Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: August 30, 1971

to: Distribution

B71 08044

from: F. El-Baz and W. L. Piotrowski

subject: Apollo 15 Preliminary Orbital Science Results
Case 340

ABSTRACT

The orbital science phase of the Apollo 15 mission encompassed an interval of 214 hrs, of which 135 hrs was devoted to experiment operation in lunar orbit. During this time almost the entire area overflown in sunlight was photographed at varying resolution, the geometric shape of the moon along the groundtrack was determined, the Subsatellite was launched into a 76 x 54 nm orbit, and approximately 62 hrs of prime geochemistry data were acquired.

Although the final scientific results must await analysis of the photography and downlink telemetry, some preliminary conclusions have been reached:

1. the high level of radioactivity found in the Apollo 14 samples is not typical of the lunar highlands;

2. a depletion of Al and an enhancement of the Mg/Al ratio were observed in the maria relative to that of the adjacent highlands;

3. the rate of radon evolution on the moon appears to be two to three orders of magnitude less than on earth;

4. the concentration of argon at orbital altitude is a factor of three higher in sunlight than in darkness;

5. mascons have been tentatively located at the craters Humbolt and Balmer;

6. magnetic anomalies have been detected over the craters Gagarin, Van de Graaff, and Korolev;

7. cinder cones were observed in the Littrow area and other significant geological observations were made by the CMP.

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MEMORANDUM FOR FILE

I. INTRODUCTION

The orbital science activities on Apollo 15 were initiated at SIM door jettison at 74:06 hrs GET (11:40 a.m. EDT, 29 July 1971) and terminated at 288:10 hrs GET (9:44 a.m. EDT, 7 August 1971), approximately seven hours before splashdown. In this interval almost the entire area of the moon overflown in sunlight was photographed at varying resolution, the bulk chemical composition of the lunar surface was mapped, the geometric shape of the moon along one groundtrack was determined, a visual geological survey of the regions in sunlight was performed and processes which have formed significant geological features were identified, the composition of the lunar atmosphere was investigated, and γ-ray and x-ray galactic surveys were conducted, including detailed observations of seven galactic x-ray sources. Due to the nature of the data, final results must await the processing and analysis of the film and reduction and analysis of the downlink telemetry. However, some very preliminary results are available based on the "quick-look" or Thrift Data made available to the Principal Investigators in near real time. In this memorandum the Apollo 15 orbital science activities are discussed and the very preliminary science results* are summarized.

II. REAL TIME MISSION PLANNING

Real time orbital science mission planning was accomplished primarily in Room 210 of the Mission Control Center (MCC) where a sampling of the scientific data output of each experiment could be monitored and the condition of

* The science data are reserved for the exclusive use of the PI for one year. These results are presented in order to assist in programmatic planning and not to report the scientific results of the mission.

each instrument determined. Direct communications were maintained between the Principal Investigators (PI's) and the OSO (Orbital Science Officer) who reported directly to the Flight Director. Proposed changes in the orbital science portions of the flight plan generally followed this route.

The Apollo 15 orbital science mission activities were near nominal prior to the CSM plane change for rendezvous. Problems were encountered in the Panoramic Camera Velocity/Height (V/H) sensor and the Laser Altimeter (LA), but the only significant timeline changes as a result of these anomalies were deletion of Laser Altimeter/Mapping Camera operation on the darkside and deletion of LA operation during Mapping Camera (MC) oblique passes. The net result of these changes was the loss of LA data for the later portion of the mission, availability of MC film for other uses, and an increase in prime geochemistry data acquired (since the MC/LA door would be closed and subsequently provide partial shielding for the Gamma-Ray Spectrometer against the thoriated MC lens).

