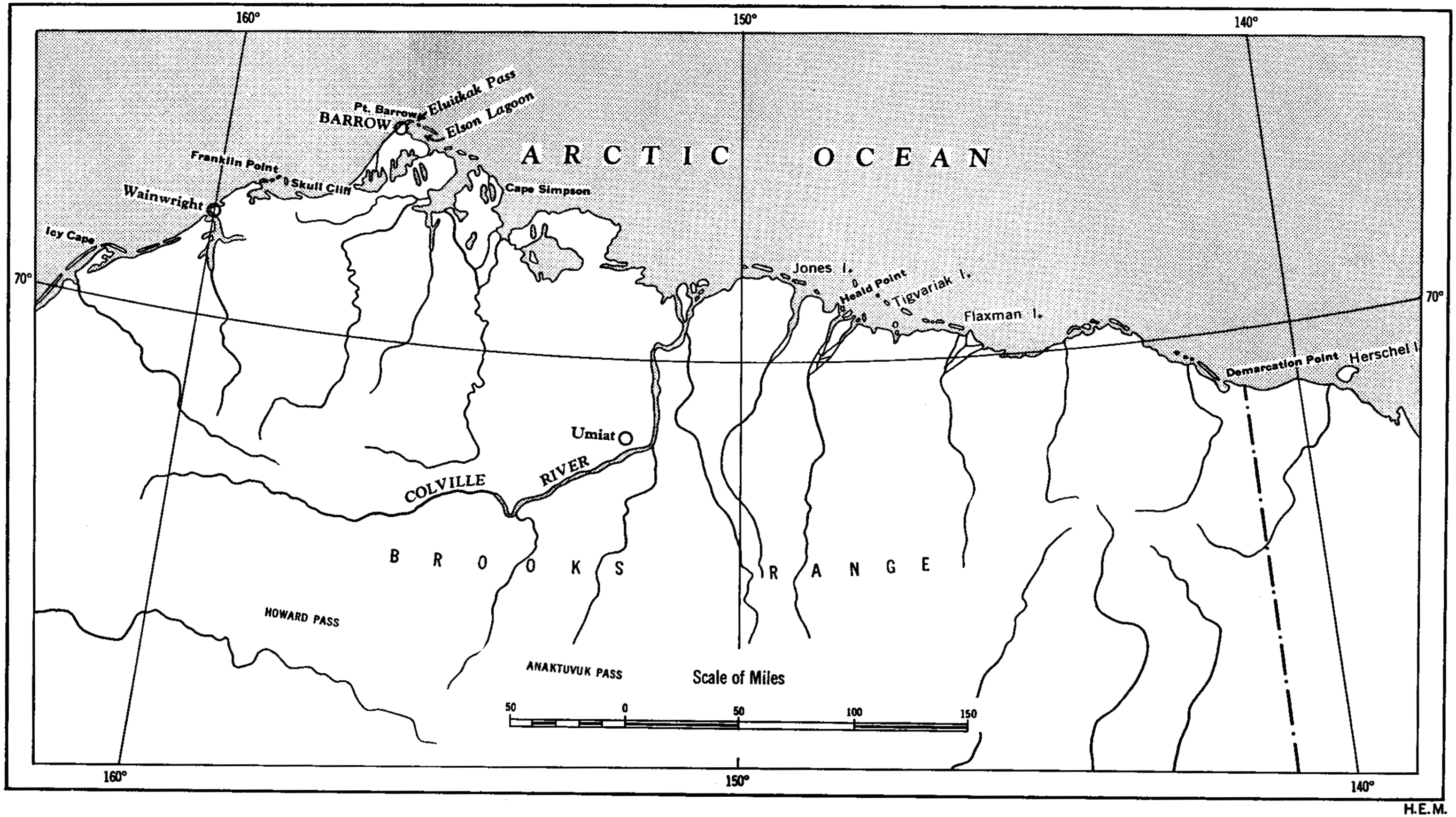

Fig. 1. Sketch map of part of the arctic coast of Alaska.

GLACIAL BOULDERS ON THE ARCTIC COAST OF ALASKA*

Gerald R. MacCarthy†

ALTHOUGH it seems definitely established that the Pleistocene glaciers of Alaska did not extend north beyond the northern foothills of the Brooks Range, except for small tongues that occupied the upper reaches of some of the major river valleys without reaching the coast (Flint, 1947, p. 222), there are scattered references in the literature to glacial boulders found along and close to the shore of the Arctic Ocean (Smith and Mertie, 1930, pp. 241-2; Stefansson, 1910, pp. 460-1; Brooks, 1906, p. 261). The only published comprehensive summary of these scattered observations is that by Leffingwell (1919, pp. 142-9, 175, 177) who, after summing up earlier observations, describes a deposit of till-like material under the name of the "Flaxman formation". His discussion of this formation can be briefly summarized as follows.

