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THE ROLE OF FLUIDS IN POST SOLIDUS TRANSFORMATIONS IN THE NEPHELINE SYENITES FROM THE DITRĂU ALKALINE MASSIF, TRANSYLVANIA, ROMANIA

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The Ditrău Alkaline Massif (Romania) is situated in the central part of the Eastern Carpathians, as an intrusion introduced in the Bukovina nappe system of the Mesozoic crystalline zone (Balintoni, 1997). Unique rock types and their variations of the Alkaline Massif led to numerous unequivocal theories about their formation. However, several questions about the petrogenesis of the Massif still exist. Nepheline syenite is the most abundant rock type in the Massif. It is composed of pertitic feldspars, nepheline, biotite, amphibole, pyroxene as primary minerals, and cancrinite, sodalite and calcite, analcite as secondary minerals. Titanite appears as accessory mineral. This rock type occurs in the central and eastern part of the Massif representing the youngest intrusion of the complex.

The nepheline occurs frequently as euhedral crystals, with short prismatic, square or hexagonal shape. This latter one a typical for low temperature crystallization (Hamilton, 1961). The cancrinite, sodalite, analcite are secondary minerals which forms at the expense of the nephelinek. Although several author denoted the importance of the liquids and chlorides in the formation of the above-mentioned secondary minerals, none of them provided substantial proves for this process. However, these secondary minerals are those, which typify the Massif.

We observed fluid inclusions in nepheline, which can provide information about the transformation of the nepheline to cancrinite, sodalite or analcite. The inclusions have elongated negative crystal shape and sizes between 5-40 μm, in extreme cases they even reach 100 μm. They occur oriantated, pareallel to the *b* and perpendicular to the *a* and *c* crystallographic axes of the nepheline. The study of the fluid inclusions were carried out by microthermometric methods with a Fluid Inc USGS stage in the Lithosphere Fluid Research Lab at the Department of Petrology and Geochemistry, Eötvös University, Budapest, and a Linkam THMSG 600 stage at the Department of Mineralogy, University of Buchrest, Romania.

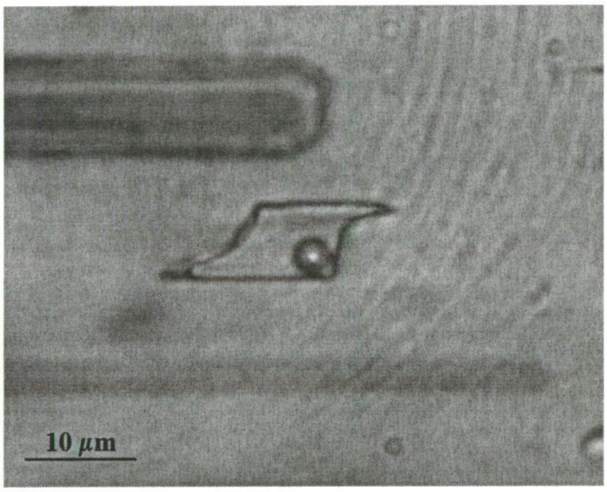

Figure 1. *First type* two-phase (liquid-vapor) fluid inclusion in nepheline. Nepheline syenite, sample DA4.

The observed fluid inclusions can be grouped in four major types, based on the microthermometric data and properties of the inclusions. The fluid, in most cases, represents a simple NaCl-H_2O system with different NaCl content. The *first type* (*Fig. 1*) inclusions are two- or three-phased (liquid-vapor, liquid-vapor-solid), in which the solid phases do not show phase changes during the heating experiments. Consequently, this solid phase might have crystallized prior to the formation of the nepheline and trapped as solid phase. The inclusions show a calculated (Bodnar, 1993) medium salinity with average value of 21.1 wt% NaCl eqv., and homogenization temperatures between 171.8°C and 305.0°C. The *second type* inclusions are two-phase inclusions, in these inclusions during the freezing process hidrohalite is the phase that melts last, accordingly the salinity of the inclusion is higher than in the first type inclusions, with average value of 26.75 wt% NaCl eqv. (close to the peritectic value of the pure NaCl-H_2O system), and homogenization temperatures between 268.0°C and 275.0°C. The *third type* fluid inclusions have three-phases. The solid phase is halite. The average salinity value of these inclusions, calculated by the method of Sterner et al. (1988), is 37.2 wt% NaCl eqv., with homogenization temperatures between 276.0°C and 299.0°C. The *fourth type* fluid inclusions have also three phases, with a huge solid phase of halite (*Fig. 2*). The average salinity of these inclusions have a supposed value between 40 and 45 wt% NaCl eqv., and the suspected homogenization temperatures between 325°C and 375°C. Concerning third and fourth types of inclusions, it should be noted, that during the heating of these inclusions, the liquid-vapor homogenization temperature was lower than the halite dissolution temperature.

We also observed some inclusions with different appearance, regarding to the phase relations at room temperatures and the different behavior of the transformations in the inclusions during the microthermometric analyses. These inclusions are two-, three- or multiphase inclusions. Concerning their specail behavior, the inclusions represent a complex solution with ions of Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, OH^-, H^+, and CO_3^{2-}. However, the microthermometric properties of these complex fluid inclusions have not been constrained properly, yet.

