PETER J. VINCENT*
Salford

SOME PERIGLACIAL DEPOSITS NEAR ABERYSTWYTH, WALES, AS SEEN WITH A SCANNING ELECTRON MICROSCOPE

Abstract

Samples of the well known drifts at Morpha-bychan, Wales, have been examined with a Scanning Electron Microscope. Examination of the quartz grain surface textures indicates that the deposits cannot be regarded as solely the products of periglacial slope activity. Grains in the Blue Head have surface texture attributable to glacial abrasion.

A recurrent problem in the examination of many drift sequences is the decision as to whether or not a particular deposit is a till, a soliflucted till or a true solifluction deposit. A number of criteria have been suggested for distinguishing these sediments one from another. For example, some indication as to the origin of such a deposit may be given by a study of the particle orientation, particle shape and the presence or absence of erratic material. On occasions, however, such studies do not prove conclusive. One may cite, by way of example, a case where ice had moved downslope over a monotonous bedrock and has produced a till which may prove very difficult to distinguish from a non-glacial periglacial slope deposit.

It is now known that many geomorphological processes produce characteristic surface textures on quartz grains (KRINSLEY and DOORNKAMP, 1973). Recently, the author has studied quartz grain surface textures of samples of fresh till and young morainic soils from Norway. During the course of these investigations it occurred to the writer that such quartz surface textures may prove helpful in determining the mode of origin of many problematic drift sequences.

Quartz grain surface textures are easily studied with the aid of a Scanning Electron Microscope (SEM) which detects and displays information derived from the action of an electron probe scanning the surface of the specimen. The SEM has several major advantages over other types of microscope. In particular the depth of field is at least 300× magnification that of a conventional microscope and allows the entire surface of a specimen to be viewed in focus. The specimen image, which is displayed on a TV screen, has a three-dimensional image, a feature which greatly

* Department of Economics and Geography, University of Salford, Salford 5, Lancashire, England.

aids identification of grain surface topography. As compared with the conventional transmission electron microscope specimen preparation for the SEM is relatively simple and rapid. With the SEM grains are viewed directly and the operator does not have the bother of preparing surface replicas for each individual grain, as in the case of transmission electron microscopy.

In order to test some of the notions cited above the problematic coastal drift deposits at Morfa-bychan, Wales, were chosen for an initial investigation and it is these results which are reported here.

THE MORFA-BYCHAN DRIFT SEQUENCE

Only a brief account of the Morfa-bychan sequence will be given here. These complex stratified coastal drift deposits at Morfa-bychan have been studied in great detail by EDWARD and SYBIL WATSON who have been kind enough to supply the writer with the samples used in the present study (WATSON, 1967).

The Morfa-bychan coastal drift deposits are found some ten to twelve kilometres south of Aberystwyth (Fig. 1). Cliffs of these well stratified deposits are banked up against, and cover a low coastal platform some 30—35 m in elevation. The very consistent bedding of the sequence shows a sloping stratification from the coastal platform toward the sea, an orientation which is consistent with deposition either by local Welsh ice or by periglacial slope processes but not by Irish sea ice moving southward into Cardigan Bay.

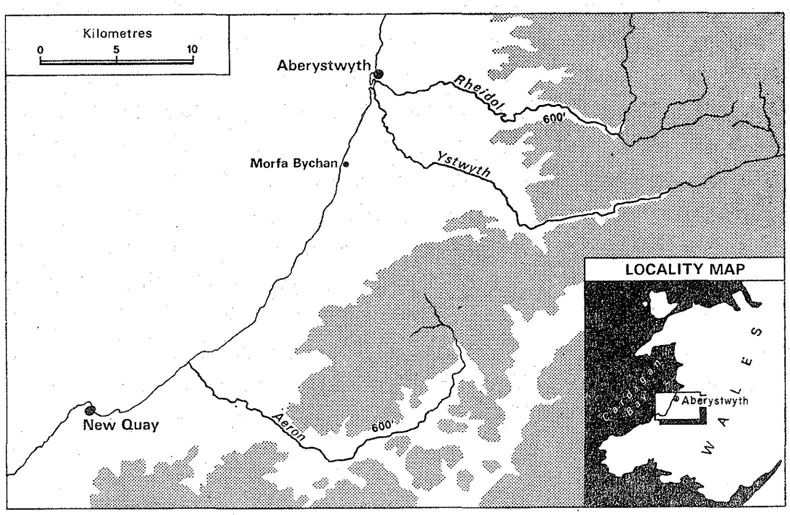

Fig. 1. Morpha-Bychan coastal site, West Wales

The sequence, as interpreted by WATSON (1967) is shown in Fig. 2. They interpret the whole sequence of deposits at Morfa-bychan as periglacial slope deposits derived almost entirely from local Silurian greywacke. Other researchers, notably WILLIAMS (1927) and WOOD (1962) have, however, concluded that some of these coastal deposits are not periglacial slope deposits but are, in fact, true glacial tills. In particular the Blue Head, as recognised by WATSON (Fig. 2), is described both by WILLIAMS and WOOD as a glacial till, doubtless because of its generally massive unbedded structure and silty matrix. Erratics are absent from these deposits which adds to the difficulty in deciding as to whether or not the sequence has a periglacial, glacial, or perhaps, a polygenetic origin. Furthermore, we would not expect local tills produced by Welsh ice moving coastward to have a different make-up from the local periglacial deposits. With these problems in mind, samples of the drifts were examined to see what light the SEM could throw upon the origin of the deposits.

