

# Characteristics of inclusions in topaz from Serrinha pegmatite (Medina granite, Minas Gerais State, SE Brazil) studied by Raman spectroscopy



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## ARTICLE INFO

### Article history:

Received 19 February 2016

Received in revised form 29 April 2016

Accepted 29 April 2016

Available online 2 May 2016

### Keywords:

Topaz  
Inclusion  
Carbon dioxide  
Serrinha pegmatite  
Brazil

## ABSTRACT

Eastern Brazilian Pegmatite Province includes many topaz-bearing pegmatitic bodies. Residual melts from the Fe–K-rich alkaline Medina granite (ca. 500 Ma) formed the Serrinha pegmatite—a system of branched thin pegmatite veins hosted by pink facies of the parent granite. The colourless topaz from Serrinha pegmatite contains both mineral and fluid inclusions. Microcline (513, 476, 456 cm<sup>-1</sup>), albite (507, 479, 457 cm<sup>-1</sup>), topaz (926, 858, 267, 239 cm<sup>-1</sup>), quartz (463 cm<sup>-1</sup>), rutile (610, 444 cm<sup>-1</sup>), wolframite (884 cm<sup>-1</sup>) and uranophane (968, 788 cm<sup>-1</sup>) represent solid inclusions formed by fluid-induced processes from the pneumatolytic (~600–400 °C) to hydrothermal (<400 °C) stages of pegmatite crystallization. Fluid inclusions are mainly liquid or liquid-gas, which contain CO<sub>2</sub> (marker bands ~1388 cm<sup>-1</sup> and ~1285 cm<sup>-1</sup>) and traces of methane (2917 cm<sup>-1</sup>). They are mainly of primary and pseudo-secondary origin, indicating tectonic quiescence during and after topaz crystallization (in agreement with the post-collisional nature of the parent granite). Topaz crystallized in high temperature conditions of the pneumatolytic stage at a depth around 8.5–10.0 km.

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## 1. Introduction

Topaz shows fairly constant composition Al<sub>2</sub>SiO<sub>4</sub>(OH<sub>x</sub>F<sub>(1-x)</sub>)<sub>2</sub>. It is mainly associated with granites and pegmatites, as well as pneumometasomatic and hydrothermal veins. It commonly coexists with biotite, tourmaline, chrysoberyl, cassiterite, muscovite, fluorite, beryl and quartz [1]. The most important sources of topaz crystals are found in Brazil, mainly in Ouro Preto region in Minas Gerais State [2] and in pegmatites of the Eastern Brazilian Pegmatite Province [3] as well as in the USA, Russia, Pakistan, Ukraine and many other parts of the world [4].

One of the world leaders in producing gem-quality topaz is Brazil. The State of Minas Gerais is the largest producer and exporter of diamonds, and wide diversity of coloured stones, such as: topaz (blue, colourless and imperial), beryl (emerald, aquamarine, heliodor, goshenite, morganite), tourmaline (schörl-elbaite series), spodumene (kunzite, hiddenite), chrysoberyl (chrysoberyl cat's eye and alexandrite), quartz (amethyst, citrine, morion, smoky quartz) and brazilianite [5]. The famous “Imperial topaz”

occurs in strongly weathered kaolinite-quartz-K-feldspar veins in saprolites from Palaeoproterozoic dolomitic rocks of the Minas Supergroup, in the Ouro Preto region of Minas Gerais State [5]. Excluding “Imperial topaz”, diamond and some other minerals (e.g., amethyst), a large amount of Brazilian gems have been exploited from pegmatites and hydrothermal deposits related to the Ediacaran and Cambrian granites of the Eastern Brazilian Pegmatite Province [3]. The colourless topaz from Serrinha pegmatite (Medina granite, Jequitinhonha valley), is not as famous as the “Imperial topaz” from Ouro Preto. Nevertheless, Serrinha topaz forms colourless to blue, large, prismatic and bi-terminated gem-quality crystals.

Generally, topaz crystals contain both, solid and fluid inclusions. Solid inclusions usually comprise several minerals including albite, apatite, goethite, muscovite, fluorite and monazite. This gem is poor in guest minerals, but rich in fluid inclusions [6,7].

The spontaneous break of a large (13 cm in length) gem-quality crystal of topaz, during washing in warm water, was the inspiration for this work. The gem split into an 11 cm crystal and three smaller fragments, which were analysed by Raman micro-spectroscopy (RS) and supported by electron-scanning observations (SEM-EDS) and micro-thermometry. In this paper, we characterize solid, as well as primary and secondary fluid inclusions found in the topaz

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**Fig. 1.** Topaz from Serrinha pegmatite with inclusions of Fe hydroxides and biotite.

