SATELLITE GEOLOGICAL AND GEOPHYSICAL REMOTE SENSING OF ICELAND

Richard S. Williams, Jr.
U.S. Geological Survey
Washington, D.C. 20244

1 September 1973

Type II Progress Report for the Period 15 January 1973 - 31 August 1973

Prepared for:

Goddard Space Flight Center
Greenbelt, Maryland 20771

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16. Abstract

Under a binational, multidisciplinary experiment ERTS-1 imagery is being used to measure and map dynamic natural phenomena in Iceland, the knowledge of which has a direct relation to management of the country's natural resources. A few of the initial results from the project are: 1) a large variety of geological and volcanic features can be studied on ERTS imagery, particularly imagery acquired at low sun angle (<10°), which have not previously been recognized; 2) under optimum snowcover conditions, geothermal areas can be discerned on ERTS imagery by their snowmelt pattern or by warm spring discharge into frozen lakes; 3) a variety of map types at scale of 1:1,000,000 and 1:500,000, can be compiled, made more accurate, or updated (e.g., changes in coastline, glaciers, lakes, etc.); 4) the persistence of snow in the highland areas, during the summer months, has important ramifications to rangeland management; 5) false-color composites (MSS) permitted the mapping of four types of vegetation; forested, reclaimed, and cultivated areas and grasslands, and the mapping of the seasonal change of the vegetation, all of high value to rangeland management when complete, repetitive coverage of Iceland becomes a reality with an operational satellite; and 6) the volcanic eruption on Heimaey was recorded.

17. Key Words Suggested by Author	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	N/A	~~29~~ 30	3.50

Figure 2A. Technical Report Standard Title Page. This page provides the data elements required by DoD Form DD-1473, HEW Form OE-6000 (ERIC), and similar forms.

INT: 2090-72

Type II Progress Report
ERTS-1

a. Title: Satellite Geological and Geophysical Remote Sensing of Iceland
ERTS-A Proposal No.: SR (9)651

b. GSFC ID No. of P.I.: IN 079

c. Statement and explanation of any problems that are impeding the progress of the investigation:

The investigation is proceeding well with sufficient imagery to carry out all or part of 8 of the proposed 10 experiments. The sea ice and spring flooding of rivers experiments cannot be carried out because of lack of data. The lack of imagery during the spring of 1973 (late March to late June 1973), because of the tape recorder problem, was a serious drawback to fully reaching many of the experimental objectives. The spring time period in Iceland, as it is in most of the temperate and polar regions, is the time of the most dynamic change in many types of natural phenomena. The lack of the spring data is a serious handicap.

The most serious problem, however, results from limitations of data acquisition over foreign areas by the ERTS-1 satellite. Persistent cloudcover over Iceland is the rule rather than the exception, although occasional periods of fine weather do occur at sporadic intervals which last from a few hours to several days, but rarely more than a week. To achieve complete seasonal coverage of Iceland requires data acquisition (4 or 5 scenes) on each orbit which passes over Iceland (10 days out of each 18 days, because of latitude). A particular feature in Iceland can be imaged 3 days in a row (because of scene overlap at high latitude), thus increasing the possibility of recording the feature, even with the cloudcover persistence problem.

The problem for coverage of Iceland is both tape recorder capacity (made worse by the reduction in amount of usable tape since March 1973) and command and control limitations of ERTS-1. At present the tape may be full by the time the satellite reaches Iceland, thus no data can be recorded. This was less of a problem when the full tape capacity existed. But because the orbit over Iceland continues south over South America, and because the storage of satellite commands on board is limited, coverage of Iceland or South America becomes an either/or proposition. Therefore, not all possible imagery of Iceland has been acquired, thus substantially limiting seasonal coverage of Iceland or even achieving at least one cloud-free scene of each part of Iceland.

