# GRANITIC PEGMATITE CHRYSOBERYL IN A SHEAR ZONE OF THE ACHALA BATHOLITH, CÓRDOBA, ARGENTINA

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## Introduction

Chrysoberyl of granitic pegmatite affiliation was found in the Ethel Mary mine, at coordinates S 31º 42' 24.8'' and W 64º 57' 25.1'', in the western margin of the Sierra Grande, San Alberto Department, Córdoba province, Argentina (Fig. 1).

Up to date, the sole published finding of chrysoberyl in Argentina was reported by Gay & Galliski (1978) and Galliski *et al*. (2011), near Virorco, Sierra de San Luis. At this site, chrysoberyl occurs as a subordinate phase in the assemblage dumortierite-tourmaline-kyanite, in zoned veins or dikes of uncertain origin, emplaced in norite and hornblende gabbro.

This contribution describes the geological setting and mineralogical peculiarities of this finding of granitic pegmatite chrysoberyl in the country, in an attempt to constrain its formation environment.

## Pegmatite Geology

Arias (1983) described the Ethel Mary mine as a 120 m NNE-SSW extended and 50 m wide lens–shaped pegmatite, recognizing four major zones: a fine grained "contact" zone (Qtz-Kfs-Ms-Bt), followed by a "marginal" zone (external and internal), with the same mineralogy, distinguishing 7cm long bladed biotite crystals in the external zone and a few prismatic beryl crystals up to 20 cm long in the internal zone; the innermost zone was described as a quartz core. Surface mine workings were done for beryl extraction. Chrysoberyl was not identified at that time.

Chrysoberyl is hosted in a fracture-filling Qtz-Mc-Ab-Ms (±Bt±Brl) pegmatitic assemblage that crosscuts the zoned pegmatite described by Arias in 1983 (Sfragulla 2001). Both bodies are emplaced in a coarse grained, equigranular biotite-muscovite monzogranite facies of the extended Achala batholith of Devonian age (Rapela 1982; Lira & Kirschbaum 1990; Demange *et al*. 1996; Dorais *et al*. 1997; Rapela *et al*. 2008).

The older pegmatite body is tabular shaped, striking 25º and dipping 25ºE; zonation consists in a 3 to 4 m thick massive quartz core in contact with an intermediate zone about 10 m thick composed of

