DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

GEOLOGIC ATLAS OF THE MOON
NEAR SIDE OF THE MOON
I-703

GEOLOGIC SUMMARY

MARIA AND MULTI-RING BASINS

The circular basins, generally encompassed by three or more partly complete scarps or ring systems, dominate the geology of the Moon's near side. Diameters of the innermost ring range from 250 to 600 km (kilometers), and the spacing of the three inner rings increases from one to the next by a regular ratio (Hartmann and Kuiper, 1962). The observed and inferred crest lines of the most prominent of these structures are shown by brown lines on the accompanying map. The depressed central parts of the basins and the concentric troughs which lie between successive rings are completely or partly filled with dark plains material (mare) which is younger than the basins and which appears to have been emplaced in a fluid and probably molten state. These basins and their subsequent mare fill have destroyed large parts of the earlier geologic record, and in this respect have acted like terrestrial orogenies. The historical geology of the Moon can be understood only in terms of these dominant, primitive structures which, if ever present on Earth, have long since been obliterated or deeply buried and severely modified.

The general circularity of the basins, the textural similarity of the materials of the ring structures, and the regularity of the ring spacing suggest a common origin. If all basin-related features are considered, particularly for the best preserved basins, an impact origin, as first suggested by Gilbert (1893), is strongly favored. The inner rugged rings of the two best preserved basins, Orientale (just outside the map area) and Imbrium, are surrounded by distinctive ejecta blankets (Hevelius Formation and Fra Mauro Formation respectively) which can be traced outward for hundreds of kilometers. Relicts of what is probably a third, more degraded and older ejecta blanket (Janssen Formation) can be recognized south of the Nectaris basin. Within and beyond these blankets, chains and clusters of craters have been identified as probable secondary impact craters on the basis of morphology, size, and distance from the basin (see section on crater materials). Observable differences among basins—such as the presence or absence of a recognizable blanket, the completeness of the concentric ring structures, the freshness and relief of the rings, the character of the radial structures, and the types and numbers of superposed craters—can be explained by variations in relative age, degree of filling by younger mare, or proximity to younger basins. Alternative explanations for the multi-ring basins calling for an internal origin (Spurr, 1944; Green, in Oriti and Green, 1967) are inadequate because of failure to account for all of the basins' observable properties, relative ages, and relations to subjacent and superposed units such as the maria.

A considerable body of stratigraphic evidence shows that the mare material in the basins is not the immediate and direct product of the basin-forming impact but a later volcanic fill: (1) The mare truncates all other basin-related deposits and structures. (2) It is located in basin-related topographic lows, including troughs between the outer rings far from the basin centers. (3) The mare surface materials in all basins appear to have a narrower age range (determined from the number of superposed craters) than the basins, which differ greatly in state of preservation and apparent relative age. (4) Craters which are superposed on the basin ejecta or basin-related structures but are embayed or filled by mare material occur in every basin (for example, Posidonius, Gassendi, Cleomedes, and Fracastorius in the Serenitatis, Humorum, Crisium, and Nectaris basins respectively). The postbasin, premare craters within the Imbrium basin (that is, Imbrian-age craters) are approximately equal in number to the total number of postmare craters (Eratosthenian and Copernican ages) in the same area. Thus a considerable interval between basin formation and final mare filling is suggested. (5) A distinct geologic unit, light plains material (unit Ip), lies stratigraphically between the deposits of the Imbrium basin and postbasin, premare crater materials, including those of Archimedes, Cassini, and Plato. (6) Features far from and unrelated to the Imbrium basin are also of Imbrian age, demonstrating an extensive history between the formation of the basin and the last mare fill. Orientale is one such Imbrian-age feature, and many Imbrian craters apart from those in the Imbrium basin both predate and postdate Orientale. (7) The nearside basins are filled by mare to varying structural levels independently of their size. For example, Nectaris is filled to the first ring and Crisium and Imbrium to the second and third respectively. Uneven filling suggests different volumes of mare material in each, reflecting internal rather than external (impact melting) controls on their filling.

