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# REEs AND OTHER TRACE ELEMENTS DISTRIBUTION IN THE VINŢA GRANITIC INTRUSION (APUSENI MOUNTAINS, ROMANIA)

MITICĂ PINTILEI[1], HAINO UWE KASPER[2], EMANOIL IOAN GANDRABURA[1]

[1]“Al.I.Cuza” University of Iaşi, Department of Geology, 20A Carol I Blv., 700505 Iaşi, Romania
[2]University of Cologne, Department of Geology and Mineralogy, Zuelpicher Str. 49 A, Germany

## Abstract

Based on REEs abundances, Eu anomalies, Ce anomalies and some interelementcorrelations two different groups of rocks are distinguished in the Vinta graniteintrusion, sustained also by the Zr/Hf and Nb/Ta ratios. These rocks belong to the VAG and syn - COLG tectonic setting. Two different magma types are proposed for the rocks formation.

**Key words**: granites, REE, LIL and HFS elements, Vinţa intrusion

## Introduction

There are only few geochemical data regarding the Vinţa granite intrusion, which give contents of some chemical elements (Pb, Cu , Zn, etc.) with a little utility in the granite rocks characterization. Only two samples of granites were analyzed for major components (Ianovici et al., 1969). This paper presents for the first time abundance data for REE, LIL (Rb, Ba and Sr) and HFS (Y, Zr, Hf, U, Th, Nb and Ta) elements for eight granite samples from Vinţa intrusion are given. These observed abundances are used for a geochemical characterization and to elucidate tectonic setting of the studied rocks.

[1] e-mail: pimi5@yahoo.com

## Geological data

The small granite body from Vinţa (Apuseni Mountains, Romania) has an irregularly contour and is intruded into the crystalline schists of the Baia de Aries Series. These granitic rocks were considered as belonging to the syn-orogenic pre-Baikalian plutonism cycle (Ianovici et al., 1969) or as pre-Hercynian granitoids (Ianovici et al., 1976). Ianovici et al. (1969) determined a K-Ar whole rock age of 508 Ma (recalculated as 486 Ma; Ianovici et al., 1976). Petrographically the small granite body consists of quartz, microcline, sodium plagioclase, biotite and muscovite, in variable proportions. As accessory minerals tourmaline, sphene, apatite and garnet were identified.

In the contact zones of the Vinţa granite intrusion with metamorphic rocks, of the Baia de Arieş Series, thermal metamorphosed rocks were formed and in some places slightly metasomatised rocks were encountered. In the southern part of the granite intrusion pegmatite bodies are present, with microcline and muscovite as mineral components. Such pegmatite bodies also occur in the surroundings crystalline rocks of the Baia de Arieş Series. Sporadically small bodies with quartz and tourmaline occur (Ianovici et al., 1969).

In this paper we give first abundance data for REEs and other trace elements from eight granite samples from Vinţa intrusion. The analyses were carried out by ICP-MS at the Department of Geology and Mineralogy of the Köln University.

## Geochemistry

The contents of rare earth elements (REEs) and other trace elements along with some ratios in eight samples of granitic rocks from Vinţa intrusion are listed in table 1. The contents of some mobile large ion lithophile elements (LILEs): Ba (216-1057 $\mu g \cdot g^{-1}$), Sr (92-239 $\mu g \cdot g^{-1}$) and Rb (98-213 $\mu g \cdot g^{-1}$) show a wide range of variation, suggesting that primary distribution of these elements was disturbed by late-magmatic or post-magmatic processes. These contents suggest that the primary distribution was disturbed by a late input of Ba, Sr and Rb in the studied rocks. In this case the action of the metasomatic process seems to be a reasonable explanation. On the other hand the contents of some immobile HFS (high field strength) trace elements show relatively narrow limits of variation (Ta, 0.23-1.50 $\mu g\ g^{-1}$; Nb, 6.70-14.66 $\mu g\ g^{-1}$ and Zr, 83-195 $\mu g\ g^{-1}$; tab. 1). In addition pair immobile trace element ratios show narrow range of variation such as: Ce/Y (1.9-3.7) Y/Ho (25-32), Zr/Hf (34-47) and Nb/Ta (7-36) (tab. 1). All these aspects regarding abundances of immobile trace elements suggest that they are representative for primary non-disturbed composition of these rocks. Additionally REEs contents are characteristic for granite rocks (tab. 1). Chondrite-normalized REEs patterns are shown in Fig.1A, where a fractionation between LREEs and HREEs is visible, with LREEs enrichment and HREEs depletion, expressed quantitatively as $La_N/Lu_N$=7.50-24.24 (tab. 1). Also a general trend to parallelism can be seen.