SURFACE TEXTURES OF QUARTZ GRAINS FROM THE DRIFTS

Four samples from the drift sequence were examined. The location of the samples is shown in Fig. 2. Air dried samples were prepared in the manner suggested by KRINSLEY and DOORNKAMP (1973). The prepared quartz grains were then gently

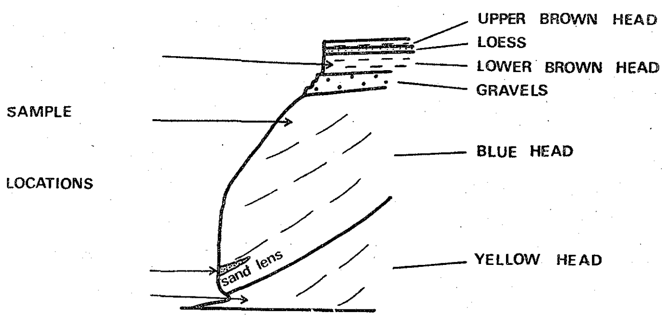

Fig. 2. Generalised section of the Morpha-bychan section and positions of sample localities (After WATSON, 1967)

poured on to a metal specimen plug, placed in a vacuum evaporator and coated with gold palladium. The instrument used in this study was a Cambridge Stereoscan Mark 2A. Approximately two hundred grains were examined in each sample at magnifications ranging from 50× to 25,000×.

THE YELLOW HEAD

The Yellow Head consists of sharp, angular rock fragments in a yellowish-grey silty matrix (WATSON, 1967, p. 422). All researchers regard this as a periglacial slope deposit banked up against, but not overlapping, the buried cliff of the shore platform. One of the most characteristic features of the Yellow Head quartz grains is their general smooth surface textures, as seen in Plates 1 and 2. If we remember that the Yellow Head, because of its location banked up against a buried cliff, is reasonably interpreted as a very local slope deposit it is most probable that this smooth surface texture is a common feature of grains liberated from the local greywacke bedrock, the Aberystwyth Grits. In a detailed study of the Lower Palaeozoic Grits in Wales OKADA (1967) indicates that rounded quartz grains, even in the fine fractions, are not uncommon. They were probably derived from older sediments and OKADA suggests that their roundness is polygenetic in derivation rather than the result of beach action as this last process is insufficient to account for the marked degree of rounding observed (OKADA, 1967, p. 267). This is not to say, however, that textural forms are absent from such grains. Plate 3, for example, clearly shows a number of V-shaped patterns. The lack of consistent orientation of these V-shaped patterns is typical of textures which are commonly produced in high energy sub-aqueous environments. Such textural patterns are entirely in keeping with the turbidity origin of the parent Aberystwyth Grits (KRINSLEY and DOORNKAMP, p. 12). It would appear that the removal and subsequent deposition of the Yellow Head in a periglacial environment has left little evidence, by way of surface textures which, in this case, appear to be totally inherited from the parent material.

THE BLUE HEAD

This deposit is the most problematic in the Morfa-bychan sequence and as has been indicated already, the Blue Head has been interpreted both as a periglacial slope deposit (WATSON, 1967) and as a true till (WOOD, 1962). Because of its massive unbedded structure and the presence of debris with worn surfaces, the Blue Head differs considerably from the underlying Yellow Head.

It is well known that glacial environments produce a number of well defined characteristics both in the type of surface textures present and the general shape of the grains. Fresh quartz grains from such an environment are usually angular and typically exhibit conchoidal surface fractures producing sharp edges.

A great many of the grains examined from the Blue Head had surface textures typically produced in a glacial environment. Often the grains have a number of angular faces with sharp edges showing little sign of rounding. An example of such a grain is shown in Plate 4. Another typical feature of grains having undergone mechanical failure in a glacial environment is the irregular conchoidal fracture. Some of these may be observed on the grain in Plate 4. High magnification of the grain faces reveal the detailed nature of such fractures. The conchoidal patterns, so typical of glacial grains, which were observed on the Blue Head samples, occurred both as single fractures, as in Plate 5 and as complex patterns as seen on the grain face in Plate 6. These complex textures and the more angular shape of the quartz grains in the Blue Head clearly distinguish it from the underlying Yellow Head.

SAND LENS IN THE BLUE HEAD

One sample was examined from a lens of poorly washed and sorted sand contained with the Blue Head. The position from which the sample was taken is shown in Fig. 2. In appearance the surface textures of grains in the lens were very similar to those of the Blue Head. A representative view of the surface texture seen at low magnification is seen in Plate 7. This grain is very clearly the product of a glacial environment. Conchoidal fractures, sharp face boundaries, irregular cleavage blocks are all to be seen in this example. Details of one set of arcuate fractures and upturned cleavage plates are shown in Plate 8. Clearly, then, we have present in the sand lens, sand grains which have undergone glacial abrasion.