For an operational satellite to be a reality for monitoring of the dynamic environmental phenomena of Iceland and thus assist in resource management decisions, greater tape recorder capacity (and redundancy) must exist and a larger on-board, stored-command capability or a larger number of ground stations must become a reality. Until such changes are made the ERTS-type satellite must remain an experimental system for Iceland.

d. Discussion of the accomplishments during the reporting period and those planned for the next reporting period:

Most of the accomplishments achieved during the reporting period have been published or are in press. (See paragraph f., this report, for a cumulative list of reports.) A summary of the accomplishments is given in paragraph e., q.v. Accomplishments which have not been published are included in this paragraph.

(1) A two-week trip to Iceland was accomplished from 3-15 February 1973 to meet four principal objectives: (a) to carry out the research objectives of the binational, multidisciplinary ERTS-1 experiment with my six Icelandic co-investigators; (b) to discuss with these scientists the future research objectives of the ERTS-1 and two proposed ERTS-B and NOAA-2/Nimbus-V experiments in Iceland; (c) to discuss all of the past, present, and future research in Iceland with Steingrímur Hermannsson, Director, National Research Council of Iceland (Rannsóknaráð Ríkisins); and (d) to carry out geological research, with Icelandic scientists, on the 23 January 1973 effusive volcanic eruption of Kirkjufell on the island of Heimaey, Vestmannaeyjar (Vestmann Islands), Iceland. All of the objectives were reached during this trip.

(2) Two combination ERTS-B and NOAA-2/Nimbus-V research proposals on Iceland were prepared and submitted to NASA in January 1973.

(3) All of the ERTS-1 imagery of Iceland from September 1972 through March 1973 has been catalogued. One set is being analyzed by me; the other set has been archived at Landmælingar Íslands (Icelandic Surveying Department), where it is available to my Icelandic co-investigators and to the general public. All usable (significant areas which are cloud-free) ERTS-1 imagery has been studied on a preliminary basis. Of the 80 ERTS-1 images acquired of Iceland (41 during 1972 before it became too dark, 39 during 1973 when it became light enough) 53 images have at least some value to one or more of the 10 proposed experiments. Only a handful of the images, however, (13 out of 80) have 50% or less cloud cover.

(4) One-half of the third quarterly period (the month of July) was devoted to field work in Iceland. Sites were visited on the ground and by aerial reconnaissance. Specific field trips were made to Heimaey (site of the catastrophic volcanic eruption), the margins of the Vatnajökull glacier, and several geothermal areas. Both hand-held (35mm) color and color-infrared photography were acquired and plans were made for the acquisition of conventional, cartographic-quality color infrared aerial photography by Landmælingar Íslands. Time was devoted to the revision of various manuscripts and the drafting of several new ones.

Plans for the next reporting period are to analyze the data from the aerial surveys (with color and color infrared aerial photography and aerial thermography) of ERTS-1 test sites (approximately 20 principal areas). The aerial surveys were conducted during the last two weeks of August 1973, by the NASA NP-3A aircraft. Most arrangements for the aerial surveys were carried out in July 1973.

Additional ERTS-1 imagery of Iceland which was acquired since March 1973 will be catalogued and studied. Scientific papers will be prepared for the symposium in Sioux Falls in October 1973 and for the annual meeting of the Geological Society of America in November 1973. Abstracts and papers for other meetings will also be prepared.

e. Discussion of significant scientific results and their relationship to practical applications or operational problems including estimates of the cost benefits of any significant results:

A binational, multidisciplinary research effort in Iceland is directed at an analysis of MSS imagery from ERTS-1 to study a variety of geologic, hydrologic, oceanographic, and agricultural phenomena. A preliminary evaluation of available MSS imagery of Iceland has yielded several significant results - some of which may have direct importance to the Icelandic economy. Initial findings can be summarized as follows: (1) recent lava flows can be delineated from older flows as Askja and Hekla; (2) MSS imagery from ERTS-1 and VHRR visible and infrared imagery from NOAA-2 recorded the volcanic eruption on Heimaey, Vestmann Islands; (3) coastline changes, particularly changes in the position of bars and beaches along the south coast (e.g., north and west of Ingólfhöfði), are mappable; (4) areas covered with new and residual snow can be mapped, and the dark appearance of newly fallen snow on ERTS-1, MSS band 7 appears to be related to melting; (5) sediment plumes from the discharge of glacial rivers along the south coast can be delineated; (6) the area encompassed by glacial ice (ice caps, valley and outlet glaciers, etc.) can be mapped,

