Table 1. Argon and potassium analyses from three plutonic bodies found in the northern Palmer Peninsula and southern Chile.

	Ar^{40*} (10^{-3} ppm)	Ar^{40*} / Total Ar^{40}	K (%)	K^{40} (ppm)
	Sample 1			
	4.7 ± 0.5	0.243	0.82	
	5.0 ± 0.3	0.307	0.87	
			0.97	
Av.	4.9 ± 0.3		0.89	1.09
	Sample 2			
	1.2 ± 0.2	0.100	0.131	
	0.9 ± 0.2	0.114	0.139	
Av.	1.0 ± 0.2		0.135	0.165
	Sample 3			
	17.5 ± 0.7	0.542	3.03	
	18.7 ± 0.6	0.616	3.25	
Av.	18.1 ± 0.7		3.14	3.83

analyses were made of samples of three plutonic bodies found in the northern Palmer Peninsula and southern Chile. Ar^{40*} refers to radiogenic Ar-40. Sample 1 (H-62-19) was obtained on Palmer Peninsula, latitude 63°25′S., longitude 58°03′W. A biotite concentrate, −40/+100 mesh, was separated from light gray granodiorite. The estimated composition of this concentrate is: 20 percent biotite, 80 percent chlorite, and a trace of feldspar and other minerals. The ratio Ar^{40*}/K^{40} is 0.0045 ± 0.0005, and the age of the sample is 75 (±8) × 10^6 years. Sample 2 (H-62-14), was also obtained on Palmer Peninsula, at latitude 63°17′S, and longitude 57°58′W. Dark green pyroxene (possibly augite, as determined by x-ray diffractometry), −40/+100 mesh, was separated from dark gray gabbro. The composition of this sample is more than 98 percent pyroxene. It has a trace of biotite and a trace of other minerals. The ratio Ar^{40*}/K^{40} is 0.0060 ±0.0012, from which the age was calculated to be 100 (±20) × 10^5 years. Sample 3 was obtained from Cascade Bay, in southern Chile, at latitude 53°57′35″S, longtitude 71°31′25″W. A biotite concentrate, −40/+100 mesh was separated from gray diorite. The estimated composition of the concentrate was 65 percent biotite, 35 percent of what might be amphibole, and a trace of other substances. The ratio Ar^{40*}/K^{40} was 0.0046 ± 0.0003. The age is calculated at 77 (±5) × 10^6 years.

In the analysis of the three samples, the constants used were:

$$\lambda_\beta = 4.74 \times 10^{-10}/\text{year}$$
$$\lambda_e = 0.585 \times 10^{-10}/\text{year}$$
$$K^{40}/K = 1.22 \times 10^{-4}\ \text{g/g}$$

$$\text{Age} = \frac{1}{\lambda_e + \lambda_\beta} \times \ln\left(\frac{\lambda_e + \lambda_\beta}{\lambda_e} \cdot \frac{Ar^{40*}}{K^{40}} + 1\right)$$

Petrographic examination of the Antarctic samples shows absence of crushing or straining of the minerals. This probably indicates that the plutonic bodies post-date the main tectonic disturbances.

Adie (*2*) assigned a late Cretaceous or early Tertiary age to the Antarctic Peninsula intrusive suite on the basis of petrologic and geochemical correlation with the intrusive suite of the Patagonian Andes. The potassium-argon ages provided in this paper substantiate Adie's designation of age, as far as the north end of the peninsula and the Cascade Bay region of southern Chile are concerned.

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References and Notes

1. The dating of the samples was carried out by Geochron Laboratories, Inc., Cambridge 39, Mass., and was financed through a grant from the National Science Foundation. This paper is contribution No. 82 of the Geophysical and Polar Research Center, University of Wisconsin.
2. R. J. Adie, "The Petrology of Graham Land," II. *The Andean Granite-Gabbro Intrusive Suite* (Falkland Islands Dependencies Survey Scientific Reports No. 12, 1955).

