A DESCRIPTIVE CATALOG OF SELECTED AERIAL PHOTOGRAPHS OF GEOLOGIC FEATURES IN AREAS OUTSIDE THE UNITED STATES

U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY PROFESSIONAL PAPER 591

A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in Areas Outside the United States

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INDEX

DETAILED DESCRIPTIONS OF SETS OF AERIAL PHOTOGRAPHS

Antarctica 1. East side of Sentinel Range and Edith Ronne Ice Shelf

Area: Sentinel Range.
Lat 78°20′ S.; long 84° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:35,000.
Focal length: 6 in.
Date flown: Dec. 15, 1959.
Map reference: U.S. Geol. Survey Vinson Massif and Newcomer Glacier sheets, Antarctica, 1962, scale 1:250,000.
Geology reference: Craddock, Campbell, and Webers, G. F., 1964, Fossils from the Ellsworth Mountains, Antarctica: Nature, v. 20, p. 174–175.

Features illustrated.—Looking north-northwest along the east edge of the Sentinel Range (left) and an arm of the Edith Ronne Ice Shelf (right) toward Ellsworth Land (skyline). The relief on the east side of the range is only several hundred meters in contrast to several thousand meters on the west side. (See Antarctica 2.) Ice from within the range flows eastward into the Ronne drainage system whose flow is toward the viewer. The local ice streams from the mountains retain their identity on the ice shelf for many tens of miles downstream.

This eastern edge of the range is composed of folded slate, quartzite, and graywacke; the youngest strata contain a glossopterid flora of Permian age. Older Paleozoic metasedimentary rocks underlie other parts of the range.

Antarctica 2. Mile-high escarpment on west side of Sentinel Range

Area: Sentinel Range.
Lat 78°25′ S.; long 86° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:20,000.
Focal length: 6 in.
Date flown: Dec. 15, 1959.
Map reference: U.S. Geol. Survey Vinson Massif sheet, Antarctica, 1962, scale 1:250,000.
Geology reference: Craddock, Campbell, Anderson, J. J., and Webers, G. F., 1964, Geologic outline of the Ellsworth Mountains, *in* Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 155–170.

Features illustrated.—Looking north from the west flank of the Vinson Massif (off right foreground) along the sheer west front of the Sentinel Range toward Ellsworth Land (skyline). From the west-facing escarpment at altitudes of about 4,000–5,000 meters, the crest of the range declines eastward to about 500 meters. West of the range, the plateau ice flows northward away from the viewer. Mount Tyree, altitude 4,965 meters, is the highest peak in the photograph (top center). Deformed quartzites of Paleozoic age underlie the west escarpment and most of the visible mountains.

Antarctica 3. Deformed quartzite in west face of Mount Tyree, Sentinel Range

Area: Sentinel Range.
Lat 78°25′ S.; long 86° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:16,000.
Focal length: 6 in.
Date flown: Dec. 15, 1959.
Map reference: U.S. Geol. Survey Vinson Massif sheet, Antarctica, 1962, scale 1:250,000.
Geology reference: Craddock, Campbell, Anderson, J. J., and Webers, G. F., 1964, Geologic outline of the Ellsworth Mountains, *in* Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 155–170.

Features illustrated.—Looking east over Mount Tyree, altitude 4,965 meters, across the 50-kilometer-wide Sentinel Range to the Edith Ronne Shelf. Mount Tyree is part of the mile-high escarpment that forms the west side of the range whose summits decrease in height eastward to only a few hundred meters. Ice drains from areas of local accumulation within the range to the Edith Ronne Ice Shelf. Mount Tyree is composed of Crashsite Quartzite, a well-bedded metasandstone of Paleozoic age. Sharp folds and crenulations, joint sets, and faults are visible on the mountain face. Younger Paleozoic formations underlie the east side of the range.

Antarctica 4. Scott Glacier and polar ice plateau, Queen Maud Mountains

Area: Queen Maud Mountains.
Lat 86° S.; long 151° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:45,000.
Focal length: 6 in.
Date flown: Dec. 9, 1960.
Map reference: U.S. Geol. Survey Nilsen Plateau sheet, Antarctica, 1967, scale 1:250,000. Am. Geog. Soc., Antarctica, 1965, scale 1:5,000,000.
Geology reference: Gould, L. M., 1935, Structure of the Queen Maud Mountains, Antarctica: Geol. Soc. America Bull. v. 46, p. 973–983. Doumani, G. A., and Minshew, V. H., 1965,

General geology of the Mount Weaver area, Queen Maud Mountains, Antarctica, *in* Hadley, J. B., ed., Geology and paleontology of the Antarctic: Am. Geophys. Union Antarctic Research Ser. v. 6, p. 127–144.

Features illustrated.—Looking south up Scott Glacier to the polar ice plateau, altitude about 3,000 meters, on skyline. This rapidly moving outlet glacier drains from the plateau ice sheet through the Queen Maud Mountains to the Ross Ice Shelf (off photograph to right). Snow covers much of the intensely crevassed ice stream, although median shear zones along the joins of various tributary glaciers are not sufficiently covered to completely obliterate the underlying rough ice surface. The glacially eroded, pyramid-shaped mountains in the foreground and middle distance are underlain by deformed quartzite, slate, schist, and gneiss and by intrusive granitic rock, all of probable late Precambrian and early Paleozoic age. The broad-topped mountains (right and left background) are underlain by flat-lying sandstone of Devonian(?) to Permian age and contain thick dolerite sills of probable Jurassic age. The sandstone and dolerite dip gently southward (away from viewer) and unconformably overlie the older rocks.

Antarctica 5. Flow lines and crevasses near head of Shackleton Glacier, Queen Maud Mountains

Area: Queen Maud Mountains.
Lat 85° S.; long 177° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:45,000.
Focal length: 6 in.
Date flown: Nov. 25, 1960.
Map reference: U.S. Geol. Survey Shackleton Glacier and Liv Glacier sheets, Antarctica, 1967, scale 1:250.000.
Geology reference: Gould, L. M., 1935, Structure of the Queen Maud Mountains, Antarctica: Geol. Soc. America Bull., v. 46, p. 973–983. Wade, F. A., Yeats, V. L., Everett, J. R., Greenlee, D. W., La Prade, K. E., and Shenk, J. C., 1965, Geology of the central portion of the Queen Maud Range, Transantarctic Mountains: Science, v. 150, p. 1808–1809.

Features illustrated.—Looking south-southwest up Shackleton Glacier to polar ice plateau (left skyline) and Dominion Range (right skyline) at head of Beardmore Glacier. Shackleton Glacier has an intensely crevassed surface that is typical of such rapidly moving outlet glaciers. The many flow lines are median shear zones between ice of the many tributary glaciers and that of the main stream. The lenticular disruption of the main ice stream (left center) is caused by a buried rock mass that splits the main channel beneath the surface ice. Disruptions of flow lines downstream (center) are structures within the ice that are exposed at the surface by ablation. The surface pattern has been further modified by local melting and freezing. Flat-lying strata of the Beacon Group (dark gray), here of Devonian to Permian age, and sills of Ferrar Dolerite (black) of Jurassic age form broad tabular mountains so typical of the interior side of the Transantarctic Mountains. The horizontal strata in the mountain in the right foreground are underlain by metasedimentary or granitic rocks of late Precambrian and early Paleozoic age.

Antarctica 6. Moraines on Plunket Point between Beardmore and Mill Glaciers, Queen Maud Mountains

Area: Queen Maud Mountains.
Lat 85° S.; long 167° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:30,000.
Focal length: 6 in.
Date flown: Nov. 17, 1960.
Map reference: U.S. Geol. Survey, Plunket Point and The Cloudmaker sheets, Antarctica, 1967, scale 1:250,000.
Geology reference: Oliver, R. L., 1964, Geological observations at Plunket Point, Beardmore Glacier *in* Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 248–258. Grindley, G. W., McGregor, V. R., and Walcott, R. I., 1964, Outline of the geology of the Nimrod-Beardmore-Axel Heiberg Glaciers region, Ross Dependency, *in* Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 206–219.

Features illustrated.—Looking northeast down Beardmore Glacier (left) from Plunket Point (center) to the Commonwealth Range (skyline). Mill Glacier (middle right) joins the Beardmore below Plunket Point. These two outlet glaciers drain from the polar-ice plateau (behind the viewer). Surface ablation strongly accentuates the crevasses and flow lines. The median shear zone downglacier from Plunket Point and the two parallel shear zones along the left side of Plunket Point contain many small frozen lakes caused by intense ablation.

Plunket Point is covered with drift. Parallel recessional moraines, ice-marginal channels, and kames and kettles are conspicuous. Patterned ground is well developed on the lower slopes. A small ice tongue (right foreground) has left recessional moraines on the adjacent valley sides.

The Beacon Group, here of Devonian to Permian age, and intrusive sills of Ferrar Dolerite of Jurassic age underlie the massive tabular mountains across Mill Glacier and downglacier on the east side of the Beardmore Glacier.

Antarctica 7. Ice-covered slopes of mountains near the lower Beardmore Glacier

Area: Holland Range.
Lat 83°15′ S.; long 167° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:25,000.

Focal length: 6 in.
Date flown: Nov. 6, 1960.
Map references: U.S. Geol. Survey, Mount Elizabeth and Mount Rabot sheets, Antarctica 1966, and The Cloudmaker and Buckley Island sheets, Antarctica 1967, scale 1:250,000.
Geology reference: Grindley, G. W., 1963, Geology of the Queen Alexandra Range, Beardmore Glacier, Antarctica: New Zealand Jour. Geology and Geophysics, v. 6, no. 3, p. 307–347.

Features illustrated.—Looking southwest across the Hewitt Glacier (foreground) and sheer ice slopes of the Holland Range (middle) to the Bowden Névé (back center). The Bowden Névé drains to the left down a rough ice fall of the Lennox-King Glacier (upper left). Beyond is the Grindley Plateau (left skyline) and the high peak of Mount Kirkpatrick (4,528 meters) in the Queen Alexandra Range. To the right over Mount Miller (4,160 meters) is the Prince Andrew Plateau (right background) of the Queen Elizabeth Range.

The slopes of the Holland Range are being vigorously eroded by ice. Some small glaciers are fed by local icecaps, as in the middle ground, whereas some of the ridge and cirque ice is nourished entirely by snow accumulation upon the slopes. The broad flat-topped mountains and plateaus in the background are underlain by flat-lying strata of the Beacon Group, here of Devonian to Triassic age and intruded by sills of Jurassic dolerite. In the upper Alexandra Range, abundant flat-lying flood basalts of Jurassic age make the top of the sedimentary section.

Antarctica 8. Crevasses and seracs on Byrd Glacier, Britannia Range

Area: Britannia Range.
Lat 80°15′ S.; long 158° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:25,000.
Focal length: 6 in.
Date flown: Nov. 14, 1956.
Map reference: U.S. Geol. Survey Mount Olympus and Cape Selborne sheets, Antarctica, 1966, scale 1:250,000.
Geology reference: Swithinbank, C. W. M., 1963, Ice movement of valley glaciers flowing into the Ross Ice Shelf, Antarctica: Science, v. 141, no. 3580, p. 523–524. Haskell, T. R., Kennett, J. P., and Prebble, W. M., 1964, Basement and sedimentary geology of the Darwin Glacier area, *in* Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 348–351.

Features illustrated.—Looking west up Byrd Glacier along the south flank of Britannia Range (right) to the polar ice plateau. Byrd Glacier has the fastest rate of flow of any measured glacier in Antarctica; its surface movement is slightly less than 2.5 meters per day. The strong surface lines are median shear zones between main-stream ice and tributary ice. These zones are readily discernible on the photograph despite extremely abundant crevasses and seracs.

The hills to the right of the glacier are granitic rocks of probable early Paleozoic age unconformably overlain by flat-lying strata of the Beacon Group of late Paleozoic age (center and right skyline). Intrusive sills of the Ferrar Dolerite of probable Jurassic age occur in the section.

Antarctica 9. Glacier tongue and sea ice near Okuma Bay, Ross Ice Shelf

Area: Edward VII Peninsula.
Lat 77°30′ S.; long 156° W.
Number of photographs: 1.
Photograph scale (foreground): About 1:7,000.
Focal length: 6 in.
Date flown: Oct. 25, 1961.
Map reference: U.S. Geol. Survey Saunders Coast-Marie Byrd Land, Antarctica Sketch Map, 1968, scale 1:500,000. Am. Geog. Soc., Antarctica, 1965, scale 1:5,000,000.
Geology reference: Gould, L. M., 1949, Glaciers of Antarctica: Am. Philos. Soc. Proc., v. 82, no. 5, p. 836–860.

Features illustrated.—Looking southeast across the mouth and floating ice tongue of an unnamed glacier draining the low-lying ice-covered west coast of Edward VII Peninsula (background). In many respects this 14-kilometer-wide tongue resembles the barrier front of the nearby Ross Ice Shelf which is about 30 meters high and moves 1–2 meters per day. The broad longitudinal swales (backcenter) are hinge-line depressions that roughly parallel the coast line and are formed by tidal action. At and near the ice front, a secondary set of hinge lines result in sharply crevassed domes. Several small icebergs (upper right), detached from the glacier front, are frozen in the sea ice. This photograph, taken in the spring, shows the breaking up of 1-year-old sea ice (light gray). In some of the openings, new ice (dark gray) has formed during intermittent periods of cold.

Antarctica 10. Ice deformation on Ross Ice Shelf at Ross Island

Area: Ross Island.
Lat 77°50′ S.; long 167° E.
Number of photographs: 1.
Photograph scale: 1:2,500.
Focal length: 6 in.
Date flown: Feb. 15, 1960.
Map reference: U.S. Geol. Survey Ross Island sheet, Antarctica, 1965, scale 1:250,000.
Geology reference: Hochstein, M. P., 1967, Pressure ridges of the McMurdo Ice Shelf near Scott Base, Antarctica: New Zealand Jour. Geology and Geophysics, v. 10, no. 4, p. 1165–1168. Heine, A. J., 1967, The McMurdo Ice Shelf, Antarctica: New Zealand Jour. Geology and Geophysics, v. 10, no. 2, p. 474–478.

Features illustrated (set no. Antarctica 10 in south corner of photograph).—En echelon anticlines and synclines in floating ice (north corner) have an average wavelength of 60 meters. The undulations terminate against thrust faults where the ice is grounded on shore of Ross Island (shadow of island in west corner). The faults are delineated by jagged pressure ridges (center to south corner). Deformation occurs along a zone less than 1 kilometer wide by about 2 kilometers long (see Antarctica 12) where the floating Ross Ice Shelf (main shelf to east) presses against Ross Island. Local ice movement is to west-southwest. Tensional crevasse patterns are seen along the crests of the anticlines. Scott Base (New Zealand) is just off the photograph to the southwest. Scale is indicated by vehicular road with one vehicle near the midpoint. Several dozen Weddell seals, masked in shadow, and seal tracks are visible among the pressure ridges.

Antarctica 11. Craters of Mount Erebus, Ross Island

Area: Ross Island.
Lat 77°30′ S.; long 167° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:30,000.
Focal length: 6 in.
Date flown: Nov. 22, 1960.
Map reference: U.S. Geol. Survey Ross Island and Mount Discovery sheets, Antarctica, 1965, scale 1:250,000.
Geology reference: Smith, W. C., 1954, The volcanic rocks of the Ross Archipelago: British Antarctic (*Terra Nova*) Exped., 1910, Nat. History Rept., Geology, v. 2, no. 1, 107 p.

Features illustrated.—Looking south over the 3,794-meter summit of Mount Erebus, the best known active volcano in Antarctica. A faint plume of steam is rising from one of the two summit craters. The modern summit cones fill an older, larger crater. In the foreground is the rim of a still older and larger crater. Hut Point Peninsula, extending south from Erebus, has McMurdo Station (United States) on its southern tip. Ross Island consists of basalt, trachyte, and "kenyte" of Cenozoic age.

To the right is McMurdo Sound covered mostly with 1-year-old sea ice. To the left is the Ross Ice Shelf. The floating Erebus Glacier tongue with characteristic saw-toothed edges extends westward (right) into McMurdo Sound from the base of Hut Point Peninsula.

Antarctica 12. Williams Airfield, McMurdo Station, and Hut Point Peninsula, Ross Island

Area: Ross Island.
Lat 77°50′ S.; long 167° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:30,000.
Focal length: 6 in.
Date flown: Nov. 14, 1959.
Map reference: U.S. Geol. Survey Ross Island Sheet, Antarctica, 1965, scale 1:250,000.
Geology reference: Smith, W. C., 1954, The volcanic rocks of the Ross Archipelago: British Antarctic (*Terra Nova*) Exped., 1910, Nat. History Rept., Geology, v. 2, no. 1, 107 p.

Features illustrated.—Looking north-northeast across McMurdo Sound (foreground and left) to Ross Island where Mount Erebus looms on the skyline. Erebus, a stratiform volcano, is the best known active volcano on the Antarctic continent—a thin plume of steam rises from its 3,794-meter summit. Mount Terror (right skyline), 3,262 meters, and Mount Bird (left background), 1,766 meters, are also stratiform volcanoes. McMurdo Station (United States) at the landward end of the roadway (center of photograph), is on the southern tip of Hut Point Peninsula. Volcanic rocks of Cenozoic age (basalt, trachyte, and "kenyte") underlie the whole of Ross Island.

