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DIAMOND SOURCE TRACKING

Study on Garnet from Meretris Complex, South Kalimantan and Its usefulness on
Alm39.5±4Prp28.8±4Grs7.3±2Ado8.7±2SpS5±2. In some samples, its core has more pyrope molecule instead of the almandine, while in the rim, the pyrope molecule are always slightly smaller. Some samples contain the molecule of some 0.002 - 0.007. Pyrope is Mg-rich garnet formed at high pressure environment. Generally, its existence are in eclogite and in kimberlite, both which enables contain diamonds. Pyrope is trace mineral for high pressure rock formation, and knorringite is typical species in kimberlite. This study represents an initial approach done in such tracing.

Keywords: garnet, metapelitic, spessartine, grossular, almandine, pyrope, eclogite and kimberlite

1. INTRODUCTION

Garnet is particular characteristic of metamorphic rocks but also found in some igneous and as detrital grain in sedimentary rocks. This group is subdivided into two series: pyralpite (pyrope-almandine-spessartite) and ugrandite (uvarovite, grossularite, andradite). The unit cell of garnet contains eight $X_3Y_2Z_3O_{12}$ formula units. The structure contains alternating $Z_4$ tetrahedra and $YO_6$ octahedra which share corner to form the three-dimensional network (Dear et al., 1992). The X site is usually occupied by Fe$^{2+}$, Mg$^{2+}$, Mn$^{2+}$ and Ca$^{2+}$, the Y site by Al$^{3+}$, Fe$^{3+}$ and Cr$^{3+}$. Garnets are almost found in dodecahedral crystal habit and somtimes trapezohedral.

From the composition of X and Y sites, garnets are subdivided into at least 6 common natural species and some 16 other experimental garnets. Almandine (Fe$\text{3Al}_2\text{Si}_3\text{O}_{12}$) is the most common species in the garnet group. Almandine generally contains appreciable amount of both the pyrope and spessartine molecules and may have amounts of grossular molecule. Pyrope (Mg$_3$Al$_2$Si$_3$O$_{12}$) is Mg rich garnet which is sometime the Y site substituted with Cr$^{3+}$ to form Knorringite. Pyrope is one of the most diagnostic tracer garnet used in prospecting for kimberlite. Spessartine (Mn$_3$Al$_2$Si$_3$O$_{12}$) is Mn rich garnet while grossular (Ca$_3$Al$_2$Si$_3$O$_{12}$) is CaAl garnet which if the Y side is occupied by Fe usuallly named andradite. Uvarovite (Ca$_3$Cr$_2$Si$_3$O$_{12}$) is member of ugrandite which is rich Cr molecule in the Y side. Hardness of this group is about 6.5 - 7.5 in Mohs scale and usually used as abrasive and the beautiful one as gemstone (Dear et al., 1992).

Like many other diamond placer localities in Kalimantan, Cempaka mining site is diamond placer site located in the Meratus Complex. It is situated in the flat topography of the Quaternary alluvial deposits south of Martapura. Debate on the source rocks of diamond have been highlighted during some decades which still put down some controversies. Kimberlite pipe or eclogite, two possible rocks which may supply diamond have not been indicated yet in adjacent regions. The Pamai breccias located near by the Riam Kanan reservoir is supposed to be boulder conglomeratic source of the (of course) redepositing diamond (Bergman et al., 1987) while later they coincide minette dykes in the Central Kalimantan diamondiferous region. Although non-diamondiferous, the primitive high Mg$^*$, elevated Ni and Cr led them to suggest that as yet undiscovered related alkaline intrusives such as lamproite could be the local source of the diamonds (Bergman et al. 1988).

Occurrences of alluvial diamonds located within relatively young geological terrains without an obvious primary source are normally found over the world (Smith et al. 2009). Some efforts have been done for approaching to find the diamond source. This study will concern on variety of garnet contained by metamorphic rocks in SE Kalimantan which might be correlated to the occurrence of the primary source of the diamond source in kimberlite and eclogite contain garnet.

