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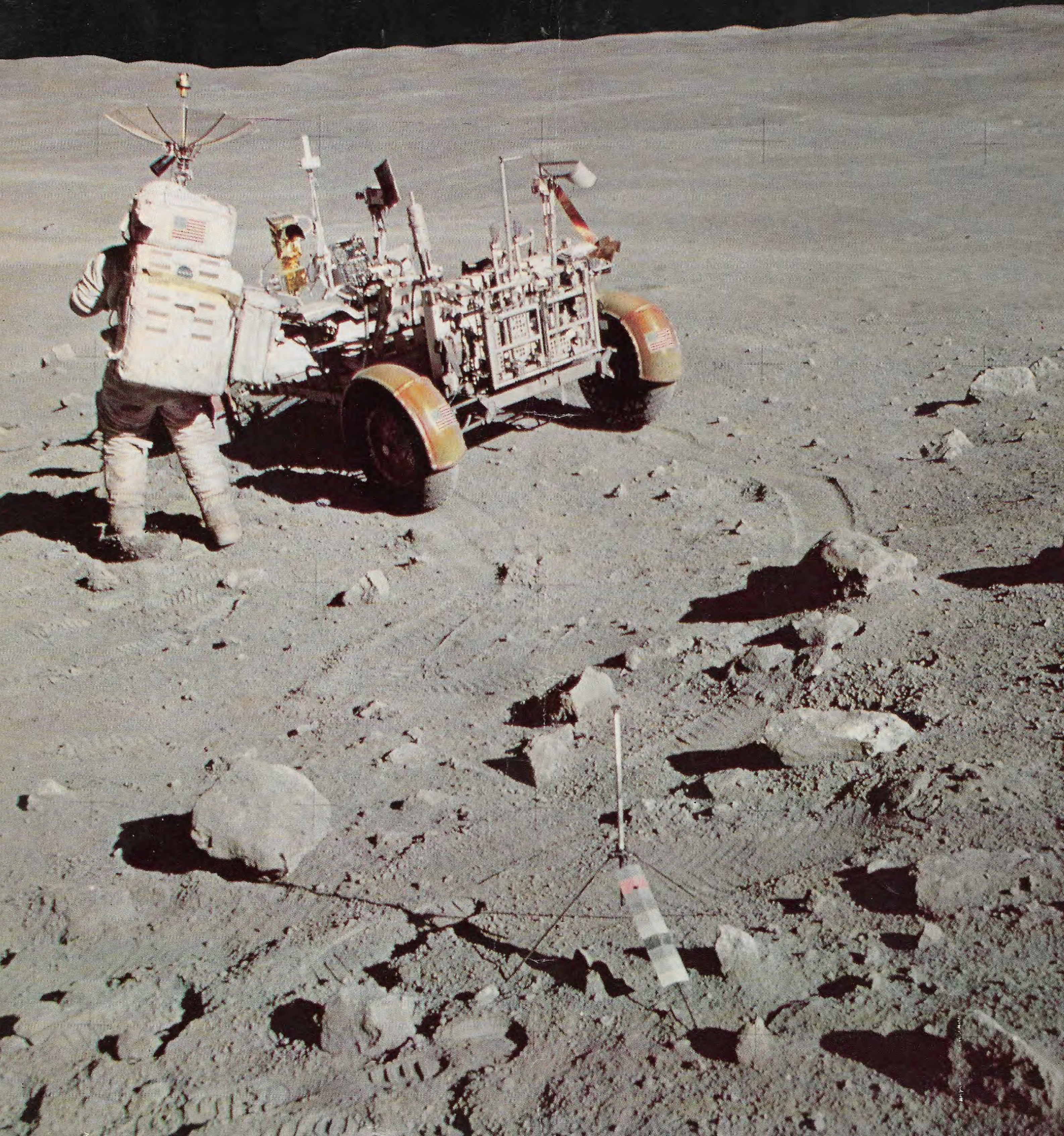
First Apollo 16 Photos



Apollo 16 at Descartes landing site

Future Trends in Space

(Dr. Homer E. Newell, a distinguished associate administrator of the National Aeronautics and Space Administration, has played a key role in directing scientific exploration of space. His views on the future trends of this effort during the next two decades were recently presented to a technical conference in Maryland. The principal thrust of his prophetic vision is presented below.—R. B. H.)

I am sure that the things we will be able to do in the 1980s using space for human progress will be truly remarkable. Those that I am about to suggest will represent a tremendous return, in my view, on our investment in space and should be of great national and international benefit. I recognize that these suggestions may sound very much like more of the same. After a mere 15 years of space activity, people have become blase about the subject, and even the most difficult of accomplishments seem to be taken for granted, and extensive benefits in the fields of weather, communications, environment and resources tend to fade mentally into the background of the commonplace.

Nevertheless, the economic and social benefits are there, and I cannot relinquish the conviction that we will continue to pursue them vigorously. Following are some of the major thrusts I expect to see:

First, Space Applications. With the research and early operational experience of the 1970s behind us, I expect we will be vigorously engaged in developing, demonstrating, and perfecting operational systems and techniques that will make space activities useful and practical to the widest possible spectrum of the national and world communities:

- Putting into operation some time during the decade of the 1980s regional and, as appropriate, world-wide systems for wise and efficient monitoring and management of the natural environment and resources.
- Providing economically viable and socially acceptable means of developing electrical power from the virtually inexhaustible supply of radiation from the sun.
- Utilizing the space environment as a laboratory for the development of new technological principles and processes and for the advance of applications.

