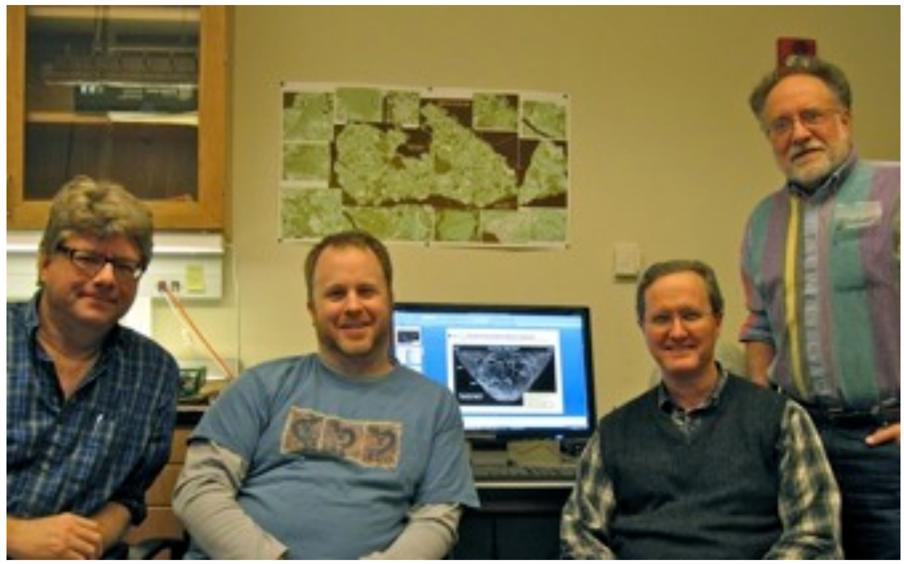
Fly me to the moon: Wash U's MoonRise project is vying for NASA funds

by Jo Seltzer, Special to the Beacon. Posted 11:57 a.m. Tues., 02-02-10

The excitement was palpable when four Washington U. faculty members got together to explain just why it is so important to go back to the Moon and gather new rocks to analyze.



Members of the Washington University team spearheading MoonRise, one of three finalists for a NASA space mission. Left to right: Paul Carpenter, Ryan Zeigler, Bradley Jolliff, Randy Korotev.

"The Moon is like a storage locker of early solar system history," explained Paul Carpenter, director of the microprobe laboratory in Earth Sciences. "The youngest rock on the Moon is older than almost all the rocks on Earth."

Professors Brad Jolliff and Randy Korotev elaborated. "The Earth is an active planet, with plate tectonics, mountains, oceans, and volcanos—things are always changing. But the Moon has been sitting there like a 'witness plate' for 4.5 billion years, being acted upon. If you look at the Moon and realize that all those craters have resulted from collisions with other bodies, and if you consider the common origin of the Earth and its Moon, you must conclude that the young Earth was similarly bombarded. "

Jolliff is the principal investigator of MoonRise, one of three proposals competing to be the third venture in NASA's New Frontiers space science program. If awarded the mission, which is capped at $650 million, MoonRise will send a robotically controlled lunar lander to the far side of the Moon by 2018 to collect lunar samples. When analyzed, these samples should yield important data for understanding the early history of both the Moon and Earth. The samples will be "regolith", grains ranging in size from fine powder to pebble-sized rock fragments.

The Moon and Earth are both about 4.5 billion years old, some 30 million years younger than the sun. The early solar system was a violent unstable place, hardly the ordered structure we know today. Current theory says that the Moon was formed when a body about the size of Mars (called Theia by some) collided with the barely formed Earth. The Earth had already differentiated into a core and mantle. In the course of this massive collision, the two bodies fused. Theia's core melted into the Earth's core, and some of Theia's mantle fused with Earth's mantle. The energy of the impact threw off large amounts of debris that circled the Earth for a while. Gradually, gravity caused the Earth-Theia debris to coalesce into the Moon.