Tab. 1 REEs and other trace elements contents in the granitic rocks from the Vinta intrusion

| Sample | V01 | V02 | V03 | V04 | V05 | V06+ | V07 | V09 |
|---|---|---|---|---|---|---|---|---|
| Sc | 5.55 | 13.41 | 5.13 | 3.67 | 4.48 | 4.55 | 2.51 | 5.74 |
| Rb | 122.75 | 126.45 | 108.04 | 143.69 | 213.28 | 97.84 | 167.96 | 124.77 |
| Sr | 106.52 | 238.54 | 227.26 | 147.09 | 171.66 | 163.10 | 91.51 | 184.33 |
| Y | 28.90 | 28.44 | 9.11 | 10.67 | 15.03 | 12.30 | 7.52 | 14.77 |
| Zr | 83.45 | 141.81 | 168.80 | 143.64 | 195.17 | 172.89 | 113.02 | 173.42 |
| Nb | 8.25 | 14.66 | 6.70 | 8.43 | 9.47 | 9.46 | 9.92 | 9.29 |
| Cs | 3.49 | 4.56 | 7.55 | 10.13 | 11.08 | 4.33 | 5.16 | 9.57 |
| Ba | 1057.07 | 870.63 | 308.48 | 264.28 | 340.71 | 216.23 | 249.52 | 290.72 |
| La | 29.65 | 45.18 | 15.10 | 11.97 | 25.95 | 18.32 | 12.50 | 21.19 |
| Ce | 55.25 | 98.53 | 33.04 | 30.28 | 40.04 | 35.58 | 27.94 | 41.35 |
| Pr | 6.62 | 10.57 | 3.39 | 2.77 | 5.49 | 4.23 | 3.04 | 4.87 |
| Nd | 24.68 | 39.94 | 12.36 | 10.14 | 20.57 | 16.20 | 11.48 | 18.79 |
| Sm | 5.04 | 7.78 | 2.39 | 2.17 | 4.16 | 3.35 | 2.53 | 3.83 |
| Eu | 1.00 | 1.24 | 0.86 | 0.68 | 1.18 | 0.90 | 0.54 | 1.04 |
| Gd | 4.87 | 7.00 | 2.01 | 1.95 | 3.83 | 3.10 | 2.35 | 3.49 |
| Tb | 0.75 | 0.93 | 0.28 | 0.29 | 0.49 | 0.42 | 0.32 | 0.47 |
| Dy | 4.54 | 5.54 | 1.57 | 1.68 | 2.51 | 2.24 | 1.56 | 2.64 |
| Ho | 0.97 | 1.12 | 0.32 | 0.35 | 0.47 | 0.43 | 0.26 | 0.52 |
| Er | 2.58 | 2.91 | 0.85 | 0.96 | 1.11 | 1.07 | 0.54 | 1.33 |
| Tm | 0.38 | 0.44 | 0.13 | 0.15 | 0.16 | 0.15 | 0.07 | 0.20 |
| Yb | 2.43 | 2.79 | 0.88 | 1.03 | 1.00 | 1.03 | 0.40 | 1.27 |
| Lu | 0.35 | 0.42 | 0.15 | 0.17 | 0.16 | 0.16 | 0.05 | 0.20 |