Williams Airfield (left foreground), used from 1956 to 1961, is on old sea ice about 12 meters thick. The scalloped north-facing edge (foreground) of this ice adjoins 1- to several-year-old sea ice, probably less than 5 meters thick, covering McMurdo Sound. Barrier ice of the Ross Ice Shelf (right middle ground) presses against the southern end of Hut Point Peninsula adjacent to Scott Base (New Zealand) and forms anticlines and synclines (pressure ridges, see Antarctica 10). A typically saw-toothed floating glacial tongue extends westward into McMurdo Sound from the base of Hut Point Peninsula.

Antarctica 13. Crevasses in floating tongue of Koettlitz Glacier at head of McMurdo Sound

Area: Victoria Land.
Lat 78°10′ S.; long 164° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:30,000.
Focal length: 6 in.
Date flown: Dec. 19, 1957.
Map reference: U.S. Geol. Survey Mount Discovery sheet, Antarctica, 1965, scale 1:250,000.
Geology reference: Blank, H. R., Cooper, R. A., Wheeler, R. H., and Willis, I. A. G., 1963, Geology of the Koettlitz-Blue Glacier Region, Southern Victoria Land, Antarctica: Royal Soc. New Zealand Trans., v. 2, no. 5, p. 79–100. Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p.

Features illustrated.—Looking west-southwest across lower Koettlitz Glacier and adjacent ice-free foothills to the Royal Society Range (center and right skyline). Mount Lister (right) is 4,025 meters high, and sharp-peaked Mount Huggins (left of center) is 3,733 meters high. Koettlitz Glacier, which originates within the Royal Society Range (upper left), floats on the waters of McMurdo Sound from Heald Island (left of center) to foreground. The surface of the ice is extremely

312-465 O - 69 - 2

rough because of ablation which is aggravated by windblown dust (dark areas) that accumulates on the surface. Etching by ablation accentuates rectilinear crevasse pattern, typical of floating ice tongues and tidal action. On the valley walls, morainal ridges mark higher levels of Koettlitz Glacier. These moraines can be traced up the adjacent dry valleys such as Miers Valley (right midground), where the Koettlitz morainal ridges extend up the tributary valley to the ice-covered Lake Miers. The summit of the range consists of flat-lying strata of the Beacon Group, here of Devonian to Permian age, intruded by sills of Ferrar Dolerite (black) of Jurassic age. The lower hills below the escarpment are metasedimentary and granitic rocks of probable late Precambrian and Cambrian age.

Antarctica 14. Dry valleys of the Koettlitz Glacier area, Victoria Land

Area: Victoria Land.
Lat 78° S.; long 164° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:30,000.
Focal length: 6 in.
Date flown: Dec. 6, 1956.
Map reference: U.S. Geol. Survey Mount Discovery sheet, Antarctica, 1965, scale 1:250,000.
Geology references: Blank, H. R., Cooper, R. A., Wheeler, R. H., and Willis, I. A. G., 1963, Geology of the Koettlitz-Blue Glacier Region, Southern Victoria Land, Antarctica: Royal Soc. New Zealand Trans., v. 2, no. 5, p. 79–100. Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p.

Features illustrated.—Looking west-southwest across the foothills of Koettlitz Valley (near sea level) to the high escarpment of the Royal Society Range. Mount Lister, altitude 4,025 meters, is on skyline just to the right of center. A short tongue of the Koettlitz Glacier (left foreground) extends westward up the Garwood Valley. The surface of this tongue is exceedingly rough, because of ablation which is intensified by a partial cover of dust (black stipple) blown onto the ice from the adjacent exposed rock. Concentric recessional moraines (black) on the valley floor indicate that a tongue of the Koettlitz Glacier once extended at least 8 kilometers up Garwood Valley. The modern ice tongue dams the ephemeral drainage of Garwood dry valley (middle ground) and forms a serpentine, ice-covered lake. In the upper part of this dry valley, the expanded-foot Garwood Glacier (middle right) blocks upvalley drainage and forms ice-covered Colleen Lake. Schist, marble, gneiss, and granitic rocks of possible Cambrian or late Precambrian age underlie the hills in the foreground. The escarpment of the Royal Society Range consists of flat-lying strata of the Beacon Group and Ferrar Dolerite sills resting unconformably on crystalline rocks.

Antarctica 15. Polar ice plateau and upper parts of Taylor and Ferrar Glaciers, Victoria Land

Area: Victoria Land.
Lat 78° S.; long 160° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:15,000.
Focal length: 6 in.
Date flown: Dec. 22, 1958.
Map reference: U.S. Geol. Survey Taylor Glacier sheet, Antarctica, 1965 scale 1:250,000.
Geology reference: Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p. Hamilton, Warren, and Hayes, P. T., 1963, Type section of the Beacon Sandstone of Antarctica: U.S. Geol. Survey Prof. Paper 456–A, 18 p.

Features illustrated.—Looking northeast from edge of polar ice plateau to Ross Sea with Mount Erebus, altitude 3,794 meters, on skyline to right. Beyond Beacon dry valley (upper center) are the Kukri Hills (upper right) between the Ferrar Glacier to the right and the Taylor Glacier to the left. Flat-lying beds of the Beacon Group (gray), here of Devonian to Permian age, and sills of Ferrar Dolerite of Jurassic age are exposed in Beacon Valley. Metasedimentary schist and gneiss and granitic rocks of probable late Precambrian and early Paleozoic age underlie the Kukri Hills and adjacent mountains.

Antarctica 16. Ferrar Glacier, Kukri Hills, and Taylor Valley across edge of McMurdo Sound.

Area: Victoria Land.
Lat 77°40′ S.; long 163° E.
Number of photographs: 1.
Photograph scale (foreground): About 1: 30,000.
Focal length: 6 in.
Date flown: Dec. 19, 1957.
Map reference: U.S. Geol. Survey Ross Island and Taylor Glacier sheets, Antarctica, 1965, scale 1:250,000.
Geology reference: Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p. Angino, E. E., Turner, M. D., and Zeller, E. J., 1962, Reconnaissance geology of Lower Taylor Valley, Victoria Land, Antarctica: Geol. Soc. America Bull. v. 73, p. 1553–1562.

Features illustrated.—Looking southwest along the Kukri Hills (center) toward the polar ice plateau (skyline). Taylor Valley, a typical dry valley, on the northwest side of the Kukri Hills extends for 32 kilometers to the terminus of Taylor Glacier. Ferrar Glacier on the southeast side of the hills is a typical valley glacier about 5 kilometers wide which flows 100 kilometers from the polar ice plateau. Small highland ice sheets in the Asgard Range (right, middle ground) nourish two expanded-foot glaciers, Commonwealth Glacier (to right) and Canada Glacier (center), on the valley floor. Much of the drainage in Taylor dry valley is to frozen Lake Fryxell (up valley from Commonwealth Glacier) and to frozen Lake Chad (up valley from Canada Glacier) because a glacial tongue from McMurdo Sound formerly occupied the valley.

Dust, blown downvalley, accentuates cracks in the sea ice on McMurdo Sound (foreground) and outlines individual floes of pack ice that are frozen into slightly younger sea ice (right foreground).

Metasedimentary and granitic rocks of probable late Precambrian and early Paleozoic age underlie the rugged mountainous terrain in the middle ground. Flat-lying strata of the Beacon Group and Ferrar Dolerite form most of the broad-topped mountains in the background.

Antarctica 17. Lower Taylor Glacier and Lake Bonney in Taylor Valley, Victoria Land

Area: Victoria Land.
Lat 77°45′ S.; long 162°30′ E.
Number of photographs: 1.
Photograph scale (foreground): About 1:40,000.
Focal length: 6 in.
Date flown: Nov. 7, 1959.
Map reference: U.S. Geol. Survey Taylor Glacier and Ross Island sheets, Antarctica, 1965, scale 1:250,000.
Geology reference: Angino, E. E., Turner, M. D., and Zeller, E. J., 1962, Reconnaissance geology of lower Taylor Valley, Victoria Land, Antarctica: Geol. Soc. America Bull., v. 73, p. 1553–1562. Gunn, B. M., and Warren, Guyon, 1962, geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p.

Features illustrated.—Looking west-southwest up Taylor Valley from near sea level to the polar ice plateau at 2,000–2,500 meters on skyline. Permanently ice-covered Lake Bonney (center) at terminus of Taylor Glacier is a saline-stratified lake with basal warm-water layers. Local glaciers flow into the dry valley from hanging tributary valleys in the Kukri Hills (left middle) and the Asgard Range (right). The Ferrar Glacier is to the left of the Kukri Hills. Metasedimentary and granitic rocks of probable late Precambrian and early Paleozoic age underlie Taylor Valley and adjacent mountains. Lamprophyre dikes cut granitic rocks in sharply defined fracture sets in the left foreground. The black splotches on the valley floor here and farther southwest are small basaltic cinder cones and flows that are younger than the oldest moraines. Taylor dry valley has a valley-in-valley form. The broad glacial valley is older than the basalt cones and flows, whereas an inner glacial valley, presently occupied in its upper part by the snout of the Taylor Glacier, is younger than the basalt. At the head of the lower Taylor Valley where the Taylor Glacier makes its last sharp abrupt bend, a black subhorizontal dolerite sill cuts the steep granitic valley sides. Upvalley from this area, most of the exposed rocks are flat-lying sandstones and arkoses of the Beacon Group, here of Devonian to Permian age, that are cut by many dolerite sills of probable Jurassic age.

Antarctica 18. Commonwealth Glacier, an expanded-foot glacier, Taylor Valley, Victoria Land

Area: Victoria Land.
Lat 77°35′ S.; long 163°15′ E.
Number of photographs: 1.
Photograph scale (foreground): About 1:15,000.
Focal length: 6 in.
Date flown: Jan. 1, 1958.
Map reference: U.S. Geol. Survey Ross Island sheet, Antarctica, 1965, scale 1:250,000.
Geology reference: Angino, E. E., Turner, M. D., and Zeller, E. J., 1962, Reconnaissance geology of Lower Taylor Valley, Victoria Land, Antarctica: Geol. Soc. America Bull. 73, p. 1553–1562. Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p.

Features illustrated.—Looking northwest across Taylor Valley to the terminus of Commonwealth Glacier which is fed by a local ice sheet in the eastern foothills (midground) of the Asgard Range. Beyond are the Ross Sea (upper right) and peaks of the Prince Albert Mountains (background). Commonwealth Glacier is an expanded-foot glacier with vertical terminal walls about 10 meters high. The relations of the faintly visible concentric layers and of the radial extension joints, which are crevasses deeply etched by ablation and by ephemeral melt water, to the curvature of the terminus imply a dynamic state of at least approximate equilibrium. The absence of excessive morainal debris at the terminus suggests growth rather than recession. However, growth may be only slight because the distributary melt-water channels are apparently well adjusted to the present position of the ice front. Drift, with polygonal patterned surface, that mantles the Taylor Valley floor is derived from a main-valley glacier that flowed upvalley from McMurdo Sound, less than 1 mile to the right; hence drainage on the valley floor is upvalley. Lateral moraines related to this upvalley glaciation, are visible on the valley side. Metasedimentary and granitic rocks of probable late Precambrian and early Paleozoic age are exposed on the valley side.

Antarctica 19. Onyx River and iced-covered Lake Vanda, Wright Valley, Victoria Land

Area: Victoria Land.
Lat 77°30′ S.; long 162° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:40,000.
Focal length: 6 in.
Date flown: Nov. 7, 1959.
Map reference: U.S. Geol. Survey Ross Island and Taylor Glacier sheets, Antarctica, 1965 scale 1: 250,000.
Geology reference: McKelvey. B. C., and Webb, P. N., 1962, Geology of Wright Valley, pt. 3 of Geological investigations in southern Victoria Land, Antarctica: New Zealand Jour. Geology and Geophysics, v. 5, no. 1, p. 143–162. Gunn, B. M., and Warren, Guyon, 1962, Geology of Victoria Land between the Mawson and Mulock Glaciers, Antarctica: New Zealand Geol. Survey Bull. 71, 157 p.

Features illustrated.—Looking southwest up Wright Valley from near sea level to the polar ice plateau at 2,000–2,500 meters on skyline. The ephemeral Onyx River drains south 35 kilometers up the dry valley to permanently ice-covered Lake Vanda (upper center). In center foreground the river flows through a recessional moraine of south-flowing Wright Lower Glacier that is beneath the camera. The Asgard Range (left) is the source of several local glaciers that terminate in Wright dry valley. These glaciers have characteristic steep-walled snouts. Gneiss and granodiorite of early Paleozoic age cut by lamprophyre dikes (about parallel to trend of valley) underlie Wright Valley. The terminus of Wright Upper Glacier rests on a structural bench underlain by a thick resistant sill of Ferrar Dolerite of Jurassic age. This sill is at the unconformity between the crystalline rocks and the overlying Beacon Group, here of Devonian and Permian age.

Antarctica 20. Moraines and patterned ground near Bull Pass, Wright Valley, Victoria Land

Area: Victoria Land.
Lat 77°30′ S.; long 162° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:10,000.
Focal length: 6 in.
Date flown: Jan. 1, 1956.
Map reference: U.S. Geol. Survey Taylor Glacier sheet, Antarctica, 1965, scale 1:250,000.
Geology reference: McKelvey, B. C., and Webb, P. N., 1962, Geology of Wright Valley, pt. 3 of Geological investigations in southern Victoria Land, Antarctica: New Zealand Jour. Geology and Geophysics, v. 5, no. 1, p. 143-163.

Features illustrated.—Looking north from Wright Valley into the Olympus Range. The broad valley in center and left background is Bull Pass which hangs nearly 300 meters above the floor of Wright Valley. Bull Pass contains morainal debris, small frozen lakes, and several kames where two streams debouch into the valley from the east (right). The streaked west (left) slope of the pass suggests solifluction. The ephemeral Onyx River (foreground) on the Wright Valley floor flows west (left) up valley. An alluvial fan is being built below the mouth of the pass. Polygonal ground is especially visible in moist alluvium (right foreground). The valley wall is composed of granitic rocks of probable early Paleozoic age, which are cut by steeply dipping lamprophyre dikes, joints, and small faults that are differentially etched by erosion. The ragged dark-gray edge at the lip of Bull Pass is a dolerite sill of Jurassic age that cuts the granitic rock (light gray). The full thickness of the sill can be seen to the right.

Antarctica 21. Floating tongue of Campbell Glacier in Terra Nova Bay, Victoria Land

Area: Victoria Land.
Lat 74°30′ S.; long 165° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:40,000.
Focal length: 6 in.
Date flown: Oct. 11, 1960.
Map reference: U.S. Geol. Survey Mount Melbourne sheet, Antarctica, 1968, scale 1:250,000.
Geology reference: Richer, J. F., 1964, Outline of the geology between Mawson and Priestly Glaciers, Victoria Land, in Adie, R. J., ed., Antarctic geology: New York, John Wiley and Sons, p. 265–275.

Features illustrated.—Looking west across Terra Nova Bay to the 20-kilometer-long floating tongue of Campbell Glacier surrounded by 1-year-old sea ice. Flat-lying basalt flows and dolerite sills of probable Jurassic age form the plateau of Mount Nansen (in background) in front of which lies Priestley Glacier that extends from right skyline downward and to left across the photograph. Basalt flows and tuffs of Cenozoic age underlie most of the low-lying hills in the middle ground.

Antarctica 22. Priestley Glacier and polar ice plateau near Terra Nova Bay, Victoria Land

Area: Victoria Land.
Lat 74°30′ S.; long 163°30′ E.
Number of photographs: 1.
Photograph scale (foreground): About 1:45,000.
Focal length: 6 in.
Date flown: Dec. 6, 1961.
Map reference: U.S. Geol. Survey Mount Melbourne sheet, Antarctica, 1968, scale 1:250,000.
Geology reference: Richer, J. F., 1964, Outline of the geology between Mawson and Priestley Glaciers, Victoria Land, *in* Adie, R. J. ed., Antarctic geology: New York, John Wiley and Sons, p. 265–275.

Features illustrated.—Looking south across edge of a small highland ice sheet to Priestley Glacier. Terra Nova Bay and Ross Sea are in upper left. Windablation moats (as much as 30 meters deep) surround small nunataks in left foreground. Basalt flows and tuffs of Cenozoic age underlie the foothills on either side of Priestley Glacier. The plateau in the right background, Mount Nansen (2,700 meters high), is underlain by about 1,200 meters of flat-lying basalt flows, interbedded sandstone, and dolerite sills of probable Jurassic age. Granitic rock of probable early Paleozoic age makes up the foothills below the scarp. The polar ice plateau, at an altitude of about 1,800 meters, lies beyond Mount Nansen on the right skyline.

Antarctica 23. Aretes, matterhorns, and U-shaped valleys near Trafalgar Glacier, Admiralty Mountains, northern Victoria Land

Area: Admiralty Mountains.
Lat 73°30′ S.; long 168°15′ E.
Number of photographs: 1.
Photograph scale (foreground): about 1:30,000.
Focal length: 6 in.
Date flown: Nov. 4, 1960.
Map reference: U.S. Geol. Survey Northern Victoria Land, Antarctica Sketch Map, 1968, scale 1:500,000. Am. Geog. Soc., Antarctica, 1965, scale 1:5,000,000.
Geology reference: Harrington, H. J., Wood, B. L., McKellar, I. C., and Lensen, G. J., 1967, Topography and geology of the Cape Hallet district, Victoria Land, Antarctica: New Zealand Geol. Survey Bull. 80, 99 p. Le Couteur, P. C., and Leitch, E. C., 1964, Preliminary report on the geology of an area southwest of upper Tucker Glacier, northern Victoria Land; *in* Adie, R. J., ed., Antarctic Geology: New York, John Wiley and Sons, p. 229–236.

