

The mechanism of emplacement of the pluton is probably a cauldron subsidence (as for the other granites of the Serie dei Laghi), with fields evidences of a stoping mechanism on the topmost part of the stock.

In the Quarna pluton following rock types have been recognized from SE to NW: leucogranite (about 75% of the pluton), granodiorite (about 15%), quartz-diorite and gabbrodiorite (about 10%).

Field evidences show that the more leucocratic facies intrude the basic ones (appinites s.s.); weak thermometamorphic effects have been recognized in thin section. The granite is characterized by granoblastic aggregates of bi + pl + qz + ap + sphene  $\pm$  allanite, very similar to the typical structure of appinites.

Appinites and granite display major and trace elements variation trends suggesting their comagmatic character. The typologies of their zircon populations are also similar. They are indicative of calcalkaline magma with potassic affinity. The crystallization temperatures of zircon are in the range 850°-750° both for the appinite and the granite. The high zircon crystallization temperature in the granite can be explained by a low Pf in the magma, which is also supported by the very low frequency of hydrozircon overgrowths.

Geological, petrographical and geochemical data, together with zircon typologies, suggest an interaction between a basic magma (appinite) and crustal materials and/or differentiation processes in a deep magmatic chamber.

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**CASTORINA F.\***, **FARRIS M.\***, **RETTIGHIERI M.\***  
- *Petrological and geochemical features of the Goceano plutonic complex (Central eastern Sardinia, Italy)*

The plutonic complex studied was intruded during the first phase of Hercynian orogenic cycle and constituted the central part of the Goceano ridge (Central eastern Sardinia, Italy).

The samples analysed are mainly composed by tonalitic - granodioritic rocks.

The samples, in the thin section, shows: quartz, plagioclase and biotite as principal constituents while K-feldspar, amphibole and chlorite are subordinated minerals: the accessory phases include: apatite, zircon, muscovite, titanite and more rarely allanite.

A series of characteristic diagrams are used to interpret the magmatic evolution of the plutonic bodies.

Particularly, it is possible to remark that all diagrams show the same trend; both Larsen and de LA ROCHE et Al. index display widely the same path like.

The following analyses give an example of chemical composition of the studied complex:

|                                  | BO 87  | BO 161 | BO 131 |
|----------------------------------|--------|--------|--------|
| SiO <sub>2</sub>                 | 58.64  | 64.61  | 68.22  |
| TiO <sub>2</sub>                 | .69    | .53    | .37    |
| Al <sub>2</sub> O <sub>3</sub>   | 17.03  | 16.36  | 16.23  |
| Fe <sub>2</sub> O <sub>3</sub> * | 6.98   | 4.74   | 3.16   |
| MnO                              | .12    | .08    | .07    |
| MgO                              | 4.68   | 2.63   | .89    |
| CaO                              | 6.20   | 4.10   | 1.77   |
| Na <sub>2</sub> O                | 2.65   | 2.85   | 3.27   |
| K <sub>2</sub> O                 | 2.06   | 3.25   | 4.61   |
| P <sub>2</sub> O <sub>5</sub>    | .14    | .12    | .14    |
| H <sub>2</sub> O <sup>+</sup>    | .83    | .72    | 1.28   |
| Tot.                             | 100.02 | 100.01 | 99.99  |

\* Fe<sub>2</sub>O<sub>3</sub> as Fe total.

Isotopic analyses are in progress for a better characterization of this investigated area.

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**CATHELINÉAU M.\*** - *U-Th-REE mobility during subsolidus alteration of peraluminous granites*

Accessory minerals such as monazite, uraninite, apatite and, at a lesser degree, zircon constitute the main mineralogical form of U-Th-REE in per-aluminous granites. Although their nature and distribution are controlled by magma features, they can be significantly affected by subsolidus alteration. Thus, different examples of quartz leaching combined or not with albitization, from the southern part of the French Massif Central exhibit contrasted behaviour of trace elements and accessory phases. Observed changes are due to differential stability of primary accessory minerals (monazite and zircon) and crystallization of authigenic phases (complex solid solutions involving thorite, coffinite, apatite, xenotime, and zircon end members). P-T-X conditions of alteration are similar in the different occurrences: temperatures ranges from 450 to 350°C, fluids are aqueous and have low to medium salinities, fO<sub>2</sub> is high, and high F<sup>-</sup>, PO<sub>4</sub><sup>3-</sup> activities are suspected (CATHELINÉAU, 1987). Considering such conditions and the experimental data on solubilities, and speciation of U, Th, REE, the solubilization, transport and deposition of these elements appear to be mainly controlled by phosphate activity. U-Pb geochronological studies show that, in some albitites, they are close connection between magmatic U-Th-REE bearing phases dissolution (sources) and crystallization of authigenic phases in metasomatic rocks. At the contrary, in quartz depleted rocks, no time relation exists between reservoir rock formation (quartz depleted granite) and U-mineralization. However, in such deposits related spatially to quartz leaching, monazite in the nearby granite still plays a role as U and LREE source during the later hydrothermal, events which give the economic pitchblende ores, as evidenced from REE analysis, and Sm/Nd isotopic studies on ores and rock sources.

