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Compositions and possible sources of lunar meteorite NWA 4884

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1 Introduction

Lunar mare basalts represent the products of partial remelting of deep mantle sources and provide windows into the compositions of lunar interior. Nine Apollo and Luna missions returned large amounts of mare basaltic samples, while remote sensing suggests that sampled basalts may cover only a small number of the lunar basalt types and there is still no samples confirmed to originate from the lunar farside maria (Jolliff et al., 2006). Since basaltic lunar meteorites sampled from random locations on the lunar surface, they are likely to be launched from unexplored mare regions on the Moon. Determining their source regions and studying the composition and chronology of the sampled lava flow will contribute to our understanding of the magmatic evolution and thermal history in the lunar mantle. This work utilizes chemical information of lunar meteorite NWA 4884 (Korotev et al., 2009) and spectroscopic compositional data of basalt units (Lawrence et al., 2002; Lucey et al., 2000), to derive the potential source regions of NWA 4884.

2 Compositions and possible sources of NWA 4884

NWA 4884 is a lunar regolith breccia composed of feldspathic lithology and very low titanium (VLT) mare basalt clasts. The little KREEP (K-potassium, REE-rare earth elements, P-phosphorus) content of NWA 4884 suggests a source region distant from the Procellarum KREEP Terrane where mare basalt mixed with feldspathic regolith (Korotev et al., 2009). Regolith samples as the uniform mixtures produced by continuous impacts, would be able to compare with chemical maps with a spatial resolution of ~km obtained from remote sensing data (Gillis et al., 2004).

Combine the low Th (~0.93±0.06 ppm) and intermediate FeO (13.72±0.5 wt.%) concentrations of NWA 4884 with lunar Th and FeO maps derived by Clementine (Lucey et al., 2000) and Lunar Prospector (LP, Lawrence et al., 2002) mission data as well as the maria extents from Lunar Reconnaissance Orbiter Camera (LROC) images (Nelson et al., 2014), We evaluate that two most likely source regions are the southern Lacus Veris (SLV, 20.5°S, 84.5°W) within Orientale basin and the western mare unit (45.3°N, 151.3°E) of Campbell crater (Fig. 1). The model ages for mare basalt units of these two regions are 3.5 Ga (SLV, Greeley et al., 1993) and 2.72 Ga (Campbell, Morota et al., 2011), respectively. The mare basalts in these two regions are obscured by ray systems emitted from the adjacent fresh craters, which could be the source of highland materials in NWA 4884.

The TiO_2 contents of mare basalts in the two possible source regions are 0.1~4.0 wt.% and 0.1~2.6 wt.% (Lucey et al., 2000), respectively, mostly falling within the TiO_2 range of low Ti and VLT mare basalts (Giguere et al., 2000), and consistent with the composition of basalt clasts in NWA 4884. The Mg numbers (Mg’) of two candidates (SLV, 55.0 and Campbell, 57.9) derived from Chang’e-1 Imaging Interferometer are also similar to the NWA 4884 (53.8). Furthermore, lunar CaO and Al_2O_3 distributions from Kaguya and LP gamma ray spectrometers (GRS) data (Prettyman et al., 2006; Yamashita et al., 2012) can be used to verify the chemical correlations between the two candidates and NWA 4884. The Kaguya GRS CaO content of mare unit within Campbell crater is 13.6 wt.%, closer to the values of NWA 4884 (13.9±0.3 wt.%) than SLV (16.9 wt.%), while LP GRS Al_2O_3 contents of two candidates (SLV, 17.5 wt.% and Campbell, 16.6 wt.%) both meet the case as the source region of NWA 4884 (17.0 wt.%).

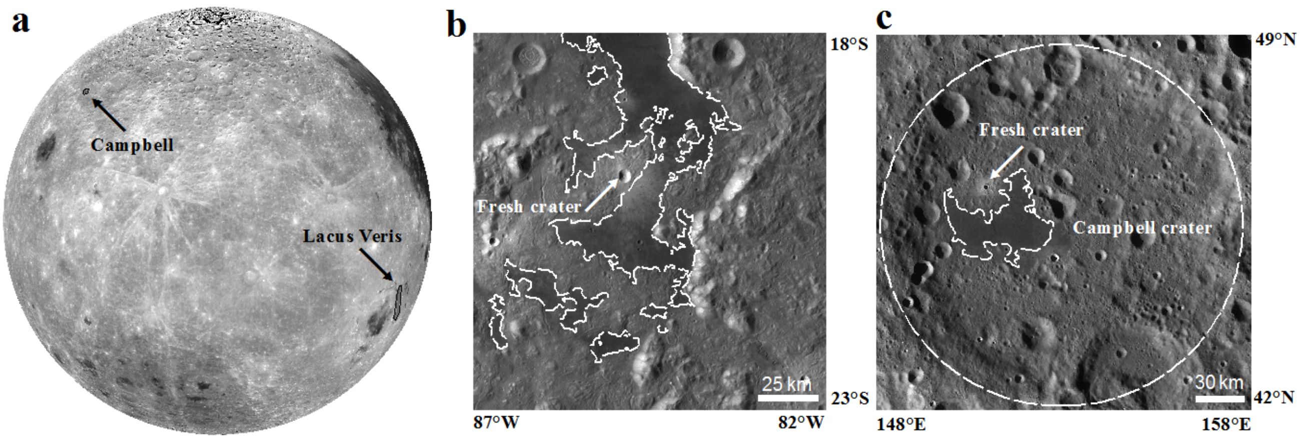

Fig. 1. Lunar images of possible source regions of NWA 4884.
(a), Chang'e-1 CCD image showing the locations of the Lacus Veris and the Campbell regions;
(b), LROC WAC (Wide Angel Camera) image (https://astrogeology.usgs.gov/tools/map-a-planet-2) of southern Lacus Veris;
(c), LROC WAC image of western mare unit within Campbell crater.

3 Future Work

We will examine the mineral modes and mineral chemistries within NWA 4884 section with Renishaw inVia® plus Raman Microscope in Shandong University, Weihai, and combine with the elemental spatial distributions and mineral abundances of those two candidates through lunar remote spectroscopic analysis to better constrain the source crater of NWA 4884.

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