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A methodology to select valid results from Lab tests to estimate properties of intact rock with microdefects

Russo, A.
SRK Consulting (Chile) S.A., Santiago de Chile, Chile
Hormazabal, E.
SRK Consulting (Chile) S.A., Santiago de Chile, Chile

ABSTRACT: Porphyry copper deposits are characterized by a rock mass with a stockwork of mineralized veins and veinlets affecting the strength behavior of the intact rock and rock mass. The observation of tested samples and blocks at draw points pointed out that veinlets and veins have a high participation in the failure mode, according to this a small volume of rock containing veinlets lees than 1mm is considered to be representative of the intact rock. The structural description of the tested samples pointed out four typical failure types and three of them can be considered valid results to estimate the intact rock properties. This failure classification system is useful to define valid results to estimate the intact rock properties. This method had been applied to several operating mines and projects in Chile obtaining a better estimation of the intact rock and rock mass properties and has been applied to estimate pillars strength, fragmentation curves, large open pit slopes stability or cavability for deep underground mines increasing the reliability of the results.

1. INTRODUCTION

The estimation of the intact rock properties from Lab tests, as unconfined compressive strength, tensile strength and triaxial tests represents an important item of the intact rock and rock mass geotechnical characterization, as these parameters are used as inputs for the geotechnical classification systems, geotechnical design and numerical modeling in the mining industry.

The porphyry copper deposits are characterized by a host rock affected by different alteration types and a mineralization mostly hosted in a stockwork of veins and veinlets that makes difficult to obtain samples of intact rocks, as homogeneous and avoid of defects or veins. The presence of the stockwork can produce a strength anisotropy in the collected sample, affecting the value of the Lab test and the estimation of the intact rock properties. Due to this in El Teniente Mine was developed a methodology [1] to select valid results from UCS, triaxial and Brazilian test to estimate in a better way the intact rock properties.

2. PREVIOUS WORKS

In the past, at El Teniente Mine, the estimation of the intact rock properties was based on the statistical analysis of the results obtained from the Lab tests [1], [2], [3], however, the different results obtained from several geomechanical campaign, pointed out the necessity to have a good structural description of the tested samples [4], [5], [6] and was developed a method for a detailed structural description of each sample previous and post the Lab test [1]. According to this method it was possible to quantify the participation of pre-existing veins in failure mode in tested samples and from observed blocks in draw points, pointing out that over 70% of the tested samples have a failure with participation of pre-existing veins and 100% of blocks at the draw points are delimited by pre-existing veins [1]. Figure 1 shows the statistical analysis of the failure mode for tested Lab samples and blocks at the draw points at El Teniente Mine [1].