18 July 1962

Surface Textures of Sand Grains—an Application of Electron Microscopy: Glaciation

Abstract. To simulate glacial conditions, a mixture of ice and quartz grains was subjected to grinding under hydrostatic pressure of 500 bars. Electron microphotographs of these "synthetic" glaciated surfaces were then compared with electron microphotographs of grain surfaces which had been abraded and crushed by glacial action, and the correspondence was found to be good. Thus it appears possible to distinguish glacial sands from beach and eolian sands by examining the surface textures of these grains with the electron microscope.

During the process of transportation by glacial ice, sand grains may be subjected to considerable pressure and abrasion by the weight and movement of the overlying ice and sediment. This process may create surface textures which can be observed megascopically and which may also be observed microscopically with the electron microscope. Approximately 800 sections prepared from 75 samples from a number of known glacial outcrops were studied by means of the electron-microscopic techniques described in an earlier report (*1*). Quartz grains ranging between 0.5 and 1.5 mm in diameter were selected for the study. Polycrystalline grains were rejected to avoid complexity in interpretation. The surface textures of these natural grains were compared with those of synthetic grains to determine whether there were certain characteristic features which might be used in the identification of glacial environments.

A quartz plate slice was cut from the face of a Brazilian quartz crystal, and its surface was examined by electron microscopy; it proved to be essentially featureless. The plate was fastened on an Inconel piston which could be fitted into a stainless steel cylinder. A mixture of water and crushed Brazilian quartz weighing approximately 10 g, sieved to particle size of 8 to 10 mesh, was placed in the cylinder, the piston was inserted, and the entire device was frozen at −15°C. This device was then placed in a press and the contents were subjected to hydrostatic pressure of 500 bars. The piston was rotated at 5 revolutions per minute, and the experiment was continued for 5 minutes at constant pressure. Under the initial operating conditions of the experiment—temperature of −15°C and pressure of 500 bars—ice I was the stable phase. During rotation the temperature of the sample increased, due to frictional heat and the heat conducted from outside. The experiment was terminated at the first indication of melting, when friction suddenly decreased.

Pressure and duration of grinding in the glacial environment are extremely variable, and we therefore somewhat arbitrarily selected our values. The rotation at 5 rev/min for 5 minutes is equivalent to movement of 150 cm. Pressure of 500 bars may correspond to 5 km of pure ice at a density of 1, or 2.5 km of ice and rock debris at a density of 2.

Figure 1 is an electron microphotograph of the essentially featureless surface of a quartz plate before experimentation. Figures 2 and 3 show the results of our glacial experiments. The most prominent features are large conchoidal fractures which are characteristic arc-shaped sweeping steps. In addition, semiparallel irregular steps which may represent shear fracturing can be observed.

By comparison with grains from beach and eolian environment, these experimental grains have extremely high relief. Figure 4, a sand grain sampled from the Montauk till at Montauk

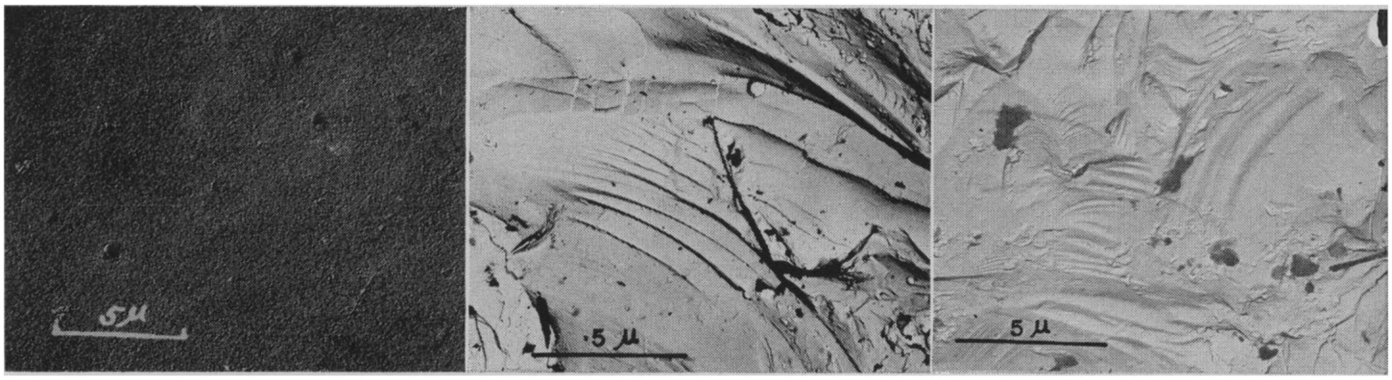

Fig. 1 (left). Surface of a quartz crystal before experimentation. Fig. 2 (middle). Artificially prepared glacial surface. Fig. 3 (right). Artificially prepared glacial surface.