At Flaxman Island, the type locality, the formation consists of till composed of clay, boulders, gravel, and sand in proportions similar to those found in other tills. The Flaxman boulders are of many types: quartzites of several kinds, greenstone, granite, limestone, diabase, quartz diabase, and basalt. Petrographic descriptions of three boulders of granite, two of diabase, and one of basalt, are given. Nowhere is the till thicker than 2 or 3 feet. Typical till is mentioned at Flaxman Island and at Heald Point; elsewhere along the coast only scattered boulders are noted. These are described as occurring in localized patches from as far east as Demarcation Point to at least as far west as Barrow, mainly along the coast and rarely as much 1 mile inland. They seem to be confined to altitudes under 25 feet. None of the Flaxman rocks were known from the interior, either in moraines or in place. The till of the inland regions was found to be composed chiefly of sandstone, limestone, and metamorphic rocks, none of which could be identified among the Flaxman boulders. Striations are rare on rock fragments in the inland moraines, but abundant on the boulders along the coast. These various features led to the belief that the boulders of the Flaxman formation have an origin totally different from that of those found in the inland tills.

After considering various possibilities the conclusion was reached that all these scattered boulders, as well as the till at Flaxman Island and Heald Point, represent morainic material left by melting icebergs during a stand

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of the sea somewhat higher than that at present. The further suggestion was made that the glacier producing these bergs probably came down the valley of the Mackenzie River and that the source of the boulders should therefore be sought in the drainage of that river. Though it is not specifically stated, the impression is given that the boulders were more prevalent in the east, diminishing both in numbers and in size toward the west. This would definitely imply that they had been transported from east to west.

Recent observations

While engaged in geothermal work in the Barrow-Cape Simpson area (Figs. 1, 8) during 1949 and 1950 the writer saw several of the boulders mentioned by Leffingwell and many others not noted by him. In all 56 erratic boulders belonging to Leffingwell's Flaxman formation were found near Cape Simpson and Point Barrow on the beaches and on the tundra as far as 8 or 9 miles from shore. Many of them are faceted and bear distinct striae. Included are diabase, granite, quartzite, chert, tonalite, limestone, pegmatite, and an augengneiss. Leffingwell's conclusion that the Flaxman boulders represent berg-rafted debris still appears to be the only logical one and this paper merely extends his observations.

As each boulder was examined rough size measurements were made and chip samples were collected. These samples were turned over to Anna Hietnan of the U.S. Geological Survey who studied the majority in thin sections. Some of the smaller boulders were collected whole and are now exhibited in the library of the Arctic Research Laboratory at Point Barrow. They bear labels giving location, field number, and tentative identification. Several of the field identifications do not agree precisely with later petrographic determinations made from thin sections.

Occurrences of the boulders

Erratic boulders, some of which are faceted and bear distinct striae, were seen near Cape Simpson and near Barrow and were observed by others at Tigvariak Island, Wainwright, and other localities along the coast (Table 1). They are scattered thinly over the tundra and along certain shores, particularly those of sheltered estuaries and lagoons. The tundra boulders do not occur at altitudes above 25 feet, as previously noted by Leffingwell. The shore boulders are, of course, at or very close to present sea-level.

Of the 56 boulders noted at least 10 seem to be well faceted and to bear definite striations. In addition there are five or six others that seem to be definitely striated, although no unmistakable facets have been developed on them. In this latter group several show the supposed striae on more than one face.

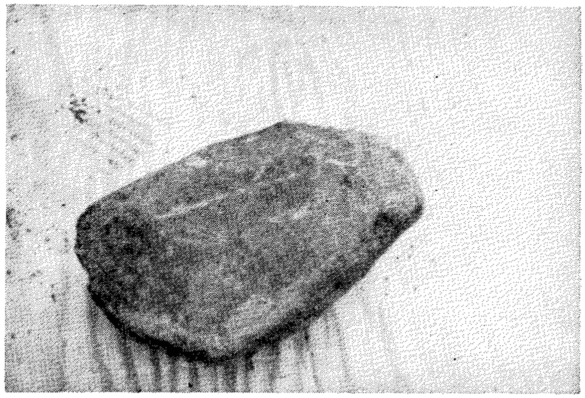


Fig. 2. Quartzite cobble (No. 2) from beach at Barrow. Note faceted upper surface.

Shore boulders

Very few boulders were found on the open sea beaches. For example, the 14-mile stretch that extends from Barrow village beyond Point Barrow to Eluitkak Pass was searched carefully several times for erratic boulders, but despite Leffingwell's assertion (1919, p. 146) that "there is a noticeable amount of Flaxman material in the beach wash at Barrow", only one small cobble was found. This beach is composed of rather fine gravel and coarse sand, with hardly any pebbles larger than egg-size. The one cobble that was found was lying on the beach near the Arctic Research Laboratory (Fig. 2). It measures 9 by 5 by 4½ inches, weighs 14 pounds, and is composed of a tough, indurated quartzite (Table 2, No. 2). It has one well developed flat face, which is very suggestive of glacial abrasion. A small number of boulders lying on the beaches at other localities, e.g., Tigvariak Island, Skull Cliff, Wainwright, have been reported, but they are relatively uncommon. Stefansson (1910, pp. 460-1) says "There are boulders at Cape

