selected for mineralogic and chemical investigation. Sediment samples (a total of 10) were taken at one-foot intervals in the eleven-foot core. The sediment is a brown (7.5 YR4/2) clay which has only a minor silt fraction. It shows no vertical variation but it contains some plant fragments.

Chemical analysis for the major elements using the techniques described by Groves (1951) were made on one part of each sample. Both D.T.A. methods and x-ray Debye-Scherrer powder photographs were used to identify the mineral components of the sediment.

Little vertical mineralogic variation is apparent in the core. The basic constituents are quartz and feldspar with illite the predominant clay mineral though some kaolinite is present in part of the core. The results of the chemical analyses are shown in Table 1.

Acknowledgments. The author wishes to express his thanks to Dr. W. R. Trost, to the Faculty of Graduate Studies, and to the Institute of Oceanography at Dalhousie University for guidance, research facilities and financial support.

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UNDULATORY RANGE AND CRYSTAL SIZE OF QUARTZ

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Some sedimentary petrologists have investigated the relation between undulatory extinction in quartz and other properties. So far, studies have been made on undulatory range of quartz and the age of the rocks (DeHills & Corvalán, 1964), the percentage of undulatory to the total quartz (Blatt & Christie, 1963) and the relation between the range of undulatory extinction of quartz and the average quartz crystal sizes of sandstone (Conolly, 1965).

The purpose of this study is to determine if the range of undulatory extinction varies within a rock, and if so, if it correlates with crystal size of quartz in the rock.

Experimental procedure

Measurements of crystal size of thin sections were done with Leitz

Mikrometer. An approximation was made as to the shape of the crystals. Any crystal was regarded as either rectangular or triangular and the length and width were measured. From the first order pale yellow maximum interference colour of quartz, the thickness of the thin sections were judged as 0.03mm. From these data, the volumes of the individual quartz crystals in a thin section were calculated. Using the Leitz universal stage, the undulatory quartz was set so that the c crystallographic axis of the central portion of the quartz crystal was parallel to the microscope stage.
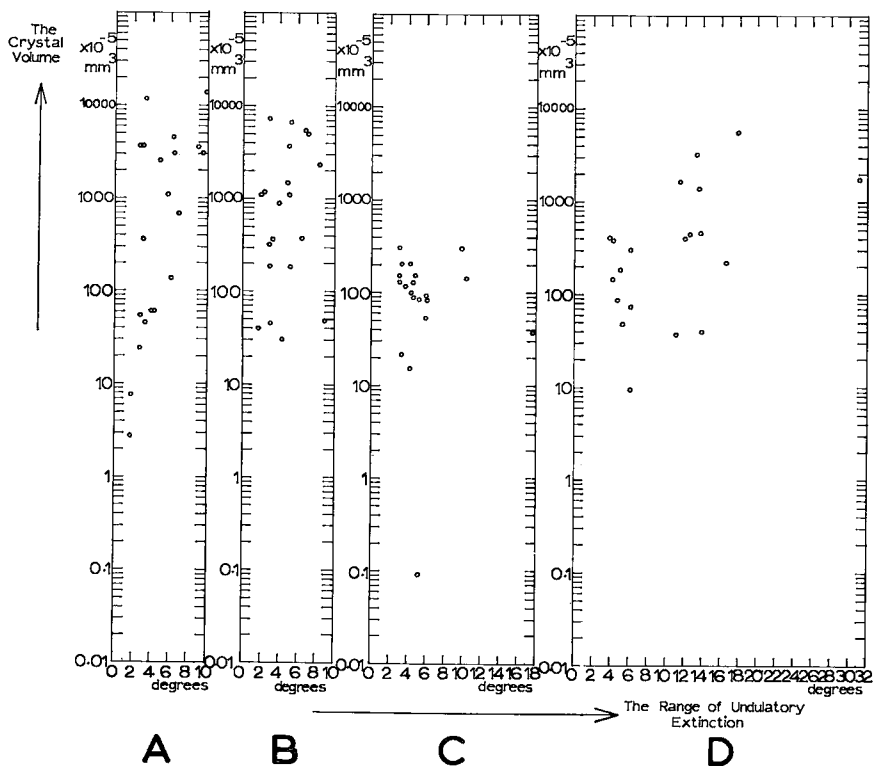

FIG. 1. The relationship between the range of undulatory extinction in quartz, degrees, and the crystal volume in thin sections, mm³. The range of undulatory extinction increases with increase in grain size.

