A COMPUTER PROGRAM FOR DETERMINING OPTICAL PARAMETERS AND OPTICAL AND CRYSTALLOGRAPHIC DIRECTIONS DIRECTLY FROM UNIVERSAL STAGE READINGS

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Measurement of optical parameters on the universal stage remains one of the quickest and potentially most accurate methods of determining the major chemical composition of a member of certain solid solution series, but there remain several unsatisfactory aspects of the method. Amongst these are:

(i) The lack of a convenient method of correcting readings for the differences in refractive index of the hemispheres, the mineral and the glass slide (Wyllie, 1959).

(ii) When the trace of an optical symmetry plane is plotted on a stereographic net it rarely passes precisely through the poles of the other optical symmetry planes, and there is no satisfactory method of finding the mean direction.

(iii) Even when one has decided on mean positions for two optical directions, there are many orientations of the great circle connecting them on which it is difficult to make an accurate measurement of the angle between them.

(iv) The process of plotting and measuring the angles is very lengthy compared with the time taken for the actual setting of the axes of the universal stage.

The effect of these various inaccuracies inevitably reduces the dependability of the correlation of optical properties with chemical composition. Even in a simple series such as the olivines the values of $2V$ show a considerable scatter (Deer, Howie & Zussman, 1962), which must be attributed to error of determination, since the amounts of elements other than iron, magnesium and silicon are negligible. In other series where several compositional factors determine the optical properties the uncertainties in the measurement of the latter increase the difficulty of separating the optical variations due to individual elements.

In order to eliminate or reduce the effect of the second, third and fourth objections noted above, a computer program has been developed which will calculate the optical parameters $2V$ and $Z \wedge c$ (the latter only for minerals with monoclinic symmetry and prismatic cleavage) directly from universal stage measurements, thus eliminating the errors and the time consumed in plotting. The problem of non-intersecting optical symmetry planes and optical directions is dealt with by calculating a vector average direction for each principal optical direction, or cleavage

intersection, from all the relevant poles and intersections, each weighted according to the reliability of the original reading as estimated at the time of measurement.

The first difficulty, that of correcting the universal stage readings for difference of refractive index of mineral and hemisphere, is more difficult to overcome. A partial solution and an idea of the magnitude of the error involved can be obtained by measuring several differently oriented grains, so that measurements are made over both the acute and the obtuse bisectrix, and finding the standard deviation. Because tracing has been eliminated this is not a lengthy process: eight grains can be determined and the data punched on cards within an hour.

With hornblendes having $\beta = 1.65$ (close to the refractive index of the hemispheres) eight measurements gave a standard deviation for $2V$ of about $\pm 1.5°$. As would be expected from the foregoing remarks, olivines, which have a higher mean refractive index ($\beta = 1.73$), produced a larger standard deviation, around $\pm 2.0°$. Measurements of $Z \wedge c$ for clinopyroxenes showed a very small standard deviation, often less than $\pm$ 1.0°. Unfortunately this parameter is of little diagnostic value.

Another use of the method described here is the determination of crystal orientations for structural purposes. Part of the print-out consists of a list of azimuth and dip values for each optical and crystallographic direction, allowing immediate plotting of the relevant poles, or direct feeding to a program designed to contour fabric diagrams (Spencer & Clabaugh, 1967). Using such techniques, the time required for the production of a fabric diagram from a series of thin sections can be drastically reduced.

The program is coded in FORTRAN IV for IBJOB compiler, IBSYS monitor and IBM 7094-II computer, and conforms to the current conventions of the Institute of Computer Science, University of Toronto. This work was done under the support of National Research Council of Canada grants to Professor J. Gittins. Copies of a detailed write-up of the program can be obtained from Professor F. G. Smith, Department of Geology, University of Toronto.

REFERENCES

DEER, W. A., HOWIE, R. A. & ZUSSMAN, J. (1962): *Rock-Forming Minerals*, **1**.

SPENCER, A. B. & CLABAUGH, P. S. (1967): Computer program for fabric diagrams, *Am. J. Sci.*, **265**, 166–172.

WYLLIE, P. J. (1959): Discrepancies between optic axial angles of olivines measured over different bisectrices, *Am. Mineral.*, **44**, 49–64.

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