DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE
USAF AERONAUTICAL CHART AND INFORMATION CENTER

GEOLOGIC ATLAS OF THE MOON
BONPLAND PQC REGION
I-678 (RLC-4)

### NOTES ON BASE

The base chart was produced in consultation with Dr. Gerard P. Kuiper and the staff of the Lunar and Planetary Laboratory, University of Arizona.

CONTROL

The lunar features on this chart are positioned to conform with the selenographic latitude and longitude coordinates based on the selenographic control as compiled by D.W.G. Arthur and E. A. Whitaker in the Orthographic Atlas of the Moon, edited by Dr. Gerard P. Kuiper, 1960. The position of the impact point is provisional since it was located in respect to surrounding features.

NAMES

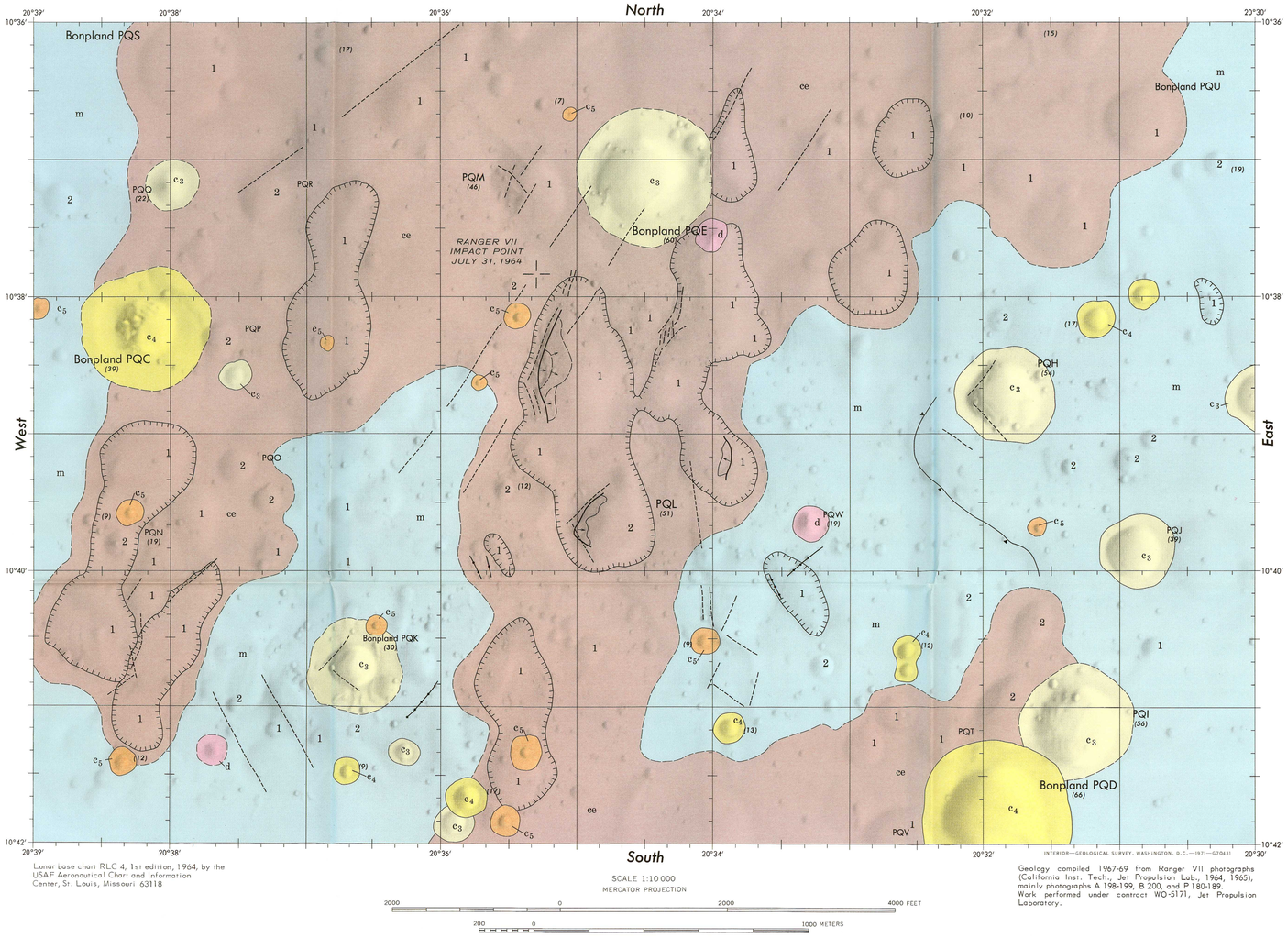
Feature names are adopted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the I.A.U., 1961 and 1964. Supplementary features are associated with the named features through the addition of identifying letters. Craters are identified by capital letters.

