DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE
USAF AERONAUTICAL CHART AND INFORMATION CENTER

NOTES ON BASE

The base chart was prepared by ACIC with advisory assistance from Dr. Gerard P. Kuiper and his collaborators, D. W. G. Arthur and E. A. Whitaker.

DATUM

The assumed lunar figure is that of a sphere corresponding to the mean lunar radius of 1738 kilometers. Elevations are referred to a spherical datum 2.6 kilometers below the mean radius to minimize minus elevation values.

CONTROL

The horizontal and vertical positions of features on this chart are based primarily on the positions of 130 major craters measured by J. Franz and computed by Schurbe-Reichenstoner. This control network is supplemented by ACIC extensions in localized areas. Additional horizontal control points are based on the lunar coordinates of craters of Selenographic Positions by D. W. G. Arthur and the coordinates of 488 lunar features by B. Baldwin. The probable error of the control is evaluated at 1000 meters.

ELEVATIONS

All elevations are in meters. They are referenced to the assumed vertical datum unless indicated as relative elevations. The relative elevations of crater rims and other prominences above the surrounding terrain and depths of craters are determined by the shadow measuring technique as refined by the Department of Astronomy, Manchester College, Oxford, England, for Project Ranger. The probable error of the localized relative elevations is 100 meters in the vicinity of the center of the moon with the magnitude increasing to 300 meters at 75° from the center due to foreshortening.

Elevations (referenced to datum)	1100
Depth of crater (rim to floor)	(400)

Relative Elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated 3000

NAMES

Feature names were adopted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the I.A.U. (1961 and 1964).

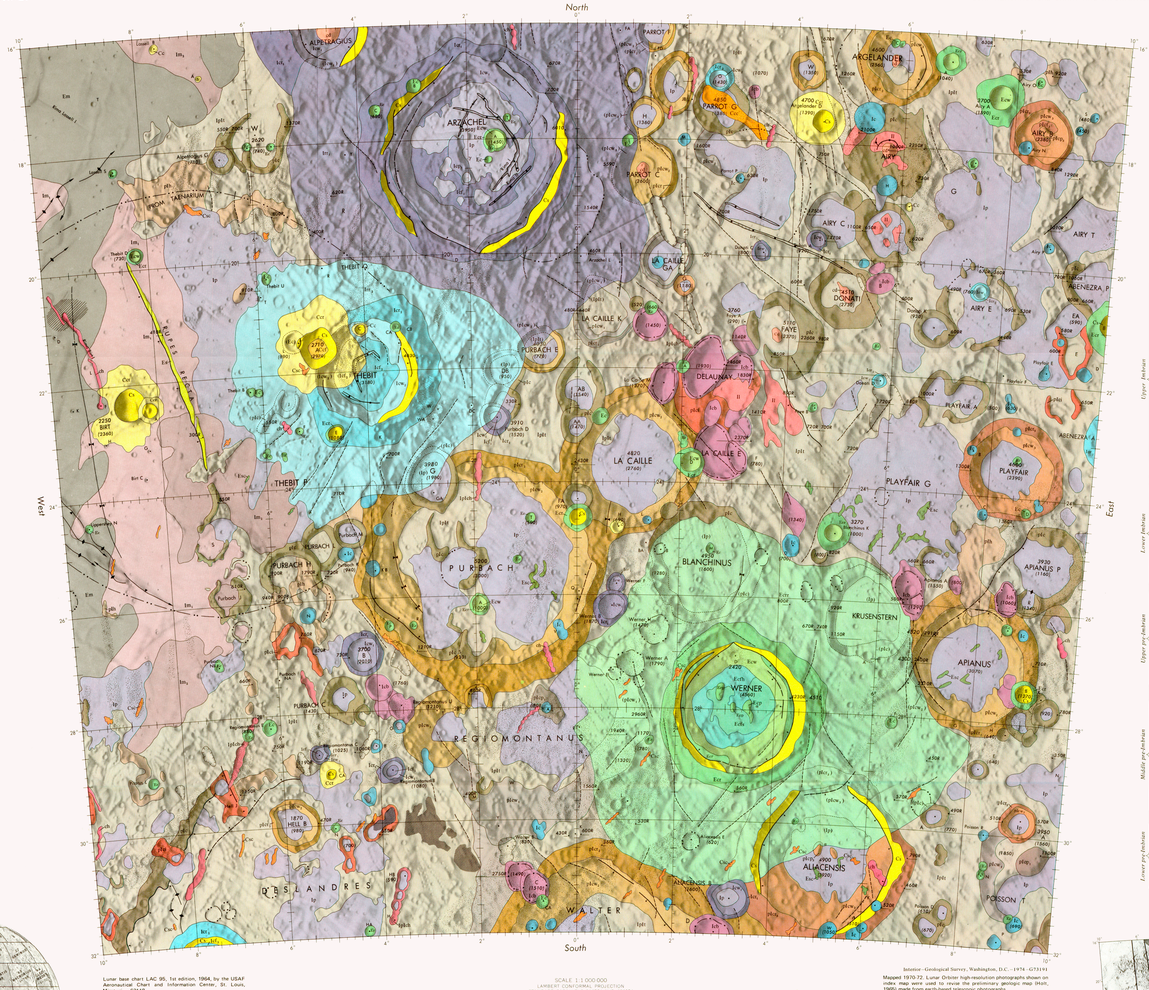
Supplementary features are associated with the named feature and are identified by lowercase letters. Craters are identified by capital letters. Entrances are identified by Greek letters.