Next, Science. It seems inevitable to me that we will continue the investigation of earth and space, providing the space systems and services for the investigation of the solar system necessary to its wise utilization by man, and the space systems and services needed by the scientific community to investigate and understand the universe. This will involve:

- Continued intensive investigation of the solar system, including the sun, earth, and other planets.
- Creation of an orbiting astronomical facility, to be comprised ultimately of a variety of instruments for stellar, solar, and planetary observations, and use of the facility for continuing investigation of the universe.
- Utilizing the unique properties of the space environment as a laboratory for the advancement of science.

Thirdly, Exploration. It also seems inevitable to me that mankind will continue exploration of the space around him, and that the United States will continue to be deeply involved. I suspect, therefore, that the 1980s may well be a period of preparation for the continued manned exploration and exploitation of the solar system, perhaps as a world enterprise. I believe we will also see:

- The development and demonstration of a two-way direct information transfer capability between users via satellites without the need for ground relay stations.
- The development and operation of a long-duration manned space station as a laboratory in space and to support, as appropriate, science, applications, exploration and human technology.
- The development and operation of automated outer planet orbiters and atmospheric probes, and probes to comets and asteroids.
- Perhaps before the end of the 1980s we will be engaged in the establishment of a manned lunar base for continued exploration and scientific research, including the development of planetary exploration techniques.

Of particular interest . . . is the continued exploration of the solar system, for here electric propulsion is bound to play an essential role.

There are many scenarios one can imagine for the continuing exploration of the solar system in the 1980s. But I would venture to say that among the most important will be those of very deep space missions to smaller bodies of the solar system, the comets and asteroids, visits to satellites of the outer planets, missions out of the ecliptic, and to the reaches of interstellar space. For many of these, electric propulsion will be essential.

For example, one can imagine initial staging on the shuttle, upper staging by chemical rockets into a trajectory to a comet, and then continuing propulsion by means of solar electric propulsion. There is general agreement that the most fruitful missions to a comet would be those of a rendezvous in which the spacecraft can move along with the object under study, remaining close to it for very long periods of time. . . .

The decade of the 1970s, it seems to me, will be devoted to an increasing emphasis on beneficial returns from our investments in the first decade of the space age.

It will also be a decade in which we will consciously seek to avoid the large funding peaks that characterized the Apollo era. As a consequence, the number of things achievable with the resources to be available will be limited. In the science arena, and in particular in the exploration of the solar system, this will mean some effort on extending our exploration of the earth-like planets. And that will be about it, unless some circumstances again change our emphasis on space science.

I think we should tell ourselves that we will be getting to those very special, very important missions to the smaller bodies of the solar system in the 1980s, which will give us probably our best look at the very earliest days of the solar system. Then in addition, we should during the 1970s look to the best husbanding and application of our space science resources to see if we can't get in one or two early missions of this type.

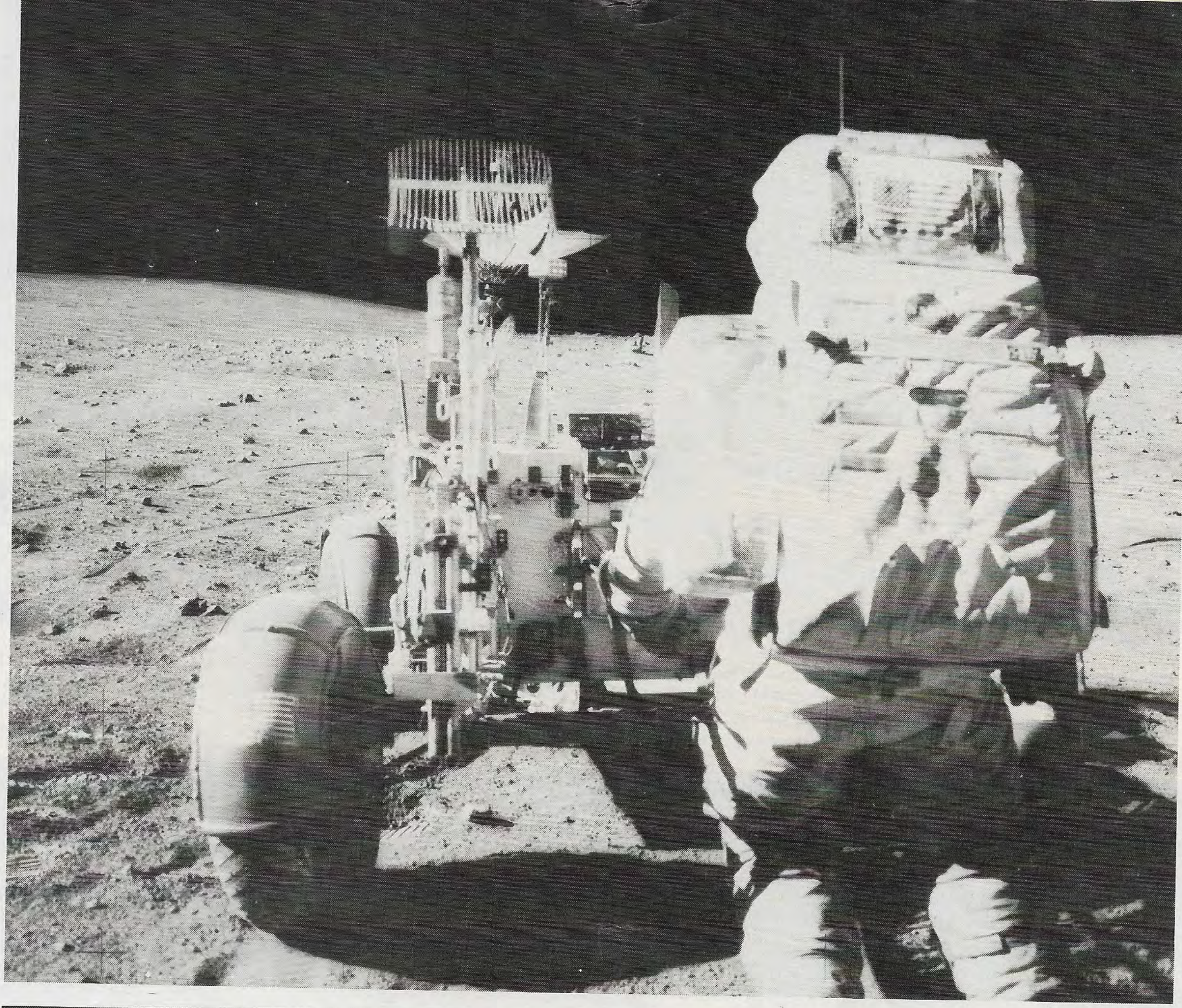
At any rate, however fast we progress, the nation, and indeed the world, is not going to run out of important and exciting and inspiring things to do in exploring and seeking to understand this wonderful universe. . . .

