Mitt.Österr.Miner.Ges. 153 (2007)

AGE DETERMINATION BY μ-PIXE ANALYSIS OF CHERALITE-(CE) FROM EMERALD-BEARING PEGMATITES OF VIGEZZO VALLEY (WESTERN ALPS, ITALY)

by

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Introduction

The albitized pegmatites of Vigezzo valley (Western Alps, Verbania, Italy) are renowned since the early '70 of the last century for the findings of rare accessory minerals and of collection specimens with green, Cr-rich, beryl crystals (emeralds). The two new minerals roggianite (PASSAGLIA, 1969) and vigezzite (GRAESER et al., 1979) were first described in the Alpe Rosso pegmatite. Emerald gems, feasible to be faceted up to one carat, were found in the Pizzo Marcio northern pegmatite (BOSCARDIN et al., 1976). These pegmatites occur in the southern root portion of the Alpine Penninic nappe and are hosted by amphibolite-grade metamorphic rocks (Fig.1). They show sensible enrichment in high field strength elements (HFSE) and they cross-cut metaperidotite-serpentinoschists interpreted as metaophiolites strips (REINHARDT, 1966). The Pizzo Marcio-Alpe Rosso albitized pegmatites belong to an extended pegmatite field several tens of kilometres in length occurring along the Insubric Line, a major tectonic structure in the Alpine chain (e.g. SCHMID et al., 1987). This pegmatitic field is limited to the west by the Simplon Pass (nearby Domodossola town) and to the east by the Alpine tonalitic-granodioritic Masino-Bregaglia pluton (Bergell pluton, e.g. BERGER et al., 1996). Numerous pegmatites of this field, occurring in amphibolite gneiss along the north-eastern part of the Vigezzo valley, were investigated by various authors for the occurrence of rare accessory minerals including aeschynite, allanite, columbite, euxenite, pyrochlore group minerals and gadolinite group minerals, niobian-rutile (strüverite), yttrian-fluorite and tanteuxenite (CANTADORE & GRAMACCIOLI, 1967; DE POL & VESCOVI MINUTTI, 1967; ALBERTINI & ANDERSEN, 1988; DEMARTIN et al., 1993). SCHÄRER et al., (1996) dated between 30 and 25 Ma some pegmatites located along the Centovalli area and belonging to such extended pegmatite field.

Age determination

A green transparent homogenous crystal of cheralite-(Ce) was separated from a pegmatitic dike outcropping at the summit of Mount Pizzo Marcio and analysed with a proton-induced X-ray emission microprobe (μ-PIXE) for total U-Th-Pb age determination.

This analytical technique has been demonstrated to be feasible for total U-Th-Pb dating (MAZZOLI et al., 2002) of Th-rich phosphates such as monazite, and competitive with other techniques more commonly used in geochronology. The abundance of isotopes, trace and ultra-light elements, is often assessed by means of secondary ion mass spectrometry (SIMS). Although this analytical tool is extremely powerful both in terms of detection limit and of acquiring time, and therefore it has been widely used for monazite geochronology (DEWOLF et al., 1993; ZHU et al., 1997; STERN et al., 2000), the main disadvantage is related to the analysed spot size, which is generally of several tenths of μm. This can be particularly misleading when high resolution ion microprobe (SHRIMP) is used for geochronological purposes either on strongly zones crystals or on crystals with complex zoning which has not been previously recognised. For this reason, EMPA has been also used for U-Th-Pb dating on monazite, as this mineral phase is generally rich in U and Th (SUZUKI & ADACHI, 1991; 1994; SUZUKI et al., 1994; MONTEL et al., 1994; RHEDE et al., 1996; BRAUN et al., 1998) and common Pb is generally assumed to be negligible (PARRISH, 1990). Unfortunately, an intrinsic limitation arises in the application of this analytical technique to monazite geochronology from the measurement of radiogenic Pb, connected to the relatively high detection limit, which is generally between 50 and 100 ppm for U, Th and Pb, depending on analytical conditions. Therefore, only relatively old (typically >200 Ma) monazites can be dated, with errors on the age determination between 10 and 20 Ma for a single data point. In order to reduce such uncertainties, a statistical approach based on a large number of analyses has been also proposed (BRAUN et al., 1998). μ-PIXE overcomes the main disadvantages and limitations described for the other analytical techniques, and combines high spatial resolution (< 5 μm) and ability to determine trace element concentrations with a detection limit in the range 2-40 ppm for most elements heavier than sulphur. In addition, the high energy of the accelerated protons (2 MeV) produces the excitation of the K and L lines of REE and of heavy elements, which are generally determined by EMPA measuring their L and M lines. For these reasons μ-PIXE has the potentiality to (i) measure total U, Th and Pb with high spatial resolution and low analytical error, (ii) obtain ages affected by errors comparable to those obtained by SHRIMP, (iii) date younger monazite with respect to EMPA.
In the specific case study here considered, 9 spot analyses have been performed on the separated crystal of cheralite-(Ce), obtaining ages in the range 30.4-34.3 Ma, with errors on single analysis of ±1.6 Ma. These ages are not statistically different and do not show systematic distributions within the analysed crystal (i.e. either in the core or in the rim). Therefore an average age of 32.7 Ma was calculated, with a propagated error of ± 3.2 Ma. This age represents the youngest total U-Th-Pb age ever obtained on a mineral of the monazite group.

