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Contribution to the study of cutting mechanism of Capão Bonito Granite, São Paulo State, Brazil

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ABSTRACT: Granite blocks from Capão Bonito was used at a sawing enterprise to obtain slabs and the final product had streaks on the Quartz mineral and this defect motivated this study. The resulting slabs were also of a lighter color than the usual dark red that is one of the most appreciated feature of this mineral, and this is a cause of great concern as this factor may sharply influence the commercialization of the end product. Two hypothesis were considered for this study as follows: the first one related to possible modifications in the quartz mineral from a determined area of the deposit, and a second alternative related to the operational conditions during the industrialization phase due to the sawing procedure adopted at the plant. Mineralogical and microhardness analyses of the quartz from many samples provided useful information, which were compared with identical analysis performed with other samples that did not present this problem. The purpose of the quartz mineralogical analysis is to determine the technological characteristics of those crystals. The complete absence of quality control procedures for cutting tools (sawing blades and grit) as well as gang saw operational conditions at the mining enterprise prevented more conclusive analysis. Capão Bonito granite comes from the same area where this problem occurred and is exported in great scale as well as consumed in the domestic market, and the recommended solution is to improve tooling quality control and the operational conditions of the sawing equipment.

1 INTRODUCTION

Last year at MPES'1999 (Hennies et al., 1999) there was the presentation of a detailed study of the exploitation system used to produce the Capão Bonito red Granite Blocks in São Paulo State, Brazil, with the use of jet piercing.

The first beneficiation (Hennies & Stellin, 1996) of this Capão Bonito granite blocks in a sawing enterprise to obtain the slabs demonstrated the appearance of streaks in the quartz mineral and motivated this study.

The main problem is that the resulting slabs also display a lighter color than the usual dark red that is one of its most appreciated features in the commercialization, which caused great concern that this factor could sharply affect prices of the end product, as well as the concern that this characteristic could extend to zones or regions of the deposits.

Two major work hypothesis were established for the study as follows: first, the possible modifications in the quartz mineral at a specific area of the deposits that could be a feature of this area; or second, the operational conditions during the sawing of the slabs at the beneficiation plant because of the sawing machinery or procedures that originated the color loss.

As granite from the Capão Bonito area is exported in large volumes as well as consumed in the domestic market, and the mineral comes from the same area where the problem occurred, the study of the exploitation control system was first examined.

Following these laboratory studies on petrographic slices, several detailed mineralogical and microhardness analyses of the quartz samples were performed to provide useful information. These samples were compared with identical analysis performed with rock samples that did not display any sawing machinery issues.

The studies are presented in the following paragraphs of this paper.

2 DEPOSITE AREA FEATURE

As mentioned above, the first hypothesis for the slab's loss of dark red color is that the blocks come from a specific area of the deposit. Thus, the lighter quartz color comes from blocks exploited from a certain deposit location and this may be considered as a feature of the deposit area.

To eliminate the possibility that the deposit area feature is responsible for the problem, a research was made on blocks exploited from the same area or near this area. This was performed by means of the controlled numbering system used on the blocks extracted from the deposit.

Other blocks from the same area were sawed, and many of them were exported to the international market as they did not display that loss of color. The obvious conclusion was that the problem must be related to the sawing process at the plant and that the first hypothesis must be discarded as the cause of the problem.

Below, in figure 1, we can see the exploitation control system. Every exploited Block received an Identification Number at the site to control the place from which it was extracted. This Number remains permanently on the block until it is processed at a domestic plant or when it is sold to the international market. Thus, all the commercialization of any Capão Bonito red Granite is made with the same identification number, which provides data about the actual location of the deposit area from which it was extracted.

Figure 1. Identification Number of Capão Bonito granite block.

Summarizing, we may say that there is no deposit area feature that could result in lighter end product color, and that there are no regions or extraction zones in which the red color is darker and other regions in which this color is lighter. The red granite of Capão Bonito is very homogeneous in its color features, and present no variation from one point to another within the full area of the current deposit.

3 MINERALOGICAL AND MICROHARDNESS ANALYSIS

The second hypothesis relied on the laboratory examination of normal and defective slabs.

For a more precise examination of the problem, a series of slabs were collected and then prepared as samples for petrographic analysis. These thin and polished slice samples were prepared according to adequate fracture orientation.

Some of these samples display the orientation of the rock's easiest plane of fracture in mining, referred to as the "rift" direction. Others samples display a normal orientation to this easiest fracture plane, in mining technology designated as head and grain.

As mentioned before, for most dimension-stone quarrying, the success of the art depends largely on taking advantage of joints and cleavage planes in the rock.

In the red granite rock there is a "rift" along which it may be easily split. The rift of the red granite is the surface parallel plane (i.e., parallel to its outcrop).