This theory explains lots of facts, such as similar chemical composition of the Earth and Moon.

Early history of the Moon

"But our concern is not with the birth of the Moon," emphasized Korotev. "We're mostly asking questions about what happened next." These geologists want to study Moon's early childhood, and, by extension, the early childhood of the Earth.

The St. Louis connection to moon rocks dates back about 40 years. The late Robert M. Walker, Washington University professor of physics was one of several scientists recruited by NASA for advice on what to do with the rock samples brought back by the Apollo missions. He told NASA that the samples had to be kept pristine, stored well, and distributed to the institutions that could learn from them.

One of the institutions was Washington University.

Ryan Zeigler, one of the WU team on the MoonRise proposal, was introduced to the Moon rocks by his advisor, the late Larry A. Haskin. He has remained fascinated with the subject and the "hands on" aspect of this work. "I see it as a kind of twenty first century exploring. Each rock has a story to tell," said Zeigler.

The story behind the rocks is the unifying drive behind the MoonRise team. None of the team members spoke of childhood ambitions to be an astronaut. Instead, working with actual samples from the moon has led to life long fascination with solar system geology.

STILL IN THE BUDGET

Much of the news surrounding NASA lately has concerned budget cuts and a scaling back of lofty ambitions concerning space travel. But the MoonRise program is one project that still has support, says Brad Jolliff, principal investigator for MoonRise.

The proposed budget makes cuts in NASA's plans for manned space flights. MoonRise is a robotic mission. The budget proposal cites robotic precursor missions to the Moon as the kind of endeavor that will continue to be supported, according to Jolliff. "The President's budget proposal for 2011 has no effect on MoonRise," Jolliff wrote in an e-mail.

"Our project is now in a competition that will end a year from now with the selection of just one of the three New Frontiers candidate missions. This program focuses on Solar System exploration. In Jan. 2011, we will submit our 'Concept Study Report,' which is basically a step-2 proposal. Then, in about June or July 2011, NASA will probably make the final decision on which project will go forward in development for launch."

Korotov got to work on Apollo 11 samples when he was a 20-year-old undergraduate at the University of Wisconsin. "I haven't got it all figured out, so I'm still doing it."

MOON ROCK CENTRAL
Randy Korotev's labs at Washington University are collection central for lunar meteorites found on Earth. Only a few of the meteorites found (about 1/10 of 1 percent)have come to Earth from the moon.

Korotev studied the first recognized lunar meteorite and participated in an Antarctic expedition that collected more than 870 meteorites, including some from the moon and Mars. Through his website, readers learn about lunar meteorites and send him samples. He occasionally buys a lunar meteorite on eBay from reputable dealers.

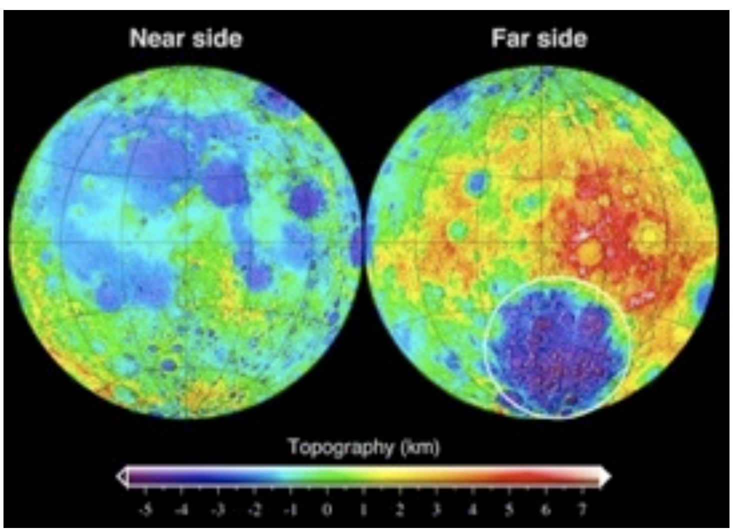
Jolliff was a graduate student at the South Dakota School of Mines and Technology hoping to be a petroleum geologist, just when the bottom fell out of that industry. "An excellent professor got me interested in planetary materials (more early Apollo samples) and here I am."