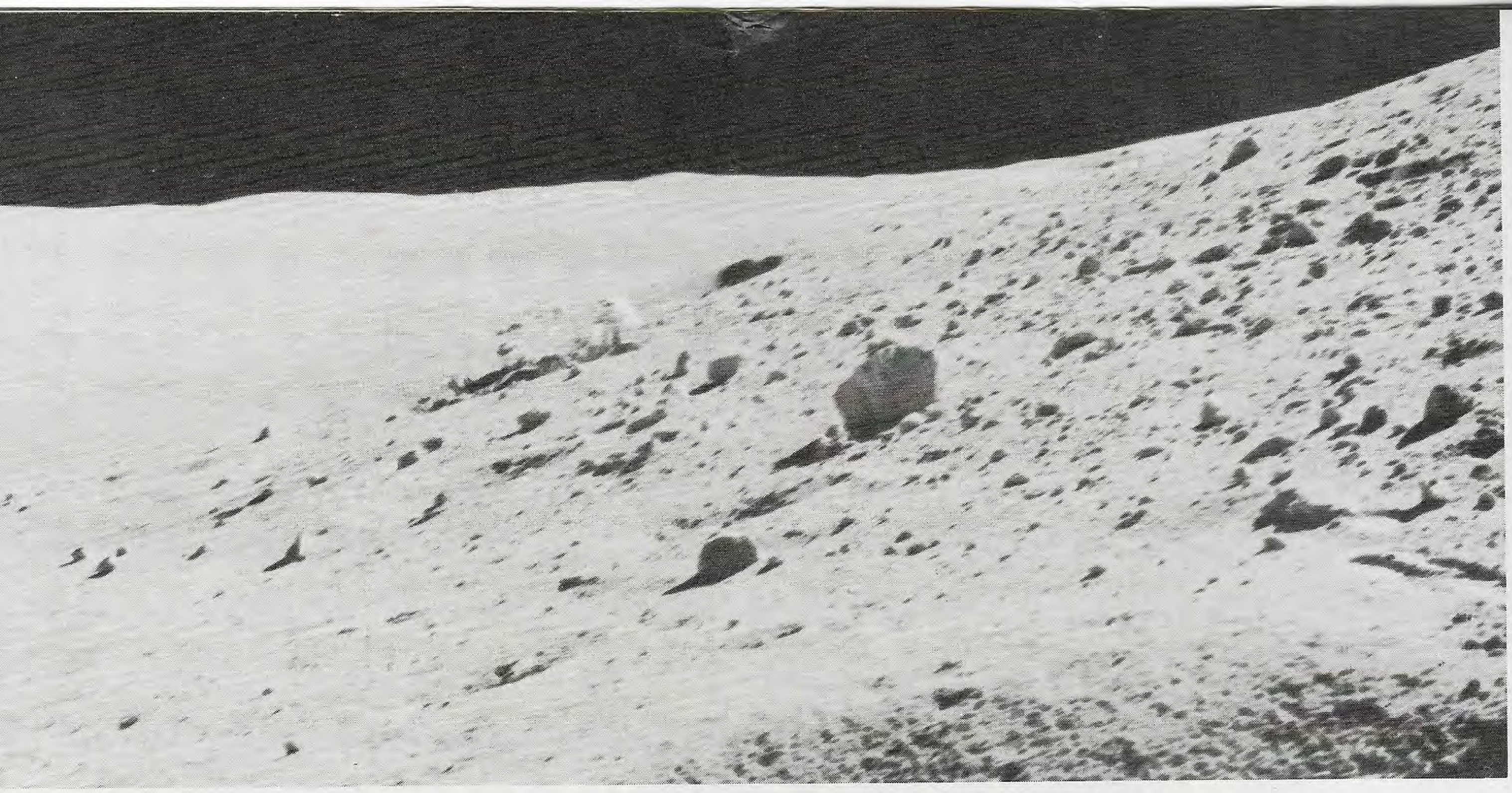
First Apollo 16 Photos Depict Extravehicular Lunar Sorties

