the interbedded slate, phyllite, and crystalline limestone in the extreme eastern part of the quadrangle. A few unmetamorphosed diabase dikes and sills have been found.

Metamorphic effects, probably of Devonian age, show in all rocks except the granite and the diabase. Most of the rocks in the quadrangle are in the low-grade metamorphic zone marked by the occurrence of chlorite, although a middle-grade zone with hornblende, almandite, and kyanite is centered in the Worcester Mountains. Metasomatic effects include porphyroblasts and quartz segregations and, on a larger scale, steatitization and carbonatization of serpentinite. Most of these effects are the expression of metamorphic differentiation, in which movement of material was confined to a few inches or at most a few feet; but some material, chiefly carbon dioxide, may have moved greater distances. Contact metamorphic effects, chiefly occurrences of cordierite and diopside, have been noted in the vicinity of the granite.

The principal folds in the region, including the Green Mountain anticlinorium, are probably of Devonian age. Most of the strata of the Montpelier quadrangle dip very steeply in the east limb of the Green Mountain anticlinorium, with the tops of the beds facing east; most of those in the southeastern half of the quadrangle are overturned to the east. A northeast-trending anticline centered in the Worcester Mountains is the most notable departure from the homoclinal structure. Minor structural features include schistosity, which is predominantly parallel or nearly parallel to the bedding, minor folds, most of which plunge very steeply, and lineation produced by fine crinkles parallel to the axes of the minor folds.

The leading mineral resource of the area of the Montpelier quadrangle is talc, an alternation product of serpentinite. It occurs nearly pure in steatite and mixed chiefly with the mineral magnesite in talc-carbonate rock. Other products derived from the bedrock include granite, now being quarried, and slate and copper, which have been recovered in the past.

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Received April 20, 1954.

Fabric Studies of Gravelly Sediments: An Introduction to a New Sampling Procedure

Fabric, the spatial orientation of particles composing a solid, is an important characteristic or parameter of sediments that bears on genesis and post-depositional history. Orientation studies of large particles in sediments are of demonstrated value to research in sedimentation (*1*), but much work remains before diagnostic relationships between sedimentary fabrics and the processes that form and modify sediments are established. One approach, only partly realized, is the application of fabric characteristics of modern sediments to identification and genetic interpretation of older deposits.

Fuller application of orientation studies to the solution of sedimentary problems has been restricted by the labor and time required. Two general methods have been followed: (i) Direct measurement of linear elements of particles partly exposed in outcrop, generally by Brunton compass; (ii) marking of partly exposed particles in a way to permit subsequent reorientation and parameter measurements under laboratory conditions.

Direct measurement at the outcrop is a simpler, faster procedure and obviates preparation, transportation, and rehandling of bulky samples. The marking method, although more elaborate, offers distinct advantages in permitting more accurate and detailed evaluation of orientation elements. The apparent shape of a particle partly exposed in outcrop does not necessarily reflect its true shape. Direct measurement of such particles, therefore, introduces possible erroneous data, may result in an arbitrary selection of particles if sampling is not carefully done, and at best requires removal of each measured particle to ascertain whether the exposed portion is a true reflection of important shape characteristics. In contrast, the marking method involves no selection—except by size—thus eliminating much of the subjective element in sampling.

Karlstrom (*2*) describes improved equipment and techniques that facilitate sampling and analysis of marked particles from vertical cuts. A vertical orientation template is used for marking. A horizontal orientation template is readily devised which extends use of the marking method to the deposits that are more conveniently sampled from near-horizontal surfaces. The two templates are similar in principle and basic design. With the vertical orientation template, the marked lines are referred to a vertical plane in vertical and horizontal directions, whereas with the horizontal orientation template the lines are referred to a horizontal plane in N-S, E-W directions. In combination, the two templates can be used to sample exposures on all slopes intermediate between the horizontal and the vertical. Sampling with the horizontal orientation template applies most directly to fabric studies of such modern gravelly sediments as beach, alluvium, mud flow, lag gravel, outwash, and till; it is hoped that the procedure may stimulate increased use of fabric studies in these areas of research.

A simply designated horizontal orientation template consists of a slotted lucite plate, about 4 in. square and 0.5 in. thick, inset with a bull's-eye bubble level and compass. Slots, in the form of a cross, are cut just wide enough to permit insertion of a marking pencil. For marking, the template is leveled in position directly above the particle with the slots oriented N-S and E-W, and lines are drawn by guiding the marking pencil along the slots. Before removal from the outcrop, the lined particle is marked with an arrow to indicate its attitude relative to north.

