NOTES AND NEWS

A TECHNIQUE FOR MODAL ANALYSES OF MEDIUM- AND COARSE-GRAINED (3–10 mm.) ROCKS*

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Representative modal analyses of rocks with an average grain size greater than 2 or 3 mm., and of rocks which contain large, irregularly distributed crystals, cannot be made from standard 1–1½ inch square thin sections. Rapid, moderately precise modes of many such rocks can be obtained by sawing and grinding or polishing a smooth surface on a hand specimen, etching and staining the surface to aid in mineral identification, applying dot pattern Zip-A-Tone to the surface, and making a point count with the aid of a magnifier. The method has been developed for obtaining modes of medium- and coarse-grained granitic rocks from the Sierra Nevada and subsilicic rocks from the Stillwater complex. Detailed techniques are presented for etching, staining, and counting rocks ranging in composition from granite to dunite, but the general method should be applicable to a wider variety of rock types.

The general method has four principal advantages: (1) a slabbed face can be conveniently cut and prepared large enough to give a representative determination of mineral proportions in most medium- and coarse-grained rocks; (2) point counts can be made considerably faster on many etched rock slabs than on thin sections; (3) modal percentages of only one or two minerals can be determined without counting all the points; and (4) the method eliminates the problem of holes in thin sections. Larsen and Miller (1935, p. 263) and Chayes (1954, p. 1238–1239) have pointed out that standard thin sections of coarse-grained rocks do not contain sufficient grains to provide suitable samples for modal analysis; however, rock slabs can be conveniently prepared that contain 16 times the area of a thin section. Point counting on etched and stained slabs is relatively rapid because most principal minerals are quickly recognized and because the mechanics of manipulation are simpler. Furthermore, the most abundant mineral constituent need not be counted: the total number of dots in the area to be counted can be calulated, the minor minerals can be counted, and the major constituent can be found by difference.

The method has three principal limitations: (1) minerals must be identifiable on rock slabs; (2) the method cannot be conveniently applied to rocks with an average grain size less than about 2–3 mm.; and, (3) some small grain sections are concealed by Zip-A-Tone dots. In Stillwater and Sierra Nevada plutonic rocks most minerals are readily iden-

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tifiable on slabs after etching and staining, but distinctions between orthopyroxene-clinopyroxene and biotite-hornblende are difficult. Representative modal analyses of most rocks with average grain sizes less than 3 mm. can be obtained from standard thin sections; application of the dot count method to fine-grained rocks for which standard thin section areas do not provide a representative sample is limited by the relative increase in the size of the dots with respect to the grains. Patterns with finer dots than those now available would reduce the problem of concealment of small grains.

A slab surface provides a better sample of a coarse-grained rock than a standard thin section, and the dot-count method is believed to provide a representative sample of the area counted. The overall accuracy of the method has, however, not been worked out in detail. The assumed theoretical precision is based on the concept that the Zip-A-Tone overlay is essentially a simultaneous projection of a point counter pattern over the rock surface, and, that as such, it should be subject to the same theoretical treatment proposed by Chayes (1949, p. 1–11, et seq.). In practice, it is generally assumed that a minimum area 100 times the area of the largest grain in the hand specimen provides a representative sample of a structureless plutonic rock (Larsen and Miller, 1935, p. 271), but a larger area is prepared and counted if there is doubt of the applicability of this ratio to the particular rock. It is further assumed that a minimum of 1,000 dot counts in such an area provides an adequate sample of the area. To test the accuracy of the latter assumption, repeated point counts were made on etched slabs with the dot pattern shifted one-half of the dot interval between analyses. The modal percentage of individual minerals was generally reproduced within 1 per cent and the maximum variation was 2 per cent. Analyses of the same slab areas using different density Zip-A-Tone dot patterns produced results within these same limits.

Preparation of the Rock Slabs

A hand specimen is examined and the approximate area of the largest grain is computed; a saw cut is then made that will provide a surface at least 100 times the area of the largest grain. The surface is ground on a standard lap with 280 carborundum abrasive until cleared of saw marks. Further grinding and polishing do not materially improve results on granitic rocks, and in some such rocks further polishing is apparently the cause of an unsatisfactory etch on the plagioclase. In rocks containing orthopyroxene and/or olivine, however, mineral distinctions after etching are accentuated on more highly polished surfaces; slabs of these rocks are therefore further ground with 3F carborundum and $303\frac{1}{2}$

alundum abrasive on a steel lap, then polished with 303½ alundum on a canvas lap.

