fragments covered with quartz.

### 2. Regional Geological Setting

The stratigraphy in the southeastern arm of Sulawesi consists of three constituent rocks are ophiolite complex are dominated by mafic and ultramafic rocks accompanied by pelagic and melange sedimentary rocks in several places; continental terrain composed of metamorphic rocks (Pompangeo Complex) consisting of mica schist, quartzite, glaucophane schist and chertand; and Sulawesi

Molasse composed of clastic sediments and carbonate. Contacts between the ophiolite complex and metamorphic rocks, including their basement rocks are faulted. The Sulawesi Molasse unconformably overlies both the ophiolite complex and continental terrain (Surono, 2013).

Chromite deposits are encountered in Kabaena Utara District which is part of Kabaena Island in Bombana Regency, Southeast Sulawesi Province (Figure 1). The morphology of the study area consists of high hills to mountainous areas, caused by the geological structure it consists of shear fault thrust faults with irregular fault directions (Simandjuntak et al., 1993). In the study area, there is also a Sungkup Fault following West-East direction. This fault shifts the Ultramafic Complex over the

Pompangeo Complex and the Kabaena metamorphosed sediment which is thought to have occurred in the Mesozoic (Moe'tamar, 2005).

The formation indicated as a chromite-bearing formation is the Ultramafic (KU) complex, which is Cretaceous in which there are peridotite rocks consist of harzburgite, dunite, wherlites, serpentinite, gabbro, basalt, dolerite, diorite, mafic meta, ampybolite, magnesite, and local rodingit (Simandjuntak et al., 1993).

Ultramafic Complex (Ku), this formation comprises harzburgite, dunite, wherlites, serpentinite, gabbro, basalt, dolerite, diorite, meta mafic, amphibolite, magnesite, and local redingote. This unit is estimated to be Cretaceous (Simandjuntak et al., 1993)

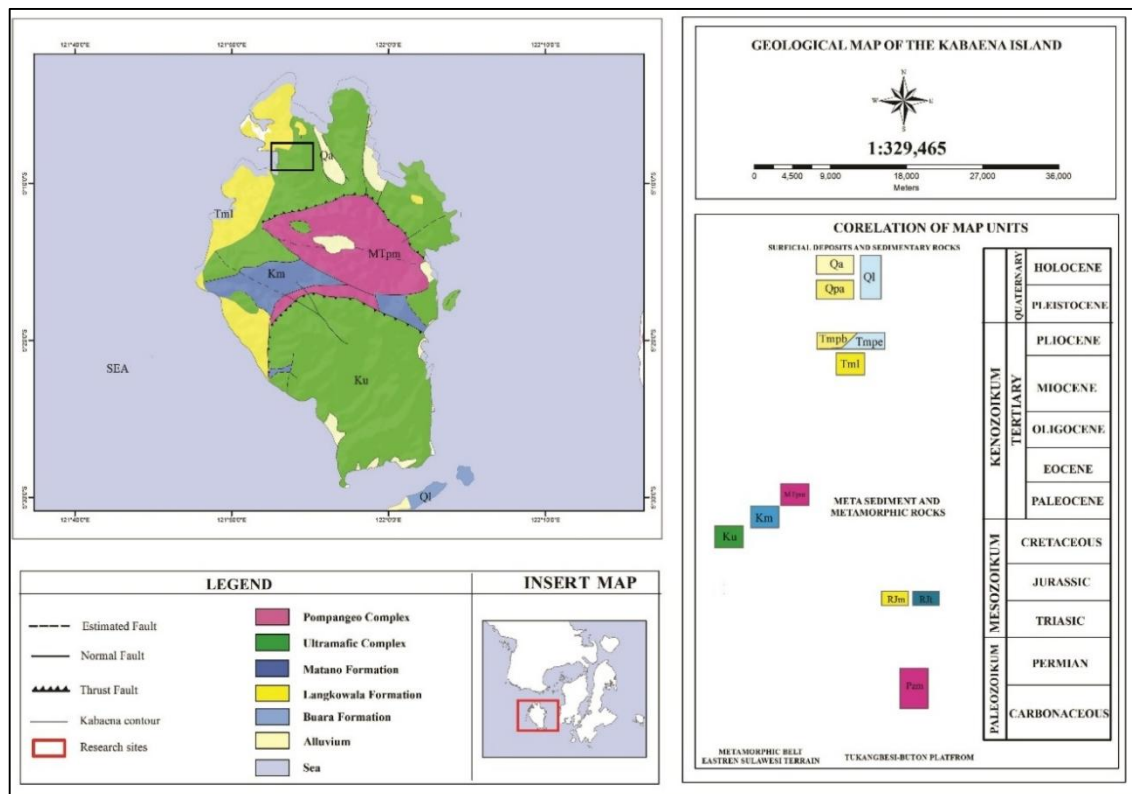


Fig 1. Kabaena Geology and Stratigraphy Map (modification of Simandjuntak et al., 1993)

