

The pegmatite deposit at Mina Maya, Piquet Carneiro, Ceará, Brazil.

- Prasiolite, citrine and amethyst -

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Prasiolite and citrine, two varieties of quartz, are very rare to find naturally in nature. The few specimens that exist are highly prized and can reach a very high price in the gemological market. A new locality has been recently discovered in the region of pegmatites in Ceará state, at

around 300 km from the coast, in Brazil, which could be a deposit of major proportions for these minerals since they appear in large quantity and quality unknown until now. It is an area with poor agricultural resources and where mineral resources have not yet been exploited.

After several years without visiting the mining provinces of Ceará State, I went to study several findings reported and dated by the DNPM (National Department of Mineral Production) of Fortaleza, through the Ministry of Environment of the State, in addition to my miners friends indications, familiar with the region. The purpose was to verify the possibility of finding possible future deposits where quality stones could be extracted, in particular, minerals that could produce colored

gems, in a wide area of pegmatites in the region.

It is an area without relief, with heights ranging from 300 to 450 meters above sea level. The region is a platform that has been deeply eroded by several streams that have left little hills formed by harder pegmatitic rock as witnesses. Many of the streams remain dry for most of the year, and only in the rainy season and due to the tropical atlantic weather it is rapidly covered with greenery. This area of Brazil has been so far very little explored in terms of its mineral resources.

Following the available indications I walked, for months, many miles in the municipalities of Quixadá, Quixeramobim, Mombaça, Acopiara, Iguatu, Solonopolis and Piquet Carneiro.

Among the several interesting points I discovered and left for a later detailed study, one in particular drew my attention: Piquet Carneiro.

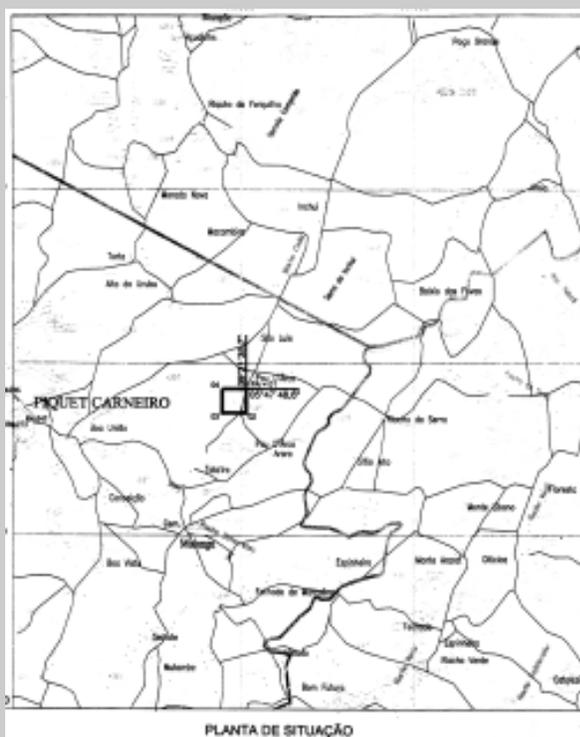
It is a municipality with a population of approximately 16,000 inhabitants in a geographical area of 587 km². It's a village with diverse agriculture production: rice, beans, cassava and cotton, which employs much of the population only during the rainy months, from March to June, so exploiting the mineral deposits in this area during all year will be very profitable to its inhabitants.

The pegmatites of this area are granitic, mostly heterogeneous, with typically tubular shapes and dimensions of hundreds of meters and about 10 meters of thickness, and can reach up to 80 meters deep. They are

transversal to container orientation and have a direction predominantly SW-NE and E-W, with vertical and subvertical disposition.

From the trial pits and the points where there have been sporadic withdrawals, it was concluded that large deposits with a very high production could be exploited.

Overall in the region a wide variety of minerals has been found, some with large crystals of gem quality, as tourmaline, beryl (aquamarine), garnet, quartz, and feldspar among others.



Sketch of Maya mine situation, in the municipality of Piquet Carneiro, Ceará, Brazil.

Cassiterite, amblygonite, tantalite, lepidolite and spodumene can be found in many parts of this vast region.

