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CATHODOLUMINESCENCE INVESTIGATIONS OF ZIRCON CRYSTALS
FROM MIGMATITE OF THE WESTERN TATRA MTS.

Abstract: Zircon crystals from stromatitic migmatite from Western Tatra Mts were examined by means of scanning electron (SE), electron microprobe study and cathodoluminescence (CL) images. CL images reveal that anatexis of pelitic metasediments produced prograde zircon overgrowths on detrital cores in the mesosomes and new crystallization of magmatic zircon in the associated leucosomes. Uranium and hafnium may suppress the CL intensity. Both elements are negatively correlated with the CL signal.

Keywords: zircon, cathodoluminescence, Tatra Mts.

INTRODUCTION

Cathodoluminescence (CL) investigation has been widely applied as a petrologic tool in the earth sciences since the mid-1960's (Hanchar, Miller 1993). Combined cathodoluminescence investigation of zircon sections, oriented parallel and perpendicular to the *c* axis through the center of the crystals, enables the reconstruction of internal evolutionary trends of the crystal shape. In this study I present the discussion of the correlation between the CL intensity of zircon crystals and their chemical composition and connection of different types of zircon domains to various geological processes. Knowledge of the internal structure of zircon grains should help in their future geochronological studies. It can be used to obtain the more concordant analyses or to explain eventually discordance.

METHODS OF INVESTIGATION

Zircon crystals from the mesosome and leucosome part of the anatectic, stromatitic migmatite of metasedimentary origin from the Upper Unit (Smreczyński Wierch) have been separately investigated. The samples size was about 25 kg. The rock was crushed in a jaw crusher and the broken material was sorted on a Wilfley table for initial density separation. Further mineral concentration was carried out with a magnetic separator. Finally, zircon crystals were hand-picked under a binocular microscope. Morphological features were imaged with secondary electrons (SE) at 15 kV and 1 nA with a FET Philips XL 30 at the Silesian University. Cathodoluminescence images (CL) and electron

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microprobe analyses were obtained at 15 kV and 20 nA with a CAMECA SX 100 electron microprobe at the Warsaw University.

GEOLOGICAL SETTING

The crystalline basement of the Western Tatra Mts. is composed of metamorphic rocks, intruded by the Variscan Rohače granitoid pluton. Within the metamorphic complex two superimposed tectonic units (lower and upper) have been distinguished, differing in lithology and metamorphic grade (Kohut, Janak 1994; Gawęda et al. 1998). In Lower Unit ($T = 545\text{-}600^{\circ}\text{C}$ and $P = 5\text{-}8$ kbar) mica schists predominate, with subordinate intercalations of gneisses and amphibolites. The Upper Unit ($T = 690\text{-}780^{\circ}\text{C}$, $P = 7.5\text{-}10$ kbar) is composed mainly of migmatites, gneisses and amphibolites. Exclusively of amphibolites (metabasalts), the rest of the metamorphic rocks is of sedimentary protolith. In the rocks of the Upper Unit two stages of migmatization were discovered: first stage – metamorphic differentiation, influenced by high stress, in the chemically closed system and the second stage, connected to the partial melting and intrusion of leucogranites (Burda, Gawęda 1997, 1999).

RESULTS

In leucosome and mesosome of stromatitic migmatite different generations of zircon were found. Zircon crystals from leucosome are mainly euhedral, transparent, lightcoloured with elongation from 2:1 to 4:1. They represent mostly S_{1-2} (I generation) and S_{21-22} forms (II generation) according to Pupin's classification (Pupin 1980). The population of zircon grains from mesosome is dominated by the normalprismatic crystals, differing in colours (colourless, greyish, yellow-greyish and abundant brown and darkgrey crystals). The elongation ranges from 1:1 to 3:1. A degree of crystal roundness changes in the large scale, but in general subhedral crystals predominate. Euhedral zircon are both short and prismatic and elongated ones. In the population of short, isometric crystals the rounded, subhedral to anhedral forms are the most common. Different forms of zircon corrosion are observed in the analysed grain population. Zircon grains from mesosome represent mostly S_{1-2} forms (I generation) (Pupin 1980).

CL imaging reveals a wide variety of internal growth structures. The first generation of zircon (S_{1-2}) comprises the core surrounded by younger complex rims (fig. 1). Many of the cores have well-developed, simple, fine zonation, usually with moderate luminescence (fig. 1b,g,h). Sharp truncations of the core zonation indicate that most of the zircon cores are broken or abraded fragments of originally much larger grains (fig. 1b,g,h). These cores represent probably the detrital zircon from the original sediment. The rims are structurally complex. Most of them consist of strongly luminescent layer, which fills embayments in the cores (fig. 1a,b,g,h). Often this rim is overgrown by an additional outer zone, showing weak luminescence and euhedral oscillatory zonation (fig. 1a,c,d).