Optimum procedures for etching and staining rock surfaces for counting were found to be considerably different for rocks of different composition, and techniques for the suites investigated are therefore treated separately. Polished slabs of Stillwater peridotites, feldspathic pyroxenites, and pyroxene gabbros are immersed in concentrated HF acid at room temperature for 1½ minutes, drained, dipped in water to neutralize the acid, and blown dry with compressed air. On the dry-etched surface plagioclase is chalky-white; olivine is dull gray; orthopyroxene, unaffected by the HF bath, is lustrous deep brown; clinopyroxene is a dull gray brown. In rocks containing both olivine and clinopyroxene distinction is aided by next immersing the slab in a 0.5 N solution of K_2CrO_4, and again blowing dry with compressed air. The pyroxenes are unaffected by the stain, olivine is brownish yellow, and plagioclase canary yellow. Ground slabs of Sierra Nevada granitic rocks are fumed about 1 to 2 cm. above the surface of a concentrated HF bath at room temperature for 3 minutes, and allowed to dry. The dry slab is then submerged in a sodium cobaltinitrite solution (50 g. in 100 ml. water as suggested by Chayes (1952, p. 339) gives satisfactory results) for about 20 seconds, rinsed in a gentle flow of cold water, and blown dry with compressed air. The etched and dry rock surface has bright yellow K-feldspar, chalky-white plagioclase, clear quartz, green biotite, and black hornblende.Care must be taken during washing, staining, and drying to avoid contact with the etched surface to prevent flaking off the delicate coatings on K-feldspar, plagioclase, and olivine. It is important that specimens stained with cobaltinitrite be thoroughly washed; excess solution will work out of cracks and mask all feldspar with an orange stain.

To protect the delicate etched and stained surface of the slab, several coats of clear liquid plastic are sprayed on the surface. Unfortunately, a plastic veneer generally leads to loss of distinction between orthopyroxene and clinopyroxene and between biotite and hornblende. In many rocks which contain either of these pairs of minerals, they can be distinguished by habit or color, but in some rocks distinction after coating with plastic is impossible. Dot patterned Zip-A-Tone may be applied to the final plastic spray coat while the surface is wet, or the Zip-A-Tone may be put on the dry plastic coated surface by using a small amount of mineral oil as an adhesive.

Mechanics of Counting

Zip-A-Tone pattern no. 3, which has relatively fine dots spaced about 1½ mm. apart (289 dots per square inch), is convenient for systematic point by point counting of slabs; but a finer adhesive dot pattern, such as Para-Tone Company's Contak DT-45 (2116 dots per square inch) is more suitable for slabs on which only one or two minor constituents need be counted. Slabs up to 3 inches square covered with Zip-A-Tone no. 3 can be counted in one setting under a two power magnifier with a large field size. Finer dot patterns must be counted with a binocular microscope, and this not only slows counting, but leads to errors in transferring from one field to the next. Counts are tabulated with a blood counter from which the 100 count lock has been removed so that a continuous count can be made. It is relatively easy to complete a traverse of 30–40 counts without looking up from the slab after the touch system on the counter is familiar. A line in black ink along one side of the Zip-A-Tone cover is helpful so that a pin scratch mark can be made to show what line of dots has just been counted, as it is necessary to continue each traverse to the end without looking away from the surface of the rock. Zip-A-Tone dots cover part of the rock and it is therefore helpful and somewhat more accurate to choose consistently the same point on the circumference of each dot for the count. In some of the nearly monomineralic rocks of the Stillwater complex, counts of a given area can be made on an etched slab in about one-tenth the time needed to count the same area in thin section with a mechanical stage adapted for point counting. In granites, a 4 square inch etched slab can be counted in 20 minutes, about half the time necessary to make a point count on a 1 square inch thin section. The time it takes to saw, grind, polish, etch, and stain a coarse-grained rock plus the time necessary to make a point count on a Zip-A-Tone-covered surface of 4 square inches is less than the time it would take to make standard point counts on the 3 or 4 thin sections necessary to cover a similar area.

The slab point-counting method permits a rapid, reasonably accurate modal analysis on most varieties of medium- and coarse-grained plutonic rocks. The method should also be applicable to some metamorphic rocks, to some porphyritic extrusives, and possibly to certain indurated sedimentary rocks, such as granule conglomerates or stained carbonate rocks.

References

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