Each basin immediately after excavation and early gravitational slumping probably resembled the present youthful-appearing Orientale basin (McCauley, 1967b, p. 439-446; 1968). Orientale is the key to the internal configuration of the more degraded and deeply filled basins because of its lack of extensive mare filling and its relative youth. Its present shallow profile suggests that the thickness of the mare fill even in more deeply flooded and obscured basins like Imbrium is on the order of only 2 to 5 km. Mare material, although covering almost 30 percent of the nearside surface (and very little of the far side) is, therefore, volumetrically a small part of the Moon (radius 1738 km). The deeply flooded basins like Imbrium may lie in regions where potential source material was at shallower depth than it was in the less filled basins like Orientale and Nectaris. The existence of numerous thalassoids (basins without mare fill) on the far side of the Moon (Lipskiy, 1966) further supports the conclusion that the location of a basin and local crustal conditions determine the degree of later flooding.

Oceanus Procellarum is unusual because of its non-circular, somewhat irregular shape. It is the largest expanse of mare on the Moon that is not obviously controlled by a single circular multi-ringed basin. It contains, throughout most of its extent, numerous terra islands and large ghost or vestigial craters such as the Flamsteed ring which collectively suggests that the mare is relatively shallow. Its overall shape however, appears to be controlled by outer ring structure of the Imbrium basin and two vague, ancient ring structures centered near Copernicus and Flamsteed which were identified during this work.

During and after the period of flooding, meteorite bombardment eroded and subdued the basin rings and blankets through direct hits, impact of far-flung secondary ballistic fragments (Shoemaker, 1965), and seismic shaking of the surrounding terrain triggering downslope movement of loose materials (Titley, 1966). This process led to the eventual disappearance of the distinctive depositional textures of the circumbasin blankets. Catastrophic premature aging and partial obliteration of basins is exemplified by Serenitatis, whose rings have been disturbed structurally and mantled by ejecta from the nearby Imbrium basin. The trend of the younger Imbrium rings has in turn been influenced by the presence of the earlier Serenitatis structure as seen in the change in the trend of the "Apennine" ring in the Montes Caucasus region.