A second problem was a non-nominal Mass Spectrometer (MS) boom retraction which occurred on rev 21 and was repeated on rev 32. The CMP reported that binding occurred when the boom was retracted about half-way. The extension/retraction mechanism was cycled several times and the boom then retracted. If the MS boom had not been fully retracted the MS would have had to be jettisoned at 165:13 GET (prior to the SPS burn for the CSM plane change). The PI decided not to acquire prime MS data at the next scheduled operational period (152:13 - 162:18 hrs GET) since, if the boom did not retract, it would have had to be jettisoned before background data could be acquired (MS background data was considered more important than additional prime data). Changes in the orbital timeline which would permit MS background data acquisition were then investigated and agreement reached among the impacted experiments (Gamma-Ray Spectrometer, Mass Spectrometer, Mapping Camera, and Panoramic Camera).

The delay of 2.2 hours in the time of LM jettison and the subsequent delay in the start of the sleep period impacted all experiment operations since operation of the experiments was planned during the sleep period and camera passes were scheduled immediately after the sleep period. In addition, the MS was not turned on by the crew prior to the sleep period and the crew were not awakened to turn the instrument on because of the taxing day they had experienced. Consequently, another operating period for MS prime data acquisition was lost. Changes in the experiment operating schedule following the sleep cycle were agreed upon by all the orbital PI's which resulted in additional MC passes, prime geochemistry data, and MS background data acquisition.

In general, the procedure for implementing real-time changes in the Apollo 15 orbital science flight plan worked well. The result of real-time changes was increased prime data acquisition by the Gamma-Ray Spectrometer, additional MS background data acquisition, and additional MC passes. The data acquisition times of the experiments are tabulated in Tables I and II.

III. PRELIMINARY RESULTS

A. Command Module

1. Command Module Photography

Lunar surface photography from the Command Module was planned to complement the Service Module photography. This included the following:

a. Oblique photography of special targets using the Hasselblad Camera with the 80 mm and 250 mm lenses using both black-and-white and color film. The targets varied from coverage of areas not photographed by the SM photography to targets which require obliquity to produce the desired detail. Only two targets out of 24 were deleted (due to the delay in LM jettison and subsequent extension of the sleep cycle). All 22 targets were acquired. These included the Luna 16 site in Mare Fecunditatis and the Luna 17-Lunokhod site in Mare Imbrium.

b. Near-terminator photography using high speed black-and-white film. Only one target out of ten was deleted (also due to the delay in LM jettison).

c. Photography of the lunar surface in earth-shine was completed as planned.

Photography of the solar corona and UV photography of the earth and the moon were accomplished as planned but the Gegenschein was not photographed due to a planning error in computing the CSM pointing attitude.

2. Visual Observations from Lunar Orbit

The objective of "Visual Observations from Lunar Orbit" was formally implemented for the first time on Apollo

15. The CMP was asked to make and record observations of special lunar surface areas and processes. Emphasis was placed on characteristics which are hard to record on film and which could be delineated by the eye such as subtle color differences between surface units. All of the scheduled targets were observed and the CMP relayed to the ground results of his careful and geologically significant observations such as:

a. Discovery of fields of cinder cones made by volcanic eruptions on the southeast rim of Mare Serenitatis (Littrow area) and southwest rim of the same mare basin (Sulpicius Gallus area).

b. Delineation of a landslide or rock glacier on the northwest rim of the crater Tsiolkovsky on the lunar farside.

c. Interpretation of the ray-excluded zone around the crater Proclus on the west rim of Mare Crisium as due to the presence of a fault system at the west rim of the crater.

d. Recognition of layers on the interior walls of several craters which were interpreted as volcanic collapse craters or "Calderas" in the maria.

B. Service Module

1. SIM Bay Photography

a. Panoramic Camera

The objective of the 24 inch Panoramic Camera was to obtain high resolution (2-3 meters) photography of as much as possible of the lunar surface areas overflown in daylight. Priorities for the photographic coverage were:

(1) Apollo 15 landing site area pre- and post-EVAs; the purpose of this photography is to tie the panoramas taken on the lunar surface to the general setting as well as to delineate the LRV tracks for post-mission analyses.

(2) The highlands between Mare Crisium and Mare Serenitatis. This segment of the

highlands will be analyzed for a possible landing site for Apollo 17.

(3) The LM ascent stage impact area. Pre- and post-impact photography was required for comparison.