THE LOWER BROWN HEAD

The Lower Brown Head (Fig. 2) has also been described by WILLIAMS as being part of an Upper Boulder Clay complex (WILLIAMS, 1927). WATSON (1967) points out, however, that the Lower Brown Head, with its angular, unweathered rock debris and lack of fines in the matrix, has little resemblance to a boulder clay.

On the whole the quartz grains observed in the Lower Brown Head sample were remarkably similar to those observed in the Yellow Head. Compare, for example, Plate 3 (= Yellow Head) and Plate 9 (= Lower Brown Head). At both low and high magnification the surface textures of the grains in the Lower Brown Head appear relatively smooth (Plates 10, 11 and 12). A number of shallow irregular V-shaped depressions are observed on Plate 9 and are similar in origin to those previously mentioned on samples in the Yellow Head. There is no evidence of glacial abrasion on grains from the Lower Brown Head.

DISCUSSION

From the textural evidence presented here it is self-evident that the four samples from the Morfa-bychan drift sequence fall into two groups. In one group are the Yellow and Lower Brown Heads. The smooth surface textures of quartz grains from these Heads is most probably derived from the parent rock. The Blue Head and its associated sand lens, on the other hand, are quite distinct; their quartz grain surface textures bear all the hallmarks of glacial abrasion. Whatever the ultimate mechanism for the emplacement of the Morfa-bychan sequence it is evident that the interpretation of the drift sequence suggested by WATSON can only be accepted in part. The textural evidence presented here supports the view that the Yellow Head and the Lower Brown Head are periglacial slope deposits.

It is not possible, however, to accept the view that the Blue Head is totally periglacial in origin. The quartz grain surface textures clearly demonstrate that this sedimentary unit, derived from the same local bedrock as the Yellow and Lower Brown Head has, at some stage, undergone glacial abrasive processes. This observation is in accord with WILLIAMS, who described this sediment as a Lower Boulder Clay. This is not to say that the Blue Head (= Lower Boulder Clay) could not have been moved into position by periglacial slope processes. A local till disturbed and transported by such processes would be in accord with the fabric data presented by WATSON (1967). Alternatively the Blue Head could have been moved into position as a mudflow complex or even, perhaps, as a flow till.

CONCLUSIONS

This examination of the diagnostic quartz grain surface textures indicates quite clearly that the Blue Head of the Morfa-bychan drift sequence contains sand grains which show evidence of glacial abrasion. As such the Blue Head must be differentiated from the Yellow and Lower Brown Heads which have no such distinctive textures. The Blue Head is most probably a local till which has been redeposited downslope, although the exact mechanism of the redeposition cannot be deduced from the evidence presented here. An examination of sand grain surface textures seems particularly appropriate for distinguishing soliflucted local tills, lacking erratics, from solifluction sediments proper.

ACKNOWLEDGEMENTS

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References

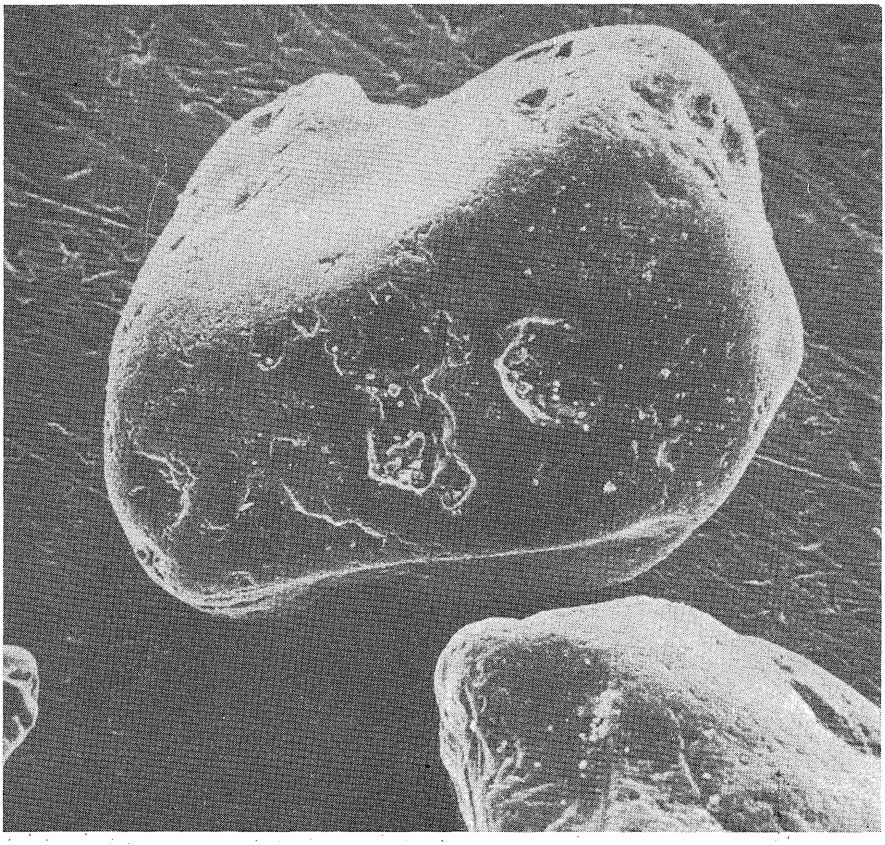
KRINSLEY, D. H. and J. C. DOORNKAMP, 1973 — Atlas of Quartz Sand Surface Textures. Cambridge University Press; 91 p.

