Age Detection of Moon using Crater Counting Techniques

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Abstract

Moon being the nearest celestial body to earth, has been subjected to extensive exploration. Geological Mapping of Moon provides important clues to characterise the lunar surface in the context of its geological evolution and also to estimate the age of the moon. Direct evidences on the evolution and current state can be found from the Lunar Impact Craters as these are the most typical morphological units (Min Chen et al. 2017). The Moon Mineralogy Mapper onboard Chandrayaan-1; India's first unmanned mission to the moon provided information about the Lunar surface, did simultaneous selenological (selenology implies geology of moon), chemical and mineralogical mapping of the moon. The data is open for researchers to further explore lunar surface for various studies. As an addition to the already existing studies, in the current research an attempt has been made to estimate the age of a crater on lunar surface. The study area chosen is part of Wegener crater, which is an impact crater on the far side of the moon. It lies in between the equator and the northern hemisphere (the co-ordinates extending between 45.2°N and 113.3°W). The data used is High Spectral Data of Moon Mineralogy Mapper of Chandrayaan-1, which is available on **ISDA** (ISRO Science Data Achieve). The methodology involves two steps; statistical analysis of data and build model to estimate age and degradation of crater. Statistical analysis uses descriptive indices, (i.e. quantitative indices that describe and summarize the features for a particular collection of information and analyse the statistics, which are defined for both crater and sub-craters on the lunar surface) to calculate basic composition of crater like- crater rim, crater wall, crater floor, uplift, slope; basic geometry- surface diameter, transient diameter, max crater depth, impact crater depth; other indices- like volume, circularity, posture ratio, sphericity, depth-diameter ratio, number of peak rings in central peak, case diameter, central peak height, floor slope, floor roughness, slope of outer rim, slope of inner rim, average slope of rim, ejecta. These descriptive parameters provides clear understanding of geometric morphology of lunar craters. It provides basis for in-depth studies on physical structure, classification and evolution of lunar craters. As a crater analysis includes a vast range of disciplines, crater size frequency distribution was chosen as appropriate for the crater analysis. The descriptive indices defined above (quantitative indices) for crater and sub-craters are used to relate the degree of freshness of the crater. After the statistical work, identification of rocks/minerals was done and a statistical model is built. The minerals that form the rocks on the Wegner crater (as found from literature review) are studied and more common minerals were identified, their spectrum was generated and is compared with the available lunar spectral library. The rationale of mapping of the rocks/minerals present in the crater (study area), is an attempt to know the time from which the minerals are present since the crater formed. Crater counting is done within the ejecta deposits of each crater (mineral), by following Crater Counting Techniques using python based, an open source package-Crater Counting. Impact craters which superpose geologically homogeneous surface but are situated outside the reference area are also included in the evaluation i.e. the distance within which the crater counting is done constitutes a distance from center to the crater rim plus one crater radii beyond

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the crater rim, although we avoid counting near the rim of main crater because the slope of rim tends to be steepy which prevents mass wasting which causes crater to disappear quickly. Crater size frequency distribution requires data like area size, dia of crater. The crater counting techniques perform undistorted re-projection of each digitized impact crater and use undistorted crater dia as true measurement output. All the information like latitude, longitude, area etc is stored in point features. The modes by which the above information is calculated are: calculation of dia, axis length, polyline, ejecta extent and ejecta area. Procedure was carried out to estimate the age of the minerals present in the image of the crater, where the model used chronological function and square root function of two binnings. The saturation line displacement tells about degradation of crater and the result shows the degradation of crater in terms of degree of freshness of the crater. The relation between degree of freshness and absolute model age is derived and the age is calculated (in billion years) by estimating the time from which the minerals are present on the surface of the crater. The study observed the degree of freshness of Wegner crater to be 4.8 billion years. Thus the availability of open data and tool made it possible to estimate the age of lunar crater effectively.

(a) (b)

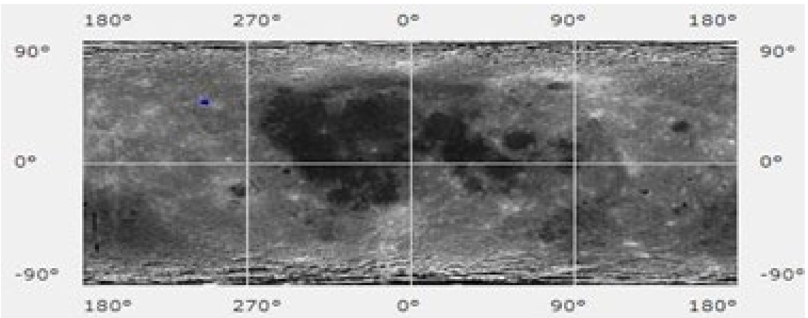

Fig. 1. (a)The blue dot in the above image is the location of Wegener Crater; (b) Wegener Crater

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Author/sBiography

Tarnpreet Singh Gill is a Masters student at Earthquake Engineering Research Center, IIIT-Hyderabad, India. He has pursued his Bachelor's in Civil Engineering at RIMT Institute of Engineering and Technology, Punjab. His Masters study is in Computer Aided Structural Engineering, where advances in structural engineering and computer science are used to make sure the structures serve their intended purpose for which they are built, which involves analysing the structure for design forces and finally proportioning the members.

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