POTASSIUM AND SODIUM ABUNDANCES ON THE LUNAR SURFACE: IMPLICATIONS FOR ATMOSPHERIC COMPOSITION; P.E. Clark (CUA), and William Smyth (AER)

A lunar potassium abundance map with a resolution of approximately 100 km was derived from the Apollo GRS experiment (1,2). To the first order, potassium has a unimodal distribution on the lunar surface (3). The primary high in K is centered around 5 to 10 degrees west longitude north and south of the equator, and covers approximately a quarter of the western nearside. Modest increases in potassium are associated with the maria. K values range from 4000 ppm in this area to as low as 500 ppm in farside highlands, decreasing by an order of magnitude. Potassium values of up to 10000 ppm have been found in lunar rocks (1,2,3,4). No maps of sodium abundance are available; however, lunar Na abundances and the relationship of sodium to other elements have been determined from studies of lunar rocks (4).

Na and K show a clearly different distribution (4). The potassium cation is too large to be easily accommodated in the crystal lattice during rock formation, and thus is primarily found with rocks formed late in crystallization, in potassium feldspar formed in the residual melt; thus, high potassium abundances are found in Fra Mauro basalt (4). The Na cation is smaller, and is continuously accommodated in the crystal lattice throughout the rock formation process, where Na and Al substitute for Ca, in plagioclase feldspar (4). Na shows no clear trend of correlation with Al, Ca, Fe, or any other element, so no Na map can be derived on the basis of association with these mapped elements. Na distribution is not markedly different in highland and mare rocks, both of which contain plagioclase feldspar. Na generally ranges from 2000 to 3000 ppm, but can increase to 5000 ppm, a factor of two, in residual melt rocks which are rich in feldspars, such as KREEP (4). Thus, lunar soils, averages of major rock types, could be expected to show less than a factor of two variation in Na overall, with very subdued increases in the western nearside.

A series of more recent observations (5,6,7,8) of the lunar sodium atmosphere have shown spatial intensity variations in the atmosphere. These observations, acquired by ground-based detection of the solar resonance scattered D-line emission brightnesses of this gas, are line-of-sight measurements and are obtained above the bright lunar limb. For observations above the luminance equator for different lunar phase angles, a factor of ~10 less emission intensity is measured (5) above the limb at Full Moon (sub-solar point near the center of the lunar disk) than at first or last quarter (sub-solar point on the limb). For observations made at a given lunar phase angle near last quarter, an approximate order of magnitude decrease in the emission is also observed (7) from equator to pole. These effects of brightness variations are larger than can be readily explained by changing viewing geometry or by simple (cosine function) changes in a surface gas source for solar wind or photosputtering (5,7). The remaining effects could include surface abundance variations (source) as well as more
complex gas-surface interaction processes, such as spatially variations introduced by the surface temperature-dependent rates for atom energy-accomodation and atom sticking to the lunar surface (9).

In the case of sodium, overall surface abundance variations would be small, possibly 'in the noise' and easy to miss within the order of magnitude variation actually observed. If Na emission was measured from first to last quarter as a function of phase angle, then such emission would show enhancement by no more than a factor of two in Na due to compositional effects. Potassium, however, enhanced by an order of magnitude in half of the western nearside due to surface composition, would show an increase of a factor of about five, and this should be noticeable enough to be observed. Observations of K emission from the Moon could thus have major implications in understanding the brightness distribution of the lunar potassium atmosphere and hence in constraining the role of gas/surface interactions on the Moon and analogous bodies, such as Mercury and minor planets. Observational astronomers are strongly encouraged to do observations of lunar potassium emission.