### 3. Research Methods

This study is conducted in four stages including fieldwork, laboratory analyses, data analyses and interpretation. Fieldwork includes mapping of surface geology, as well as sampling of representative rock types. Laboratory work includes textural and structural analyses and mineralogy analyses (petrography and ore microscopy analyses). The mineralogical analysis was conducted at Department of Geological Engineering, Hasanuddin University, Indonesia.

### 4. Results and Discussions

#### 4.1 Characteristics of Chromite

The formation of ultramafic is by high-temperature mineral minerals which are magmatic deposits such as olivine, pyroxene, chromite, and hematite (Purawardi, 2014).

This type of ultramafic rocks in research area has a brown weathered color and fresh dark green color, hypocrystalline, phaneritic, euhedral-subhedral and equigranular relationships. Based on field observation can

be seen the primary minerals such as olivine and pyroxene and secondary minerals are serpentine.

Based on the results of petrographic analysis, it shows that the abundant mineral olivine content is then replaced by orthopyroxene minerals and olivine minerals have been altered by lizardite-type serpentine veins with a fractured structure (Fig. 2A). In Figure 2B there is a chrysotile mineral with a fibrous structure as a secondary mineral that replaces the mineral olivine.

The results of petrographic analysis (Fig. 3) show that the antigorite mineral with a banded structure is present in the middle of the lizardite mineral with a granular structure. The appearance of lizardite minerals with a granular structure is formed due to the weathering process. In the thin section, the texture of the olivine mineral crystals has completely changed to the mineral serpentine (Rasilainen et al., 2016).

Chromite is formed because of the crystallization process of magma at a temperature of 1200°C, found in metamorphic rocks such as serpentinite (Robinson et al., 1997).

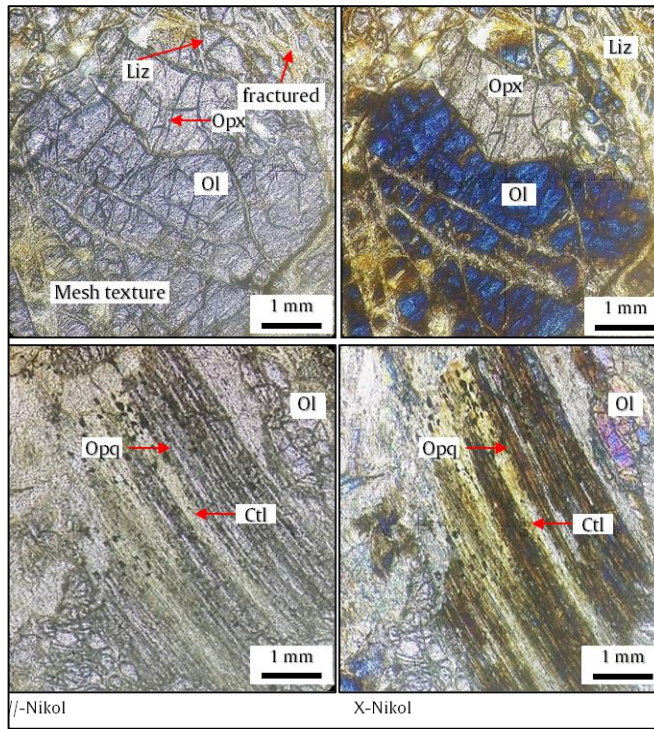


Fig 2. (A) Thin section at x-nicol and parallel nicol of the serpentine-dunite; (B) Thin section at x-nicol and parallel nicol of the serpentine-dunite with the mineral olivine which is replaced by orthopyroxene.

Chromite is field area partly in fresh conditions, but in some samples found to undergo a lateritization process that replaces chromite into mineral magnetite, hematite, and goethite. Based on ore microscopy analyses, magnetite colour of bluish gray, measuring 50-250  $\mu\text{m}$ , anhedral, has no pleochroism, isotropic and medium-high reflectance.

by tectonic processes that occurs in the research area. From the results of the chromite host rock analysis of peridotite that has subsurface serpentinization consists of partially transformed olivine into serpentine, magnetite and chromite (Robinson et al., 1997).