(4) General coverage of lunar surface areas near the terminator, at the sub-solar point and under intermediate lighting conditions.

Telemetry from the first camera pass on rev 4 indicated that the V/H sensor was not operating nominally. When the V/H is off-scale, it automatically resets to a normal IMC for the 60 nm altitude.

For the remainder of the mission the V/H sensor oscillated between nominal and off-scale operations. The result will be the degradation of resolution due to smear. It is expected that at least 80% of the photographs will be good quality, i.e., nominal 2-3 m resolution. The rest will show varying degrees of smear within small portions of the frames where the resolution will be to 5-10 m. However, good quality photography was obtained of all the critical areas (items (1), (2) and (3) above).

b. Mapping Camera

The objective of the Mapping Camera was to obtain cartographic quality photographs of all sunlit areas overflown by the spacecraft. To assist in data reduction, a photograph of a star field and a Laser Altitude measurement were to be made in synchronism with each Mapping Camera photograph. Mapping Camera operation was desired on all Panoramic Camera passes (to help reduce the Pan Camera photography), and on selected darkside passes where the Laser Altimeter was operating.

The Mapping Camera operation was nominal throughout the mission. The film has been processed and the results are excellent. The stellar camera film is somewhat fogged, but the required data is registered. The Laser Altimeter, however, ceased to operate on rev 38 as will be discussed below. All subsequent darkside passes with the Mapping Camera were deleted from the flight plan.

On rev 50, the Mapping Camera was turned off during the Pan Camera pass over the Apollo 15 landing site. This was done against the remote possibility that the V/H malfunction might be related to reflections from the Mapping Camera cover while the latter was open. There was an insignificant loss in coverage and no effect on Pan Camera operation.

Changes in planned photographic passes caused by the delay in LM jettison decreased the sidelap between revs 50 and 60. This will cause a slight weakness in data reduction in this area.

Loss of Laser Altimeter data will also cause a decrease in accuracy of the lunar control network to be established from the Mapping Camera photographs. The absolute heighting accuracy of $\pm$ 15 m will be reduced to $\pm$ 30 m.

The film cassettes were easily retrieved during TEC and in spite of the aforementioned losses, all major objectives of the Mapping Camera were successfully met.

c. Laser Altimeter

The objectives for the Laser Altimeter were to provide an altitude measurement in synchronism with each Mapping Camera exposure on the light side, and to provide independent altitude measurements on the dark side to permit correlation of topographic profiles with gravity anomalies.

Altimeter operation was nominal through rev 24. On rev 27 it was noted that some altitude words were clearly in error and this situation became progressively worse on revs 33, 34, and 35. This was associated with a rise in cavity temperature. The Mapping Camera/Laser Altimeter was left extended, but not operating, for the dark side pass on revs 36 and 37 in order to lower the temperature of the instrument. However, when telemetry was obtained after altimeter operation on rev 38, it was clear that the altimeter had failed completely.

Operation of the altimeter was deleted from all subsequent dark side passes, but it was operated with all light side Mapping Camera passes. An occasional seemingly valid altitude word was obtained, but these can have no effect on subsequent analyses.

On rev 63 an attempt was made to revive the altimeter by a switch operation routine (cycling it sixteen times) conducted by the CMP, but it was not successful.

Only about half of the total planned altimetry was obtained. Loss of the altimeter data will degrade the accuracy of the control network to be established with the Mapping Camera photographs. An accuracy of ± 15 meters in point coordinates is expected with altimetry and ± 30 meters without. Although correlation of topography with gravity can be done on the light side using elevation data obtained from eventual reduction of the mapping photographs, the ability to do this on the dark side will be reduced to those areas where valid altimetry was obtained.

On rev 15 the LA was operated for a complete revolution and these data, reduced and corrected for the orbital ellipticity by Sjogren and Wollenhaupt, are shown in Figure 1. These data indicate that the center-of-mass is approximately 2 km nearer to the frontside than the center-of-figure and that the lunar radius is 1738 km only at the eastern and western limbs, the points from which the classical telescope measurements were made. In general, the frontside is 2-5 km lower than the mean radius and the backside is 2-5 km higher. The relative relief between the floor of Mare Smithii and the rim of the crater Gagarin in the nearby highlands is 9.5 km (which corroborates the visual observations of John Young on Apollo 10); Gagarin itself is 6 km deep.