2. GEOLOGY OF THE MERATUS COMPLEX

Meratus Complex is situated in the southeast Kalimantan Island (formerly Borneo), Indonesia (Figure 1.1). It is ridges and mountainous region extends NNE-SSW trend, started from southern end of Pelaihari Peninsula to the south to the Balikpapan to the north. The complex was Jurassic Cretaceous subduction zone which has been corrected...
Figure 1: Geologic map of the Meratus area, Southeast Kalimantan province and modified from Hegner et al., 1999, K.R. age data taken from Santoro et al., 2007; Psahon et al., 1995; Hegner et al., 2007; Skjerve and Hegner, 1999. 

Legend
- 1: DEPOSITS OF THE MERAUSS COMPLEX
- 2: INDONESIAN MESA

The stratigraphic column (left) shows the sequence of formations, and the legend (right) indicates the geologic units. The site is of interest since it represents a large reservoir of oil and gas. The formation is composed of Cretaceous volcanic and sedimentary rocks, including the Meratus Complex, which is a significant reservoir for hydrocarbons. The map is correlated to the Late Miocene-Miocene interval in geological time.
Crystalline basements

Paleozoic and Mesozoic geology of the Meratus Complex are dominated by crystalline rocks. Outcrops of Late Paleozoic up to Early Mesozoic are plutonic rocks. The Late Carboniferous-Early Permian Lumo, S-type granite of syn-COLLG granite, located at east of Buntok City in northwestern part the Meratus complex is the oldest rock outcrop of the complex. K-Ar ages are 319 ± 1.7 Ma and 260 ± 1.66 Ma (Dirk & Aminuddin, 2000). To the east of this granite there is Late Jurassic Purui Dalam plagiogranite or oceanic trondhjemitic which is overlaid by Late Cretaceous turbidites and volcanics. K-Ar dating age is yielded 155 Ma (Dirk & Aminuddin, 2000). Both granites together with high pressure metamorphic rock are basement to Late Cretaceous sediments and volcanics in the complex (Sikumbang, 1986; Heryanto, 2000).

Early - Middle Jurassic and probably continue to Early Cretaceous high pressure metamorphic rocks are another crystalline basement below Late Cretaceous turbidites and volcanics. It consists of Hauran schist, Pelaihari phillitites to the south (Sikumbang, 1986; Sikumbang & Heryanto, 1994) and Batangalai schist, Kusan amphibolites to the north and northeast (Rustandi et al, 1995; Heryanto & Sanyoto, 1994; Heryanto et al, 2007). The Hauran schist consists of muscovite-quartz schist, micaceous meta-quartzite, biotite-epidote schist, peidmontite schist, glaucophane schist, and barroisite-epidote schist. Kyanite bearing quartz schist were also found in the Hauran schist, close to Marapuera. Its mineralogy exhibits greenschist up to epidote amphibolite facies (Parkinson et al, 1998). Mica in schists near Arano, north of Riam Kanan River shows K-Ar age of 180 ± 9 Ma and 165 ± 8 Ma while south of the Riam Kanan River yielded ages of 119 ± 6 and 110 ± 6 Ma (Wakita et al, 1998). The data consistent with the previous K-Ar dating done by Sikumbang & Heryanto, 1994 that yielded 119 and 108 Ma.

Huge Alkal-Calk Alkali granitoid of Volcanic Arc Granite and gabbro are found in the main body of the Meratus Complex. They consist of trondhjemitic, granite, tonalite, diorite and subordinate gabbro. They are cropped out at Riam Andungan, Hajawa in eastern flank and at Batangalai to the centre of the complex. K-Ar ages are 118. 61 ± 1.45 Ma and 101 ± 2.6 Ma while Hajawa granitoid are 70.96 ± 0.49 Ma up to 87.184 ± 1.04 Ma (Dirk & Aminuddin, 2000). With exception to Hajawa granite, the plutons were basement for the Late Cretaceous sediments and volcanics.

