ANALELE ŞTIINŢIFICE ALE UNIVERSITĂŢII „AL. I. CUZA" IAŞI
Geologie. Tomul LIII, 2007

# GEOTHERMOMETRICAL CONSIDERATIONS ON THE CONŢU-NEGOVANU PEGMATITES (LOTRU-CIBIN MTS.)

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**Abstract**

The aim of this paper is to provide data on the geothermometrical range of crystallization conditions of the pegmatites belonging to the Conţu-Negovanu area, in the Lotru-Cibin Mountains. Previous research carried out mainly by means of XRF, EMPA and ICP-MS provided important geochemical data which are used in the assessment of temperatures involved during pegmatite crystallization. Several metamorphically calibrated geothermometers were considered, such as garnet-biotite, muscovite-paragonite, Sc and Li accommodation in biotite. The obtained temperatures show different ranges for the two pegmatite types, indicating an early crystallization stage for the FPs and a later one for the LPs.

**Keywords**: lithian pegmatites, feldspar-mica pegmatites, XRF, EMPA, ICP-MS, geothermometers.

## Introduction

In order to complete the research we made during the last years on the pegmatites belonging to the Conţu-Negovanu field, a thorough geothermobarometric study is required. This paper is focused on some preliminary data on geothermometric conditions of crystallization within the pegmatitogenesis processes.

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## Geological setting

The Conţu-Negovanu pegmatite field is located within the central-west part of the Southern Carpathians, on the slopes of Conţu river, a tributary to Sadu river. The pegmatites are hosted by mesometamorphic rocks belonging to the Sebeş-Lotru Group, which is the most extended litostratigraphic entity of the Getic Crystalline Realm. The Sebeş-Lotru sequence represents a crustal fragment of Cadomian-Caledonian age, part of an active continental margin or an island arc near a continent. Possibly, arround 430 M.a., this terrain collided with an ahead block, being consequently involved in a subduction process (Balintoni et al., 2004). The genesis of the Conţu-Negovanu pegmatites is considered to be metamorphic, as they seem to have originated mainly, if not entirely, as a result of segregation within a fluid under preanatectic conditions (Săbău et al., 1987). Beside the albite-spodumene pegmatites (or lithian pegmatites – LPs), in the Conţu-Negovanu field are also present common feldspar-mica pegmatites (FPs). The mineralogical composition, as well as the bulk chemistry features and geochemical signatures suggest their affiliation to two distinct pegmatite classes, according to Černý`s (1992) systematic classification of pegmatites: (a) rare-element class and (b) muscovite class, respectively (Murariu, 2001). FPs are of ceramic and mica-bearing type, being barren or poorly mineralised (Li, Be, Ti, Nb, Ta, U, Th, Y, REE); the LPs are assigned to one of the five subdivision types of the rare-element class: the albite–spodumene type, characterised by minor to extensive minerallisation (Li, Rb, Cs, Be, Ga, Y, REE, Sn, Ti, U, Th, Hf, Nb, Ta), with typical substantial Li and variable rare-alkali fractionation (Černý, 1992). The former consist of quartz + K-feldspar, plagioclase + muscovite ± biotite ± tourmaline ± garnet and also small amounts of staurolite, apatite, ilmenite, rutile etc., whereas the latter present the typical mineral assemblage: albite (cleavelandite) + spodumene + quartz + muscovite and contain also subordinate amounts of microcline, biotite, garnet, apatite, kyanite, triphylite-lithiophilite, heterosite-purpurite, amblygonite-montebrasite, uraniferous magnocolumbite, hureaulite, tavorite etc. (Hann, 1987; Săbău et al., 1987; Murariu, 2001).

## Materials and methodes/techniques

Our previous research (Androne, 2005; Androne et al., 2006) has been focused on mineralogical–geochemical issues, providing valuable data for the assessment of geothermometric conditions of pegmatite crystallization. The pegmatite minerals – quartz, K-feldspars, plagioclases, muscovite, biotite, garnets, tourmaline, spodumene, phosphates – were investigated by means of X-ray powder diffraction (32 samples), XRF (40 samples), EMPA (255 samples) and ICP-MS analysis (48 samples). A part from the former, which was carried out in the laboratories of „Petru Poni” Institute of Macromolecular Chemistry of Iaşi, the other analyses were performed at the Geological Institute of the University of Köln, Germany.