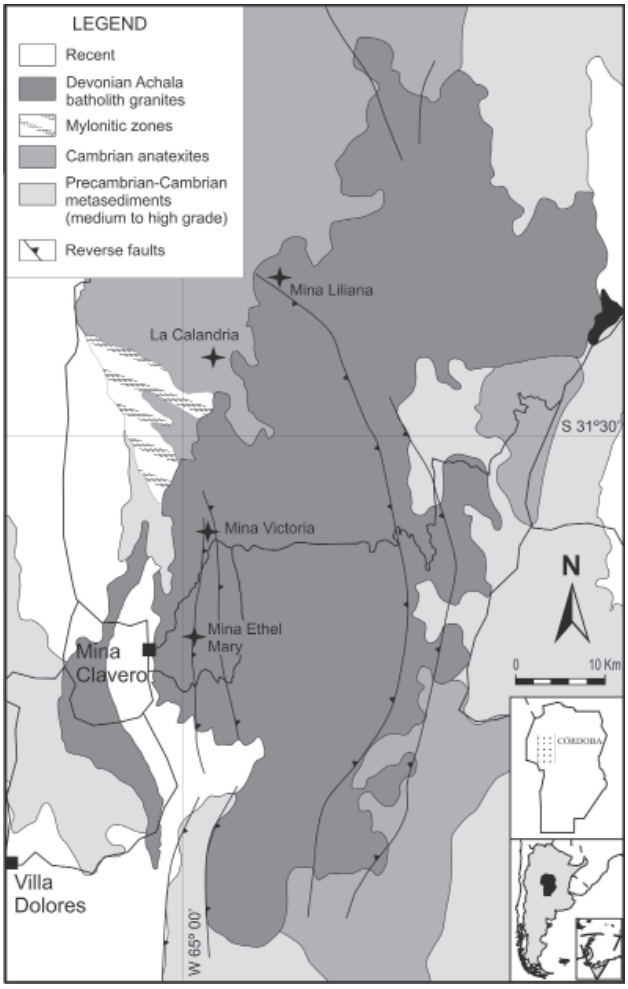


Figure 1. Location of the Ethel Mary beryl-chrysoberyl mine within the *ca.* 2500 km$^2$ Achala batholith. Three neighboring topaz bearing pegmatites of the Punilla district are drawn for reference (Liliana, La Calandria and Victoria). Regional geology summarized after Bonalumi *et al*. (1999).

50% volume plagioclase in anhedral crystals (0.5-2 cm), 30% blocky pink K-feldspar (5-20 cm, partially graphic), 10% greyish white anhedral quartz (0.5-1 cm), and 10% volume of micas (muscovite and biotite) occurring in small booklets (up to 1cm), being biotite partially oxidized. Only prismatic beryl is found as

an accessory phase (1 to 20 cm long). This pegmatite body is crosscut by granite dykes varying in width from 0.2 to 2 m thick.

The younger infilling pegmatite body is thin (0.5 to 1 m wide), and shows two main textural domains evidenced by a fine grained (0.5-1 cm) mica-rich zone (Ms±Bt±Ab) that resembles a replacing assemblage which irregularly passes into a distinct coarser grained zone (1-2 cm) composed of moderately albitized perthitic microcline, albite and quartz, where chrysoberyl is preferentially concentrated (Mc-Ab-Qtz-Cbl±Brl, Fig. 2A). Quartz is always the latest anhedral phase. In the mica-rich zone, both subhedral Ms and Bt are intergrown in equilibrium; muscovite in contact with microcline has developed myrmequitic texture.

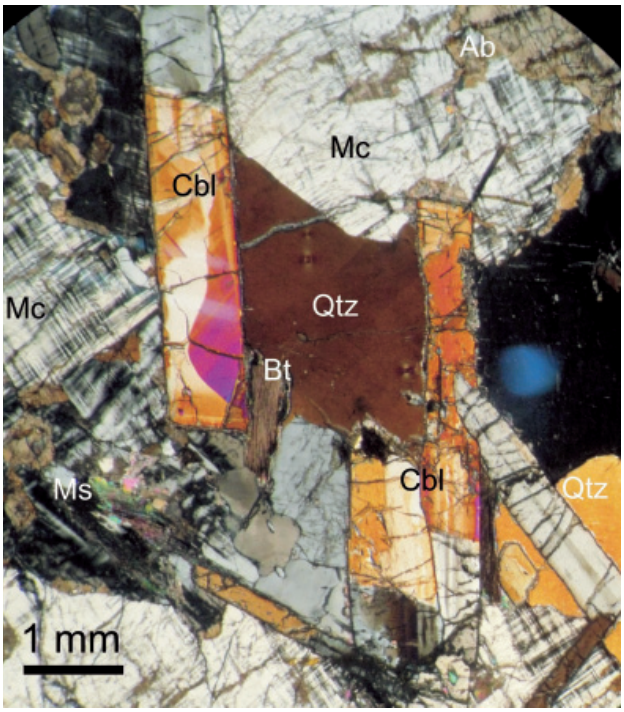


FIGURE 2A. Representative chrysoberyl (Cbl) – bearing assemblage. Most Cbl tabular crystals are twinned and show complex color zoning; some show a replacing alteration rim. Mc: perthitic microcline, Ab: albite (partially replacing Mc), Qtz: quartz, Bt: biotite, Ms: muscovite.