Table 1. List of glacial boulders found in the Barrow area

Rock type	*Cape Simpson*	*Tigvariak Island*	*Elson Lagoon*	*Imekpuniglu Lagoon*	*Sinnyu Lagoon*	*Ikpili Lagoon*	*Barrow Base*	*Tundra near Barrow*	*Skull Cliff*	*Sea Floor*	*Total*
Diabase	3	1	—	8	2	—	—	1	1	1	17
Granite	—	—	2	6	1	1	—	4	1	1	16
Quartzite	—	—	2	3	2	1	1	—	1	—	10
Chert (or Chalcedony)	—	—	2	1	—	—	—	1	—	—	4
Tonalite	1	—	—	—	1	—	—	1	—	—	3
Limestone	1	—	—	—	1	—	—	—	—	1	3
Pegmatite	—	—	—	—	1	—	—	—	—	—	1
Augengneiss	1	—	—	—	—	—	—	—	—	—	1
Undetermined	—	—	—	—	—	—	—	1	—	—	1
Total	6	1	6	18	8	2	1	8	3	3	56

Fig. 3. Granite boulder (No. 50) nearly buried in tundra swamp. This is the largest boulder seen. The flags mark the approximate dimensions of the upper, exposed surface.

Simpson[1] and at various points between that cape and the Colville. Natives say that there are boulders here and there inland from Point Barrow. True, there are stretches of a mile or two here and there without a stone of noticeable size." It is to be noted that, although he is speaking of boulders *along the coast,* most of those he mentions would here be classified as *tundra boulders.*

The boulders are far more common on the shores of estuaries and lagoons, such as those just east of Barrow village, even of those which are now separated from the ocean by continuous beach barriers, and along the south (landward) shore of Elson Lagoon than on the open-sea beaches. In these sheltered spots are numerous, closely spaced groups of small boulders, as well as isolated specimens of larger size. This grouping strongly suggests that drifting bergs, which entered the sheltered coves, were trapped there, melted at the spot where they first grounded and left a concentration of debris in a small area.

Dredging operations carried out in the shallow waters just off-shore between Barrow village and Point Barrow have brought up a few small boulders and many pebbles, which were also probably ice-rafted. These boulders must have been dropped recently as they have not been buried by sediments.

Tundra boulders

Eighteen of the fifty-six erratics studied were found behind the present beaches, from the tops of the low bluffs directly at the shore to several miles inland. The largest was a piece of granite (No. 50), located well over a mile from shore. It was completely buried in a tundra swamp except for most of its upper surface, which was flush with the ground (Fig. 3). The exposed

[1] None were found on the *beaches* in the Cape Simpson area in 1949-50.

surface measured 5 feet 8 inches by 3 feet 2 inches; by prodding with a thin steel rod the greatest dimensions were found to be about 6 feet 3 inches long, 4 feet 2 inches wide and 2 or 3 feet thick. It must, therefore, weigh at least 4 or 5 tons. The boulder most distant from salt water was a large, light-coloured granite boulder (No. 42), which was estimated as weighing at least a ton. It is about 13.6 miles south 17½ degrees east of Barrow Aero, 11.4 miles inland from the shore to the west and 8.9 miles from the nearest point on Elson Lagoon. It stands 2 or 3 feet above the tundra surface. No other cobbles or boulders were seen farther from the coast line than this, except deposits in the channel bars of the major streams, such as those of the Colville River at Umiat.

All these boulders were accidentally discovered during the course of other work and no particular search was made for additional specimens on the tundra. It is not possible to state at this time whether there is any particular environment in which they are more common than elsewhere. Still, an impression remains that they are most common — certainly the larger ones seem to be — in the ovate swamps, where they should be least easily visible, and less common on the abandoned beach ridges and other "high" ground. If this impression is correct, it might be considered as rather slender evidence in favour of the view that some of these peculiar ovate depressions, both tundra lakes and swamps, are actually kettle holes of a sort, formed by the wasting away of large tabular bergs that had settled into, or been partially buried by, the soft sediments on which they had grounded.

Like the shore boulders, these tundra boulders are fresh and unaltered, so that it is impossible that they could have been lying exposed on the surface for any great length of time, even in the arctic climate. There seems no conceivable way in which they could have reached their present positions other than by being rafted by drifting icebergs during a higher stand of the sea. At the time Leffingwell wrote his paper (1919) relatively little was known of the Canadian Arctic and so the Mackenzie glacier seemed the only logical source of bergs.

When the floating ice islands in the Arctic Ocean were discovered (Koenig *et al.*, 1952) it was thought possible that the boulders had been brought down from the Canadian Arctic Archipelago and not from the Mackenzie River area. However, direct comparison of specimens from T-3 with the Barrow boulders has shown that whereas they are somewhat similar, there are sufficient differences to indicate very definitely that they could not have originated in the same deposit.