including the new position of a surging glacier, Eyjabakkajökull, and such related phenomena as nunataks and moraines; (7) the plotting of changes in position of rivers, changes in size of lakes, and the occurrence of new lakes are feasible; (8) low sun-angle imagery, particularly of snow-covered terrain, markedly enhances the morphologic expression of constructional glacial and volcanic landforms, thus permitting the mapping of previously unrecognized structural features such as central or subglacial volcanoes; (9) the MSS color composites permit regional mapping of the distribution of vegetation in Iceland and its change with time; and (10) at least at 1:250,000 map scale and smaller, ERTS-1 imagery provides a means of updating various types of maps of Iceland and will permit the compilation of special maps specifically aimed at those dynamic environmental phenomena which impact on the Icelandic economy.

There is no question that a low sun angle (as low as 7°) on ERTS-1 imagery, particularly when the terrain is snow-covered, markedly enhances subtle geologic structure and landforms. A small geothermal area (approximately 2.5km^2 in area with an estimated heat flow of 25-125 x 10^6 cal/sec.) was recorded on ERTS-1 imagery from the snowmelt pattern. Hot springs, discharging into frozen lakes, form an ice-free area which can be easily seen on ERTS-1 imagery. In colder climes this finding could serve as a useful exploration tool in the search for exploitable geothermal areas. The ice breakup on a small lake was recorded. In remote areas ERTS-1 imagery can, therefore, be used in climatologic studies by using the time of lake ice freeze-up and break-up as a measure over large areas. Most of the ERTS-1 imagery which included the area of the erupting volcano, Kirkjufell, on the island of Heimaey, was cloud-covered. Of the 14 possible images, only 3 are usable for study, and one image is a pre-eruptive view of the island. ERTS-1 provides a powerful new tool for volcanologists to study erupting volcanoes: new deposits, whether lava flows or tephra falls, and the direction and areal distribution of the eruption plume. Some success was achieved in a preliminary study, using photogrammetric instrumentation, of measuring relative elevation of mountains using ERTS-1 imagery of Iceland, where considerable overlap exists in successive orbits. An object is imaged on 3 successive orbits at the latitude of Iceland (65°N. latitude). (About 130km baseline separation between the "first" and "third" orbits.) Sufficient parallax separation existed on a mountain with 1,000 m. of local relief to warrant additional research on the use of ERTS-1 imagery to measure local relief differences of such magnitudes. [2D, 2I (photogrammetry), 3C, 3F, 3I, 3K, 3L (Disaster assessment), 4G, 4H, 4I, 5D, 7A, and 10A]

f. A listing of published articles, and/or papers, preprints, in-house reports, abstracts of talks, that were released during the reporting period:

Papers Published

(A) Williams, R. S., Jr., 1972, Satellite geological and geophysical remote sensing of Iceland (abs.): in Proc. Eighth Int. Symp. on Remote Sensing of Environment, Univ. of Mich., Ann Arbor, Mich., p. 1465-1466.

(P) Williams, R. S., Jr., Böðvarsson, Á., Friðriksson, S., Pálmason, G., Rist, S., Sigtryggsson, H., Thorarinsson, S., and Thorsteinsson, I., 1973, Satellite geological and geophysical remote sensing of Iceland - preliminary results from analysis of MSS imagery: in Proceedings of Symposium on Significant Results obtained from ERTS-1, NASA, Goddard Space Flight Center, Greenbelt, Md., p. 317-327.

(P) Williams, R. S., Jr., 1973, Disaster in Iceland: Letter published in Geotimes, v. 18, no. 5, May, p. 9.