Apollo 16 astronaut takes regolith sample in shadow of a boulder during the second extravehicular activity to Stone Mountain (above). Two rounded lighter-tone inclusions are in left center of boulder. During the third extravehicular activity, Astronaut John W. Young inspects Shadow Rock (below) at Station 13 between North Ray and Ravine Craters. This was the site where Young obtained a permanently shadowed soil sample, sought for study of volatile element trapping on the lunar surface. Regolith is more loosely compacted here than at North Ray crater, 600 m. (1,968 ft.) to the north-northwest.

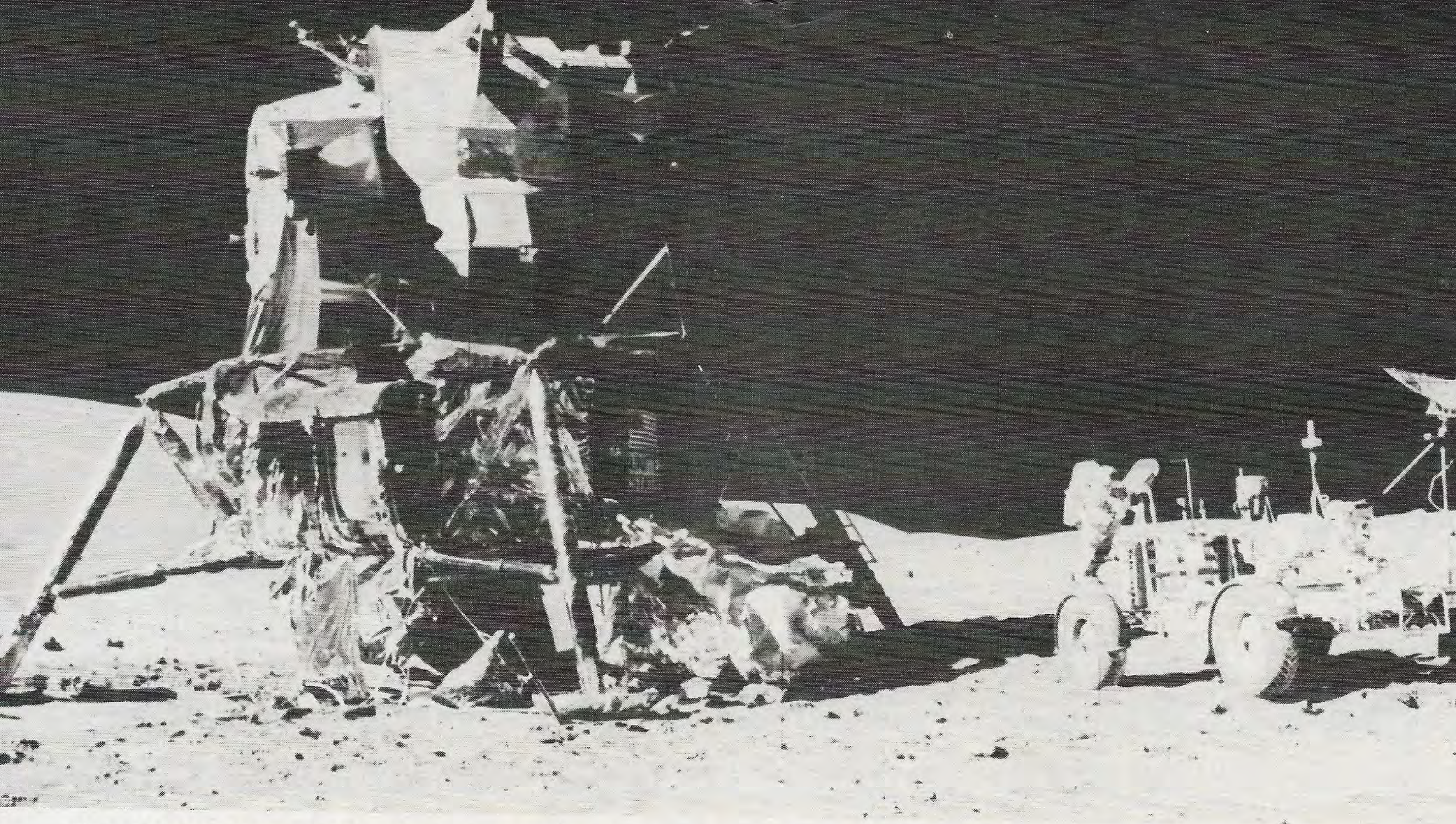
Boeing lunar rover is parked on opposite rim of Plum crater as Astronaut John W. Young searches for samples during the crew's first EVA. Center of crater bears some resemblance to a terrestrial sink hole, caused by subsurface erosion and collapse. Gnomon is in foreground.