Features illustrated.—Looking north-northeast across the Trafalgar (left and center) and Tucker Glaciers (middle) to the rugged Admiralty Mountains (background). The Ross Sea is behind the black pyramid of Mount Herschel, altitude 3,335 meters, on the upper right. Mount Minto is the highest peak (altitude 4,163 meters) just to left of center skyline. The presence of matterhorns, steep slopes, and U-shaped valleys indicates vigorous glacial erosion.

Granitic rock of Paleozoic age underlies the rough blocky rock surfaces in the center foreground. Low-grade metasedimentary slate and graywacke of the Robertson Bay Formation of probable late Precambian age underlie most of the rest of the terrain. The metasedimentary rocks are intensely folded about northwest-trending axes nearly parallel to the trend of the Tucker Glacier.

Antarctica 24. Glaciers of the Admiralty Mountains on edge of ice-covered Robertson Bay, northern Victoria Land

Area: Admiralty Mountains.
Lat 71°30′ S.; long 170° E.
Number of photographs: 1.
Photograph scale (foreground): About 1:50,000.
Focal length: 6 in.
Date flown: Nov. 2, 1961.
Map reference: U.S. Geol. Survey Northern Victoria Land, Antarctica Sketch Map, 1968, scale 1:500,000. Am. Geog. Soc., Antarctica, 1965, scale 1:5,000,000.
Geology reference: Harrington, H. J., Wood, B. L., McKellar, I. C., and Lensen, G. J., 1967, Topography and geology of the Cape Hallett district, Victoria Land, Antarctica: New Zealand Geol. Survey Bull. 80, 99 p. Rastall, R. H., and Priestley, R. E., 1921, The slate-graywacke formation of Robertson Bay: British Antarctic ("Terra Nova") Exped., 1910, Nat. History Dept., Geology, v. 1, no. 4, p. 121–128.

Features illustrated.—Looking south-southwest across Robertson Bay and the icebound shore of the Pacific Ocean to the Admiralty Mountains, which rise to an altitude of 4,000 meters. Cape Adare is just off the photograph to the left, and Cape Hallett is to the upper left (below skyline). U-shaped valleys 500–1,000 meters deep, aretes, and horns indicate vigorous erosion by valley glaciers in the mountains. The Dugdale Glacier with its jagged floating ice tongue is left of center, and the sinuous Ommanney Glacier is to the right. One-year-old sea ice (gray) covers Robertson Bay, and north-northwest-trending sastrugi (light-gray streaks) on the bay ice are parallel to the length of the bay.

Low-grade metasedimentary slate and graywacke of the Robertson Bay Formation of probable late Precambian age underlie the mountains. These rocks are intensely folded about northwest-trending axes nearly parallel to the shoreline in the middle ground. Volcanic rocks of Cenozoic age underlie most of the mountain on the right end of the shoreline as well as Cape Hallett.

Bikini 1. Airukiiji Island and adjoining reefs, Bikini Atoll

Area: Airukiiji Island.
Lat 11°31′ N.; long 165°25′ E.
Number of photographs: 3.
Photograph scale: 1:5,000.
Focal length: 24 in.
Date flown: Unknown.
Map reference: Chart 2 in geology reference, scale 1:50,000.
Geology reference: Emery, K. O., Tracey, J. I., Jr., and Ladd, H.S., 1954, Geology of Bikini and nearby atolls: U.S. Geol. Survey Prof. Paper 260–A, p. 1–264. See pl. 15, fig. 2.

Features illustrated (set nos. Bikini 1 A–C in southwest corner of photographs. Photographs trimmed from 9- by 18-inch size).—The channeled seaward edge of the platform of Bikini Atoll is visible through several tens of feet of water near the south edges of photographs. The fringing reef at the breaker line has an irregular "combtooth" margin, unlike the reef on the lagoonward (north) side. The water of the lagoon is much quieter than the rough water of the open sea, even though whitecaps are present.

Waves have washed sand toward the lagoon in the pass between Airukiiji Island (photograph 1 B) and

Airukiraru Island (southwest quadrant photograph 1 A); the broad pass east of Airukiiji is Enyu Channel (photograph 1 C). A stand of coconut palms, identified by the stellate pattern and open canopy, contrasts with surrounding woods and brush covering most of the island.

Bikini 2. Storm-damaged coral reef, Enirik Island, Bikini Atoll

Area: Enirik Island.
Lat 11°30′ N.; long 165°20′ E.
Number of photographs: 4.
Photograph scale: 1:5,000.
Focal length: 24 in.
Date flown: Unknown.
Map reference: Plate 2 in geology reference.
Geology reference: Emery, K. O., Tracey, J. I., Jr., and Ladd, H. S., 1954, Geology of Bikini and nearby atolls, Part 1, Geology: U.S. Geol. Survey Prof. Paper 260–A, p. 1–264. See text figs. 8 and 9 and fig. 4 of pl. 13, taken from northwest quadrant of photograph 3.

Features illustrated (*set nos. Bikini 2 A–D in southwest corner of photographs. Photographs trimmed from 9- by 18-inch size*).—Enirik Island and adjoining reef, at southernmost point of Bikini Atoll. Southeast of island, the reef has long, narrow, subequal reentrants ("combtooth" pattern, type II–B–2, of Emery and others), but on southwest side the reef has large irregular reentrants (type II–B–1; photographs A and B). The large reentrants are the result of erosion by storm waves. Although area is on lee side of atoll in relation to prevailing trade winds (note wave pattern at sea and breaker pattern on reefs), reef is occasionally battered by severe storm waves from south. Blocks thrown up onto reef by storm waves are visible in southeast quadrant of photograph C.

Bolivia 1. Achocalla Mudflow, south of La Paz, Bolivia

Lat 16°33′ S.; long 68°07′ W.
Number of photographs: 4.
Photograph scale: 1:50,000.
Focal length: 6 in.
Date flown: May 28, 1956.
Map reference: Plate 2 in geology reference.
Geology reference: Dobrovolny, Ernest, 1962, Geología del valle de La Paz; Bolivia, Departamento Nacional de Geología, Bol. no. 3, p. 62–63. See lamina 2.

Features illustrated (*set nos. Bolivia 1 A–D in southwest corner of photographs*).—The Rio Mallasa heads in breaks of a high plain (the altiplano, west half photograph A) and flows east to south-flowing Rio La Paz (east half photograph C). The Achocalla Mudflow originated near head of Rio Mallasa, descended more than 600 meters in 10 kilometers to main valley where a bedrock spur deflected it south. Landslide topography, with closed depressions and ponds, persists (southwest quadrant photograph C). According to Dobrovolny, the mudflow, about 2.5 cubic kilometers of material, ponded Rio La Paz to a depth of at least 150 meters. This ponding flooded site of La Paz suburb Calacoto (prominent racetrack); deposits of Lake Calacoto reach a thickness of 45 meters. Lake apparently is younger than glacial drift which is 9,000 years old by radiocarbon dating; thus Achocalla Mudflow is probably of Recent age. The railroad grade descending from the altiplano in northwest quadrant of photograph B was abandoned in 1928 when it was destroyed by landslides.

Bolivia 2. Oriented lakes in the Beni Basin northeast of La Paz

Lat 14°45′ S.; long 66°00′ W.
Number of photographs: 4.
Photograph scale: 1:40,000 (verticals).
Focal length: 6 in.
Date flown: 1948.
Geology reference: Plafker, George, 1964, Oriented lakes and lineaments of northeastern Bolivia: Geol. Soc. America Bull., v. 75, p. 503–522.

Features illustrated (*Bolivia 2 A is an oblique photograph, view east. Set nos. Bolivia 2 B–D in northwest corner of photographs*).—Two of several hundred shallow lakes with shorelines oriented roughly northeast-southwest and northwest-southeast. Most lakes have no inlet or outlet. The lakes are in upper Cenozoic clastic sediments that overlie crystalline rocks of the Brazilian Shield. Lakeshores parallel structural trends in the basement, and Plafker infers that the lakes formed by subsidence of individual basement blocks. The lake near the northwest corner of photograph C is just above the center of photograph A and near the right edge of Plafker's figure 2. Photograph A shows other oriented lakes in the distance. The region is predominantly grassland; forest is largely confined to belts along streams and to fringes along much of the lakeshores.

Brazil 1. Pontal de Sernambetiba, a tombolo southwest of Rio de Janeiro

Lat 23°02′ S.; long 43°28′ W.
Number of photographs: 3.
Photograph scale: 1:20,000.
Focal length: 6 in.
Date flown: Nov. 29, 1964.
Map reference: See geology reference.
Geology reference: Brazil, Secretaria Geral de Agricultura, Indústria e Comércio, 1949, Mapa geológico do Distrito Federal, scale 1:87,000.

Features illustrated (*set nos. Brazil 1 A–C in southwest corner of photographs*).—A cliffed bedrock hill of granite and "lenticular gneiss" (near center of photograph B) is tied to the mainland by a sandbar or tombolo. The coast is mainly wave built; a notation on the map indicates that near the tombolo the shore is advancing at the rate of 1 meter per year. Patterns in the water show how waves are refracted by the former island. These waves caused sand to move in behind the island and build the sand bar that ties it to the shore. Another steep-sided hill of granite gneiss, near the west edge of photograph B, rises above the coastal plain; a third granite gneiss hill (Peças, in the southwest quadrant of photograph A) is still an offshore island. East of the tombolo, a lagoon and tidal marsh are behind the beach, which here becomes a bar.

Chile 1. Artesian conditions at Pica oasis, Atacama Desert

Area: Province of Tarapacá.
Lat 20°30′ S.; long 69°20′ W.
Number of photographs: 4.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 7, 1955.
Map reference: Pica and Matilla sheets in geology reference, scale 1:50,000. U.S. Air Force World Aeronautical Chart, Point Angamos sheet (1258), scale 1:1,000,000.
Geology reference: Galli Olivier, Carlos, and Dingman, R. J., 1962, Cuadrangulos Pica, Alca, Matilla y Chacarilla, con un estudio sobre los recursos de agua subterránea, Provincia de Tarapacá: Chile, Instituto de Investigaciones Geológicas, 125 p. Dingman, R. J., and Galli O., Carlos, 1965, Geology and ground-water resources of the Pica area, Tarapacá Province, Chile: U.S. Geol. Survey Bull. 1189. See figs. 22 and 23.

Features illustrated (set nos. Chile 1 A–D in southeast corner of photographs).—East half of area is a west-facing dip slope, partly dune covered, on an ignimbrite member of Altos de Pica Formation. Ridge west of Pica oasis (southeast quadrant of photograph C) marks upthrown side of a north-south fault that brings impermeable Jurassic rocks (exposed near center of photograph D) against an aquifer in basal Altos de Pica beds. Ground water escapes upward through fractures to form springs that irrigate the fruit groves of Pica. The several oases from Pica to Puquio de Núñez (south center of photograph A) are fed by infiltration galleries that recover seepage water from Pica irrigation. A flowing well at Salto Chico (dry falls that breach ignimbrite southeast of Pica) yields water for irrigation in the quebrada (arroyo) and for the city of Iquique, some 75 miles away on the coast. A pipeline runs northwest beside the road in northwest quadrant of photograph A. Stereoscopic coverage of Puquio de Núñez is provided by Chile 2 B.

Chile 2. Mudflow fan of Quebrada Chacarilla, Atacama Desert

Area: Province of Tarapacá.
Lat 20°40′ S.; long 69°20′ W.
Number of photographs: 2.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 7, 1955.
Map reference: Matilla sheet in geology reference, scale 1: 50,000. U.S. Air Force World Aeronautical Chart, Point Angamos sheet (1258), scale 1:1,000,000.
Geology reference: Galli Olivier, Carlos, and Dingman, R. J., 1962, Cuadrangulos Pica, Alca, Matilla y Chacarilla, con un estudio sobre los recursos de agua subterránea, Provincia de Tarapacá: Chile, Instituto de Investigaciones Geológicas, 125 p. Dingman, R. J., and Galli O., Carlos, 1965, Geology and ground-water resources of the Pica Area, Tarapacá Province, Chile: U.S. Geol. Survey Bull. 1189, 113 p.

Features illustrated (set nos. Chile 2 A, B in southeast corner of photographs).—Quebrada (arroyo) Chacarilla, which enters area of photograph A near southeast corner, has built a broad fan marked by complex patterns of braided channels. The most recent flow, along north edge of fan, largely effaced the fan of smaller Quebrada Puquio Núñez (northwest quadrant of photograph A). According to Dingman and Galli O., the fans are built by mudflows that occur at intervals of several years; the conspicuous channels in the mudflow deposits are carved as the flow is decreasing. Above its fan, Quebrada Chacarilla carries water at night and in the morning and dries up each afternoon (Dingman, written commun., 1964). The water is too salty—2,423 ppm (parts per million) chloride, 5,531 ppm total dissolved solids—for domestic or irrigation use. A small oasis, Puquio de Núñez (dark patch near center of photograph B), gets its water from an infiltration gallery. For stereoscopic coverage of the northern part of photograph B, see Chile 1A.

Chile 3. Open pit copper mine at Chuquicamata, Chile

Area: Province of Antofagasta.
Lat 22°20′ S.; long 68°55′ W.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Apr. 18, 1961.
Map reference: U.S. Air Force World Aeronautical Chart, Point Angamos sheet (1258), scale 1:1,000,000.
Geology reference: Renzetti, B. L., 1957, Geology and petrogenesis at Chuquicamata, Chile: Dissert. Abs., v. 17, no. 10, p. 2249.

Features illustrated (set nos. Chile 3 A, B in southeast corner of photographs).—The copper mine at Chuquicamata, in the Chilean desert at an altitude of about 9,000 feet, is an open pit about 2 miles long with terraced slopes. The great dumps of waste as well as the size of the pit reflect the large amount of material that has been mined. Vegetation is completely lacking, the result of an extremely arid climate that doubtless accounts for the unique mineralogy of the deposit; according to Renzetti, the deposit is generally similar to other porphyry copper deposits, except that much of the copper is in the form of hydrous sulfates.

Chile 4. Volcanoes in the high Andes on the Chile-Bolivia border

Area: Andes mountains.
Lat 22°50′ S.; long 67°52′ W.
Number of photographs: 3.
Photograph scale: 1:45,000.
Focal length: 6 in.
Date flown: Apr. 27, 1961.
Map reference: U.S. Air Force World Aeronautical Chart, Point Angamos sheet (1258), scale 1:1,000,000.
Geology reference: Chile, Instituto de Investigaciones Geologicas, 1960, Mapa Geológica de Chile, scale 1:1,000,000.

Features illustrated (*set nos. Chile 4 A–C in southeast corner of photographs*).—Licancábur Volcano (northwest quadrant photograph B), a symmetrical cone with summit crater about 800 feet in diameter, has radial grooves (avalanche scars?) on steep upper slopes and radiating lava tongues; several have curved transverse ridges and natural levees on lower slopes. The lavas were viscous; the tongues have high steep flanks and fronts. Southeast of Licancábur, a second cone, with a summit caldera more than a mile in longer diameter, has lava tongues with subdued forms that imply an age greater than that of Licancábur. Though both peaks show autumn snows that indicate their high altitude, they lack cirques such as occur at high altitudes to the north (see Ecuador 2) and south. This fact suggests that the climate was dry in the Pleistocene as it is today. Both volcanoes stand on an older surface of ignimbrite (southwest quadrant of photograph A) at altitudes above 12,000 feet.

Chile 5. Lavas controlled by stream valleys

Area: Province of Antofagasta.
Lat 22°45′ S.; long 68°05′ W.
Number of photographs: 3.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 7, 1961.
Map reference: Maps in geology references.
Geology reference: Dingman, R. J., 1967, Geology and groundwater resources of the northern part of the Salar de Atacama, Antofagasta Province, Chile: U.S. Geol. Survey Bull. 1219, 49 p. Dingman, R. J., 1968, Carta geológica de Chile, Cuadrangulo San Pedro, Provincia de Antofagasta: Chile, Instituto de Investigaciones Geológicas.

Features illustrated (*set nos. Chile 5 A–C in southeast corner of photographs*).—The west slope of the Andes is here a dip slope on a Pliocene welded tuff (southwest quadrant of photograph A). Canyons carved in this surface determined the locations of two basalt tongues, which descended westward from the high mountains (outside area shown in photographs). The mechanism of this control is suggested by the westernmost tongue, which is in part a collapsed lava tube. The basalt, in turn, has partly controlled postbasalt erosion. The basalt was viscous and has an aa surface. North of the flows are several partly exposed ring dikes that surround the base of an old volcano, now largely eroded away.

