BULK TiO2 CONTENT OF CHANG'E-5 MARE BASALT AND ITS CLASSIFICATION: EVIDENCE FROM COMPOSITION OF PYROXENE Chengxiang Yin[1], Xiaohui Fu[1*]. [1]Shandong Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, School of Space Science and Physics, Institute of Space Sciences, Shandong University, Weihai, Shandong, China (fuxh@sdu.edu.cn).

Introduction: On December 16, 2020, Chang'e-5 (CE-5) mission returned 1731 g of lunar soil samples in the northeast of Oceanus Procellarum, the first sample return mission since Luna 24 in 1976. Based on various state-of-the-art instruments, CE-5 samples have been studied in detail, which expands our understanding of the evolution history of the Moon, especially the late lunar volcanism. Isotopic dating results indicate that CE-5 mare basalt represent the youngest basalt sample so far (about 2 billion years) [1, 2].

Mare basalts exhibits a wide range of titanium content, which also provides important criteria for the classification of basalts [3,4]. It is important to clarify the titanium content of CE-5 basalt, which will help to constrain the source composition and evolution trend of CE-5 basalt. Unfortunately, due to the small size of CE-5 basalt, it is difficult to directly measure its bulk compositions. So far, different groups obtained different results [2, 5-6], and the estimated bulk TiO_2 ranges from 3 to 14.3 wt% [7]. In this study, we investigated the mineral chemistry of two CE-5 lunar regolith breccias. The chemical compositions of pyroxene indicate that CE-5 basalt has a high-Ti origin.

Samples and Methods: The samples studied in this work are two lunar regolith breccias allocated by the China National Space Administration, CE5C0800YJYX136GP (136GP) and CE5C0800-YJYX143GP (143GP). The two samples were embedded in epoxy resin and well-polished.

Quantitative analysis of major elements composition of pyroxene was conducted with a JEOL Electron Probe Microanalyzer (EPMA) at Shandong University. The acceleration voltage is 15kV and the beam current is 20 nA. For pyroxene analysis, the electron beam is 1-5 μm in diameter.

Results and Discussion: The pyroxene in CE5C0800YJYX136GP (136GP) and CE5C0800-YJYX143GP (143GP) exhibits a wide composition range (En_{0-62}, Fs_{20-89}, Wo_{4-44}), but generally iron-rich (Fig. 1). The pyroxene in the two breccias is chemically similar to the pyroxene in CE-5 basalt clasts [2, 5] in terms of composition range and chemical evolution trend. This indicates that these two breccias are mainly composed of local mare basalt at the CE-5 landing site. Although remote sensing investigations indicated the presence of ejecta deposits from impact craters in vicinity of the CE-5 landing site [8, 9], laboratory sample studies demonstrated that local mare basalt dominates the materials in CE-5 soil and the proportion of exotic material is very low [10].

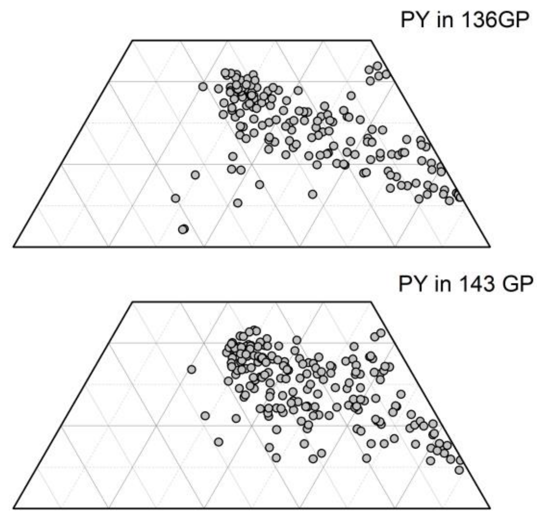

Figure 1: Pyroxene composition of CE-5 sample 136GP and 143GP.

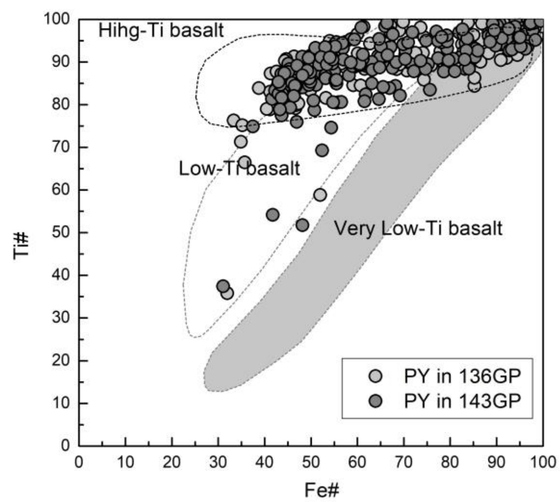

Figure 2: Fe# versus Ti# of pyroxene in CE-5 sample 136GP and 143GP. Fields of very low-Ti, low-Ti, and high-Ti basalt are from [4, 11].