Names of the supplementary lettered features are deleted when the association with the named feature is apparent. A block dot is included, where necessary, to identify the exact feature or features named.

PORTRAYAL

The configuration of the lunar surface features shown on the base chart is interpreted from photographs taken at Lick, McDonald, Mt. Wilson, Yerkes, Story Ridge, Kwasan, and Pic du Midi Observatories. Supplementary visual observations with the 20 and 24 inch refracting telescopes at the Flagstaff Observatory are included where they are identified by capital letters. Entrances are identified by Greek letters.

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.



Lunar base chart LAC 95, 1st edition, 1964, by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

SCALE 1:1 000 000
LAMBERT CONFORMAL PROJECTION
STANDARD PARALLELS 21°30' AND 42°40'

Interior—Geological Survey, Washington, D.C.—1974—G73191

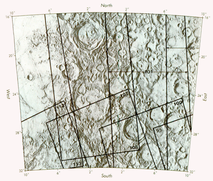
Mapped 1970-72. Lunar Orbiter high-resolution photographs shown on index map were used to revise the preliminary geologic map (Holt, 1968) made from earth-based telescopic photographs

Prepared on behalf of the National Aeronautics and Space Administration under contract Nos. R-66 and W-13, 130

INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON
(Number above quadrangle name refers to lunar base chart (LAC series); number below refers to published geologic map)

GEOLOGIC MAP OF THE PURBACH QUADRANGLE OF THE MOON

By
H. E. Holt
1974



LUNAR ORBITER IV HIGH-RESOLUTION COVERAGE OF PURBACH QUADRANGLE

EXPLANATION

Cc, Ccr, Csf — Materials of rayed, topographically sharp craters

Characteristics
Cc, crater material, undivided
Ccr, crater rim
Csf, floor material
Interpretation
Material of primary impact craters. Rim material, ejecta. Floor material, fallback and brecciated bedrock

Cbr — Material of bright crater cluster

Characteristics
Sharp, bright, mostly circular, shallow craters forming a northwest-trending swath east of crater Tycho
Interpretation
Swarm of probable primary impact craters

Csc — Satellitic crater material

Characteristics
Small, bright, sharp-rimmed, elongate craters mostly occurring in aligned, overlapping clusters; or radial-textured pattern. Long axes of clusters radial to crater Tycho (outside quadrangle)
Interpretation
Materials of secondary impact craters formed by blocks ejecta from crater Tycho