Chile 6. Thrusting in near-surface rocks near San Pedro de Atacama

Area: Province of Antofagasta.
Lat 22°45′ S.; long 68°20′ W.
Number of photographs: 3.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 9, 1961.
Map reference: Plate in pocket of second geology reference.
Geology reference: Dingman, R. J., 1963, Reversal of throw along a line of low-angle thrust faulting near San Pedro de Atacama, Chile: U.S. Geol. Survey Prof. Paper 450–E, p. E25–E27. Dingman, R. J., 1963, Carta geológica de Chile, Cuadrangulo Tulor, Provincia de Antofagasta: Chile, Instituto de Investigaciones Geológicas, Carta no. 11, scale 1:50,000.

Features illustrated (*set nos. Chile 6 A–C in southeast corner of photographs*).—Thrust faulting formed a line of hills that extends southwest from the northeast corner of photograph B across a southeast-sloping piedmont. Welded tuffs of late Tertiary age (light tone) were faulted when underlying Tertiary rocks (northwest quadrant of photograph B) glided toward basin that lies to southeast (see Chile 7, which adjoins this set on south). On Photograph A the fault is an underthrust that extends along northwest side of ridge; here tuff in the static block overrode rocks of same and somewhat younger age. In next hill to northeast (south of center of southeast quadrant of photograph C), fault is an overthrust that crops out near southeast side of ridge; here Quaternary mudflows (dark tone) cap tuff in the active plate. Bajadas, built chiefly by mudflows, show braided stream patterns.

Chile 7. Salt-lubricated folding and doming in the Atacama Desert

Area: Province of Antofagasta.
Lat 22°54′ S.; long 68°20′ W.
Number of photographs: 3.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 9, 1961.
Map reference: Plate in pocket of second geology reference.
Geology reference: Dingman, R. J., 1962, Tertiary salt domes near San Pedro de Atacama, Chile: U.S. Geol. Survey Prof. Prof. Paper 450–D, p. D92–D94. Dingman, R. J., 1963, Carta geológica de Chile, Cuadrangulo Tulor, Provincia de Antofagasta: Chile, Instituto de Investigaciones Geológicas, Carta no. 11, scale 1:50,000.

Features illustrated (*set nos. Chile 7 A–C in southeast corner of photographs*).—In the Cerros de la Sal (most of photograph B) both anticlinal and synclinal ridges and valleys are well illustrated. The rocks are continental arid-basin deposits of early Tertiary age, chiefly fine-grained clastic rocks with many salt and gypsum beds. Dingman attributes the complex structures to incompetent folding under compression, as rocks lubricated by the evaporites glided toward the axis of the basin from both sides (Chile 6 adjoins this set on north). Dingman interprets the dark ridge (resembling a railroad embankment) across valley about 1.5 inches northeast of center of photograph B as eolian sand; similar dark-toned sand occurs on the lee (southeast) sides of ridges elsewhere. Figure 147.2 in the first geology reference is an annotated copy of most of photograph B.

Chile 8. Fan diversion of drainage

Area: Province of Antofagasta.
Lat 23°10′ S.; long 70°08′ W.
Number of photographs: 2.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Apr. 14, 1955.
Map reference: U.S. Air Force World Aeronautical Chart, Point Angamos sheet (1258), scale 1:1,000,000.
Geology reference: Chile, Instituto de Investigaciones Geológicas, 1960, Mapa Geológica de Chile, scale 1:1,000,000.

Features illustrated (*set nos. Chile 8 A, B in southeast corner of photographs*).—A precipitous fault scarp trending north-northeast marks the straight west side of a narrow fault valley (west half of photograph A). The main stream, flowing south-southwest in the fault valley, is forced to detour around two fans built by streams that drain small valleys in the mountains to the west. Elsewhere the scarp is fronted by a bajada built by small streams that head on the scarp. Where a fan built by a stream from the east is opposed to the bajada, the main stream is confined to a narrow, straight channel. Upstream (north half of photograph B) the valley widens, and the main stream forms a wide belt of braided channels. The mountains west of the fault are of Mesozoic granite; east of the valley they are of Jurassic volcanic and sedimentary rocks.

China 1. Dissected loess plain on lee side of Gobi Desert

Area: Shansi Province.
Lat approx 38° N.; long approx 112° E.
Number of photographs: 3.
Photograph scale: 1:30,000 (verticals).
Focal length: 6 in.
Date flown: Mar. 27, 1947.
Map reference: Army Map Service series 1301, sheet NJ49, Yang-Chu sheet, scale 1:1,000,000.

Features illustrated (*China 1 A is oblique view, south-southwest. China 1 B, C are vertical, set nos. in north corners*).—Thick loess blankets this region where rainfall is sufficient to support vegetation that can catch and hold dust deflated from the Gobi Desert to the west. The loess is deeply dissected; the mud load that gives the Yellow River its name testifies to the easy erodibility of this material. Most gullies are dendritic in pattern (contrast with China 2). Every hill and gully slope is terraced for cultivation. Long, narrow, cultivated fields of a flat tableland in photograph B extend approximately north-south.

China 2. Gully erosion in loess, promoted by works of man

Area: Shansi Province.
Lat approx 39° N.; long approx 114° E.
Number of photographs: 2.
Photograph scale: 1:50,000.
Focal length: 6 in.
Date flown: 1943.
Map reference: Army Map Service, series 1301, sheet NJ 50, Pei Ping sheet, scale 1:1,000,000.

Features illustrated (*set nos. China 2 A, B in west corner of photographs*).—Area shown is in western China on the lee (east) side of the Gobi Desert. In mountainous areas, including much of the north-northeast half of the photographs, loess is thin or absent and valleys have a dendritic pattern, but in more level areas, including most of the south-southeast half, thick loess (see China 1) forms dissected tablelands on which many gullies are rectilinear. Near the east edge of the area of stereoscopic coverage, rectilinear gullies form two sets, which drain south and west, respectively. Many of the rectilinear gullies, as near the south corner of photograph A and south of the center of photograph B, are parallel to or collinear with cultivation patterns that reflect property boundaries. This relation arises because the gullies originated as washed-out roads and washed-out cultivation furrows.

Ecuador 1. Lava flow on flanks of Antisana Volcano

Area: Pichincha.
Lat 0°26′ S.; long 78°16′ W.
Number of photographs: 3.
Photograph scale: 1:60,000.
Focal length: 6 in.
Date flown: Mar. 7, 1963.
Map reference: Army Map Service, series 1301, sheet SA17, Quito sheet, scale 1:1,000,000.

Features illustrated (*set nos. Ecuador 1 A–C in southeast corner of photographs*).—Lava emerged from two vents (near northeast corner of photograph C) on the side of a deep valley on the lower slopes of Antisana Volcano. Most of the lava flowed downvalley, but a little flowed a short distance upvalley, where it now impounds a lake. The main flow has conspicuous levees, where it is confined within the valley and downslope where it emerges onto the adjacent plain. There the flow bifurcates into two steep-sided tongues with bulbous protrusions on their flanks. Lava cascades descend from the plain into a deep canyon, where the lava has dammed two more lakes.

Ecuador 2. Mount Cotopaxi, a glacier-clad equatorial volcano

Area: Pichincha.
Lat 0°41′ S.; long 78°27′ W.
Number of photographs: 3.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: June 22, 1963.
Map reference: Army Map Service, series 1301, sheet SA17, Quito sheet, scale 1:1,000,000.
Geology reference: Whymper, Edward, 1892, Travels amongst the great Andes of the equator: London, John Murray, and New York, Charles Scribner's Sons, 456 p. See p. 123 and 136–155.

Features illustrated (*set nos. Ecuador 2 A–C in southeast corner of photographs*).—The great bulk of this nearly symmetrical volcano, which rises to an altitude of 19,344 feet, dwarfs its round summit crater. Despite its proximity to the equator, glaciers (severely crevassed) cover most slopes above 16,000 feet. In places, the limit of glacier ice is difficult to determine because snow whitens ground to well below glacier limit. According to Whymper, snow falls nightly and melts daily under the tropical sun. Snow on the rim of an inner crater is apparently thick, suggesting that the volcano is not continuously active as in Whymper's day. Catastrophic eruptions have occurred. In 1877, ash from Cotopaxi turned day into night at Quito, 32 miles away; ash fell on ships 200 miles away, and lava pouring onto glaciers initiated destructive mudflows. Below snowline, drainage is radial.

Equador 3. Cirques in jointed metamorphic rocks east of Gualaceo

Area: Azuay.
Lat 2°55′ S.; long 78°45′ W.
Number of photographs: 2.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: June 22, 1963.
Map reference: Army Map Service, series 1301, sheet SA17, Quito sheet, scale 1:1,000,000.

Features illustrated (*set nos. Ecuador 3 A, B in southeast corner of photographs*).—Rock basins containing ponds are evidently cirques with tarns. Snow is lacking; snowline must have been lower when the cirques were formed. The absence of snow even in midwinter, in an area of appreciable rainfall, indicates that the lower snowline was due at least partly to lower temperatures rather than heavier precipitation. Cooling at this equatorial latitude suggests that Pleistocene cooling was worldwide. The jagged forms of the cliffs, ridges, and valleys are controlled chiefly by strong foliation and joint patterns in bedrock, perhaps emphasized by frost action. Rock is widely exposed; very little regolith, either residual or transported, is present.

Guatamala 1. Radial drainage on Agua Volcano

Area: Sacatepéquez.
Lat 14°28′ N.; long 90°45′ W.
Number of photographs: 2.
Photograph scale: 1:50,000.
Focal length: 6 in.
Date flown: Jan. 29, 1954.
Map reference: Coast and Geodetic Survey, series ONC K–25, scale 1:1,000,000.
Geology reference: Williams, Howel, 1960, Volcanic history of the Guatemalan Highlands: California Univ. Pubs. Geol. Sci., v. 38, no. 1, p. 47–48.

Features illustrated (*set nos. Guatemala 1 A, B in southwest corner of photographs*).—A composite volcano, one of many in the Guatemalan Highlands. Crater rim is complete, except on north-northeast side. Height of cone (about 7,000 ft above base) approaches that of Cotopaxi (Ecuador 2), but because altitude (12,336 ft) is less, snow is lacking, and upper part of cone is forested. According to Williams, there is no authentic record of eruptions from Agua in historic times. Mudflows from its summit crater destroyed the first capital of Guatemala, Ciudad Vieja (near northwest corner photograph B), in 1541. These mudflows have been attributed to an eruption, but more likely were caused by sudden discharge of a lake when part of the crater rim collapsed during heavy rains. All the lavas and pyroclastic ejecta of Agua are hypersthene-augite andesites.

Iran 1. Wind transportation of dust: Dust devils

Lat 33°48′ N.; long 58°24′ E.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Aug. 7, 1956.
Map reference: Coast and Geodetic Survey, series ONC G–5, scale 1:1,000,000.

Features illustrated (*set nos. Iran 1 A, B in northeast corner of photographs*).—The sun is blazing from a cloudless sky on the dark-toned surface of a cultivated plain where two light-gray cones with indistinct boundaries rise almost vertically from the surface. These cones cast dark-gray shadows and are evidently "dust devils," vortexes of air that rise convectively from the hot ground and are revealed by the dust they carry upward. Dust haze obscures the pattern of the fields in the vicinity of the dust devils. A third vortex, indistinct on photograph A, is apparently just forming; a fourth appears near east edge of photograph B outside area of stereoscopic coverage. The dust devils moved southwest after photograph A was taken and before photograph B was taken. This movement shows that the dust is actually being transported across the plain, not merely being redistributed. The irrigated area in the northeast corner of photograph B is outside Sarāyān (Robert S. Jones, oral commun., 1965.)

Iran 2. Streaks inferred to be tracks of dust devils

Lat 30°52′ N.; long 58°38′ E.
Number of photographs: 1.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Aug. 25, 1956.
Map reference: Coast and Geodetic Survey, series ONC, H–7, scale 1:1,000,000.

Features illustrated (set no. Iran 2 in northeast corner of photograph).—An aggraded alluvial desert plain is marked by a pattern of faint lines. According to Robert S. Jones (oral commun., 1965), these are tracks left where dust devils have moved across the surface. The alluvial plain, a gently sloping bajada on the flank of a bolson, is seamed with a pattern of roughly parallel braided channels draining southwest. The supposed tracks form an intersecting pattern of straight to gently curving streaks, trending generally from northwest to southeast, roughly at right angles to the channels. The streaks are darker in tone than the background, possibly because the removal of light-colored fines from the surface leaves a residue of coarse material that is darker in tone.

Iran 3. Wind-scoured troughs and yardangs of the Shahr-e Lūt

Lat 30°50′ N.; long 58°15′ E.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Aug. 22, 1956.
Map reference: Coast and Geodetic Survey, series ONC, H–7, scale 1:1,000,000.

Features illustrated (set nos. Iran 3 A, B in northeast corner of photographs).—Carving of troughs, evidently by wind erosion and deflation, has left intervening residual ridges (yardangs). The long, narrow, steep-sided ridges are a few hundred to 1,500 feet wide, a few feet to more than 100 feet high, and 0.1 mile to several miles long; they are spaced a few hundred to nearly 2,000 feet apart. They are parallel, have blunt noses, and tail off to the south-southeast; clearly, the effective winds are from the north-northwest. The troughs are carved in fine-grained material (lake beds?) accumulated in the central part of this broad desert basin. This area of ridges and troughs is sometimes known as the Shahr-e Lūt (City of the Desert) because the troughs bear a fancied resemblance to streets between rows of mud-brick houses. The floors of the troughs, between the yardang ridges, are uneven, form closed depressions, and are dark in color; they are probably floored with lag deposits (sand?). Iran 4 adjoins this set on the east.

Iran 4. Possible doming of the Shahr-e Lūt basin

Lat 30°50′ N.; long 58°15′ E.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Aug. 22, 1956.
Map reference: Coast and Geodetic Survey, series ONC, H–7, scale 1:1,000,000.

Features illustrated (set nos. Iran 4 A, B in northeast corner of photographs).—Area shown is at northeast edge of the Shahr-e Lūt (see Iran 3, adjoining this set on west). A stream from the north that approaches the Shahr-e Lūt northwest of the photographs is diverted southeast along the margin of the yardang area and finally ends in the north half of these photographs (limits reached by water the last time the stream flowed are shown by white saline incrustation). Stream was ponded repeatedly by low residual ridges at edge of the Shahr-e Lūt. This ponding filled each flat up to the level at which water could spill over into the next one. The manner in which the stream detours around the margin of the Shahr-e Lūt, without extending far along the deep troughs toward the center of the bolson, suggests that the (lake?) beds from which the yardangs were carved have been tilted after deposition, perhaps by isostatic doming analogous to that inferred in the basin of Lake Bonneville.

Iran 5. Khanats, the underground water-collecting galleries of Iran

Lat 30°54′ N.; long 55°18′ E.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: July 6, 1956.
Map reference: Coast and Geodetic Survey, series ONC, H–7, scale 1:1,000,000.

Features illustrated (set nos. Iran 5 A, B in northeast corner of photographs).—The rows of dots extending west across southwest quadrant of photograph B mark the courses of khanats, underground infiltration galleries that collect ground water moving northeast through the alluvial deposits and divert it to flow obliquely to the fan's surface to the town of Anar (southeast quadrant). The khanat tunnels are driven from shafts; the spoil from a shaft and from the tunnel excavated in both directions from its bottom is dumped around the shaft head, and these piles of waste are the dots seen on the photographs. Such tunnels are subject to caving and require cleaning out from time to time. This enlarges the piles of spoil around the shafts. Eventually the time comes when it is considered better to drive a new khanat than to try to reopen an old one; this accounts for the parallel rows of dots. At least seven lines of dots can be seen on the photographs.

Iran 6. Dah Kuh salt plug and salt glacier

Lat 27°55′ N.; long 54°25′ E.
Number of photographs: 3.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: May 27, 1956.
Map reference: Army Map Service, series K501, sheet G–40 A, Lar sheet, scale 1:250,000.
Geology reference: Harrison, J. V., 1930, The geology of some salt-plugs in Laristan (southern Persia): Geol. Soc. London Quart. Jour., v. 86, no. 344, p. 463–520. See p. 492; pl. 53, fig. 1; and location map, p. 476.

Features illustrated (*set nos. Iran 6 A–C in northeast corner of photographs*).—Folded Tertiary sedimentary rocks in the Iranian desert form strike ridges that trend west-northwest and that are separated by valleys containing alluvial deposits. Harrison's Dah Kuh salt plug has been extruded at the crest of an anticlinal mountain. In this arid climate, the salts, chiefly halite and gypsum, not only survive in outcrop but form the highest summit in the vicinity. The salts have flowed in both directions along an adjacent valley. The resulting salt tongues, the longer one about 3 miles long, have rough surfaces and steep sides and resemble glaciers or tongues of viscous lava. The area is poorly known, and the features shown on Harrison's maps cannot be positively tied to those shown on the Army Map Service map; the village in the southwest quadrant of photograph B may be Dehkūyeh (Dehkūh of the Army Map Service map) and the salt plug the hill Kūh-i-Nimak.

Iran 7. Kūh-i-Gach salt plug and salt glacier

Lat 27°35′ N.; Long 54°25′ E.
Number of photographs: 3.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: May 28, 1956.
Map reference: Army Map Service, series K501, sheet G–40 A, Lar sheet, scale 1:250,000.
Geology reference: Harrison, J. V., 1930, The geology of some salt-plugs in Laristan (southern Persia). Geol. Soc. London Quart. Jour., v. 86, no. 344, p. 463–520. See p. 485 and pl. 56.

