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Editorial: New advances in lunar and related planetary studies

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Editorial on the Research Topic
New advances in lunar and related planetary studies

Significant strides have propelled the lunar and planetary sciences field forward in recent years, with notable achievements stemming from the booming U.S. Apollo missions. These missions stand as landmarks in our exploration of the lunar landscape, providing invaluable insights into surface conditions, evolutionary dynamics, and the internal structure of the Moon. Similarly, American Curiosity and Exploration Mars landers have left an indelible mark on Martian exploration, unraveling mysteries of the Martian terrain and atmosphere, for example.

Moreover, nations across the globe, including Europe, China, Russia, Japan, and India, for example, have redoubled their efforts in advancing our understanding of celestial bodies. Notably, China has emerged as a critical player in deep space exploration, with its Chang'e, Tianwen, and Shenzhou programs spearheading missions to the Moon and Mars. These initiatives have not only conducted lunar orbital maneuvers, surface landings, and sample retrievals but have also successfully landed on Mars, significantly expanding our knowledge of the Martian environment.

Planetary science including lunar studies needs to be based on remote sensing observations in deep space orbits, instrumented observations on planetary surfaces, patrol observations of probe landings, experiments on returned material samples, and numerical simulation studies of coupled multiphysics fields. To showcase the latest advancements in planetary science, including lunar studies, a team of nine leading experts in Earth and planetary sciences from China and the United States curated this Research Topic. Ten academic manuscripts were considered for development, undergoing rigorous review by external experts and subsequent revisions by the authors. Ultimately, eight manuscripts were accepted, representing cutting-edge research in the field. This collaborative effort makes a fundamental contribution to the establishment of an international scientific research station on the Moon and the exploitation of planetary resources in the near future. Through collaboration and innovation, we continue to push the boundaries of scientific knowledge, paving the way for future discoveries and breakthroughs in space exploration.

Research into Martian terrain features and landform identification is pivotal, encompassing Mars exploration, data acquisition, mapping techniques, and methods for classifying Martian landforms. Of particular significance are wind-sand-wind-formed, hydromorphic fluvial, and impact landforms Liu and Cheng. Quantitative analysis of rock characterization and size-frequency distribution at the Zhurong landing site on Mars can be conducted utilizing images captured by the Navigation and Terrain Cameras (NaTeCams) aboard the Zhurong rover Sun et al..

Geophysical inversions are essential for probing the Moon's internal structure. Employing wavelet multiscale analysis, Yu et al. used inverted lunar gravity data to unveil three-dimensional morphological features of two large dense masses in Mare Serenitatis. Additionally, the deeper lunar core interface morphology was quantitatively studied using characteristics of Apollo moonquake observations. Yang and Wang utilized a pseudo-spectral and finite-difference hybrid method to simulate wave propagation of deep moonquakes, considering near-surface scattering effects and analyzing the impacts of these factors on the results of superimposed reflected and converted phases of the outer lunar core.

The electrostatic migration of lunar surface dust mineral particles due to electron irradiation poses potential challenges for human settlement on the Moon. Gan et al. conducted a comparative analysis of the electrostatic migration characteristics of pyroxene, olivine, and ilmenite grains, measured using laser Doppler methods, with previous experiments on anorthosite grains. This comparison highlights distinct migration behaviors among various mineral compositions in lunar dust.

This Research Topic showcases recent advancements in numerical modeling of Earth's polar dynamics. Shi et al. demonstrate significant enhancements in prediction accuracy for Earth's polar motion across various time scales, including short-term (within 360 days) and medium-to long-term, through the innovative integration of iterative oblique singular spectrum analysis (IOSSA) with pseudo data (IOSSApd).

The lunar poles, potential sites for human research bases due to possible water ice presence, are of significant interest. Wei et al. utilized data from the Chang'e 2 microwave radiometer and Diviner observations to invert lunar polar heat flow. Their findings reveal an average heat flow of 4.9 ± 0.2 mW/m^2 in the permanently shadowed craters Haworth and Shoemaker at the lunar south pole.

Ground Penetrating Radar (GPR) plays a pivotal role in deciphering the shallow surface structure of the Moon and related planets. Lv and Zhang conducted a quantitative inversion of the underground permittivity of lunar clastic rocks within the Chang'e-4 landing zone utilizing isolated hyperbolic diffraction migration and local focusing analysis.

The future of planetary science including lunar studies is poised for further advancements, driven by ongoing initiatives and promising developments on multiple fronts. For instance, under Elon Musk's visionary leadership, SpaceX's starship program continues to make significant strides, propelled by its unparalleled carrying capacity and cost-effectiveness. Concurrently, China's space exploration efforts have garnered considerable attention, with the successful Magpie Bridge 2 mission and the highly anticipated Chang'e-6 mission on the horizon. These endeavors promise to expand our understanding of the Moon and pave the way for future exploration missions.

As we look ahead, we anticipate a wealth of new observation data, research methodologies, and technological applications that will deepen our knowledge of the moon and related planets. The continuous influx of data and innovative approaches will undoubtedly fuel groundbreaking discoveries and shape the trajectory of future space exploration endeavors.

In closing, we sincerely thank the handling editors, editor-in chief, reviewers, and authors whose unwavering dedication and contributions have been instrumental in the successful publication of this Research Topic. In particular, we honor the memory of Professor Yin An, one of the handling editors, whose profound insights and invaluable contributions left an indelible mark on the publication process. It is with deep appreciation and respect that we dedicate the success of this publication to Professor Yin An, whose legacy continues to inspire and guide us in the pursuit of scientific excellence.

Author contributions

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