Carpenter, an igneous petrologist (one who studies how rocks are put together) migrated to Washington U. after running labs at Caltech and the NASA's Marshall Space Flight Center. He is interested in how "technique and science put together" lead to understanding of the solar system, and hopefully eventually to interplanetary travel.

Why another Moon mission?

The Apollo astronauts brought back over 800 pounds of Moon rocks. Why is MoonRise proposing to bring back more?

Apollo missions went to several sites on the near side of the Moon. The sites were close to different impact basins, but we know that these basins are not the oldest on the Moon.



Topographic image of the moon, showing the SPA basin, circled on the right.
Topographic data from the JAXA/Kaguya mission, image processed by Mark Wieczorek."

MoonRise will take samples from a specific site on the moon's far side. The site, the South Pole-Aitken (SPA) basin is the oldest, widest, and deepest impact basin on the Moon. Its size (2400 x 2000 km) and depth tell of a massive collision, probably the impact of an object 100 kilometers (62 miles) across. It stretches from the South Pole nearly to the Moon's equator. At places it is 8 km deep. Compare that to the Grand Canyon, about 1.5 km (9/10 of a mile) deep.

The ancient status of the South Pole basin is known from visual evidence, among other things. This impact basin is pockmarked with other impact craters—those obviously have come later in time than the host basin. Certain kinds of ejecta ‘rays’ and how they cross other structures add to the picture. If a spray of material cuts across a feature, the feature must be older than the ray. Then, of course, such a huge impact would probably be characteristic of the chaos in the early solar system.

Lunar geologists know that any impact on the Moon will scatter impact rocks huge distances, probably as far as 1000 km (620 miles). The scatter occurs because the major real force on the Moon is impact—much less gravity than Earth’s, no plate tectonics, and certainly no moving water.

The importance of 3.9 billion years

So some of the impact rocks that Apollo missions collected should have come from the ancient craters on the far side of the Moon. Yet, all these “impact-melt breccias” have been dated as being about 3.9 billion years old—500 million-600 million years younger than the Moon itself.

Why are there no impact-melt breccias of different ages in the Apollo collections? Is it possible that the Moon, once formed, had no major impacts for 600 million years? Or could the oldest rocks had been covered by the ejecta resulting from more recent impacts?

IMPACT-MELT BRECCIAS

MoonRise will be looking for rocks that were liquified because of the heat and pressure resulting from a collision with a meteorite big enough to form a basin. As the rock cools, the melted matrix will incorporate other rock fragments and dust to form an “impact-melt” breccia.

Questions like these lead to two hypotheses that MoonRise will address by bringing home thousands of small rocks from a site carefully chosen to optimize the chances of analyzing very old rocks.

- One cataclysmic event about 3.9 billion years ago may have been caused by readjustments in the orbits of Jupiter and Saturn. Changes in the behavior of planets with such strong gravitation fields could destabilize the asteroid belt and potentially release a rain of impactors on the inner solar system. This hypothesis will be favored if all new impact melt rocks are 3.9 billion years old.

- Planets in the youth of the solar system were subject to major bombardments that tailed off and stopped 3.9 billion years ago. This hypothesis will be favored by finding older impact rocks in the samples.