OKADA, H., 1967 — Composition and Cementation of some lower Palaeozoic Grits in Wales. *Mem. Fac. Sci., Kyushu Univ., Ser. D., Geology*, vol. 18: p. 261—276.

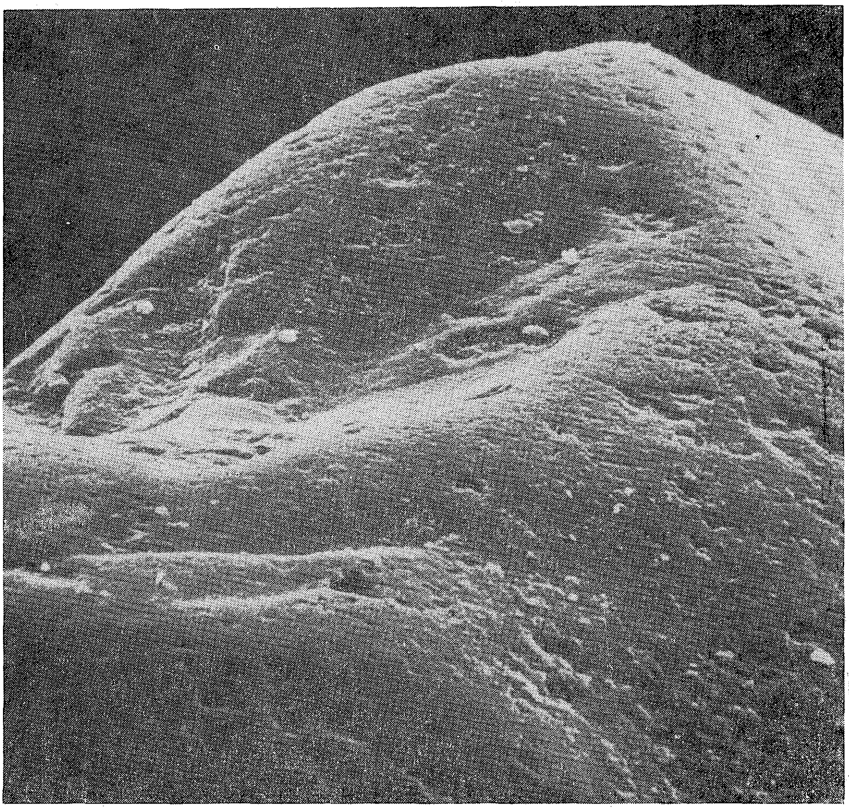
WATSON, E. and S., 1967 — The periglacial origin of the drifts at Morfa-Bychan, near Aberystwyth. *Geol. Jour.*, vol. 5; p. 419—440.

WILLIAMS, K. E., 1927 — The Glacial drifts of western Cardiganshire. *Geol. Mag.*, vol. 64; p. 205.

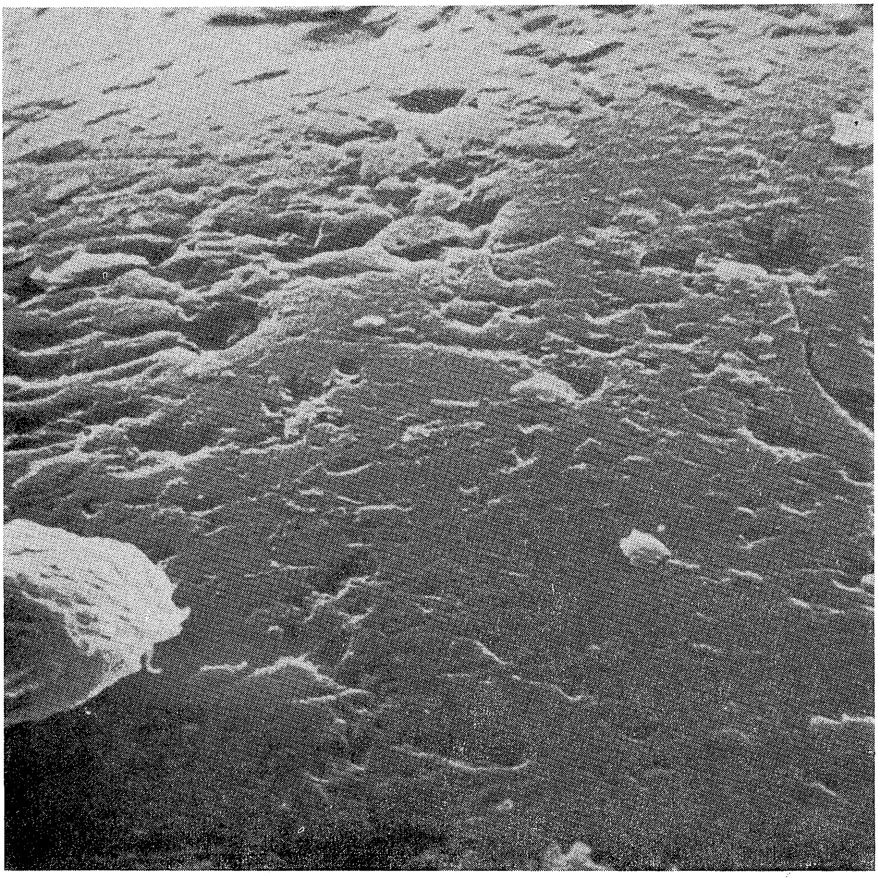
WOOD, A., 1962 — Coastal Cliffs: Report of a symposium. *Geogr. Jour.*, vol. 128; p. 303—307.