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|---|---|---|---|---|---|---|---|---|
| Hf | 2.34 | 4.18 | 3.57 | 3.40 | 4.35 | 4.15 | 3.06 | 4.18 |
| Ta | 0.23 | 1.36 | 0.75 | 1.25 | 1.15 | 1.18 | 1.50 | 1.11 |
| Pb | 19.05 | 28.07 | 25.17 | 30.27 | 29.81 | 23.39 | 37.88 | 26.50 |
| Th | 10.22 | 16.62 | 3.79 | 4.53 | 5.68 | 5.21 | 3.98 | 5.02 |
| U | 1.83 | 2.72 | 1.90 | 3.22 | 2.72 | 3.05 | 6.89 | 2.97 |
| Ba/Sr | 9.92 | 3.65 | 1.36 | 1.80 | 1.98 | 1.33 | 2.73 | 1.58 |
| Ce/Y | 1.91 | 3.46 | 3.63 | 2.84 | 2.66 | 2.89 | 3.71 | 2.80 |
| Zr/Hf | 35.74 | 33.96 | 47.27 | 42.26 | 44.83 | 41.64 | 37.00 | 41.51 |
| Nb/Ta | 35.57 | 10.76 | 8.93 | 6.74 | 8.23 | 8.05 | 6.62 | 8.41 |
| Y/Ho | 29.72 | 25.29 | 28.25 | 30.26 | 31.88 | 28.52 | 29.46 | 28.31 |
| Eu/Eu* | 0.62 | 0.51 | 1.19 | 1.01 | 0.91 | 0.85 | 0.67 | 0.87 |
| Ce/Ce* | 0.95 | 1.08 | 1.11 | 1.27 | 0.81 | 0.97 | 1.09 | 0.98 |
| $La_N/Lu_N$ | 8.74 | 11.25 | 10.80 | 7.50 | 16.89 | 11.55 | 24.24 | 10.85 |

Based on Eu and Ce anomalies, two groups of samples are distinguished: one with negative and the other with positive anomalies showing differences of $fO_2$ in the magma from which the studied rocks crystallized. These Ce and Eu relations suggest that the two genetically unrelated rocks, rather than rocks which underwent different degrees of metasomatism. The negative and positive Ce and Eu anomalies are also visible in the Upper Crust normalized REEs patterns (fig. 1B) showing some compositional similarities between the studied rocks and Upper Crust

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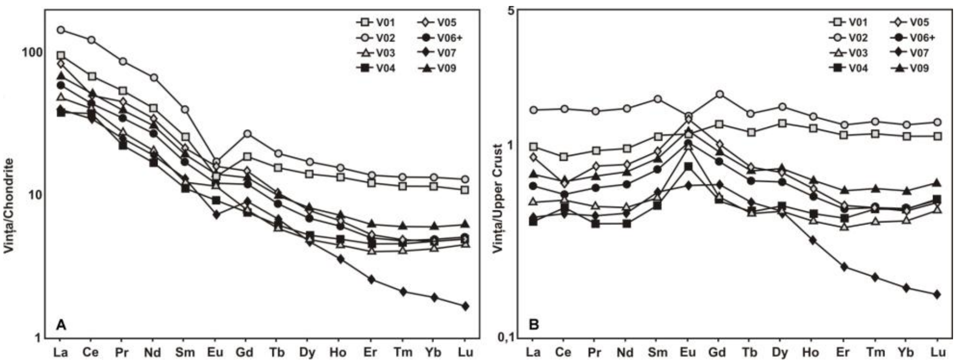


Fig. 1 Chondrite-normalized REEs patterns (A) and Upper Crust-normalized REEs patterns (B) for rocks from Vinta granite intrusion. Chondrite-normalizing values from Boynton (1984) and Upper Crust-normalizing values from Rudnick and Gao (2004).

