Alteration sequences of aluminium phosphates from Montebras Pegmatite, Massif Central, France

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INTRODUCTION

Montebras pegmatite is one of the most famous pegmatites of Western Europe and also the type-locality for montebrasite, $LiAl(PO_4)(OH,F)$, and for morinite, $NaCa_2Al_2(PO_4)_2(OH)F_4.2H_2O$ (Lacroix, 1910). A new investigation of samples collected decades ago, and preserved in the Museum of the "Ecoles des Mines", Paris, has been undertaken to establish the alteration sequences, starting from primary amblygonite which occurs in this pegmatite.

Observations of phosphate minerals from Montebras show the occurrence of three mineralization stages. The magmatic stage, with crystallization of primary minerals and with F and Li enrichment, the metasomatic stage, with Na and Ca enrichment, and finally low-temperature hydrothermal and meteoric processes.

MAGMATIC STAGE

The first crystallization of phosphates at Montebras is characterized by massive pods of amblygonite, $LiAlPO_4(F,OH)$, with $F/(F+OH) = 0.8$. This primary mineral is quickly replaced by secondary montebrasite along cleavage planes. Minor triplite and eosphorite might appear at some stage as well as some quartz and muscovite; all related with hydraulic fracturation of the deposit.

METASOMATIC STAGE

One of the main features of Montebras amblygonite is its strong replacement by Na-bearing phosphates. Primary phosphates are therefore affected by patchy lacroixite, $NaAl(PO_4)F$, and by some fluorapatite. Numerous vugs and cracks are filled by a low-fluorine montebrasite, as well as by lacroixite. Calcium enrichment increased later on with the crystallization of morinite and wardite. An unknown mineral, with composition $Na(Mn,Ca)Al(PO_4)(F,OH)_3$, has also been observed in replacement of eosphorite.

Destabilization of morinite in Na-rich apatite occurs with the crystallization of rare viitaniemiite and of an unknown Na-Al-F phase similar to cryolite.

Analogous results have already been obtained experimentally (Fisher & Volborth, 1960).

At the end of this metasomatic enrichment, tin is deposited as cassiterite and stannoidite; some crystals of tantalite and hübnerite are also visible.

HYDROTHERMAL AND METEORIC STAGES

Decreasing temperature makes fluids less aggressive in regard to previously formed minerals. Crystallization during hydrothermal stage mainly occurs in fractures by deposition and filling. This phase is particularly characterized by kaolinization of feldspars and formation of kaolinite veins through phosphate pods. Crandallite-group minerals are also very common, and progressively shift from a Ca-rich to Sr- and Ba-rich compositions, due to decreasing pH conditions (Dill, 2001). Below 150°C, variscite appears in vein assemblages containing also kaolinite and gorceixite.

Oxidation and alteration of ore minerals at this stage form varlamoffite from cassiterite and stannoidite. Copper from this later mineral reacts with phosphates to form turquoise.

Near the surface, Montebras pegmatite is affected by meteoric water. Aqueous conditions are more acidic and facilitate the crystallization of crandallite-group minerals. A meteoric kaolinite is sometimes visible, as well as some variscite. Wavellite forms acicular crusts alternating with clay minerals, probably due to ground water level fluctuations.

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