Rock species

Of the 56 individual boulders and cobbles noted 16 were granite, 17 were diabase, 10 were quartzite, 4 were chert or chalcedony, 3 were tonalite, 3 were limestone, 1 was pegmatite, 1 was an augengneiss, and 1 was undetermined. Two of the quartzites were somewhat conglomeratic. It should be noted that the granites and diabase greatly outnumber the quartzites. Leffingwell states (1919, p. 143) that at Flaxman Island "the most conspicuous, both in colour and abundance, are the quartzites." This discrepancy may be purely accidental or, more likely, may be caused by the Flaxman deposit having been brought in by a single large berg that had originated in a locality where quartzite predominated among the morainic materials. The wide spread in the composition of these boulders seems to imply a great diversity of places of origin and this is in itself a very strong argument for the glacial origin of the deposits.

Table 2. Detailed description of the 56 boulders and cobbles recorded in 1949-50

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
		Cape Simpson area	
6	Open tundra near main oil seep. 4½ × 3½ × 1½	Tonalite cobble; rounded corners; one poorly developed flat face.	Intermediate intrusive rock, abundant oligoclase, little or no potash feldspar, considerable quartz; hornblende and biotite in equal amounts; accessories are sphene, magnetite, apatite, allanite, and epidote. Biotite altered to chlorite, which includes rutile. Epidote and sericite are present as alteration products.
7	Flank of highest mound near north seep, about ¼ mile from beach. 78 × 68 × 23	Diabase; angular. (Fig. 4)	Coarse olivine diabase with sparse granophyric quartz and potash feldspar between plagioclase laths; augite main dark constituent; olivine partly altered to iddingsite and serpentine; ilmenite, magnetite, apatite accessories; worm-like inclusions of ilmenite along borders of serpentine aggregates; symplectitic intergrowths of ilmenite and augite; chlorite and serpentine common alteration products after augite.

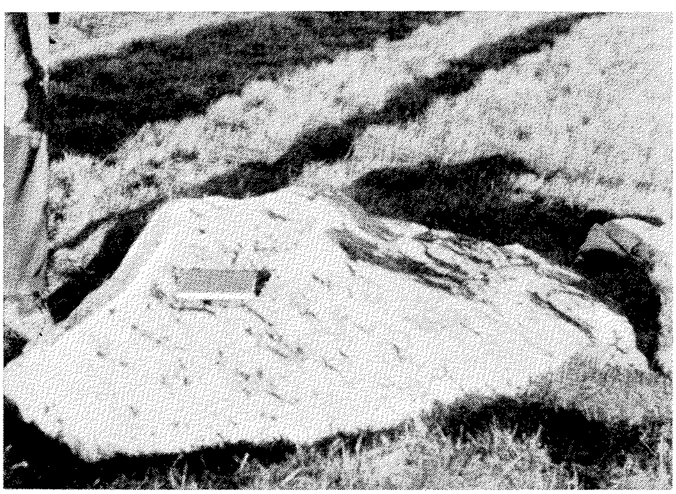


Fig. 4. Large diabase boulder (No. 7) at Cape Simpson. This is undoubtedly the one mentioned by Leffingwell (1919, p. 146).

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
8	A few feet from No. 2; on tundra surface. 18 × 12 × 10	Sandy dolomitic limestone; fragment of small, lenticular mass.	Sandy limestone; small quartz grains in fine-grained dolomitic matrix; magnetite also occurs.
9A and 9B	Surface of tundra near north seep. 8 × 3 × 1 (8 - 10 lbs.)	One shows obscure striae.	Diabase, no thin sections made.
10[1]	Short distance south of middle seep. "About size of oil drum".	Granite gneiss; a triangular point projecting through tundra.	Gneissic granite of quartz, plagioclase, microcline, and biotite, with large feldspar "augen". Quartz shows strong strain shadows. Inclusions of zircon and allanite in light minerals surrounded by epidote. Many biotites rimmed by small ilmenite scales and epidote grains. Alteration products are chlorite and sericite.
		Tigvariak Island	
43[2]	South beach, 70°10′N. 147°15′W. 66 × 36 × 30	Coarse diabase; rounded; 5 similar specimens seen in bottom of drained pond; also smaller ones on north beach.	*See* No. 7 (Cape Simpson area).
		South shore of Elson Lagoon	
29[3]	Tundra, near triangulation station Brant. 9 × 6 × 5	Chert cobble, grey; no obvious glacial features.	*See* No. 26 (Imekpuniglu Lagoon).
30[3]	Tundra, near first small stream south of triangulation station Brant. 8 × 7 × 5	Chert, brownish cobble.	Contains more large quartz grains and less chalcedony than No. 26; *see* No. 26 (Imekpuniglu Lagoon).
5	Top of bluff near triangulation station Lead, 7½ miles southeast of Arct. Res. Lab. 11 × 4 × 2	Quartzite, angular.	Light reddish and contains few fragments of tourmaline; compare No. 21 (Imekpuniglu Lagoon). G. A. Llano (oral communication) reports similar quartzite from Anaktuvuk Pass.
32	Tundra, 65 feet from water line, south side of estuary, north of triangulation station Lead. 16 × 16 × 24	Granite boulder, no facets or striae, almost completely buried in tundra muck and soft plastic grey clay. (Fig. 5)	Specimen too small to be representative; thin section shows very little potash feldspar but several grains are in fine-grained mosaic between large rounded oligoclase grains. Composition is thus near tonalite. Biotite is only dark constituent. Sphene, allanite, epidote, and zircon are accessories.