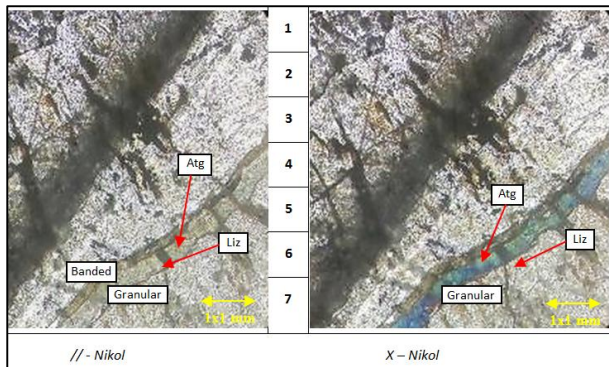


Fig. 3. Thin section at x-nicol and parallel nicol of the serpentine-dunite which indicates the presence of antigorite minerals with a banded structure.

Podiform deposits are chromite bodies in the form of pockets up to tubular shape, usually related to the direction of magmatic stratification (Robinson et al., 1997). The structure in the chromite body varies. Solid chromite crystals in massive ore formations contain 75% to 85% percent chromite volume. Spherical or speckled ores consisting of round chromite crystals 0.5-2 cm in diameter in the basic mass of silicates such as olivine, pyroxene, serpentine, are characteristic of chromite ore deposits. Ribbon-shaped ore is closely related to massive ore, but it is richer in silicates and then forms links with mottled ores (Fig. 4).

Based on ore microscopy analysis can be seen that the chromite found in the study area subsurface the process of its host rocks, likewise other minerals (Fig. 5). it is caused

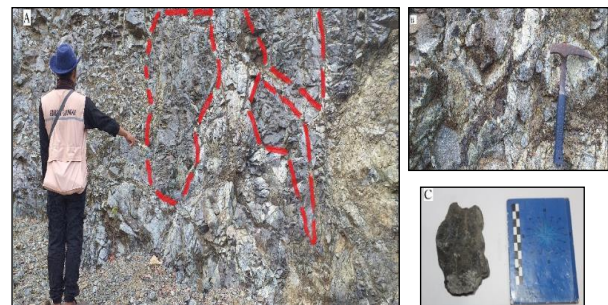


Fig. 4. The appearance of chromite nodules on peridotite rocks (A), Appearance of chromite ore (B), Podiform chromite with a diameter reaching 15 cm (C).

Olivin absorption colour is grayish-white, with the interference colour of the bluish-green type of oblique darkness, subhedral-anhedral shape, high relief, imperfect hemisphere (none), irregular fractions, and mineral size of 0.2mm to 0.5mm. The olivine mineral in the incision with a percentage of 30% shows the weathering process where around the body the olivine mineral has changed colour to brown and the mineral body of olivine has broken up into several parts caused by serpentine veins which intersect from two directions to form a mesh structure in the mineral olivine.

Lizardite white absorption color, white color interference, anhedral shape, medium relief, no hemisphere, low order double bias, mineral size from 0.20 to 0.250mm. Types of tilting darkness. Lizardite minerals present as veins with fractured structures that cut olivine and orthopyroxene minerals where serpentine veins cut

one another, indicating that the serpentine process has occurred in more than one phase.

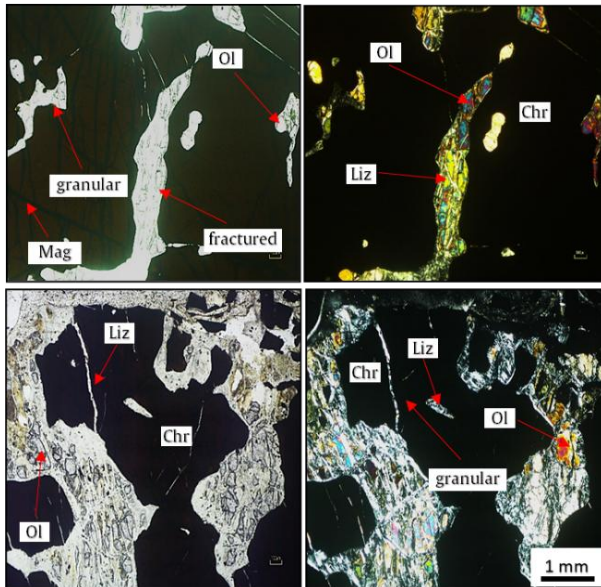


Fig. 5 Chromite in photomicrograph (Liz: lizardite, Ol: olivine, Chr: chromite, Mag: magnetit).

Magnetite has mineral opaque, black interference color, opaque, high relief, high intensity and has a size (0.1-1.0 mm), granular euhedral crystal boundary shape.