Ophiolite out crops in the Meratus Complex represent oceanic plate stratigraphy. It is found in incomplete slices that consist of ultramafic rocks, pillow basalt, limestone, chert, silicious shale, shale and sandstone as tectonic blocks (Sikumbang, 1982). The ultramafic rocks comprise serpentinized peridotite, harzburgite and dunite with minor pyroxenite and are associated with gabbro and amphibolite (Suparka, 1988). From the age of radiolarian chert overlaid on the ultramafic can be dated that its age is older than early Middle Jurassic (Wakita, et al, 1998).

Sedimentary Rocks

Sediments unconformably overlie the crystalline basement are the Late Cretaceous Sediments and volcanics and the Cenozoic sediments. During Late Cretaceous time, traction and turbidite deposits interfingered with volcanics derived deposits. Shallow intrusive, lava and volcaniclastic deposition of dolerite, basalt and porphyry andesite, andesitic lava intercalated with volcanic breccias occurred together with deposition of clastic limestone, polymict conglomerates and turbidite sediments (Sikumbang, 1986). It construct formations of Batununggal, Paliungan, Pudak, Kintap, Keramaian, Manunggal and Alino which are group as Manunggal and Alino group to the south (Yuwo et al, 1988; Sikumbang & Heryanto, 1999) and are popularized as Heryuwan and Pitap groups to the north (Sikumbang, 1986; Heryanto & Sanyoto, 2007; Heryanto et al, 2007). Geochemistry analysis and K-Ar dating of some volcanic rocks of Alino and Manunggal Formation exhibit orogenetic Calc Alkali rocks of 92 - 72 Ma (Yuwo et al, 1988).

Pre Tertiary rocks in Meratus Complex are unconformably overlain by Tertiary System sediments. It comprises Tanjung, Beral, Wardan and Dahor Formations. The oldest formation
4. RESULTS

The petrography of garnet-bearing metamorphic rocks is described from various localities across South Kalimantan. Two different characteristics are displayed by the rocks:

- Two assemblages of garnet-bearing metapelites. The first assemblage contains garnet, quartz, and clinopyroxene with or without biotite and muscovite. These rocks are metapelites of the Meratus Complex, occurring mainly in the Palangka Raya area.
- The second assemblage consists of garnet, quartz, and feldspar with or without biotite and muscovite. These rocks are metapelites of the Tanjung Selor area, occurring mainly in the Murung Raya area.

5. ANALYTICAL METHODS

Petrographic analysis was carried out using a polarizing microscope at the University of Kiel, with the assistance of the Electron Microscopy Laboratory of the same institution. The mineral chemistry was determined by electron probe microanalysis at the Electron Microscopy Laboratory of the University of Kiel. The accelerating voltage used for analyses was 15 kV, and the beam current was 10 nA.
The second garnet bearing metamorphic rocks are granulites which are out-cropped at Kusan River west of Batulicin. They are located among or windowed inside ultramafic rocks. Its relation to the ultramafic rocks is tectonic contact. The assemblage are typical high pressure granulite which consist of Grt + Cpx + Hbl + Zo ± Kfs ± Tc ± Zo ± Qz ± Rt ± Ilm ± Pl. The assemblage are typical high pressure granulite which suffered about 9 - 12 KBar and temperature 675 – 900°C during regional metamorphism process.

**Garnet in metamorphic rocks**

Garnet contained in sample number Mrt 13 and Mrt 18 that was taken from Apukan River display high concentration ratio of XSpSs and X GsRs. Garnet of Mrt 13 has formula as AlM(0.630)xPrP(0.31)Gr(24.8-

36.2)Ad(0.2)Sps(40.8-62.9). Its core has higher Spessartine than its rim while its almandine content is higher in the rim. The garnet is 0.14 mm in diameter. Garnet of Mrt 18 has no regular pattern. Its XSpSs is high up to 0.7 which makes other contents are slightly low even in some part has no pyrope content. Garnet of Mrt 18 present as inclusion inside crocortex-glauconphane and as matrix embedded among bulk quartz and subordinate muscovite of quartz rich schist.