Features illustrated (*set nos. Iran 7 A–C in northeast corner of photographs*).—The Kūh-i-Gach salt plug has punched its way through to the surface, where it forms a hill more than 1,000 feet high (north half of photograph B). The salt and gypsum have flowed downhill toward the south; the resulting tongue-shaped body, more than 3 miles long, resembles a glacier or a flow of viscous lava, with arcuate transverse ridges separated by crevasselike gullies and with steep sides and front. Though the surface is rough, the tongue as a whole slopes gently southward from the base of the steeper slope of the dome that fed it. A stream is diverted around the terminus of the tongue. The village west of the tongue near center of photograph C is Nīhmeh; that southeast of the terminus in the southwest quadrant of photograph A is Karmusteh. The terminus of another salt glacier, Kuh-i-Siah Taq, lies 4 miles east of Karmusteh (southeast corner of photograph A).

Japan 1. Suggested analog of Moon's sinuous rills on Asama Volcano

Area: Honshū Island.
Lat 36°25′ N.; long 138°32′ E.
Number of photographs: 3.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: Nov. 6, 1947.
Map reference: Army Map Service, series L774, sheet 5856 III, Karuizawa sheet, scale 1:50,000.
Geology reference: Aramaki, Shigeo, 1963, Geology of Asama Volcano: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 14, pt. 2, p. 229–443. Aramaki, Shigeo, 1956–57, The 1783 activity of Asama Volcano: Japanese Jour. Geology and Geography, v. 27, p. 189–229 and v. 28, p. 11–33. Cameron, W. S., 1964, An interpretation of Schröter's Valley and other lunar sinuous rills: Jour. Geophys. Research, v. 69, no. 12, p. 2423–2430.

Features illustrated (*set nos. Japan 1 A–C in northeast corner of photographs*).—Central cone of Asama-yama (southwest quadrant of photograph B), one of Japan's most active and dangerous volcanoes, has a deep crater and is bordered on the west by a partial somma (caldera rim). Recent ash covers most ground near crater. Farther away are pyroclastic deposits, loose and gullied (northwest quadrant same photograph) to welded and little dissected (northeast quadrant). Ko-asama-yama, a conical hill (southeast quadrant), is a dome of viscous dacite lava. The Onioshidashi-iwa lava flow of 1783 (east half of photograph A) is hypersthene-augite andesite and has a rough, blocky surface. The flow partly fills the head of a flat-floored, steep-sided trench, the so-called Kambara ditch (northwest quadrant photograph C), carved by a nuée ardente that immediately preceded the lava. Cameron suggests the Kambara ditch as a terrestrial analog of the sinuous rills that occur on the Moon; her figure 5 is an annotated copy of part of photograph B.

Japan 2. Ō-shima Volcano: Volcano Mihara-yama, in an older caldera

Area: Ō-shima (island).
Lat 34°44′ N.; long 139°24′ E.
Number of photographs: 3.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: Sept. 27, 1947.
Map reference: Army Map Service, series L774, sheet 5951 II, Ō-shima sheet, scale 1:50,000.
Geology reference: Foster, H. L., and Mason, A. C., 1955, 1950 and 1951 eruptions of Mihara Yama, O Shima Volcano, Japan: Geol. Soc. America Bull., v. 66, p. 731–762.

Features illustrated (set nos. Japan 2 A–C in west-northwest corner of photographs).—A deep central inner pit in the crater of the volcano Mihara-yama (southwest quadrant of photograph B) has nearly vertical walls. Mihara-yama rises somewhat higher than a surrounding caldera rim, some 2 miles across. The rim is a somma, the highest remaining parts of an ancient volcano which Foster and Mason call Ō-shima Volcano because it makes up most of the island of Ō-shima. The rim rises 10–100 meters above the adjacent caldera floor, except in the northeast quadrant where lavas have poured out onto the outer slopes of the island (see also Japan 3). Plate 1 of Foster and Mason is reduced from photograph B.

Japan 3. Ō-shima Volcano: Explosion craters and lava delta

Area: Ō-shima (island).
Lat 34°43′ N.; long 139°25′ E.
Number of photographs: 5.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: Sept. 27, 1947.
Map reference: Army Map Service, series L774, sheet 5951 II, Ō-shima sheet, scale 1:50,000.
Geology reference: Foster, H. L., and Mason, A. C., 1955, 1950 and 1951 eruptions of Mihara Yama, O Shima Volcano, Japan: Geol. Soc. America Bull., v. 66, p. 731–762.

Features illustrated (set nos. Japan 3 A–E in southeast corner of photographs).—A strait connects Habuminato, a circular harbor surrounded by cliffs some 50 meters high (southeast quadrant of photograph D), to the sea. Foster and Mason believe the harbor is a crater formed by an explosion that occurred when ground water came in contact with hot rock; Hikubo crater, on land nearly a mile to the west resulted from another similar phreatic explosion. In 1778, basaltic lavas that descended eastward from Mihara-yama (volcano with crater in southwest quadrant of photograph B) spilled over a cliff as a lava cascade and built a delta out into the sea. According to Foster and Mason, the cliff is probably a fault scarp. Five parasitic cinder cones are alined about 2 kilometers west of the cliff; these include three in the northeast quadrant of photograph B, and Futago-yama and Tahei-yama, south of center of photograph C. For Mihara-yama, see also Japan 2.

Japan 4. Aso-san and other volcanoes within the same caldera

Area: Kyūshū Island.
Lat 32°53′ N.; long 131°04′ E.
Number of photographs: 5.
Photograph scale: 1:25,000.
Focal length: 6 in.
Date flown: Dec. 7, 1947.
Map reference: Army Map Service, series L772, sheet 4345 IV, Aso San sheet, scale 1:50,000.
Geology reference: Matsumoto, Tadaichi, 1943, The four gigantic caldera volcanoes of Kyūsyū: Japanese Jour. Geology and Geography, v. 19, special number, p. 1–57.

Features illustrated (set nos. Japan 4 A–E in northeast corner of photographs).—More than a dozen complete or partly destroyed craters can be identified on these photographs. These craters include bleached and unbreached cinder cones (photograph A); a lava-filled crater, probably a small caldera, containing a pond (southwest quadrant photograph C); and two complexes of intersecting craters. The eastern complex (southwest quadrant photograph D) has recently been active, as shown by a surrounding blanket of dark ejecta; columns of steam still rise from two fumaroles. Aso-san (southwest quadrant photograph E) stands more than 3,000 feet above the floor of the caldera (north edge of photographs) and 1,000 to more than 2,000 feet above the rim. The caldera in which Aso-san stands is one of the largest recognized, 10 miles across from east to west and 15 miles from north to south. According to Matsumoto, the postcaldera lavas are predominantly augite-andesite (auganite). Japan 5 adjoins this set on the west.

Japan 5. West rim of caldera surrounding Aso-san

Area: Kyūshū Island.
Lat 32°53′ N.; long 130°58′ E.
Number of photographs: 3.
Photograph scale: 1:25,000.
Focal length: 6 in.
Date flown: Dec. 7, 1947.
Map reference: Army Map Service, series L772, sheet 4245 I, Kikuchi sheet, scale 1:50,000.
Geology reference: Matsumoto, Tadaichi, 1943, The four gigantic caldera volcanoes of Kyūsyū: Japanese Jour. Geology and Geography, v. 19, special number, p. 1–57.

Features illustrated (set nos. Japan 5 A–C in northeast corner of photographs).—The western rim of the caldera surrounding Aso-san (through center of photograph B) is 200 to more than 400 meters high. In the southeast quadrant of this photograph Shira Kawa ("White River"), which drains the southern part of the caldera basin, is joined by Kuro Gawa, which drains the interior of the caldera north of the central peaks, and the comb ned waters flow west through a water gap in the caldera rim (southeast quadrant of same photograph). Kuro Gawa is incised in the lower part of its course, but in northwest quadrant of photograph C it meanders through rice fields. Japan 4 adjoins this set on the east.

Japan 6. Sakura-jima volcano: Young and old lavas on southwest slope

Area: Kyūshū Island.
Lat 31°33′ N.; long 130°38′ E.
Number of photographs: 3.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: Dec. 4, 1947.
Map reference: Army Map Service, series L772, sheet 4241 IV, Kagoshima sheet, scale 1:50,000.
Geology reference: Kotō, Bunjirō, 1916, The great eruption of Sakura-jima in 1914: Tokyo Imp. Univ., Coll. Sci. Jour., v. 38, art. 3, p. 1–237.

Features illustrated (*set nos. Japan 6 A–C in northeast corner of photographs*).—Minami-take, the southern cone of Sakura-jima, has a deep crater (at north edge of photograph C; for stereo this set must be combined with Japan 7). The upper part of the cone consists largely of pyroclastic materials. Two lava flows have built peninsulas out into Kagoshima-wan (Kagoshima Bay); one of these (near east edge photograph B) is prehistoric; the other, to the northwest, was erupted in 1475–76. North of the latter flow, but not reaching the sea, is a 1749 flow, partly buried by the western 1914 lava flow (north edge of photograph B). The 1914 flow built new land more than a kilometer into Kagoshima-wan toward Kagoshima (northwest quadrant of photograph A), a seaport and the prefectural capital. The lavas of Sakura-jima, like those of the postcaldera peaks at Aso-san, are chiefly augite-andesite.

Japan 7. Sakura-jima volcano: Flow of 1914 on southeast slope

Area: Kyūshū Island.
Lat 31°33′ N.; long 130°42′ E.
Number of photographs: 3.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: Dec. 4, 1947.
Map reference: Army Map Service, series L772, sheet 4241 IV, Kagoshima sheet, scale 1:50,000.
Geology reference: Kotō, Bunjirō, 1916, The great eruption of Sakura-jima in 1914: Tokyo Imp. Univ., Coll. Sci. Jour., v. 38, art. 3, p. 1–237. Matsumoto, Tadaichi, 1943, The four gigantic caldera volcanoes of Kyūsyū: Japanese Jour. Geology and Geography, v. 19, special number, p. 1–57.

Features illustrated (*set nos. Japan 7 A–C in northeast corner of photographs*).—Sakura-jima (Cherry Island) volcano was an island in Kagoshima-wan (Kagoshima Bay) until 1914, when lavas from its southeast flank joined the island to the mainland (near center of photograph B). The lava came in part from vents at the eastern foot of the breached cone Nabe-yama, built in 1471, and in part from a vent well up on the slope of Sakura-jima. The terminal parts of some of the flows, both on land and in the sea, are highly lobate; in pattern that Kotō compares with the "bird's-foot delta" of the Mississippi. The lava destroyed without trace the previously thriving hot-spring resort, Arimura; its site was on the shore near center of photograph A. According to Matsumoto, Sakura-jima is near the breached south rim of a caldera some 15 miles across; the high ground at center of photograph B is part of the rim. Japan 6 adjoins this set on the west.

Pagan 1. Erosion forms in volcanic materials of Pagan Island

Area: Mariana Islands.
Lat 18°09′ N.; long 145°47′ E.
Number of photographs: 3.
Photograph scale: 1:30,000.
Focal length: 6 in.
Date flown: Feb. 12, 1946.
Map reference: Army Map Service, series W843, sheet 3376 II NW, Shomushon sheet, scale 1:25,000.
Geology reference: Corwin, Gilbert, Bonham, L. D., Terman, M. J., and Viele, G. W., 1957, Military geology of Pagan, Mariana Islands: U.S. Army, Chief Eng., Intelligence Div., Headquarters U.S. Army Japan [Tokyo], 259 p.

Features illustrated (*set nos. Pagan 1 A–C in south corner of photographs*).—Mount Pagan is a basaltic cone within a somma. Remnants of the caldera rim form inward-facing cliffs to the south, southwest, and north of the summit crater and outward-facing cliffs (formerly sea cliffs) northeast and east of it. Where the sea has breached the rim in west quadrant of photograph B, differential erosion by waves has cut an almost circular cove in the weak tuffs within the caldera. The remnant of the rim north of the cove resembles a tombolo, but the neck that ties it to the mainland is erosional not constructional in origin. Stacks occur along cliffed parts of the shore. Two lakes west of the summit crater mark a subcircular subsidence area; ridges of pyroclastic material within this subsidence are gullied. The young lavas (dark area) that extend northeast from the summit crater are shown at larger scale in Pagan 2.

Pagan 2. Differential soil development on lavas, Pagan Island

Area: Mariana Islands.
Lat 18°09′ N.; long 145°48′ E.
Number of photographs: 2.
Photograph scale: 1:10,000.
Focal length: 12 in.
Date flown: Jan. 16, 1948.
Map reference: Army Map Service, series W843, sheet 3376 II NW, Shomushon sheet, scale 1:25,000.
Geology reference: Corwin, Gilbert, Bonham, L. D., Terman, M. J., and Viele, G. W., 1957, Military geology of Pagan, Mariana Islands: U.S. Army, Chief Eng., Intelligence Div., Headquarters U.S. Army Japan [Tokyo], 259 p.

Features illustrated (set nos. Pagan 2 A, B in north corner of photographs).—Hills covered by coconut palms northwest and southeast of center of photograph A are remnants of a caldera rim (see Pagan 1). Relatively young lava has poured over this rim in a lava cascade (center of photograph). Comparably young lavas cover most of the rest of the photograph; they support vegetation only in patches. According to Corwin (oral commun., 1965), the vegetated patches are places where the original surface was pahoehoe or slab lava; it evidently takesmuch longer to establish vegetation on the prevailing clinkery aa lava than on pahoehoe. A thick flow of viscous ball aa lava (south quadrant photograph A) stands well above the younger flows, which are more fluid and hence thinner, that lap up around it. Several flows in west quadrant show arcuate ridges. In southwest half of photograph B, lava rivers form a radial pattern on the slope of Mount Pagan.

Pakistan 1. Complex transverse sand dunes south of Khārān Kalāt

Area: West Pakistan.
Lat 28°06′ N.; long 65°15′ E.
Number of photographs: 2.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: 1953.
Map reference: Army Map Service, series U501, sheet H–41 X, Khārān Kalāt sheet, scale 1:253,440.
Geology reference: Hunting Survey Corp., Ltd., 1960, Reconnaissance geology of part of West Pakistan; a Colombo Plan cooperative project: Toronto, Geologic map no. 19, Kharan Kalat, scale 1:253,440. (A report published for the Government of Pakistan by the Government of Canada.)

Features illustrated (set nos. Pakistan 1 A, B in southeast corner of photographs).—Major transverse dunes, with sharp crests spaced about half a mile to a mile apart, trend north-northwest; steep northeast-facing slip-off slopes show that the dominant dune-forming wind is from the west-southwest. Several small white patches of salt incrustation indicate that locally a pond sometimes forms at the foot of a dune. The gentle windward slopes of these major dunes have complex patterns of secondary dunes.

Pakistan 2. Mud volcanoes and a faulted plunging anticline

Area: West Pakistan.
Lat 25°27′ N.; long 65°51′ E.
Number of photographs: 5.
Photograph scale: 1:46,000.
Focal length: 6 in.
Date flown: 1953.
Map reference: Army Map Service, series U501, sheet G41–R, Kanrāch sheet, scale 1:253,440.
Geology reference: Hunting Survey Corp., Ltd., 1960, Reconnaissance geology of part of West Pakistan; a Colombo Plan cooperative project: Toronto, Geologic map no. 5, Ormara, scale 1:253,440. (A report published for the Government of Pakistan by the Government of Canada.)

Features illustrated (set nos. Pakistan 2A–E in southeast corner of photographs).—Two conical hills with summit craters, conspicuous in northwest quadrant of photograph E, are about 0.3 mile in diameter. Just south of the southwestern large cone is a smaller but otherwise similar cone, and to the northwest is a feature that appears to be the collapsed remnant of a fourth cone. These cones are mud volcanoes, formed by spattering by natural gas that rose under pressure through the saturated alluvium of the coastal plain. They are approximately on the axial line of an anticline that is cut by several faults where it is exposed to the southwest. The northeast-plunging nose of the anticline is sharply delineated by resistant sandstone layers interbedded with mudstone in the Miocene or Pliocene Hinglaj Formation.

Pakistan 3. Lakes between longitudinal dunes east of Mīrpur Khās

Area: West Pakistan.
Lat 25°37′ N.; long 69°35′ E.
Number of photographs: 3.
Photograph scale: 1:35,000.
Focal length: 6 in.
Date flown: 1953.
Map reference: Army Map Service, series U502, Sheet NG42–11, Mīrpur Khās sheet, scale 1:250,000.
Geology reference: Hunting Survey Corp., Ltd., 1960, Reconnaissance geology of part of West Pakistan; a Colombo Plan cooperative project: Toronto, Geologic map no. 7, Hyderabad, scale 1:253,440. (A report published for the Government of Pakistan by the Government of Canada.)

Features illustrated (set nos. Pakistan 3 A–C in southeast corner of photographs).—Lakes occupy depressions between long, roughly parallel ridges that trend north-northeast. Most lakes are a few hundred feet wide and less than half a mile long, but half a dozen are ¼–½ mile wide and as much as 2½ miles long. The ridges have forms characteristic of longitudinal sand dunes, but they are evidently stabilized; no active dunes are evident. The agent stabilizing the dunes is not obvious; the sparse growth of bushes they support appears to be too scattered to anchor them securely. The dunes are older than the lakes; the crest of a dune rises as an island within a lake.

