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Mechanical Properties of a Gaspe Rock

by

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SUMMARY

The uniaxial compression and Brazilian tests were conducted on rock cores taken from the Gaspe Peninsula of Quebec.

Strength tests show that the ore and wall rocks are essentially equal; both can be classified as "high" strength rocks.

Mechanical properties for both rock types are:

compressive strength	(25, 240 ± 31%) psi
splitting strength	(3, 340 ± 23%) psi
elastic modulus	(8.1×10^6 ± 27%) psi.

Preliminary testing results suggest that further testings with reference to weak bedding planes could be useful for ground control.

Rock Testing: Mechanical Properties: Rock Classification: Gaspe Rock

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INTRODUCTION

A small quantity of drill core was obtained for mechanical property testing from a mine operating in the Gaspe Peninsula. The mine does not have ground control problems; on the contrary ground conditions are remarkably good. Anticipating that ground conditions might degenerate with depth or time a small amount of test work was undertaken to identify basic rock properties. These results might be used as a basis for additional research, e.g. in cooperation with a university or to assist judgement in analyzing ground failure where it does occur.

In any case the work undertaken here is very limited and the results are of a preliminary nature.

BACKGROUND

The ore bodies occur in hornfels which occurs in a metamorphic aureole surrounding a large granite stock intrusion. The hornfels "is a dense rock with numerous closely spaced parallel fractures in several different planes giving it a tendency to break into angular blocks. In the ore bodies these fractures are mineralized with copper sulphides mainly chalcopyrite and bornite in roughly equal amounts. The sulphides have re-cemented the rock which stands well; and there is very little overbreak." (1)

The main ore body is somewhat pear-shaped in plan with a length of 500 to 600 ft and a maximum width of 200 ft at one end. It dips at 70° and plunges at 55° on the upper levels, steepening at depth. This ore body outcrops on a mountain top and has been traced down to well over 1000 ft. Several smaller ore bodies have been found within 1000 ft of the main ore zone (1).

The ore is worked from the top down in a series of transverse open stopes with rapid removal of pillars. The long-hole stopes are 150 ft high by 60 ft wide. Transverse pillars between stopes are 40 ft wide and associated crown pillars 30 ft thick. Ore is drawn through scram crosscuts on the level. Temporary pillars and scram development are blasted into the stope below so that all of the ore is removed. At the surface outcrop a 60 ft pillar has been left so the effect of mining is to form one large open stope. Backfilling is not practised.

EXPERIMENTAL PROCEDURE

Rock was supplied in the form of E-size core and identified by the geologist at the property as follows:

Group	Description
1.	Ore of main zone: Quartz-Biotite hornfels with Chalcopyrite and Bornite Mineralization 3080 level.
2.	Wall-rock: Quartz-Biotite hornfels (on the footwall side of main zone) 3080 level.
3.	Wall-rock: Shaly Feldspathic sandstone (at the north end of SF-1 zone) 2400 level.
4.	Wall-rock: Quartz-Biotite hornfels (at the north end of SF-1 zone) 2400 level.

Test specimens were prepared from core in each group and the following mechanical properties determined:

(a) Uniaxial compressive strength
(b) Tensile strength
(c) Elastic modulus.

Uniaxial strength was obtained from test cylinders (0.9 in. diam x 2 in. high) finished so the end faces were parallel to 0.001 inches. Strain gauges were attached to two of the five specimens in each group to determine elastic modulus.

The specimens were seated on a spherical loading block by applying a load of 1000 lbs and releasing it. In a few cases a very thin sheet of teflon was placed between the rock and loading plattens in an attempt to get more uniform loading.

Elastic modulus is the slope of the line tangent to the load-deformation curve at a stress of 9,000 psi.

RESULTS

Test results are shown in the appendix and summarized in Table 1.

TABLE 1

Summary of Test Results

Core Group	Compressive Strength psi	Splitting Strength psi	Elastic Modulus psi x 10^6
1	28,900 ± 19%	4200 ± 27%	6.7
2	21,060 ± 54%	2920 ± 11%	9.3
3	30,100 ± 16%	3140 ± 11%	10.3
4	20,640 ± 13%	3360 ± 24%	6.6

DISCUSSION

Many problems in ground stability can be attributed to an increase in stress level or a decrease in rock strength. Stresses increase with depth and size of stopes. Stresses previously applied to ore body are now concentrated on surrounding rocks. At the same time, a decrease of strength in wall rocks occurs due to the geological structure (joint, fracture and weakness plane). The practical question is whether a significant change in rock strength has occurred when poor ground conditions are met.

The results reported here are specific properties for a specific sample of rock. In order to apply this data in the mine a decision is required on the representativeness of the sample with respect to the formation, e.g. typical, weakest or strongest sections. Our assumption here is that it is typical.

Secondly a distinction must be drawn between properties of the rock substance and the rock mass. Engineering tests are done on the rock substance and mine openings are located in the rock mass. In order to make practical use of detailed technical data it is often helpful to classify the various rocks using an established classification system. The system recommended by the Canadian Advisory Committee on Rock Mechanics follows (2, 3).

