## The most complex yet

One keeps thinking that the moon will recapture some of its mystery and pull some tricks out of the bag. Not that scientists understand it; there are still more puzzles than answers. But since the Ranger, Lunar Orbiter and Surveyor programs of the early 1960's began returning facts to support or destroy hypotheses, the scientific consensus of what might be found on the moon has been growing more accurate with each shot. Thus one of the more surprising things to scientists doing a preliminary examination of the Apollo 14 lunar material (SN: 2/27/71, p. 142) has been the accuracy of their predictions about what they might find.

The way lunar history is being unraveled is a lucky result of a "balance between the growth of the spacecraft [sophistication] and our evolving knowledge of the moon," says Dr. Paul Gast of the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston. Results from Apollos 11 and 12 gave "first order pictures" about the maria, which were the easier areas to land on and the less complex geologically.

**"It is a blessing,"** says Dr. Robin Brett, vice chairman of the 23-man MSC team involved in the first examination, "that we got these [returns] on Apollo 14; if we had gotten them earlier, it would have been an incredibly difficult job."

Whether or not Fra Mauro, the landing site of Apollo 14, is representative of typical highland material, the material returned is the most complicated yet.

The complexity of the rocks is due to the large number of minerals they contain, their fragmental makeup and the numerous and often superimposed histories they reflect. The rocks contain 23 different minerals—as many as were found in the Apollo 11 and 12 samples combined. Ten of them have yet to be identified. The majority of the samples are breccias that contain a variety of rock fragments in a fine-grain matrix. Many contain large numbers of clusters or breccias that in turn are composed of smaller clusters that are themselves made up of still smaller fragmental clusters. Each fragment can be isolated, studied and dated. The breccias within breccias indicate either multiple events or multiple fragmentations in one event.

The chemical composition of the rocks differs considerably from the Apollo 11 and 12 rocks. "Some are ten times as enriched in the sort of elements that are enriched in the earth's crust," says Dr. Brett. Compared with most rocks, "they are misfits."

Although the scientists were most happy about the confirmations, findings of the 45-day preliminary study, announced last week, contained several significant surprises. Compared with the breccias of Apollos 11 and 12, the new rocks contain a low amount of solar wind materials. "This poses a problem," says Dr. Brett. "All we can say now is that the history of these rocks is different from the breccias of Apollos 11 and 12." There also seems to be a correlation between the amount of solar wind materials found in the rocks and their toughness or friability. The more solar wind or surface exposure, the more the rocks tend to crumble.

"But the most surprising find," says one MSC scientist, "is related to one of the two igneous rocks." One of them has a composition similar to the igneous rocks of Apollo 12 basalts. But the composition of the other is similar to that of the fragmental rocks of Apollo 14. The dating of this rock could identify either the date of the formation of the lunar crust or the date of the event at Mare Imbrium that spewed out the blanket of material to form Fra Mauro.

**The rocks** are to be released from quarantine this week and then distributed to some 176 different scientists. Each of the scientists will do from 500 to 1,000 experiments on their samples, estimates Dr. Michael Duke, curator of the Lunar Receiving Laboratory. "The chances of their getting good highland material dating back to 4.6 billion years are very good," says Dr. Gast. The principal investigators will barely have time to start before a new batch of rocks will be returned from Hadley Apennines this summer by Apollo 15. □

### More light on mascons

Ever since their discovery in 1968, mascons (mass concentrations of material) found in the circular basins or lunar maria have proved a major problem in constructing models of the moon's history and structure. No one seems to know quite what to do with them.

It is known that the positive gravity anomalies associated with the mascons produce orbital perturbations in spacecraft. It is not known what the mascons are or what their relationship is to the basins themselves.

The mass concentrations could be the remnants of meteoroid or asteroid impact. Or it could be that the impact that caused the basins also caused a filling in of the area with more dense material from the interior of the moon—a kind of upwelling. Scientists have disagreed about whether mascons are near the surface or deeply buried.

**Now a few clues** may be emerging. As a result of the bistatic radar orbital experiment on Apollo 14, "it looks like the mascon in Mare Nectaris is more of a surface feature than a buried one," says Dr. William L. Sjogren, the principal investigator. Dr. Sjogren was one of the scientists who originally discovered the mascons in the lunar orbiter program.

Although the data are very preliminary, it looks consistent for the five orbits the command module made at an altitude of 30 kilometers, he says.

**It had been predicted** that if the mascons were flat disk surface features, data collected from a spacecraft orbiting at that low level would show a flat-top shaped acceleration curve. The preliminary data give this kind of flat-top curve, indicating that the mascon is within 20 to 30 kilometers under the mare, instead of as deep as 100 kilometers as some had suggested.

The fact that the Nectaris mascon is more of a broad disk-shaped object contradicts an earlier hypothesis that mascons were small concentrations near the center of the basin.

According to the theory of Drs. Michael Yates and Donald Wise, mascons are related to the existence of undulations in the presumed crust-mantle boundary of the moon. The mass concentrations resulted when the basins were dug out by impact (or whatever) and there was a subsequent upwelling of material from below and a filling in from the surface. But says Dr. Yates, "There is a serious problem with the mascons with any theory that says the moon is hot." There is no reason for the structures not to sink in a hot moon, unless the inner structure cools sooner to give strength, or unless there is some insulating region between the inner and outer areas.