Conclusions

The total U-Th-Pb age of 32.7 ± 3.2 obtained from these pegmatites indicates that during the Alpine event two potential sources of pegmatitic magmas producing the Vigezzo valley pegmatitic field can be taken into consideration. A first potential magmatic source is represented by the granodioritic-tonalitic Masino-Bregaglia pluton, aged from 32.9 to 28 Ma., associated with the peraluminous two micas granitic stock of S. Fedelino 25 Ma old (MOTICSKA, 1970, BERGER et al., 1996, HANSMANN, 1996). A second potential source could be related to the Barrovian metamorphism responsible for the development of the so called Lepontine Gneiss Dome (WINTER, 2001), that affected the Central Western Alps during Oligocene.

Such metamorphism was concomitant with dextral strike-slip movements along the Insubric Line. Subsequently, the main thermal updoming producing migmatites, which started about 32-30 Ma ago with the intrusion of the Masino-Bregaglia pluton, migrated towards west reaching the metamorphic peak in the Simplon Alpine region, about 20 Ma ago (ENGI et al., 1995, BOSQUET et al., 1997).

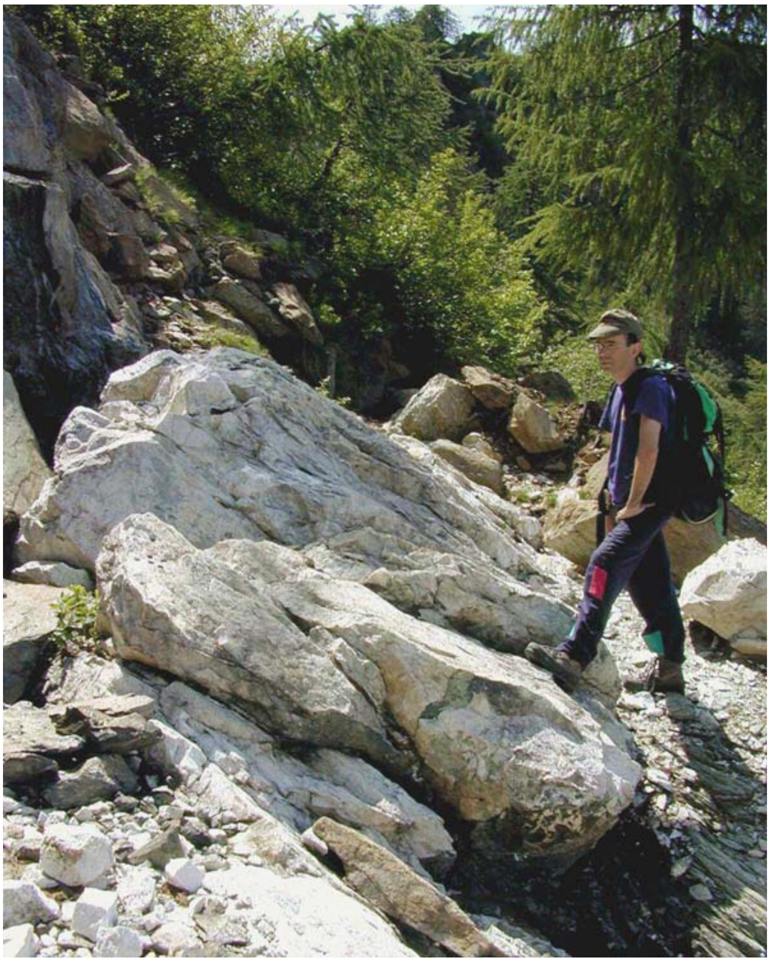

Fig.1
The emerald bearing albitized pegmatitic dike outcropping near the summit of Mount Pizzo Marcio, Vigezzo Valley.

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received: 21.05.2007
accepted: 21.05.2007