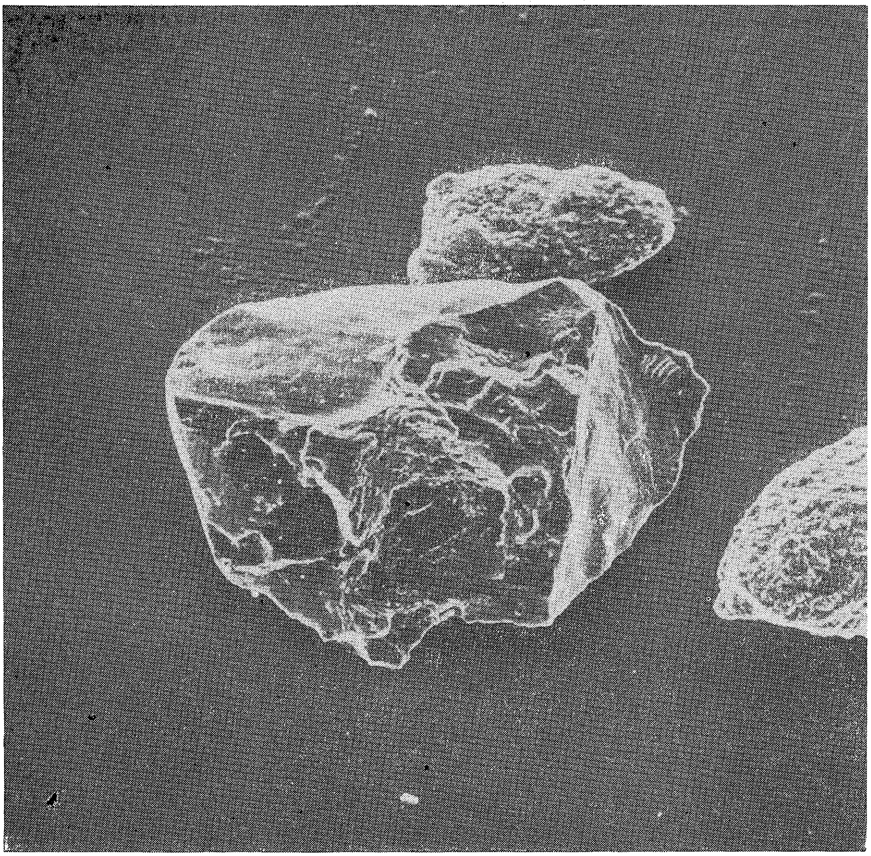
Pl. 1. Yellow Head. Single grain 190× magnification. The rounding of edges and general smooth appearance is typical of grains from the Yellow Head



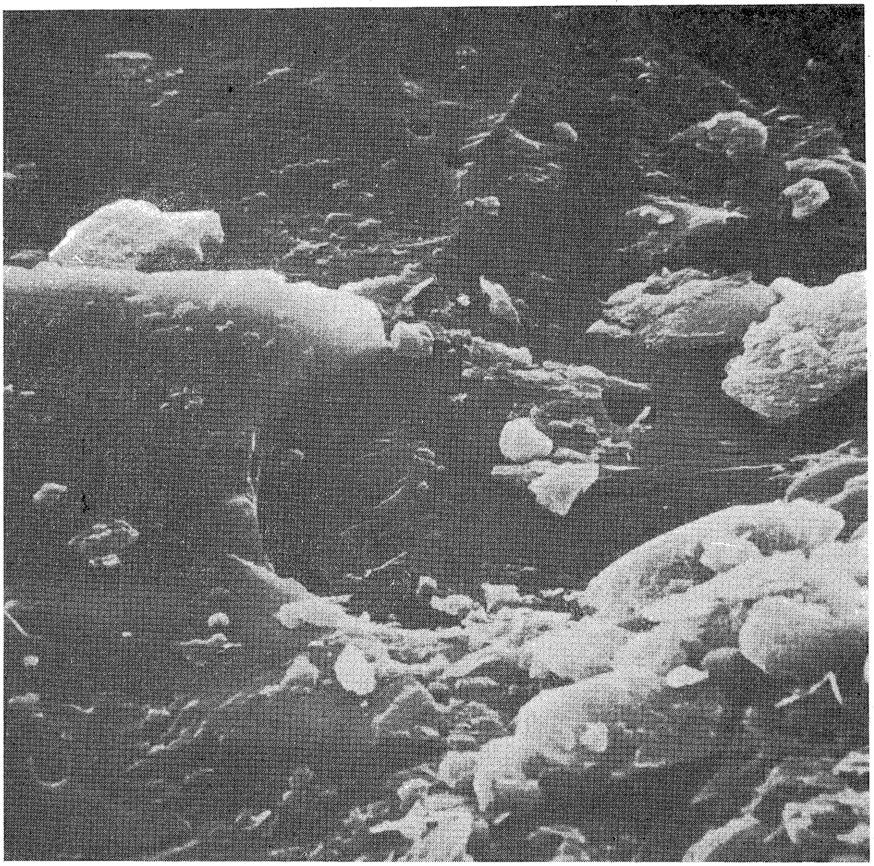
Pl. 2. Yellow Head. Surface detial of a single grain 600× magnification. Some irregular V-shaped notches are visible. These features are most probably inherited from the depositional environment of the Aberystwyth Grits