Palau 1. Bauxite mines on Babelthuap Island, Palau Group

Area: Caroline Islands.
Lat 7°35′ N.; long 134°35′ E.
Number of photographs: 1.
Photograph scale: Unknown.
Focal length: Unknown.
Date flown: 1944.
Map reference: Figure 3 in geology reference.
Geology reference: Bridge, Josiah, and Goldich, S. S., 1948, Preliminary report on the bauxite deposits of Babelthuap Island, Palau Group: U.S. Geol. Survey for GHQ, Far East Command. See pl. 3 and fig. 4. Bridge, Josiah, and Goldich, S. S., 1948, Bauxite deposits of Babelthuap Island, Palau Group [abs.]: Geol. Soc. America, Bull., v. 59, p. 1313.

Features illustrated (*oblique view southeast*).—These strip mines were operated by the Japanese between 1938 and 1944. The bauxite was derived by lateritic weathering from volcanic agglomerate of Miocene age. The approximate distribution of bauxite is indicated by the vegetation; where the bauxite is thick it supports ferns rather than trees. The ore came from surficial deposits that averaged only about 7 feet in thickness; mining was by hand methods. The mines are in the northwestern part of Babelthuap (Babeldoab) Island, largest of the Palau Group. Plate 3 of the first geology reference is reduced from this photograph.

Palau 2. Augulpelu Reef, an offshore (barrier) reef

Area: Caroline Islands.
Lat 7°18′ N.; long 134°33′ E.
Number of photographs: 3.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: Jan. 10, 1948.
Map reference: Plate 4 in geology reference.
Geology reference: Mason, A. C., and others, 1956, Military geology of the Palau Islands, Caroline Islands: U.S. Army, Chief Eng., Intelligence Div., Headquarters, U.S. Army Forces Far East [Tokyo], 285 p. See pl. 4.

Features illustrated (*set nos. Palau 2 A–C in south corner of photographs*).—Augulpelu Reef (central part photograph B) is all under water except the sandbar near north end of the southwestern hook. Coral heads, visible in stereoscopic view, rise to near low-tide level in the lagoon behind the reef. A fringing reef grows along the shore, even where a barrier reef extends offshore. The islands Babelthuap (north corner photograph A) and Garreru (north corner photograph B) are separated from Koror (north corner photograph C) by Toagel Channel. The sea is unusually calm, and breakers on the reef are few and small; on January 10, 1948, this was a lee shore (see Palau 3).

Palau 3. Pitted limestone and living reefs of Eil Malk Island

Area: Caroline Islands.
Lat 7°08′ N.; long 134°23′ E.
Number of photographs: 2.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: Jan. 10, 1948.
Map reference: Plate 4 in geology reference.
Geology reference: Mason, A. C., and others, 1956, Military geology of the Palau Islands, Caroline Islands: U.S. Army, Chief Eng., Intelligence Div., Headquarters, U.S. Army Forces Far East [Tokyo], 285 p. See pl. 4 and pl. 6B.

Features illustrated (*set nos. Palau 3 A, B in south corner of photographs*).—Solution has deeply pitted the Palau Limestone, of Miocene to Pleistocene age, after it was uplifted to form an island. Many of the solution pits are ponds and lakes. Others are breached and connected to the sea by channels. Elsewhere, remnants of the limestone protrude as islands. According to Gilbert Corwin (oral commun., 1965), all the ponds and lakes are at sea level and have salty water that rises and falls with the tides, although connection with the sea is confined to subterranean openings except in the breached lakes. Living reefs shown include a fringing reef, a barrier reef attached at both ends and enclosing a shallow lagoon, and an offshore barrier reef.

Palau 4. Angaur Island, an uplifted atoll with phosphate deposits

Area: Caroline Islands.
Lat 6°55′ N.; long 134°09′ E.
Number of photographs: 3.
Photograph scale: 1:40,000.
Focal length: 6 in.
Date flown: Jan. 10, 1948.
Map reference: Plate 2 in geology reference. U.S. Hydrographic Office Hydrographic chart 6073.
Geology reference: Irving, E. M., 1950, Phosphate deposits of Angaur Island, Palau Islands: U.S. Geol. Survey for GHQ, Far East Command. 100 p.

Features illustrated (*set nos. Palau 4 A–C in south corner of photographs*).—The island, about 3 miles across, has had a complex history. Two uplifts are evident from the photographs. The hills in the northwest were a small atoll which was uplifted to form an island. The airfield is on a fringing reef that was built around that island before a second uplift. A new fringing reef is growing and is widest on the west side of the southern peninsula. According to Irving, the actual history is even more complex: the lakes left by phosphate mining extend well below sea level, and when the phosphate was accumulated Angaur must have stood at least 74 feet higher above the sea than today.

Refracted waves, breakers on the reef flat, and the distribution of whitecaps suggest that surface winds are northwest, although movement of cloud shadows shows that at cloud height the wind is east.

Saudi Arabia 1. Wabar Crater, a small astrobleme

Lat 21°30′ N.; long 50°30′ E.
Number of photographs: 2.
Photograph scale: 1:55,000.
Focal length: 6 in.
Date flown: Nov. 28, 1954.
Map reference: Army Map Service, series K462, sheet NF39W, Northwestern Rub' al Khāli sheet, scale 1:500,000.
Geology reference: Chao, E. C. T., Fahey, J. J., and Littler, Janet, 1961, Coesite from Wabar crater, near Al Hadida, Arabia: Science, v. 133, no 3456, p. 882–883.

Features illustrated (set nos. Saudi Arabia 1 A, B in southeast corner of photographs).—Wabar Crater is a circular depression approximately 300 feet in diameter (less than 0.1 inch at scale of photographs) about 0.8 inch from east edge of the photographs and midway in the area of stereoscopic coverage. The presence of coesite and meteorite fragments identifies it as an astrobleme or meteorite crater. The rim of the crater is distinctly raised, though low; the nature of this raised rim cannot be demonstrated at the scale of the photographs, but analogy with Meteor Crater, Ariz., suggests it is partly upturned bedrock and partly ejecta. The entire area is one of dunes trending irregularly east-northeast. Most of these are normal transverse dunes formed by northwest winds, but a few are sharp ridges with depressions (suggesting wind scour) on their southeast sides; possibly these sharp ridges reflect the effect of southeast winds that alternate with the prevailing or stronger northwest winds.

REPRESENTATIVE AERIAL PHOTOGRAPHS


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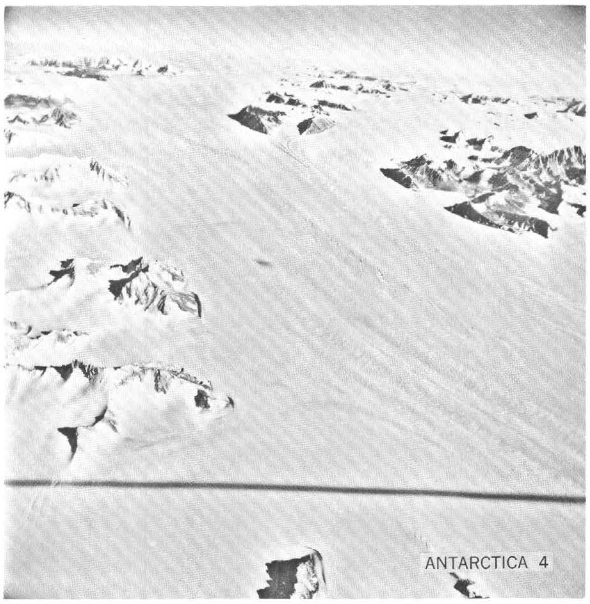
ANTARCTICA 2


ANTARCTICA 3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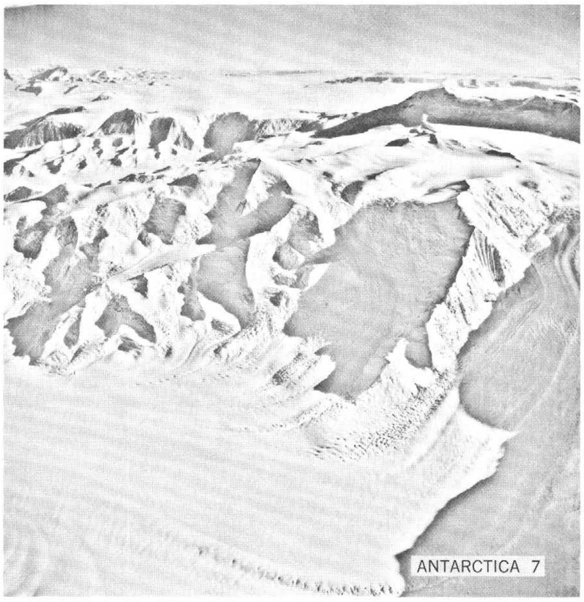
ANTARCTICA 5


ANTARCTICA 6

Antarctica 7–12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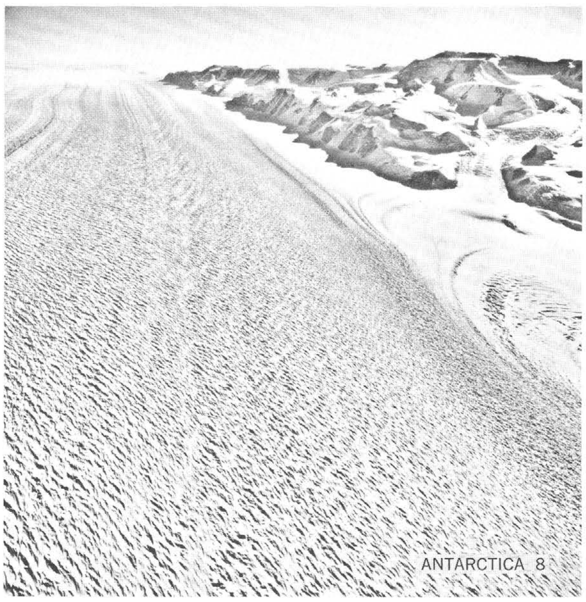
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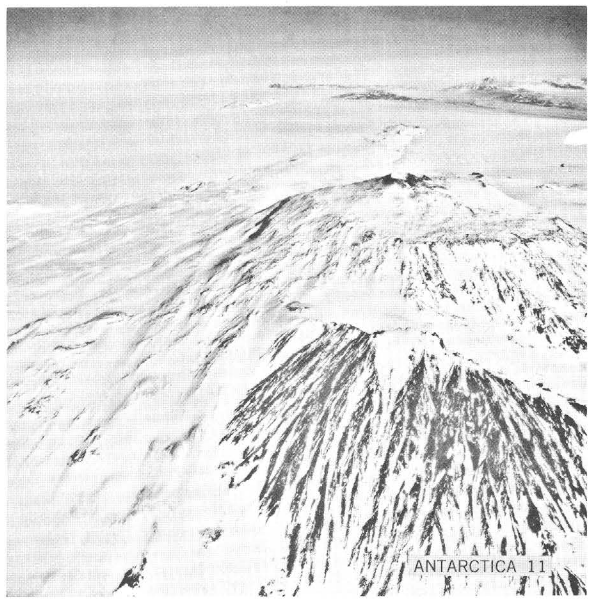
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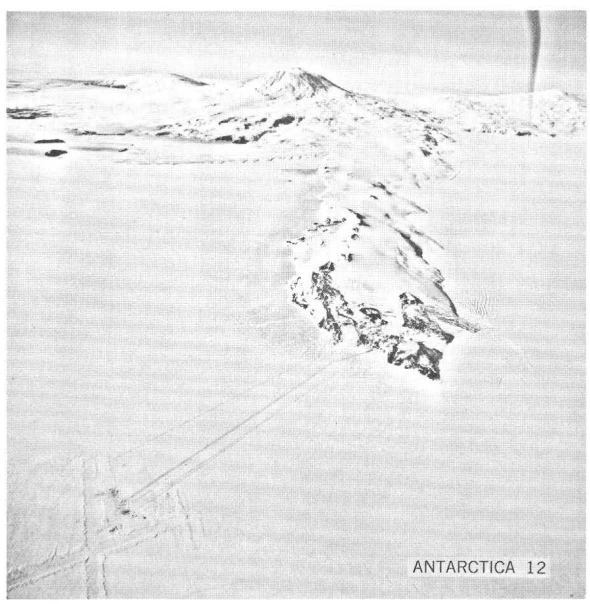
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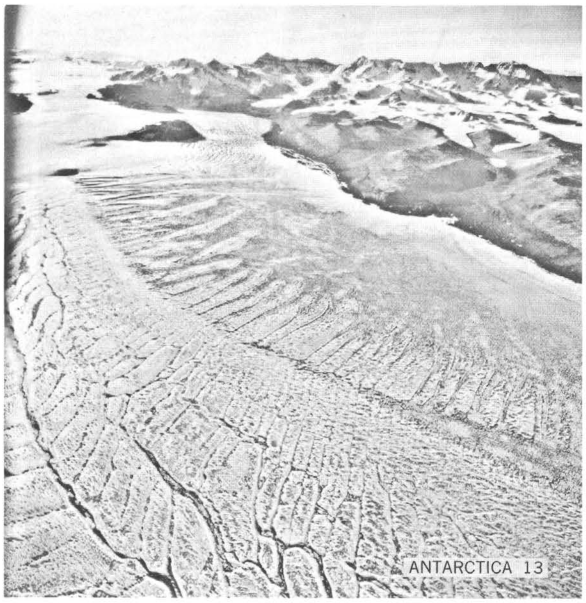

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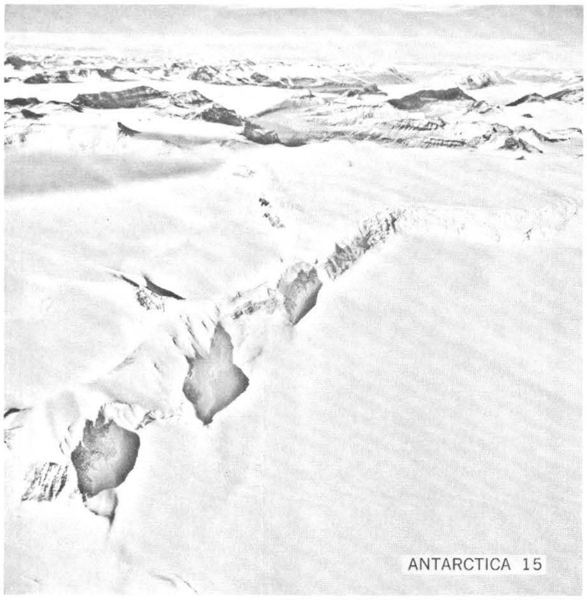

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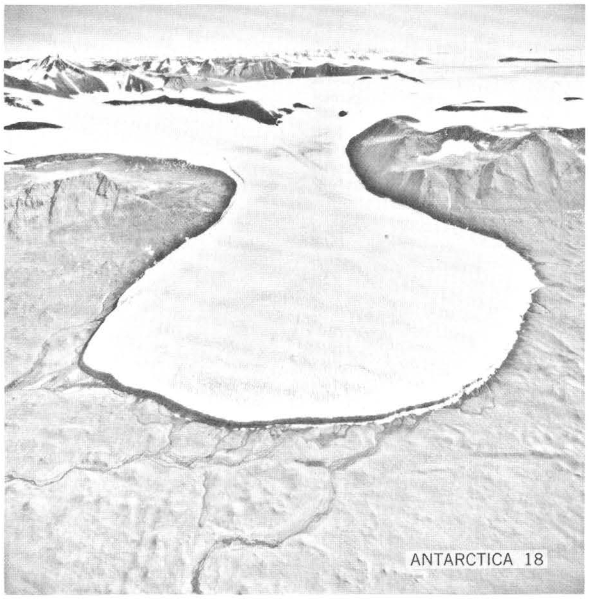

