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A special unbrecciated granoblastic textured basaltic eucrite meteorite

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1 Introduction

Generally, we can observe varying degree of ophitic texture or sub-ophitic texture in unbrecciated basaltic eucrites. However, a few unbrecciated basaltic eucrites possess the special characteristic of crystalloblastic texture by high metamorphism, which are called as granoblastic textured basaltic eucrites (Mayne et al. 2009, Mittlefehldt 2015). Up to now, there are only 5 granoblastic textured eucrites having been briefly reported, which have important implications for research on Vesta late thermal metamorphism because of having not completely preserved their original igneous textures. M16341 is the latest confirmation of the unbrecciated granoblastic textured basaltic eucrite, expanded the list of such meteorites, more detailed petrologic characteristics also supplement the previous shortage.

It is obvious that the meteorite M16341 have experienced a significant late thermal metamorphism because of rounding and equigranular mineral texture, while the weak shock characteristics indicate that the late thermal metamorphism is related to the magmatic processes. The two-pyroxene thermometer point the thermal equilibrium temperature of meteorite M16341 is ~794 ± 89℃. Additionally, special mineral assemblage of symplectite structure, large size and euhedral zircons and apatites and so on, show that the M16341 meteorite have special and important research value.

2 Petrological-Mineralogical Characteristic

Meteorite M16341, with weak magnetic properties and residual visible black fusion crust, whose rock structure is dense and section is full of small metal (Fe). Within polished thin section, mineral is slightly broken, rock structure is not brecciated. Essential mineral, plagioclase and pyroxene, are subhedral to anhedral, and have similar content and homoeoblastic structure. The mineral rounding phenomenon is obvious, and the adjacent same kinds of mineral, with unclear grain margin, are adhered to each other. Plagioclase is abnormal extinction, but only a handful of feldspar particles present locally wavy extinction, which indicates that the meteorite M16341 underwent a warm impact process. The mineral modal abundance is as follows: Low-Ca pyroxene (36.2 vol%), high-Ca pyroxene (10.6 vol%), plagioclase (44.3 vol%), SiO_2 (6.1 vol%), metal-Fe (0.3 vol%), chromite (0.6 vol%), other minerals such as ilmenite, troilite, apatite and zircon and so on (1.9 vol%).

3 Meteorite Classification

As mentioned above, M16341 is unbrecciated, with weak magnetic properties and residual visible black fusion crust, and is full of small mental-Fe grains. The mineral assemblage is plagioclase+pyroxene+SiO_2. Comparison of meteorite mineral assemblage characteristics of M16341 and Hutchison (2004) and Weisberg (2006), we designate M16341 as unbrecciated planetary differentiated achondrite.

Contrasting the mineral composition of M16341 with Vesta meteorite (HED), Martian meteorite and lunar meteorite, we find the M16341 meteorite falls within the HEDs meteorite region in the differentiated achondrite classification chart of pyroxene Fe (afu) vs. Mn (afu), pyroxene FeO/MnO vs. MnO (wt%) and Fe/Mn (pyroxene) vs. An (feldspar). So, M16341 is belonged to unbreccited HEDs meteorite.

As we know, unbrecciated HEDs meteorites can be subdivided into diogenites, cumulate eucrites and basaltic eucrites (Mittlefehldt 2015). In the HEDs meteorites classification schemes of Py-SiO_2-Pl modal

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abundance ternary diagram, pyroxene quadrilateral diagram, histograms of low-Ca pyroxene $Mg^{\#}$, Ti (apfu) vs. Al (apfu) and Cr (apfu) vs. $Mg^{\#}$ of low-Ca pyroxene, and Ti (apfu) vs. $Mg^{\#}$ of chromite, M16341 is all consistent with basaltic eucrite. Thus, M16341 is divided into unbrecciated basaltic eucrite.

In the other hand, the mineral margin of meteorite M16341 is evidently rounding, plagioclase and pyroxene have homoeoblastic structure, and the ophitic texture or sub-ophitic texture is completely invisible, which are all accorded with the diagnostic characteristics of granoblastic textured basaltic eucrites (Mayne et al. 2009, Mittlefehldt 2015). Therefore, M16341 is defined as unbrecciated granoblastic textured basaltic eucrite here.

4 Special Research Value

In general, symplectites, with vermicular or viscous textures, are defined as fine or very fine grain intergrowths of multiphase, which are products of decomposition of metastable phases or precipitation of immiscible melts. Thus, symplectites result from fractional crystallization of highly fractionated magmas, and play an important role in the late magma evolution of planet. At present, research of extraterrestrial samples symplectites are mainly focused on lunar and Martian meteorites. In contrast, only a few work have carried out for HEDs meteorites and been limited to brecciated eucrites symplectites, which consist of Fe-rich augite + fayalite + SiO_2 (Patzer et al. 2012). This work we find that the symplectites of meteorite M16341 are composed of FeS+SiO_2+silicate (FeO ≈ 45 wt%) and a small amount of metal-Fe, ilmenite, chromite and high-Ca pyroxene, which is inconsistent with previous studies but similar to the abnormal symplectites of howardite LAP 04838 (Patzer et al. 2012). Therefore, analysis of the symplectites of meteorite M16341 has a significant guiding role to understand Howardites formation mechanism and late magmatism of Vesta.

Zircon is a good carrier for the study of magmatism and later thermal events (Roszjar et al. 2016). This work we find zoned texture zircon and thermal disturbance zircon at the same time, whose grain size are more than 0.1mm, the largest grains in known zircons of HEDs meteorites. In addition, we calculate the thermal equilibrium temperature of meteorite M16341 is about 794 ± 89℃ by two-pyroxene thermometer (Kretz 1963), which is less than the closure temperature of U-Pb system in zircon (>1000℃) (Flowers et al. 2005). Thus, zircon should well record the magmatic crystallization process and subsequent thermal metamorphism of meteorite M16341.

The content and distribution of water and other volatiles in the planet play an important role in the field of geology and biology, and apatite is the most important carrier to study the water and volatile matter of the planet (McCubbin et al. 2015). This work 40 apatites have been discovered within the polished thin section of meteorite M16341, the largest grain of which is ~0.25mm, providing the necessary material support for the analysis of fluid process in Vesta during the early solar system.

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