Cs — Bright stope material

Characteristics
Material on steep slopes, usually smooth-appearing and featureless. High albedo. Common on crater walls, near crater rim crest, may include areas of smaller craters
Interpretation
Brecciated bedrock and talus probably exposed by mass-wasting on steep slopes

Cry — Ray material

Characteristics
Material of high albedo extending as diffuse streaks northeastward across quadrangle and radial to crater Tycho (outside quadrangle). Also occurs as bright irregular halos around small Copernican craters
Interpretation
Impact ejecta made up of small, fresh rock fragments and materials within numerous young unprovided secondary impact craters. Mostly originates from crater Tycho

STRATIGRAPHY

Em — Mare material

Characteristics
Smooth, relatively dark material with well-defined boundaries. High-resolution photographs indicate that oldest superposed craters are of Eratosthenian age
Interpretation
Basaltic flows of probable Eratosthenian age

Ec, Ecr, Ecc, Ecw, Ecfb, Ecrb, Ecp — Materials of sharp-rimmed, rayless craters

Characteristics
Ec, crater material, undivided
Ecr, rim material
Ecc, rim material, radially ridged
Ecw, wall material
Ecfb, floor material, smooth
Ecrb, floor material, hummocky
Ecp, central peak
Interpretation
Impact crater materials; erosional processes have only slightly subdued crater units. Rim material, ejecta, blocks from rim crest, smaller fragments towards outer rim. Radial rim material, ejecta, decreasing in thickness outward. Wall material, brecciated bedrock, mostly talus. Floor materials, brecciated shocked material, mostly fallback; may include shock-melted material and volcanic material. Peak material, fractured and faulted bedrock uplifted by rebound after impact

Ess — Slope material

Characteristics
Moderately bright slope material along the Rupes Recta scarp. Albedo higher than surface materials effect by fault
Interpretation
Blocks, rock fragments, and bedrock of mare and other materials exposed along fault scarp. Albedo due to relatively recent exposure of fresh materials by downslope movement

Imr, Im — Mare materials

Characteristics
Extremes due to gently undulatory dark surfaces, smooth appearance on LO IV high-resolution photographs; contacts between units gradational
Imr, has lower albedo and lower density of small craters than unit Im, and overlays Im
Im, has lower albedo and lower density of small craters than plains unit (Ip) and overlays plains unit
Interpretation
Volcanic material, mostly interlayered basalt flows and ash beds. Albedo differences probably reflect age differences, the higher albedo unit being the older, probably due to greater brecciation and/or compositional differences between the basalts

Il — Lobate material

Characteristics
Smooth to slightly hummocky, flowlike material having lobate margins with steep scarps, smooth material (ils) and irregular (ilci) and bowl-shaped (ilcb) craters. Major occurrence is at crater Delaunay along southern extension of large trough radial to Imbrium basin. Also present on rim and floor of crater Airy
Interpretation
Volcanic material extruded from fissures structurally controlled by troughs radial to Imbrium basin

Icr — Crater material

Characteristics
Similar to undivided material of younger craters (Ec, Ecr) but more subdued and less bright
Interpretation
Impact crater materials of Imbrian age

Ip — Smooth plains material

Characteristics
Forms smooth to moderately cratered generally level floors in Imbrian and older craters; occurs as irregular patches in low interrupter areas. Partly overlapped by older mare material (Im,) and younger ring plains material (Ir). Differs from depression in depression. Albedo intermediate
Interpretation
May be accumulations of relatively fine impact debris and volcanic ash. Some of the smooth and gryskatic material may be mixed com ponents. Variation in small-crater density suggests intermittent accumulation over long period, emplaced before major episodes of mare volcanism

Ir, Irr, Icw, Icf, Icp — Materials of moderately subdued craters

Characteristics
Ir, rim material, undivided
Irr, rim material, radially ridged
Icw, wall material
Icf, floor material
Icp, central peak
Interpretation
Impact crater materials of late Imbrian age. Morphologic characteristics have been slightly altered by lunar erosional processes