Chromite has a physical characteristic of black colour, metal gloss, hardness 4.5-5.5, uneven shards, granular-shaped, paramagnetic magnetics, and the properties in brittle. The observation of ore texture is carried out in a ore microscopy that shows the gray chromite, measuring 100-300  $\mu\text{m}$ . The form of the euhedral-subhedral has no pleochroism, isotropic, brecciation fractions, high reflectance, bireflectance not observed.

Chromite deposits in the study area were found to have a grain size of 0.3-20cm asnodules or forming small pockets of peridotite that had subsurface serpentinization and were only localized (Lintjewas, 2015). Chromite analysis was performed by observing 4 petrographic samples and 4 mineragraphic samples under a microscope (Fig. 6).

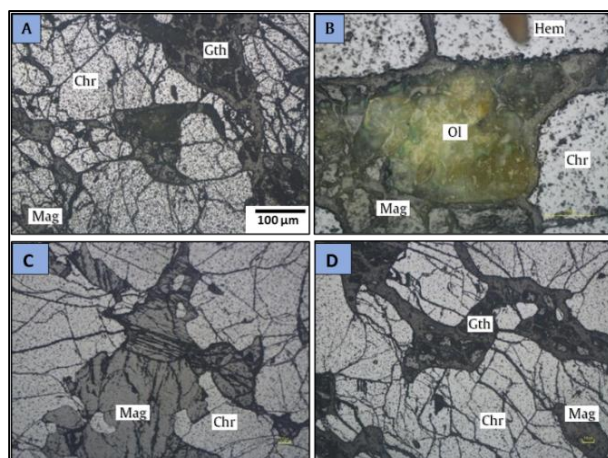


Fig. 6 (A) Goethite secondary presence minerals; (B) Secondary minerals such as goethite and hematite related chromite ore weathering processes, podiform chromite texture shown by using disseminated chromite ore on silicate minerals containing olivine; (C), and (D) Magnetite is looked replacing chromite.

Chromite is generally partly observed in fresh conditions, but some samples have been found to undergo a lateritification process that replaces chromite into mineral magnetite, hematite, and goethite. Bluish gray magnetite, measuring 50-250  $\mu\text{m}$ , anhedral, has no pleochroism, isotropic medium-high reflectance, has no observed effect. Blackish gray goethite, size <50  $\mu\text{m}$ , anhedral form, weak pleochroism, anisotropic, moderate reflectance, bireflectance not observed. Brown-colored hematite, <50  $\mu\text{m}$  in size, euhedral-subhedral form, do not have pleochroism, isotropic, high reflection, bireflectance not observed (Fig.4).

Goethite-colored blackish gray, measuring <50  $\mu\text{m}$ , anhedral form, weak pleochroism, anisotropic, medium-reflectance, bireflectance not observed. It is a brown colour, measuring <50  $\mu\text{m}$ , a euhedral-subhedral, with no pleochroism, isotropic, high reflection, unobserved bireflectance.

Magnetit has mineral opaque, black interference color, opaque, high relief, high intensity and has a size (0.1-1.0 mm), granular euhedral crystal boundary shape. Hematit Brown color, size <50  $\mu\text{m}$ , euhedral-subhedral form, do not have pleochroism, isotropic, high reflection, bireflectansi not observed.

#### 4.2 Chromite mineralization type

Chromite ores in study areas are found in podiform type (Fig. 7) A podiform precipitate is a bag of chromic body-shaped to a tube or lens, usually associated with the direction of magmatic stratification (Purawardi, 2014). Chromite deposits in the study area are also encountered in podiform deposits, distributed locally and shows podiform to tubular shape with the dimensions of 30-60cm and along the circumference of the mountain (Fig. 7). This precipitate can be found in the host rock, which is the constituent ultramafic rock (Ibrahim et al, 2014) and upper coat which is commonly called the ophiolite sequence which supports this type of deposition, where the parent rocks in the peridotite and serpentinite research areas are included into the ultramafic rock of the coat.