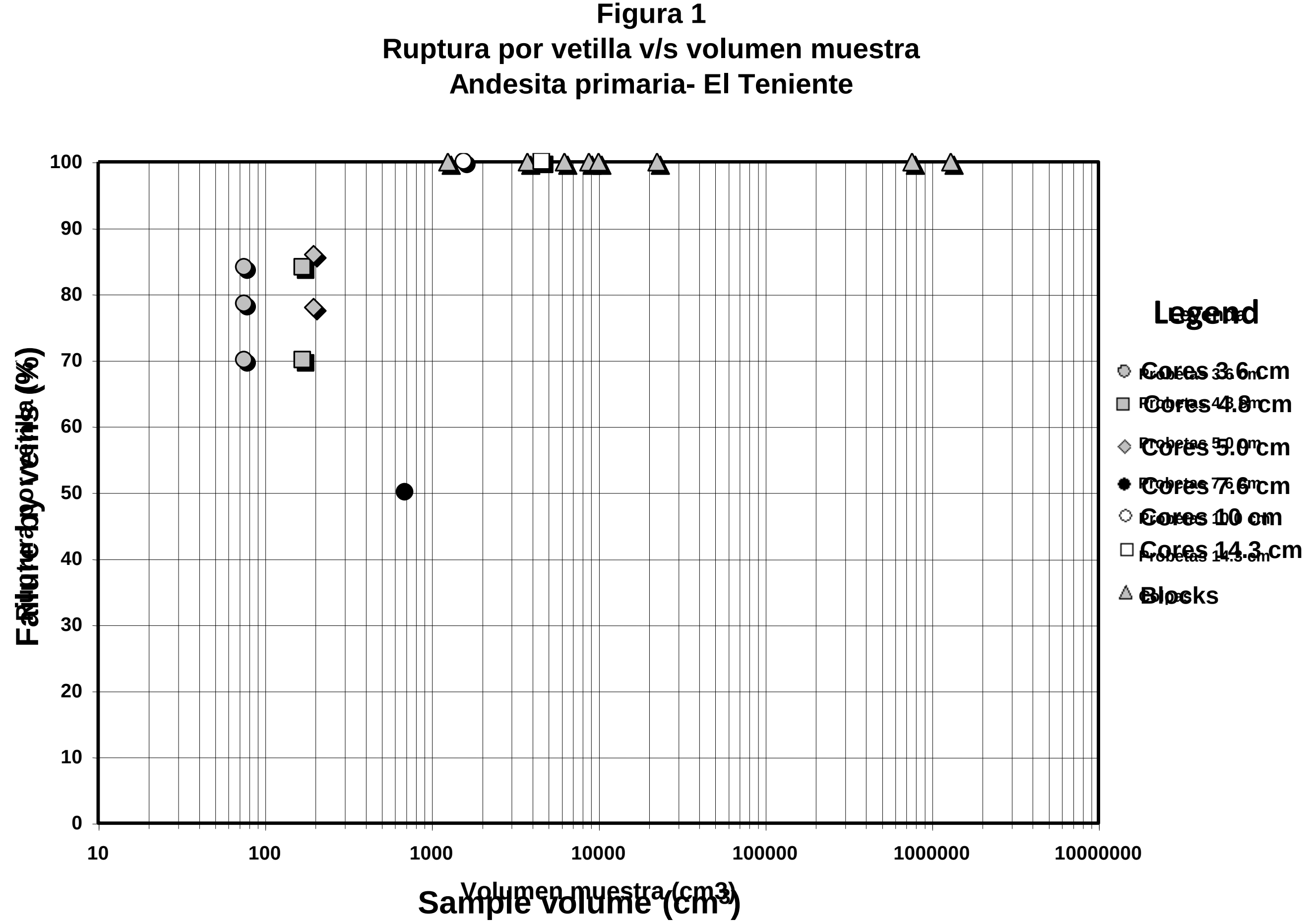


Fig. 1. Statistical analysis of the failure mode for Lab samples and blocks at the draw points at the El Teniente Mine [1].

Due to the relevance that have the stockwork in the failure mode of the samples lead to modify the concept of the intact rock. Since 2000 [1] at the El Teniente Mine the intact rock is not represented by an homogeneous and isotropic rock, but consists of a core samples with stockwork, which veinlets are discontinuous, with a thickness less than 1mm and that are not considered in the geological or the geotechnical mapping.

These types of veinlets can be related to the microdefects in the IRMR classification system of Laubscher and Jakubec (2001) [7]. According to this concept a small volume of rock with veinlets, contained between continuous joints is representative of the intact rock in a porphyry copper deposit (Figure 2).

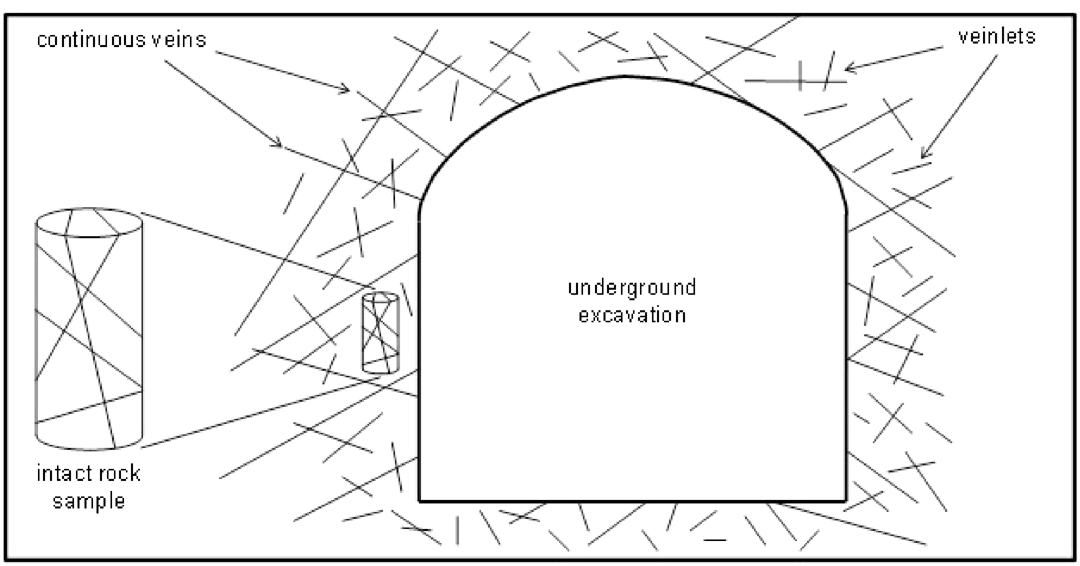


Fig. 2. Example of intact rock in a porphyry copper deposit. [1].