2. Geochemistry

a. Gamma-Ray Spectrometer

The Gamma-Ray Spectrometer (GRS) performed a remote compositional survey of the upper 30 cm of the lunar surface by detecting the γ-rays emitted during the radioactive decay of the naturally occurring radioisotopes (^{40}K, ^{238}U, ^{232}Th, and their daughter products) and of the radioisotopes produced by cosmic ray bombardment of lunar surface materials.

The objectives of the experiment were to detect variations in composition over the surface, and, on the basis of the distribution of K, U, and Th, to determine the degree of chemical differentiation the moon has undergone.

The preliminary data from the GRS indicated that the continuum level is comparable to that predicted on the basis of the Ranger 3 and Luna 10 data. Peaks due to K, Th, O, Si, and Fe have been identified in the lunar data and areas of enhanced Th activity were reported in the vicinity of the Imbrium/Procellarum boundary on rev 25. However, no increase was noted in the real time data in the Th activity over the Aristarchus region.

The real time display of the γ-ray data in the MCC and the "Thrift" printouts were necessarily brief summaries of the total data acquired. However, some interesting observations can be made:

(1) the total γ-ray spectra in the 0.10-10 Mev range is more intense on the backside than on the frontside;

(2) particular γ-ray lines (e.g., Th) are more intense on the backside than on the frontside;

(3) the high level of radioactivity found in the Apollo 14 samples is not typical of the highlands nor of a very large fraction of the highland area.

A detailed analysis of the data by the Principal Investigator (Arnold) is expected to detect the presence (and distribution) of U, Mg, Al, and Ti in addition to those already identified. Data on the cosmic ray proton and alpha particle fluxes and some source strengths of particular galactic γ-ray sources will also be obtained.

Operation of the GRS was nominal throughout the lunar orbit phase of the mission. 61.8 hrs of data was acquired in lunar orbit in the prime mode (boom extended, MC/LA cover closed), 5.8 hrs in a slightly degraded mode (boom extended, MC/LA covers opened), and for 10.2 hrs with the LM attached (see Tables I and II). Prior to CSM/LM separation, the γ-ray spectrum was dominated by the ALSEP/RTG and the γ-ray line at 2.61 Mev due to the RTG was particularly evident.

The instrument was operated in several different configurations (boom extended/retracted, MC/LA cover open/closed, LM attached) at different times during the mission. A detailed analysis of the data will indicate the advantages/disadvantages of each operating configuration and the benefits of such operation on Apollo 16.

b. X-Ray Spectrometer

The X-Ray Spectrometer performed a remote compositional survey of the topmost portion of the lunar surface ($\sim$ upper 3 mm) by detecting the secondary fluorescent x-rays emitted when solar x-rays bombard the constituent elements. Since the sun was the excitation source, the Apollo 15 experiment was limited to the sunlit portion of the moon (70°W -

170°E) and the field-of-view was limited to 65 km on either side of the ground track. Approximately 80 hrs of prime x-ray data were acquired in lunar orbit and an additional 10 hrs were acquired prior to CSM/LM undocking (see Tables I and II). The Principal Investigator (Adler) reports that the experiment is 100% successful.

The fluorescent x-ray flux was more intense than had been predicted. However, this does not necessarily mean that the elemental concentrations are higher than previously calculated, since determination of absolute concentrations is not feasible with the present instrument. The experiment determines elemental ratios and detects the presence of particular elements.