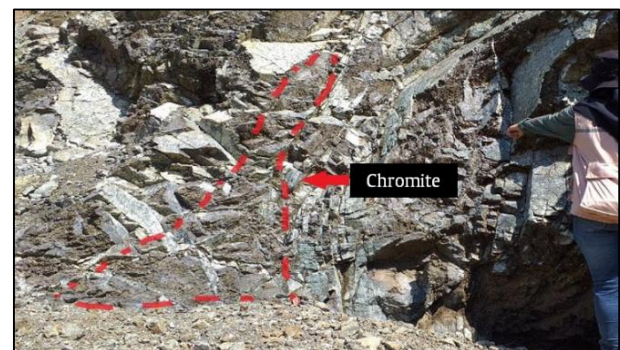


Fig. 7 Appearance of chromite podiform deposits on the research area

Chromite research areas include the type of chromite podiform deposits, these deposits are found on the stem rocks of ultramafic rock compilers of the ocean crust or commonly called Fibonacci Ophiolite. Rocks associated with the type of podiform sediment are commonly referred to as Alpine-type ultramafics and are found along the archipelago and on a volcanic belt that is always moving at a Paleozoic or younger age (Robinson et al, 1997; Zhou and Robinson, 1997).

The formation of chromite minerals in the ofiolit sequin sequence rocks can be caused by partial melting and remobilization of rock differentiation at a certain depth due to fractional crystallization. Chromite is eliminated because of the appointment process by regional tectonic (Robinson et al., 1997 ; Mosier et al., 2012 ; Robinson et al., 1997; McClay, 1992)

## 5. Conclusion

Chromite has experience process of weathering and alteration from its source rock caused by tectonics that occurred in the study area to cause changes in chromite mineralogy to magnetite, hematite, and goethite. Sedimentary ores containing compounds Fe<sub>2</sub>Cr<sub>2</sub>O<sub>4</sub> or FeO (Cr, Al) <sub>2</sub>O<sub>3</sub> are always associated with magma breakthroughs. Characteristics of chromite deposits in study area has generally encountered in peridotite rocks which have a grain size of 0.3-20 cm. Furthermore, chromite deposits in the study area are also encountered in podiform deposits, distributed locally and shows podiform to tubular shape with the dimensions of 30-60cm was encountered along the circumference of the use of the study area.

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## References

Ibrahim, M. A., Rustandi, U., Suryana, A. 2014. Penyelidikan Bitumen Padat Daerah Pulau Kabaena Kabupaten Bombana, Provinsi Sulawesi Tenggara, in: Proceeding Pusat Sumber Daya Geologi. pp. 1-10.

Lintjewas, L. 2015. Tipe Endapan Kromit Di Daerah Konawe Utara Propinsi Sulawesi Tenggara, Pemaparan Hasil Penelitian Geoteknologi 2015.

McClay, K. 1992. The Mapping of Geological Structures. John Wiley & Sons, K. R. McClay Department of

Geology Royal Holloway and Bedford New College University of London.

- Moe'tamar 2005. Inventarisasi Dan Evaluasi Mineral Logam Di Daerah Kabupaten Bombana Dan Kabupaten Muna Provinsi Sulawesi Tenggara. Direktorat Inventarisasi Sumber Daya Mineral, Bandung.
- Mosier, L.M., Singer, D.A., Moring, B.C., Galloway, J.P. 2012. Podiform Chromite Deposits-Data Base an Grade and Tonnage Models, U.S Geological Survey, Reston, Virginia.
- Purawiardi, R. 2014. Karakteristik Bijih Kromit Barru, Sulawesi Selatan. J. Ris. Geol. dan Pertamb. 18, 1. <https://doi.org/10.14203/risetgeotam2008.v18.3>
- Rasilainen, K., Eilu, P., Halkoaho, T., Karinen, T., Konnunaho, J., Kontinen, A., Törmänen, T. 2016. Quantitative assessment of undiscovered resources in stratiform and podiform chromite deposits in Finland, Tutkimusraportti - Geologian Tutkimuskeskus.
- Robinson, P.T., Zhou, M.F., Malpas, J., Bai, W.J. 1997. Podiform Chromitites.pdf. J. Econ. Geol. 20, 247-252.
- Santoso, B., Supriyana, E., Wijatmoko, B. 2016. Pendugaan Mineral Kromit dengan Metode Electricalresistivity Tomography di Daerah Wosu-Morowali Sulawesi Tengah. Proceeding Semin. Nas. MIPA 2016 27-28.
- Simandjuntak, T., Surono., Sukido. 1993. Peta Geologi Lembar Kolaka , Sulawesi, Skala 1:250.000. Pusat Penelitian dan Pengembangan Geologi, Bandung.
- Surono, 2013. Geologi Lengan Tenggara Sulawesi. Badan Geologi, Kementerian Energi dan Sumber Daya Mineral Jl. Diponegoro No. 57 Bandung 40122 Telp. 022-7215297, Fax. 022-7218154.
- Zhou, M.F., Robinson, P.T. 1997, Origin and Tectonic Enviroment of Podiform Chormite Deposits: Journal Economic Geology, 92, p. 259-26.



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