U-PB ZIRCON AND APATITE CHRONOLOGY OF A QUARTZ-RICH BASALTIC EUCRITE AND CONSTRAINT ON THERMAL HISTORY OF THE VESTAN CRUST

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Introduction: The ubiquitous thermal metamorphic features of HEDs have been studied for decades. The timing of thermal metamorphism could provide key informations for understanding the thermal history of eucrite and the mechanism of thermal metamorphism. However, it is difficult to discriminate the ages that record the primary metamorphism from those of secondary heating, because most of the ages determined on eucrites were made either on whole rocks or mineral separates and have no clear petrological contexts [1-5]. Isotopic and genetic studies of zircon provided constraint on the peak thermal metamorphic age [6-7], whereas the closure temperature of zircon U–Pb system (usually>900 °C) is generally beyond the thermal metamorphic temperatures of eucrites (700 to 1000°C). Evidence from isotopic systems with relatively low temperatures (i.e., apatite U–Pb, in situ Ar–Ar) are essential to cover the full range of metamorphic history of eucrites.

Results and Discussion: Northwest Africa (NWA) 6594 is an unbrecciated basaltic eucrite comprised of about 46 % pyroxene, 47% plagioclase, 6% silica, 1% opaque phases. Silica phases are mainly tridymite (~5%) and subordinate quartz (~1%). Such high abundance of quartz in HEDs has not been observed before. Silica phases in NWA 6594 are usually coexisting with apatite in mesostasis areas. The crystal structure of silica is very sensitive to both pressure and temperature [8-9]. Therefore it is useful to reconstruct the thermal history of apatite grains and to set crucial thermal constraints on the U–Pb system of apatites.

After detailed petrographic and mineralogical studies, we found that silica phases in NWA 6594 have two generations, corresponding to two major thermal pulses. The first generation includes primary quartz that crystallized slowly below 870°C during thermal metamorphism. The second generation is composed dominantly of monoclinic tridymite, which was formed by partial melting of quartz and minor other minerals induced by a later reheating event followed by a rapid cooling. This genetic sequence of quartz and tridymite in NWA 6594 is different from those proposed by previous authors, who suggested a crystallization of tridymite prior to quartz [10-11].

In situ U–Pb analyses were carried out on zircon and apatite. Twenty-four spots from seven zircons are concordant to nearly-concordant on the normal concordia diagram and yield almost identical $^{207}Pb/^{206}Pb$ ages, which have a weighted average of $^{207}Pb/^{206}Pb$ age of 4547±11 Ma (95% confidence, MSWD=1.3). This age could be interpreted as the crystallization age. As zircons in eucrite may have formed during global metamorphism [6-7], instead of solely crystallized during magmatism [12-14], the igneous age of the rock would thus not be latter than 4547±11 Ma.

Most Pb–Pb ages of apatite grains in NWA 6594 are identical within error. Eleven spots from seven apatites define a weighted mean $^{207}Pb/^{206}Pb$ age of 4523±2 Ma (95% confidence, MSWD=0.76), which is distinctly younger than the age of zircon (4547±11 Ma) beyond 2σ analytical uncertainties. Integrated petrographic and isotopic studies indicate that the younger Pb-Pb age of apatite could not be simply attributed to slow cooling after formation of NWA 6594. It is most likely due to an independent thermal event related to formation of quartz. The protracted time lag (~24±13Myr) between the two ages indicate that the later thermal metamorphism cannot be related to burial of successive lava, but is most likely induced by a reheating event of the Vestan crust that had a steep thermal gradient.

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Acknowledgments: This work was supported by the National Natural Science Foundation of China (Grant No. 41573059, 41573060, 41773059), the Natural Science Foundation of Jiangsu Province (BK20151609; BK20161098), the Minor Planet Foundation of China, and Macau FDCT (005/2017/A1; 119/2017/A3; 079/2018/A2).