ELEVATIONS

The depths of craters were determined by the shadow measuring technique, utilizing Ranger VII photography. Depths are shown in meters.
Depth of crater (rim to floor) .....(60)

PORTRAYAL

The configuration of the relief features shown on this chart is interpreted from Ranger VII television records. The pictorial portrayal of relief forms is developed using an assumed light source from the west, with the angle of illumination maintained equal to the angle of slope of the features portrayed. Cast shadows are eliminated to enable complete interpretation of relief forms.




Lunar base chart RLC 4, 1st edition, 1964, by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

SCALE 1:10 000
MERCATOR PROJECTION

2000 0 2000 4000 FEET
200 0 1000 METERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1971—G70431

Geology compiled 1967-69 from Ranger VII photographs (California Inst. Tech., Jet Propulsion Lab., 1964, 1965), mainly photographs A 198-199, B 200, and P 180-189. Work performed under contract WO-5171, Jet Propulsion Laboratory.

# GEOLOGIC MAP OF THE BONPLAND PQC REGION OF THE MOON

By
S. R. Titley
1971

## EXPLANATION

**$c_5$** — Crater material

Characteristics
*Bright halos; sharp rim crests; interiors cup-shaped; exterior slopes steep; all less than 60 m in diameter*
Interpretation
*Primary impact craters. Ejecta probably the same composition as the material impacted*

**$c_4$** — Crater material

Characteristics
*No bright halos; rim crests slightly subdued; interiors slightly flattened; exterior slopes lower than on $c_5$; mappable rim deposit*
Interpretation
*Primary impact craters, slightly degraded*

**d** — Dimple crater material

Characteristics
*Rimless; convex-upward interior; all less than 100 m in diameter*
Interpretation
*Collapse crater*

**$c_3$** — Crater material

Characteristics
*Rim crests strongly subdued; steep interior walls; flat floors; faint but mappable rim deposits*
Interpretation
*Primary and secondary impact craters, strongly degraded*

**ce** — Material of cluster of elongate craters

Characteristics
*Abundance of shallow gouges and depressions 200-400 m across running approximately north-south; albedo slightly higher than that of surroundings*
Interpretation
*Secondary impact craters formed by clots of material ejected during the formation of Tycho. On map of Bonpland H region (U.S. Geol. Survey, 1971), these craters are interpreted as probably formed by ejecta from Copernicus*

**2 | 1** — Crater materials

Characteristics
*Very strongly subdued rims, 1 more so than 2; flat floors; no mappable rim deposits; shown by number only without geologic contacts; craters labeled "1" mostly in unit ce*
Interpretation
*Highly degraded primary and secondary impact craters*

**m** — Mare material

Characteristics
*Level; albedo low; more extensive outside map area*
Interpretation
*Originally volcanic materials; now soil-like surficial material derived by impact-comminution and other lunar surface processes*

Contact
*Dashed where approximately located*

Lineament
*Gentle trough or very subdued scarp. May be surface expression of faults in bedrock*

Mare scarp
*Barbs point downslope*

Crater chain
Characteristics
*Small, round craters connected by narrow, shallow depression; not overlapping; mostly 10 to 20 m in diameter*
Interpretation
*Either collapse craters along a buried fracture or groups of impact craters*

Irregular depression
*Either elongate single crater or overlapping craters of similar morphology. Probably secondary impact crater or craters*

Slump block
*Arrow shows inferred direction of movement. Probably indicates downslope movement of a discrete mass of loose debris with low cohesion*


INDEX MAP OF THE NEAR SIDE OF THE MOON SHOWING REGIONS MAPPED GEOLOGICALLY FROM RANGER PHOTOGRAPHS
Large arrow indicates area of this report. First number refers to base chart (RLC-4). Second number refers to published geologic map (I-678)

## GEOLOGIC SUMMARY

This geologic map has been prepared from the photographic data returned by Ranger VII and is one of a series prepared from the data returned by the Ranger VII, VIII, and IX spacecraft. The map area, in Mare Cognitum, includes the Ranger VII impact point. The map shows the geologic relationship of surface units at the distal end of a ray from either the crater Tycho (Shoemaker, 1965, p. 86) or the crater Copernicus (U.S. Geol. Survey, 1971). None of the craters nor the surface detail have been resolved on Earth-based photographs; the map area appears as only a faintly bright spot on high-quality full-Moon photographs.

