Fluid inclusion study of Ponte Segade rare-element deposit, northern of Galicia, Spain: Preliminary results

Canosa, Francisco, Fuertes-Fuente, Mercedes and Martín-Izard, Agustín

Department of Geology, University of Oviedo, Jesús Arias de Velasco s/n 33005, Oviedo, Spain

Introduction

The Ponte Segade deposit is a recently discovered rare element mineralization, probably related to an evolved granite-pegmatite system in north-western Spain. This work presents a preliminary fluid inclusion study of on the Ponte Segade deposit to determine the composition of fluids involved in the mineralizing processes.

Geological setting

The Ponte Segade Deposit is located in the NW of the Iberian Peninsula (northern Galicia), between the villages of Viveiro (Lugo) and Ortigueira (A Coruña). Geologically, this area is in the Variscan Iberian Massif which has been divided into six zones (Julivert *et al.*, 1972), the inner one being the "Central Iberian Zone" (CIZ) where Ponte Segade deposit is located. In the CIZ, two main units were designated the Esquisto-Grauváquico Complex and the Ollo de Sapo Antiform Unit. The latter, lower Ordovician in age, is composed of augen-gneisses, porfidic schists, quarzites and slates. Variscan synkinematic S type granitoids intrude the Ollo de Sapo Antiform Unit, the Ponte Segade Deposit being related to these intrusions.

Ponte Segade deposit

The rare-element mineralized area of Ponte Segade comprises cassiterite-rich quartz veins, pegmatites and albite-rich leucogranites that are the result of magmatic differentiation from muscovite peraluminous synkinematic granites, widespread in the district. The cassiterite-rich quartz veins are tabular bodies whose thickness varies between 2 cm and 4 m and are boudinage bodies when they cut the augen-gneisses of the Ollo de Sapo Formation. These veins have the highest proportion of ore-bearing minerals, which are cassiterite, beryl, columbite-tantalite, wodginite, microlite and different sulphides. The pegmatites are tabular and lenticular intragranitic bodies that are hosted by albite-rich leucogranites. Two types, the zoned pegmatites and layered aplite-pegmatite, have been distinguished according to their mineralogical and petrographical features. In this case, the main ore minerals are beryl, cassiterite, arsenopyrite, columbite-tantalite, wodginite, microlite, and molybdenite in zoned pegmatites, while in layered aplite-pegmatite they are elbaite, montebrasite, eosphorite, beryl and cassiterite.

Fluid inclusion study

Microthermometric studies were performed on fluid inclusion wafers (150-300 µm in thickness) using a microscope equipped with a Linkam THMSG-600 stage in the Ore Deposit Laboratory of the Geology Department of Oviedo University (Spain). The samples used for this study are quartz from cassiterite-rich quartz veins and beryl from zoned pegmatites. From petrography and microthermometric studies, 4 types of aqueous-carbonic ($Lw\text{-}c_1$, $Lw\text{-}c_2$, $Lw\text{-}(c)_1$ and $Lw\text{-}(c)_2$) and 2 types of aqueous (Lw_1 and Lw_2) fluid inclusions have been found. The nomenclature of fluid inclusion types used in this work is modified from Cathelineau *et al.* (1993).