Consistent with the metamorphic origin of both types of pegmatites and their position within the mesometamorphics belonging to the Sebeş-Lotru Group, several metamorphically calibrated geothermometers were considered, as suitable for the previously obtained geochemical data. Among these, were used geothermometers relying on (a) ion exchange reactions, (b) *solvus* relations and (c) trace element accomodation within mineral lattice (Bucher and Frey, 1994). In this approach, the PTMEDIUM computer program (Radu et al., 1997) was used, as a reliable tool based on ten selected geothermometers considering nine ion exchange reactions and one net-transfer reaction.

## Results

(a) The garnet–biotite geothermometer involving the $Fe^{2+}$ and Mg intercrystalline exchange is one of the most widely used, as there are several calibrations made on experimental work or from thermodynamic calculation. It was used for the first time by Pomârleanu and Murariu (1975) and afterwards by Murariu (1979), Murariu et al. (1998), Murariu (2001) for the metamorphic rocks which host the pegmatites belonging to the Carpathian Province, as well as for the pegmatites themselves (Smaranda Rădăşanu, 2002).

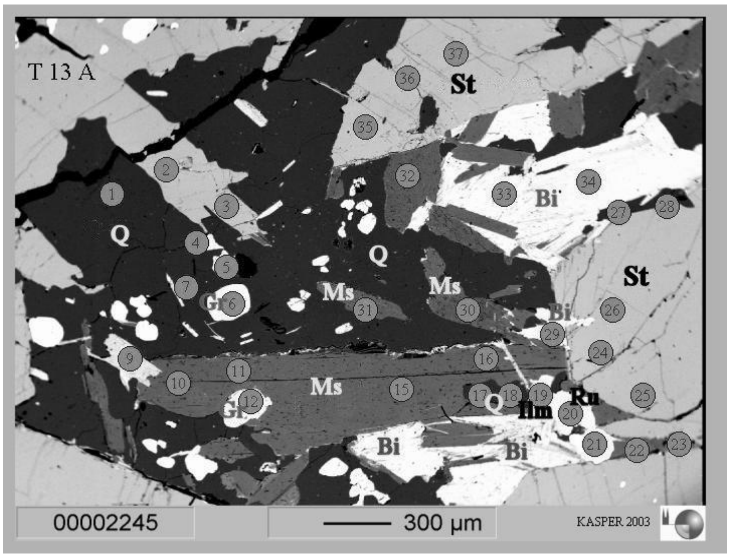


Fig.1 *EMPA* image: garnet (Gr) and biotite (Bi), in association with muscovite (Ms), quartz (Q), staurolite (St), ilmenite (Ilm) and rutile (Ru) in feldspar-mica pegmatite

The samples we used are from the FPs only (fig. 1) and the calibrations applied were made by Ferry and Spear (1978), Perchuk and Lavrent`eva (1983), Ganguly and Saxena (1984), Hodges and McKenna (1987), Holland and Powell (1990) and Holdaway et al. (1997).

The obtained temperatures for the feldspar-mica pegmatites of Conţu–Negovanu area are presented in Table 1, concluding in a general range between 414,19 – 524,40°C, which is of comparable magnitude with respect to that of Răzoare pegmatites: 417,53 – 500,86°C (Smaranda Rădăşanu, 2002). The crystallization temperature of the metamorphic rocks hosting the Conţu–Negovanu pegmatites was established with this geothermometer by Murariu (2001) at a much higher range: 635 – 640°C.

Tab. 1 Temperature (°C) of garnets from Conţu–Negovanu pegmatites and metamorphics along with comparative data

| | Calibration authors | | | | | | General range |
|---|---|---|---|---|---|---|---|
| | Ferry and Spear (1978) | Perchuk and Lavrent`eva (1983) | Ganguly and Saxena (1984) | Hodges and McKenna (1987) | Holland and Powell (1990) | Holdaway et al. (1997) | |
| Temp. (°C) | 449.62-461.86 | 516.63 – 524.40 | 445.43 - 468.72 | 438.52 - 451.65 | 414.19 - 427.98 | 461.53 - 467.33 | 414.19 - 524.40 |
| Temp. (°C)# | - | 500.86 | - | - | - | 417.53 | 417.53 - 500.86 |
| Temp. (°C)* | - | - | - | - | - | - | 635 - 640 |