The oldest materials recognized are those which once formed the level mare surface. These materials have been comminuted by impact and modified by shock, radiation, solar wind, and temperature effects. They are interpreted to have originally been volcanic.

Superposed on the mare material is a cluster of elongate craters (unit ce). The topographic forms and surface characteristics of this unit appear to be contiguous with a belt to the south of similar forms and characteristics. In the map area, parallel to subparallel north-trending subdued craters and very gentle depressions, generally deepest and most pronounced at their north ends, are the most conspicuous landforms. They lack prominent rims and are not as distinct as typical circular craters of the same size. Their floors are irregular in profile, and the walls are gently sloping. This form, the consistent alinement of the elongate craters, and the fact that the belt of elongate craters extends to the south suggest the impact of a group of objects traveling at low velocities and low trajectory angles after ejection from Tycho, about 1,000 km to the south.

All the craters in the map area are younger than the mare surface and are probably correlative with the younger class of post-mare craters (Copernican). At the smaller scale of Earth-based photography, most craters of this class are sharp and appear bright under full-Moon illumination.

Individual craters which have been mapped fall into three categories. One category consists of numbered craters. The numbers assigned express relative age in a very general way, the higher numbers for younger craters. The small sharp bright craters, mapped as 5, are probably the youngest. The elongate depressions and the craters they comprise are numbered 1 or 2 without geologic contacts. The depressions are the oldest post-mare features in this area. However, because the influence of crater size on the "weathering" rate of secondary craters could not be assessed in this region, it is possible that these depressions and craters are as young as some craters with higher numbers; numbers 1 and 2 may be accurate only in indicating characteristics of form.

A second category of craters is made up of "dimple" craters, a name suggested by Kuiper (1965, p. 11). These craters, indicated by the letter "d," tend to be uniformly circular in this area; they lack rims, and their walls are convex upward. They have been interpreted as the result of collapse of surface materials into subsurface openings, which may be lava tubes or fractures underlying the surface materials. Although dimple craters in other parts of the Moon tend to be alined, suggesting a subsurface linear control, they are not alined in this part of Mare Cognitum.

The third category of crater types consists of chains of small craters, probably quite young, but with no details resolvable by the Ranger data. As many of the small craters are connected by shallow troughs, two possible modes of origin are suggested. They may represent lines of small dimple craters and their alinement may be the result of a subsurface opening, or they may represent clusters of small secondary impact craters formed by objects of unknown provenance.

A northeast-trending structural grain is expressed by the parallelism of linear features such as minor scarps and troughs, as well as by some polygonal craters whose sides also trend northeast. It is probable that more structural grain than has been mapped exists in this region. The illumination of the surface at the time of the Ranger VII experiment was such as to enhance the image of structural detail present on east-facing forms and to weaken the image of such detail on west-facing forms.

Two features of special interest were discussed in a report on Ranger VII. One of these, at lat 10°38′30″S., long 20°35′30″W., has been interpreted as a scarp developed by slumping (Shoemaker, 1965, p. 106, 108) or as a crack (Urey, 1965, p. 145). It is shown on the map as a slump block. The other feature, at lat 10°38′15″S., long 20°38′15″W., is a crater whose floor appears to be strewn with large blocks. Shoemaker (1965, p. 108) has suggested that the protuberances in this crater are the result of slumping of the crater wall. Urey (1965, p. 138) suggested two origins for this feature, one involving deposition, by evaporation, of material carried upward by gasses from within the Moon and the second, which he favors, calling upon pelletizing of some low-density material upon impact.

## REFERENCES

California Institute of Technology, Jet Propulsion Laboratory, 1964, 1965, Ranger VII photographs of the Moon: U.S. Natl. Aeronautics and Space Adm. Spec. Pubs. 61, 62, 63.

Kuiper, G.P., 1965, Interpretation of Ranger VII Records; *in* Ranger VII, pt. 2, Experimenters' analyses and interpretations: California Inst. Technology, Jet Propulsion Lab. Tech. Rept. 32-700, p. 9-74.

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Urey, H.C., 1965, Observations on the Ranger VII pictures, *in* Ranger VII, pt. 2, Experimenters' analyses and interpretations: California Inst. Technology, Jet Propulsion Lab. Tech. Rept. 32-700, p. 135-148.

U.S. Geological Survey, 1971, Geologic map of the Bonpland H region of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-693.

For sale by U.S. Geological Survey, price $1.00