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Role of Rock Mechanics in Mining Development in Indonesia

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Tropical countries are those that lie within the region that is called the tropics and the region is between the Tropic of Cancer, the parallel of latitude at 23 ½° North, and the Tropic of Capricorn, the parallel of latitude at 23 ½° South. Indonesia is a large archipelagic nation of 5 main islands, 2 main archipelagos and more than 60 smaller archipelagos lying between latitudes of 6°N and 11°S of the equator, and longitudes of 95° to 142°. Straddling the equator, the climate of Indonesia is typically equatorial and characterized by heavy rainfall, high humidity, high temperature, and low winds. Rainfall in lowland areas averages 1800 - 3200 mm annually, increasing with elevation to an average of 6100 mm in some mountain areas. In the lowlands of Sumatra and Kalimantan, the rainfall ranges from 3000 mm to 3700 mm, and the amount diminishes southward. The relative humidity in Indonesia is in the range of 70 - 90% and the average humidity is 82%.

At least three major plates of Indian-Australian, Pacific, and Eurasian Plate surround the Indonesia. According to Carlile, & Mitchell (1994) there have been fifteen major arcs identified with a total on land extent of over 15,000 kms. Whereas, recognized ore-bodies and major prospects are confined to six arcs. In Indonesia, these arcs total approximately 7,000 kms in length and contain combined historical production and current resources of gold and copper, and individual of arcs are characterized by specific types of mineralization. It can therefore be said that Indonesia is a proven country with a number of world class mining operations and highly prospective for most metals, particularly Cu and Au but remains underexplored.

Coal in Indonesia is generally formed at a young age about Miocen-Eocen with a relatively wide spread. Basin during this period included the Barito basin and the South Sumatra basin, etc. Delta depositional basin coal in East Kalimantan (Kutai and Tarakan) occurred immediately above the Eocene transgressions that were in Sangata, especially in KPC. Most of the coal has the quality of semi-anthracite bituminous because intruded by intrusive rocks resulting in the addition of temperature. Coal aged older, the old Paleogene that is considered as bituminous coal are located in Ombilin (West Sumatra), Bayah (West Java), Pasir (South-east Kalimantan), Sebuku Island (South Kalimantan), Melawai (West Kalimantan) and partly in South Sulawesi.

Moreover, about 80-90% of Indonesian land is covered by quarter sediment resulted from volcano activities, as well as trass alluvial, and soils resulted from rock weathering. Intensive weathering process leading to deterioration within this particular area would not be uncommon & hard rock formation would turn to be so called soft rock formation.

According to Ernst & Young (2016-2017) the risks of mining and metal business may be of the groups of finance related, legal and social licenses to operate, transparency, innovation, energy access, and security. The risks inherently come from uncertainties, and as mining development can be divided into three categories of activity during the Life of a Mine (LOM) namely, prior to mining, mining, subsequent to, and processing and marketing. At the beginning of the mining development geologists and mining engineers should be aware that uncertainty starts from activities of finding and proving, and then from decision making process as to whether mining will be on the surface, underground or combined methods and determination of types of mineral or coal processing. Open-pit, underground or combined mining should be selected depending on among others, the geometry and dimension properties of the deposit, rock conditions, production level, method of excavation, finance related issues, ore or coal recoveries, safety, and environmental aspects. In relation to rock condition the rock mechanics discipline is one of the disciplines in the mine that function under conditions of uncertainty, and the rock mechanics uncertainty is one of several sources of uncertainty affecting on the realization of the mine plan.

The sources of rock mechanics risk may be of

the uncertainty of geological conditions and limited information on rock mechanics parameters obtained from investigation both in the field and in the laboratory. The former includes geological structure such as faults, shear zones, minerals contents, and the parameters consisting of orientations, spacing, and persistence and shear strengths of joint sets in the rock mass. The rock mechanics uncertainties may be related to inaccurate selection of parameters for stability analysis such as physical properties of intact rock and rock mass, values of the main mechanical properties of intact rock (for examples UCS and Young Modulus), rock mass classification values and their use in estimating rock mass properties. Some other uncertainty on rock mechanics related parameters take account of lack on the comprehension of the constitutive behavior of intact rock and rock mass; unidentified weathered rock zone; ground water conditions, incorrect estimated in-situ stresses and induced stresses in relation to geological structures. In order to reduce these uncertainties, statistical and probability analysis should then be carried out thoroughly and properly, design changes should be done if necessary, do not too simplify engineering analysis and rock mechanics engineers and mine plan engineers should always be well trained.

Rock mechanics investigations in Indonesia suggest that rock mechanics analysis when necessary should consider deterioration of rock mass characteristics due to weathering, carry out comprehensive analysis, make use of monitoring equipment and perform risk management. From the rock mechanics perspective, the practitioners of rock mechanics should share and exchanges experience with academic and government and subsequently take steps to present an integrated program and research for rock mechanics education. Insufficient preliminary site investigations have been recognized as one of the major contributors to rock mechanics risk. Thus, it is essential for the geologists and rock mechanics engineers make more efficient use of the resources allocated for site investigation. In the effort to continually improve the safety and efficiency of mine planning and mining operation in Indonesia.