Planes perpendicular to the rift are the "head" and "grain", and along these orientation planes the rock is not so easily split. Joints in granitic rock are at perpendicular angles, and this excavation method is referred to as block quarry.

The head direction that is most difficult to split is a direction perpendicular to the valleys, and the grain, or third direction of intermediate splitting difficult is parallel to the valley. As the head direction is the most difficult surface to obtain, this surface generally created with the use of jet flaming equipment.

Other samples were made from regular Capão Bonito granite slabs (or problem free slabs) to give us a comparison between slabs with problems and slabs without problems, and their possible cause.

Petrographic and mineralogical identification of defective slabs with color loss demonstrated that the quartz crystals present some anomalous iridescence, caused by some superficial fragmentation. These phenomena were probably the consequence of sawing operations with the use of poorly controlled steel grit, and another factor that may influence results are the blades used in the equipment. This anomalous superficial iridescence must be a consequence of the beneficiation phase, and may not be attributed to the rock block itself.

A total of twelve different samples were studied and they are described in table 1.

Table 1. Samples of red granite slices examinated.

Sample Number	Orientation
1A	rift
1B	head
2A	rift
2B	head
3A	rift
3B	head
4A	rift
4B	head
5A	rift
5B	head
6A	rift
6B	head

Additional examination of the polished slices were performed after a microhardness indentation test. The quartz crystals were submitted to a microhardness test that demonstrated their behavior when a diamond tetragonal pyramid was used to print a square indentation at the quartz as shown in the figures 2, 3 and 4.

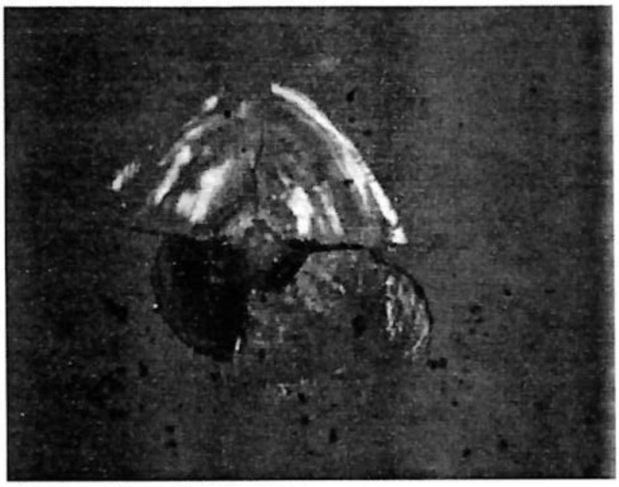

Figure 2. Indented sample normal to rift.

Figure 3. Indented sample paralel to rift.

Figure 4. Indentation paralel to rift direction.

At figures 2, 3 and 4 above, it is possible to notice that the indentation promote a series of cracks that may identify other features as follows:

1 A white indentation point area with intense fragmentation making the whole area white.
2 Area of the conchoidal fracture with different dip angles, promoting the whitening and iridescence of the quartz mineral.
3 Area of radial and vertical fractures.
4 Area of concentrical and vertical fractures.

Careful petrographic examination of the defective slabs compared to the normal samples indicates the existence of indentation streaks parallel to direction of sawing of the slab that caused quartz fragmentation and iridescence along these streaks. This is similar to the results obtained in the microhardness tests in which there are punctual fragmentation and iridescence marks.

In his article, Berry (1989) described the performance of indentation tests with grit in granites and noted the formation of white streaks and this coincides with our observations.

Antonini (1988) (apud Antolini et al., 1989) has verified in practice that there is a change to granite color after sawing, a phenomenon that he attributed to the existence of grit of greater diameter that contaminated the circulating abrasive pulp.

The observation of thin and polished slices allow us to conclude that the loss of color of sawed slabs must be related to poor control of grit granulation during pulp preparation; that pulp preparation requires better quality control; and that color loss is not related to the granite block original location at the deposit.

4 CONCLUSIONS

Main conclusions from this study are:

1 Quartz mineral is friable, and so more susceptible to fracture than feldspar and mica. The whitening results from the conchoidal fractures and the indentation generated during the sawing operation.
2 Quartz behavior during the indentation tests is the same for all samples of prepared rock slices.
3 The abrasive pulp was not the object of our study, in terms of material quality, mostly grit.
4 It is known that grit granulometry, contamination of the grit with larger diameter particles, grit hardness, feeding failure of the pulp, sudden changes of grit granulometry within the pulp during sawing operations, and other factors may lead to streaks on the rock surface.
5 Sawing and polishing operations must be changed to provide adequate conditions for good surface finish of the end product, thus ensuring the best exploitation of our rock mineral resources.
6 Blocks exported from Brazil to Japan did not display any loss of color after the sawing operations.

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