South Ray crater makes a splash of white in a darker lunar terrain near the Apollo 16 landing site (above). Photo was taken with a 500-mm. telephoto lens from Station No. 4 during the crew's second extravehicular activity, the highest elevation reached in the traverse up Stone Mountain, south of the touchdown point. South Ray is a fresh crater and was a source for angular ejecta samples collected by the crew. Large white blocks were numerous in the vicinity, but there were also dark strips oriented radially to the crater that were covered with dark blocks. Crew interpretation was that both the light and dark colored materials were excavated from deeper crustal layers by the impact that created South Ray. White crystalline rocks also were found in this area, as were others with a chalky appearance. Astronaut John W. Young works at the rear of the lunar rover (top, opposite page) during a stop at Station No. 6 at the base of Stone Mountain during the same traverse. View is looking south, with South Ray crater to the right. Astronaut Charles M. Duke, Jr., obtains a regolith sample with the lunar rake (below, opposite page). Rover is parked in front of one of several large rounded boulders in the area, this one just to the right of Duke's helmet. Rock collecting tongs are standing in the loose regolith to the right of the rake. Sample was being taken during the third traverse, to the north of the lunar module landing site. Both sample stops on this traverse were near North Ray crater. Largest blocks encountered during the mission were found during this traverse.





Deep depression partly conceals the parked lunar rover (above) during the second extravehicular activity to Stone Mountain. Boulders of assorted sizes strew the slope. Alsep deployment site (below) includes central station and damaged heat flow experiment at right center. Stems for the lunar surface drill are to the left and the drill head itself to the right of Astronaut John W. Young. Radioisotope thermoelectric generator and the lunar surface magnetometer also are visible. Photo was taken during the first extravehicular activity.



Stone Mountain forms a backdrop for the lunar module, Orion, and the lunar rover at the Apollo 16 Descartes landing site (above). Scene was during the second extravehicular activity for the crew, which explored the slope of the mountain to the southwest of the landing area. Reverse of this view, from the highest point reached on Stone Mountain (below) shows Astronaut John W. Young replacing geological tools on the parked rover. View is toward the northeast, generally toward Smoky Mountain and Ravine crater.

Apollo 16 May Revise Cayley Theories

Abundance of breccia indicating impact formation raises questions as to volcanic source of landing site plains

By Erwin J. Bulban

Houston—Cayley plains on which the Apollo 16 Grumman lunar module, Orion, landed may be composed of stratas of light and dark-colored breccia layers, rather than lava flows, as had been widely supposed prior to the mission.

This is an initial reaction of the Apollo Lunar Geology Investigation team based on close study of Apollo 16 crew comments during the lunar traverse and orbital observations and of television tapes made during their lunar exploration.

Geologists say that they are now inclined to believe the formation is a premare accumulation of single or multiple impact breccias from major basins and craters, a theory advanced in 1962. Later theories, which were considered as more likely up to the flight of Apollo 16, were that the Cayley represented a relatively local volcanic flow from the lunar interior.

Pre-mission interpretation of the Cayley formation origin was largely based on study of photography, which showed a light-colored surface composition, indicating to geologists a close resemblance to feldspar-rich basalts.

"The big shock of the mission was that Cayley turned out to be virtually all breccias, and they [Capt. John W. Young and Lt. Col. Charles M. Duke] talked about tuffs, ash flows, those fluid volcanics, only a few times," said William R. Muehlberger, principal investigator for Apollo 16 lunar geology.

The ash flow tuffs referred to by the crew could be rocks having a frothy matrix within which there would be crystal and rock fragments—or they could also be flow breccias, rocks that break themselves up as they travel over long distances, according to Muehlberger.

"They are clearly not lava flows of any normal kinds that we see here terrestially," he added.

The lunar geology team had considered the Cayley was younger than the Fra Mauro formation, which was formed by the Imbrium event 3.9-4 billion years ago, and older than the mare basalts, which lap onto the edges of the highlands. This would have placed the Cayley as older than 3.7 billion years.

Now, according to Muehlberger, the interpretation involves an admittedly "mind boggling" concept that the Cayley may be only minutes younger than the Fra Mauro, landing site of Apollo 14, the result of a giant surge of material from the Imbrium impact. The most fluid material, having a maximum gas content, would have splashed into the highlands, such as Descartes, and filled in the basins.

Successive impacts would then have contributed to the multi-content of the Cayley materials described by the crew, the geologists now believe. The regolith covering the entire Cayley is relatively thick, they believe. No definite outcrops were observed in the area. Initial data from the geophone "thumper" experiment performed at the Apollo Lunar Surface Experiment Package (ALSEP) site indicated that the regolith at this station is at least 17-27 m. (55.7-88.6 ft.) thick, including ray material.

The Apollo lunar geology team still believes that the Descartes mountains are composed of a locally generated flow of volcanic material.

Characteristics of the local terrain and the surface materials identified by the Apollo lunar geology team indicate to them that the samples collected by the crew will provide the basis for extrapolation of what was found at the scene to other similar areas of the moon.

The geologists here believe that the sampling included three dominant rock types—black matrix breccia, white matrix breccias and white crystalline rocks. It is estimated that 80% of the documented rocks collected will be breccias and the remainder crystalline rocks. Many of the rocks identified as crystalline types may be clasts, or individual rock components, that were disloged from breccias, or may be pieces of fine-grain clast-poor breccia matrix. The geologists say that, from the astronaut descriptions, basaltic rocks comprised a minor place in the block field in the vicinity of lunar module landing site and may have appeared as clasts in breccia at North Ray crater, the farthest point reached during the third extravehicular activity (EVA).