A. Quartz in quartz veins of Burnt Hill Tungsten Mine, New Brunswick. Lower Devonian. Collector: R. R. Potter. Thin sections: 1094B1, 1094D1.

B. Quartz in cordierite pyroxene schist of Otter Lake, Leslie Township, Quebec. Grenville. Collector: J. M. Moore, Jr. Thin sections: OL-51-5-64, OL-54-2-64, OL-67-25.

C. Quartz in sillimanite muscovite biotite schist of Clarendon Township, Ontario. Grenville. Collector: J. M. Moore, Jr. Thin section: G-32-61/4.

D. Quartz in calcite chlorite schist of Kenilworth Mine, Ogden Township, Ontario. Archean. Collector: P. George. Thin section: 64-RFA-371.

When some portion of the crystal showed complete extinction, upon rotation of the microscope stage, it was regarded as the beginning of undulatory extinction of the crystal. On further rotation the total extinction moved from one part to another. The end of undulatory extinction was noted, when the last portion finally extinguished completely before the whole crystal changed to the pale or deep yellow colour again. The range was measured four times with one complete rotation of the microscope stage. The mean of the four values was obtained.

In this way 80 quartz grains, 20 from each of four rock samples, were measured. They were chosen at random. The four quartz-bearing rock specimens are described in the explanation for Fig. 1.

Results and discussion

The quartz crystal size, i.e. volume, and the corresponding undulatory range for each grain of each rock were plotted on semi-log paper (Fig. 1). In Fig. 1, it is obvious that there are large variations in the grain size and the range of undulatory extinction. It appears that the undulatory range increases with increase in grain size in A, B and D in Fig. 1. In this case the mean undulatory range is meaningless, since it ignores the relation with grain size. In C grain size shows less variation, and so does the range of undulatory extinction. If C had many varieties of grain size, it might have well exhibited the same trend as A, B and D.

It is reasonable to assume that the same amount of hydrostatic pressure per unit surface area acted towards any quartz crystal in a rock. Then, obviously, the stress caused the same amount of strain per unit quartz surface area. The total strain of a crystal being now expressed as the range of undulatory extinction in quartz is proportional to the surface area of the crystal. The relation between the surface area of each natural quartz grain and its volume was not measured. The surface area of any prism with parallel bases is linearly proportional to the volume. (In the experiment all quartz volumes were measured as prisms.) Therefore, the undulatory range of prismatic quartz is linearly proportional to the volume of the quartz crystal. Generally, the range of undulatory extinction is not proportional to the volume. In this experiment, especially in A, B and D, the range increased with volume, because quartz volumes happen to increase with the increase in surface area. Choosing only the undulatory quartz in a rock sample, the measurements of surface area of quartz and the undulatory range might have indicated linear functions in Cartesian coordinates.

From measurements of only 2 to 9 unoriented random quartz grains in a thin section, the reported mean undulatory ranges of quartz by Bailey *et al.* (1958) are largely meaningless. Blatt & Christie (1963,

p. 564) pointed out that the range can vary from 0 ° to 90 °, if the quartz grains were oriented at random. The author would suggest that in future work the range should be measured at a special orientation, e.g. with the *c* axis of quartz parallel to the microscope stage.

Conclusions

There are wide variations of the undulatory range of quartz, as well as crystal size in the rocks studied. The range of undulatory extinction in quartz increases with increase in grain size, because quartz volumes happen to increase with increase in surface area.

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AN IMPROVEMENT OF THE
PLAGIOCLASE GLASS FUSION METHOD

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Introduction

The correlation between refractive index of plagioclase glass and An content, for both synthetic and natural specimens, is well established (Larsen, 1909, Foster, 1955, Dawson & Maxwell, 1958, Schairer, Smith, & Chayes, 1956). The fusion method for producing plagioclase glass is rapid and simple; the index of the glass giving estimates of An content that are equal to or exceed those obtained by normal optical and powder x-ray procedures (2 mole per cent An).

For the fusion process, Foster (1955) heated powdered plagioclase, wrapped in platinum foil, with an oxygen-gas blowpipe. After several minutes in the hottest part of the flame the platinum-wrapped sample