Garnet inclusion is about < 0.05 mm while the matrix are < 0.11 mm big. The composition is AlM(8.7-19.8)xPr(0.5-1.1)xGr(15.1-20.8)xAd(0.2)xSp(8.7-69.9).

Unlike previous garnets, garnet contained in garnet-granulite of Kusan Region display different character. It appears as pyrope-almandine garnet with composition of AlM(9.5-41.9)xPrP(4.4-40.8)xGr(12.5-

22.2)Ad(0.2)xSp(14.1-19). Their cores have similar almandine pyrope content and alternating or substitute each other but in its rim almandine tend to be higher than its pyrope (figure 3 below). Some of garnets crystalize in a bit big size up to 4 mm. Many inclusions found inside of these garnets consists of hornblende, augite, zoisite, rutile and quartz. Other mineral assemblage beside garnet in sample number Mrt 91 are:

**Assemblage 1:**

\[ Tc + Grt + Cpx + Hbl + Zo + Rt + Qz \]

**Assemblage 2:**

\[ KFs + Grt + Cpx + Hbl + Rt + Pl \]

**Assemblage 3:**

\[ KFs + Grt + Cpx + Hbl + Ilm + Pl \]

Those assemblages represent garnets generated at high pressure high temperature environment which suffered pressure of about 9 – 12 kbar and temperature 675 – 900°C.

![Figure 3](image_url)

Figure 3. Kinds of garnet found in garnet bearing metamorphic rocks in Meratus Complex. Sample number Mrt 18 contain Spessartine with subordinate grossularite while Mrt 22 contains Almandine and subordinate Spessartine, Mrt 91 is garnet granulite that contains pyrope and almandine in almost similar amount, even in higher amount of pyrope content.
<table>
<thead>
<tr>
<th>Table 2. Mineral chemistry of sample of ore from Mr. JG and Mr. G.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>100A</td>
</tr>
<tr>
<td>101A</td>
</tr>
<tr>
<td>102A</td>
</tr>
<tr>
<td>103A</td>
</tr>
</tbody>
</table>

Note: Figures represent weight percentages.
### Table 1c. Mineral chemistry of Garnet of sample number Mrt 91(continued)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mrt 91</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>grt 1</td>
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<tr>
<td>SiO₂</td>
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<tr>
<td>TiO₂</td>
<td>0.072</td>
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<tr>
<td>Al₂O₃</td>
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<tr>
<td>Cr₂O₃</td>
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<tr>
<td>MgO</td>
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<td>CaO</td>
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<td>99.991</td>
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<td>Ti</td>
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<td>Cr</td>
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<td>Fe²⁺</td>
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<tr>
<td>Mg</td>
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<tr>
<td>Mn</td>
<td>0.034</td>
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<tr>
<td>Ca</td>
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<tr>
<td>Sum_B</td>
<td>3.013</td>
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<tr>
<td>Sum_cat</td>
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<tr>
<td>Alm</td>
<td>41.492</td>
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<tr>
<td>And</td>
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<tr>
<td>Pyrope</td>
<td>35.577</td>
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<tr>
<td>Spess</td>
<td>1.114</td>
</tr>
<tr>
<td>XCrnt</td>
<td>0.218</td>
</tr>
<tr>
<td>XFengt</td>
<td>0.415</td>
</tr>
<tr>
<td>XMggnt</td>
<td>0.356</td>
</tr>
<tr>
<td>Fe_Mggnt</td>
<td>1.166</td>
</tr>
</tbody>
</table>

**Origin of garnet containing rocks and its tectonic environment**

Garnet containing rocks are subdivided to be two main groups. Spessartine, spessartine-grossular and almandine containing rocks of Mrt 13 and Mrt 18 and Mrt 22 are low grade metamorphic rocks of shelf sedentary protolith. It was blueschist of high pressure rock and retrograded to green schist with chlorite-epidote-actinolite assemblage (figure 2a). That imply subduction related metamorphism influence and then had been followed by post subduction metamorphism.