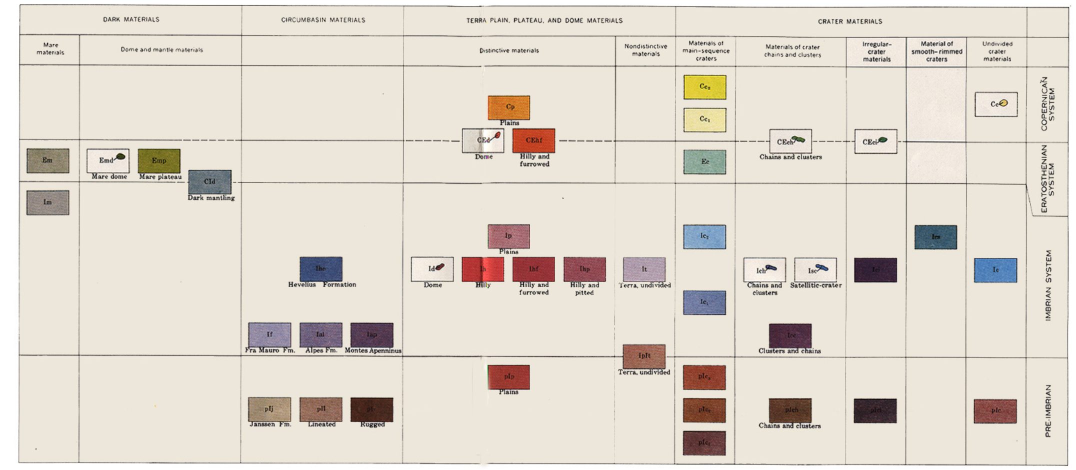
TERRA PLAIN PLATEAU AND DOME MATERIALS

Prior to formation of the youngest mare material, the basins were also modified by the deposition of several types of distinctive terra units described in detail in the accompanying explanation. The most extensive of these are the light terra plains materials of Imbrian age (unit Ip) which lie predominantly in circumbasin troughs and on the floors of pre-Imbrian and lower Imbrian craters. Plains identified as pre-Imbrian (pIp) by superposition of lowermost Imbrian crater clusters occupy more restricted areas in the southern terra. These two marelike plains units may represent earlier generations of volcanism and crustal flooding; their present high albedo relative to the mare material being due either to initial compositional differences or to more extensive churning and consequent brightening by prolonged meteorite bombardment. The most distinctive terra unit (hilly and furrowed material, Ihf) forms level or shieldlike plateaus that cover basin ejecta and postbasin craters and contain numerous small primary volcanic landforms. The two largest occurrences lie west of Nectaris between the third and fourth rings and northwest of Humorum athwart and beyond the third ring. These plain and plateau units, which apparently modify earlier basin or crater deposits, suggest a more extensive history of lunar volcanism than previously recognized. Moreover, they differ markedly in albedo and roughness from the dark, relatively smooth mare volcanic deposits and they may thus represent the products of a distinct terra magma or of mare magma contaminated by terra materials. The bulk differences in composition from the maria could, however, be minor, as in the case of terrestrial cone and flow materials within the same volcanic field. The distribution of the terra volcanic units is controlled predominantly by basin ring structures; some occur at the intersection of younger rings structures with vague circular depressions which are the probable relicts of very ancient basins. In addition to these more extensive deposits, several types of domes, mostly in the 10 km size range, have been identified both in the maria (units Emd, Emp) and in the terrae (units Id, CEd). Many of these, including the largest and most distinctive, the postmare terra domes of the Gruithuisen area southwest of Sinus Iridum, lie along circumbasin ring structures.

CRATER MATERIALS

Craters of all ages, mostly circular, dominate the lunar landscape at all scales. The circular craters, except those deeply buried or in a poor state of preservation because of their antiquity, have physiographic characteristics that indicate an explosive origin (Baldwin, 1949, 1963). Their cumulative frequency distributions are difficult to explain by a volcanic model (Green, 1962) but do fit well with an impact model (Baldwin, 1963). The circular

EXPLANATION



DESCRIPTION OF UNITS

DARK MATERIALS

Materials of the extensive and conspicuous dark plains known as maria are the principal constituents of this class, but less extensive dark domes, dome-studded plateaus, and terra mantles, all of which occur within or near the maria, are also included.

MARE MATERIALS

Mare materials cover about 40 percent of the area mapped. Most are located in the centers and concentric troughs of the large approximately circular multi-ring depressions such as the Imbrium basin and within large irregular depressions such as Oceanus Procellarum. Smaller patches are in terra depressions such as those east of Mare Vaporum and in craters such as Archimedes.

Relative age is determined principally from superposition and embayment relations with adjacent units, from density and age of main-sequence craters (see below) superposed on and overlapped by the maria,[1] and to some extent from albedo[2] and color[3] properties. The maria are clearly younger than almost all terra materials, including those of the crater-like multi-ringed basins. They are older, however, than almost all ray craters, such as Copernicus, and non-ray craters such as Eratosthenes, both of which show symmetrical rim deposits and fields of satellitic craters superposed on the mare. Crater frequency counts on telescopic photographs (Shoemaker and others, 1962)[4] suggested that the maria are approximately contemporaneous, and the material at the present mare surface was used to define informally the top of the Imbrian System (Wilhelms, 1970b, p. 23), although the probability of substantial local variations in age was generally recognized (McCauley, 1967b; Wilhelms, 1970b, p. 30-32; Offield and Pohn, 1970). Lunar Orbiter photographs confirm that mare surfaces differ in density and age of superposed and overlapped craters, and an attempt has been made on this map, as on recent larger scale maps (Trask, 1970a), to divide the maria according to relative age. Contacts between mare units as observed on Orbiter IV photographs are, however, gradational and locally diffused by ray cover. In the absence of synoptic coverage at the required higher resolution, the two-fold subdivision used here should be regarded as a preliminary and incomplete portrayal of age variations within maria.

