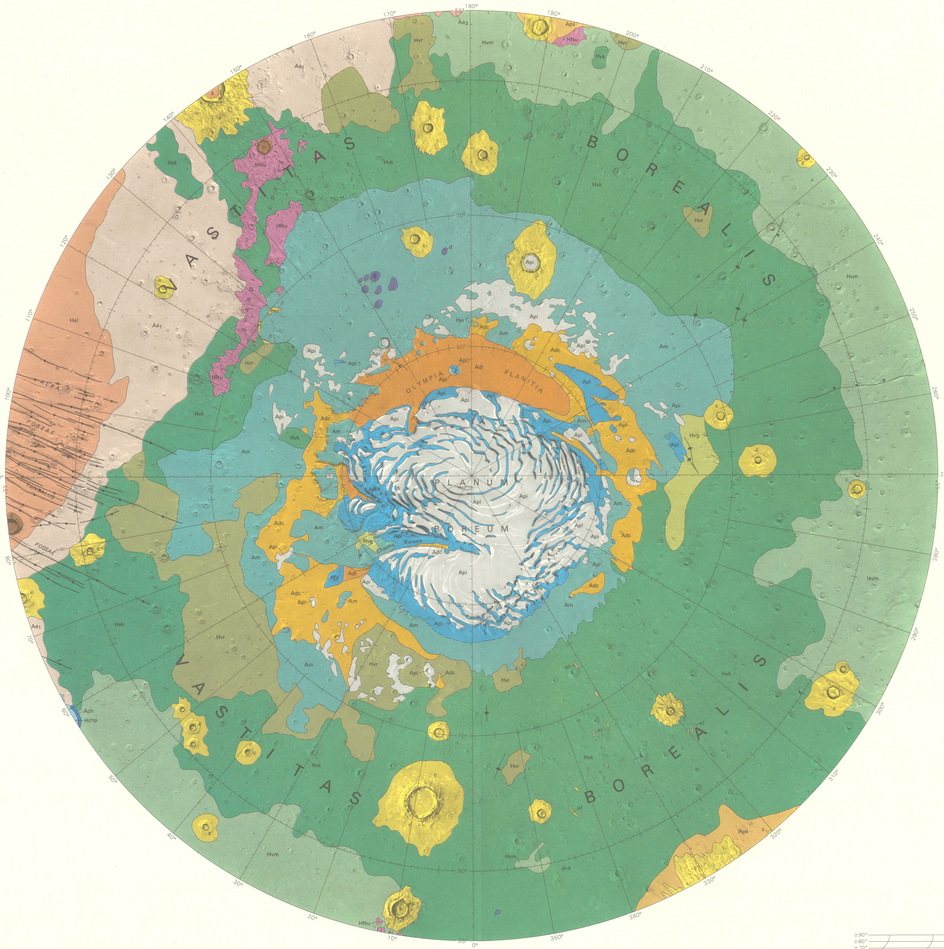
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:15,000,000 GEOLOGIC SERIES
M 15M±90/0 G 1987
I-1802-C



NORTH POLAR REGION

NOTES ON BASE

This map sheet is one of a series covering the entire surface of Mars at a scale of 1:15,000,000. Sources for the map base were 1:5,000,000-scale shaded relief maps described by Batson and others (1979). Data used in the map portrayal were obtained from Viking Orbiter images.

ADOPTED FIGURE

The figure of Mars used for computing the map projections is an oblate spheroid flattening of 1/192 with an equatorial radius of 3,393.4 km and a polar radius of 3,375.7 km.

PROJECTIONS

The Mercator projection is used between the 57° parallels; the Polar Stereographic projection is used for the polar regions north and south of the 57° parallels. Scales are 1:15,000,000 at the equator and 1:9,203,425 at the poles. The projections have a common scale of 1:8,418,000 at lat ±56°. Longitude increases to the west in accordance with astronomical convention for Mars. Latitudes are areographic.