Ilci, Ilcr, Ilcw, Ilcf, Ilcp — Materials of subdued craters

Characteristics
Ilcr, rim material
Ilcr, rim material, radially ridged
Ilcw, wall material
Ilcf, floor material
Ilcp, peak material
Interpretation
Largely impact crater materials

Ilcb — Material of bowl-shaped craters

Characteristics
Undivided material of shallow, elongate to circular, narrow-rimmed craters ranging in diameter from about 8 to 10 km. Rim crests generally well defined; walls grade into surrounding terrain. Most craters occur in trough along southern extension of major trough radial to Imbrium basin where it is associated with lobate material (unit Il). Craters resemble bowl-shaped craters in Mare Orientale quadrangle (Scott, 1972)
Interpretation
Material of secondary craters formed by ejecta from Imbrium basin or by volcanic activity

Ilpci, Ilpcw, Ilpcf, Ilpcp — Materials of subdued craters

Characteristics
Ilpci, rim material
Ilpcw, wall material
Ilpcf, floor material
Ilpcp, peak material
Interpretation
Materials similar in origin and nature to corresponding younger units but more highly modified by mass-wasting and impacts

Ilpcr, Ilpcw — Materials of very subdued craters

Characteristics
Ilpcr, rim material
Ilpcw, wall material
Interpretation
Probably impact crater materials

Ilpcr, Ilpcw, Ilpcp — Materials of highly subdued craters

Characteristics
Ilpcr, rim material
Ilpcw, wall material
Ilpcp, peak material
Interpretation
Probably materials of impact craters but definitive morphologic criteria of origin absent

Ilpc — Undivided crater material

Characteristics
Undivided materials of craters mostly having irregularity; highly degraded rims and walls
Interpretation
Impact origin generally assumed because of random distribution and lack of definitive morphologic criteria of origin lacking

Ilpci — Materials of irregularly shaped craters

Characteristics
Undivided material of shallow craters having elongate or irregular outlines. Craters occur in trough along southern extension of major trough radial to Imbrium basin where it is associated with lobate material (unit Il). Craters resemble bowl-shaped craters in Mare Orientale quadrangle (Scott, 1972)
Interpretation
Unknown origin; some craters possible formed by ejecta from pre-Imbrian basins or are of volcanic origin

Ilpb — Hilly material

Characteristics
Material of irregular hills, small ridges, and domes having moderate to steep slopes and rounded summits. In places embayed by rolling terra (unit Ilpt) but small isolated occurrences of hilly material may be mistaken for associated with pre-Imbrian crater rims. Appears similar to the Descartes materials at the Apollo 16 landing site (Milton and Hodges, 1972)
Interpretation
Ejecta deposits and partly buried crater materials formed by pre-Imbrian impacts; possibly includes some volcanic material. Apollo 16 lunar samples did not include typical volcanic materials but did include partially fused (melted) breccias (Apollo Lunar Geology Investigation Team, 1972)

Ilpt — Rolling terra material

Characteristics
Cratered, hilly to hummocky, undulatory terrain containing small isolated smooth-appearing tracts. Slopes gentle to moderate; rarely steep. Hills and hummocks have rounded summits. Appears to overlap rim materials of some pre-Imbrian and early Imbrian craters
Interpretation
Pre-Imbrian and Imbrian impact ejecta material, mostly fine-grained, with some coarser material. Some of the smooth and gryskatic material may be mixed components. Variation in small-crater density suggests intermittent accumulation over long period, emplaced before major episodes of mare volcanism

Ilpch — Chain-crater material

Characteristics
Three or more aligned overlapping craters. All craters in a chain have similar morphology, but degree of subdual varies among chains. Rims moderately raised around larger members in a chain, and floors covered by plains material. In smaller chains rims absent and craters walls merge with floors. Chains mostly aligned along major lunar grid directions
Interpretation
Volcanic craters, alinement structurally controlled by lunar grid fracture system. Age variable but probably ranges from pre-Imbrian to Imbrian