[1] Reported by D. S. O'Leary, Arctic Contractors.

[2] Collected by Louis Weeden, Cornell University, Arctic Research Laboratory.

[3] Collected by Owen E. Rye, University of Alaska.

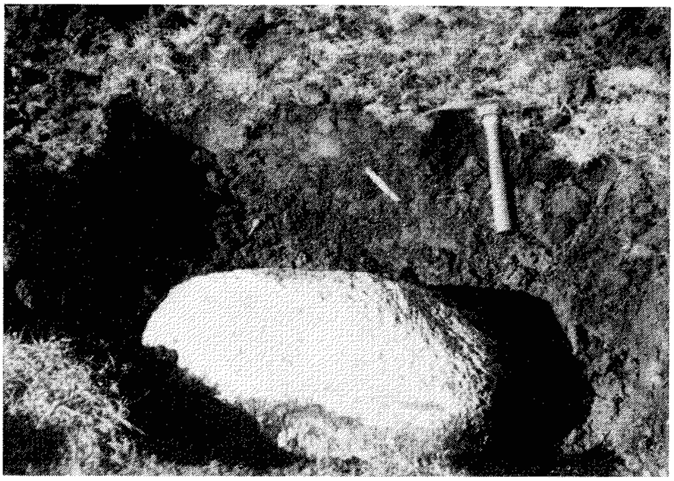
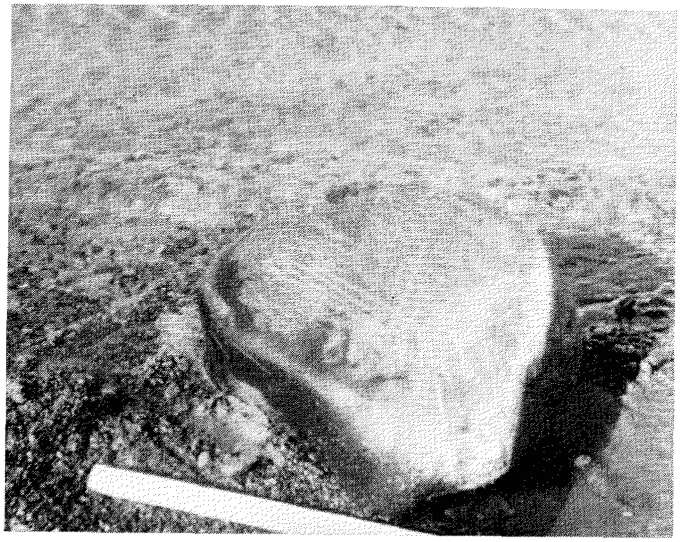


Fig. 5. Granite boulder (No. 32) near Triangulation Station "Lead".

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
33	Inner edge of beach near Avak Bay, ¼ mile south of triangulation station Avak, southeast of Arct. Res. Lab. 22 × 12 × 6	Quartzite, angular wedge-shaped fragment, with sharp corners and edges.	Bioclastic quartzite containing pebbles of chert, chalcedony, and quartzite in addition to rounded quartz grains with overgrowths of quartz; dark red. Like No. 36 (Sinnyu Lagoon).
34	Top of frost mound on tundra, ½ mile south of triangulation station Avak. 21 × 19 × 14	Granite, reddish, subangular boulder; well rounded corners and edges; no striae.	*See* No. 12 (Imekpuniglu Lagoon).
		South shore of Imekpuniglu Lagoon	
11	Tundra on inner edge of lagoon beach. 23 × 15 × 12	Granite, aplitic, one well developed facet and distinct striae; nearly buried.	Aplitic red granite, microcline-rich; gneissic structure; albitic plagioclase present; accessory magnetite. *See* No. 18 (Imekpuniglu Lagoon).
12	Beach, a few feet east of No. 11. 12 × 10 × 8	Granite, reddish cobble, faceted but not striated.	Like Nos. 34 (Elson Lagoon) and 45 (Skull Cliff), is a light reddish medium-grained granite. Equal amounts of quartz, albitic feldspar, and microcline; plagioclase is partly subhedral, partly anhedral. Dark mineral is biotite with zircon inclusions. Biotite altered to chlorite, which includes zircon and rutile; muscovite sparse; sericite is common alteration product.

Fig. 6.
Boulder of fine-grained diabase (No. 15), half awash on the beach of Imekpuniglu Lagoon. Note the distinct striae.



Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
13	*See* No. 11. 9 × 7 × 4	Quartzite, dark grey, facets and striae.	Like No. 22 (Imekpuniglu Lagoon) contains abundant rounded plagioclase and quartz grains. Matrix is fine- to medium-grained quartz and feldspar. Accessories are chlorite (after biotite) with rutile inclusions, sericite, and magnetite.
14	*See* No. 11. 12 × 10 × 8	Diabase cobble, subangular with suggestions of facets but no striae.	Normal diabase; radiating structure formed by intergrown plagioclase and augite.
15	Half immersed in lagoon near No. 14. 14 × 12 × 8 (weight 108 lbs.)	Diabase, 2 well developed facets, each with 3 directions of cleanly incised striae (Fig. 6).	Fine-grained augite diabase with a few serpentine aggregates after olivine. Augite partly altered to serpentine and chlorite. Ilmenite and magnetite are the ore minerals.
16	5 feet from No. 15. 6 × 4 × 3½	Diabase cobble, no facets or striae.	No thin section made.
17	Near No. 16. 10 × 8 × 6	Suggestion of facets but no striae.	Altered diabase. Plagioclase in part altered to sericite and augite to hornblende, chlorite and serpentine.
18	Near No 17. 8 × 5½ × 5	Suggestion of facets but no striae.	Aplitic red granite. Biotite altered in part to chlorite. (*See* No. 11, Imekpuniglu Lagoon).
19	With No. 18. 5½ × 4½ × 2½	Diabase cobble; two definite facets, each bearing striae.	*See* No. 15.
20	Beach. 9 × 8 ×3½	Diabase, rectangular slab, no striae.	No thin section made.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
21	*See* No. 20. 7½ × 6 × 4	Quartzite, subangular (well rounded outline broken at one end).	Bioclastic quartzite, reddish; granoblastic overgrowths on original round quartz. Some grains are chalcedony or quartzite. Sericite, biotite, chlorite, and magnetite are scarce.
22	*See* No. 20. 5 × 4 × 3	Quartzite cobble, subangular, no facets or striae.	*See* No. 13 (Imekpuniglu Lagoon).
23	*See* No. 20. 13 × 8 × 6	Granite, subangular, shape indicates it was broken from a larger, well-rounded boulder. No facets or striae. Medium coarse, light yellowish granite.	No thin section made.
24	20 feet east of No. 23. 13 × 7 × 6	Diabase, medium-grained resembling No. 43 (Tigvariak Island).	No thin section made.
25	———— 6 × 5 × 4	Granite, rounded cobble fragment, medium grained. No facets or striae.	Medium-grained, reddish granite, a few chlorite flakes (altered biotite); rutile and magnetite inclusions in chlorite.
26	Tundra, 100 yards inland, 10 or 12 feet above sea-level. 10 × 6 × 6	Chert, angular fragment, broken from large well-rounded boulder.	Fine-grained chalcedony with coarse quartz in vugs and layers.
27	———— 13 × 10 × 5	Granite, fine-grained, pink, gneissic, like No. 3 (Barrow area).	No thin section made.
28	Lagoon beach. 7 × 6 × 6	Diabase cobble, coarse-grained. Visible grains of metallic sulfide (?).	*See* No. 7 (Cape Simpson area).

Sinnyu Lagoon

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis*
35A	———— 11 × 9 × 4	Limestone, slabby boulder, dark grey, fossiliferous.	Fossiliferous limestone, largely recrystallized along former fossil positions.
36	Inner end of estuary leading back to tundra from lagoon. 9 × 7½ × 5	Quartzite, subangular cobble, greenish.	Contains pebbles of chert, chalcedony, and quartzite. Many of these pebbles are angular. Like No. 33 (Elson Lagoon).
37	*See* No. 36. 8½ × 6½ × 3½	Tonalite, grey, subangular.	Like No. 6 (Cape Simpson).
38	Half-way up east side of lagoon. 24 × 24 × 14	Granite pegmatite.	Granite pegmatite with albitic plagioclase, quartz, and muscovite. Specimen too small to be representative.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
39A	East side of inlet leading into lagoon. 6 × 6 × 3	Diabase cobble, one distinct facet, no striae.	*See* No. 7 (Cape Simpson).
39B	*See* No. 39A. 11 × 6 × 4½	Diabase cobble, one large and one small moderately developed facet, no striae.	*See* No. 7 (Cape Simpson).
40	Beach, east shore of Lagoon. 18 × 14 × 8	Granite boulder, red. No facets or striae.	Granite, with quartz, oligoclase, and microcline. Accessory apatite and zircon. Nos. 40 and 51 (Barrow area) are darker red than Nos. 12 (Imekpuniglu Lagoon) and 45 (Skull Cliff).
35B	Close to No. 35A. 9 × 8 × 5	Quartzite, rounded cobble, red-banded, no facets or striae.	No thin section made.
		Ikpilin Lagoon	
41A	Eastern shore. 14 × 8 × 6	Granite, aplitic, red cobble, well rounded; no striae. Like No. 11 (Imekpuniglu Lagoon).	*See* No. 11 (Imekpuniglu Lagoon).
41B	Eastern shore. 8½ × 7 × 3	Quartzite boulder, grey, slabby, angular; no striae.	No thin section made.
		Barrow area	
2	Sea beach between Barrow village and tip of spit running southeast from Point Barrow. 9 × 5 × 4½ (weight 14 lbs.)	Quartzite cobble, appears to be glacially polished and striated. (Fig. 2).	Blastoclastic quartzite.
3	Tundra 2½ miles south of Barrow Base. 20 × 14 × 16	Granite boulder; no facets or striae. (Fig. 7).	Fine- to medium-striated, foliated granite, rich in microcline. Square, small dark-brown flakes of biotite contain zircon inclusions with dark, pleochroic haloes.
4[4]	Tundra south of Barrow, 6 miles from coast. 10 × 10 × 9 (weight 54 lbs.)	Chert boulder, vuggy, squarish. Similar to No. 26 (Imekpuniglu Lagoon); no striae.	*See* No. 26 (Imekpuniglu Lagoon).
1	Tundra 4½ miles southeast of Barrow Base. 20 × 19 × 11	Tonalite boulder; roughly rectangular, rounded corners and edges; no striae.	*See* No. 6 (Cape Simpson area).