CONTROL

Planimetric control for the 1:5,000,000-scale maps used to compile the bases for these sheets was derived from photogrammetric triangulations by use of Mariner 9 pictures (Davies, 1973). This control net was upgraded through the use of Viking data (Davies and others, 1978). At least 85 percent of the image control points lie within 0.5 mm of the positions published in 1978.

MAPPING TECHNIQUE

The mapping bases for this series were assembled from 1:5,000,000-scale shaded relief maps reduced and digitally transformed where necessary to fit the projections. During shaded relief portrayal, features on these bases were used to position details taken from Viking Orbiter pictures. Features were drawn as if illuminated uniformly from the west, through use of airbrush techniques described by Inge (1973) and photointerpretive methods described by Inge and Bridges (1976). The shading is not generalized and accurately represents the character of surface features.

Shaded relief analysis and portrayal were made by Barbara J. Hall (south pole) and Jay L. Inge (north pole).

NOMENCLATURE

All names on this sheet are approved by the International Astronomical Union (IAU), 1974, 1977, 1980, 1983, and 1986). Named features and their positions are taken from published maps of Mars that have scales of 1:2,000,000, 1:5,000,000 and 1:25,000,000.

M 15M ±90/0 G Abbreviation for Mars; 1:15,000,000 series; center of maps, lat 90° N. or lat 90° S., long 0°; geologic map (G).

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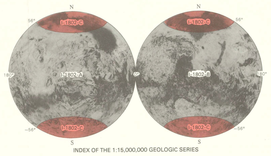

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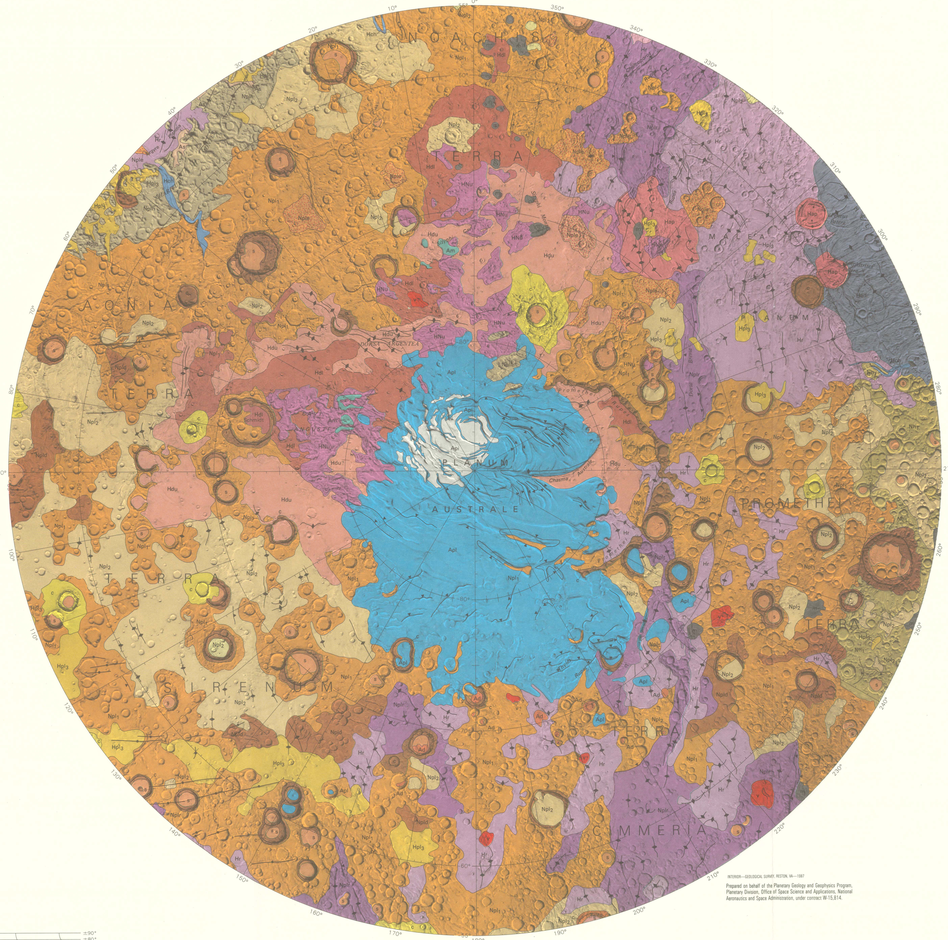
SCALE 1:9 203 425 (1 mm=9.2 km) AT ±90° LATITUDE
1:8 418 000 (1 mm=8.418 km) AT ±56° LATITUDE
POLAR STEREOGRAPHIC PROJECTIONS



INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1987
Prepared on behalf of the Planetary Geology and Geophysics Program, Planetary Division, Office of Space Science and Applications, National Aeronautics and Space Administration, under contract W-15,614.

INTRODUCTION

These geologic maps of the north and south polar regions of Mars, extending to 55° north and south latitudes, cover roughly 2° the geologic maps of the northern and southern quadrangles, which extend to lat ±57°. The maps were compiled from Viking medium-resolution photomosaics at scales of 1:2,000,000 and from higher resolution Viking image mosaics. Most photographs of the Viking pictures are superior to those of Mariner 9 used to prepare the previous map (Scott and Carr, 1978) that includes these two regions. Because of the Viking orbital configuration, a vast number of high-resolution images of the area within 10° of the north pole was obtained, whereas many areas in lower northern latitudes were covered only by low-resolution images. In contrast, the south polar region is nearly completely covered by images at medium resolution but is not imaged at high resolution.

Names of geologic units and a method for relative age determinations based on crater densities were developed for the geologic map of the western equatorial region (Scott and Tanaka, 1986). These names, where applicable, and this objective method are used on these polar maps. New geographic nomenclature and several new geologic units were added.

The Mariner 9-based map of the north polar region (Scott and Carr, 1978) indicates mottled, ridged, and smooth units comprising the polar deposits. Recent mapping at 1:5,000,000 scale and crater counts at 60° N. by Dial (1984), based largely on Viking images, have defined the vast sand sea that surrounds the north polar cap, changed the age of the plains of Vastitas Borealis from Noachian-Amazonian to Amazonian-Hesperian, identified faulted terrain associated with Alba Patera, and reclassified some craters three structures previously identified as volcanoes. Dial subdivided the plains units largely on the basis of albedo, mantling by debris, and presence of channels, which now include features were available to him for much of the plains. Our mapping covered 10° more of latitude and used new Viking-based 1:2,000,000-scale photomosaics (resolution ranges from 200 to 400 m/pixel) that fully cover these plains, as well as high-resolution images of the polar ice cap. We subdivided the northern plains materials, excluding relatively thin eolian deposits, into six members of the Vastitas Borealis Formation and Formerly, the mottled member was added.

Our south polar map was based on Viking 1:2,000,000-scale photomosaics made up mostly of images ranging in resolution from about 130 to 200 m/pixel. Higher resolution images are about 110 m/pixel. Some areas, particularly those within the arc between lat 55° and 60° S. and long 0° and 180°, are covered only by lower resolution images (1 km/pixel). Previous mapping at 1:5,000,000 scale south of lat 60° S. (Condit and Soderblom, 1978), based on Mariner 9 images (300 to 500 m/pixel), identified the volcanic plains of Hellas Planitia as Hesperian in character of the highlands, and large areas of relatively smooth plains. Important modifications in the new south polar map include the following: (1) a finer subdivision of highland units into without rough units, (2) new relative age assignments; (2) an improved view of the cratered terrain of ridged plains material from a relatively small area to many areas surrounding the south pole; and (3) the inclusion of the Hesperian Dorsa Argentea and Amphitrites Paterae formations, consisting of four units.