Materials from the Cayley formation were predominantly light-colored breccia

Crew Shows Improved Work Tolerances

Houston—Postflight medical examinations on the Apollo 16 crewmen indicated that they exhibited considerably improved return to pre-flight baselines than the crew of the previous mission.

Work-level tolerances, or ability to deliver measured work performance in relation to various levels of exertion, were down only approximately 20% within 24 hr. following recovery aboard the carrier, according to Dr. Charles A. Berry, director of life sciences, NASA headquarters.

The Apollo 15 crew showed far longer periods of recovery (AW&ST Aug. 23, 1971, p. 21). Mission commander David R. Scott took up to 13 days to regain his normal exercise tolerance, lunar module pilot James B. Irwin took 9 days and command and service module pilot Alfred M. Worden took 3-5 days.

Heart arrhythmic patterns, or premature beats from the normal rate, which showed up graphically during the Apollo 15 mission on the lunar module crew, with Scott and Irwin displaying several series of these patterns following their return to the command and service module, were not a factor in the recent mission. Only Charles Duke, lunar module pilot, who was making his first space flight, showed any signs of arrhythmia, and this totaled only three irregular beats, each separated by wide time spans.

Berry attributed improved Apollo 16 crew condition to better work-rest cycles enjoyed by the astronauts compared to the previous mission, and also less strenuous extravehicular activity, which meant that the astronauts had to exert themselves less. Improvements in the lunar surface drill and in the seat-belt on the lunar rover vehicle reduced their workloads considerably over the previous mission, Berry stated.

Another factor, which probably was significant, was the addition of greater amounts of potassium to the crew's diet for this flight, which helped maintain vital body fluids balance.

Berry noted that the astronauts had each received a one-half rad dose as the result of a minor solar flare that occurred during the mission, but that this was insignificant, being approximately 1/100th the dosage that might cause any concern.

Crew weight losses were 7.5 lb. for mission commander Capt. John W. Young; 5.5 lb. for lunar module pilot Charles M. Duke, Jr.; and 6.5 lb. for command and service pilot Thomas K. Mattingly, which were all within the ranges experienced on prior flights.

One of the puzzlers of the flight, according to Berry: Why Mattingly did not report seeing flashes, believed to have cosmic ray origins, as the other two crew members, and as other U. S. astronauts have reported?

with dark or a mixture of dark and light clasts, but dark gray breccia with light clasts also seemed to be abundant. White fine-grain crystalline rocks appeared to be scattered widely. The dark-colored rocks, most prominent of which during the third traverse was the giant so-called house rock, were predominantly breccias with white or mixed white and dark fragments.

Cayley material at North Ray crater appeared to be largely friable white breccias, which may contain fine-grained crystalline and basalt clasts and some dark breccias with white clasts.

Also reported in the area were breccias with three kinds of clasts, dominantly dark ones, in a white matrix. There were also multiple breccias containing dark clasts, which themselves contained darker clasts. Frothy black rocks were also in the area. The dark matrix breccias, seemed to decrease in abundance away from the crater rim, which to the geologists suggests that these samples would represent the deepest material from the crater.

Descartes material sampling consisted of light-colored breccias, with one sample containing black needle-like crystals, considered highly unusual by geologists here. Fine-grain white crystalline rocks were also sampled in this grouping.

Material from the ray patterns of South Ray crater also seemed to consist mainly of breccias, most of which were gray rocks with white clasts. There were also white breccias, glass-coated rocks and indurated, or hardened, regolith breccia and possible scarce fragments of vesicular basalt.

Geologists noted that a contact between the Cayley and Descartes units was not recognized by the crew at the base of Stone or Smoky Mountains. This is ascribed to continual degradation of Descartes and Cayley surfaces, mass wasting on the mountain slopes and superimposition of younger ray materials.

Terrain characteristics identified by the geology team in their preliminary analysis include:

- **Surface of the Cayley plain** in the vicinity of the Orion's resting place was broadly undulating, with local relief of approximately 5 m. (16.4 ft.). The terrain southward sloped toward Survey Ridge and then gradually rose toward Stone Mountain, with numerous craters. Most of these were old, subdued and well-rounded and the majority appeared to be only a few meters across. A few measured several hundred meters in diameter.

Northward from Orion's site, from Palmetto crater onwards, the terrain was also rolling, but more subdued than in the south. East-west trending ridges, up to 5 m. high, appeared to be the principal relief. Slopes of the Descartes unit at Stone Mountain, viewed on television from the ALSEP site, were much steeper than expected. This appeared to be particularly true in the area adjoining Stubby crater, where the TV profile indicated a slope of up to 25 deg. and approximately 20 deg. in the vicinity of Cinco craters. At the north mountain front, it appeared that slopes at the base were approximately 10 deg.

- **Parallel lineaments** appeared to be seen on the slopes of Stone and Smoky Mountains, with the north front of Stone seeming to have narrow ridges or terraces parallel to contours and closely-spaced striations trending upslope westwards.

Lineations were reported as horizontal on northwest wall of Ravine crater and inclined 30 deg. east on the north wall.

Crew Reports on System Performance

Houston—"It was a cliff-hanger of a mission from where we were sitting in the cockpit," was how the Apollo 16 commander, John Young, described the wait for approval from the ground to proceed with a lunar landing.

