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Is Mining Rare Minerals on the Moon Vital to National Security?

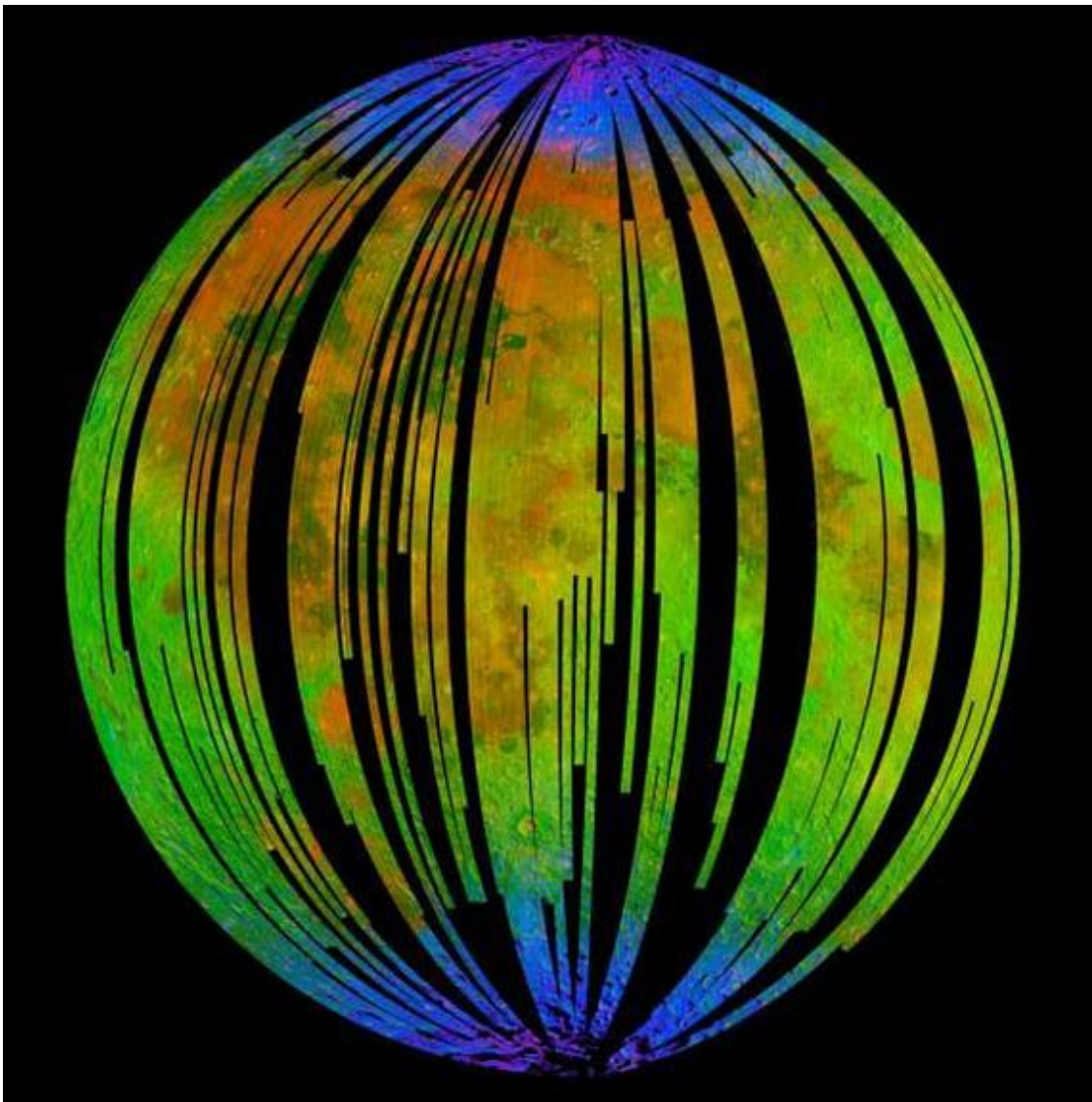
by [Leonard David](#), SPACE.com's Space Insider Columnist | October 04, 2010 08:10am ET

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The seemingly barren moon may actually be a treasure-trove of priceless resources: a potentially bountiful, mineral-rich ? yet untapped ? cosmic quarry. Still, few see the moon as an alluring mining site, ripe for the



This image of the moon is from NASA's Moon Mineralogy Mapper on the Indian Space Research Organization's Chandrayaan-1 mission. It is a three-color composite of reflected near-infrared radiation from the sun, and illustrates the extent to which different materials are mapped across the side of the moon that faces Earth. Small amounts of water and hydroxyl (blue) were detected on the surface of the moon at various locations. This image illustrates their distribution at high latitudes toward the poles.