The north and south polar regions are strikingly different in physiography, geology, relative age, and surface processes. Most of the differences reflect the contrast between younger lowland plains of the northern hemisphere and older highland terrain in the southern. The northern plains consist of comparatively few rock types that are mostly of Hesperian and Amazonian age. After their emplacement, chiefly as lava flows and sediments, the plains-forming units were modified and stripped (Carr and Schaber, 1977; Scott, 1978). These older units now exist only as numerous small knobby hills and pedestal craters throughout the region. Some scattered craters of Hesperian age, from Scandia Colles, for example, remain of the remnants of an old highland surface that projected above the later lava flows of the plains. The plains north of about lat 60° N. are nearly covered by dune fields, dust mantles, and polar layered deposits that form Planum Boreum and some outlying mesas. The extensive residual water-ice cap around the north pole covers most of the layered deposits. In contrast, the rock units of the south polar region are continuations of many highland units of Noachian and Hesperian age that are exposed throughout the equatorial zone. These rocks are overlain south of about lat 70° S. by Planum Australe, a broad, smooth structure composed of layered deposits and a small residual ice cap. Relatively little dune and mantle material surrounds these deposits. The contrasting characters of the polar highlands and lowlands are probably manifestations of different crustal thicknesses of highland and lowland terrain (Bills and Ferrari, 1978) and, therefore, of early global crustal evolution.

Isolated volcanoes, mountains, and domes are scattered throughout the map areas, but as a group they are not assigned a position in the stratigraphic column because the small size of the features precludes reliable crater counts on an individual basis. The stratigraphic relation between low domes (symbol d) and surrounding plains in the north polar region is uncertain. Some mountains of the south polar region are younger and others are older than surrounding units. Mountains having features interpreted to be volcanic, such as summit depressions and flow patterns on their flanks and around their bases, are shown in the geologic map explained by the symbol v. Others may be degraded volcanoes, tectonic mountains, and remnants of plateau-sequence materials; these are shown in gray and are designated by the symbol m.

NORTH POLAR REGION

Physiographic setting

The north polar region of Mars consists largely of broad, flat plains surrounding Planum Boreum, a subcircular plateau 1,100 to 1,200 km in diameter centered near lat 87° N., long 0°. The height of the plateau is about 3 km, low-resolution stereoscopic Mariner 9 pictures suggests about 4 to 6 km of relief (Duxbury and Blasius, 1975), and similar work on Viking images suggests about 1 to 2 km of relief (Wu and others, 1979). Although the plateau is broad and long, accurate images that form a counterclockwise swirl pattern extending outward from the pole. Deposits of Planum Boreum are 200 to 800 km in diameter (Blasius and others, 1977). Outlying remnants of the plateau form an annular belt of mesas partly encircling it between lat 75° to 80° N. and long 100° to 270°. Near the mouth of Chasma Boreale, these mesas are several hundred meters higher than the plateau. Layered deposits of Planum Boreum are composed of water ice. Outlying remnants of the plateau form an annular belt of mesas partly encircling it between lat 75° to 80° N. and long 100° to 270°. Near the mouth of Chasma Boreale, these mesas are several hundred meters higher than the plateau. Layered deposits of Planum Boreum are composed of water ice. Outlying knob-shaped highland remnants that make up Scandia Colles and by scattered impact craters as large as 180 km in diameter. A belt of linear dunes forms the broad, arcuate Olympia Undina adjacent to Planum Boreum between long 120° and 240°

Stratigraphy and structure

The oldest rocks in the map area are *undivided material* (unit HNu). Its most widespread outcrops form the knobby hills of Scandia Colles, which are interpreted to be remnants of ancient cratered highland terrain (Scott and Tanaka, 1986). Although the surface of the unit is too for meaningful crater-density determinations, the hills are considered Noachian-Hesperian in age because their form is similar to that of the cratered highland terrain of Noachian age. Much of the cratered terrain of the equatorial and south polar regions, and because the hills are embayed by younger Hesperian plains material. They are likely to be similar in composition to the plateau sequence (highland rocks), which probably consists of interbedded impact breccia and lava flows. Some of the knobs may be local volcanic edifices. Erosion of the early heavily cratered terrain materials probably occurred during late Noachian time and continued during Hesperian time, as evidenced by stripping of upper Hesperian plains materials that had embayed the older highland remnants.

