Fracture Analysis of Uranium-Bearing Rock in Eko-Remaja Exploration Tunnel at Depth 50-200 Meters, Kalan, West Kalimantan

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Abstract. Remaja Sector is one of the potential sectors of U mineralization at Kalan Area, West Kalimantan. Host rock of the mineralization is metasiltstone and schistosed metapelite. The 618 meters long Eko-Remaja Exploration Tunnel was built in 1980 to understand the character of uranium ore in this sector. The U mineralization in Kalan, West Kalimantan is influenced by the host rock type and fractures formed by regional tectonic. Regionally, ductile and brittle deformation occurs at Kalan. The ductile deformation observed from N 70º E fold plunging 30º NE that generate schistocity plane dipping 70-80º relatively to the north. First brittle deformation resulting open-mode fractures and schistocity planes that later filled by U-rich solution forming U veins, veinlets and breccia mineralization. Later, brittle deformation forming fractures that filled with calcite-gypsum solution afterwards, forming centimetric-desimetric vein and veinlet cutting the U vein. The purpose of this study is to determine the characteristics and main structure that control the U mineralization in the tunnel. The method is by collecting data of fracture such as joints and fault planes, schistosity planes (S1), and bedding plane (S0) together with its cross-cutting relationship at depth 50 - 200 meter from the tunnel mouth which at this interval representing the presence of mineralization in the Remaja Sector. The data then plotted and analyzed on upper hemisphere stereographic projection. Fracture analysis conducted to understand the families of fractures developed and the force direction resulting fractures the tunnel. From the analysis, the mineralization of U in the tunnel controlled by N 280º E fractures that relatively parallel to the schistocity plane as vein and breccia mineralization and analytical fold axis on Eko-Remaja Tunnel is N 73 Eº / 30 tilted to E-NE. Joints in the tunnel mainly affected by faults that formed by couple force

1. Introduction

For effective natural resources exploration, it is substantial to understand rock fractures due to its largely control on Earth’s dynamic process including fluid transport in the crust [1]. These structure developed by brittle failure [2] can be pathways for U-rich fluid that eventually forming U-bearing veins occur in a broad range of lithologies and geologic environments including acidic intrusives (granite, etc.) volcanics, metasediments and sedimentary rocks[3]. The U mineralization in metasediments of Remaja Sector, one of the potential sectors of U mineralization in Kalan, West Kalimantan, also taking place in the fractures [4]. The 618 meters long Eko-Remaja Exploration Tunnel was built in 1980 to understand the character of uranium ore in this sector. Even was built many years ago, the mineralization in relation with various fracture planes on the tunnel is not fully understood. The study of multiscalar processing of fracturation network data from remote sensing in Kalan [5] has been done but it does not discussed...
the relationship of the fracture and uranium mineralization. [4] stated that the fracturation also taking control on uranium mineralization as well as the lithology, but the fracturation was not explained further. Later, the microtectonic study of fracturation in Eko-Remaja Exploration Tunnel resulting in five fracture group in the tunnel with their chronological order and how they indicate the type of fold near the study area conducted [6]. Yet, how these fracture families affected the mineralization was not explained further. Fracture analysis in this paper conducted to understand the families of fractures developed and the force direction resulting fractures the tunnel so the characteristics and main structure that control the U mineralization in the tunnel can be learned.

2. Data and Method
Kalan located in the northern margin of Schwaner Mountains. The mountains lie North East-South West from Ketapang to Tumbang Hiran separating West Kalimantan and Central Kalimantan Province (Figure 1). Lithology of this area consist of Early Cretaceous Pinoh Metamorphics intruded by Early Cretaceous Sepauk Tonalites that later intruded again by Late Cretaceous Sukadana Granites. These groups of Cretaceous rocks are related to South West Borneo (SWB) Block accretion to Sundaland [7]. During Early Cretaceous the northward drift of SWB, the magmatic and volcanic process from subduction-related arc activity (Figure 2) producing the volcanogenic protoliths of Pinoh Metapelites (c. 130 Ma; based on U-Pb Zircon dating) [7]. These protoliths then subsequently metamorphosed due to emplacement of later Sepauk Tonalites (c. 75-130Ma) and Sukadana Granites (c. 65-103 Ma) intrusions [8,9]. However, other literatures [10,11] stated that the protolithsof Pinoh Metamorphic were formed in Paleozoic based on paleontological data.