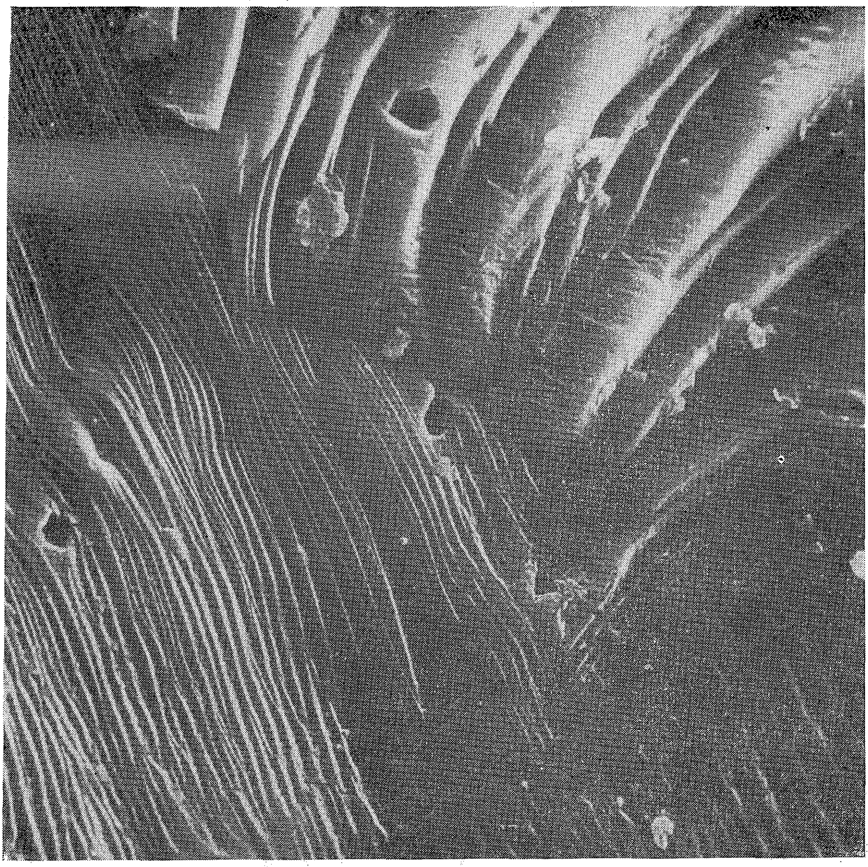
Pl. 3. Yellow Head. Surface detial of grain in Pl. 2 at 6000× magnification showing irregular V-shaped notches in the smooth surface