Credit: ISRO/NASA/JPL-Caltech/Brown Univ./USGS

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picking of rare elements of strategic and national security importance.

Here on Earth, China recently [blocked the export](#) of rare earth elements to Japan for use in an array of products; from wind turbines and glass for solar panels to use in hybrid cars, and even guided missiles and other defense-oriented creations.

China is increasingly putting the pinch on quotas of such elements out of their country. And as the scarcity of these valuable minerals grows, so too does the concern in other nations regarding the availability of this limited resource.

For instance, a recent report from the Congressional Research Service ? a study arm of the U.S. Congress ? reviewed the worldly use of [rare earth elements](#) for national defense.

The report looked at the production of elements such as europium and tantalum, among others, outside the United States and flagged the important issue of supply vulnerability.

The study pointed out that rare earth elements

are used for new energy technologies and national security applications and asked: Is the United States vulnerable to supply disruptions of these elements? Are they essential to U.S. national security and economic well-being?

Among the policy options flagged in the Congressional Research Service assessment is establishing a government-run economic stockpile and/or private-sector stockpiles. Doing so "may be a prudent investment," the study noted, and would contain supplies of specific rare earth elements broadly needed for "green initiatives" and defense applications.

Local concentrations

Given all the mineral mischief here on Earth, the moon could become a wellspring of essential resources ? but at what quality, quantity and outlay to extract? [10 Coolest New Moon Discoveries]

Providing a lunar look-see is Carle Pieters, a leading planetary scientist in the Department of Geological Sciences at Brown University in Providence, R.I.

"Yes, we know there are local concentrations of REE on the moon," Pieters told SPACE.com, referring to rare earth elements by their acronym REE. "We also know from the returned samples that we have not sampled these REE concentrations directly, but can readily detect them along a mixing line with many of the samples we do have."

Pieters is also principal investigator for NASA's Moon Mineralogy Mapper, known as M3, which was carried on India's Chandrayaan-1 lunar-orbiting spacecraft. That probe was lofted by the Indian Space Research Organization in October 2008 and operated around the moon until late August 2009.

Among other findings, the M3 gear found a whole new range of processes for mineral concentrations on the moon ? unappreciated until now.

For example, the M3 experiment detected a new lunar rock ? a unique mixture of plain-old plagioclase ? plentiful in the Earth's crust and the moon's highlands ? and pink spinel, an especially beautiful arrangement of magnesium, aluminum and oxygen that, in its purest forms, is prized as a gemstone here on Earth.

What about the whereabouts of precious elements sitting there on our celestial neighbor in gravitational lock?

Pieters said lunar scientists have a good idea how lunar rare earth elements became concentrated ? it occurred as part of the moon's magma ocean differentiation sequence. But it is now also recognized that "early events disrupted and substantially reorganized that process in ways we are still trying to decipher," she added.

With the recent, but limited, new data for the moon from the international [fleet of lunar orbiters](#) with remote sensing instruments ?? from Europe, Japan, China, India and now the United States, "we are beginning to see direct evidence for the activity of geologic processes that separate and concentrate different minerals," Pieters said.

On the moon, these areas and outcrops are local and small. Exposure is largely dependent on using impact craters as probes to the interior.

Current data are only sufficient to indicate the presence of some [concentrations of minerals](#), but are inadequate to survey and map their character and distribution, Pieters observed.

Lunar KREEP creep

Also working in the lunar mineral fray is Leslie Gertsch, a [space mining](#) expert and deputy director of the Rock Mechanics and Explosives Research Center at the Missouri University of Science and Technology in Rolla. She's got the low-down on KREEP.

KREEP is an acronym based on element symbols for the geochemical component in lunar rocks rich in potassium (K), rare-earth elements (REE), phosphorus (P), thorium, and other incompatible elements, Gertsch explained.