[4] Collected by Karl VonderAhe, Arctic Contractors.

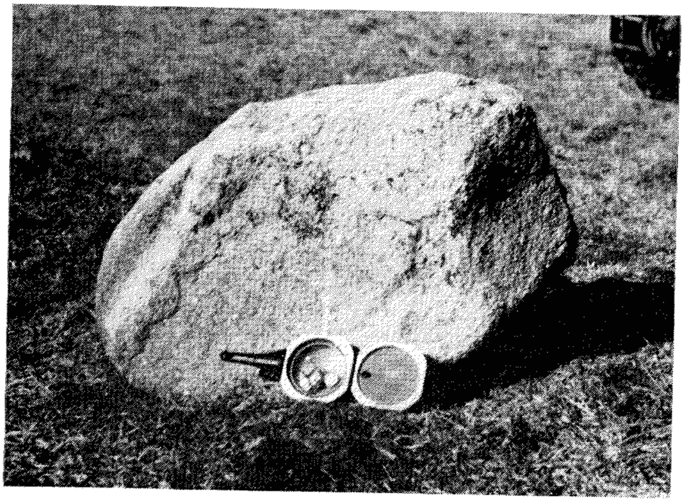


Fig. 7. Granite boulder (No. 3) on tundra about 2½ miles inland from the Arctic Ocean.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
48[5]	Crest of low knoll, about 1½ miles southeast of Barrow village. 11 × 8 × 6	Diabase cobble, crudely faceted.	Chip specimen lost; no thin section made.
49[6]	Tundra just south of Imekpuniglu. 6 × 3½ × 2 weight about 3 lbs.)	Igneous or metamorphic rock with network of thin quartz veins; dark-grey, fine-grained.	Chip specimen lost; no thin section made.
50	1¾ miles south of the south shore of Imekpuniglu Lagoon. 75 × 50 × 24 or 36 (partly buried)	Granite, coarse; upper, exposed surface is flat and flush with ground. Largest boulder seen in area. (Fig. 3).	Specimen is too small to be representative. A little potash feldspar (antipertite in plagioclase). No hornblende, only biotite. Accessory magnetite.
51	Tundra, at head of small ravine 1 mile southwest of Barrow village. 15 × 13 × 6½ (weight 63 lbs.)	Granite, slabby; 2 very flat, parallel surfaces, rounded edges and corners, no striae.	Darker red than No. 45 (Skull Cliff) and No. 12 (Imekpuniglu Lagoon). Main minerals as No. 45, but there is less microcline, and the plagioclase is oligoclase. Subhedral forms and weak zoning common in plagioclase. Accessory sphene, epidote, magnetite, and zircon.
42[5]	Near beach of large lake of Barrow. (*See* text, p. 75) ("must weigh about a ton"[4])	Granite boulder, light coloured; no striae; extends 2 to 3 feet above tundra surface.	No sample taken.

[5] Found by B. J. Longeski, United Geophysical Company.
[6] Found by G. S. Scholl, Navy Ordnance Laboratory.