We were pleasantly surprised, at this stage of the search in Piquet Carneiro, that in the mine Maya a pegmatite vein of considerable size was found presenting numerous quartz crystals in both sides. The collected quartz crystals presented an intense green coloration and a considerable transparency that in some points was even gem quality. Other quartz veins, with milky layered white and green color, and sometimes with intense violet color of the purest amethyst next to the green prase together in a single crystal.

The yellow color, citrine quartz, is present in quartz crystals in parallel contact with prase and violet amethyst. This quartz which has three different primary colors, but also presents different colorations, will allow the exploitation to extract precious stones and gems for various uses such as lapidary work and carving.

The quartz, that in mineralogy is called prasio, is called "prasiolite" in gemology when the specimens have transparent crystals, and those specimens that have a green and yellow coloration in contact or in transition are called "prasiotrine". This name comes from green quartz and citrine quartz in regard to yellow quartz. The Maya mine prasiotrine is sold under the name of Shalimar. The prase name of the green quartz comes from the Greek "prasios" meaning leek, referring to the color of the leaves of this vegetable. Prase quartz variety is quite common in opaque crystals but translucent crystals and very rare and gem quality transparent crystals are an exception.

Citrine quartz is also very rare in nature. It appears in some localities but in very small quantities. But in the mineral market the yellow quartz is very common. The commercial citrine quartz is obtained by artificially manipulating amethysts. Quartz crystals that are amethyst variety and have a color range not intense enough to be considered and sold as amethyst are used to make citrines. Violet or purple coloration is produced by trivalent iron impurities and, according to recent studies they also suggests that aluminum may play an important role to maintain a relation with iron. Although amethyst is very

stable to acids, it is very vulnerable to heating, turning yellow at 450 °, thus providing commercial citrine. After 500 ° it changes to bright orange, being called burnt or toasted amethyst. At 600 ° it loses transparency taking a milky hue. Depending on the origin of the amethyst crystals, different shades of yellow, orange, pink and even green can be produced. These color changes from purple to yellow are produced by changing the valence of iron that the crystals contain and are reversible, making the recovery of the original color possible by irradiation. There is

also a variety of ametrine quartz, name for the transparent quartz crystals that have a double coloration, purple from amethyst and yellow from citrine in the same crystal.



Overview of Piquet Carneiro landscape with the profile of the relict mountains formed by geological denudation. Antonio Velasco photo.



The hills are formed by granite rock and covered with vegetation. Antonio Velasco photo.