(P) Williams, R. S., Jr., and Moore, J. G., 1973, Iceland Chills a Lava Flow: Geotimes, v. 18, no. 8, August, p. 14-17.

Papers in Press

(P) Williams, R. S., Jr., Böðvarsson, Á., Friðriksson, S., Pálmason, G., Rist, S., Sigtryggsson, H., Sæmundsson, K., Thorarinsson, S., and Thorsteinsson, I., 1973, Iceland: Preliminary results of geologic, hydrologic, oceanographic and agricultural studies with ERTS-1 imagery: in Proceedings of Symposium on Management and Utilization of Remote Sensing Data, Amer. Soc. Photogrammetry, Sioux Falls, South Dakota, (in press).

(P) Williams, R. S., Jr., and Thorarinsson, S., 1973, ERTS-1 image of Vatnajökull area: General comments: Jökull, v. 23, (in press).

(P) Thorarinsson, S., Sæmundsson, K., and Williams, R. S., Jr., 1973, ERTS-1 image of Vatnajökull: Analysis of glaciological, structural, and volcanic features: Jökull, v. 23, in press.

(A) Williams, R. S., Jr., Thorarinsson, S., and Sæmundsson, K., 1973, Vatnajökull area, Iceland: New volcanic and structural features on ERTS-1 imagery: in Geol. Soc. Amer. Abstracts with Programs, 1973 Ann. Mtng., Dallas, Texas, (in press).

Presentations

Williams, R. S., Jr., 1972, Satellite geological and geophysical remote sensing of Iceland: Eighth Intl. Symp. on Remote Sensing of Environment, Univ. of Mich., Ann Arbor, Mich., 6 October.

Williams, R. S., Jr., 1973, ERTS-1: A New Window on Our Plants: Lecture presented at University of Iceland, Reykjavik, Iceland, 13 February.

Williams, R. S., Jr., Böðvarsson, A., Friðriksson, S., Pálmason, G., Rist, S., Sigtryggsson, H., Thorarinsson, S., and Thorsteinsson, I., 1973, Satellite geological and geophysical remote sensing of Iceland - Preliminary results from analysis of MSS imagery: Symposium on Significant Results Obtained from ERTS-1, NASA, Goddard Space Flight Center, Sheraton Motor Inn, New Carrollton, Maryland, 7 March.

Williams, R. S., Jr., 1973, Kirkjufell volcanic eruption, Heimaey, Vestmann Islands, Iceland: Lecture presented at EROS Program "Brown Bag Forum," U. S. Geological Survey, Matomic Building, Washington, D. C., 28 March.

Williams, R. S., Jr., 1973, Kirkjufell volcanic eruption: Destruction of the town of Vestmannaeyjar: Lecture presented to Herra and Frú Haraldur Kröyer, Icelandic Ambassador to the United States, Embassy of Iceland (Residence), 2443 Kalorama Road, Washington, D. C., 29 March.

Williams, R. S., Jr., 1973, Geology and geomorphology of Iceland: Land of fire and ice: Lecture presented as part of Barbour-Schramm Memorial Lectures, Department of Geology, University of Nebraska, Lincoln, Nebraska, 9 April.

Williams, R. S., Jr., 1973, ERTS-1: A new window on our planet: Lecture presented as part of Barbour-Schramm Memorial Lectures, Department of Geology, University of Nebraska, Lincoln, Nebraska, 9 April.

Williams, R. S., Jr., 1973, Kirkjufell volcanic eruption: Destruction of the town of Vestmannaeyjar: Lecture presented to Department of Geology, University of Nebraska, Lincoln, Nebraska, 10 April.

Williams, R. S., Jr., 1973, Geological remote sensing: Lecture presented as part of Barbour-Schramm Memorial lectures, Department of Geology, University of Nebraska, Lincoln, Nebraska, 10 April.

