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Space resources are essential for space settlement: Large space settlements on the Moon or Mars will require use of indigenous resources to build and maintain the infrastructure and generate products for export. Prospecting for these resources on the Moon is a crucial step in human migration to space and needs to begin before the establishment of industrial complexes. We are devising a multi-faceted approach to prospect for resources that involves planetary research, technology development, human workforce training, and education. Our work builds on previous studies [e.g., 1,2].

Methodology for planetary prospecting:

Economics of planetary ore deposits. We will develop models that define what ore deposits are on other planets. By definition [3], ores are "rocks or minerals that can be mined, processed, and delivered to the marketplace or to technology at a profit." The planetary context tosses in some interesting twists to this definition. First, the costs are compared to getting materials or products from the Earth or another planetary body, a very different case than for terrestrial ores to be used on Earth. Second, we must consider the cost of delivering extraction equipment to the Moon; these costs are much higher than delivering mining equipment to a location on Earth. The cost of extraction equipment becomes less important as a settlement grows, eventually becoming moot when local planetary industry can manufacture all equipment needed. Martian development may depend on lunar resources. For example, the cost effectiveness of extraction of some Martian resources will have to be judged against their production on the Moon and shipment to Mars. This may be particularly pertinent during the early phases of Martian settlement.

Theoretical Assessment of Potential Ore Deposits. A basic framework for understanding how ores form and in what geologic settings they occur guides the search for ore deposits on Earth. This will form the basis of our theoretical study of economic deposits on the Moon and Mars. However, our understanding of the compositions, geological histories, and geological processes on those bodies will lead to significant differences in how we assess extraterrestrial ores. For example, the bone-dry nature of the Moon (except possibly at the poles) eliminates all ore deposits associated with aqueous fluids. On the other hand, ore-forming processes might have operated on the Moon, but not on Earth. For example, solar wind (H, He, C, N) deposited in the lunar regolith may be a crucial resource for lunar oxygen production, agriculture, and ^{3}He production. Similarly, ice deposits at the poles could be crucial for Martian development. Thus, it will be important to develop a new classification for ore deposits for both the Moon and Mars, beginning with Guilbert and Park's [3] modification (their Table 8-4) of the classic Lindgren [3] classification of ore deposits. Without such a guide, it will be difficult to organize the search for resources on the Moon and Mars.

Search for resources using current lunar data. Prospecting can begin immediately. We have a good collection of remote sensing data for the Moon. In addition, we have a good sampling of the Moon by the Apollo and Luna missions, now supplemented by lunar meteorites. We can target specific types of deposits already identified (e.g. lunar pyroclastics) and look for other geological settings that might have produced ores and other materials of economic value. Another approach we will take is to examine all data available to look for anomalies. Examples are unusual spectral properties, large disagreements between independent techniques that measure the same property, or simply apparent exceptional properties such as elemental abundances much larger than anywhere else in a region.

Developing a strategy for prospecting. We are developing a strategy that represents a comprehensive, integrated program to prospect for resources throughout the solar system. The plan involves a hierarchy of surface exploration techniques. At the base is a huge swarm (thousands to millions) of microrobots equipped with sensors to identify targeted resources (e.g., water ice, phosphorus, rare earths). The tiny robots work in consort with orbiters and sophisticated all-terrain rovers that serve as communication links and make detailed observations at promising locations identified by the microrobots.

Training the planetary economic geologists of the future: Effective and comprehensive resource exploration and prospecting on other planets will require the expertise of specially trained planetary economic geologists. Our plan includes developing a curriculum in planetary economic geology that will include hands-on exploration projects using available data.

References: [1] McKay, M. F. et al. (1992) *Space Resources*. NASA SP-509. [2] Lewis, J. et al. (1993) *Resources of Near-Earth Space*, U. Ariz. Press. [3] Guilbert, J. M. and Park, C. F., Jr. (1986) *The Geology of Ore Deposits*. Freeman, 985 pp. [4] Lindgren, W. (1933) *Mineral Deposits*. McGraw Hill, N.Y., 930 pp.