![Figure 1](image1.jpg) Location of Kalan Area in the northern margin of Schwaner Mountains

![Figure 2](image2.jpg) West Borneo paleogeographic reconstruction during Early to Late Cretaceous [7].

Regionally, ductile and brittle deformation occurs at Kalan [5]. The ductile deformation observed from N 70o E fold plunging 30o NE that generate schistocity plane dipping 70-80o relatively to the north. First brittle deformation resulting open-mode fractures and schistocity planes that later filled by U-rich solution forming U veins, veinlets and breccia mineralization. These U rich solution interpreted
comes from the intrusion of Sukadana Granites [8]. Later brittle deformation forming fractures that filled with calcite-gypsum solution afterwards, forming centimetric-desimetric vein and veinlet cutting the U vein. Remaja Sector consist of Pinoh Metamorphic’s member, andalusite metapelites, metaamapelite, schistosed metapelites and metasiltstones [5] The favorable rocks is metasiltsones and schistosed metapelites. Commonly, the U mineralization forms in vein and tectonic breccia. The Eko-Remaja Exploration Tunnel lies NE-SW at elevation 450 m cutting metasiltstones and schistosed metapelites (Figure 3). There are 19 mineralization plane with high U anomaly in the tunnel mostly as tectonic breccia.

The method is by collecting data of fracture such as joints, veins, and fault planes, schistosity planes (S1), and bedding planes (S0) together with its cross-cutting relationship at depth 50 - 200 meter from the tunnel mouth which at this interval representing the presence of mineralization in the Remaja Sector. The U anomaly of the vein also detected using Surveymeter gamma RS-125. Each orientation data then plotted and analyzed on upper hemisphere stereographic projection as poles included clusterizing the poles based on their distribution. Clustering joints and fault plane using plunged stereonet conducted to normalize the kinematic axe resulting them.

3. Result and Discussion

The clustering of the fracture’s pole resulted 5 sets as seen in Figure 4A. These sets then grouped again into 3 Families (Figure 4B-D) based on their relationship to fault type that generate them and their chronological cross-cutting relationship. Each family described below:

1. Family 1 that consist of Set 1 cut by all other fractures. This family derived from a pair of strike-slip fault orienting E-W facing N with dip 50-80o. The mean of this family is N270o E/75o. Fractures in Family 1 are relatively parallel to schistosity plane (S1) and most of them are tourmaline vein with high content of U due to its high anomaly. Some of the tectonic breccia in the tunnel such as BM having general orientation parallel to this set.

2. Family 2 consist of Set 2 and 3. These fractures are cutting fractures from Family 1 cut by Family 3 fractures. These fractures derived from a pair of normal fault orienting WNW-SSE facing NE and NNW-ESW facing WSW with dip 50-80o. Fractures in Set 2 are also relatively parallel to schistosity plane. Some of these fractures in this set are tourmaline vein with high content of U.

3. Family 3 consist of Set 4 and Set 5. These fractures cutting all other families. These fractures derived from a pair of normal fault orienting NW-SE facing NE and NNE-SSW facing WNW with dip 45-80o. Fractures of this family are mainly calcite-gypsum.

Some of the schistocity plane appear as plane that can be measured using geological compass. The direction of them could be approximated N 260-300o E with various dip from 60 – 80o facing N-NW (Figure 5). This is suited to the strike and dip that measured directly from a measurable plane in previous work [6,8].
Figure 4. West Borneo paleogeographic reconstruction during Early to Late Cretaceous [7].

Figure 5. Schistocity plane’s pole

Figure 6. Bedding plane’s pole
Result of measurement and plotting of SO, S1 orientation data, then analyzed on upper hemisphere stereographic projection as poles to determine the position of the fold axis. From the analysis can be determined the position of the analytical fold axis on Eko-Remaja Tunnel is N 73° E / 30 tilted to E-NE (Figure 7).

4. Conclusion
1. U mineralization in Eko Remaja Tunnel controlled by Family 1 and Family 2. Family 1 derived from a pair of strike-slip fault orienting E-W facing N with dip 50-80° resulting fractures relatively parallel to schistocity plane (S1) as tourmaline vein with high content of U due to its high anomaly while family 2 derived from a pair of normal fault orienting WNW-SSE facing NE and NNW-ESE facing WSW with dip 50-80°. Fractures in Set 2 are also relatively parallel to schistocity plane. Some of these fractures in this set are tourmaline vein with high content of U.

2. The position of the analytical fold axis on Eko-Remaja Tunnel is N 73° E / 30 tilted to E-NE

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