THE LUNAR GEOPHYSICAL PACKAGE (LGP): A "SUITCASE SCIENCE" APPROACH TO BUILDING A LONG-LIVED, HUMAN-DEPLOYED, LUNAR NETWORK

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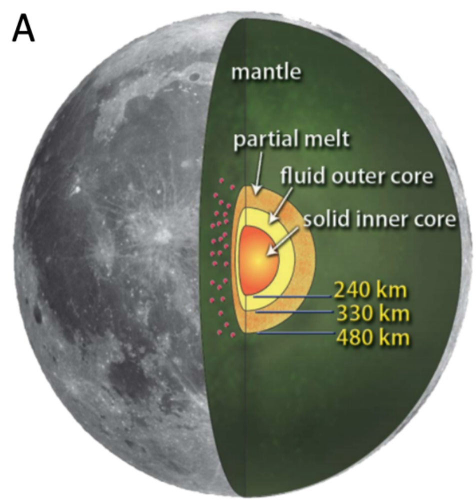
Introduction: Geophysical measurements are required to address many of the science goals outlined in the Artemis III Science Definition Team Report [1] and the 'ESA Strategy for Science at the Moon' [2]. Many Artemis experiments will consist of autonomous instrument packages, which will be installed on the lunar surface robotically or by astronauts. The Lunar Geophysical Package (LGP) is a long-lived surface package, combining seismic, electromagnetic, heat flow and laser ranging measurements, which is ideal for this "suitcase science" approach.

Package Design: The LGP will consist of a magnetotelluric sounder, a heat flow probe, a corner cube retroflector, and two seismometers. The seismometers will be a three-component SSP microseismometer [3] (based on InSight's SEIS-SP) and an extremely sensitive vertical component VBB (based on InSight's VBB) [4]. The package will be enclosed in a thermal box, to maintain an even operating temperature. The LGP will maintain its own power source and communications (which will be capable of communicating directly with a relay satellite) to support the required length of operations.

Science Goals: The LGP will address many of the goals in the Artemis III Science Definition Team Report [1]. In the Apollo era, researchers recognized the importance of geophysical measurements and deployed geophysical instruments as part of the Apollo Lunar Surface Experiments Package [5,6]. Re-examination of Apollo data and sample analyses combined with a wealth of new data from later missions have led to a general understanding of the crust [7], mantle, and core [8,9]. Despite recent advances, many questions remain (e.g. Fig. 1). In particular, constraints on core composition and structure are inadequate, resulting in large variations among current seismic models [11]. Yet this deepest region of the Moon is key to understanding lunar evolution, including whether the Moon could have supported an early global dynamo [e.g. 12]. Questions also remain about discontinuities within the mantle and the nature, depth extent, and thermal characteristics of the Procellarum KREEP Terrane [e.g. 13]. Local and global crustal thickness can be constrained from a combination of receiver functions [14,7] and an estimate of local seismic velocities. The GRAIL gravity model of crustal thickness [15] is tied to estimated thickness at Apollo 12. An additional data point would reduce uncertainty in the model.



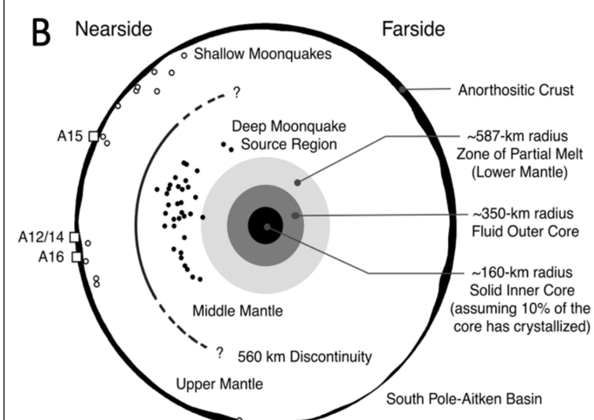


Fig. 1: Geophysical measurements have illuminated the first-order internal structure of the Moon (A, from [9]) and significant lateral variation between the near and far sides of the Moon (B, modified from [8, 11]), but significant questions remain about the size of the core, layering in the mantle, and lateral heterogeneity.

LGP will address these questions by constraining the current seismic state and internal structure of the Moon,

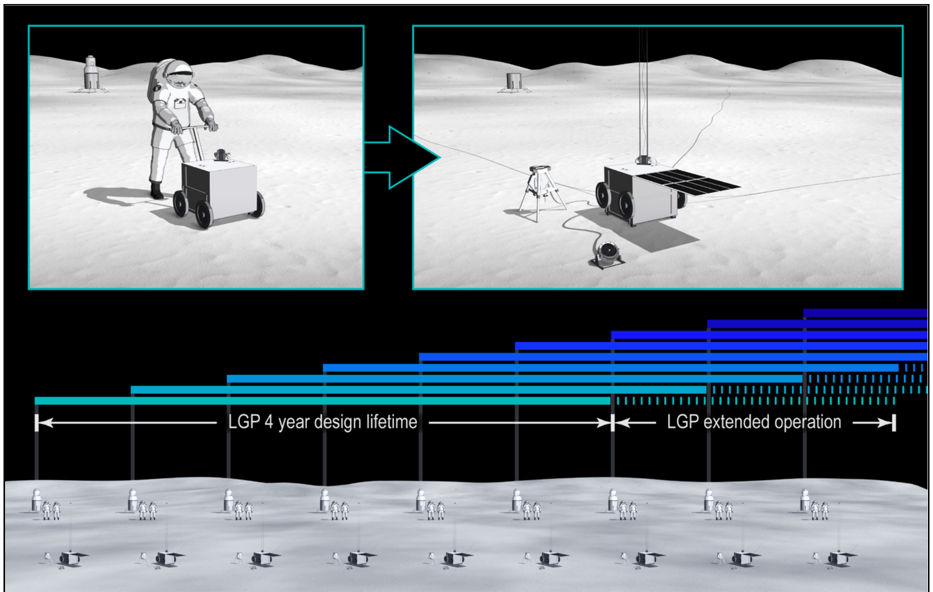


Fig. 2: The LGP can be wheeled to the deployment site. Artist's conception (top). The package can be deployed at all Artemis sites (bottom) and modified to fly on commercial landers. Overlapping timespans at different sites would provide many of the advantages of a full network.

measuring its heat flow to characterize the temperature structure [16,17], installing a next-generation laser ranging capability to further constrain deep structure [18,19], and measuring the electrical conductivity of the lunar interior [20,21]. Additionally, the LGP will record shallow moonquakes for human hazard assessment.

Networking: Each autonomous LGP will be capable of networking with other LGP packages, to provide a distributed network. Although the system is designed to be deployed by Artemis astronauts (Fig. 2), additional nodes could be distributed around the Moon by commercial landers. While the InSight mission has shown that some seismic objectives can be met with a single lander [22] and the other geophysical measurements are powerful from a single site, the lunar science community prioritizes a Lunar Geophysical Network (LGN) as a New Frontiers Mission [23,24] to fully address the community's science objectives. The LGN would supply up to four geophysical stations around the Moon. A long-lived LGP node could achieve many science goals in advance of the LGN by progressively building a network of nodes with overlapping lifetimes. Alternatively, the LGP could provide additional nodes to the LGN, increasing coverage of the Moon.

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