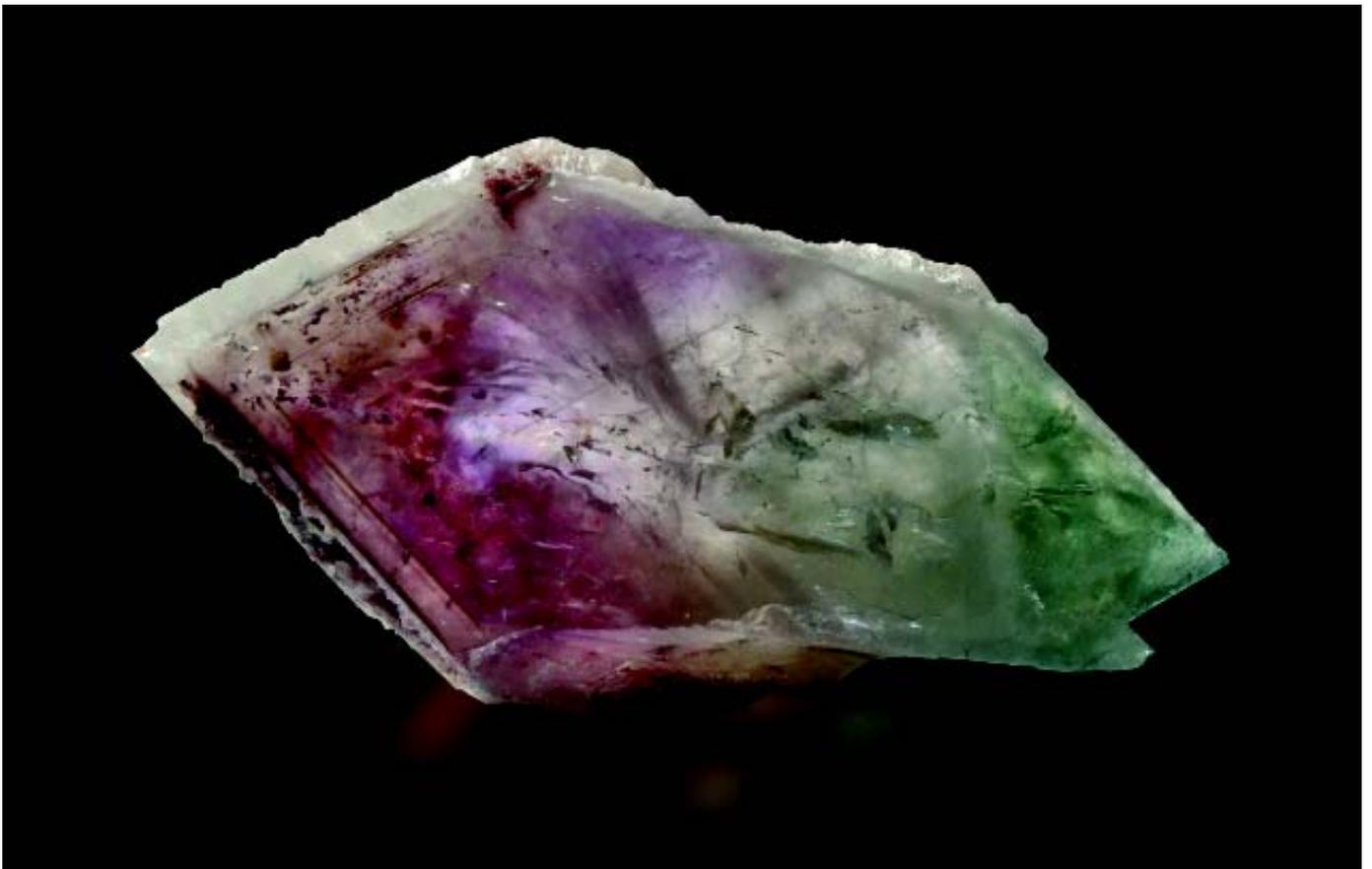


Quartz crystal showing green interior color (prasiolite). 8.2 cm.



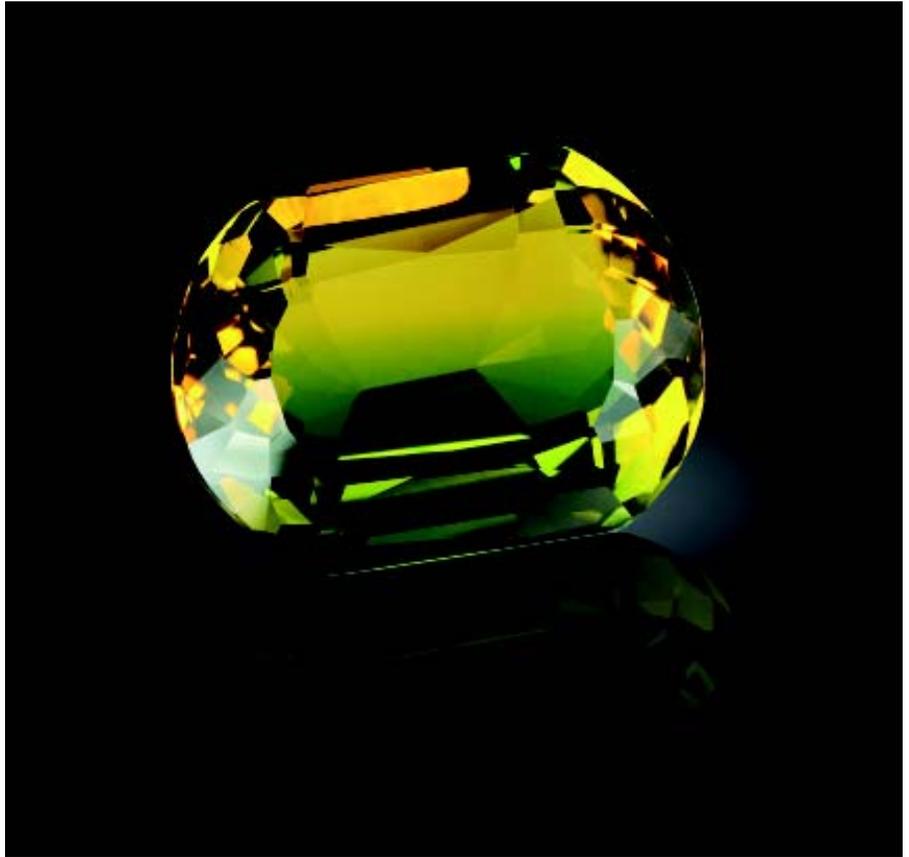
Quartz crystal showing internal tricolor ghost. 5 cm.