"This classification considered the rock in two stages, first as the actual rock substance (items 1, 2 and 3) and then as the rock mass (items 4 and 5). It includes the appropriate term in each of the following five categories:

Rock Substance: 1. Geological name of the rock.
2. Strength (dry): VERY HIGH, HIGH, MEDIUM, LOW or VERY LOW. (b) Strength (wet): as above, when warranted.

Rock Mass:

3. Deformation : ELASTIC or YIELDING.
4. Gross Homogeneity: MASSIVE or LAYERED.
5. Continuity of Formation: (a) SOLID, BLOCKY, SLABBY or BROKEN. (b) LOOSE or TIGHT, when warranted.

Thus, one rock might be described as "sandy-shale, low strength, yielding layered and blocky," and another rock might be described as "diabase, very high strength, elastic, massive and solid."

The above categories are described and defined as follows:

1. The *geological name* generally ought to be fairly simple, such as could be obtained by examination of a hand specimen.
2. Strength is to be based on uniaxial compressive loading to failure of a cylinder with a L/D ratio of approximately 2. The ranges are: *very high*, >32,000 psi; *high*, 16,000-32,000 psi; *medium*, 8,000-16,000 psi; *low*, 4,000-8,000 psi; and *very low* <4,000 psi.
3. Rocks are to be classed as *elastic* if the relative permanent strain at the ultimate compressive load is less than 25 per cent or if they show a creep rate of less than 2 micro inches per inch per hour when loaded to half of their ultimate strength. If these values of permanent strain or creep are exceeded, the rock is to be classed as *yielding*.
4. Visual examination will generally enable the rock to be classed as either *massive* or *layered* (or occasionally as *irregular*).
5. Rocks may be classified as *solid* if joint spacing exceeds 6 ft, *blocky* if the joints are spaced from 3 ins. to 6 ft and with spacing not dependent on direction, *slabby* if the joints are spaced from 3 ins. to 6 ft but are closer in one direction than in another, and *broken* if the fractures or joints are closer than 3 ins."

On the basis of uniaxial compressive strength the rocks obtained here would be classified as follows:

Group	
1.	High,
2.	High,
3.	High,
4.	High,

Three comments relating to the tests performed here are worth documenting:

1. The four specimens which were loaded on teflon failed by vertical splitting rather than shear. Hence, these values are likely to be lower than they would be in a normal test. Three of these tests were from Group 2, so the average uniaxial compressive strength given for this group is likely too low.

2. Failure of the Group 3 specimens appeared to be influenced by bedding oriented at 20°-40° to the long axis of the specimen.

The strength of this rock would be influenced by the orientation of the bedding in the specimen.

3. Splitting strength is intended to give some indication of tensile strength of the rock. The splitting strength is usually much higher than the tensile strength as determined by a normal pull test.

CONCLUDING STATEMENT

Preliminary tests show the ore and wall rocks to be of essentially equal strength and both are in the range of "HIGH" strength rocks. Since properties of the rock mass are very important in analyzing in-situ rock behaviour it might be worth making an attempt at classifying according to this group of characteristics.

Initial discussions suggested that the greatest potential hazard at this mine would be the occurrence of sudden and large scale failure in the back or walls of the large mined-out stope. Present work is a small contribution to the information required to evaluate that problem. Further work might be pursued along the following lines:

1. Classification of rock according to properties of the mass as outlined above.

2. Further testing of the rock substance using standard tests and possibly giving some consideration to the assessment of brittleness as distinct from strength.

3. Monitoring of deformation in the mine especially those areas weakened by geological discontinuities or where the geometry of the opening leads to tensile stresses.

ACKNOWLEDGEMENTS

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REFERENCES

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2. Patching, T.H., and Coates, D.F., "A Recommended Rock Classification for Rock Mechanics Purposes", CIM Bull., October 1968.

3. Coates, D.F., "Rock Mechanics Principles", Mines Branch Monograph 874 (Revised 1970) Department of Energy, Mines and Resources.

APPENDIX

Test Results

Specimen No.	Compressive Strength psi	Elastic Modulus psi x 10^6	Specimen No.	Splitting Strength psi
Group 1				
1-1	35,380		1-4	5840
1-2	31,250	7.8	1-5	3780
1-3	23,680	5.6	1-6	3870
1-9*	25,270		1-7	3300
			1-8	2900
Group 2				
2-1*	26,210		2-4	3360
2-2	29,850	11.2	2-5	3030
2-3	31,550	7.3	2-6	2510
2-9*	7,690		2-7	2720
2-10*	10,000		2-8	2970
Group 3				
3-1	34,600		3-4	2890
3-2	30,000		3-5	2980
3-3	24,040	10.3	3-6	2800
3-9	35,200		3-7	3600
3-10	31,920		3-8	3420
3-11	24,850			
Group 4				
4-1	16,800		4-4	4730
4-2	24,050		4-5	2750
4-3	21,020	6.6	4-6	3060
4-9	20,910		4-7	3410
4-10	20,440		4-8	2870

* Teflon on loading surfaces