Observations of Titanium, Aluminum and Magnesium in the Lunar Exosphere by LADEE UVS. A. Colaprete[1], D. Wooden[1], A. Cook[1], M. Shirley[1], M. Sarantos[2,3], [1]NASA Ames Research Center, Moffett Field, CA 94035 USA, [2]University of Maryland Baltimore County, Baltimore, MD. [3]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD.

Introduction: The Lunar Atmosphere and Dust Environment Explorer (LADEE) was an orbital lunar science mission designed to address the goals of the 2003 National Research Council decadal survey, the Lunar Exploration Analysis Group Roadmap, and the "Scientific Context for Exploration of the Moon" (SCEM) report, and has been recommended for execution by the 2011 Planetary Missions Decadal Survey. The LADEE mission goal was to determine the composition of the lunar atmosphere and investigate the processes that control its distribution and variability, including sources, sinks, and surface interactions. It will monitor variations in known gasses, such as sodium, potassium, argon and helium, and will search for other, as-yet-undetected gasses of both lunar and extra-lunar origin. Anotherr goal of LADEE was to determine whether dust is present in the lunar exosphere, and reveal the processes that contribute to its sources and variability.

The Ultraviolet-Visible Spectrometer (UVS): One of three science instruments on LADEE, the Ultraviolet and Visible Spectrometer (UVS) was designed to make observations of the lunar exosphere and search for dust. UVS consists of a CCD spectrograph and two fore-optics: a three-inch telescope and a solar viewing optic. Both fore-optics are fed to the spectrometers via optical fibers [1].

UVS deployed its limb-viewing telescope door on October 17 and began a series commissioning activities, including pointing, wavelength and preliminary radiometric calibrations. UVS made limb observations between October 23, 2013 and April 17, 2014. UVS routinely monitoring two previously measured atmospheric species, potassium and sodium, and also searched for other, previously-sought species including OH, H_2O, Si, Al, Mg, Ca, Ti, and Fe. UVS was also able to detect the scattered light from lofted dust between the altitudes of a few km up to 50 km using its limb telescope, as well as search for dust very near the surface using solar occultation measurements. The UVS instrument operates between 230 – 810 nm with a spectral resolution of <1 nm.

Observations: UVS had two means of observing: a "Limb Telescope" and a "Solar Occultation Viewer". Limb observations, using the UVS three-inch telescope, were made on a routine basis, with limb "stares" at 20 km at the terminators, and 40 km at around local noon time. For the first half of the mission the spacecraft nodded the telescope the terminators between the surface and about 50 km. At noon it was found that near-surface scatter precluded observations below about 30 km, so nods are not performed then. There

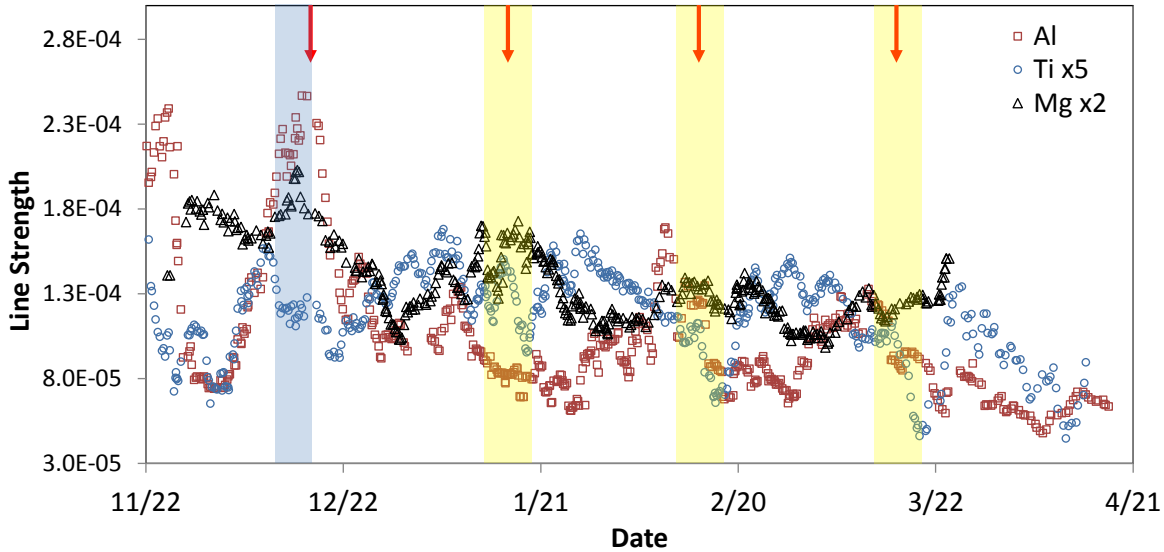

Figure 1. Observations of limb "noon" (Solar Longitude between 165-185) Al, Ti and Mg emission line strengths. The position of full Moon (red arrows) and approximate span of the magnetotail (yellow shading) is shown. Blue shading represents the approximate width of the Geminids meteoroid shower.

were a mix of both "backward" looks (stares that point in the anti-velocity direction of the spacecraft), and "forward" looks (which flip the spacecraft to allow UVS to look in the velocity direction). This permits observations both in and away from the direction of the sun.

Sodium and potassium were regularly measured in all activities, except for occultations. Trends in these measurements are made both spatially and temporally, and associations are with specific events, such as meteor streams, and surface composition has been reported [2].

Presented here are preliminary observations of aluminum, titanium and magnesium acquired during limb "noon" time observations. In the ultraviolet surface scatter was sufficiently small that emission liens for these species could be retrieved. Line strengths for each species were retrieved in a similar fashion as was used to retrieve sodium and potassium [2]. These observations represent the first measure of these species in the lunar exosphere. Continued work to correct for velocity effects on line strength is required, so these results are only preliminary. However, clear cycling with lunations is evident, with peaks in Ti and Mg occurring near full Moon. Al appears to have a cycle that is approximately 180 degrees out of phase with Ti and Al, consistent with the variation of Al in surface soils, which are a minimum on the near side, as opposed to Ti having larger soil concentrations on the near side. These results will be described and compared to sodium and potassium observations, and their implication for understanding how the surface composition and various release processes (e.g., meteoroid impacts and sputtering) influence the lunar exosphere composition.

References: [1] Colaprete et al., *PSS*, 2014. [2], Colaprete et al., *Science*, 2016.