"These elements are not incorporated into common rock-forming minerals during magma crystallization ? hence they become enriched in the residual magma and in the rocks that finally do form from it. This is especially so on the moon, Gertsch said.

One popular model for the moon's formation is that it solidified from a global magma ocean formed from material that aggregated after the young Earth impacted a Mars-sized planet, she explained.

KREEP is exposed on the lunar surface in certain areas, Gertsch said. Although rare earth elements are not themselves presently detectable by remote instruments, spotting thorium sharpens the ability to spot associated rare-earth elements on the moon's surface due to similar geochemical properties that caused them to crystallize under the same conditions, she added.

"However, separating rare earth elements from each other is difficult," Gertsch noted, "because there are few properties where they differ significantly enough to permit efficient sorting of ore particles ? at least by standard methods."

Gertsch said that rare earth elements do sometimes occur in the ores of other metals.

"Presumably REE mixtures could be produced on the moon and shipped to Earth for more specific separation. Neither potential mining methods nor the economics of this particular approach have been studied, to my knowledge," Gertsch

concluded.

Finding and refining

So let's say that the moon is rife with rare earth elements ?what now?

"I think that the economies of production hold sway here," said Dale Boucher, director of innovation at the Canada-based Northern Center for Advanced Technology Inc., in Sudbury, Ontario.

Boucher said that the presence of rare earth elements on the moon can only be truly determined by a dedicated [lunar exploration program](#). That would entail not just orbital sensing techniques, but actual drill cores and sampling in a fashion similar to standard mining and mineral exploration practices here on Earth.

This will only provide gradation data -- but settle the issue of valuable rare elements on the moon ? "which can then be used to determine expected returned value and information on the viability of extraction of any particular element," Boucher explained.

Boucher said that another issue is not about just digging them up, but rather the entire process of finding and refining.

"It seems that there is significant quantity of REE's in North America, [it?s] just not profitable to refine them ... yet. What value is the strategic element in this? Can one put a price on this? If so, it may be economically viable to explore the moon and extract the REEs," Boucher said.

In the end, the Boucher said, the whole premise revolves on a cost per pound at the user's front door. "A very tough problem and well suited to a mining economist," he concluded.

Distant prospect

While lunar rare earth elements may or may not be up for grabs, there's still another resource on the moon of high-value, argues one expert.

"For rare earths, they are called rare for their low abundance, not economic value. However, some do have practical use in manufacturing, as in superconducting magnets," said Paul Spudis, a planetary scientist and leading advocate for exploring the moon at the Lunar and Planetary Institute in Houston.

Spudis said that moon-situated rare earth elements are in very low abundance, except in the KREEP terrain of the western near side.

"The only possible use of such I have heard of is the possibility of mining lunar thorium ? not a rare earth, strictly speaking, but associated with them ? to fuel nuclear reactors for power generation at a lunar base. Quite a distant prospect, I suspect," Spudis advised.

For Spudis, the real strategic lunar commodity is water.

"It's useful for life support, energy storage, and propellant. It can be extracted on the moon and exported to cislunar space to create a permanent transportation system," Spudis said. "That?s strategy for you!"

All this being said, a question: On the 20- to 50-year timeframe, are there valuable or strategic resources on the moon?

"It is not possible to fully predict what will be important in the future, but I expect the answer is yes," Pieters said.

"Resource knowledge is one aspect of lunar exploration that certainly drives the non-US space-faring nations. It is disappointing that planners in our [U.S.] space program have not invested in that scope or time scale," Pieters added. "Other than the flurry over looking for water in lunar polar shadows, no serious effort has been taken to document and evaluate the mineral resources that occur on Earth?s nearest neighbor. Frustrating!"

- 10 Coolest New Moon Discoveries
- Gallery: Moon Bases of the Future
- [Moon Exploration Is Not Dead. NASA Official Says](#)

Leonard David has been reporting on the space industry for more than five decades. He is past editor-in-chief of the National Space Society's Ad Astra and Space World magazines and has written for SPACE.com since 1999.

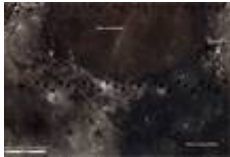
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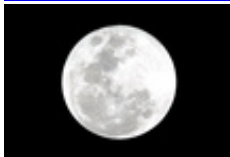
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