# Răzoare pegmatites (Smaranda Rădăşanu, 2002)
*Conţu–Negovanu metamorphics (Murariu, 2001).

(b) The muscovite–paragonite geothermometer is based on a solvus relation in coexisting muscovite and paragonite solid series. This geothermometer was used in 1968 by Pomârleanu and Aurelia Movileanu for the pegmatites belonging to the Carpathian Province and afterwards by Murariu and Maria Dumitrescu (1976), Murariu (1979), Murariu et al. (1988; 1998a; 1999a), Mârza et al. (1988), Ungureanu and Murariu (1991). We applied the calibrations realised for this thermometer by Blencoe et al. (1994) and by Guidotti et al. (1994) (fig.2) for the FPs and for the LPs muscovite-paragonite samples.

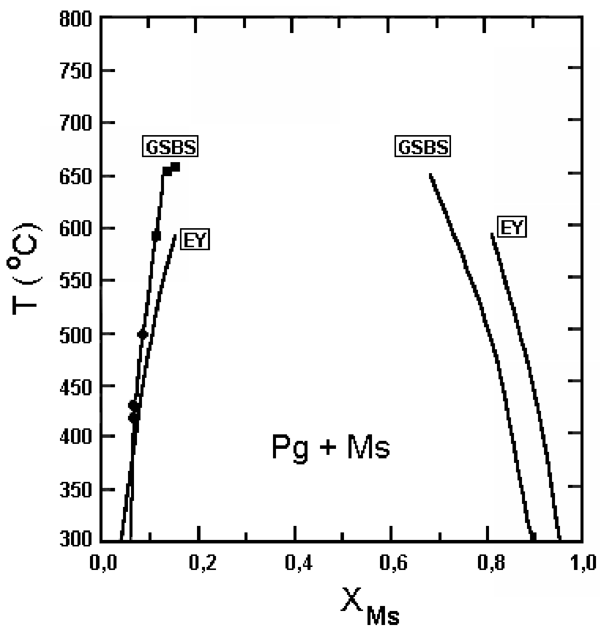


Fig. 2 Guidotti et al. (1994) diagram for the muscovites from Conţu – Negovanu pegmatites (■ FPs; ● LPs)

The resulting temperatures are presented in table 2, showing a higher range of temperatures for the FPs: 418.09 - > 650°C and a lower one for the LPs: 329.24 - 500°C. The comparative data display rather similar values as those of the FPs, fact consistent with their resemblant composition, whereas the LPs, specific only for the Conţu–Negovanu area, are obviously crystallised on a later stage, at a lower temperature.

Tab. 2 Temperature (°C) of muscovites from Conţu-Negovanu pegmatites and comparative data

| | Calibration authors | | General range |
|---|---|---|---|
| | Blencoe et al. (1994) | Guidotti et al. (1994) | |
| Temp. (°C) – FPs | 418.09 – 661.58 | 590 - > 650 | 418.09 - > 650 |
| Temp. (°C) – LPs | 329.24 | 420 – 500 | 329.24 - 500 |
| Temp. (°C)* | - | 420 - > 600 | 420 - > 600 |

| | | | |
|---|---|---|---|
| Temp. (°C)# | - | 360 - > 600 | 360 - > 600 |
| Temp. (°C)§ | 494.80 – 603.74 | 470 - > 600 | 470 - > 600 |

* Rodna pegmatites (Murariu, 2001)
# Gilău-Muntele Mare pegmatites (Stumbea, 2001)
§Răzoare pegmatites (Smaranda Rădăşanu, 2002)

(c) The geothermometers based on Sc and respectively Li trace elements accomodated within the biotite crystalline lattice relie on the increasing contents of these elements with the decreasing temperature. The former was calibrated by Oftedahl (1943) and by Dagelaiski and Krilova (1973) and was used by Murariu (2001) in the geothermometric research on the pegmatites and corresponding metamorphics from all the pegmatite subprovinces of Romania. The second thermometer was used by Pomârleanu and Movileanu (1977) in the research on the metamorphic rocks hosting the pegmatites from the Baia de Arieş Group, the Rebra Group and the Sebeş-Lotru Group and afterwards, by Murariu (1979; 2001) for the rocks of the same groups, as well as for the corresponding pegmatites. Applying some of these geothermometers to our samples (fig. 3 and fig. 4), a close temperature range was inferred for the LPs biotites ($T_{Li}$: < 540°C; $T_{Sc}$: 560°C), whilst the FPs biotites show a much wider temperature range (tab. 3).