Section of a double terminated quartz crystal showing internal ghosts and double coloration. 15 cm.





Amethyst quartz crystal showing a clear zonation in the upper part. 11.6 cm.



Prasiotrine specimen (Shalimar) with ancient carving in cushion form. 14x10 mm.

Polished specimen showing prasiolite in the upper part and amethyst in the lower part. 4.6 cm.



Morion Quartz. 7.6 cm.



The most interesting characteristic of the quartz crystals of the pegmatite deposits of Piquet Carneiro is that they are transparent and gem quality with an intense green color (prasiolite) in different shades, natural citrines also have high transparency and gem quality, and have a good size that allows sizable stone carving and also in large quantity. Amethyst also appears forming specimens of high purity, good color and large size. There are specimens in which the same quartz crystal shows the three colors, with a gradual transition from one color to another and with inner ghosts. In some places the color transition is not gradual, showing very marked contact lines. Recrystallization is observed in the upper faces of some milky quartz crystals with a second generation of amethyst. The different colors within the quartz crystals have been produced by the subsequent crystallization of phases with variable richness of coloring substances in the same crystal. Trivalent iron inclusions generate purple and lilac crystals of varying intensity with banded crystals



A small hole in the pegmatite, for the extraction of prasiolite. Antonio Velasco photo.



Fragments of quartz crystals in the Maya mine were repetitive inner ghosts with purple and white colors can be observed. Antonio Velasco photo.

with multiple stripes indicating a repetitive alternation of the chemical conditions of deposition. The X-ray fluorescence analysis performed on a sample of prasiotrine has detected, apart from Si of quartz, the presence of Fe and Al, and with less security Mg and K. The detection of Si, Fe, Al and K in the sample is consistent with the presence of fine inclusions of silicates of the smectite group as ferrocaldonite ($K(Fe^{2+}, Mg^{2+})(Fe^{3+}, Al)[(OH)_2/Si_4O_{10}]$) or chlorite such as chamosite ($(Fe^{2+}, Mg^{2+})_5Al[(OH)_8/AlSi_3O_{10}]$). These minerals are greenish blue to yellow or brown by oxidation of Fe^{2+} in its structure. Normally these silicates are formed during hydrothermal alteration of basic rocks rich in silicates, deposited later in the cavities where the quartz crystallization occurs. Hence they might appear as inclusions in quartz crystals. The disposition of green areas often has a very well defined limit with other colors that indicates that the intrusion of these minerals occurred abruptly in the hydrothermal solution.

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The pegmatite deposit of Piquet Carneiro, that has recently begun to be exploited still incipiently, aims to be a global supplier of high quality prasiolites, citrine and amethyst. Preliminary studies also indicate that these gems can be extracted in large quantities because of the existing stock, ensuring a steady supply to the gemological market. It might be the only locality in the world with high quality and quantity citrine and prasiolite. A very interesting data are evidence of the development of other mineral interesting for collectors. Ferriferous tourmalines have been found forming large crystals and in large numbers and there is also evidence of presence of topaze.



The Maya mine pegmatite is currently being exploited in its initial phase on the surface. Antonio Velasco photo.

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