Contact

Buried contact
Shown limit of topographic expression of the buried unit indicated by symbol in parentheses

Fault
Short dashed where concealed; bar and ball on downthrown side

Graben
Ball on line where faults closely spaced

Shallow trough

Mare ridge
Line marks ridge crest; arrow shows direction of decreasing relief

Crater chain
Three or more aligned, tangential or overlapping craters mostly greater topographically sharper than those of unit Ilpch
Interpretation
Structurally controlled volcanic craters or collapse depressions; some may be secondary craters from unidentified sources. Age indeterminate

Crater dome material
Circular to elliptical large dome or peak inside craters located along structural troughs. Domes are topographically subdued and partly associated with centers of similar size and shape
Interpretation
Structurally controlled volcanic domes. Age uncertain but probably younger than crater with which associated

Dark mantling material
Dark, smooth to slightly mottled surface. Overlies mare and terra material
Interpretation
Volcanic material, probably pyroclastic layers

Scarp
Line marks base of scarp; barbs point downslope; arrow shows direction of decreasing relief

Lineament
Linear trough or ridge

Ridge marking rim crest of highly degraded or buried crater

Prominent rim crest of bowl-shaped craters

Depression

Rimmed trough or graben
Double bar points downdrop

COPERNICAN SYSTEM

ERATOSTHENIAN SYSTEM

IMBRIAN SYSTEM

PRE-IMBRIAN

INTRODUCTION

The Purbach quadrangle is in the south-central part of the lunar near side and includes the frontal part of the Imbrian basin and the southwestern part of the Fecunditatis basin. A wide belt extending north-south through the central part of the area, locally dominated by large troughs ("sculptures") of Imbrian age (Gilbert, 1893; Hartmann, 1963a), is subdued and in places where both isolated and interconnected topographic lows are partly filled with plains material. Ir terra and plains materials of low relief in the southwest which obscure the large ancient crater Doslandes, 41 basalt flows of Mare Nubium which embay and overlap the adjacent terrae along the west-central and northwestern parts of the quadrangle.

The Purbach quadrangle is located where Mare Nubium is narrowest. The quadrangle is located near the center of the map, and the buried remnants of two large ancient craters extend beyond the quadrangle—Doslandes in the southwest and the vague nearly circular structure around Rupes Recta (Straight Wall) in the west. The much younger craters Arzachel (90 km diameter), Werner (70 km diameter), and Thebit (50 km diameter), with their associated ejecta blankets, dominate the central quadrangle.

Unlike many other areas of the Moon that have been mapped, the Purbach quadrangle seems to be devoid of ejecta from a major basin-forming event. Most of the surficial deposits are made up of mare, plains, terra, and crater materials. Most units are dated relatively by transection, superposition, embayment relationships, and the density of small craters superposed on their surfaces in addition, relative crater ages are determined from the apparent degradation of crater morphology with time (Pohn and Offield, 1970). The units are then correlated with units in the lunar time-stratigraphic systems of Shoemaker and Hackman (1962) as modified by Wilhelms (1970) and Wilhelms and McCauley (1971).

PRE-IMBRIAN MATERIALS

Much of the terra consists of overlapping and intersecting broken rims of old craters mantled as arcuate ridges and scarps which are embayed and partly covered by plains and terra materials. Some of the large early pre-Imbrian craters such as Purbach and Regiomontanus have nearly continuous outlines and shallow floors filled mostly by younger materials. Interrupter highland terrain is in large part rolling to hilly and probably exposes topographically the partly buried remnants of older craters. Much of the terra is hilly and rolling with irregular to chain-shaped depressions (Ilpb). Some of these deposits may be volcanic, but most are probably accumulations of impact ejecta and mass-wasted material. Ridges, low scarps, and lineaments mainly aligned northeast-southwest and northwest-southeast cut across the broken crater rims and hilly topography. These features are probably the surficial expressions of an ancient lunar fracture system along which faulting has occurred intermittently. Terrain that bears the imprint of such a lineament system is probably pre-Imbrian and early Imbrian in age.