The second generation of zircon (S_{21-22}) reveals only the oscillatory zonation, due to heterogeneous distribution of trace elements during the crystal growth (fig. 1e,f).

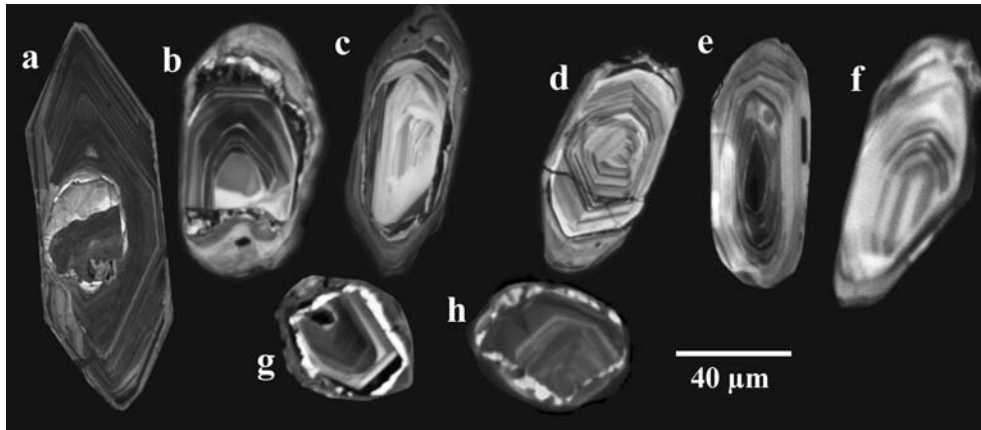


Fig.1. Cathodoluminescence (CL) images of representative zircon crystals from stromatitic migmatite. a-d – zircon grains from leucosome, showing the distinct growth domains: a inherited core, the strong luminescent second zone without zonation and a relatively thin outer zone with weak zonation; e,f - zircon grains from leucosome revealed only the oscillatory zonation; g, h- anhedral zircon from mesosome.

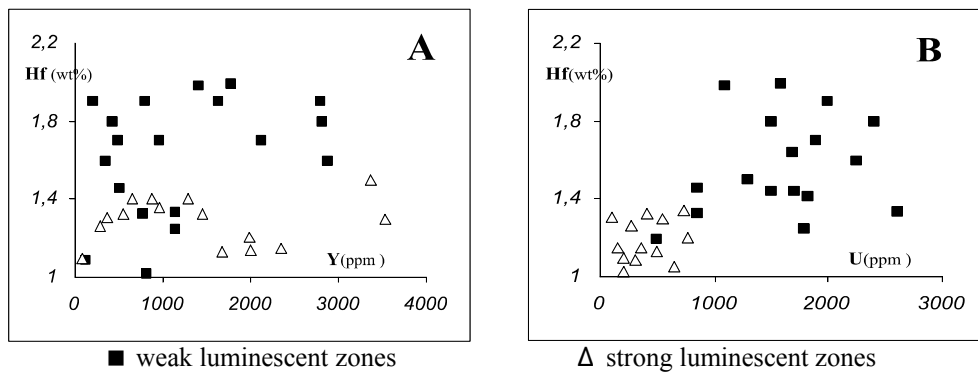


Fig. 2. Relation between the CL intensity and concentrations of Hf, Y and U. A - The Hf versus Y plot (Hf increase in weak luminescent zones). B - The Hf versus U concentration plot shows the negative correlation of both elements to the CL intensity.

The microchemical analyses showed that inherited cores have higher Zr/Hf ratios (51 – 54) than the overgrowing rims (37 - 41). There are large differences observed in U, Y and Hf concentrations between different domains in a single zircon crystal. This effect could be interpreted as a redistribution of these elements along grain boundaries due to the recrystallization during high-grade metamorphism (Hanchar, Miller 1993). The zones with strong luminescence are

characterized by decrease of Hf and U (fig. 2). Y concentrations don't correlate with CL signal (fig. 2).

CONCLUSIONS

In the leucosome and mesosome different generations of zircon crystals were found, due to the different geological processes acting. Leucosome zircon represent the euhedral, normal-prismatic varieties, with two typological maxima: S_{1-2} (I generation) and S_{21-22} (II generation). Mesosome zircon represent mainly the anhedral, short, prismatic varieties with one maximum at S_1 (I generations). In CL images the first generation (S_{1-2}) comprises of the inherited core surrounded by the younger rims. The second generation (S_{21-22}) reveals only the oscillatory zonation. The first, bright zircon overgrowth is thought to have been formed during prograde partial melting. The second zircon overgrowth, as well as whole zircon grains in the leucosome formed during retrograde melt crystallisation. The last process led to the formation of outermost zone and to the formation of completely new zircon.

U and Hf are identified as elements responsible for suppressing the CL signal of the investigated zircon. This is consistent with the results reported by Williams et al. (1996) and Poller et al. (2001).

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