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Pyrochlore Chemistry from the Bonga Carbonatite-type Nb Deposit, Huila Province, Angola: Implications for Magmatic-Hydrothermal Processes of Carbonatite.

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1 Introduction

Pyrochlore-group minerals are the most important Nb-bearing minerals (Chakhmouradian and Williams, 2004) that are produced mainly from carbonatite. Many researchers have done numerous studies of pyrochlore geochemistry in different carbonatite worldwide, which helps to better understand the magmatic, hydrothermal and low-temperature (supergene) evolution of carbonatite (Nasraoui and Bilal, 2000).

Bonga carbonatite Nb deposit with an estimated reserve of 824 Mt grading 0.48% Nb₂O₅ (Kamitani and Hirano, 1990), is located in the west side of Lucapa Early Cretaceous rift in western Angola. Only a few researchers have worked on the of carbonatite and pyrochlore in this deposit (Issa Filho et al, 1991; Coltorti et al., 1993; Bambi et al., 2012). Furthermore, the research on pyrochlore is limited in primary (magmatic) pyrochlore. In this abstract, we provide new geochemical (EMPA) data of pyrochlore from the Bonga carbonatite.

2 Pyrochlore Chemistry and Discussion

The general formula of pyrochlore supergroup minerals is A₂-mB₂X₆-wY₁-n. The structural formulas of pyrochlore were calculated based on the 2 apfu (atoms per formula unit) at the B-site, assuming all Fe as Fe³⁺ and all Si as B-site cation. Based on chemical compositions and mineral texture, five types (stages) of pyrochlore (I, II, III, IV and V) were identified in Bonga carbonatite. Fig. 1 shows the apfu of elements and the A-site vacancies of all types of pyrochlore analyzed.

Pyrochlore I is of primary (magmatic) origin while other types form from hydrothermal metasomatism.

Pyrochlore I is characterized by Nb-rich and Ta-poor, dominant occupancy of Ca and Na at the A-site and dominant occupancy of F at the Y-site. The low Nb/Ta ratio of pyrochlore I and positive correlation with fluorapatite imply that carbonatite magma was rich in volatiles (such as F and H₂O) when pyrochlore crystallized in Bonga. Ta concentration of primary pyrochlore is controlled by F fugacity of the melts, while small changes of HFSEs (such as Ti, Zr) concentrations in pyrochlore are probably related to co-crystallization of other minerals like magnetite and zircon, or controlled by the following substitution: Nb⁵⁺ + O₂⁻ ↔ (Ti, Zr)⁴⁺ + (F, OH)⁻.

All late-stage pyrochlore was formed in subsolidus hydrothermal processes. During high-temperature hydrothermal processes, pyrochlore I was replaced by pyrochlore II with less concentration of F and Na, as well as slight decrease of Ca and sharp increase of vacancies at A-site. The synchronous reduction of F and Na suggests the coupled substitution Na⁺ + F⁻ ↔ A□ (A vacancies) + Y□ (Y vacancies). Pyrochlore IV (high A vacancies, low occupancy of cations at A-site) formed by hydrothermal metasomatism at relatively lower temperature. Pyrochlore III and pyrochlore V are characterized by high concentrations of Sr, Ba, Pb and associated with hydrothermal minerals (such as quartz, strontianite, etc), which indicate low-temperature hydrothermal processes. During the whole hydrothermal processes in Bonga carbonatite, the following substitution mechanisms of pyrochlore may existed: Ca²⁺ + XO₂⁻ → A□ + X□ (X vacancies); 2Ca²⁺ + (U, Th)⁴⁺ → A□; 3Nb⁵⁺ + 2Ca²⁺ → 2Si⁴⁺ + Fe³⁺ + 2(U, Th)⁴⁺; 2Nb⁵⁺ + Na⁺ + 2Ca²⁺ → Si⁴⁺ + Fe³⁺ + 2(U, Th)⁴⁺ + A□.

Pyrochlore has been replaced by Nb-rich rutile and minor aeschynite at low-temperature and oxidizing

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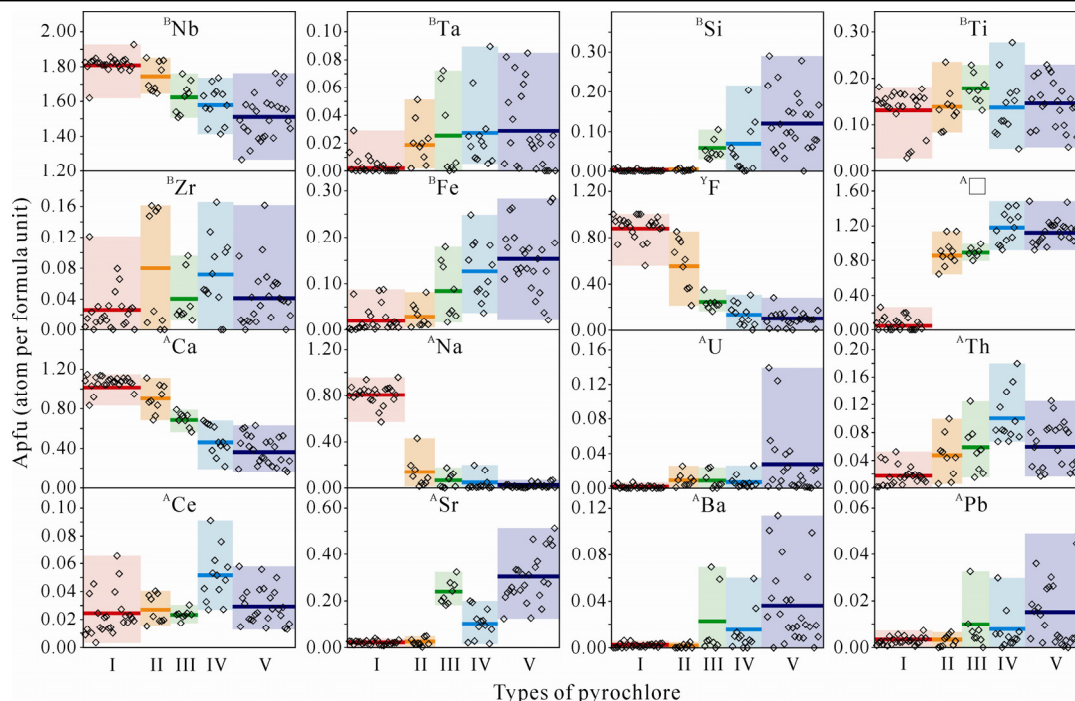


Fig.1 Apfu (atoms per formula unit) of elements and A vacancies of pyrochlores

conditions. During this process, cerium and thorium were released from pyrochlore, and have formed Ce-phosphates (e.g. monazite), Ce-carbonates [e.g. bastnäsite-(Ce), synchysite-(Ce)], an unidentified Sr-REE phosphate mineral and thoriantie. In addition, occurrence of Nb-rich goethite indicates that niobium has been remobilized during weathering process in Bonga carbonatite.

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