Several lines of evidence indicate that the maria are volcanic (in the sense that they solidified from molten rock probably formed beneath the surface). Their flat smooth surfaces generally terminate against the edges of the confining basins in abrupt contacts along elevation contours, and this indicates emplacement as fluid flows. Their distribution is controlled by the basins, but because the maria are younger they are not considered to be the direct and immediate products of basin formation. A predominantly basaltic composition is suggested by the low albedo, fluid-like emplacement relations, local flow-front morphology, Surveyor analyses, and the recent Apollo 11 and 12 results (Lunar Sample Analysis Planning Team, 1970; Lunar Sample Prelim. Exam. Team, 1970).

Em, *mare material*

Type area: Latitude 3°S. to 4°S., longitude 36°W. to 37.5°W., Wichmann CA region (Cummings, 1971; West and Cannon, 1971) (See Lunar Orbiter III frames 173-180; Orbiter IV, 137; Orbiter V, 169-176)[5]. Other typical occurrence: Surveyor I site, 2.5°S., 43.2°W., northeast of crater Flamsteed (Offield, 1972) (Orbiter I, 184-215; Orbiter III, 181-212; Orbiter IV, 143)

Includes mare materials assigned other ages on 1:1,000,000-scale maps

Less extensive than Imbrian mare, constituting about 30 percent of the dark plains; commonly localized near mare-terra contacts. Distinguished from Imbrian mare material by at least two of following criteria: (1) lower albedo[2] than adjacent mare; (2) truncation of rim materials of Eratosthenian craters (such as Manilius and Bullialdus); (3) superposed craters no older than Eratosthenian; (4) lower frequency of craters except where clusters of satellitic craters present; (5) well-preserved primary structures such as smooth-rimmed pits (as in an embayment north of Mare Vaporum), small domes (as at type area), very sharp ridges (as at type area and southeastern Mare Serenitatis), and recognizable flow fronts (in Mare Imbrium—Kuiper, 1965, p. 29-63; Fielder and Fielder, 1968; Schaber, 1969) (Orbiter V, 159-162); (6) relatively strong color[3] contrasts with adjacent mare (usually bluer, but redder along west edge of Oceanus Procellarum)

Probably relatively thin cover of young flows or pyroclastic materials over thicker accumulations of Imbrian mare material. Regolith (impact-produced "soil" layer) thinner than on Imbrian mare. Age of some patches embaying Eratosthenian craters possibly Copernican

Im, *mare material*

Type area: 0.5°N. to 0.5°S., 0.5°W. to 1.5°W., Sinus Medii (Trask, 1970b; Rowan, 1971) (Orbiter II, 93, 113-136; Orbiter III, 86-101; Orbiter IV, 101, 102, 108, 109; Orbiter V, 108-115). Reference area for mapping at Orbiter IV scale: between craters Archimedes (overlapped by mare

If, *Fra Mauro Formation*

Type area: 0° to 2°S., 16°W. to 17.5°W., north of crater Fra Mauro (informal definition: Eggleton, 1964; formal: Wilhelms, 1970b, p. 25) (Orbiter IV, 120, 121). Reference area: 3°S. to 4.5°S., 17°W. to 18°W. (Orbiter III, 132-135; Orbiter IV, 120)

Sinuous to straight, smooth-textured ridges or elongate hummocks typically 2 to 4 km across and 5 to 20 km long, oriented radially and subradially to Imbrium basin

Impact ejecta from Imbrium basin. Original form similar to Hevelius Formation but more degraded by erosion and mantling by younger materials

Ial, *Alpes Formation*

Type area: 47°N. to 48°N., 5°E. to 8°E., east of Montes Alpes (Page, 1970) (Orbiter IV, 110, 115; Orbiter V, 102)

Included in Fra Mauro Formation by Eggleton (1965) and Schmitt, Trask, and Shoemaker (1967)