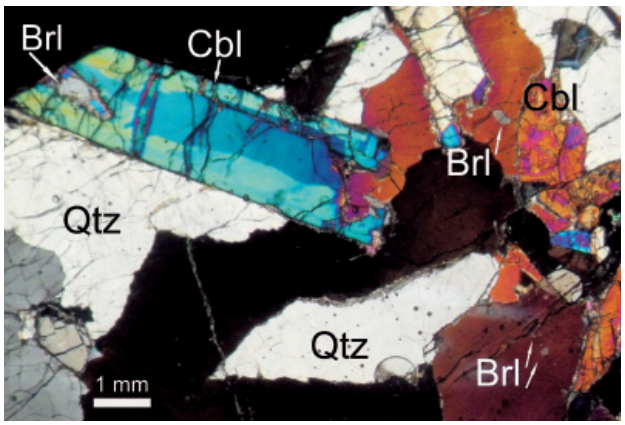


FIGURE 2B. Anhedral relics of beryl (Brl) included in chrysoberyl (Cbl), interpreted as remnants of its breakdown into the latter. Qtz: quartz.

Some sectors of the infill/replacement assemblage show textural evidence of ductile to brittle deformation as evidenced by bent and fractured feldspars and chrysoberyl crystals, and undulouse extinction of quartz, partially with mosaic texture.

## CHRYSOBERYL DESCRIPTION

Chrysoberyl is yellowish green. It occurs as tabular individual crystals parallel to (001) which commonly associate to each other in a "tree branch"-like habit. Few tabular crystals have grown as parallel aggregates. Individual crystal sizes are not longer than 1.5 cm and 0.5 to 2 mm thick. Both multiple contact {130} pseudohexagonal twins with re-entrant angles and the heart-shaped type are present.

Some crystals include subhedral biotite and muscovite booklets. Chrysoberyl is distributed in both the quartz-feldspar zone and the replacement mica-rich zone, though the largest ones are found included in quartz or feldspars. Relics of anhedral beryl grains included in chrysoberyl and adjacent patchy quartz provide textural evidence of beryl breakdown into chrysoberyl+quartz (Fig. 2B).

In thin section chrysoberyl is weakly pleochroic varying within light yellow to pale green hues. Optical, strong complex zoning is commonly evidenced by anomalous birefringence shown as blue and brown interference colours, usually like sharp wedged blades developed along the *c* axis (Fig. 2 A-B).

Practically all chrysoberyl crystals are rimmed by a thin aggregate of fine grained replacing muscovite, developed at the intergranular contact with enclosing feldspars; besides feldspars, in some cases muscovite weakly replaces chrysoberyl centripetally. This second generation of muscovite also locally replaces biotite.

In some sectors, chrysoberyl crystals are bent, fractured and strongly replaced by muscovite aggregates.

## REGIONAL GEOLOGY AND FORMATION ENVIRONMENT

The Ethel Mary intragranitic pegmatites are located within the Punilla district according to the geographic distribution established by Galliski (1994 a, b; 1999). Pegmatites of this district are representative of the REE class, Beryl type, Beryl-Columbite-Phosphate subtype, despite phosphates and columbite-group species were not found in some of them. Mineralogical

indicators for the whole district suggest to classify them as of the Hybrid family between NYF and LCT (Galliski 1994 b), characterization that would also apply for the Ethel Mary pegmatites.

Despite that it was not found in the Ethel Mary mine, topaz is a common accessory mineral present in neighbouring pegmatites like La Calandria and Liliana (Gay & Lira 1984) and La Victoria (Gay & Sfragulla 1992; Fig. 1).

The lonely occurrence of chrysoberyl in the Ethel Mary mine, is interpreted as a by-product of the breakdown reaction of beryl, i.e., beryl → chrysoberyl+3quartz+2BeO (Černý *et al*. 1992) or beryl+2 aluminosilicate → 3 chrysoberyl+8quartz (Franz & Morteani 2002). Its location in a reverse fault zone and textural evidence that shearing was active during pegmatite infill/replacement stage, suggest that chrysoberyl formation was favored by its confinement to a regional shear-stress environment, like other worldwide known examples (*e.g.,* Černý *et al*. 1992; Černý 2002; Manimaran *et al*. 2007). The stable assemblage Cbl +Qtz would be achieved at high TºC-low P conditions (Franz & Morteani 2002).

Strongly fractured and partially replaced chrysoberyl by muscovite aggregates suggest that a hydrothermal fluid was channelled through the fault zone during post-deformation stage.

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