IMBRIAN MATERIALS

There is no extensive stratigraphic horizon in the Purbach region that can be dated as early Imbrian (Wilhelms and McCauley, 1971). The oldest Imbrian materials are the deposits of unit Ilcb. Attached are radial to the Imbrian basin and may have been formed by material ejected from the basin; alternatively, they may be largely structural in origin and thus contain only of disrupted older materials. Many craters are classified as either early or late Imbrian on the basis of their morphology (Pohn and Offield, 1970) and (or) the stratigraphic position of their materials relative to other units of known Imbrian age, such as some mare and plains materials. In the northeast quadrant of the map, bowl-shaped craters (Ilcb) occur along the troughs of Imbrian sculpture. The craters appear shallower than craters of the same size in the Mare Orientale quadrangle (Scott, 1972) and Mare Nubium. The largest cluster, within and around the crater Delaunay, occurs at the southern end of a trough and some adjacent materials (Il) have lobate outlines suggesting flowage. These materials may have developed along fractures associated with the trough and may be of volcanic origin, alternatively they may be secondary ejecta produced during the Imbrian event. Prominent, rounded domes (ed) are present within some craters (Alphonsus, Purbach, and others) occurring along the troughs and lineaments radial to the Imbrium basin; the crater Airy contains dark mantling with rilles in its floor. These domes may be volcanic or intrusive in origin (Schaber, 1973).

A plains-forming unit (Ip) occupies the floors of some Imbrian craters and many older craters as well as irregular low areas throughout the terra. It covers part of the floor of the lower Imbrian crater Arzachel and the floors of many older craters. The surface of this unit is smooth and flat to gently undulating, and it has a higher density of small craters than Imbrian mare materials. Low ridges and scarps that are part of the rim of older craters are well preserved in some craters. Lineaments in the higher terra adjacent to the plains unit commonly appear more rounded and subdued than elsewhere in the uplands; these areas are probably covered by a thin veneer of plains material or volcanic ash. Contacts between the plains-forming unit and the older rolling terra material (Ilpt) are mostly gradational. The plains-forming and rolling terra materials are not clearly related to any impact event, but they probably contain some ejecta from Imbrian and younger craters. Although seemingly of local origin, these units probably consist predominantly of ejecta, with possible minor volcanic components.

Mare materials of Imbrian age overlap plains and terra materials along the west side of the quadrangle. Younger (Im,) and older (Im,) units are distinguished on the basis of albedo and the density of small craters: the younger mare is darker and less pitted than the older. Primary impact craters of Eratosthenian age are superposed on these units, and they are transected by the Rupes Recta fault scarp. The mare materials are undoubtedly mostly basalt flows similar to those at the Apollo 11, 12, and 15 landing sites.

ERATOSTHENIAN AND COPERNICAN MATERIALS

Mare material (unit Em) having a lower albedo and a lower density of small craters than mare units of Imbrian age is assigned to the Eratosthenian System. Some Eratosthenian craters are superposed upon this mare material (mostly outside the quadrangle), whereas others are embayed by it. Small patches of dark mantling material occur near Doslandes and at the north end of Rima Birt (rilles). The latter occurrence may be a pyroclastic deposit originating from an elongate crater at the end of the rille. Crater materials of Eratosthenian and Copernican age are subdivided into crater rims, walls, and floor units are represented, as well as secondary craters and bright ray and slope materials. Like rays, bright slopes darken with time (Shoemaker, 1962; p. 345) unless freshly exposed bedrock and talus are maintained through mass-wasting processes.