Blocky or knobby but smooth-surfaced, closely spaced hills 2-5 km in diameter without conspicuous preferred orientation or lineation. Occurs both within Apennine ring, as at type area, and beyond, as near Kepler

Related to nearby Imbrium basin; may be (1) erosionally degraded ejecta, (2) structurally deformed pre-basin bedrock, or (3) a combination of both

Iap, *material of Montes Apenninus*

Type area: 16°N. to 17.5°N., 3.5°W. to 4.5°W. (Orbiter IV, 109)

Included in Fra Mauro Formation, hummocky member, by Hackman (1966) and Wilhelms (1968)

Rough coarse blocks of material having elongate rectilinear outlines parallel to Apennine scarp bordering Imbrium basin, and smooth to undulating interblock materials. Blocks gradational in size with Alpes Formation (finer) and pre-Imbrian rugged material (coarser)

Probably bedrock intensely fractured at time of Imbrium impact. Interblock materials possibly basin ejecta

pIj, *Janssen Formation*

Type area: 43°S. to 45°S., 37.5°E. to 39°E., in older crater Janssen (Stuart-Alexander, 1971) (Orbiter IV, 76)

Rolling subdued terrain having numerous linear features including ridges, scarps, and grooves radial to Nectaris basin

Nectaris basin ejecta blanket equivalent to, but more degraded and cratered than, the younger Fra Mauro and Hevelius Formations

pIl, *lineated material*

Type area: 5.5°S. to 7°S., 3.5°W. to 5°W., northwest of crater Ptolemaeus (Orbiter IV, 108)

Sharp, raised ridges, intervening level areas or deep troughs, and smooth whaleback-shaped hills with narrow grooves; linear features oriented radial to Imbrium basin. Distal to and gradational with Fra Mauro Formation

Mostly prebasin rock pervasively faulted by Imbrium impact; some structures tectonically reactivated after basin formation. Some basin ejecta (Fra Mauro Formation) possibly present

pIr, *rugged material*

Type area: Mons Hadley, 26.5°N., 4.5°E. (Orbiter IV, 102; Orbiter V, 106)

Includes material of smooth ridges and hills (Trask and Titley, 1966; Titley, 1967)

Rugged blocks most commonly 10 to 30 km across, generally with rectilinear outlines; forms highest and most rugged parts of arcuate raised ridges in and around major circular multi-ringed basins; most extensive and rugged around Imbrium, more subdued elsewhere. Slopes steep, smooth, and bright at Orbiter IV scale. Gradational contacts with adjacent low terrain, or bordered by apron of material that encroaches on adjacent materials

Prebasin rock uplifted during formation of basins by impact. Possibly some post-impact tectonic rejuvenation. Certain more rounded rocks possibly formed or modified by volcanism

TERRA PLAIN, PLATEAU, AND DOME MATERIALS

This class comprises all bright and intermediate-albedo materials of the terrae or "highlands," except those of craters and the distinctive circumbasin units; it includes flat or gently undulating light plains materials that occur in depressions at about the same elevation as the maria. The class is divided into nine distinctive and two nondistinctive units.

Some terra materials overlap the mare materials in age but most are older, as shown by embayment relations and crater density comparisons. Plain, plateau, and dome materials transect and cover the circumbasin units or modify their textures, thus are younger than nearby multi-ringed basins.

The distinctive deposits are believed to be mostly of volcanic origin, and the nondistinctive materials are of mixed or unknown origin.