To reorient after removal from outcrop, each marked particle is placed in a modeling-clay mount at the center of a horizontal circle to be used for orientation measurements. A leveled transparent plate with two inscribed lines oriented N-S and E-W in accordance with the compass coordinates of the horizontal circle is placed over the mounted particle, which then is adjusted in its mount so that the lines on the particle coincide with the lines on the inscribed plate when viewed directly from above. Reorientation of particles by this method permits use of either the orientation goniometer for parameter measurements or other methods not requiring a goniometer (*2*). A convenient combination of inexpensive and readily available equipment consists of the inscribed transparent plate mounted on three legs, a large circle drawn on a horizontal surface, and an improvised clinometer or Brunton compass for measuring the parameters of reoriented particles.

Measurement of only two parameters, the long and short axes, precisely determines the attitude of a particle in space and is sufficient for most orientation studies (*3*). However, measurements of other parameters such as faces and surface markings, readily accomplished by the foregoing method, may significantly enlarge the scope and increase the accuracy of conclusions derived from the fabric studies of gravelly sediments.

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Received April 20, 1954.

Helicopter Support for the Geologist

Geological fieldwork in Greenland has generally been curtailed by the difficulties of transport. Movement across country or along the coast has taken place mostly in spring and fall, when snow and ice conditions were favorable for sledging. However, the snow and ice that favor travel have an adverse effect on geologic observation, for they conceal much of the ground and limit observations to projecting outcrops. In summer, when the snow disappears and the details of the rocks are abundantly displayed, the geologist is faced with the necessity of back-packing across country or boating along the coast. In this season, he either is limited to an area close to his base or his observations are confined to only a few lines of traverse. The use of the helicopter for transport, however, has altered these conditions; and now the geologist can utilize the summer season for his fieldwork without the restrictions formerly imposed by lack of adequate transportation.

During the summer of 1953, several members of the U.S. Geological Survey and geologists from several colleges were requested by the Corps of Engineers and Transportation Corps, U.S. Army, to do fieldwork in northwestern Greenland in the vicinity of Thule. The area of interest was 650 mi^2 of hilly-to-mountainous terrain divided into two segments by a large glacier. The northern segment, consisting of 180 mi^2, was investigated by geologists operating from a single base camp, whereas surveys for the larger southern segment were carried out from a number of field camps as well as from a permanent base. The helicopters used were Bell H-13 Army-type, which proved to be well suited for such fieldwork. With a cruising range of about 140 mi, they were capable of carrying a geologist and pilot and about 400 lb of rock samples, or, for long trips, a corresponding load of additional gasoline.

In the northern part of the area, the helicopters were used primarily to carry the geologist between his base and his area of operations. In the southern segment, the helicopters were used in several ways. After the area close to the base had been covered on foot, the geologists and their equipment were transported to field camps, from which they traversed the surrounding country on foot, as in normal areal geologic mapping. This proved too slow, and as the summer advanced it was apparent that such a method would not permit the completion of the survey before the season drew to a close.

The use of helicopters was increased considerably in order to accomplish the work that remained. Aerial photos were examined and the ground patterns, which in a barren area such as Greenland directly reflect the mappable rock units, were outlined. Flight courses were established in order to cover each discernible unit and to cover the entire area systematically. The flight plans were used for organizing fieldwork and also provided a safety factor; if a helicopter was disabled, a search for it could be made more easily by following its flight pattern for the day.

For fieldwork, the helicopters were quickly flown to the area of interest, and at a height of 1500 to 2000 ft the general features of the terrain were observed. The helicopters then flew at altitudes of 10 to 200 ft above the ground at speeds of 10 to 40 mi/hr. At such low altitudes and slow speeds, it was possible to observe closely the characteristics of the material at the surface. Frequent landings were made at outcrops or where ground or photo patterns indicated a change. At all landings, samples were taken and the necessary geologic observations were made. In this manner, 30 to 60 mi^2 a day could be surveyed in detail equal to that obtained by traverse on foot.

The extreme versatility of the helicopter was demonstrated during periods of ground fog, which often persisted for a week at a time. During such weather, fieldwork with helicopters was possible, even though ground traverses were curtailed because features needed by the geologist to identify his position were obscured. The helicopters were able to rise above the fog and descend through openings in it, allowing the geologist to carry on the fieldwork. In extreme cases, it was practical to fly through fog at very slow speeds and very low altitude, using contact navigation to stay on course.