3. ANALYSIS OF FAILURE MODE

After the structural description of the cores previous and post the Lab Tests it was possible to recognize four types of failures of the tested cores and that are described as follow:

Type A: Rock Failure. The failure of the sample occurs with several planes that are not following pre-existing veinlets. Each failure surface cuts both the matrix of the rock and the veinlets. The sample is split in several pieces (Figure 3).

Type B: Mixed Failure. This type is characterized by simultaneous failure planes developed both through the matrix of the rock and along pre-existing veinlets. Two sub-types have been recognized:

Type B1: One Mixed Surface. The failure occurs along a single plane that is propagating both along a pre-existing veinlet and through the rock matrix. The sample is split in two pieces (Figure 3).

Type B2: Several Failure Planes. This sub type is characterized by the generation of several simultaneous failure planes that are propagating both along the matrix and the veinlets. The sample is split in several pieces (Figure 3).

Type C: Failure along Several Veinlets. The failure occurs by, at least, two simultaneous failure planes following two pre-existing veinlets. The sample is split in several pieces (Figure 3).

Type D: Veinlet Failure. The failure plane occurs by a single failure plane along a pre-existing veinlet. The sample is split in two pieces (Failure D1 in Figure 3). A special case of this failure type is characterized by several failure planes, with a major failure plane along a pre-existing veinlet and minor failure planes generated after the failure peak (Failure D2 in Figure 3).

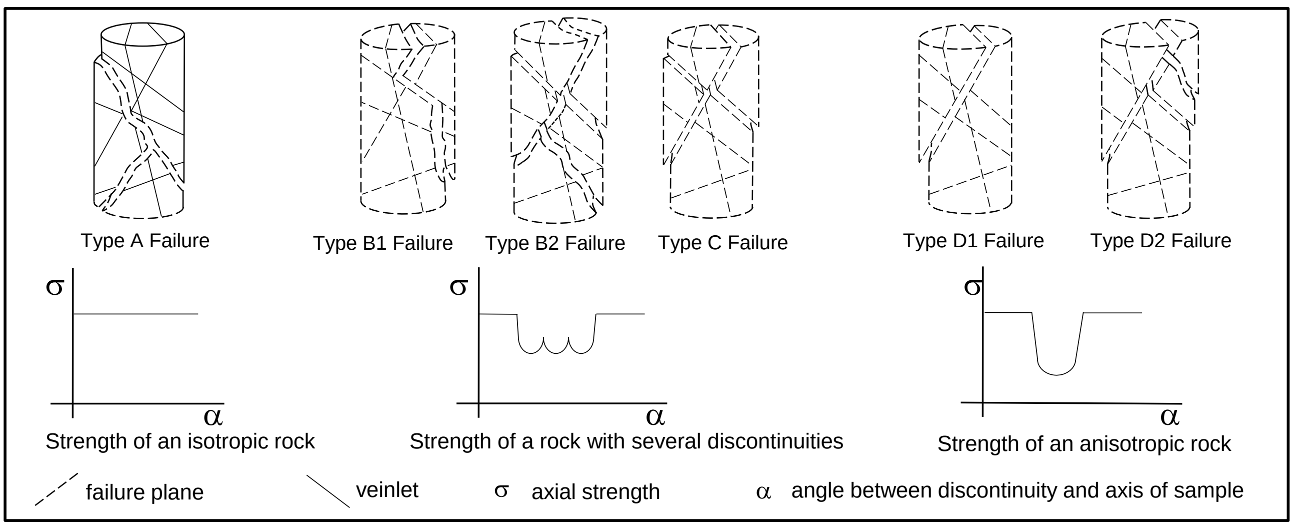


Fig. 3. Types of failure observed in tested samples and type of anisotropy strength [1].

4. SELECTION OF VALID LAB TESTS RESULTS

To determine which Lab Tests results can be considered valid to estimate the intact rock properties it is necessary to review the tested samples and classify the failure type as described above.

The samples which failures are of Type A and B show an isotropic or les anisotropic behavior and can be considered representative of the intact rock and can be considered as valid results.

Results obtained by failure Type C show a less anisotropic behavior and are representative of a rock mass with stockwork. These results can be considered valid to estimate the intact rock properties.