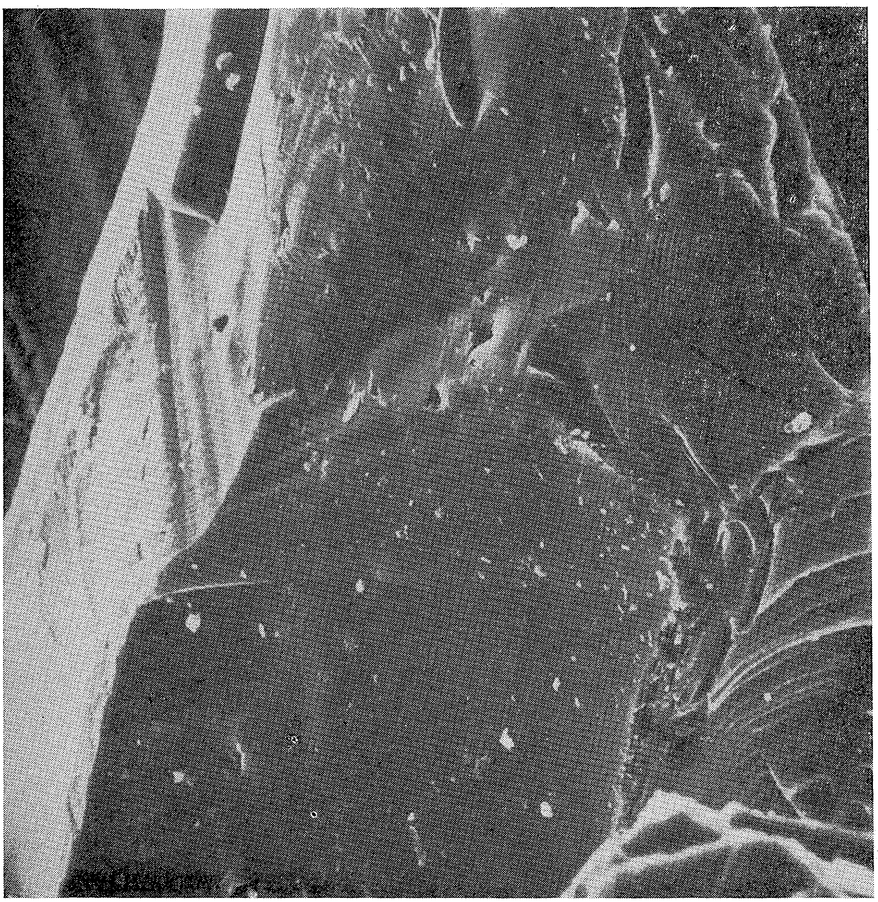
Pl. 4. Blue Head. A large angular grain seen at 100× magnification. Angular edges, conchoidal fractures indicate that this grain has undergone glacial abrasion



Pl. 5. Blue Head. Detailed view of a typical crescentic scar, 2200× magnification. Such scars are common on rains havin been subjected to a lacial enyronment

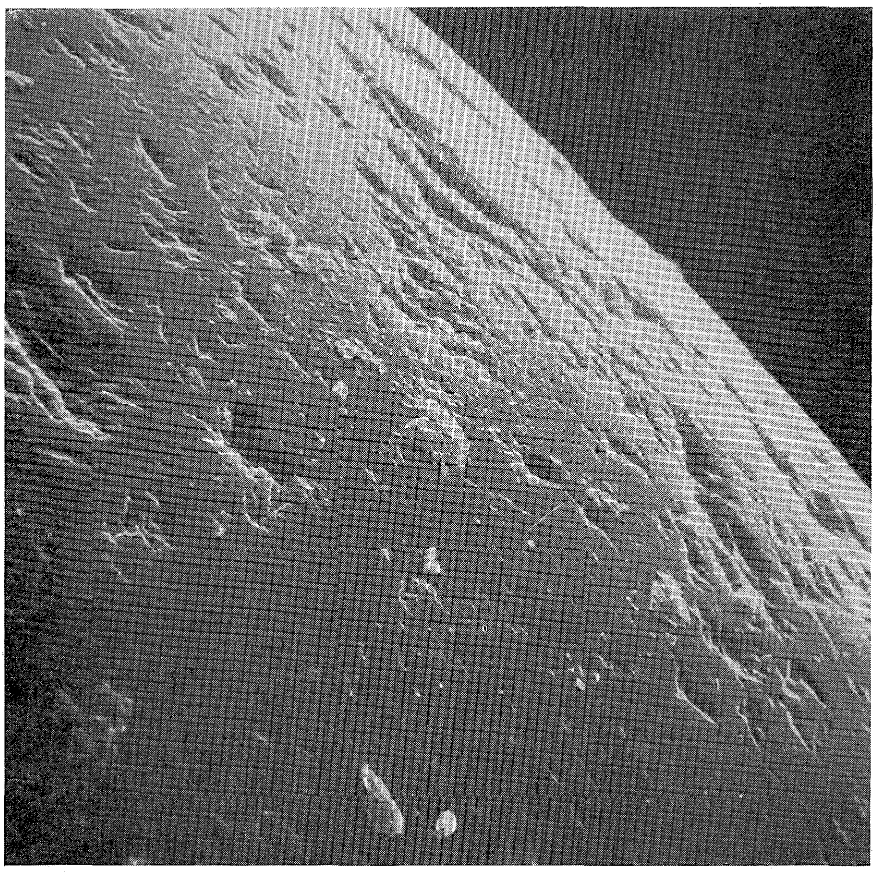


Pl. 6. Blue Head. Complex pattern of conchoidal fractures and cleava·e plates, 3000× magnification

