PROPOSED LUNAR GEOTECHNICAL GIS. L. Croukamp[1], [1]University of Stellenbosch, Private Bag x1, Matieland, 7602, lcroukamp@sun.ac.za,

Introduction:

The Lunar Mapping and Modelling Project (LMMP), [1] is a NASA led initiative with the aim of creating a single, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar mapping and modelling products, tools and media. The Lunar Web Mapping Aplication, PDS and PIGWAD (USGS) are GIS systems following the principles advocated by the LMMP.

It is however ironic that there are many countries such as USA, Japan and Turkey who state the need for construction of lunar bases as part of their strategy but there seems to be limited research on geotechnical engineering [2] with very limited information on a geotechnical Lunar GIS.

A dedicated Lunar geotechnical GIS is proposed to support construction of a lunar base and determine least-cost paths to resources and experimental outstations. This GIS will rely heavily on data obtained from the various satellites circling the moon currently and those scheduled for launch in the next few years. Data will be analysed for various geotechnical and in-situ resource usage. [3]

Method and Results:

A vast amount of data was collected during the Apollo era and during the years that followed data was collected from laboratory experiments on lunar rock, soil and soil simulants. Many thick volumes of articles had been written based on research of the data and samples collected from the lunar surface during the Apollo era and from earth-based observations. [3][4]

Very few references however could be found on the use of GIS for lunar observation and or exploration. Interpretation of photographs taken of each landing site was done by hand and very few layers of information were overlayed to determine precise landing localities. [4][5]

Although a fair proportion of the experiments executed on the lunar surface were focused on the geotechnical information gathering, no reference to the use of GIS in geotechnical decision making for lunar exploration could be found in the literature.

The use of GIS in many everyday and geoscience fields is commonplace and range from site selection for geological exploration to the placement of a new franchise, utilities mapping in municipal areas and many more.

Similarly, GIS techniques had been researched and applied in earth-based geotechnical research and investigations. [6][7] The principle behind earth-based investigations is that areas with similar geology, topography, landform and climate result in the same geotechnical properties. A similar approach is proposed for the lunar geotechnical GIS.

The flexibility that modern GIS technology offers is ideal for use in geotechnical and other research, exploration and utilisation of the moon.

During the selection of a site for a permanent or temporary moon base a number of engineering properties of the soil and rock need to be assembled and analysed separately and collectively. A GIS is ideally suited for this kind of analyses. The GIS therefore becomes a decision making tool in the selection of the optimal site for a moon base. At the same time, the same set of information, combined with other important information layers, such as mineral composition, occurrence locality, volume and concentration, etc. can be analysed with the GIS to determine best possible mining sites, for In-situ Resource Utilisation (ISRU) [3] as well as determine least-cost paths to these resources around obstacles and impassable terrain. Scientifically important sites could be built in as a parameter during the calculation of such optimal paths.

The data required for such a GIS covers a wide range of scientific fields and the project will start by collecting currently available data and have the analogue data converted into digital format should it not be available already. New satellite missions currently circling the moon (Chandraan-1, Kayuga, LRO, etc) and future satellite missions planned for the next few years, will further contribute to the data and information required to populate the GIS.

Several data layers are envisaged for such a GIS, with the main data sets focussing on the physical properties (source), such as but not limited to:

- slope angle: (LOLA, LROC),

- slope aspect: (LOLA),
- geology: (USGS, LRO),
- excavatibility: (Apollo, MiniRF, Diviner),
- sun/shadow areas: (LROC),
- topography: (LOLA, LROC),
- surface roughness: (LOLA, Diviner),
- soil density: (Diviner, MiniRF),
- bearing capacity: (Diviner, Apollo, MiniRF),
- etc.

[8]

Other layers that will enhance the decision making aspect of the GIS will include:

- resource type,
- resource locality,
- resource abundance,
- etc.

Some information, such as bearing capacity and soil density, will be inferred from the interpretation of known geology and information gathered during the Apollo missions, as well as experiments done on lunar soil simulants. This will allow for the creation of a probability map, of certain geotechnical properties, that could influence site selection of a moon base or manoeuvre ability of rovers and manned craft.

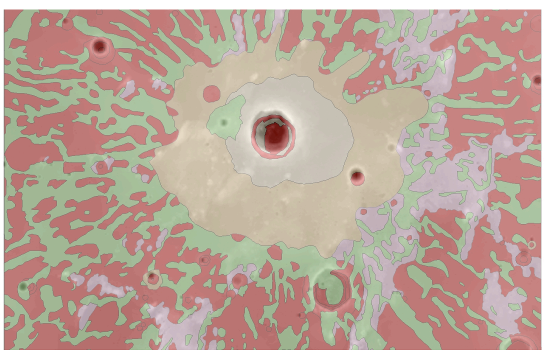

Figure 1. Simplified geological map of Kepler Region showing ray patterns as red/rough areas overlain on the DEM

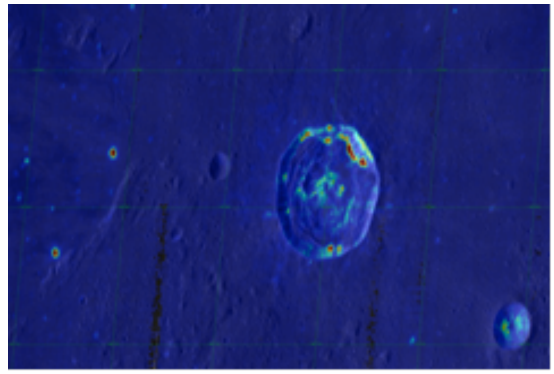

Figure 2. Rock abundance for Kepler region derived from Diviner data

Correlation between the various datasets need to be investigated to determine the correctness of assumptions made. In figure 1 there seems to be little correlation between elevation data and the areas mapped as rays, but good correlation between the mapped craters. Similarly, there is almost no correlation between rock abundance (figure 2) and the geology of the ray areas.

References:

[1] Cohen BA, et al, 2008; The Lunar and Mapping and Modelling Project (LMMP), Lunar and Planetary Science XXXIX, 2008. [2]Murat, M (2013); Importance of geotechnical engineering on development and sustainability of lunar bases, 6th Int. Confon Recent Advances in Space Technologies, RAST 2013. [3] B.L Joliff, et al (2006); New Views of the Moon, reviews in Mineralogy & Geochemistry, vol.60. [4] Heiken GH, Vaniman DT, French BM, (1991):;Lunar Sourcebook, A User's Guide to the Moon, ISBN 0-521-33444-6, Cambridge University Press. [5] T.M. Hare, et al, 2007; Lunar Geographic Information Systems (GIS) for Dataset synthesis and analysis, Workshop on Science Associated with the Lunar Exploration Architecture, Tempe, AZ, 2007. [6]Croukamp. L (1998): An engineering geological information system for land-use planning in South Africa: Results from the Pretoria-Johannesburg region, 8th IAEG Congress, 21 - 25 September 1998, Vancouver, Canada. [7] Croukamp L. (1996): Unpublished MSc thesis, A Geotechnical GIS for use by Engneering Geologists,.Univ. of Pretoria. [8] AGU (2012); results of the Lunar Reconnaissance Orbiter Mission, Reprinted form Journal of Geophysical Research.