News Releases

*Photos/Text (U. S. Geological Survey)

1. Pre-eruptive View of Icelandic Volcano (24 January 1973)
2. Site of Icelandic Volcano [Oblique Aerial Photo] (24 January 1973)
3. Site of Icelandic Volcano [Vertical Aerial Photo] (2 February 1973)
4. Iceland Volcano Eruption Shows up on Space Image [NOAA-2] (2 February 1973)
5. View of Iceland Volcano from Space [NOAA-2] (2 February 1973)
6. Iceland Volcano Eruption on Space Image [NOAA-2] (2 February 1973)
7. Plan Satellite Experiment for Iceland Volcano [ERTS-1 and NOAA-2] (2 February 1973)

*Text/Photos (U. S. Geological Survey)

Iceland Helped by Space Imagery (10 April 1973)

Newspaper Article (Based on interview and scientific lecture)

Morgunblaðið (Reykjavik Daily Newspaper), 14 February 1973, p. 3., "Icelandic Research from Satellite."

*Available from U. S. Geological Survey Information Office, Reston, Va., 22092, ATTN: Frank H. Forrester or Donovan Kelly (703-860-7444).

g. Recommendation concerning practical changes in operations, additional investigative effort, correlation of effort and/or results as related to maximum utilization of the ERTS system:

The repetitive ERTS-1 imagery (MSS) acquisition over Iceland has created a large cataloging problem. For that reason a geographic matrix for Iceland has been created to place each image in its proper geographic area. The attached matrix shows how each image (and repetitive images of the same area) has been arbitrarily given a specific geographic name. Each matrix square (image) contains one or more images of nearly the same area. Successive images differ only in their date (season) and the amount of cloud cover (obscuration). The handling of ERTS-1 imagery then becomes quite similar to map or aerial photo handling.

In a true sense, then, the arbitrary geographic matrix for ERTS-1 imagery of Iceland becomes a series of "quadrangle maps," easily correlative with existing map and aerial photographic coverage. NASA should consider holding the orbit more closely over time (more frequent correction) and holding the "framing" to the same area. In this way successive ERTS-1 (for a specific satellite) images would become "maps" of specific areas. The study of dynamic phenomena could be more easily carried out, particularly computer-assisted "change-detection" mapping.

h. Listing by date of any changes in Standing Order Forms:

None

i. ERTS Image Descriptor Forms:

Eighteen forms provided as attachments to this report.

j. Listing by date of any changed Data Request Forms submitted to Goddard Space Flight Center/NDPF during the reporting period:

Because of the late contractual start date, all 1972 ERTS-1 imagery of Iceland was individually ordered on separate Data Request Forms which were submitted to Arthur Fihelly on 4 January 1973, 26 January 1973, 20 April 1973, and 10 May 1973, and through Fred Gordon on 11, 18, and 27 June 1973 and 16 July 1973.

NDPF Computer Abscissa

NDPF Computer Ordinate	133	119	105	91	77	63	49	35	21	7	Iceland Project Ordinate
13	A1	A2	A3 KOLBEINSEY	A4	A5 SLÉTTUGRUNN	A6	A7	A8	A9	A10	A
14	B1	B2	B3 SKAGI	B4 EYJAFJÖRÐUR	B5 TJÖRNES	B6 AXARFJÖRÐUR	B7 MELRAKKAS-LÉTTA	B8 LANGANES	B9 LANGANES-GRUNN	B10	B
15	C1	C2	C3 HVAMMS-FJÖRÐUR	C4 LANGJÖKULL	C5 AKUREYRI	C6 MÝVATN	C7 ÓDÁÐAHRAUN	C8 LANGARFLJÓT	C9 SEYÐIS-FJÖRÐUR	C10 GLETTINGA-NES	C
16	D1 JÖKUL-DJÚP	D2	D3 REYKJAVÍK	D4 THING-VALLAVATN	D5 HEKLA	D6 ÞÓRISVATN	D7 VATNAJÖKULL	D8 INGÓLFS-HÖFÐI	D9 HÖFN	D10	D
17	E1 ELDEYJAR-GRUNN	E2	E3 SKERJADJÚP	E4 GRINDA-VÍKURDJÚP	E5 SURTSEY	E6 VEST-MANNAEYJAR	E7 VÍK	E8 KÚÐAFLJÓT	E9	E10	E
18	F1 ATLANTIS-HAF (SV)	F2	F3	F4	F5	F6	F7	F8 SKAFTÁRDJÚP	F9	F10	F
	1	2	3	4	5	6	7	8	9	10	