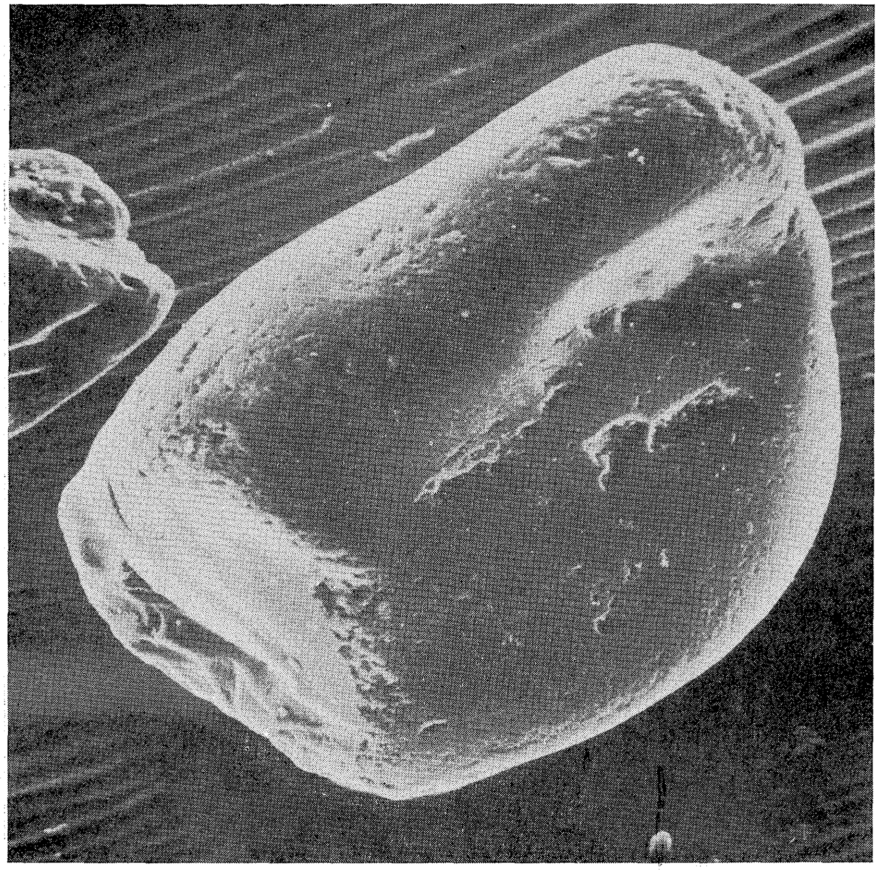


Pl. 7. Blue Head-Sand Lens. Single grain showing angular edges, conchoidal fractures and cleavage blocks, 300× magnification

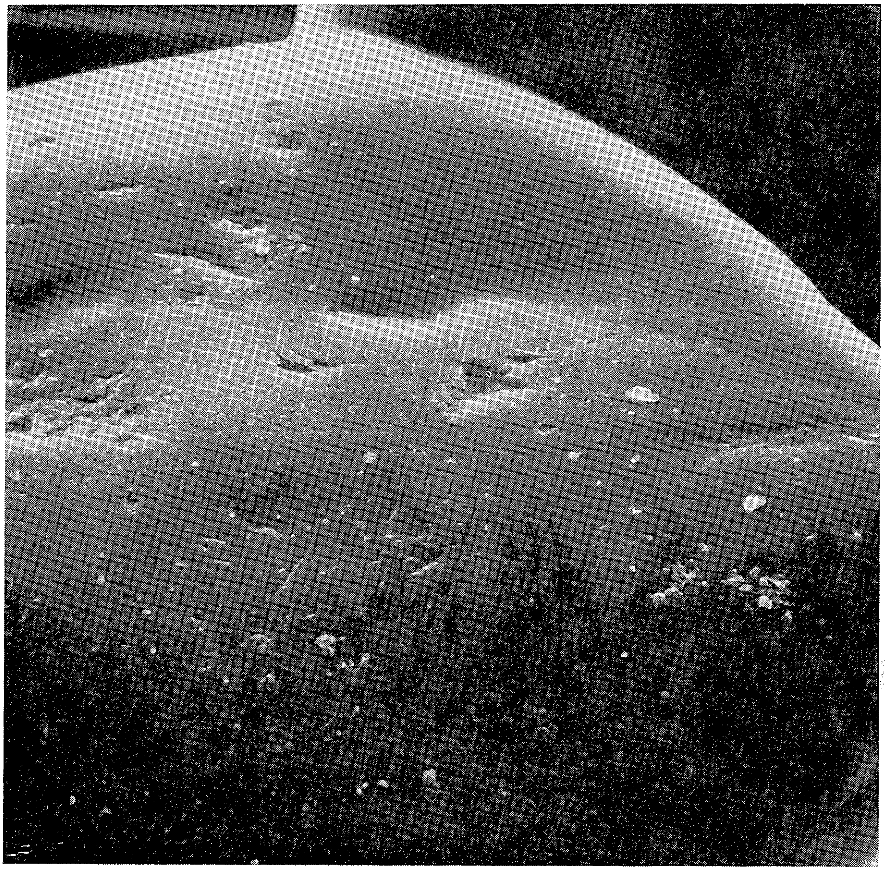
Pl. 8. Blue Head-Sand Lens. Clevage plates and arcuate fractures, the product of glacial abrasion seen at 2000× magnification



Pl. 9. Lower Brown Head. Grain surface seen at 2200× magnification. Compare this surface with Pl. 3



Pl. 10. Lower Brown Head. Typical rounded grain, 150× magnification



Pl. 11. Lower Brown Head. The smooth surface seen in Pl. 10 at higher magnification, 500×

Pl. 12. Lower Brown Head. The same grain surface as in Pl. 10 and Pl. 11 seen at very high magnification, 19000×, demonstrating the smooth nature of the surface