# NOTES

## Barth's felspar geothermometer: a rapid method

BY

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### INTRODUCTION

The use of the felspar geothermometer (BARTH 1956, 1961, 1962) for the purpose of estimating the temperature of crystallization of two-felspar rocks depends on the determination of the albite content of both the alkali and plagioclase felspars. Each of these determinations is beset with difficulties, however. The alkali-felspar is frequently perthitic (often possibly a secondary condition), and, unless previously homogenized by heating at temperatures up to 900°C (TUTTLE and BOWEN 1958, pp. 13 seq.), it is very difficult to separate from the whole rock sample for wet chemical or X-ray analysis. The plagioclase composition may sometimes be reliably determined by optical methods. However, secondary alteration, at least to fine-grained 'saussurite' minerals, is common, and, as this will have increased the albite content of the remaining plagioclase, a minimum figure only will be determined for the temperature of crystallization.

The method described attempts to overcome these difficulties; only the results of mineral modal and wet chemical analyses are required.

### PRINCIPLE OF THE METHOD

Two sets of data are required:

1) A modal analysis of the rock in which the proportions of plagioclase and alkali-felspar are expressed as percentages of total felspar.

2) A chemical analysis of total felspar of the rock, re-calculated and expressed as percentages of the ideal felspar molecules: Or, Ab, and An (here referred to as the felspar 'norms'). Alteration products of

both felspars should be treated as felspar during the above procedures, provided that such alteration is slight, fine-grained, and iso-chemical.

Modal alkali-felspar will exceed the Or norm by the amount of albite contained by the alkali-felspar. This difference may be deducted from the Ab norm and the remainder of the latter, when taken with the An norm, will give the Ab: An ratio of the plagioclase. Using these values, the albite partition coefficient may be simply calculated. (The An content of alkali-felspar, and, likewise, the Or content of the plagioclase, may reasonably be supposed to be of the same order, low and of negligible significance for this method. See also ORVILLE 1962, p. 344.)

### EXAMPLE OF THE METHOD

A granite from the Hestbrepiggan area of the N.W. Basal Gneiss Area of southern Norway (BANHAM and ELLIOTT 1965, BANHAM 1966) is used for the purpose of illustration. The method may conveniently be divided into three stages:

1) *Microscope work*. An accurate modal analysis of the rock is prepared, using the methods of CHAYES (1956):

Quartz          32%
Biotite          7%
Alkali-felspar  41% (67% of total felspar)
Plagioclase     20% (33% of total felspar)

2) *Chemical work*. To obtain the normative felspar proportions it is not necessary to separate individual rock felspars, or even total felspar, as pure samples. An optically pure mixture of felspars and quartz may be used. This can readily be obtained by the simple separation of the powdered rock sample into a heavy (and electromagnetic) fraction, consisting only of biotite in this case, and a light (and relatively non-electromagnetic) fraction consisting of the required felspar plus quartz mixture. Normally, very few runs through an electromagnetic separator are required for a good separation.

The felspar and quartz mixture is then chemically analysed; the rapid methods of SHAPIRO and BRANNOCK (1952, 1956) have been used in this case. Theoretically, only the values of $Na_2O$, $K_2O$, and $CaO$ are necessary for the subsequent felspar recalculation. (Where the plagioclase felspar is unaltered and its Ab:An ratio determinable by

optical methods, only the $Na_2O$ (or $K_2O$) figure need be determined here.) However, the $Al_2O_3$ and $SiO_2$ values provide additional checks on the calculation, and a complete analysis is recommended as a purity and accuracy check.

The oxide percentages determined are re-expressed as cation percentages, and from these the proportions of the Or, Ab, and An norms may be calculated, using the ideal formulae. A large overall excess of Si of course reflects the presence of abundant quartz in the sample. A slight excess of Al is usual and is probably consequent on slight alteration and/or leaching of the felspars. It might represent some more fundamental substitution in the felspars themselves, however; for example, Al for Si in the tetrahedral sites.

In this case, the recalculated felspar norm proportions are:

$$Or - 50.9\% \; ; \; Ab - 41.2\% \; ; \; An - 7.9\%.$$

3) *Interpretation of the results.* Modal alkali-felspar exceeds the Or norm by the amount of albite contained by the alkali-felspar, i.e. 16.1%; thus, the albite proportion of alkali-felspar is *24%* (16.1/67.0).

The amount of the Ab norm allotted to alkali-felspar may now be deducted from (total) Ab norm to leave only the amount of Ab contained by the plagioclase-felspar (41.2% − 16.1% = 25.1%). Thus, the proportion of albite in plagioclase is *76%* (25.1/25.1 + 7.9).

The albite partition coefficient K may now be determined:
Ab in alkali-felspar: Ab in plagioclase-felspar

$$K = 24 : 76 = .316$$

Using the data given by BARTH (1962, Figs. 3 and 4), the temperature of crystallization of this granite is 590°C (approximately). (This is likely to be a minimum for a small quantity of epidote after plagioclase has probably been lost from the felspar sample during electromagnetic separation.)

### CONCLUSIONS

The method described is rapid, requires no special skills or apparatus, and many samples may be cheaply determined. Further, this method is thought to be at least as accurate and significant as those that depend upon homogenization and/or fine grinding and extremely laborious, yet imperfect, felspar separations.

## ACKNOWLEDGEMENTS

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