Since the sun was stable during the lunar orbital experiment period, the Thrift Data could be readily analyzed. The PI reported the presence of fluorescent x-rays due to Si, Al, and Mg and determined the Al/Si and Mg/Al ratios for selected portions of the ground tracks. (Fluorescent x-rays from Fe, K, and possibly Na require an "active" sun.) The preliminary results of the experiment indicate distinct differences in elemental composition between the highlands and maria. Based on a portion of the ground track for rev 16 from 95°E to 40°E over Mare Smithii, Mare Crisium, the intervening highlands, and the highlands to the east and west of the two maria respectively (and assuming the Si concentration to be uniform), the PI has determined that:

(1) the Al concentration in the highlands is ∿50% greater than in the maria;

(2) the Mg/Al ratio in the two maria is similar and is ∿50% greater than in the surrounding highlands.

These data were repeatable on subsequent revolutions. Data acquired on rev 40 over Mare Fecunditatis (near the Luna 16 landing site) indicate a Mg/Al ratio somewhat higher than in Mare Smithii and Mare Crisium.

During TEC the X-Ray Spectrometer was used to perform galactic x-ray observations. Seven known x-ray sources were observed continuously for approximately one hour each, namely, Centaurus X-3, the Mid-Galactic Latitudes, SCO-X1, CYG-X1, the South Galactic Pole, the North Galactic Pole, and the Galactic Plane Anti-Center. (This was the first time that these sources have been observed continuously for an hour. Previous observations had been carried out on spinning spacecraft or on rocket flights.) Simultaneously with the observations of SCO-X1 by Apollo, observations were made of nearby stars by the Crimean Astrophysical Observatory to determine if there is a correlation between the x-ray fluctuations of SCO-X1 and fluctuations of the nearby visible stars. Variations in the x-ray flux from several of the sources were noted but a detailed statistical analysis is required before any conclusions can be drawn.

The instrument operated close to nominal throughout the mission and very stably. The instrument became noisy once during TEC and was shut down. The noise was not present when the instrument was turned back on.

c. Alpha-Particle Spectrometer

The Alpha-Particle Spectrometer attempted to locate cracks or fissures in the lunar surface by detecting the α-particles emitted by the radioactive decay of two of the isotopes of the inert radioactive gas radon. The two radon isotopes are the daughter products of uranium and thorium, respectively, and were assumed to diffuse to the surface through the regolith, through cracks or fissures, or to be entrained in volcanic gases.

The PI (Gorenstein) reported that the background, due primarily to cosmic ray interactions, was two to three times higher than expected. In addition, the level of radon emanation from the surface was below the level of detectibility at the sampling rate of the Thrift Data. This placed the rate of radon evolution on the moon at least two to three orders of magnitude below the rate of evolution on earth even though the lunar concentrations of uranium and thorium may be only an order of magnitude less. Therefore, the radon transport mechanism that occurs on earth is not applicable to the moon.

A detailed analysis of the data by the PI using filtering techniques should result in considerably higher sensitivity and may lead to the detection of radon.

The instrument was operated in lunar orbit in the prime mode for approximately 79 hrs and for 50 hrs during TEC to obtain instrument background and other instrument parameters (Tables I and II). Other than two intermittent noisy detectors at high temperatures, the operation of the instrument was nominal.

d. Mass Spectrometer

The Mass Spectrometer measured the composition and density of neutral molecules present in the lunar atmosphere at orbital altitudes. Gases presumed to be present in the lunar atmosphere within the mass range of the instrument (12-66 amu) and in sufficient quantities to be detected (>10^4 particles/cc) are Ar, Ne, Xe, and perhaps volcanic effluents (H_2O, H_2S, CO_2 CO, SO_2).

The instrument was operated for 8.6 hrs in the 60 x 8 nm orbit (prior to CSM/LM undocking) and for 25 hrs in the 60 nm circular orbit (see Tables I and II). During operation in the low orbit (after only one hour of ion source heater outgassing) many mass peaks were observed but most were attributed to instrument outgassing. However, the PI (Hoffman) tentatively identified the presence of Ne in the data.

During operations in the circular orbit, a large number of mass peaks were observed whose intensity varied over the ground track. A preliminary analysis of this data indicate that the density of ^{40}Ar varies from 2×10^5 particles/cm^3 on the darkside to 6×10^5 in sunlight while ^{36}Ar varies similarly from 6×10^4 to 2×10^5 particles/cm^3. In addition, the density of both bases changes abruptly at the terminator as would be expected from a native atmospheric gas. The PI also reported that the instrument detected a short intense burst of several gases, including CO_2 as well as masses 36 and 56 at 137:15 hrs GET (rev 31, ∿170°E).