Fe# and Ti# plots of pyroxene is a commonly used method to estimate the bulk titanium content of basalt clasts in meteorite research. In this study, we calculated the Fe# and Ti# values of CE-5 pyroxenes and estimated the bulk titanium content of CE-5 basalt (assuming that these pyroxenes were from basalt). Fig. 2 shows that most pyroxene falls in the high-Ti range. This suggests that the CE-5 basalt may be classified as high-Ti mare basalt. A small fraction of the pyroxene that falls in the low-Ti range may come from exotic material.

The Ti/Al ratio of pyroxene can also be used to indicate the trends of magma crystallization. In this study, the Ti/Al ratio of pyroxene in 136/143GP was compared with the Apollo/Luna high-Ti/low-Ti basalt pyroxene. The Ti/Al ratio of 136/143GP pyroxene falls at the trend line of 0.5, consistent with the high-Ti basalts (Fig. 3). This again confirms that CE-5 basalt is high-Ti basalt.

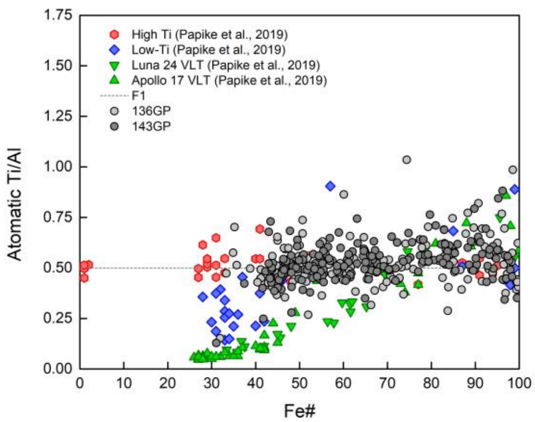

Figure 3: Ti/Al ratio with increasing Fe# of pyroxene in Apollo/Luna basalt and CE-5 sample 136/143 GP. Apollo/Luna basalt pyroxene are from [12].

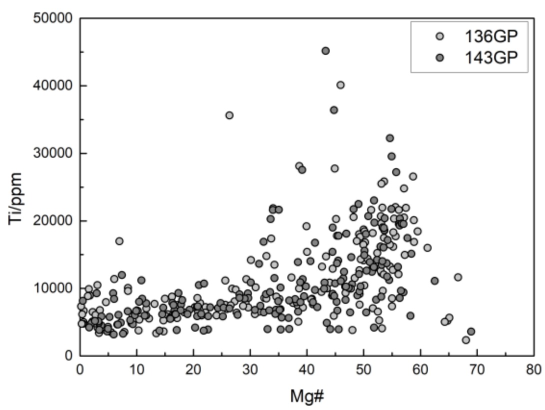

Figure 4: Ti versus Mg# plots of pyroxene in CE-5 sample 136GP and 143GP.

The change of Ti content of pyroxene with the decrease of Mg# indicates that CE-5 basalt has a high Ti origin. The crystallization time of ilmenite depends on the titanium content of the parent magma. In high-Ti magma, ilmenite can crystallize at an early stage [7, 13]. In contrast, low-Ti magma needs to undergo a period of evolution to saturate ilmenite [7, 13]. The crystallization of ilmenite will significantly reduce the titanium content in magma, which can be reflected in the composition of other minerals. Since ilmenite begins to crystallize at an early stage, the titanium content in high-Ti magma will continue to decrease. For pyroxene in 136/143GP, we found that the titanium content first decreases with the decrease of Mg#, and then is basically constant (Fig. 4). This indicates that pyroxene and ilmenite co-crystallized in the early stage, and ilmenite no longer crystallized when Mg# was less than 30 with the continuous magmatic evolution. This is consistent with the high-Ti origin of CE-5 basalt.

Conclusion: Due to the small size of CE-5 basalt, it is difficult to directly determine the bulk titanium content. Therefore, bulk titanium content of CE-5 basalt as well as its classification is still controversial. In this study, we found that the Fe# vs Ti# and Fe# vs Ti/Al plots of pyroxene in 136GP/143GP are consistent with Apollo high-Ti basalt. In addition, with the decrease of Mg#, the titanium content in pyroxene first decreases, and then basically remains unchanged, which seems to confirm its high-Ti origin.

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