Aqueous-carbonic fluid inclusions

The $Lw\text{-}c_1$ type is present in quartz of cassiterite-rich quartz veins. These fluid inclusions are characterized by irregular morphology with a size of between 18 and 19 µm. They occur in isolation. According to Roedder´s criteria, they could have a primary origin. They show a volumetric fraction of the aqueous phase (φ_{liq}) around 60 %. The melting temperature of CO_2 is -58.2 ± 0.2 ºC. The homogenization temperature of CO_2 varies between 8.7 and 10.7 ºC to the vapour phase. The eutectic temperature is observed around -20.8 ºC. The melting temperature of ice is close to -4.6 ºC and the melting temperature of clathrate, T_m(cla), is 10.3 ± 1 ºC. The total homogenization temperature varies from 335 to 347 ºC to the liquid phase. The Lw-c_2 type is present in beryl from zoned pegmatites. These fluid inclusions have an elongated morphology and the size ranges between 25 and 62 μm. Their distribution is isolated. Thus, we consider their origin was likely to have been primary. The φ_{liq} varies from 30 to 60 %. The $T_m(CO_2)$ is between -57.3 and -56.6 ºC. $T_h(CO_2)$ is observed between 13.5 and 15.1 ºC to the vapour phase. T_m(ice) ranges from -4.1 and -3.7 ºC and T_m(cla) varies from 8.1 to 9 ºC. The T_h(total) is around 355 ºC to the liquid phase. The Lw-$(c)_1$ type only appears in cassiterite-rich quartz veins. This typology occurs mainly in two ways, as several planar arrays of fluid inclusions with negative crystal shape that cut different quartz crystals. These planar arrays could be healed microfractures. Moreover, they occur in isolation with irregular morphology. The size ranges from 7 to 31 μm. From the petrographic features, it is probable that they could be secondary in origin. The φ_{liq} is around 60 %. *Te* is near to -20.8 ºC. The T_m(ice) ranges from -5.3 to -4.3 ºC and T_m(cla) has been measured between 10.2 and 10.8 ºC. T_h(total) is next to 315 ºC to the liquid phase. The Lw-$(c)_2$ type is present in quartz from cassiterite-rich quartz veins and beryl from zoned pegmatites. The morphology is irregular or rounded and between 12 and 60 μm in size. The fluid inclusions appear isolated and, more scarcely, as intragranular alignments. Thus, we consider that they may be primary and/or pseudosecondary in origin. The φ_{liq} ranges between 70 and 80 %. *Te* is observed around -20.8 ºC. T_m(ice) is close to -4 ºC and T_m(cla) is around 8.7 ºC in fluid inclusions of beryl. In the quartz fluid inclusions, T_m(ice) is between -6.8 and -5.5 ºC and T_m(cla) ranges from 9.1 to 9.8 ºC. In these fluid inclusions T_h(total) is near to 318 ºC to the liquid phase.

Aqueous fluid inclusions

The Lw_1 type appears in quartz of cassiterite-rich quartz veins and in beryl from zoned pegmatites. In quartz, these fluid inclusions are elongated or rounded morphology and appear as transgranular linear arrays. The size is between 12 and 27 μm. In beryl, they often occur isolated with irregular shapes and their size varies from 30 to 61 μm. According to Roedder´s criteria, we consider that they may be primary in beryl whereas in quartz, they could be secondary. The φ_{liq} is near to 80 %. T_e is around -20.8 ºC. The ranges of T_m(ice) are -6.2 to -3.8 ºC in fluid inclusions in quartz and -4.8 to -0.3 ºC if they appear in beryl. T_h(total) has a wide range of variation between 154 to 364 ºC to the liquid phase. The Lw_2 type occurs in quartz from cassiterite-rich quartz veins. These fluid inclusions are elongated and appear as transgranular planar. They also occur isolated with rectangular or rounded morphology. Their size varies between 20 and 50 μm. From the petrographic characteristics, we classified them as secondary in origin. The φ_{liq} is around 90 %. T_e is between -45.5 and -42.5 ºC. T_m(ice) ranges between -21.7 and -18.2 ºC. T_h(total) varies from 110 to 119 ºC to the liquid phase.

Conclusions

From this preliminary fluid inclusion study, the rare-element mineralization of Ponte Segade seems to be related to the aqueous-carbonic fluids that were trapped by the undoubtedly primary fluid inclusions (i.e. Lw-c_1 and Lw-c_2) found in quartz from the cassiterite-rich quartz veins and in beryl from the zoned pegmatites. However, further studies must be done in order to establish the composition and evolution of the fluids associated with this mineralization.

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