Iceland Project Abscissa

Iceland ERTS-1 Data Acquisition Matrix

GEOGRAPHIC NAMES FOR ERTS-1 IMAGERY OF ICELAND

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

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DATE 1 May 1973

PRINCIPAL INVESTIGATOR Richard S. Williams, Jr.

GSFC IN 079

ORGANIZATION U. S. Geological Survey

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1088-12305-4				Snow Volcano (Central) EEO Volcano (Shield) Moraine EEO Nunatak EEO Active Glacier (Icecap) Crater Fiord

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO NDPF USER SERVICES
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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1083-12021-5				EEO Caldera Active Volcano EEO Active Glacier (Icecap) EEO Advancing Glacier Braided Stream Fiord Crater Moraine Outwash Plain Snow Volcano EEO Mountain (Móberg) Lava Flows
1083-12021-B				Rangeland Dormant Vegetation

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1048-12080-5				Caldera Active Volcano EEO Active Glacier (Icecap) EEO Outlet Glacier Braided Stream EEO End Moraine Crater Moraine Outwash Plain Snow Volcano Maar Lava Flows Nunatak
1048-12080-B				Rangeland

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1047-12021-4 1047-12021-5 1047-12021-7				Active glacier Advancing shoreline Braided Stream Caldera Cartography Coast Coastal Plain Coastline Crater End Moraine Glacier Grassland Lagoon Lake Littoral Drift Morainal Lake Moraine Mountain Nunatak Outwash Plain River Sediment Snow Snow Pack Vegetation Volcano

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1047-12024-4 1047-12024-5 1047-12024-7				Advancing shoreline Cartography Coast Coastal Plain Coastline Grassland Littoral Drift River Sediment

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1083-12014-7				Snow Grasslands

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1088-12303-7				Active glacier Fiord Glacier Nunatak Peninsula Snow

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1121-12143-5				Dormant Vegetation Harbor Island Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1192-12084-7				EEO Active Glacier Advancing Shoreline EEO Braided Stream EEO Caldera EEO Cinder Cone Coast Coastal Plain Coastline EEO Crater EEO End Moraine Fault EEO Frozen Lake EEO Glacier EEO Graben EEO Lineament EEO Moraine EEO Outwash Plain Snow EEO Volcano

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1193-12140-5				Active glacier Caldera Crater Glacier EEO Moraine Snow Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1195-12260-5 1195-12260-7				Active Volcano Crater Island Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1211-12142-5 1211-12142-7				Active Glacier Caldera Crater Echelon Fault Fault Frozen Lake Geology Glacier Moraine Snow Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1213-12261-5				Bay Coast Coastline Fault Fiord Frozen Lake Graben Harbor Ice Lake Peninsula Snow

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1229-12140-7				Fault Geology Snow

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1229-12142-7				EEO Active Glacier EEO Caldera EEO Crater Echelon Fault EEO End Moraine Fault Frozen Lake Geology Geothermal Area Glacier Graben Ice Lake EEO Moraine EEO Nunatak River Snow Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1229-12145-7				EEO Active Glacier Advancing Shoreline EEO Braided Stream EEO Caldera EEO Cinder Cone Coast Coastal Plain Coastline EEO Crater EEO End Moraine Fault Frozen Lake Geology EEO Glacier Graben Lagoon Lake Lineament EEO Morainal Lake EEO Moraine Nunatak EEO Outwash Plain Snow EEO Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1229-12151-5 1229-12151-7				Active Volcano Island Lava Volcano

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1247-12145-5				Frozen Lake Ice Lake

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