REGIONAL PYROCLASTIC DEPOSITS IN THE NORTH-CENTRAL PORTION OF THE LUNAR NEARSIDES. Cassandra R. Coombs¹, B. Ray Hawke², C.A. Peterson², and S.H. Zisk², ¹SN15 NASA Johnson Space Center, Houston, TX, 77058, ²Planetary Geosciences Division, Hawaii Institute of Geophysics, Honolulu, HI 96822.

INTRODUCTION
Now that the U.S. is considering the establishment of a lunar outpost and appears to be entering a new era of space exploration and development, the need to investigate lunar resources has increased dramatically. Not only are resources needed to sustain life in the reduced gravity and atmosphereless environment of the lunar surface, but they are needed for export to sustain operations in low-Earth orbit and elsewhere in near-Earth space¹. One lunar product with a potentially large market yet requiring minimal processing is liquid oxygen for spacecraft propellant. It has been suggested that ilmenite-rich material would be a good source of oxygen for use as propellant and life support and could provide Fe and Ti for space construction¹? To date, most efforts to locate ilmenite-rich deposits have focused on the high-titanium mare basalts present on the lunar nearside³,⁴,⁵. However, we have recently suggested that ilmenite-rich regional pyroclastic deposits would make an excellent source for certain materials². These extensive, unconsolidated, and relatively thick volcanic deposits would provide many useful byproducts and may prove to be excellent sites for the establishment of permanent lunar bases². The purpose of this paper is to present the results of recent spectral and radar studies of ilmenite-rich regional pyroclastic deposits.

METHOD
A variety of spacecraft and Earth-based photography was utilized for geologic studies of ilmenite-rich regional pyroclastic deposits in the north-central portion of the lunar nearside. Some spectral information was obtained from the multispectral images presented by McCord et al.⁶. Both near-infrared (0.6-2.5μm) and UV-VIS (0.35-1.1μm) reflectance spectra were obtained for small portions of selected regional pyroclastic deposits using the Planetary Geosciences Division spectrometers at the University of Hawaii 2.2-m telescope facility on Mauna Kea, Hawaii. In addition, radar data (3.8-cm) collected by Zisk et al.⁷ were analyzed during the course of this study. In order to better characterize the surface properties of the regional pyroclastics, new, high-resolution 3.0-cm radar data were collected at the Haystack Observatory. For this study, the raw data were averaged in 4 X 4 pixel groups to form 16-look images with a spatial resolution of ~120m.

DISCUSSION
An important objective of the Apollo 17 mission was to sample the "dark mantle" deposit at Taurus-Littrow; premission analysis indicated that this deposit might be of pyroclastic origin⁸. Orange glass droplets and partially crystallized black spheres from the Apollo 17 landing site were subsequently identified as pyroclastic components in the deposit⁹. The chemical compositions of the orange and black spheres are indistinguishable, the only difference being that the black spheres are largely crystallized. The black spheres consist of very fine intergrowths of ilmenite and olivine, with olivine commonly occurring as euhedral crystals within the spheres. The Apollo 17 black spheres are rich in TiO₂ (9-10%) and ilmenite, and they are similar, though not identical, in composition to the Apollo 17 high-Ti mare basalts.

Although the orange and black pyroclastic spheres are not abundant at the Apollo 17 site, there is a major regional pyroclastic deposit (Taurus-Littrow) west of the site. A comparison of reflectance spectra obtained for the Taurus-Littrow deposit with laboratory reflectance
measurements has demonstrated that Apollo 17 black spheres are the characteristic ingredients of the Taurus-Littrow pyroclastic mantling deposits\textsuperscript{8,10,11,12}. The Taurus-Littrow mantling deposit has an areal extent of >4000 km$^2$ and a thickness of many tens of meters. The Taurus-Littrow deposit exhibits very weak to nonexistent echoes on the depolarized 3.8-cm radar maps of Zisk et al.\textsuperscript{7}. These low depolarized returns are thought to be due to the lack of scatterers (1-50 cm) on the smooth surface of the pyroclastic mantling deposit. A very low degree of small-scale surface roughness and a relatively block-free surface are indicated.

Several other major occurrences of regional pyroclastic mantling deposits have been documented\textsuperscript{8,13} including those at the following locations: Rima Bode, Aristarchus Plateau, Sulpicius Gallus, Mare Humorum, Southern Sinus Aestuum, and Southern Mare Vaporum. These units have been characterized as extensive deposits of low albedo (0.079-0.096) material which appear to subdue or mantle underlying terrain. Low returns on Earth-based 3.8-cm depolarized radar backscatter maps confirm these observations of mantled areas indicating an absence of surface scatterers in the 1 to 50-cm size range.

Spectral studies have demonstrated that several of the regional dark mantling deposits are composed of high-titanium, ilmenite-rich black spheres of pyroclastic origin\textsuperscript{2,8,10}. These include the following deposits: 1) Taurus-Littrow, 2) Rima Bode, 3) Southern Mare Vaporum, and 4) Southern Sinus Aestuum. These correspond to the lunar "black spots" described by Pieters et al.\textsuperscript{10}. Analysis of recently obtained near-IR spectra of the Southern Mare Vaporum and Southern Sinus Aestuum fully confirm the previous interpretations based on UV-VIS spectra. The new near-IR spectra show that the surfaces of these regional deposits have a strikingly uniform composition. There appears to have been very little contamination of these surfaces by non-pyroclastic material emplaced by vertical mixing and/or lateral transport. This interpretation is also supported by two new UV-VIS spectra collected for separate portions of the Southern Sinus Aestuum dark mantle deposit.

Two UV-VIS spectra were also obtained for the dark mantle deposit on the west flank of Gambart crater. This deposit appears to contain a major component of ilmenite-rich black spheres. However, the surface of the Gambart deposit is contaminated with variable amounts of highlands debris.

Finally, we have obtained 3.0-cm radar data for a portion of the Rima Bode dark mantle deposit. This data has an order-of-magnitude better spatial resolution than the data presented by Zisk et al.\textsuperscript{7} (120 m vs. 1 km). The new high-resolution depolarized radar images indicate that the Rima Bode deposit is deficient in surface scatterers in the 1-50cm size range. The near-surface area of this deposit is also deficient in fragments and blocks and is apparently composed of loose, unwelded particles.

REFERENCES