DISTINCTIVE MATERIALS

Ih, *hilly material*

Type area: 1.3°S. to 1.7°S., 6.4°E. to 7.7°E., north of crater Pickering (Orbiter IV, 96, 97)

Aggregates of closely spaced, subdued to moderately steep domes or cones with or without small summit craters or furrows. Circular or elliptical, mostly 1 to 5 km in diameter. Similar to some occurrences of Alpes Formation, but hills more regular in size and plan

Volcanic constructional features or eroded blocks of other origin

Ihf, *hilly and furrowed material*

Type area: 19°S. to 20°S., 50.5°W. to 51°W., northwest of crater Mersenius (Orbiter IV, 149)

Includes rugged material of Kant Plateau (Milton, 1968)

Aggregates of closely spaced, subdued hills and ridges 3 to 15 km long and 2 to 6 km wide capped by distinctive sinuous furrows. Irregular craters and chain craters abundant (where >10 km, mapped individually). Includes low ridges along long narrow fissures in crater floors

Densely packed array of pyroclastic or composite cones like those in some youthful terrestrial volcanic provinces

Ihp, *hilly and pitted material*

Type area: 18°S. to 19°S., 60°W. to 61°W. (Orbiter IV, 161)

Gently rolling to hilly terrain containing aggregates of subdued irregular to circular craters and hills. Craters mostly narrow-rimmed or rimless, 2 to 10 km in diameter. Hills equidimensional to elongated by 3:1, mostly <10 km in greatest dimension

Complex volcanic deposits, possibly predominantly pyroclastic, accumulated to considerable thickness over older cratered terrain. Pits probably of internal origin and related to the deposits, but some may be secondary impact craters from unrecognized sources

pIp, *plains material*

Type area: 44°S. to 45.5°S., 22.5°E. to 25°E. (Orbiter IV, 88)

Generally flat terrain with a greater population of large and older craters than on Imbrian plains-forming material and basal Imbrian units. Some craters circular, some irregular; many superposed craters of lower Imbrian clusters (Icc). Intermediate albedo

Probably volcanic, representing an older variant of the Imbrian plains-forming material

NONDISTINCTIVE MATERIALS

Terrain of intermediate albedo and moderately subdued nondescript surface texture is separated on the basis of relief into two units. The older (IpIt) has moderately high relief and forms parts of the basin-concentric rings and upland terrain between basins. The younger unit (It) has moderately low relief and generally occupies topographic depressions.

These units are not readily datable, and their assigned ages are approximations. The unit assigned a pre-Imbrian or Imbrian age is mostly pre-Imbrian inasmuch as it contains remnants of many large, very subdued pre-Imbrian craters (unmapped). In addition, exposures commonly coincide with structural highs concentric with pre-Imbrian basins such as Humorum and Crisium, so that the unit probably consists in great part of now unrecognizable basin ejecta. Its relatively smooth surface, however, suggests that the materials or processes responsible for smoothing are of Imbrian age. Occurrences of the second unit, on the other hand, show no underlying pre-Imbrian basement and seem to have a population of underlying and superposed craters like that of Imbrian units. Also, some of these occurrences lie in or near the Imbrium basin and interrupt textures of its blanket or its structures. Therefore the bulk of these materials are believed to be of Imbrian age—possibly a thicker accumulation of the same materials as on unit IpIt. The formation of both units probably extended over a considerable time.

Although basin ejecta is probably a major component of both units, they also may contain complexly interbedded impact-crater and volcanic deposits, mixed with local erosional debris. The stratigraphy of these units may never be unraveled in detail by photogeologic methods.

It, *terra material, undivided*

Type area: 21°S. to 22°S., 45°W. to 46°W., southwest of crater Gassendi (Orbiter IV, 143, 149)

IpIt, *terra material, undivided*

Type area: 8°S. to 9°S., 20.5° to 21.5°E. (Orbiter IV, 84)

CRATER MATERIALS

This class includes materials of all types of craters that are 10 km and larger in rimcrest diameter, or that form clusters or chains of this size. The term "crater" here includes rimmed depressions of diverse shapes less than 250 km in rimcrest diameter and excludes other types of depressions such as linear rilles and the

MATERIALS OF CRATER CHAINS AND CLUSTERS

Crater chains are of two types: (1) three or more individual craters alined and similar in size and morphology that are overlapping, tangential, or alined along a rille, and (2) pairs of similar overlapping craters not separated by septa. Crater clusters are nonlinear arrays of three or more similar overlapping or tangential individuals (with or without septa). Individual craters are either circular or irregular in outline, mostly ≤10 km in diameter. Rim materials, if present, are relatively smooth. Interior terraces are generally lacking, and floors are shallow. The chain and cluster category is gradational with the irregular crater category in cases where outlines merge to form a single occurrence ≥10 km in diameter.