Inter-element correlations are displayed in figure.2, depicting Zr versus mobile LIL elements (Rb, Sr and Ba) and Zr versus immobile HFS elements (Hf, Eu and Ho) relations. Two clearly distinct trends are revealed for all the elements in these diagrams one with visible negative Eu anomalies (full squares) and the other one with positive or slightly negative Eu anomalies (open circles) supporting the observations from figure 1. The Eu anomalies are somewhat correlated with Ce anomalies (tab. 1). The second group of samples shows coherent trends in several diagrams for both mobile and immobile trace elements (Ba, Sr, Hf, Eu and Ho) versus Zr (fig. 2). These observations support the idea of two existing groups of genetically unrelated rocks. The existence of the two different groups of rocks is also sustained by the Zr/Hf (33.96-35.74 first group and 37.00-47.27 second group) and Nb/Ta (10.76-35.57 first group and 6.62-8.93 second group) ratios. The same idea is supported too by the correlation matrix for all trace elements (not given here) where the correlation coefficient values, with few exceptions, are not statistically confirmed, excepting those among REEs.

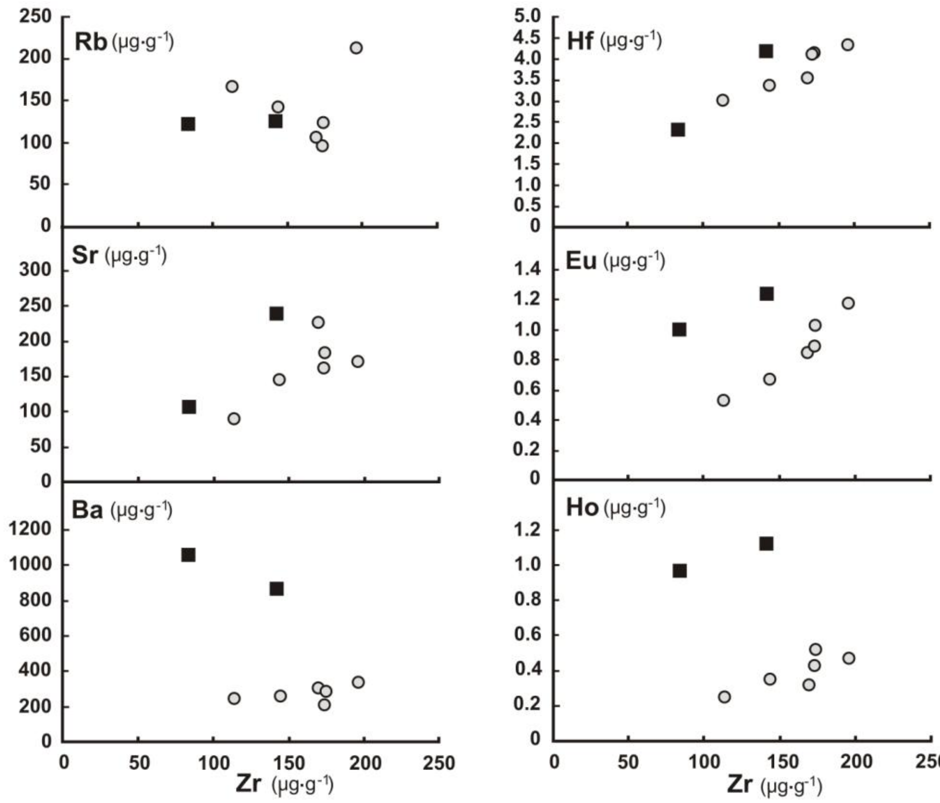


Fig.2 Trace LIL and HFS elements vs. Zr variation diagrams for the rocks from the Vinţa intrusion showing two different trends (full squares and open circles)

The utility of trace elements from granitic rocks for the tectonic interpretation is well argued by several researchers (Pearce et al., 1984; Harris et al., 1986), various discrimination diagrams being proposed for this purpose. These discrimination diagrams are based upon various immobile trace elements including HFS elements. In figure 3 the Nb-Y (A) and Ta-Yb (B) relations from Vinţa intrusion are displayed.