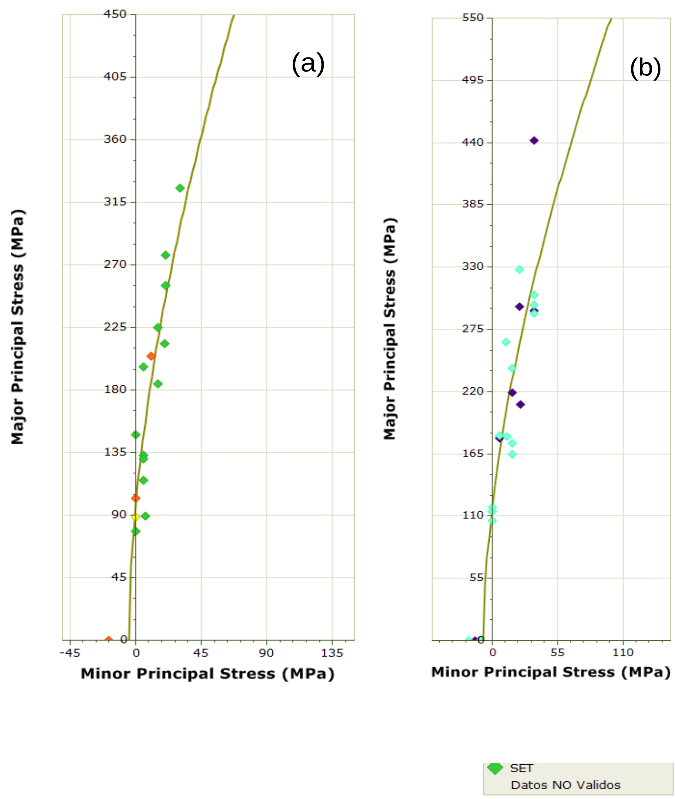
Failure Type D shows a strong anisotropic behavior and the result is representative of the strength of the veinlet infill. These results are not considered valid to estimate the intact rock properties.

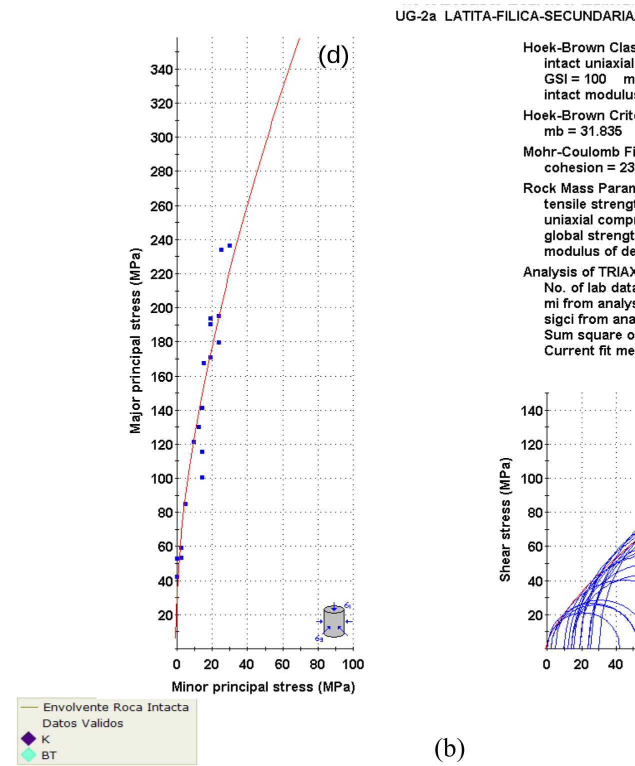
5. ESTIMATION OF THE INTACT ROCK PROPERTIES

To estimate the intact rock properties as density, porosity and seismic wave velocity all the Lab Tests results can be considered valid due to results are not depending of the type of failure.

To estimate UCS, Tensile Strength, Elastic Modulus and Hoek & Brown parameters of the intact rock results obtained by failure Types A, B and C can considered valid. Results obtained by failure Type D in Triaxial Tests can be used to estimate the cohesion and friction angle of the infill veinlets following the methodology proposed by Goodman [8].

In Figure 4, the Hoek & Brown parameters of several lithologies at Chilean Mines have been estimated according the presented methodology; the selected results fit quite well with the failure envelopes.





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6. CONCLUSIONS

The methodology presented in this work has been applied to estimate the intact rock properties in several porphyry copper deposits in Chile obtaining better results than a selection using a statistical method. Based on this, the estimation of the rock mass properties can be used in the prediction of fragmentation curves, pillars behavior estimation, large open pit slopes stability analysis or cavability for deep underground mines increasing the reliability on the results.

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