Amethyst and other quartz varieties from the Kariba deposit, Mapatizya area, Zambia

Аметист и други кварцови разновидности от находище Кариба, район Мапатизия, Замбия

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Introduction

Mining has been the economic and social backbone of Zambia since the large-scale exploitation of the Pb-Zn at Kabwe (Broken Hill) in Central Province and Copperbelt’s Cu-Co deposits, which begun in the early 1930s. Apart from these large deposits, Zambia is endowed with a variety of high-quality gemstones notably emerald, aquamarine and amethyst, about 25% of mineral production (Taupitz, 1991).

Zambia and Kariba area in particular is internationally recognised as a major producer of amethyst (ranked as the first highest world producer of rough material). Amethyst is prevalent in most places of Zambia but major production is in the Southern Province, Mapatizya area in the Mwakambiko hills under the licence of the Kariba Minerals Ltd. The deposits have been known since the 1950s. Annual production of amethyst is about 1000 tonnes. The study presents data about the trace-element content in amethyst and other color varieties of quartz from the Kariba deposit, aiming to estimate the color-responsible elements.

Brief geological setting of the Mapatyzia area

The Mapatizya area is underlain by the rocks of the Basement (1800 Ma) here comprising of gneisses, schists, amphibolites and marbles, which have been cut by intrusive bodies of different age. The NE–SW trending rocks are bound between the granitic intrusion (the Choma-Kalomo batolith) in the NW and the Karoo volcanic and sediments in the southern and SE part. The Basement rocks were subject to deformation, foliation and high grade metamorphism. These rocks are overlain by the Karoo supergroup, comprised by conglomerate, sandstone and mudstone and certain basalt bodies. The Karoo sediments and volcanics show no evidence of deformation and metamorphic processes. Late or Post-Karoo amethyst hydrothermal veins are embedded in the Basement complex as well as in the lower Karoo sandstone near the Zambezi valley margin (Bosse, 1996). The mineralization is cut through by late large subvolcanic dolerite dykes, having no direct relation to the amethyst mineralization.

The amethyst belt is some 30 km long, 15 km wide and appears to be related to the boundary faults separating Karoo from the Basement. The Kariba Minerals deposit is known to be one of the richest mineralized parts of the Kalomo amethyst field, with regards to the number of veins, quality of the amethyst and the proportion of medium to high grade material. There are more than 30 known veins so far which range in thickness from 0.1–0.5 m extending over 200 m in strike. Good quality amethysts have been found even at shallow depth of 4–6 m depth. The resources have so far been estimated to a shallow depth, in several prospects in the area – Francis, Curlew, Basil, Davidson, Cha Cha.

Methods and materials

The studied materials are collected from the Kariba deposit in May 2011. In order to determine the low content of more than 40 additional elements in the quartz LA-ICP-MS method was used. The used analytical system consists of a 193 nm ArF excimer laser coupled with an ELAN DRC-e ICP quadrupole mass spectrometer. For controlled ablation, an energy density of above 10 J/cm^2 on the sample and a laser pulse frequency of 10 Hz were used. Analyses were performed with 75 μm beam diameter. External standardization on NIST glass standard SRM-610 provides relative element concentrations, which were transformed into true values by internal standardization.