Although a statistical analysis is required before a final determination can be made on the natural constituents and their abundances, preliminary indications are that the lunar atmosphere is very rarified and may be somewhat lower than predicted theoretically.

The MS was also operated for 48.5 during TEC to gather background contamination levels at various distances from the spacecraft. The data indicate that this gaseous cloud is primarily within 4 ft of the CSM and at 24 ft (the nominal MS position) no contamination from the spacecraft is detectable.

Operation of instrument was nominal both in lunar orbit and during TEC. However, an apparent problem with the boom retraction mechanism resulted in the decision not to extend the MS during one scheduled data acquisition period and the crew failed to turn the instrument on during the scheduled data acquisition period following LM jettison. The subsequent experiment timeline was modified to include additional MS operating periods.

The problem with the boom retraction mechanism was subsequently deduced to be binding after an instrument cold soak and was nominal after a hot soak.

3. Geophysics

a. Subsatellite

The Subsatellite launch into a 76 x 54 nm orbit was nominal at 222:39 GET and the stably rotating spacecraft was photographed from the CM for $\sim$30 sec with the 16 mm DAC and the 70 mm Hasselblad Camera. Uplink was established shortly thereafter and the magnetometer and the solid state telescopes were turned-on. Turn-on of the high voltage to the charged particle electrostatic analyzers was delayed for 24 hrs in order to allow the analyzers to outgas and prevent corona. No problems were noted when the high voltage was turned on at 246 hrs GET.

Since the charging rate of the Subsatellite battery is lower than nominal, the S-band transponder (the largest user of power) is being operated every 12th rev rather than every third rev as previously planned. Following the tracking rev all experiments are turned off and the battery is charged.

The magnetometer and the charged particle detectors acquire data on every rev except during battery charging. Data have been acquired as the moon passed completely through the earth's geomagnetic tail. The field at orbital altitudes is of the order of 1 γ but variations have been noted over backside highland regions. Magnetic anomalies ($\sim$2 γ) have been noted over the craters Gagarin, Van de Graaff, and Korolev.

b. S-Band Transponder (CSM/LM - Subsatellite)

S-band doppler tracking of the CSM during inactive periods occurred over the three largest presently known gravitational anomalies (Mare Imbrium, Mare Crisium, and Mare Serenitatis). Preliminary analysis of the Apollo 15 data by Sjogren and Wollenhaupt at an altitude of $\sim$15 km corroborate the data obtained from the Lunar Orbiter at an altitude of >200 km over two of these features. These preliminary Apollo 15 data define the two anomalies in more detail than does the refined Orbiter data.

Figure 1 is a plot of the gravitational profile (as determined on Apollo 15) over the frontside of the moon superimposed on a plot of the geometric shape as determined by the

Laser Altimeter on rev 15. Further analysis of the data is required in order to remove the topographic effects and to determine the size and depths of the mascons.

Doppler tracking of the Subsatellite has led to the detection of several small gravitational perturbations with possible mascons at Humbolt (80°E, 28°S) and Balmer (70°E, 19°S). However, repeated overflights of the frontside at varying altitudes as the Subsatellite orbit decays is necessary before an accurate gravitational map can be made and the large anomalies defined.

c. Bistatic Radar

The Bistatic Radar Experiment (BRE) was performed as planned with two complete frontside passes (revs 17 and 28) in the dual-frequency mode (S-band and VHF)* and about 6-1/2 frontside passes in the VHF-only mode. In the dual-frequency mode using the S-band HGA and the VHF omni antenna, a spacecraft maneuver was performed to maintain the proper geometry between the HGA, the lunar surface, and the receiving station on earth. During the VHF-only mode the CSM remained in the SIM down attitude and prime geochemistry data was collected simultaneously.