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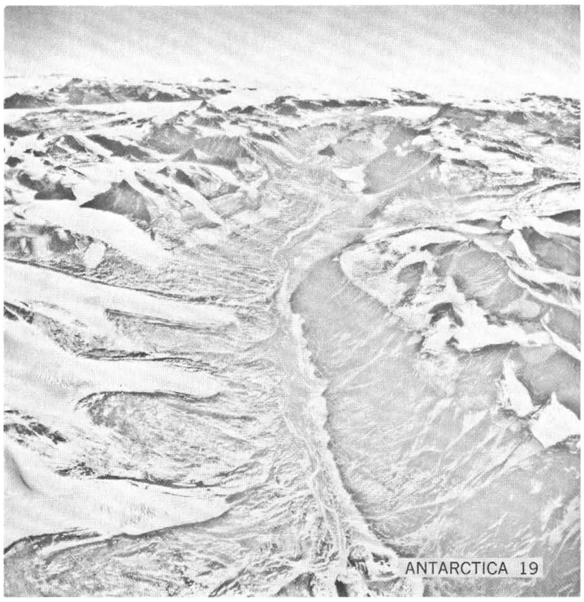
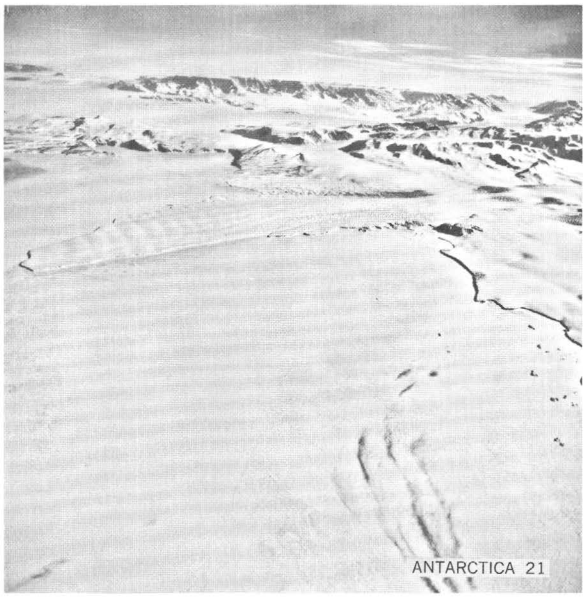
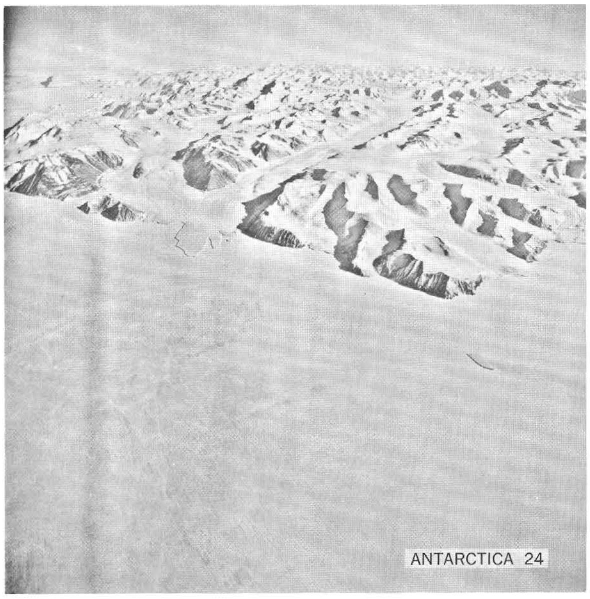
Antarctica 19–24