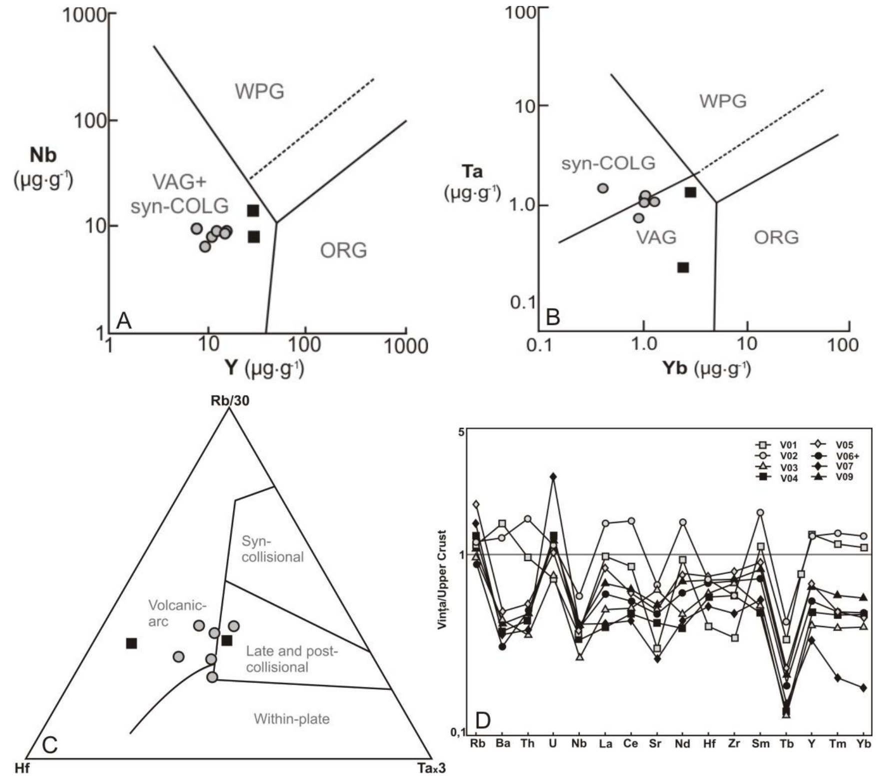


Fig.3 The Nb-Y (A), Ta-Yb (B) discrimination diagrams (field boundaries taken from Pearce et al., 1984), Rb/30-Hf-Tax3 (C; field boundaries taken from Harris et al., 1986) and spider (D; normalizing values after Taylor and McLennan, 1985) diagrams for granites from Vinta intrusion

The relationships from figure 2 and figure 3 are in good agreement evidencing the studied rocks belong to the volcanic arc granites (VAG) trending to a syn-collisional (syn-COLG) tectonic setting. Once again the two groups of rocks distinguished on the base of REEs distributions, and Zr/Hf and Nb/Ta ratios are distinctly revealed in these discrimination diagrams. A somewhat different relation is visible in the Hf-Rb/30-Ta x 3 discrimination diagram (fig. 3C) where a volcanic arc and a late and post-collisional trend is depicted instead of a syn-COLG tectonic setting. The two distinguished groups of rocks are differently enriched respectively depleted in LIL and HFS elements (fig. 3D). The first group is visible enriched in: Rb, Ba, Th, La, Ce, Nd, Sm, Y, Tm and Yb but depleted in: U, Nb, Sr, Zr and Tb. The second group of rocks has a different geochemical signature for these elements, especially for Ba and U (fig. 3D). All these geochemical features are suggesting that two different magma types are responsible for the genesis of the rocks.

## Conclusions

The first REEs, LILEs and HFSEs abundance data from rocks of the Vinţa granite intrusion are given for the first time. Two groups of rocks are distinguished on the base of the Eu and Ce negative, respectively positive anomalies. This idea is supported by the LILEs and HFSEs versus Zr relationships. The Zr/Hf and Nb/Ta ratios are also good indicators for these two groups of rocks. The studied rocks were generated in a VAG trending to the syn-COLG tectonic setting. Two different magma types were involved in the rocks formation.

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