Although considerable processing of the received signal is required before the experimental data can be analyzed, the PI (Howard) indicated the received signals were strong with good potential for determination of the bulk dielectric constant, near surface roughness along the spacecraft track, and detailed studies of moderate-sized lunar features.

The spacecraft ground track during both the dual-frequency and VHF-only portions of the experiment intersect the ground tracks of the Apollo 14 dual-frequency BRE. This will enable a correlation of the Apollo 14 and 15 bistatic data with a common reference point.

IV. SUMMARY

The orbital science phase of the Apollo 15 mission was near nominal prior to the CSM plane change for rendezvous but the delay of 2.2 hrs in jettisoning of the LM impacted most of the subsequent experiment operation. The procedures

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* The S-band signal was not received during one of the frontside passes due to incorrect HGA pointing.

established for real time changes to the orbital science flight plan worked well and the impact on the overall science of late LM jettison was minimized by such real time changes.

The net result of the Apollo 15 orbital science mission was that: 1) the entire area overflown from revs 15-72 in sunlight was photographed by the Mapping Camera at 20-30 m resolution, 2) the majority of this area was photographed by the Panoramic Camera with a resolution of 2-3 m, 3) the geometric shape of the moon along one ground track was determined by the Laser Altimeter, 4) approximately 62 hrs of prime geochemistry data was acquired, and 5) the Subsatellite was successfully launched into a 76 x 54 nm orbit. Although the final scientific results must await the processing and analysis of the photography and analysis and interpretation of the downlink telemetry, some preliminary conclusions are possible:

1. the high level of radioactivity found in the Apollo 14 samples is not typical of the lunar highlands nor of a very large fraction of the highland area;

2. a depletion of Al and an enhancement of the Mg/Al ratio were found in Mare Smithii and Mare Crisium over that observed in the adjacent highlands;

3. the rate of radon evolution on the moon appears to be two to three orders of magnitude less than on earth although the lunar concentrations of uranium and thorium may be only an order of magnitude lower;

4. argon, mass 40, varies in concentration from $\sim 2 \times 10^5$ particles/cm^3 on the darkside to about 6×10^5 particles/cm^3 in sunlight, while argon 36 varies similarly from 6×10^4 to 2×10^5 particles/cm^3;

5. doppler tracking of the Subsatellite has resulted in the tentative identification of mascons at the craters Humbolt and Balmer;

6. magnetic anomalies have been detected on the backside over the craters Gagarin, Van de Graaff, and Korolev;

7. the CMP detected a field of cinder cones in the Littrow area and delineated a landslide or rock glacier on the rim of the crater Tsiolkovsky on the lunar far-side.

W. L. Piotrowski
for F. El-Baz

W. L. Piotrowski
W. L. Piotrowski

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Attachments

TABLE I

Total Lunar Orbit Data Acquisition Times

Gamma-Ray Spectrometer*	
prime data (boom extended, MC/LA cover closed)	61.8
slightly degraded (boom est., MC/LA cover open)	5.8
seriously degraded (boom retracted)	16.4
LM attached, boom extended	10.2
X-Ray Spectrometer**	
prime data	79.9 hrs
LM attached	10.2 "
α-Particle Spectrometer**	
prime data	79.4 "
LM attached	10.2 "
Mass Spectrometer***	
prime data (-x)	24.5 "
LM attached	8.6 "
calibration (+x)	7.2 "
Bistatic Radar	
2 complete frontside passes (both S-band and VHF)	
6-1/2 frontside passes, VHF-only	

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* Operating time when CSM out of SIM attitude not tabulated.