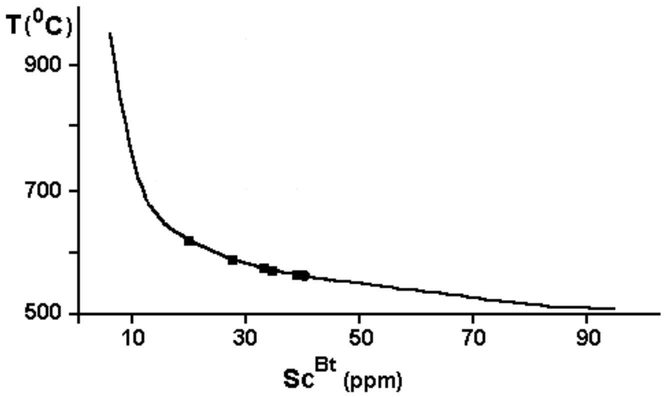


Fig. 3 Oftedahl (1943) diagram for the biotites from Conțu–Negovanu pegmatites (■ FPs; ● LPs)

Tab. 3 Temperature (°C) of biotites from Conţu-Negovanu pegmatites

| | Li (µg·g$^{-1}$) | $T_{Li}$ (°C) | Sc (µg·g$^{-1}$) | $T_{Sc}$ (°C) |
|---|---|---|---|---|
| Biotite - FPs | 159-293 | 615 - 660 | 20.9-39 | 560 - 620 |
| Biotite – LPs | 1854 | < 540 | 36 | 560 |

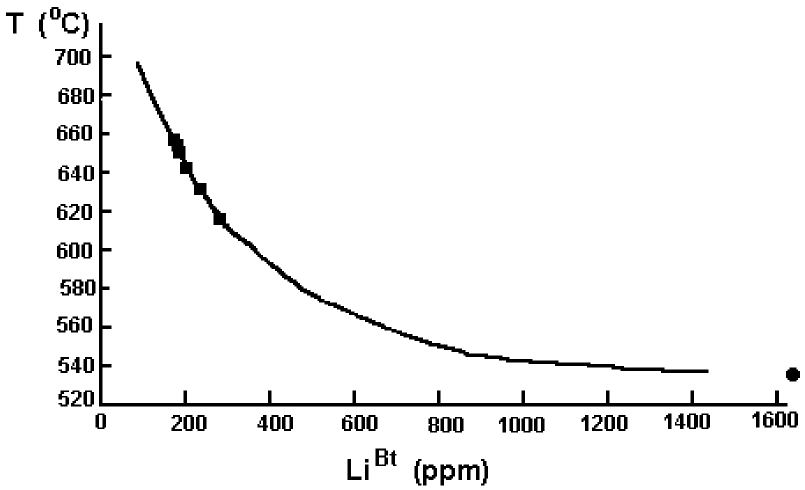


Fig. 4 Pomârleanu and Movileanu (1977) diagram for the biotites from Conţu–Negovanu pegmatites (■ FPs; ● LPs)

## Conclusions

The obtained temperatures (tab. 4) show different ranges for the two pegmatite types: the FPs crystallised between 660-414.19°C, during an early stage of pegmatitogenesis, whereas the LPs crystallised in a later stage, at 560-329.24°C. These values are consistent with those determined by Murariu (2001), who also inferred the general temperature range of the hosting metamorphic rocks: 720-424°C.

Tab. 4 General temperature ranges (°C) for FPs and LPs

| Geothermometer | T(°C) – FPs | T(°C) – LPs |
|---|---|---|
| Garnet – biotite | 414.19 – 524.40 | - |
| Muscovite – paragonite | 418.09 - > 650 | 329.24 - 500 |
| Li in biotite | 615 - 660 | < 540 |
| Sc in biotite | 560 - 620 | 560 |

**Acknowledgements**

The author gratefully thanks Dr.Haino Uwe Kasper from “Albertus Magnus” University of Köln, Germany for the analytical support of this paper.

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