AN UNUSUAL PHOTOMETRIC SIGNATURE DETECTED ON LUNAR COMPLEX CRATER RIMS AT THE SOUTH POLE, F. Vilas¹, E. A. Jensen², D. L. Domingue³, L. A. McFadden⁴, and C. R. Coombs⁵. ¹Johnson Space Center, ²Texas A & M University, ³Applied Physics Laboratory, ⁴University of Maryland, ⁵College of Charleston.

Introduction
Signals observed within 5° latitude of the lunar south pole by Clementine’s bi-static radar experiment show characteristics suggestive of trapped water ice within the 16,000 km² permanently shadowed region of the south pole [1]. Subsequent radar observations of these same regions performed at Arecibo [2] do not support the Clementine findings. Theoretical calculations [3] show that water ice can be stably trapped in permanently shadowed regions of the moon from 76.5° latitude poleward. If water ice is actually present in these permanently shadowed regions, then its proximity to the lunar rocks implies that aqueous alteration processes (the alteration of materials by the interaction with liquid water) may operate near the lunar poles. The detection of aqueous alteration products in the polar regions of the moon would provide supporting evidence for the presence of water for a sufficient period of time necessary to affect compositional changes in the rocks at the lunar poles.

Phyllosilicates, products of aqueous alteration, are indicative of adsorbed and interlayer water in rock. The most definitive spectral evidence for phyllosilicates is the detection of the strong 3.0µm bound water feature, however, other spectral indicators of phyllosilicates are the water overtone absorptions at 1.4µm, 1.9µm, and 2.3µm in the near infrared wavelength region and a 0.7µm oxidized iron band which is only observed in hydrated minerals. Ground-based telescopic observations of these spectral signatures near the lunar poles is not feasible, due to the orientation of the Earth-based observer with the lunar polar regions, and to the absorption of telluric water in the Earth’s atmosphere affecting the identification of these spectral features. Spacecraft observations are required.

Methods
The broadband filters placed on board the Clementine spacecraft (which orbited the moon) were not optimized for the identification of phyllosilicates. The Galileo spacecraft (which flew-by the moon twice, first passing over the southern pole and next passing over the northern pole), however, contained instrumentation capable of acquiring the relevant spectral measurements. The Near Infrared Mapping Spectrometer (NIMS) was activated for both flybys. The data from the first fly-by were inadequate for addressing the detection of phyllosilicates [4], and the NIMS data from the north pole flyby detected no evidence for phyllosilicates near that pole [5].

We searched for evidence of the presence of phyllosilicates using images acquired by the Galileo Solid State Imager (SSI) instrument. We searched for the presence of spectral signatures in the visible and near-infrared spectral region of iron which are indicative of phyllosilicates (e.g., an absorption feature centered near 0.7µm due to an Fe²⁺ → Fe³⁺ charge transfer transition in oxidized iron which is present in phyllosilicates) and the absence of spectral signatures indicating minerals such as mafic silicates (e.g., the 0.9µm to 1.0µm absorption characteristic of pyroxenes and olivines).

An algorithm was designed based on knowledge of telescopic spectra of various classes of asteroids, which do and do not contain phyllosilicates, and on laboratory reflectance spectra of terrestrial phyllosilicates, to identify phyllosilicates based on the presence and intensity of the spectral differences between adjacent filters from the Galileo images.

Results
Images from the Galileo Lunmap 14 image suite [6] taken in the green (560nm), red (670nm), 756nm, and 889nm filters were locally co-registered for different regions on the lunar farside (data near the lunar limbs were excluded since the co-registration errors were much greater than a single pixel). Areas near both northern and southern poles, a large region near the equator including the Oriental basin, and a region from the Aitken basin were analyzed using our algorithm. Detection of the most positive photometric signature indicative of phyllosilicates was found in areas near the southern pole south of 65° latitude (many within the region calculated to support the existence of water ice) in locations associated with the rims of large (200 to 300 km diameter) craters. This signature is superposed on a slope similar to other lunar spectra.

To test the accuracy of these detections we also examined lunar telescopic observations and laboratory spectra using this algorithm. We simulated the Galileo image photometry used in our algorithm by convolving ground-based 24-filter photometry measurements [7] (taken from 0.3µm to 1.1µm of 740 individual lunar sites of 5-20km size diameter) with the Galileo image filter passbands. We ran the resulting photometric measurements through our algorithm to support the existence of water ice) in locations associated with the rings of large (200 to 300 km diameter) craters. This signature is superposed on a slope similar to other lunar spectra.

This is a work in progress, with additional testing of the uniqueness of this signature needed to conclude this study.

References