The wait started after Command Module Pilot Thomas K. Mattingly discovered a problem with a backup control mode of his service propulsion system.

Young noted that the crew became concerned over the problem and the ensuing decision to rendezvous the North American Rockwell command module, Casper, with the Grumman lunar module, Orion, while the ground crew worked on the problem. "We were aware we had a serious problem because it takes a lot of fuel to rendezvous the CSM and LM," he said.

The landing was successfully accomplished 6 hr. behind schedule after the ground determined the command–service module was in no danger even if the engine control backup mode had to be used (AW&ST Apr. 24, p. 19).

Young reported that he had to accomplish a slight yaw maneuver to put Orion on the proper landing track after pitchover. Spotting the lunar module's shadow on the surface at a slant range of 400 ft. was a distinct landing aid, as an altitude indicator.

"Boy, with that shadow, you really don't need the landing radar and you can get a feel for the size of those craters that we were coming over," he said.

The mission commander noted that another distinct plus was that the spacecraft did not generate dust until it was down to approximately 80 ft. from the surface, and the dust never became so dense that it obscured the ground.

Landing was only 15-20 ft. from a 25-ft.-diameter crater. Young and Duke commented that they believed that, even if they had put one landing gear leg in this crater, they would not have been in danger of tipping over, but the angle might have posed serious problems in unloading their traverse equipment. Landing footpads showed no skid marks, indicating a straight-down touch and halt.

The Orion crew, in discussing performance of the Boeing lunar rover vehicle, noted that without it, traversing the Cayley Plain would have been extremely difficult, if not impossible in some places—for example, over crater ray patterns that were littered with rocks.

Some areas of the traverse were also heavily populated with small craters, which the rover negotiated easily, although several times it bounced out of craters and landed on hard surfaces causing the suspension system to bottom out.

Loss of a portion of a rear fender resulted in large clouds of dust being thrown over the vehicle, Young and Duke. This was graphically illustrated in motion pictures taken by Duke of Young maneuvering the vehicle at high speed during the grand prix engineering test to provide technicians with documentation of the vehicle's behavior on the lunar surface. Occasional clouds of dust could also be seen when the crew had the 16-mm. movie camera operating on a traverse.

During his commentary in the first public review of the mission by the crew last week, Duke jokingly referred to the result of the fender loss on the crew's appearance by describing the commander as "Pigpen No. 1" (an allusion to a messy character in the Peanuts syndicated cartoon strip).

Young described the Descartes landing area as "one of the most dazzling, beautiful sights on the moon," particularly the view from Stone Mountain, which the crew ascended to a height of 700 ft.

He believed that South Ray crater, which had been considered as a sampling site in the original traverse plan, would

Scoop Modification

Houston—Apollo 17 lunar surface explorers will be able to pick up soil and rock samples without leaving their lunar rover vehicle if a modification to one of their tools is feasible.

Engineers at the National Aeronautics and Space Administration's Manned Spacecraft Center here are studying the possibility of fitting an extension to a lunar surface sample scoop so that if the crew spots interesting material while rolling along, it can stop the vehicle and collect it without dismounting.

Many times in previous missions, the crew has seen interesting material while en route to a specific sampling site or on the way back to the lunar module, but time constraints have prevented the astronauts from leaving the vehicle to gather it.

have been impossible to visit because its dense boulder field would have posed mobility problems.

Both lunar surface explorers were satisfied with the mobility of their suits. Duke said that shortly after he began working in it, he almost forgot that he was wearing it. He said he learned to have no fear of falling down, because of the lessened rate of fall in the moon's one-sixth-g environment, and he said he never had any difficulty in getting back onto his feet after a fall.

Exercise Program

Both crewmen exercised strenuously in the suits prior to the mission, putting in approximately 350 hr. of training in them to develop optimum dexterity.

Young's only criticism of the suit was a wish that similar stability could be developed for the gloves as is available in the arm and shoulder portions of the garment. In the latter, once the astronaut assumed a position, the suit tended to hold it. But in the gloves, in order to maintain a grasp on an object, the astronaut has to exert muscular effort continuously to keep the fingers bent, or the suit pressure will pop the hand open, the crew said. This continuous effort fighting the suit pressure is extremely tiresome and becomes painful in some instances, they added.

Trying to hold a tool for several minutes is a good example.