** Operating time with X-Ray/α-Particle door closed and CSM out of SIM attitude not tabulated.

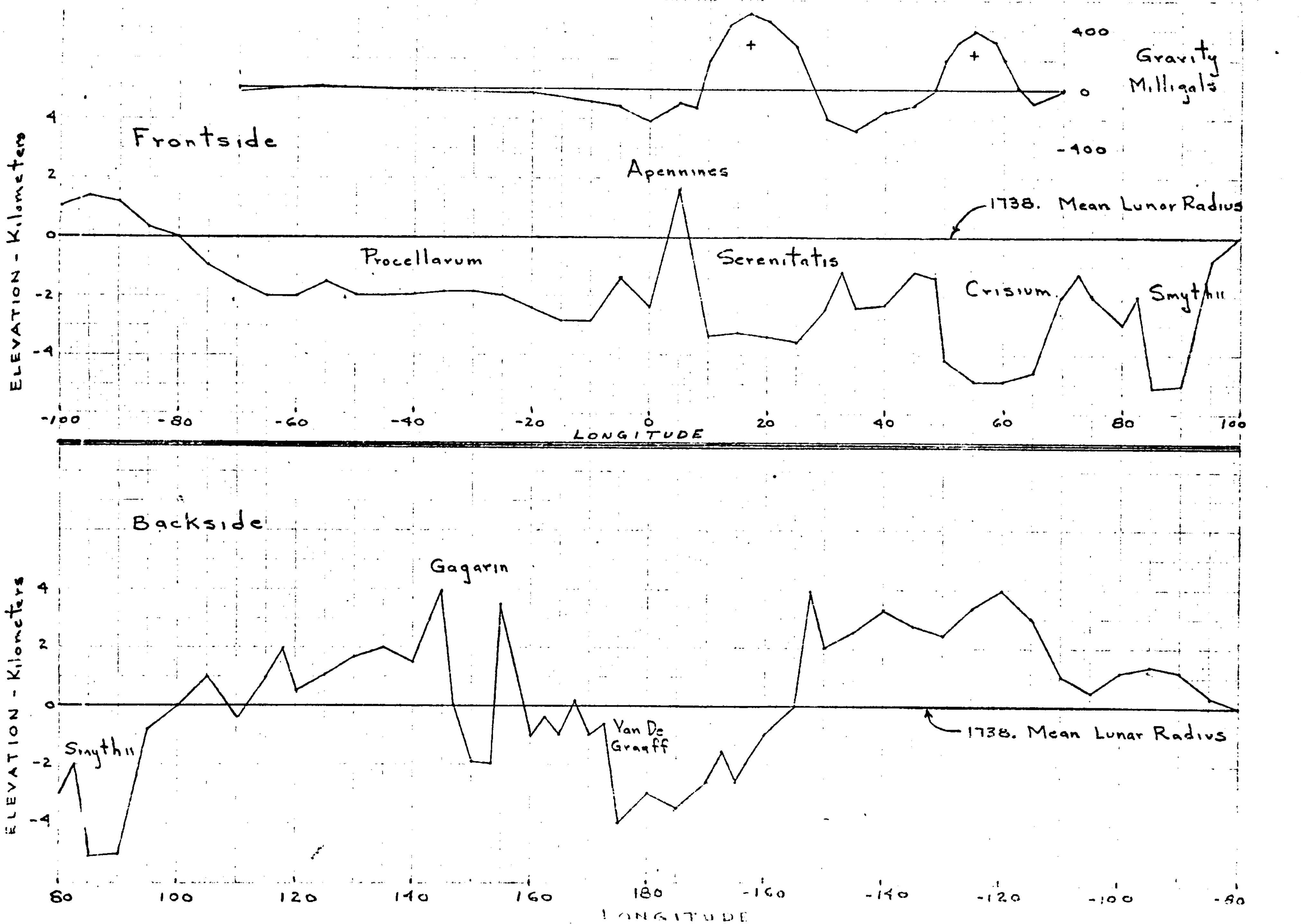
*** Outgassing time not included.

TABLE II

Transearth Coast (Total Operating Time, All Modes)

Gamma-Ray Spectrometer	54.5 hrs
X-Ray Spectrometer	26.5 "
Alpha-Particle Spectrometer	55.3 "
Mass Spectrometer	48.5 "

FIGURE 1 - APOLLO 15 GRAVITY AND LASER ALTIMETER DATA



Subject: Apollo 15 Preliminary Orbital Science Results
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From: F. El-Baz and W. L. Piotrowski

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