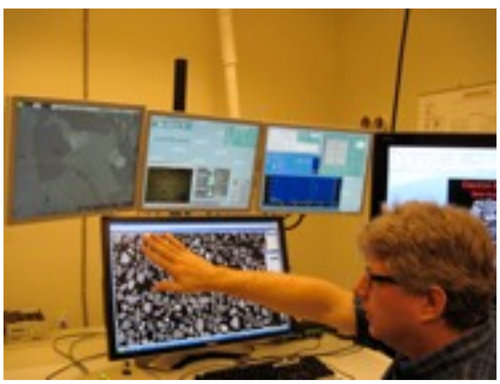
Whichever hypothesis proves true, Earth would have experienced the same impact history. But on our living planet, the evidence would have been erased by all the major geologic changes in the ensuring 3.9 billion years—such as continent formation, mountain formation, oceans and volcanoes, etc.

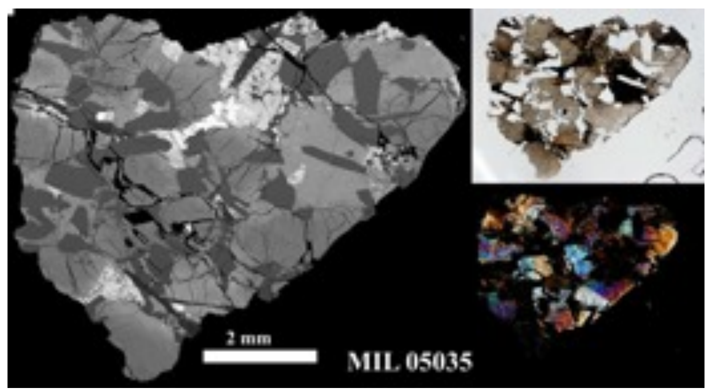
Zeigler points out that life on Earth seems to have begun shortly (in geologic time) after the putative event, about 3.8 billion years ago. The earliest life forms seem to have developed at very high temperatures, and Earth would be very hot indeed after major impact bombardment.

MoonRise is an international project

NASA has awarded the MoonRise team 3.3 million dollars to complete plans for the missions this year. The team is quite large. The Jet Propulsion Laboratory in Pasadena will be in charge of the engineering. A number of other labs both national and international will do sample handling and analysis.

Washington University will do what it is famous for. Researchers will determine the chemical composition and structure of the rocks, using a neutron activation technique honed to perfection by Korotev especially for lunar samples, and the electron microprobe used in the photo at right.The WU labs can process lots of samples, determining their chemistry and mineralogy, and sending selected ones on to other labs for age determinations.





At left, Paul Carpenter points to a scanning electron image at the electron microprobe console.

At right, multiple images of a lunar meteorite collected in Antarctica. The larger image, on the left, is a back scattered electron image, in which the brightness of a spot (a mineral) is proportional to its average density. Thus, the brightest spots are iron-rich, and the darkest spots are iron-poor. An image like this gives information about the composition of the sample. The two small images on the right are optical microscope views of the same section using polarized light. These images give information about the texture and crystallization history of the sample. Together, the images allow the scientists to understand how the particle was formed.
Photo courtesy of Ryan Zeigler, Washington University Earth and Planetary Sciences

And in the future?

Jolliff, Korotev, Zeigler and Carpenter may not have been junior space cadets, but clearly they are all interested in human exploration of the Moon and other planets. As Jolliff put it, “We want to be at the cutting edge of science in use and development of space resources. We would like to see humans living and working on the Moon to improve life on Earth.”

Although mining the Moon for natural resources would be just too expensive, it has been suggested that the Moon could be used for Earth’s energy. One idea: solar panels would be about ten times more efficient on the Moon, and the energy could be converted to microwaves and beamed back to Earth.

Carpenter points out that the Moon could be a proving ground for developing the technology needed for manned exploration of Mars. You can take oxygen and water with you for a “picnic” on the Moon, but for a Mars expedition of minimum 23 months those necessities will need to be generated on site.

When asked about the future of space studies, Jolliff simply answered, “The more we know, the more questions we will have. We couldn’t have proposed MoonRise until we realized that all those Apollo and related impact-melt rocks were the about same age.”