Morphology is a less reliable age criterion than for the main-sequence craters because most chain and cluster craters are small and topographically simple. As a first estimate, however, they are assigned an "Eratosthenian or Copernican" age if they are sharp-rimmed, relatively uncratered, and otherwise fresh appearing; an Imbrian age if moderately subdued, and a pre-Imbrian age if strongly subdued and highly cratered.

Crater chains and clusters are believed to be of internal and secondary impact origin because the alinement, grouping, distribution patterns, and morphology argue against primary impact. Alinement along fractures suggests internal origin. Concentration of similarly sized craters between one and two diameters from a crater or basin and partial alinement of clusters and chains radial to it suggest secondary impact origin. This origin is believed certain for satellitic craters (Isc) of the Iridum crater and Orientale basin (which resemble smaller unmapped secondaries of craters such as Copernicus and Eratosthenes), quite likely for crater clusters and chains (Icc) at the appropriate distance from the Imbrium basin, and possible for certain chains and clusters (pIch) around the Nectaris basin.

CEch, *material of crater chains and clusters*

Type area: Northwest segment of Rima Hyginus, 8°N., 6°E. (Orbiter IV, 97, 102; Orbiter V, 94-97)

Tangential and overlapping craters of similar size and morphology, or linear furrow with scalloped edges (in Pitatus). Individual craters 2-5 km at type area, 1-3 km at Rima Davy (11°S., 6°W.); topographically sharp; bowl-shaped profile or small flat floor. Distinct thermal anomaly at type area. Albedo high at Rima Davy and type area

Volcanic, analogous to terrestrial maars or collapse craters

Ich, *material of crater chains and clusters*

Type areas: (a) Chain extending east-southeast from 14.8°S., 13.8°E., south rim of crater Abulfeda (Orbiter IV, 89; Orbiter V, 84); (b) cluster centered at 30°S., 4°W. (Orbiter IV, 107, 108, 112, 113)

Most individual craters moderately subdued. Three general types: circular and bowl shaped, circular or irregular with narrow ridgelike rims and broad shallow floors, or linear furrow with scalloped edges

Most are probably volcanic, but some may be clusters of secondary impact craters, particularly of Imbrium and Orientale basins; linear chains in central part of Moon and radial to Imbrium probably produced during basin formation by radial faulting or secondary impact. Age range early to late Imbrian

Isc, *satellitic-crater material*

Type areas: Clusters and chains centered (a) at 55.5°S., 48°W., on southeastern side of crater Schiller C (Orbiter IV, 160, 167) and (b) at 53°N., 24°W., northeast of the crater around Sinus Iridum (Orbiter IV, 140, 145)

Type (a) individual craters in 10-15 km size range with sharp rim crests and bowl-shaped interiors without distinct floors. Alined in closely packed chains or clusters with the walls down-range from Orientale basin commonly breached and grading outward into a herringbone ridge-and-trough pattern. Most but not all located beyond mappable extent of Hevelius Formation, typically 1200 to 1500 km from center of Orientale basin. Similar in general properties and distribution to secondary impact craters identified around Copernicus but averaging about three times larger. Type (b), around Iridum, similar but in 5-8 km size range

Secondary craters formed by impact of large blocks ejected at low to intermediate trajectory angles from (a) Orientale basin and (b) Iridum crater, which are nearly of same age

Icc, *material of crater clusters and chains*

Type area: Cluster centered at 36°S., 27°E., on rim of crater Riccius (Orbiter IV, 83)

Individual craters as much as 25 km in diameter; majority of each mapped cluster and chain composed of craters >10 km. Moderately subdued rimcrest and bowl-shaped interior without distinct floor, except where (in some western occurrences) filled by younger materials. Early Imbrian age indicated by similarity of rimcrest sharpness and density of