STRUCTURE

The most prominent structure is Rupes Recta, a large northwest-trending fault scarp which transects Imbrian mare materials and some older terra. Its surface trace is over 110 km long, and the vertical displacement of the mare surface is as much as 410 meters. The fault scarp is centrally located in an ancient crater whose buried rim crest is more than 220 km in diameter. The crater's floor has subsided and has been buried by mare material, but the position of the rim crest is outlined by mare ridges. The eastern half of the crater rim, although buried by terra and younger mare material, has been structurally uplifted and tilted to form the high terra that underlies the earlier drought along the northwest and southeast extension of the Rupes Recta scarp. The present scarp thus probably results from recent movement along an older pre-existing fault that was active after mare materials were emplaced. Rupes Recta provides an ideal exposure of the mare section in this part of the Moon, and bedded mare units or layers may be resolvable when high-resolution photographs are available.

Other structural features, mostly in the highlands, include small scarps, grabens, troughs, rilles, and lineaments. They are either aligned with the Imbrian basin or have a northeast-southwest trend. The absence of obvious structural trends radial or concentric to adjacent Mare Nubium suggests that this basin may not have been produced by a major cratering event; Wilhelms and McCauley (1971), however, recognized three vague structural highs mostly to the southwest of Nubium and outside the Purbach quadrangle that may be part of an impact-related multi-ring system. Faults and lineaments in the terra are mainly aligned with the lunar grid system. Some are older yet but not plains material, and thus must be older than that material. Large troughs attributed to Imbrian sculpture die out southward within the quadrangle. Craters with large central domes occur along the southwestern margin and clusters of bowl-shaped craters occur near that terminus. Probably, either these troughs are controlled by faulting, or faults developed along the troughs, localizing later volcanic activity. Several lineaments and narrow grabens radiate southeastward from Arzachel and probably represent structural adjustments along the pre-existing lunar grid caused by the Arzachel impact-cratering event. A large graben, approximately 80 km long and 20 km wide, extends along the northwest side of the old crater Doslandes. Chain craters occur along margins of the depression. This feature appears to be structurally controlled, and it is mapped as a graben.

GEOLOGIC HISTORY

The earliest lunar surface history is recorded in the ancient highland terrain by remnants of large craters. The impacts which presumably formed these overlapping craters broke and thoroughly mixed together any pre-existing surface layers down to depths of several kilometers. The terra material represents an agglomerate of brecciated debris. Volcanism probably occurred during pre-Imbrian time, volcanic materials may be intermixed with impact ejecta and perhaps have smoothed the more rugged terrain.

The impact that formed the Imbrian basin about 3.300 km to the north initiated the Imbrian period of lunar history. Ejecta from this impact may have formed some of the bowl-shaped craters in the Purbach quadrangle as it has in the Mare Orientale quadrangle farther to the southeast (Scott, 1972). Cratering, volcanism, and structural adjustments continued during the Imbrian Period, and the formation of the crater Arzachel was the dominant impact event. Widespread ejecta blankets and perhaps some volcanism produced the smooth plains (Ip) and rolling terra (Ilpt) units. The advancing Mare Nubium basalts buried the western terra regions, covering the down-faulted western rim and floor of the large crater around Rupes Recta, whose present scarp had not yet formed.

Cratering and some volcanic activity continued into the Eratosthenian Period with the formation of the large impact crater Werner (70 km diameter) and flooding by mare basalt which encroached along the extreme western margin of the quadrangle. No major craters were formed in the Purbach region during the Copernican Period. The large Copernican crater Tycho, about 330 km to the southeast, has contributed secondary ejecta to the Purbach region. Secondary impact craters and clusters of secondary impact craters within the Purbach quadrangle. Minor local volcanic activity occurred during the Eratosthenian and Copernican periods, and dark mantling material was emplaced within the Doslandes crater and at the end of Rima Birt (rille. Major faulting reoccurred along the east margin of Mare Nubium and produced the large Rupes Recta scarp.

As previously mentioned, mare basalts in eastern Mare Nubium resemble those at the Apollo 11 and 12 landing sites and presumably are about the same age, 3.3-3.6 billion years old (Wasserburg, 1970; Jackson, 1970). Because of the close relationship between craters and Rupes Recta, nearly all the major elements of the lunar surface in the Purbach quadrangle predate the mare materials and formed early in the Moon's history—probably more than 3.5 billion years ago.

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