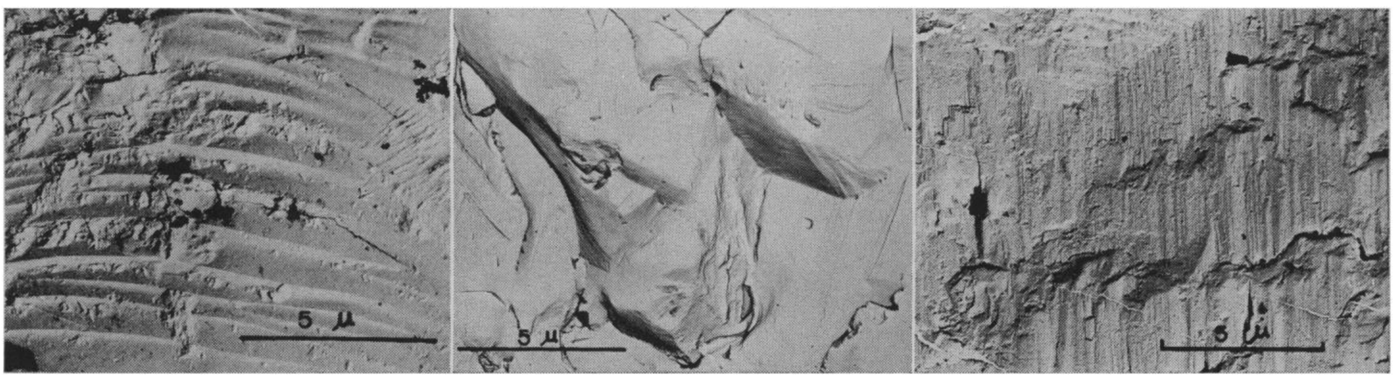

Fig. 4 (left). Surface of a sand grain from a sandy layer in till at Montauk Point, Long Island, New York. Fig. 5 (middle). Surface of sand from till at Alfred Station, New York. Fig. 6 (right). Surface of sand from a kame on route 46, near Newfoundland, New Jersey.

Point, Long Island, New York, shows wide, sweeping, arcuate conchoidal fractures which cross the photograph. A series of subparallel steps can be seen at right. Both of these features are very much like features seen on "synthetic" glacial surfaces in Figs. 2 and 3.

Figure 5 is a photograph of the surface of a sand sample taken from till at Alfred, New York. A series of semiparallel, irregular steps is clearly recognizable; very high relief is also evident. This grain, too, is clearly comparable to "synthetic" glacial surfaces. Figure 6, showing sand taken from a kame on route 46 in New Jersey, is of interest because of the tremendous number of steps which appear in the photograph; this probably indicates polishing or grinding of one grain against another by differential movement. This type of texture has been seen in a number of other grains, and we believe that it is another characteristic of glacial action. This photograph, curiously, resembles aerial photographs of portions of the glaciated Canadian Shield area.

Figure 7 shows a grain taken from the beach at the junction of Old Montauk Highway and Washington Road on the south shore of Long Island. The most prominent features (in the center of the photograph) are a series of wide, sweeping, conchoidal fractures which are closely comparable to fractures in the "synthetic" glaciated grains. Other features (Fig. 7, top, right, and bottom) are the so-called V-shaped features which are prominent on beach grains (*1*). This grain was apparently transported from Montauk Point to the west about 8 miles, to the place where it was collected (*2*). Two cycles of transportation can be clearly identified on this grain.

