GEOCHEMICAL CHARACTERISTICS OF THE PRISTINE MAGMA OF ACIDIC VOLCANIC ROCKS ASSOCIATED WITH URANIUM DEPOSITS : A MELT INCLUSION STUDY

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Introduction

Melt inclusions studies, contribute to a better understanding of magma genesis and fractionation processes. Melt inclusions study is an original tool for obtaining information on the pristine magma geochemistry in melt inclusions-bearing rocks before any late magmatic, hydrothermal or supergene alteration. The first studies were mainly based on microthermometric observations and majors element analyses (Clocchiatti, 1975); (Sobolev and Kostyuk, 1975). Nowadays, analytical techniques trace elements (EPMA, SIMS, LA-ICP-MS), water and volatile concentrations (SIMS, FTIR,RS, LA-ICP-MS) can be obtained with a good accuracy. In the present study, melt inclusions were analyzed by electron microprobe (CAMECA SX 50 and SX 100 microprobes at the Service Commun d'Analyses, Henri Poincaré University, Nancy, France) and by ion microprobe (CAMECA IMS-3F microprobe at the CRPG, Nancy, France).

Aim of the study

From the 50's to the late 70's, acid volcanic rocks were intensively explored for uranium and several deposits were found : (McDermitt and Marysvale, USA ; Ben Lomond, Australia ; Pena Blanca, Mexico ; Macusani, Peru; Streltsovka, Russia, Dornot, Mongolia ...). All these deposits are located in or near caldera structures related to magma venting in different geodynamic environments. However, these deposits display a wide variation in ore grade and size of the resources. Many of these deposits do not exceed 5000 tons of U excepting three of them: the giant Strelsovkaia caldera with more than 200.000 metric tons U, Dornot with several thousands tons U, and the McDermitt caldera with nearly 10.000 tons U. Study of source-rocks and their alteration for different deposits should lead to a better understanding of the parameters leading to world class deposit formation. As these rocks are extremely altered, their original chemistry cannot or hardly be determined from whole rock geochemistry, so we have chosen to determine the initial magma geochemistry from the study of melt inclusions trapped in minerals such as quartz and sanidine (when alteration was not too strong). Data from melt inclusions were then compared to altered whole rock chemistry (obtained by ICP AES and MS at CRPG, Nancy, France) in order to establish mass balance calculations and so estimate the rock volume that should be altered to form mineralization of the size of the ore deposit.

Geologic background

Data from two deposits will be presented: the Kings River area from the McDermitt caldera (Nevada, USA) and the Sierra Pena Blanca (Chihuahua, Mexico). The data will be compared with deposits already studied with the same techniques (Ben Lomond, Australia, Chemillac et al., 200***; and Streltsovka, Russia, Chabiron et al. 2003). The McDermitt caldera is located in north-western Nevada and is mainly filled with peralkaline to metaluminous ash flow sheets on about 20.000 km^2. Their emplacement is related to "Basin and Range" tectonics in the eastern part of the North American Cordillera. The caldera is mainly filled with rhyolites and dacites dated at about 16 Ma. The Kings River district is located at the south-west margin of the caldera in contact between a Cretaceous granite and the caldera volcanic-filling. U mineralization occurs in faulted zone along this contact. Different levels of tuffs and lavas were sampled for the melt inclusion study. The Sierra Pena Blanca deposits are located in the Chihuahua Province (north-eastern Mexico). It belongs to the Sierra Madre volcanic complex and its emplacement is also related to the "Basin and Range" tectonics. Tertiary volcanic units lie on a Cretaceous calcareous basement. These units are divided into three formations hosting the U-mineralizations. The composition of these formations range from rhyodacites to rhyolites and their ages from 44 to 37 My.

Methodology

For this study, volcanic rock samples were crushed; one part was kept for ICP-ES and MS analysis and the other part was used to separate transparent phenocrysts (i.e. quartz and K-feldspars). After a first sorting, phenocrysts containing glassy melt inclusion were mounted in epoxy resin and polished for microprobe analysis. Non glassy melt inclusions were first studied by Raman spectroscopy (Labram, Dilor, at the UMR G2R-CREGU, UHP, Nancy) to investigate the presence of gases in the shrinkage bubble and to determine the composition of various trapped crystalline phases. Non glassy melt inclusions were then homogenised using a Leitz 1350 heating stage (or and high temperature furnace when homogenisation temperatures were determined). When the inclusions were glassy ,the phenocrysts were mounted in epoxy resin and polished. Glassy inclusions were analyzed for Si, Al, Fe, Mg, Na, K, Ca, F, Cl, Mn and Ti with an electron microprobe and for U, Th, La, Ce, Pr, Nd, Sm, Eu, Gd, Dy, Er, Yb, Lu, Sr, Y, Nb, Ba, Rb, Hf, Ta, Zr, Mo, and As with a ion microprobe.

Results and perspectives

First investigations on the McDermitt volcanic rocks (Tp in Castor and Henry, 2000), gave a strong peralkaline composition with and agpaicity index about 0.76 in the glassy melt inclusions whereas it was close to 0.99 from to whole rock geochemical analysis. U content for this level has not yet been determined but will be interesting to determine for a comparison to peralkaline melts from the giant Streltsovkaia caldera uranium field (Russia). Peralkaline lavas from Streltsovkaia caldera show an agpaicity index near 0.9 and more than 17 ppm of U in the melt inclusions (Chabiron et al., 2001). Other levels in McDermitt are being investigated. Concerning Pena Blanca, the available data concern whole rock analysis; The agpaicity index for the various volcanic units ranges from 0.98 to 1.23 indicating a more "peraluminous" typology of magma but this hypothesis must be confirmed by non altered melt inclusions data.

Perspectives are to analyse the various types of volcanic levels in both areas in order to find the best sources for the ore and to compare the uranium metallogenic potential of each of the units and between the different localities. It will also permit to observe the evolution of melts during the successive volcanic events. Mass balance calculations coupled with rock alteration studies (mineralogy and fluid inclusions) will allow the characterisation of the different type of alteration and their efficiency to mobilise the metals from the rock.

References

CASTOR, S. B., HENRY, C. D. (2000): Geology, geochemistry, and origin of volcanic rock-hosted uranium deposits in northwestern Nevada and Southeastern Oregon, USA. Ore Geology Reviews, **16**, 1-40.

CHABIRON, A., ALYOSHIN, A. P., CUNEY, M., DELOULE, E., GOLUBEV, V. N., VELITCHKIN, V. I., POTY, B. (2001) : Geochemistry of the rhyolitic magmas from the Streltsovka caldera (Transbaikalia, Russia): a melt inclusion study. Chemical Geology, **175**, 3-4, 273-290.

CHABIRON A., CUNEY M., POTY B. (2003) : Possible uranium sources for the largest uranium district associated with volcanism : the Steltsovka caldera (Transbaïkalie, Russia). Mineralium Deposita,. **38**: 127-140.

CLOCCHIATTI, R. (1975): Les inclusions vitreuses des cristaux de quartz. Etude thermo-optique et chimique. Applications géologiques. Société Géologique de France, Mem 122, 96p.

SOBOLEV, V. S., KOSTYUK, V. P. (1975): Magmatic crystallisation based on study of melt inclusions. Fluid Inclusion Research, **9**, 182-253.