USE OF AIRCRAFT MULTISPECTRAL AND MULTIPLE EMISSION ANGLE DATA TO DETERMINE SURFACE ROUGHNESS AND COMPOSITION AT THE LUNAR LAKE PLAYA IN NEVADA; Edward A. Guinness, Raymond E. Arvidson, McDonnell Center for the Space Sciences, Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri, 63130; and James R. Irons, Biospheric Sciences Branch, David J. Harding, Geophysics Branch, both at Goddard Space Flight Center, Greenbelt, Maryland, 20771.

The Geologic Remote Sensing Field Experiment (GRSFE) was conducted in July and September 1989 to collect data with advanced aircraft instrumentation [1]. One of the main objectives of GRSFE was to acquire both aircraft and ground data needed to test models for determining quantitative surface property information from remotely acquired data, including data to be acquired during the Magellan and Mars Observer missions and existing Viking data. The intent of this abstract is to report preliminary results from analyses of Advanced Solid-State Array Spectroradiometer (ASAS) [2] data to determine surface roughness and composition. The ASAS instrument is designed to collect multispectral and multiple emission angle images of a given ground target with ground resolutions of a few meters. The instrument has 29 spectral bands that cover the wavelengths of 0.465 to 0.87 micrometers. ASAS can also be rotated during data collection to view a scene at seven different geometries ranging $\pm$ 45° from nadir in 15° increments.

ASAS data were acquired over the Lunar Crater Volcanic Field in Nevada [3]. This is one of the primary GRSFE locations and is about 250 km northwest of Las Vegas. The area has numerous cinder cones, fissures, lava flows, and several maars. In addition to volcanic features, the location contains the Lunar Lake playa, where three detailed modeling surfaces were established for GRSFE. One modeling surface, which is referred to as the cobble surface, consists of basalt fragments with sizes ranging from about a centimeter to several tens of centimeters sitting on a bright silty playa surface. The site also contains several meter size bushes. A second surface, called the smooth playa, consists of a clay-rich playa surface with mud cracks and some centimeter size basalt pebbles. The third surface, called the rough playa, was disturbed and roughened by driving an automobile across the playa surface using a "brody" technique. The rough playa site displayed a range of surface textures such as loose silt and clay powder, clods of playa sediment that were several centimeters in size, and undisturbed playa surface.

ASAS data over the Lunar Crater Volcanic Field were acquired at three different times on July 17, 1989. Flight lines were oriented parallel and perpendicular to the principal plane of the Sun in order to provide a large variety of phase angles. Thus far, one morning scene with the flight line along the principal plane has been analyzed. The incidence angle of the Sun is about 65°. The range in phase angles is 20° to 110°. At these phase angles the contribution due to an opposition effect should be minimal, whereas the contribution due to surface roughness should be significant [4]. In addition to the aircraft data over Lunar Lake, the spectral reflectance of the sites was measured with a Daedalus AA440 field spectrometer, and the optical depth of the atmosphere was measured with a sun photometer at the same time as the ASAS overflight.

Reflectance data for the three modeling surfaces were extracted from ASAS images at the seven different viewing angles. The reflectance data for the band centered at 0.693 μm were then modeled with the Hapke photometric function [4, 5, 6] to determine differences in the macroscopic roughness of the surfaces. In this preliminary analysis, no correction was made to the ASAS data for atmospheric scattering since the measured optical depth was about 0.1. and the difference between the ground reflectance and the ASAS reflectance from the nadir view of the rough playa site was less than 10%. Additional attenuation through the atmosphere at 45° emission angle would be only a few percent greater than for the nadir view.

The modeling results show that the three surfaces can be distinguished by their roughness characteristics. In addition, there is a correlation between the scale of roughness elements and the magnitude of the Hapke roughness parameter for the rough playa and the cobble surfaces. Reflectance data for the smooth playa surface were modeled with a macroscopic roughness angle of less than 1°, which is consistent with the smooth nature of the surface that exhibits only shallow mud cracks and a few centimeter size rock fragments. In addition, data for the smooth playa surface show a specular reflectance component at phase angles greater than 65°. Roughness elements on the rough playa surface consist of fine powder and centimeter scale sediment clods. The reflectance data for the rough playa surface were best modeled with an intermediate roughness angle of about 15°. The cobble surface had the largest roughness elements, consisting of rock fragments up to several tens of centimeters in size and several meter size bushes. Reflectance data for the cobble surface were modeled with a roughness angle of about 40°.

ASAS data can be used with ground reflectance data to evaluate the relative importance of spectral endmembers in the composite ASAS spectrum. Preliminary analysis indicates that mixing between playa sediment and basalt fragments is important at the several meter scale that ASAS samples. For example, ASAS reflectance values for the smooth playa site are about 20% lower than ground measurements, most likely due to contributions in the ASAS data from dark basalt fragments and mud crack shadows. ASAS reflectance data for the cobble surface are about 40% brighter than the ground reflectance data for individual basalt fragments. Using the ground reflectance measurements of basalt and playa sediment as endmembers yields a mixture of 85-90% basalt and 10-15% playa for the cobble surface. The observed abundance of basalt fragments at the cobble site ranged from 25% to 85%. The somewhat higher value of basalt estimated from ASAS data is most likely because the simple two component model does not account for shadows cast by rock fragments. which should be important for the large incidence angle of the ASAS data.

Future work will include: A) analysis of ASAS scenes at several incidence angles, including small incidence and phase angles, and all 29 ASAS bands; B) explicit modeling of the atmospheric contribution; and C) considering additional endmembers, such as shadows and vegetation, in mixing models. The intent will be to separate textural information from compositional information for the various surfaces.

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