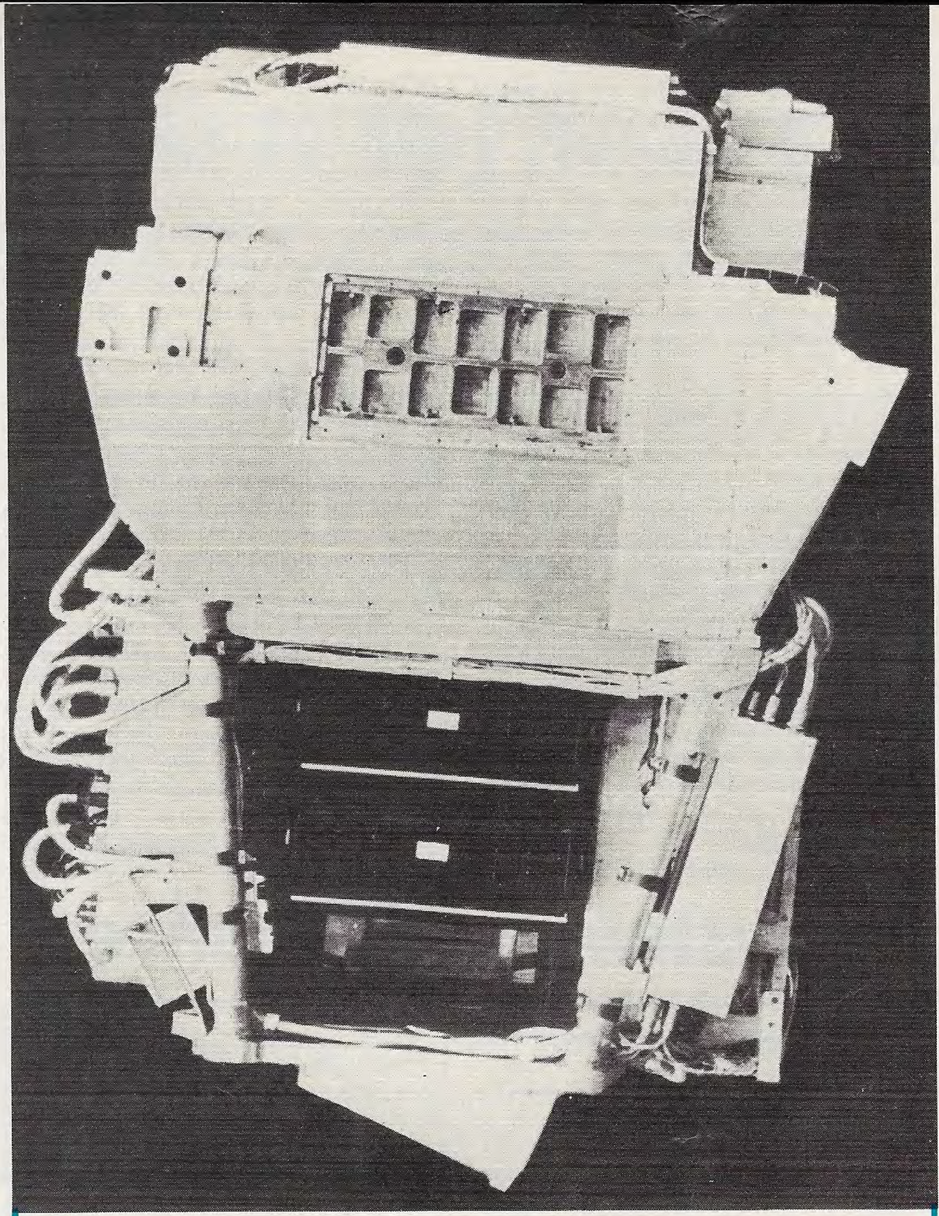
Mattingly termed his extravehicular activity to retrieve film cassettes in the command module scientific instrument module "an enjoyable thing" and very easy to accomplish. He said that the laughter, which caused some puzzlement because there was no obvious reason for it evident here at the Manned Spacecraft Center, was a simple, normal expression of what people do when they are enjoying their work.

Clock Watch

He reported that his pre-mission plan that the Capcom (Capsule communicator) watch the clock and tell him when to operate switches to turn scientific equipment on and off was a decided improvement over previous flights when the command module pilot did all the monitoring.

As a result of discussing previous missions with other command module pilots, he worked out the plan with the Apollo 16 Capcoms to do the clock watching while the spacecraft was on the front side of the moon and he did the monitoring while Casper was on the backside, out of communication.

Splitting the chore in this manner was very helpful, Mattingly said, pointing out that the time spent in watching the clock, starting 30 min. prior to operating the proper switches, was found to be irritating and placed some strain on the command module pilot.



Main scientific package orbited in the Intercosmos 6 satellite, photographed prior to launch, weighs about one metric ton, Soviets say.

Intercosmos 6 Designed to Track Cosmic Radiation

Soviet Intercosmos 6 unmanned satellite payload included a multilayered silver bromide photographic emulsion designed to track high-energy cosmic radiation, as well as electronic equipment to detect, identify and measure it.

Intercosmos 6 was recovered on Soviet territory Apr. 11, four days after launch from Tyuratam (AW&ST Apr. 24, p. 21; Apr. 17, p. 19). The emulsion was shipped to Russia's Joint Nuclear Research Institute at Dubna for processing.

Soviets withheld announcement of the Intercosmos 6 recovery for several days, causing speculation the venture was either a failure or involved a secret military mission. Initial indication that the Intercosmos 6 experiment was to be a lengthy one is now understood to include detailed post-flight analysis of the results in laboratories in the USSR, Poland, and Rumania.

Low altitude of the flight and the four-day limit were both chosen to collect optimum data. Soviet scientists explained they wished to keep the emulsion below the Van Allen radiation belt, and that a flight lasting longer than four days would have caused too much radiation to pass through the emulsion, making the tracks difficult to follow.

The stacked emulsion occupied a volume of approximately 1.6 cu. ft. At Dubna, the layers were separated, mounted on special glass plates designed by Czech scientists and developed. Later, the plates were to have been cut into sections for study, with half of the mounted emulsion shipped to the University of Krakow in Poland and the other half to Bucharest, Rumania.

Scientists plan to identify each photographic track with specific data recorded electronically on the spacecraft, providing them with a profile of each cosmic ray, including its direction, trajectory, speed and energy level. Engergy measurement is made with an ionization calorimeter.