INFRARED SPECTROSCOPIC CHARACTERISTICS OF ZIRCON IN LUNAR METEORITES NORTHWEST AFRICA 2995 AND 4485

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Introduction: Zircon is commonly used when investigating the geochronology of the Moon, because it can provide both U-Pb and Pb/Pb isotopic dates, and is resistant to isotopic resetting up to fairly high temperatures. However, it is not impervious in all environments, especially at extreme pressure and temperature conditions, and when its crystalline structure has been damaged by radioactive decay of radionuclides like U and Th [1-6]. Extreme impact shock pressure can cause metamorphism and affect the mineral structure to transform zircon into its high-pressure polymorph reidite [3]. Both radiation damage and high-T metamorphism could thus result in metamictization and amorphization of zircon [4-6]. These processes can be accompanied by diffusion of Pb and result in discordant U-Pb dates [1-7]. Identifying these processes and constraining the extent to which they affected studied samples are essential for accurately interpreting U-Pb and Pb/Pb isotopic data and derive accurate ages for lunar sample [7].

Methods: Infrared spectroscopic analysis is a useful method to investigate the effects of radiation damage and high shock pressure on zircon [3,5]. To elucidate their provenance and provide context for interpreting measured U-Pb dates, we have investigated infrared spectra features of zircon from lunar meteorites Northwest Africa (NWA) 4485 and NWA 2995. Fourier-transform infrared spectroscopy (FTIR) analysis was carried out on polished sections of NWA 2995, NWA 4485, and a set of terrestrial crystalline zircon standards with a Perkin-Elmer Spotlight-400 instrument. Mid-infrared reflectance spectra were collected between 4000 cm^{-1} to 650 cm^{-1} (~2.5 μm to 15.4 μm) at 4 cm^{-1} spectral resolution, with an instrument aperture size of 25 × 25 μm.

Results: *FTIR features of terrestrial zircon standards.* We analyzed four different zircon standards (91500, Penglai, Qinghu and Mud Tank) for comparison with lunar samples. Two main spectral types were obtained: type 1 displays a broad peak from 900-1015 cm^{-1}, and a smaller peak at ~1100 cm^{-1}; type 2 displays a main peak band at 995-1015 cm^{-1}, and two smaller peak bands at 900-925 $cm^{-1}$and 1050-1080 cm^{-1} (Fig. 1). These features are consistent with the 'untreated' zircon results in [3,5]. All analyses of standard 91500 (2 large grains) are of type 1, while the other three standards (many small separate grains) all show types 1 and 2 features, with a few grains showing intermediate features, which we interpret as reflecting different crystal orientations.

The shift of the Christiansen Feature (CF) position. The CF position (point of lowest reflectance [8]) of the zircon standards has a small range of variation between 1120 cm^{-1}-1160 cm^{-1}. The CF positions obtained in lunar zircon grains show a much wider range from ~1100 cm^{-1} to 1260 cm^{-1}. Additionally, the CF position seems to be related to variations of the intensity of two peaks at 928 cm^{-1} and 1080 cm^{-1}, shifting towards higher wavenumbers when the 928 cm^{-1} peak intensity decreases.

Metamorphism effects. Lunar zircon grains have different spectral profiles compared to the terrestrial standards. The intensity of the 928 cm^{-1} and 1080 cm^{-1} peaks can vary widely within a single zircon grain and between different zircon grains. For example, Figure 1 shows that for grain 1, an increase of the 1080 cm^{-1} peak intensity is related to a decrease of the 928 cm^{-1} peak intensity from CL-active area to CL-inactive area (both are identified as amorphous phases in Raman spectra), which likely implies different degrees of metamictization. The FTIR profile for grain 2 is different to those for grain 1, but consistent with that of type 2 terrestrial zircon standards (Fig. 1), This may indicate that grain 2 suffered lower shock pressure than grain 1, which is also consistent with Raman data.

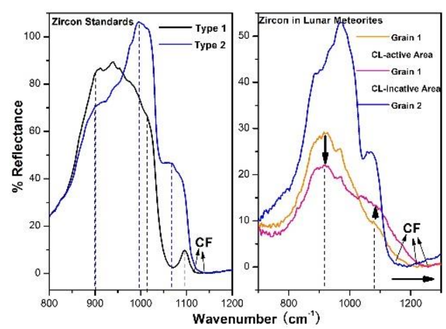

Figure 1: FTIR spectra of terrestrial zircon standards (left) and in lunar meteorite NWA 4485 and 2995 (right).

In summary, zircon grains in NWA 2995 and 4485 show that shock-induced metamorphism and metamictization result in different FTIR spectra characteristics, and that intensities and shapes of peaks at 928 cm^{-1} and 1080 cm^{-1} are good indicators for different degrees of metamictization in both terrestrial [3] and lunar zircon.

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