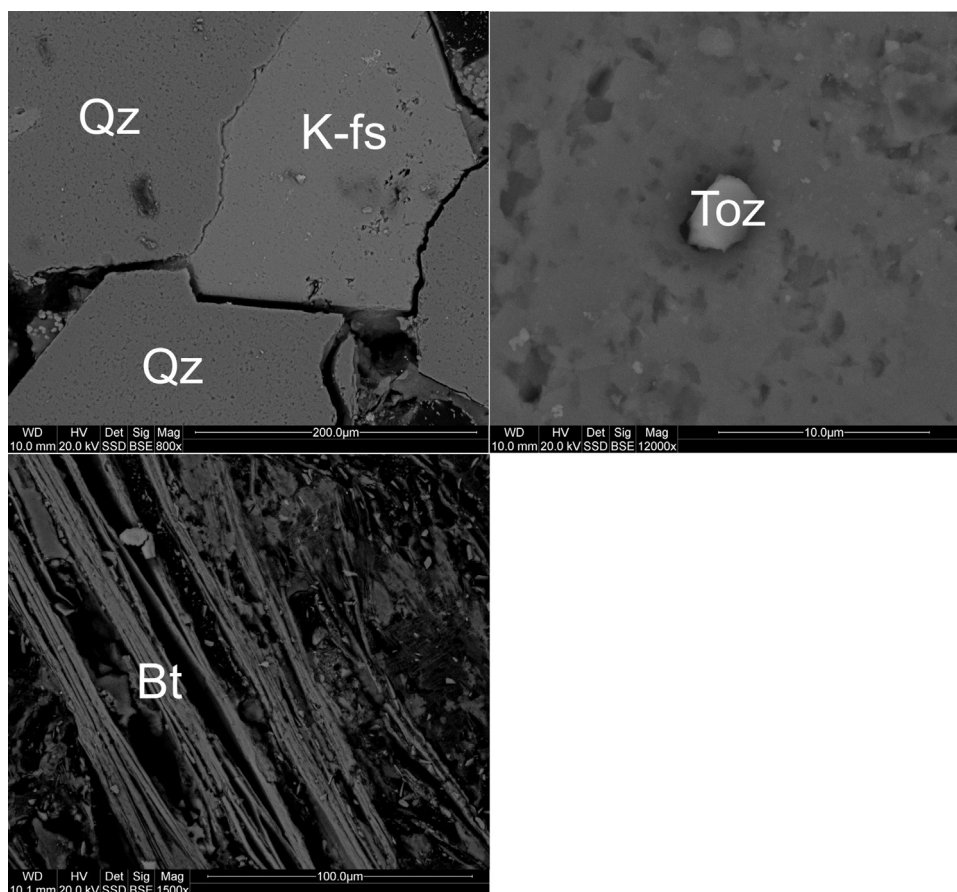
sample from the Serrinha pegmatite. The aim of this study is to assess the origin of this gem. For many types of fluid inclusions, the coupling of the two techniques, i.e., RS and micro-thermometric measurements is a good way to determine fluid inclusion compositions and access the physicochemical conditions of mineral's formation [8]. Similar types of investigations were done before for other topaz from pegmatites of Volodarsk-Volynski Massif in Ukraine by Dumańska-Słowik et al. [9]. Our paper compares inclusion characteristics in gems coming from these two pegmatite settings of the world (Ukraine and Brazil). Moreover implications of inclusions types for the genesis of the Serrinha pegmatite and granite host-bodies are discussed.

## 2. Analytical methods

Backscattered Electron (BSE) observations were performed on polished sections coated with carbon using a FEI Quanta 200 FEG scanning electron microscope with an EDS detector. The system was operated with 15 kV accelerating voltage and high-vacuum mode.

Raman spectra of inclusions were recorded with a Thermo Scientific DXR Raman microscope featuring 10×, 50×, and 100× magnification objectives. Topaz sample was excited with a 780 nm high-power near-infrared (HP NIR) laser. Laser power was from 10 to 20 mW, exposure time was 3 s, number of exposures—10 times. Laser focus diameter was approximately 2.1–0.7 μm. The spectra were corrected for background by method of sextic polynomial using Omnic software. Raman analyses were made both on clean cleavage surfaces and doubly polished wafers.

Fluid inclusion analyses were carried out on double polished wafers (0.2 mm thick). Microthermometric measurements were conducted using a Linkam THMSG600 Geology Heating and Freezing Stage mounted on NIKON ECLIPSE E600 microscope equipped with 20x, 50x and 100x objectives. The stage was calibrated using pure H<sub>2</sub>O–CO<sub>2</sub> synthetic inclusions ( $T_m = -56.9^\circ\text{C}$ ) and known homogenization temperature of pure H<sub>2</sub>O inclusions (of critical density of  $T_{m_{ice}} = 0.0^\circ\text{C}$ ,  $T_h = 374^\circ\text{C}$ ). The measurements were carried out with the rate of 10 °C/min and with accuracy of 0.1 °C. The heating rate was lowered to 1 or 0.5 °C/min when approaching  $T_h$ . The technique of cycling was applied in all homogenization runs, in order to observe the proper homogenization temperatures [10]. The calculations of pressure of homogenization and molar volumes were done according to Bakker programs [11–13].



**Fig. 2.** BSE image of solid inclusions in topaz. Symbols: Bt—biotite, K-fs—K-feldspar, Qz—quartz, Toz—topaz.

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