Figure 8 shows a sample from a kettle hole immediately in front of the Kingston Moraine, Kingston quadrangle, Rhode Island. The sample was probably carried some distance by running water and deposited in the kettle hole, which formed a small lake; thus, this sample can be considered partly glacial, modified somewhat by glacial-fluvial action. It is characterized by conchoidal fracture patterns and subparallel irregular steps. This identifies the grain as glacial; however, it should be noted that many of the prominent

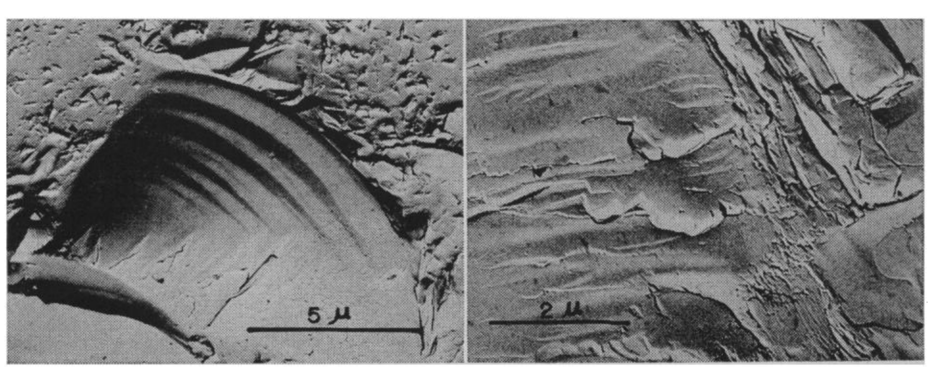

Fig. 7 (left). Surface of sand from the beach at the junction of Old Montauk Highway and Washington Road on the south shore of Long Island. Fig. 8 (right). Surface of sand from a kettle hole near Kingston, Rhode Island.

features on this grain are rounded, and this may be a result of glacial-fluvial action.

Characteristic glacial textures were universally observed on the glacially derived grains examined. Therefore we believe that these textures can be used as criteria for identifying glacial environments. It will probably be possible, with these techniques, to study surfaces thought to be consolidated glacial deposits in order to determine their precise origin (*3*).

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References and Notes

1. D. Krinsley and T. Takahashi, *Science* **135**, 923 (1962).
2. D. Krinsley, W. S. Newman, T. Takahashi, M. L. Silberman, in preparation.
3. We express our appreciation to Prof. W. B. Crandall of the College of Ceramics at Alfred University and to Bud Kipfer of the Pfaudler Company for their technical advice. We also thank Walter Newman, Miles Silberman, and Aaron Rhodes for their help. This research was partially sponsored by a grant from the Petroleum Research Fund of the American Chemical Society and by the New York State College of Ceramics at Alfred University.

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Geotropic Stimulation: Effects on Wound Vessel Differentiation

Abstract. Wounded excised shoots of *Coleus blumeni* (Benth.) were geotropically stimulated by rotation on a klinostat at 3 rev/min at right angles to the horizontal axis and placed alternately in inverted and upright positions at 24-hour intervals. These treatments resulted in the differentiation of significantly greater numbers of wound vessel members. The pattern of wound-vessel formation was altered by rotation on the klinostat but remained unaffected by 24-hour inversion.

The recent work of Goldsmith and Wilkins (*1*) supports the hypothesis that growth responses of geotropically stimulated shoots result from an asymmetrical distribution of auxin. Experiments by Lyon have indicated that gravity may play a role in auxin transport in the erect stem (*2*). Since Jacobs has shown that auxin is the limiting factor in the differentiation of wound xylem around a severed vascular bundle in stems of species of *Coleus* (*3*), it should be possible to employ wound-xylem strand formation as an indicator of both the pathway and the amount of auxin transported around a wound in geotropically stimulated shoots. The present experiments were undertaken to determine if geotropically stimulated wounded shoots would reveal a change in the number of wound-vessel members differentiated or in the pattern of wound-vessel formation (*4, 5*).

