A TECHNIQUE FOR MODAL ANALYSES OF SOME FINE- AND MEDIUM-GRAINED (0.1–5 mm.) ROCKS[1]

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INTRODUCTION

A note by Jackson and Ross (1956) describes a rapid method of modal analysis for rocks with grain sizes ranging from about 3 to 10 mm. In this paper, an analogous method of modal analysis is described which applies to the more commonly encountered rocks with grain sizes ranging from 0.1 to 5 mm. The method can be used to supplement, though not replace, the use of thin sections for obtaining quantitative bulk compositions of essentially structureless rocks.

APPLICATIONS OF METHOD

Any rock of suitable grain size can be analyzed by this method if the minerals to be counted are readily recognizable, or can be made so by etching or staining. The more commonly used etching and staining techniques are described by Twenhofel and Tyler (1941). Jackson and Ross give procedures for staining mafic and ultramafic rocks, and also modifications of the method of Gabriel and Cox (1929) of staining for potassium with sodium cobaltinitrite.

EQUIPMENT USED

A photograph of the set-up for point counting on rock slabs is shown in Fig. 1. The equipment consists of a binocular microscope modified by replacing the standard glass stage with a one-fourth inch thick sheet of plexiglass of the same dimensions. A standard point counter mechanical stage for petrographic microscopes is then fastened to the sheet. An ocular equipped with a cross hair reticule provides a reference point for counting. A cruder but less expensive reference point can be established by cementing a five-eighths inch square cover glass to the ocular reticule ring, placing a fine India ink dot in the center of the cover glass, and screwing the cover glass into the focal plane of the eye-piece. Counts can be recorded on a tabulator.

COUNTING PROCEDURE

The point count on stained slabs is carred out in exactly the same way as in customary thin section analysis, and is subject to the same theoretical treatment proposed by Chayes (1949). According to Larsen and

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Miller (1935), a minimum representative sampling of an essentially structureless rock should be at least 100 times the area of the largest grain in that rock but in practice a considerably larger area is commonly used. The coarsest grained rock to which this method is applicable is governed by the largest slab that can be handled on the mechanical stage. A standard mechanical stage can traverse 75 mm. in an "east-west" direction and 25 mm. in a "north-south" direction. The capacity of the mechanical

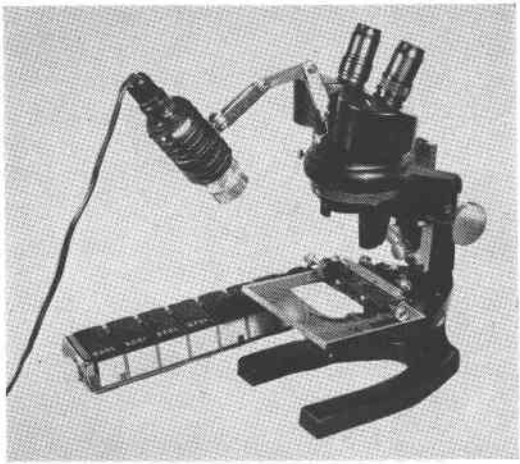

FIG. 1. Equipment used for modal analyses on rock slabs.

stage can be increased: (1) by cutting a section 75 mm. by 50 mm. and counting the south and north halves of the slab separately; (2) by counting both sides of a slab 75 mm. by 25 mm. and thicker than the maximum grain size of the rock or; (3) by combining both of these methods. This would extend the range to include fairly representative samples of rocks in which the largest grains are 6 mm. square; however, with these coarser grained rocks the method of modal analysis described by Jackson and Ross would probably be faster and more suitable. The minimum grain size that can be counted using this method is determined solely by the magnifying power of the microscope used and by the ability of the operator to distinguish between the minerals in the slab. With a microscope equipped with a 3 power objective and 15 power ocular the practical minimum grain size that could be conveniently counted was found to be approximately 0.1 mm. The staining techniques used can be sufficiently discriminative to stain selectively the very finest-grained minerals visible with the binocular microscope.

It was found in practice that approximately 1,000 point counts regularly distributed over a rock slab constituted an adequate sampling of that slab. For slabs 25 mm. by 36 mm. of rocks with maximum grain size less than 3 mm., 10 to 12 traverses are made spaced 2 mm. apart. For larger slabs of coarser grain size the counts are regularly distributed by adjusting the spacing of traverses, and by counting alternate points. After a little practice, an operator, counting four constituents can make 1,000 counts in 15 to 20 minutes.

Experienced operators can reproduce the modal percentage of essential minerals in a slab to within one per cent of the total in successive runs. The problem of determining surface boundaries with thin sections is generally not encountered in the rock slabs because the point count is being made upon the opaque upper surface of the slab which is essentially a plane. A strong point of this method is that an operator can make a fair modal analysis if he is able to distinguish the colors of the minerals being counted. No knowledge of optical mineralogy is required. As an experiment, three persons with no knowledge of mineralogy or prior experience in microscopy each made approximately 1,700 counts on a sodium cobaltinitrite-stained slab of granodiorite having a maximum grain size of 4 mm. square and average grain size of about 2 mm. After less than 30 minutes instruction and practice, the constituents, plagioclase, quartz, potassium feldspar, and mafic minerals were counted with the following results:

Table 1. Counts for Modal Analyses on a Stained Slab of Granodiorite (Volume Per Cent)

Mineral	Minimum	Maximum	Average	Max. deviation	Author's count
Plagioclase	46.8	52.0	49.3	2.7	50.7
Quartz	29.5	30.0	29.7	0.3	29.2
Mafic minerals	12.9	16.4	14.6	1.8	13.5
Potassium feldspar	5.6	7.2	6.6	1.0	6.1

With a little practice features such as grain size, shape, relative relief, and cleavage, in addition to color, are also used to identify the minerals, and a considerably higher degree of accuracy can be attained.

Conclusions

Point counting on slabs permits rapid, fairly accurate modal analyses on rocks of grain sizes ranging from about 0.1 to 5 mm. in which the essential constituents can be individually recognized. Because large slabs can be cut and measured as readily as small ones, it is possible to obtain more representative sampling of medium-grained rocks than could be done with ordinary thin sections. Furthermore, inasmuch as little cost is involved in cutting and staining the slabs, many analyses could be made to reduce errors of sampling and of imperfect mixing in a rock mass. Grain boundary estimation is generally made on a planar opaque surface; therefore, there is no accumulative error, as in thin section analysis, owing to the presence of colorless minerals over opaque or strongly colored grains. Binocular vision in making the counts markedly decreases eye strain and the possibility of errors due to operator fatigue. The entire operation of cutting slabs, staining, and counting, can be readily and economically performed by unskilled personnel.

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YTTRIA IN ZIRCON

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The isostructural relationship of xenotime (YPO_4) and zircon ($ZrSiO_4$) is well known (Vegard, (1)), and isomorphous replacement of zircon by xenotime is assumed to be a common phenomenon; however, little published information is available as to the amount of such substitution that occurs.

The present investigation is a reconnaissance of the yttria content of natural zircons. Fifteen specimens from various localities and environments have been analyzed in order to gain some insight into the distribution of xenotime in zircons.

Analyses were made using a semi-quantitative spectrographic technique in which the yttria content of one zircon, concentrated from North Carolina beach sand, was determined using the addition method outlined by Ahrens (2). Two determinations using Specpure Y_2O_3 and xenotime gave 2.4 and 2.3% Y_2O_3, respectively, for this standard. The yttria content of other samples was then found by comparison with the standard. All samples were ground to −400 mesh, tamped into carbon