Also, some fluid inclusions in cancrinite were studied. These inclusions have a liquid and vapor phase and show irregular shape. Based on the microthermometric study, the fluids have an average calculated salinity of 15 wt% NaCl eqv., with homogenization temperatures between 195°C and 241°C.

Previous publications dealing with petrogenesis of the Ditrău Alkaline Massif, emphasized the importance of ions of Cl^-, CO_3^{2-}, SO_4^{2-}, OH^- in the petrologic evolution of the nepheline syenites (Ianovici 1938, Streckeisen and Hunziker 1974, Kräutner and Bindea 1998, Morogan *et al.* 2000). Taking into consideration the compositions of the nepheline ($NaAlSiO_4$), cancrinite ($(Na, Ca, K)_{6\text{-}8}[AlSiO_4]_6(CO_3, SO_4, Cl, OH)_{1\text{-}2}\times 1\text{-}5\ H_2O$), sodalite ($Na_8[AlSiO_4]_6Cl_2$) and analcite ($Na[AlSi_2O_6]\cdot H_2O$) and even the rare scapolite ($[(Na, Ca)_4[AlSiO_4]_6(Cl, CO_3)]$) too, it is obvious that the fluids reprezented by inclusions in the nepheline could really have an important role in the transformation of the nepheline in to the above-listed secondary minerals.

During the long crystallization period of the Alkaline Massif, nepheline was in equilibrium with a salty solution, which changed its salinity and compositions in time, mostly by loosing H_2O in expense of the formation of H_2O-bearing minerals like amphiboles and micas, which started to crystallize after the nepheline. The different fluid inclusion types preserved the increasing salinity values. When the ion concentration of the fluid reached a certain level, the fluid begun to transform the nepheline into the secondary minerals such as cancrinite, sodalite or analcite. It is supported by presence of fluid inclusions in cancrinite, which have a low salinity value compared to those of nepheline.

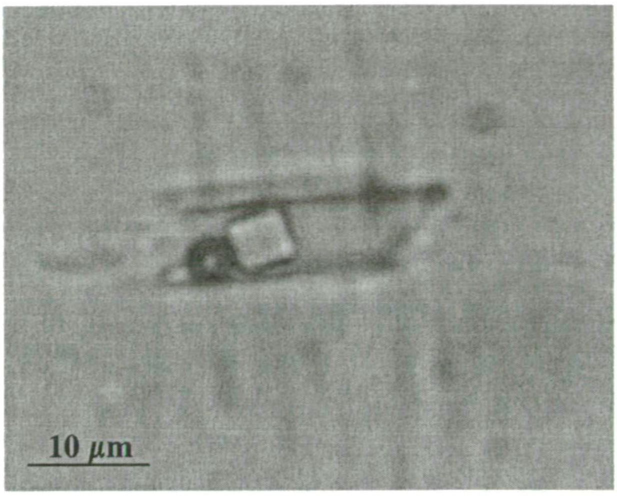

Figure 2. *Fourth type* three-phase (liquid-vapor-halite) fluid inclusion in nepheline. Nepheline syenite, sample DC1.

References:

BALINTONI, I. (1997): Geotectonica terenurilor metamorfice din România, Cluj-Napoca, p. 176.

BODNAR, R. J. (1993): Revised equation and table for determining the freezing point depression of H_2O-NaCl solutions, Geochimica et Cosmochimica Acta Vol. **57**, 683-684.

BODNAR, R. J., VITYK, M. O. (1994):Interpretation of microthermometric data for H_2O-NaCl fluid inclusions, Fluid Inclusions in Minerals: Methods and Applications, Short Course of the Working Group (IMA), Pontignano-Siena, 117-130.

HAMILTON, D. L. (1961): Nephelines as crystallisation temperature indicators, Journal of Geology, **69**, 321-329.

IANOVICI, V. (1938): Considération sur la consolidation du massif syénitique de Ditrău, en relation avec la tectonique de la région. C. R. Acad. Sci. Roum. **2**, 689-694.

KRÄUTNER, H. G., BINDEA, G. (1998): Timeing of the Ditrău intrusive comlex (Eastern Carpathians, Romania), Slovak Geol. Mag., **4**, 213-223.

MOROGAN, V., UPTON, B. G., FITTON, J. G. (2000): The petrology of the Ditrău alkaline complex, Eastern Carpathians , Min. and Petr. **69**, 227-265.

STERNER, S. M., HALL, D. L., BODNAR, R. J. (1988): Synthetic fluid inclusions. V. Solubility relations in the system NaCl-KCl-H_2O under vapor-saturated conditions. Geochim. Cosmochim. Acta, **52**, 989-1006.

STRECKEISEN, A., HUNZIKER, J. C. (1974): On the origin and age of the Nephelinsyenite Complex of Ditró (Transilvania), Romania. Scweiz. Min. und Petr. Mitt. **LIV**, 59-74.