Early in the Hesperian Period, lavas of the *lower member* (unit Hal) of *the Alba Patera Formation* flowed northward beyond lat 60° N., where they were moderately fractured by the late Hesperian, northward-trending faults of Alba and Tantalus Fossae. Also during the late Hesperian, the north tip of an extensive deposit of *flood plain material* (unit Hfp) was emplaced along the west edge of Acidalia Planitia (Scott and Tanaka, 1986).

Much of the north polar plains is covered by materials of the Vastitas Borealis Formation. Cumulative densities of craters larger than 5 km in diameter indicate that the formation is middle to late Hesperian in age, which agrees with counts by Dial (1984). The formation is divided into four members on the basis of the generally mutually exclusive attributes of knobs, grooves, ridges, and mottling, although at many places the members are gradational. The small, Mottled member (unit Hvm) is the oldest and most widespread member (unit Hvk) were interpreted as volcanoes or highly degraded remnants of highland material (Frey and others, 1979; Scott, 1979). Interknob surfaces are commonly grooved, ridged, mottled, or mantled. This unit was mapped as both mottled and mantled cratered plains material in the north polar area (Dial, 1984) and as hummocky mottled plains material and knobby plains material in the northern part of the Mare Acidalium quadrangle (Witbeck and Underwood, 1984). The *grooved member* (unit Hvg) is characterized by a pattern of grooves that form polygons generally 5 to 20 km across; the memvre is clearly younger than most of Chasma Boreale but may be covered by mantle material elsewhere. Dial (1984) assigned a lower Amazonian age to this exposure. The origin of the grooves has been attributed to wedging, ground-ice decay, thermal contraction of ice-rich flows, desiccation, tectonism, or compaction (Carr and Schaber, 1977; Scott, 1979; Hallenbaugh and Morgenstern, 1980; Fortezzo, 1980; McGill, 1985). The *ridged member* (unit Hvr) consists of ridges 1 to 2 km wide forming two distinct pattern types: (1) arcuate, locally concentric patterns that commonly have been compared by retreat of a debris lobe (Carr and Schaber, 1977) or by subsurface ice flows from plateau material (Guest and others, 1977); and (2) polygonal patterns that appear similar in size and shape to those of the grooved member. Some ridges locally glide into polygons (Hallenbaugh and Morgenstern (1980) proposed that the ridges are either the result of high-viscosity lavas extruded through the grooves or the remnants of resistant materials, deeply eroded to reveal the structure of the underlying grooved terrain. Alternatively, the ridges may be subglacial volcanic deposits (moberg ridges). The *mottled member* (unit Hvm) consists of bright patches of impact-crater ejecta (Carr and others, 1977) and smooth and patterned dark plains material. The contrast in albedo may be caused by eolian deposits or by exposure of dark material by impact cratering. Dark material is commonly excavated by impact craters (Soderblom and others, 1973b; Carr, 1981). This unit makes up most of the area between lat 55° to 65° N. and long 175° to 0°. Formerly, the mottled member was mapped as part of the Vastitas Borealis Formation, but the material in attempt to be mapped by eolian processes (Masursky and others, 1977) or ground-water seepage (Pyes, 1980, p. 148) during a period when atmospheric conditions may have allowed liquid water at the surface. The *etched unit* (unit Pe) consists of etched and knobby components of the *grooved* unit. Its surfaces were probably formed by sublimation of ground ice, perhaps instigated by local volcanic heating, and deflation of the material.

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