From a more general point of view, the effective

alteration of accessory minerals in the source rocks which results from the interaction with a fluid phase, depends on: 1) the nature of the accessory mineral, and especially the solubility of the mineral (Sd) under the dissolution conditions; 2) the solubility (Sf) of this mineral in the fluid which depends on the initial concentration of the elements such as U, Th, REE, P and ligand concentration in the fluid; 3) the water-rock ratio and the flow regime in the granite; 4) the exchange and interactions surface between fluid and minerals, which depends on the degree of microfaulting, and amount of microcracks in minerals. It is clear that fractionation results, not only from the element transport and ore crystallization, but also from differential leaching of accessory minerals in the source rocks. According to the relative stability of the accessory minerals in the percolating fluid, LREE or HREE enrichments may result respectively from monazite, allanite (or fluocerite, parisite,...) or xenotime, yttrapatite, instability.

As a summary, the following parameters have to be taken into consideration for the understanding of the U, Th, REE leaching, transport and deposition:

- 1) nature, abundance, and alterability of U, Th, REE-bearing phases in the source rocks; relative content of U-Th-REE among their different bearing (accessory or not) minerals;
- 2) composition of the fluid phase (concentration levels of trace elements, ligands, (especially  $F^-$ ,  $CO_3^{2-}$  and  $PO_4^{3-}$ ,...);
- 3) P-T-X conditions in the precipitation zone, and nature of the precipitated minerals;
- 4) behaviour of the ore minerals during post-crystallization processes (alteration, radioactive damage, weathering,...).

Such consideration may help greatly the interpretation of the ore geochemical features. Also, the study of the mineralogical form of U, Th and REE would ensure a correct interpretation of the whole rock geochemistry either in the source rocks or in the host rock of the mineralization. Then, it appears necessary to distinguish whether the mineralogical and geochemical features of these rocks were acquired at the magmatic, hydrothermal, or supergene stage.

#### REFERENCES

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CATHELIN M. \*, DUBESSY J. \*, MARIGNAC C. \*\*, POTY B. \*, WEISBROD A. \*\* - *Fluids in granitic environments*

The very general fact of spatial relations between granitoid intrusions and various kinds of ore mineralizations have from long focused interest into fluid behaviour in such magmatic bodies. Recently developed tools such as fluid inclusions or stable isotopes studies

have provided a wealth of new data which give a better insight into the fluid production and circulation associated with the emplacement of granitic plutons and their cooling and further evolution.

Three successive generations of fluids will be distinguished:

I. Magmatic fluids - Crystallization of anhydrous minerals from the magma produces a water increase and leads to the formation of a fluids phase co-existing with the melt and crystal («resurgent boiling» BURNHAM, 1979; BURNHAM and OHMOTO, 1980). Few direct initial witnesses of this stage are presently observed, because of the frequent recrystallization of the melt inclusions (NAUMOV et al. 1977). Inclusions exhibit silicate crystal with a fluid phase, and sometimes three phases (at high temperature): two immiscible melts, a silicate and a saline one plus a fluid phase (REYF and BAZHEV, 1977).

II.a. - At the end of crystallization, at last, magmatic fluids are exsolved and may be studied for themselves. Unfortunately, there is a poor record of such fluids, either because of a lack of trapping or because they were not sought for (or were not recognized). Nevertheless, there are at least three situations where the expression of late magmatic fluids was clearly observed:

- in boron enriched granitic systems, unmixing of a B-rich aqueous brine (up to 60% eq. NaCl) is locally observed, and is reflected by the crystallization of «quartz - tourmaline» or «flour» rocks frequently occurring as braccia pipes (Cornwall, Bolivia, for instance) (CHAROY, 1979; GRANT et al., 1980);
- in porphyry copper intrusives, where these fluids are complex brines, characterized by their high temperature (600°C and more) and high K/Na ratio (ROEDDER, 1971; EASTOE, 1978; DENIS et al., 1980; RAMBOZ, 1979);
- in sodalitic granites, such as the Beauvoir granite at Echassières; these late magmatic fluids appear enriched in Li and F, and are also characterized by their high temperature (close to the lowered eutectic of = 560-580°C of the F-Li-enriched magma) and high K/Na ratio (AISSA, 1978).

In these two late examples, boiling of exsolved brines (so called secondary boiling) is a common feature. In every case, the early circulations of these late magmatic fluids mark the beginning of rather long-lived hydrothermal circulations involving fluids of non-magmatic origin.

II.b. Even in the absence of evidence of late magmatic fluids, early interactions of aqueous-dominated fluids coming from the surrounding of the intrusions is often recorded and sometimes spectacularly; such is the case for:

- the greisenisation process, involving «meteoric» waters (JACKSON et al., 1982) at high temperature (up to 500-550°C) (CHAROY, 1979);
- the reducing effect to  $CO_2-CH_4$  aqueous fluids evolved from graphite-rich gneissic levels into the alaskitic magma of Rössing, yielding the massive crystallization of uraninite (CUNEY, 1980).

Fluids evolved from devolatilization of C-rich (meta)sediments are a rather frequent compound of high temperature fluid circulations in granites, as exemplified by those observed in the intragranitic contact zones in