
We are near the final stages in the processing of a large Viking Orbiter global color dataset. Mosaics from 57 spacecraft revolutions (called "revs" hereafter) have been produced, most in red and violet or red, green, and violet filters. Phase angles range from 13° to 85°. A total of ~2000 frames have been processed through radiometric calibration, cosmetic cleanup, geometric control, reprojection, and mosaicking into single-rev mosaics at a scale of 1 km/pixel. All of the mosaics are geometrically tied to the 1256°/pixel Mars Digital Image Mosaic. Photometric normalization is in progress, to be followed by production of a "best coverage" global mosaic at a scale of 1/64°/pixel (0.923 km/pixel). Global coverage is near 100% in red-filter mosaics and 88% and 60% in corresponding violet- and green-filter mosaics, respectively. Soon after completion, final datasets (including single-rev mosaics) will be distributed to the planetary community on compact disks.

Perhaps the most interesting parts of this dataset are the overlap regions, which show significant temporal variations in surface and atmospheric features. These are direct observations of atmospheric and surface processes and interactions. About half of Mars is covered at least twice by these mosaics, and many areas are covered up to five times. A few examples of these temporal comparisons are described below. All of the color-image comparisons were constructed from red- and violet-filter images only, even when green-filter images are also available, to insure comparability with color sets that lack green images. The images have been stretched to increase the contrast but with constant ratios between the stretch parameters for each color. This procedure preserves the relative color variations for comparison purposes.

Atmospheric Effects on Surface Observations

As a result of the stretching procedure, the very clear atmospheric observations are immediately obvious, because the overall scene is markedly redder than is the same area viewed through a hazier atmosphere. This color relation applies only to seasons with a relatively dust-free atmosphere, when haze variations are primarily due to aerosols. The blue images also show more discrete atmospheric features and show correlations between color and local topography, because the hazes settle into local topographic lows or because high mountains such as the Tharsis Montes rise through the low-lying regional haze. The relative atmospheric (versus surface) contribution to the scene's brightness and color is increased by large angles of illumination, emission, or phase, as well as by atmospheric opacity. These very clear atmospheric observations are crucial to accurate mapping of surface materials. Three examples are discussed below. All of the images described were acquired during times of relatively low atmospheric opacity (1-4), and all of the Mars mosaics in this dataset were selected for processing because they appear relatively free of atmospheric obscuration (except for the dust-storm initiation sequence in the southern hemisphere, described below). Therefore, these relatively reddish scenes represent unusually clear atmospheric conditions.

The first example is three views of the Tharsis Montes. Controversy exists over the nature of dark materials on the volcano flanks. In two views (revs 735A and 334S) the Tharsis Montes appear markedly darker and redder than surrounding areas, and previous workers have concluded that these flank materials are a distinct spectral (and compositional) unit (5, 6). This has been puzzling because the thermal inertia of the Tharsis Montes is consistent with atmospheric dust deposits (7-9), so we would expect the color and albedo to be similar to that of bright red areas over much of Mars. The third view (rev 583A), acquired during very clear atmospheric conditions, reveals that the color and albedo of the Tharsis Montes are indeed similar to surrounding regions. Although slope winds are clearly active on the Tharsis Montes (10), redistribution of only the very finest particles (<20 μm) may be sufficient to explain the albedo variations (11, 12); the thermal inertia may be uniformly low for particles in this size range (13).

The second example is two views of the Mangala Valles/Memnonia Fossae region. Briggs et al. (14) suggested that this may be an exceptional area for atmosphere-surface exchange of water vapor and of potential interest for future lander missions. This is another example of a very clear atmosphere observation (rev 583A) compared with a hazy view (rev 690A). In the rev 690A mosaic we see haze concentrated in discrete topographic lows such as craters and channels, as has been described previously (10). In addition, comparison with the rev 614A mosaic shows greater haze concentrations over lowland plains than highlands regions; the resultant color variations could be mistakenly related to the surface materials.

A third comparison shows the central region of Valles Marineris. In the clear-atmosphere view (rev 583A) we see a spectral unit associated with some of the interior layered deposits that is brighter and less red than other bright red (probably dust-mantled) regions; in the rev 334S view this spectral unit is not distinguishable. This unit corresponds both to an exposure in a steep slope of evenly layered deposits in Ophir Chasma and to the major surface exposure of irregular layered deposits in western Candor Chasma (15). The irregular layered deposits are of special interest because they consist of a thick sequence superposed over major landslide deposits and must have been emplaced very late in Martian history (Late Amazonian time).