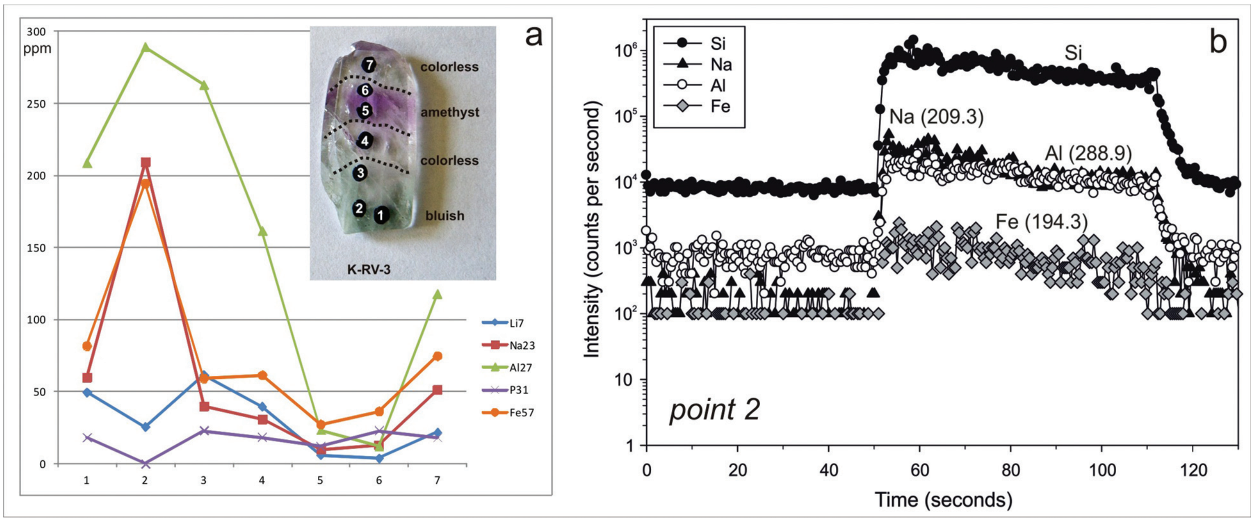

Fig. 1. Trend lines and correlation of selected trace-elements of complex-colored quartz *(a)* and representative single spot LA-ICP-MS ablation spectra *(b)*

LA-ICP-MS results

Representative quartz crystals of different color were studied for trace-element incorporation in order to establish the color dependence and regularities in the distribution of the potential chromofore ions (Fig. 1): 1) dark amethyst; 2) green quartz – prasiolite; 3) complex-colored crystals with bluish, colorless and pale amethyst zone.

Dark amethyst. The intense-colored amethysts show limited and insignificant incorporation of traces compared to the other colored and non-colored quartz crystals. The concentration of Fe in the dark amethysts reveals only slight incorporation in the studied material, showing insignificant variation in the range of 40–70 ppm within the crystal. The other traces are generally lower in quantity. Lithium reaches its maximum of 28 ppm only in the paler zone of the crystal, being up to 10 ppm in the darker amethyst. Similar values are attributed also to Na, which concentration doesn't exceed the 13 ppm limit.

Prasiolite. The Fe-incorporation in the green quartz reaches 425 ppm, showing enhanced values in the points with intense green color (~300 ppm), and lower in the colorless ones (72 ppm). Lithium content reaches 36 ppm in the green areas of the crystal and decreases to 7 ppm in the spots of transparent quartz. The Al incorporation is quite various – from traces below the detection limit to almost 170 ppm. There is available correlation of the elements in the green areas and in the colorless ones.

The complex-colored quartz reveals the relationships between the trace-elements content in the different varieties. The bluish-greenish zones and the colorless ones concentrate most of the incorporated ions in the structure (Fe up to 195 ppm; Al in the range 208–290 ppm; Li between 21–49 ppm), while the amethyst zones remains almost clear of additional elements and showing the lowest values for Fe-content (Fe ranging 27–38 ppm; Al content of 12–24 ppm; Li incorporation of 3–6 ppm).

The phosphorus is presented in almost constant concentration ~20 ppm in most of the analysed points, showing no correlation to the color zones.

Conclusions

An interesting fact was revealed concerning the trace-elements and the elements, which are accepted to be important for the color of the amethyst. The best quality amethyst concentrate the lowest as quantity and smallest as number elements compared to green, colorless and bluish varieties. It was observed that the amethyst incorporates quite insignificant number of elements in quite insignificant quantities compared to other quartz varieties. The Fe-concentration, well known as major responsible for the color in amethyst, has the lowest measured values in the most intensive-colored varieties in the studied materials.

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