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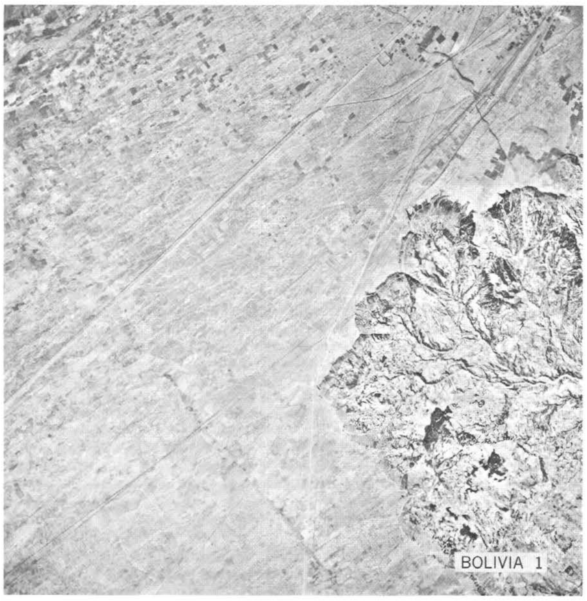
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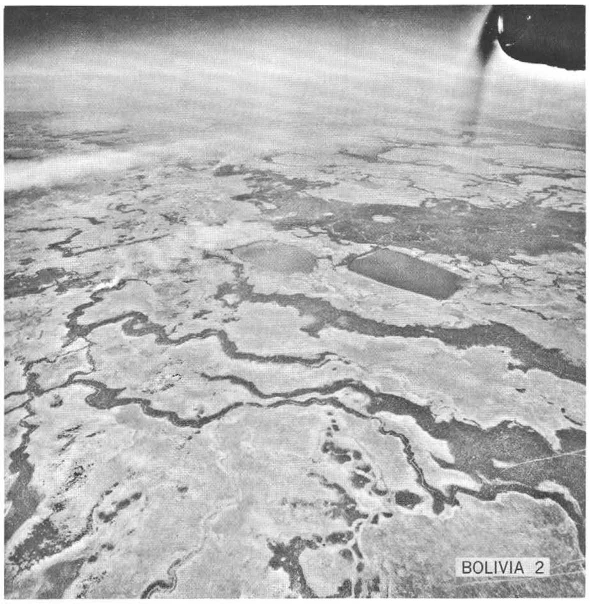
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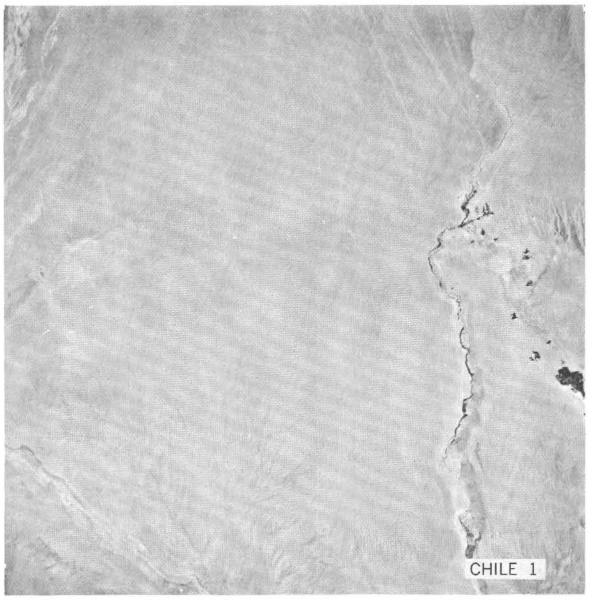
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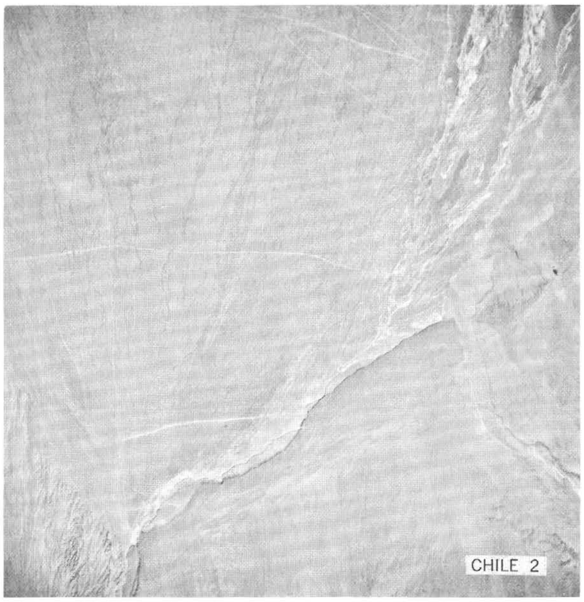
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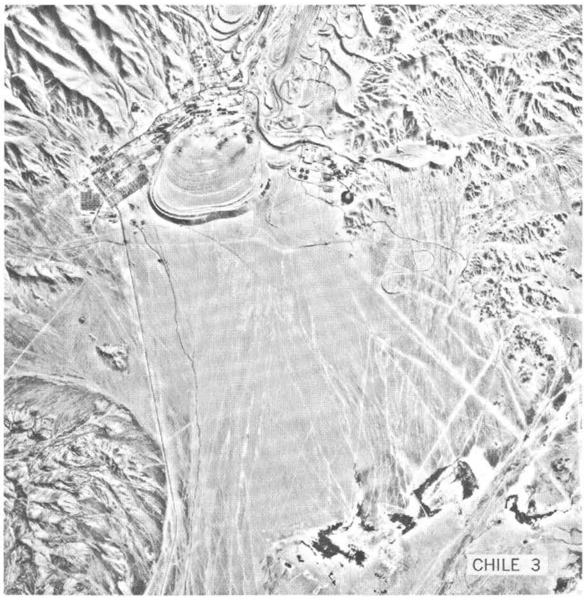
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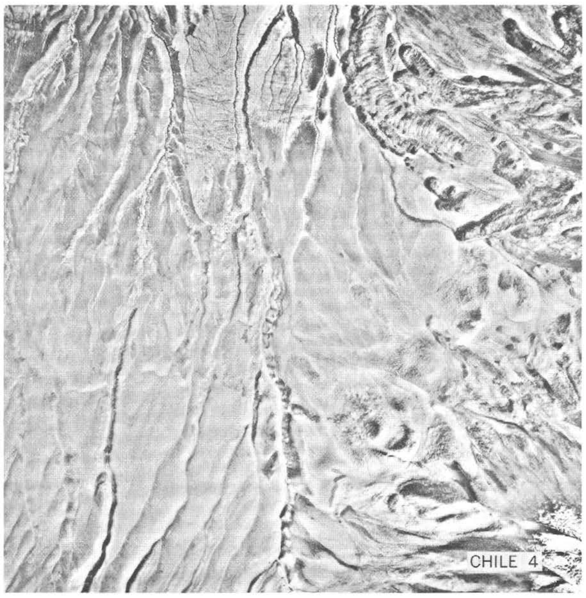
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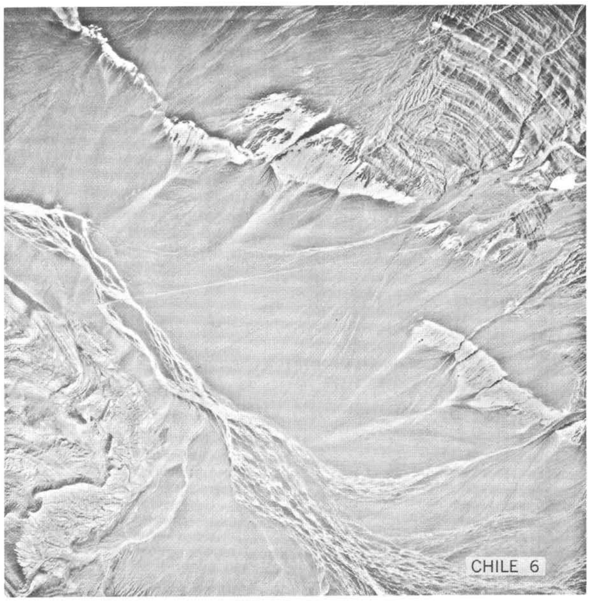
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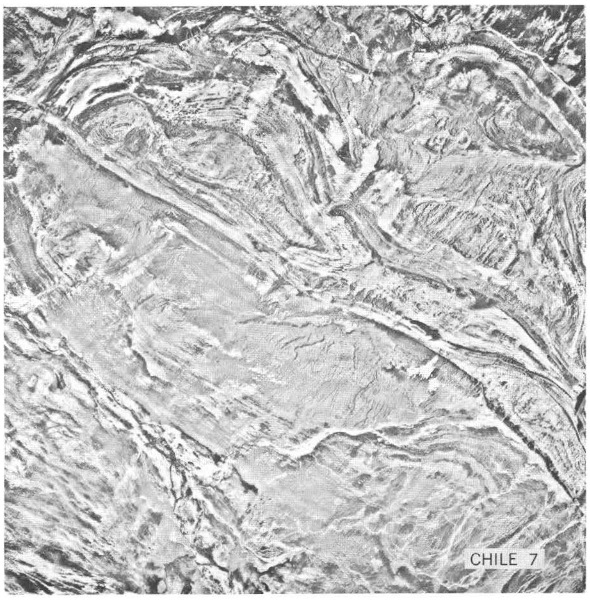
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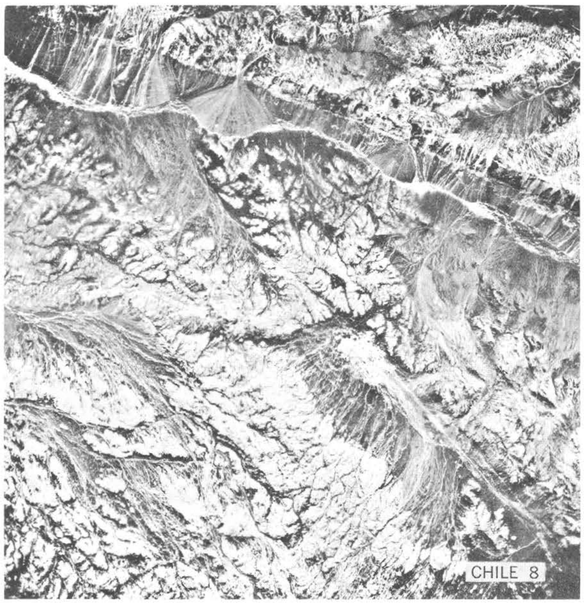
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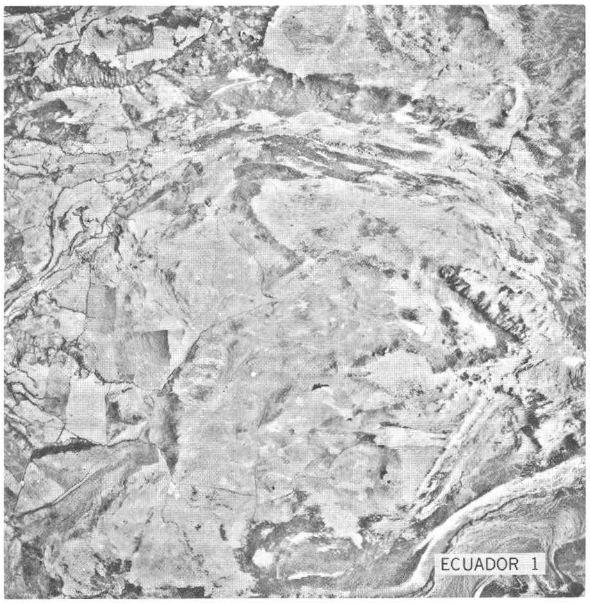
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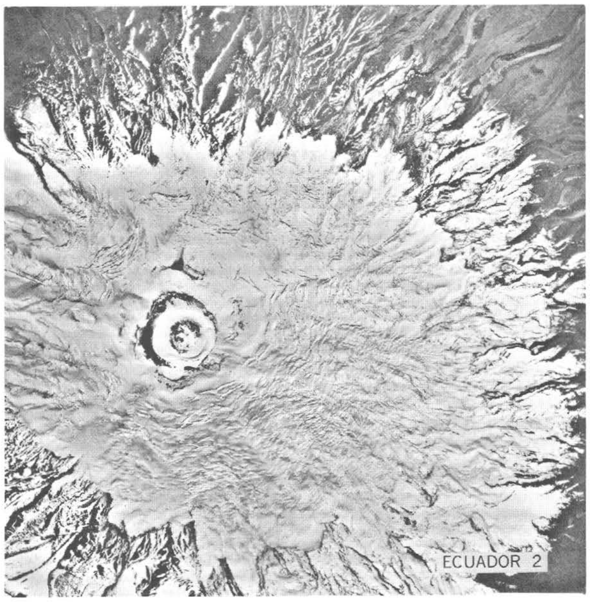
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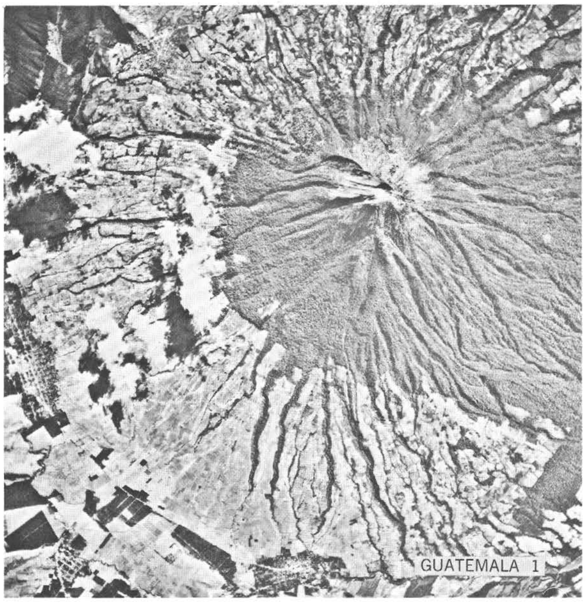
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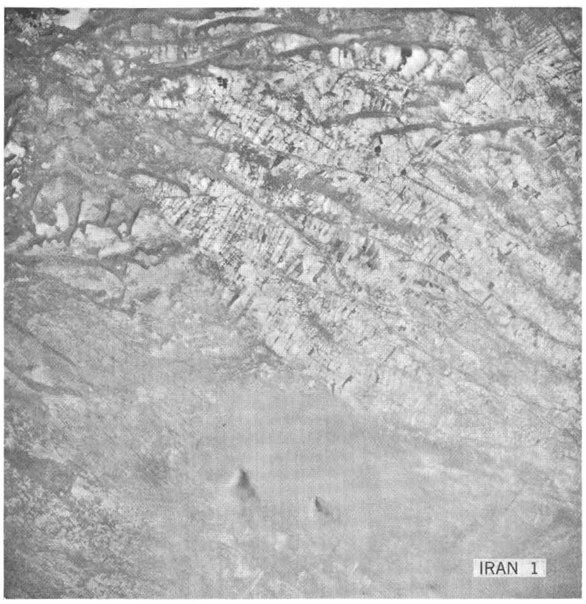
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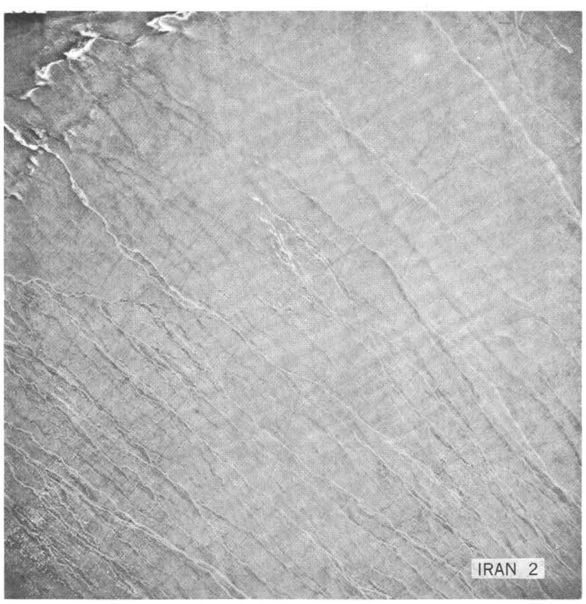
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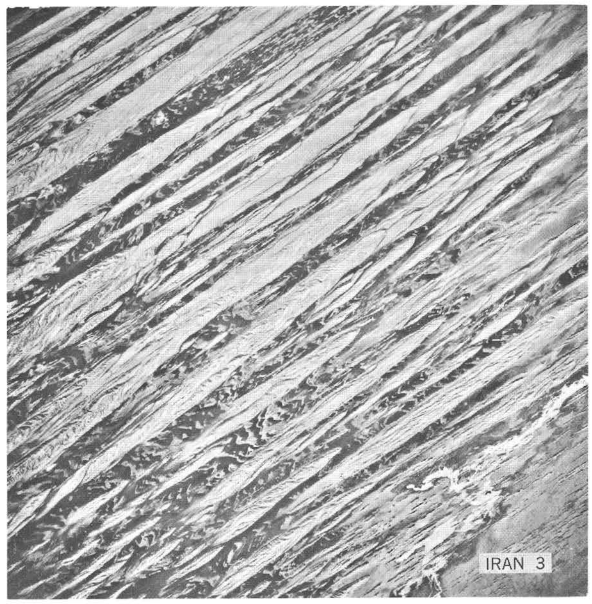
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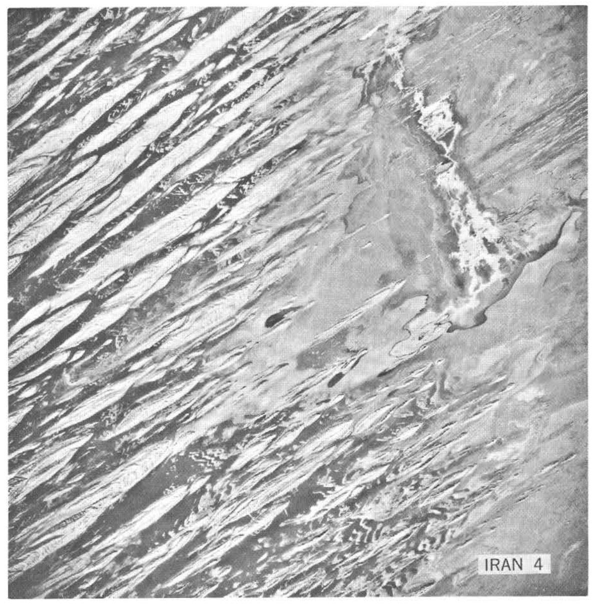
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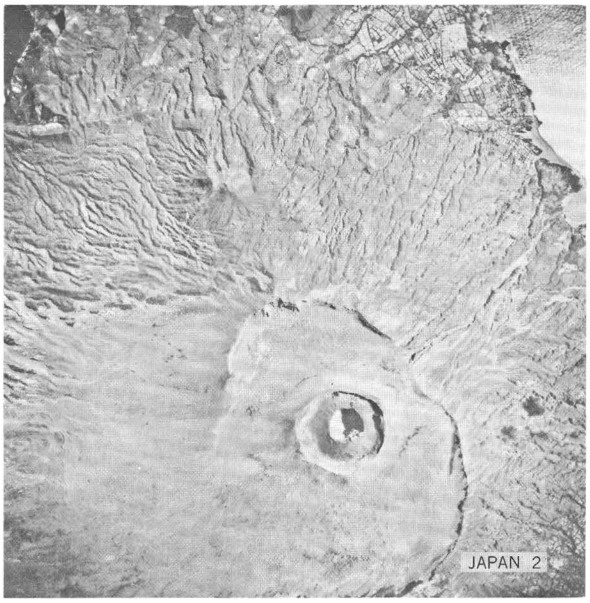
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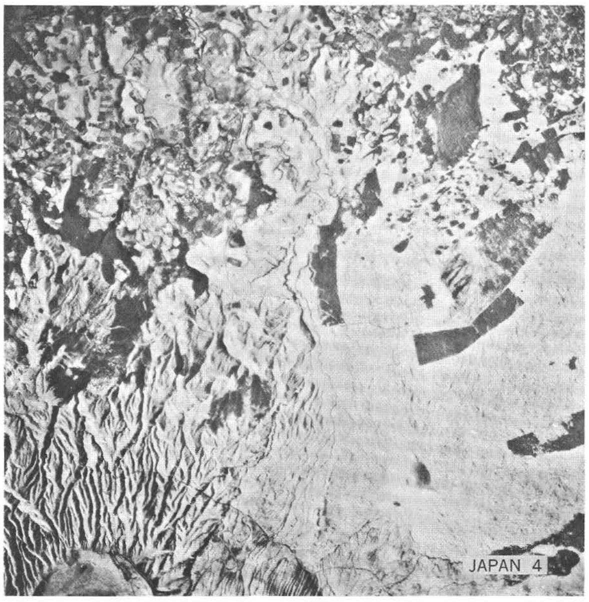
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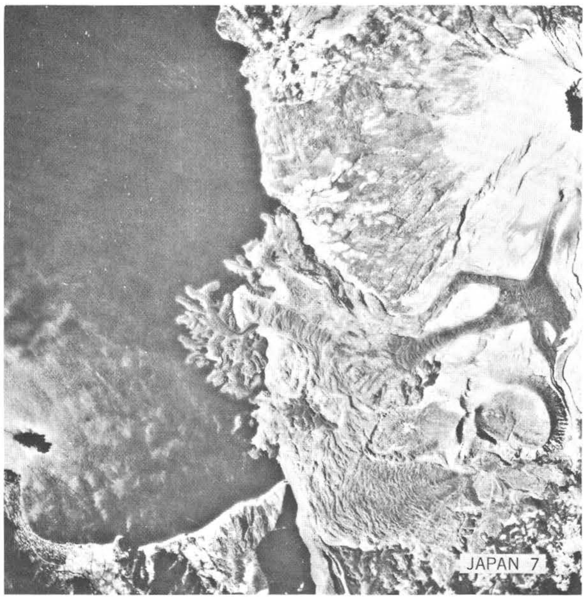
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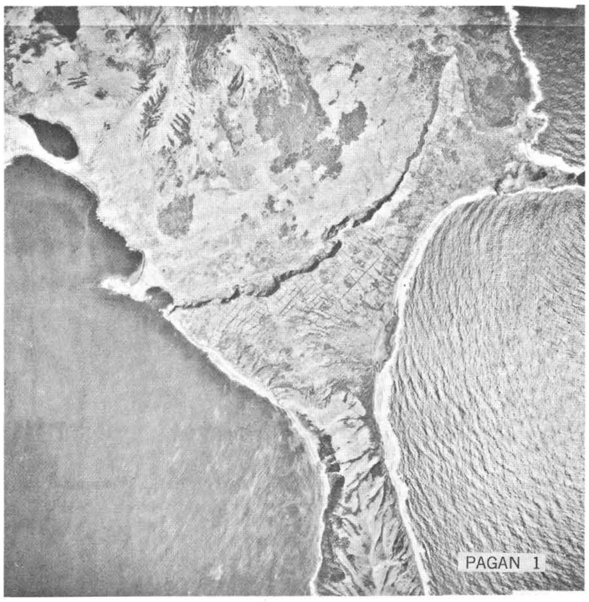
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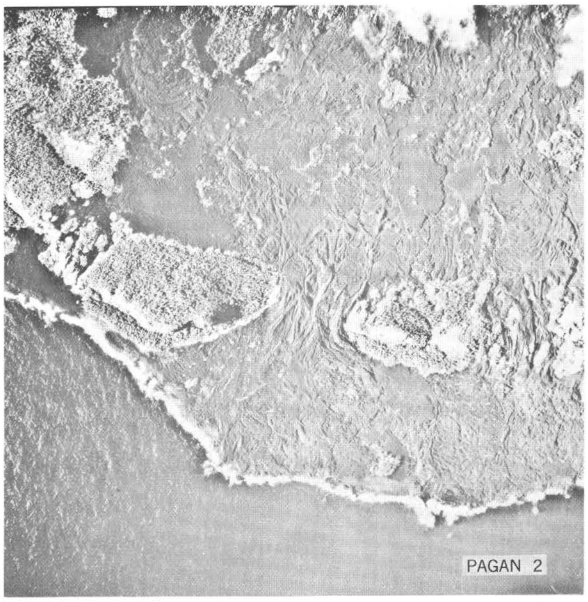
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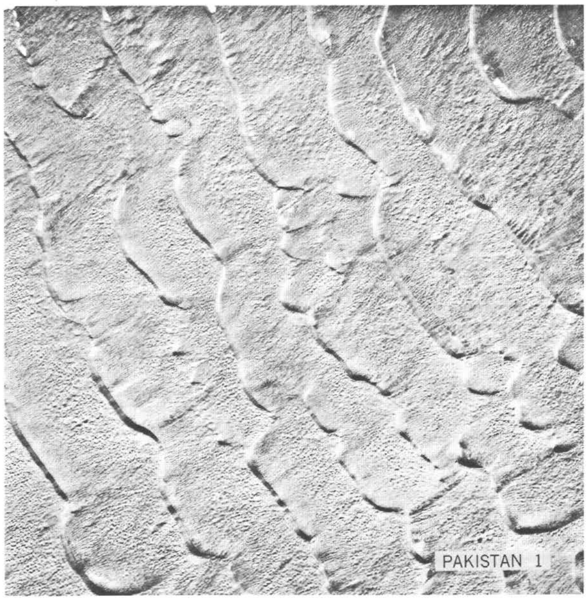
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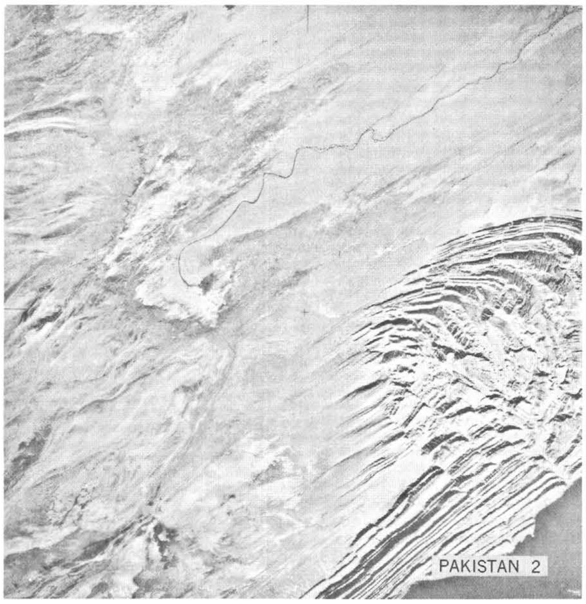
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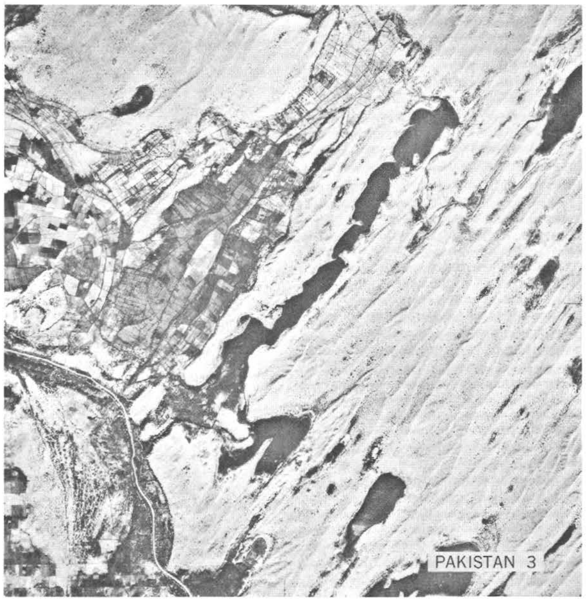
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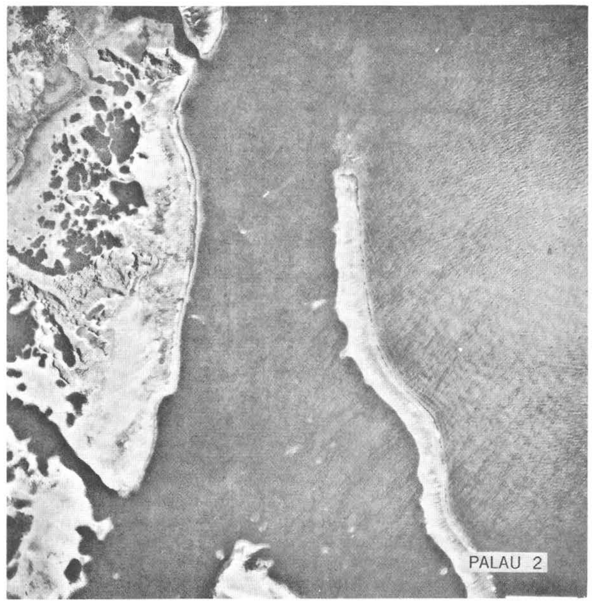
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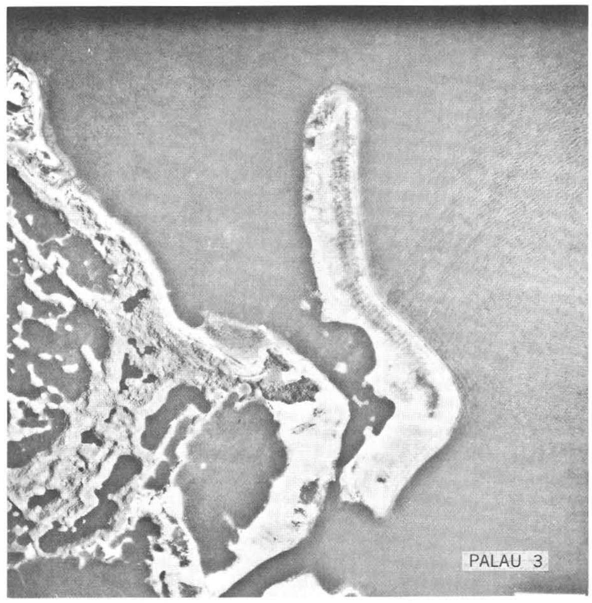
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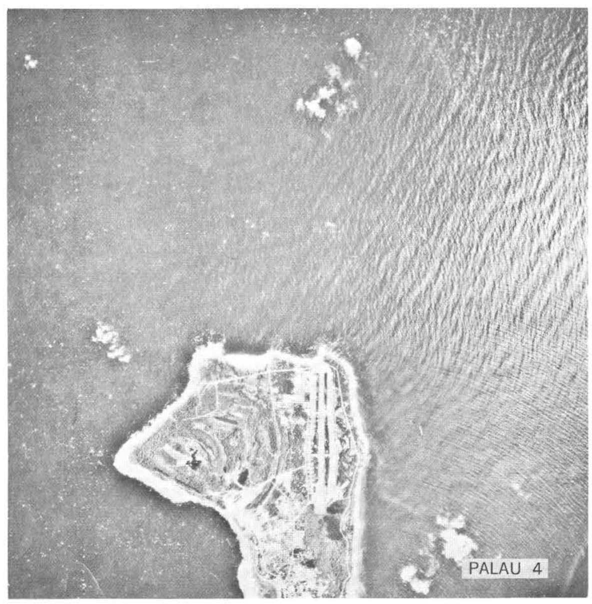
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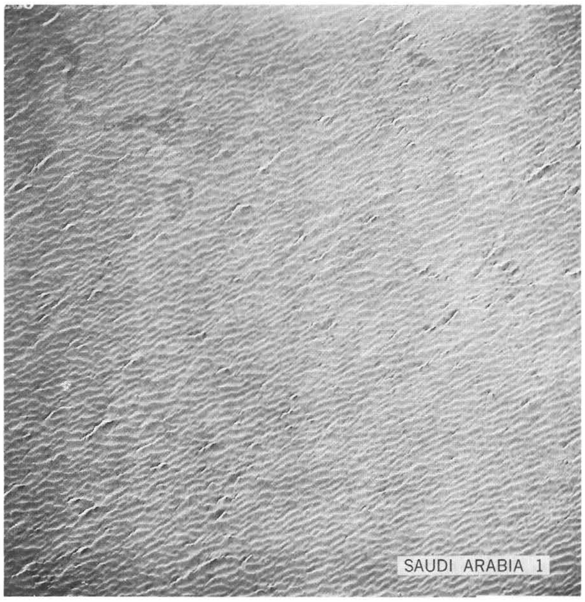

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