Temporal Variability of Surface Units

There are three major non-polar color/albedo units or end members: bright red (dust), dark red, and dark gray (bluish in enhanced images) (6, 16, 17). Many of the color comparisons illustrate variability in bright red and/or dark gray surface deposits. We have found no evidence in our temporal comparisons to contradict the suggestion that the dark red unit is relatively immobile, supporting the suggestions that this unit is either a duricrust or a lag deposit. There are many changes in "small" (tens of kilometers) discrete features. Changes in the Claritas Fossae/Syrtis Planum region (revs 583A and 334S) may have occurred during the 1977 global dust storm, but changes in the Memnonia Fossae/Deaadia Planum region (revs 614A and 690A) occurred during northern summer, perhaps due to slope winds from the Tharsis region.
Drifts of bright red dust appear to have migrated in southern Acidalia Planitia during the period between revs 590A and 334S. This period included the dusty northern winter of 1979 in which no global storm occurred (18). Arvidson et al. (17) suggested that the bright red dust border south of Acidalia accumulated because the dust-carrying capacity of the winds decreases at the border between smooth dark gray and rough intermediate-albedo red units. The color comparisons do seem to illustrate the southward migration of dust over Acidalia Planitia. This migration may account for the thin (< 1 cm) dust layer hypothesized to cover the region of Mutch Memorial Station (VL1) (19).

A remarkable set of images covers part of Terra Cimmeria (latitude -42°, longitude 210°). The first observation (rev 459A) was acquired soon after the end of the 1977 global dust storms, and all of the southern hemisphere in mosaics acquired during this period (revs 426A-469A) appears mantled with seasonal dust that has not yet been completely removed from dark areas. The second observation (rev 605A), acquired during northern spring (L₉ 48°), shows a distinctive dark feature where only scattered dark areas were present during rev 459A. In the third observation (rev 532S), the east half of the dark feature is absent. The second observation reveals a plume-shaped structure with several kilometers of vertical relief covering the east half of the dark area. It is unlikely that a surface unit more than a kilometer thick was both deposited and removed within a little more than a Martian year, so, unless the appearance of vertical relief is deceptive, this feature must be an atmospheric plume. Its morphology is similar to that of other Martian dust plumes (20), but its low albedo and relatively neutral color are anomalous.

Large-scale color and albedo changes in the region south of Capri Chasma are revealed by a four-image comparison. Geissler and Singer (21) interpreted the changes seen between rev 569A and 334S as due to the southward movement by saltation of dark material out of the canyons, but movement of more than 1000 km in a Martian year exceeds reasonable migration rates via saltation. Although dark materials may migrate southward from the canyons over longer time periods, analysis of mosaics from two additional revs shows that the observed color/albedo changes were due to removal of a regional dust mantle deposited during the global storms of 1977. The rev 469A observations are part of the post-dust-storm sequence (L₉ 342°) that shows a residual dust mantle throughout the southern hemisphere following the 1977 global storms, as discussed previously. The second observation, acquired in early northern spring (L₉ 36°, rev 586A), shows dark erosional streaks and coalesced streaks (22), indicating that some of the bright cover has been removed. (The rev 469A mosaic also shows many dark erosional streaks, so much of the dust had already been removed before this rev.) The third observation (rev 663A) was acquired in late northern spring (L₉ 72°) and shows the same pattern of bright and dark patches seen in the final view, acquired almost a full Martian year later (rev 334S, L₉ 70°). A similar sequence of albedo change in this region is apparent in the IRTM (Infra-Red Thermal Mapper) albedo maps (23). Therefore, the large-scale albedo changes occurred during northern spring, not during southern summer when the north-to-south near-surface flow from the Hadley cell would be most likely to transport materials southward from the canyons. Removal of a thin layer of dust fallout probably accounts for the reemergence of classical large-scale albedo patterns throughout the equatorial region of Mars following global dust storms (24).

**Dust Storm Initiation Sequence in the Southern Hemisphere**

A series of 25 color mosaics shows parts of the southern hemisphere just before and during the initial stages of the first and second global dust storms of 1977. In addition, color observations of almost the entire southern hemisphere from six revs (441A-498A) were acquired soon after clearing of the atmosphere in the southern hemisphere following the 1977 storms. These mosaics have been reprojected to a common format for detailed comparisons of the surface and atmosphere before, during the initial stages, and after the dust storm activity. Although Mars appears uniformly bland during mature stages of global storms, the dust clouds have considerable structure during the initial stages. Preliminary examinations have revealed many relations between the dust clouds and surface topography and color and albedo of the polar cap, which have not been previously described (cf. 14, 20, 25).