The second group is garnet granulite. Garnet granulite of Mrt 91 shows REE diagram pattern of Continental Flood Basalt type or Active Continental Margin type which displays about 20 times REE enrichment. Another garnet granulite of Mrt 91 displays a normal MORB like pattern (figure 4). It was a N-MORB that was subducted in an active continental margin of Sundaland under high pressure condition and then followed by emplaced in situ to a condition which enables it to suffer high pressure temperature metamorphism: 9 - 12 KBar and temperature 675 - 900°C. It supposed to have occurred when tectonic environment changed from subduction toward collision. The assemblages of Active Continental Margin and MORB protolith support an idea of metamorphism in Active Continental Margin.

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**Figure 4.** REE diagram of garnet granulite taken from Kusan area, South Kalimantan. Its protolith show Normal MORB like pattern and Continental Flood Basalt like type. Normalizing value based on Sun And Mcdonough, 1989.
Later, container rocks of further geological events were just discovered by mineralizing carbonates. The diamonds present were not the main focus of the occurrence of diamondiferous container rocks. Some possibility of magma source occurrence is still possible. Another possibility is that during the movement of the Kimberlite body, it is open to the argument that there is no specific location of the occurrence of diamondiferous container rocks. However, the occurrence of diamondiferous container rocks is not limited to the Kimberlite body. The Kimberlite kimberlite diatreme is the diamondiferous diatreme which indicates that the Kimberlite diatreme is the diamondiferous diatreme. Therefore, despite the occurrence of diamondiferous container rocks, the diamondiferous diatreme is not the only occurrence of diamondiferous container rocks.

Although the diamondiferous container rocks were not the main focus of the occurrence of diamondiferous container rocks, the occurrence of diamondiferous container rocks was not limited to the Kimberlite body. The Kimberlite kimberlite diatreme is the diamondiferous diatreme which indicates that the Kimberlite diatreme is the diamondiferous diatreme. Therefore, despite the occurrence of diamondiferous container rocks, the diamondiferous diatreme is not the only occurrence of diamondiferous container rocks.

6. DISCUSSION

Although the diamondiferous container rocks were not the main focus of the occurrence of diamondiferous container rocks, the occurrence of diamondiferous container rocks was not limited to the Kimberlite body. The Kimberlite kimberlite diatreme is the diamondiferous diatreme which indicates that the Kimberlite diatreme is the diamondiferous diatreme. Therefore, despite the occurrence of diamondiferous container rocks, the diamondiferous diatreme is not the only occurrence of diamondiferous container rocks.
6. CONCLUSION

Garnet found in the Meratus Complex varies from spessartine, spessartine grossular, grossular almandine and pyrope almandine garnet. They are contained inside crossite/glaucophane bearing and other quartz rich schist or garnet granulites. Mg rich garnet only present in garnet granulite. Some pyrope-almandine garnet contains molecule Cr but in a very poor amount which does not indicate knorningite character and its Cr203 content does not fit with its garnet inclusion composition inside diamond found in Cempaka placer mining site.

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REFERENCES


7-21

Frende, T. G. and Chino, P. 1988. Periodicity of the

erosion process in a tropical rainforest. Science

1998, P. 98. Geological implications of

Al Sayyari, S. and Ahmed, I. 1999. Study on the

periodicity and correlation of the North Karangasem


Preparatory for the Kailasanuf in the Merungau

Preparation for the Indonesian National Geology

Seminar in 2011

Seminar, Indonesian Geology 2011
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