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THE SMALL-CIRCLE NET METHOD IN PETROFABRIC ANALYSIS*

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ABSTRACT. A new technique for use in petrofabric analysis has been developed using flat rock sections mounted on the goniometer of an x-ray diffractometer. Intensities of 10 to 15 reflecting planes of a mineral taken from four to six appropriately cut rock slices, as well as from the powder pattern, are sufficient to construct a complete petrofabric diagram.

The method is applicable to minerals of all symmetry with nearly equal ease, absorption corrections are eliminated, and the time required to process the data can be greatly reduced by means of a simple computer program.

X-ray petrofabric diagrams of quartzite tectonites from Sierra Pelona, California, and Fionne Allt, Scotland, show prominent a-c girdles, b-axis minima, and individual maxima in position II of Sander. A T-section of Yule marble shows the well-known point maximum normal to the foliation. A dunite from northwest Washington reveals an a-axis point maximum and a c-axis girdle lying in a plane normal thereto. X-ray and optical data are in close agreement.

INTRODUCTION

Only recently have there been attempts to use the recording diffractometer in x-ray petrofabric analysis. Early studies were carried out using various film techniques most of which involved transmission or grazing incidence of the x-radiation. The use of such techniques for the study of the anisotropy of drawn wire or rolled sheet metal has become highly developed by the metals industry (see Taylor, 1961, chapter 13). Higgs, Friedman, and Gebhart (1960) give a brief summary of film and counter-recording techniques used in x-ray petrofabric analysis, and therefore further elaboration is not needed here.

Of considerable importance in recent developments using the diffractometer is that of Higgs, Friedman, and Gebhart (1960) which makes use of the spherical sample reflection technique described by Jetter and Borie (1953). This method requires an elaborate mounting apparatus which allows rotation of a hemispherical[1] sample about, (a) an axis parallel to but not coincident with that of the goniometer, and (b) another axis perpendicular to the goniometer axis. In obtaining the data axis (b) is first tilted 10° from the vertical, about axis (a), and a 360° traverse is made around the hemisphere. The axis is then tilted another 10°, and a second traverse made. At all times the reflecting surface remains tangent to the goniometer axis. In this way the lines of traverse on the hemispherical sample are seen as circles, concentric about the axis normal to that of the goniometer. The geiger arm is maintained fixed at the proper Bragg angle for the crystallographic plane under study. Intensity values are recorded on the conventional chart recorder. Here absorption can be ignored since the area of sample irradiated at any time is constant. This method has been applied to rock fabrics and the results verified by optical data. There is some disadvantage in (1) the special equipment needed to prepare

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[1] Higgs and co-workers modified the Jetter-Borie technique by using a hemisphere rather than the sphere.

the hemispherical sample and mount it for scanning, and (2) the dependence upon pinacoidal reflections in order to contour directly data for axial directions.

SMALL-CIRCLE NET TECHNIQUE

The development of the small-circle net method came essentially as an answer to the question: Why should one not be able to make use of *all* of the crystallographic reflections obtained from flat rock slices for the determination of fabric anisotropy? It seems certain that all of the reflections of the mineral pattern are modified in some way by the anisotropy of the rock.

If one were to plot intensities of basal reflections from plane rock surfaces one would need to cut a prohibitive number of sections of different orientations to obtain sufficient data for a contourable diagram. By using fifteen or twenty of the more prominent reflections of the pattern, however, a complete petrofabric diagram can be constructed by the proposed method. Four to six flat rock sections and a powder specimen would all be scanned in the usual way in a high-angle goniometer.

For any crystalline material scanned in the goniometer it can be shown by simple diffractometery geometry and the Bragg law that only certain planes from the sample irradiated by the x-ray beam can contribute to an intensity measurement such as recorded by a peak on a diffractometer chart. First of all, the Bragg law must be satisfied in that for a particular angle of reflection, θ, the d-spacing must be of a magnitude so that the paths of x-rays reflected from successive crystallographic planes will differ by an integral number of wavelengths of the radiation used. Secondly, these crystallographic planes must be coplanar with the sample surface which in turn is parallel to the goniometer reflecting surface.

If one were to take a slice of quartzite rock showing random orientation of grain and mount it like a normal "well" sample in the goniometer spindle (fig. 1), one should obtain a pattern similar to that of a firmly packed powder

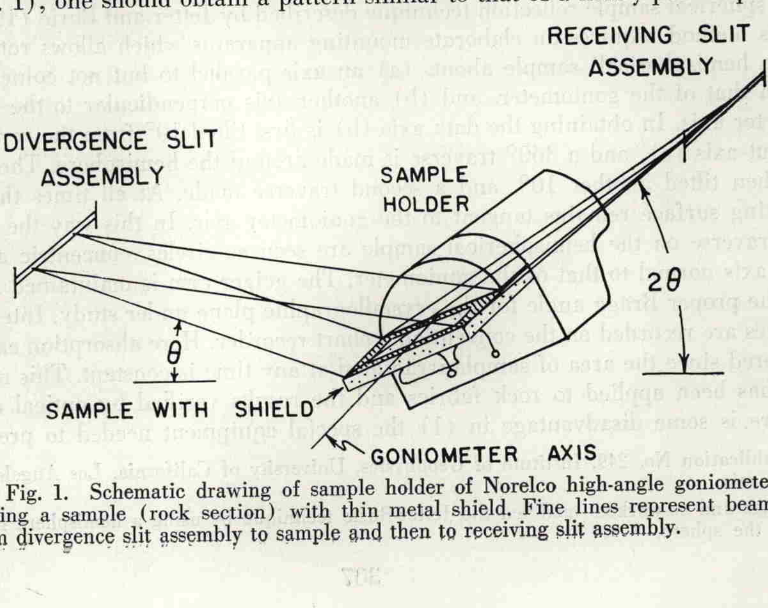

Fig. 1. Schematic drawing of sample holder of Norelco high-angle goniometer containing a sample (rock section) with thin metal shield. Fine lines represent beam path from divergence slit assembly to sample and then to receiving slit assembly.