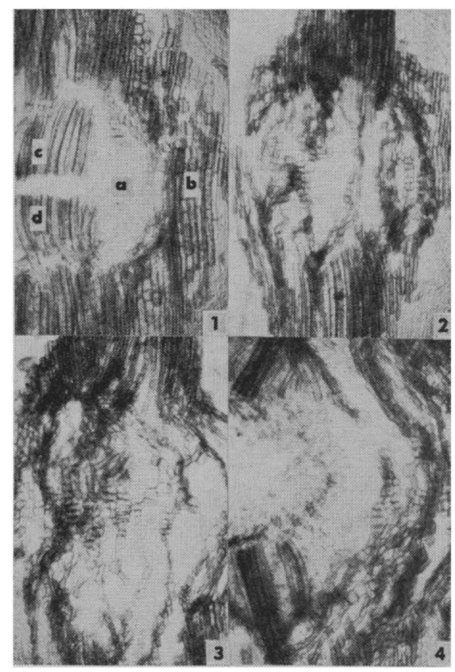
Vegetative single-axis shoots, approximately 10 cm in length, were excised from plants of a single clone of *Coleus blumeni* (Benth.). Leaves and axillary buds below the second internode were excised. The shoots were rinsed in an aqueous solution of calcium hypochlorite, immersed in distilled water for 5 minutes, and positioned with cotton plugs in test tubes containing distilled water. A water-tight seal was made between the stem and test tube with a mixture of beeswax and lanolin. A single lateral incision sufficient to sever a single main vascular bundle was made in the center of the second internode of each excised shoot. The shoots were then placed under one of the following conditions: an erect position for 7 days (controls), rotation for 7 days on a klinostat, rotation for 48 hours followed by 5 days in an erect position, rotation for 24 hours followed by 6 days in an erect position, or inversion once every 24 hours for 7 days. The shoots which were inverted once every 24 hours were inverted immediately after wounding and were rotated 90° once every 24 hours until the end of the 7-day experimental period. The axis of the klinostat was horizontal, and the test tubes containing the shoots were attached to the periphery of the machine at right angles to the axis. The klinostat was rotated at 3 rev/min in all the experiments. Each treatment was replicated three times. The experiments were conducted in the laboratory under continuous fluorescent illumination. The wounded internodes were excised at the end of the experimental period, cleared by a sodium hydroxide-chloral hydrate technique (*4*), and dissected under a stereoscopic microscope to reveal the differentiated wound vessels. The dissected preparations were stained with an aqueous solution of Safranin O and mounted in glycerin jelly. Counts were made of differentiated wound-vessel members from each dissected preparation.

The wound response from undisturbed shoots is composed of the follow-

Table 1. Summary of the effects of geotropic treatments on the differentiation of wound-vessel members.

Plants (No.)	Mean o. No. of cells regenerated*	t	P
	Control		
18	716 ± 192	—	—
	Klinostat 7 days		
13	1171 ± 375	3.792	.005
	Klinostat 48 hr, 5 days erect		
12	1046 ± 256	4.017	.001
	Klinostat 24 hr, 6 days erect		
16	1280 ± 178	9.4	.001
	Inverted 24-hr cycles		
18	905 ± 188	2.743	.05

* The mean number of wound-vessel members regenerated is given together with the standard deviation.



Figs. 1–4. Photomicrographs of dissected wounded internodes of shoots of *Coleus*. All of the photomicrographs are oriented with the cicatrix on the left-hand side of the photograph. Fig. 1. Control of wounded undisturbed shoot showing dormant zone (*a*), zone of wound-vessel differentiation (*b*), and severed ends of main vascular bundle (*c, d*). The ends of the vascular bundle, severed by the incision, appear to be disengaged from the zone of wound vessel differentiation. This is an artifact arising from the clearing and dissection technique, and microtomed sections prepared in the usual histological manner indicate that differentiation proceeds basally from the end of the severed bundle at the morphologically upper side of the wound. Fig. 2. Rotation 48 hours, 6 days in erect position. Fig. 3. Rotation 24 hours, 5 days in erect position. Note in Figs. 2 and 3 the absence of the dormant zone and the altered distribution of wound vessel strands. Fig. 4. Inverted and placed upright alternately on 24-hour cycles. Note the presence of the dormant zone.