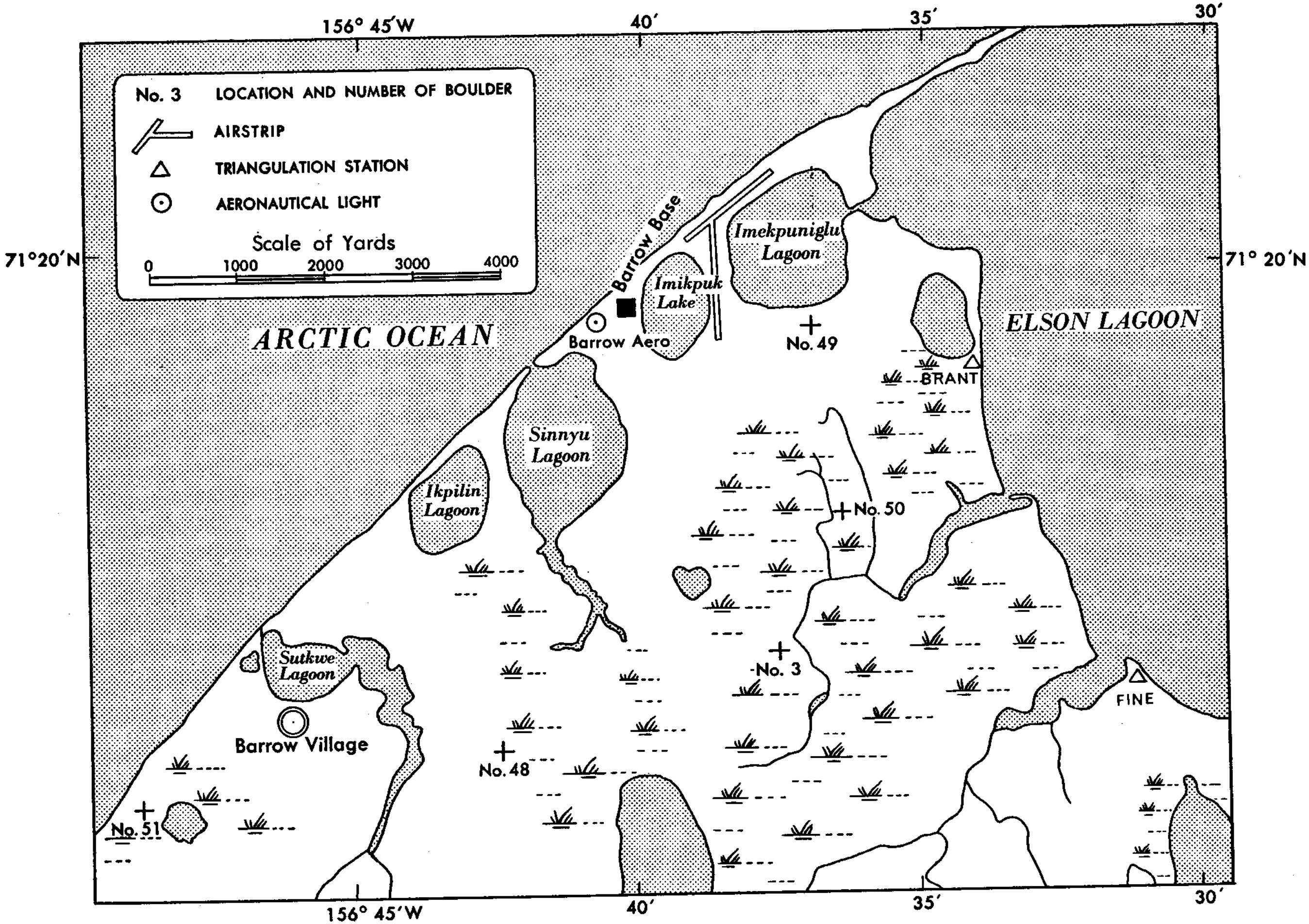


Fig. 8. Sketch map of the Barrow area, showing location of some boulders.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
		Dredged from present sea floor	
31[7]	Barrow Base; from 120-foot depth. 18½ × 10 × 3	Limestone, sandy, dolomitic; angular, lozenge-shaped fragment. 2 large flat surfaces (one barnacle-encrusted), striae on both.	Angular grains of quartz, feldspar, and abundant chalcedony embedded in carbonate matrix. Chlorite, sericite, hematite, and magnetite also.
44A[7]	Off Barrow Base; from 180-foot depth. 11 × 9 × 6 (weight 26 lbs.)	Granite, light pink, fine-grained, subangular cobble; 2 flat faces, one bryozoan-encrusted; no striae seen.	No thin section made.
44B[7]	Off Barrow Base; from 5-foot depth. 7 × 5 × 3	Diabase, small, subrounded cobble; no facets or striae.	No thin section made.
		Skull Cliff area	
46[3]	Tundra, top of bluff along coast 3.3 miles northeast of Skull Cliff. 18 × 13 × 10	Diabase boulder, well rounded, slightly weathered on one surface, thought to be a basalt until thin sections were made.	Fine-grained augite diabase with a few serpentine aggregates after olivine. Ilmenite present. Diabase texture seen in thin section. Small inclusion of sandstone contains subangular grains of quartz, chalcedony, and plagioclase, with isotopic matrix coloured brown by iron oxide.
45	Inner margin of beach, 15 miles southwest of Barrow Base. 26 × 18 × 12	Granite, light reddish, medium-grained, subangular boulder; no facets or striae.	*See* Nos. 34 (Elson Lagoon) and 12 (Imekpuniglu Lagoon).
47	High on beach 8.4 miles northeast of Skull Cliff. 16 × 11 × 4	Quartzite spall, milky-white, evidently broken from a larger boulder recently; no facets or striae.	Quartzite, coarse, white; from a highly metamorphosed area; strongly deformed.

[7] Collected by Dr. George MacGinitie, former Director, Arctic Research Laboratory.

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