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Geochemical Characteristics and U-Pb chronological of Apatite in Diamondiferous Kimberlite Pipes, the North China Craton (NCC)

Chu-Qi Cao[1], Jing-Sui Yang[1, 2*], Li-Guang Liu[3], Sheng-Biao Yang[4]

[1] Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China, chuqicao@163.com
[2] School of Earth Sciences and Engineering, Nanjing University, Nanjing, China, yangjsui@163.com
[3] Liaoning Sixth Geological Brigade Co., Ltd, Dalian, China, 373189713@qq.com
[4] Institute of Geochemistry, Stage Key Laboratory of Ore Deposit Geochemistry, Chinese Academy of Sciences, Guiyang, China, shbyang@163.com

Introduction

Kimberlites are deep-seated volatile-rich magmas that erupt on the Earth's surface. These magmas and their exotic cargos (xenoliths, megacrysts, and xenocrysts) provide a truly unique window into mantle processes and dynamics. However, it is challenging to accurately determine the timing of kimberlite magma emplacement.

Apatite (general formula $Ca_5(PO_4)_3(F,Cl,OH)$) geochemical compositions provide robust means for constraining a wide range of geological processes in earth and planetary sciences. Due to its resistance to alteration and usually high U and Th content, it is also commonly used in U-Pb chronology research of various geological events. Unlike the U-bearing accessory mineral zircon, apatite is a common accessory mineral in kimberlites. Here we extend it as a potential recorder of kimberlite processes.

Analytical Results

We distinguished two groups of apatite grains from diamondiferous kimberlite pipes in located in Wafangdian of the North China Craton (NCC). These two groups have distinct occurrences, geochemical compositions and U-Pb ages, which indicate their different origins.

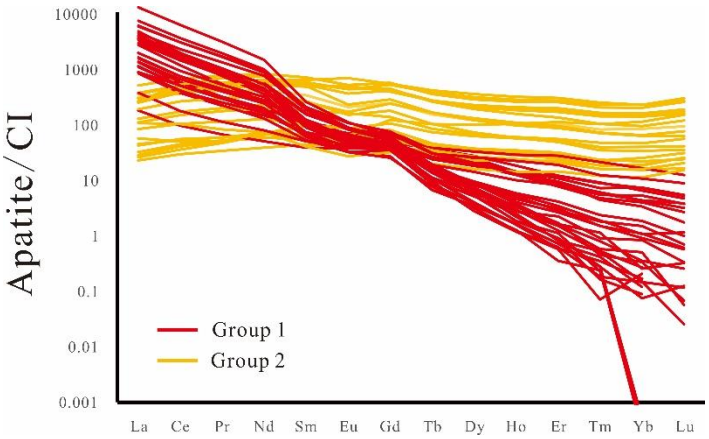

Figure 1: Chondrite-normalized REE patterns for two group of apatites from diamondiferous kimberlite pipe, Wafangdian, China.

Group 1 apatite grains mainly occur as euhedral to subhedral columnar crystals, radial aggregation, size 80~240μm, have relatively high Sr content (1932~59713 ppm) and variable chemical features such as majority negative Eu anomalies (0.43~1.01) and continuously variable REE (22~8147 ppm), LREE enrich. The lower intercept at Tera-Wasserburg concordia plots shows the age of Group 1 apatite is 462.1±8.6 Ma (MSWD = 1.2, n=44) in agreement with the previously reported ages from andradite-rich garnet U-Pb (459.3 ± 3.4 Ma), phlogopite Ar-Ar (463.9 ± 0.9 Ma) and Rb-Sr (461.7± 4.8 Ma) of kimberlite pipes in NCC. Combined with petrographic observations, whole-rock geochemistry and age data, it is indicated that Group 1 is crystallized from host magma.

Group 2 apatite grains occur as subhedral single crystals, sometimes with rounded edges, size 50~200μm, and display low Sr content (277~1235 ppm), positive to negative Eu anomalies (0.24~1.16) and relatively flat chondrite-normalized REE pattern. The lower intercept of Tera-Wasserburg concordia plots shows the age of Group 2 apatite is 1805.0±8.0Ma (MSWD=1.3, n=16), which indicates synchronous with the Paleoproterozoic crystalline basement of the NCC.

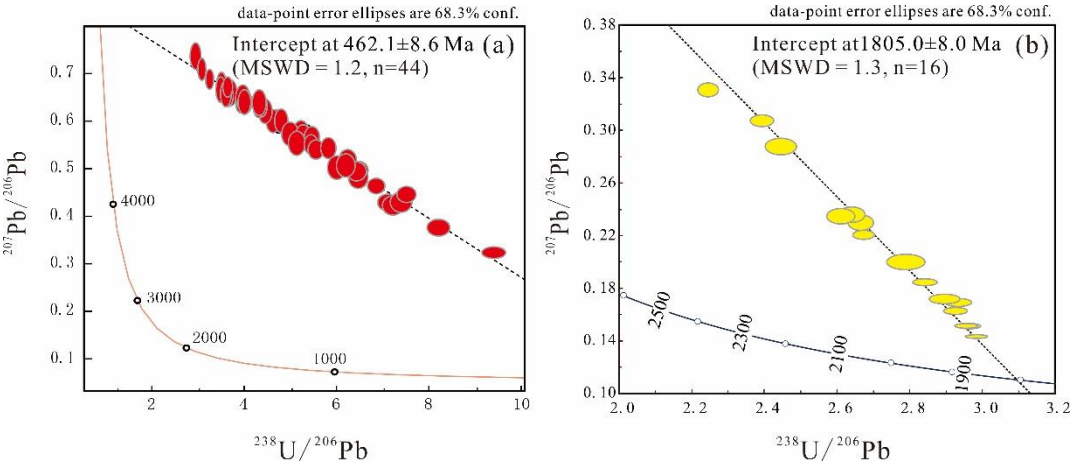

Figure 2: U–Pb Tera-Wasserburg concordia plots of two groups apatites from Wafangdian Province, China. (a) Group 1; (b) Group 2

Although the kimberlite rocks in this area are almost heavily altered and lack in perovskite for age dating, these apatite grains are shedding new light on diamond exploration and, even be promoted to kimberlite systems to study the behaviour during emplacement.

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