Petrographic microscopes in common use are not designed for magnification below 16–20×. Moreover, microscope magnification is limited to set combinations of objectives and oculars, while an enlarger makes available a continuous range of magnification from 1:1 to about 20:1, depending on the focal length of the enlarging lens used. Field diameter and exact linear magnification is obtained by placing a plastic scale in the enlarger and measuring its length in the projected image.

In addition to the advantages outlined, greater speed is possible with a photographic enlarger than with a microscope. A projected enlarged image of the entire thin section is viewed at one time and it is an easy matter to select the desired area or feature to be photographed, and since the work is done in a darkroom, an immediate check of the results is possible.

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A STAGE FOR MACRO POINT COUNTING

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Adequate sampling is the major problem in the modal analysis of the coarser-grained (3–20 mm.) and porphyritic rocks. It has been shown by several authors (e.g. Chayes, 1956, p. 93) that a standard thin section is not large enough to represent a rock with a maximum grain size of more than about 3 mm. In order to obtain a large sample area and avoid the added expense of duplicate thin sections, a technique for counting a rock slab cut from a hand specimen has been developed.

The saw cut slab is prepared for counting by grinding, etching, and staining in a manner that will make the principal minerals quickly recognizable. A mode for the rock is then determined by sampling the surface of the slab with a macro point counting stage.

The stage adapted for this purpose is shown in Fig. 1. It is a standard dual cross feed, milling table with a maximum movement in each direction of 7 inches. A spring similar to the one used on the American Optical

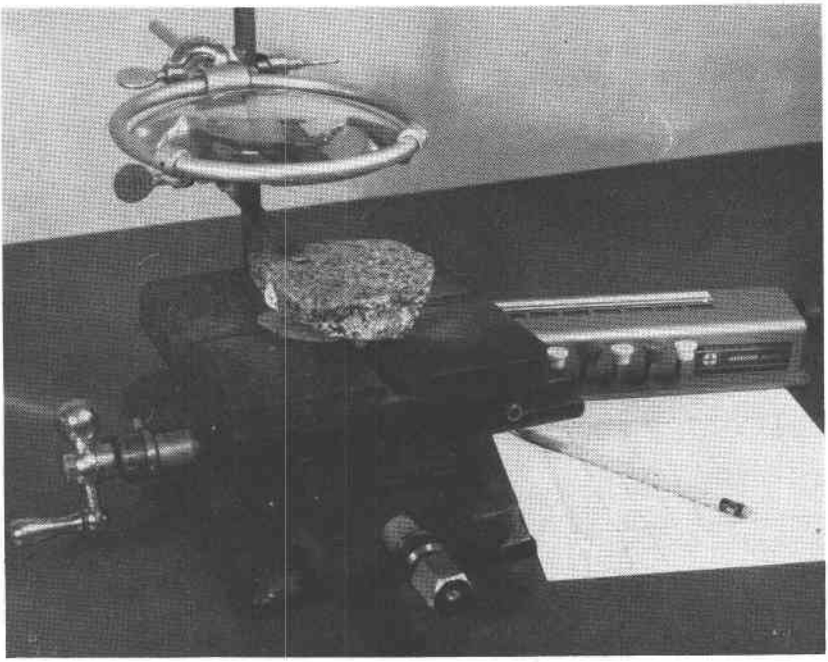

FIG. 1. Macro point counting stage.

Co. point counter stage and described by Chayes (1949) is placed so that it rides on the calibrated sleeve of the "east-west" cross feed screw. A notch filed in the sleeve will produce an audible click for each 0.1 inch of translation. The rock slab is leveled on the stage by pressing it into modeling clay. As a reference point, a small glass plate with engraved cross hairs is mounted on a movable arm so that it can be adjusted to ride over the surface of the sample. The cross hairs remain fixed as the sample translates under them. To aid in viewing the sample, a large low power lens is placed above the cross hairs. Good lighting, from a lamp not shown in the figure, is needed for rapid mineral identification. Counts can be recorded on a tabulator.

The main advantage of macro point counting with this stage is that modes can be rapidly determined from easily prepared slabs which are large enough to be representative of the coarser-grained rocks. The principal limitation is that the items counted must be identifiable on the rock slab.

In one setting, the macro point counting stage can handle a sample area of 49 square inches or the equivalent of about 35 standard thin sections. Although very small grains are visible under the cross hairs, rocks with a maximum grain size of less than about 3 mm. are counted more conveniently and with greater detail by means of the conventional micro point counting stage. A porphyritic rock with a fine-grained groundmass lends itself to a two stage modal determination. The phenocryst to groundmass ratio is determined from slabs on the macro point counting stage, and the composition of the groundmass is determined by means of thin sections on the micro point counting stage. If the phenocrysts in the rock being studied are greater than 20 mm. and they are distinguishable in a photograph, it is even possible to obtain the phenocryst to groundmass ratio by sampling the photograph of a nearly plane surface of the outcrop with a macro point counting stage. The groundmass mineral composition can then be obtained from a saw cut slab.

To reduce the errors of identification only minerals or groups of minerals which are easily recognizable are counted. One tabulator key is used to record all the points which are minerals other than those being counted. The saw cut slab is prepared for counting by grinding, etching, and staining in a manner that will make the principal minerals quickly recognizable. Preparation of the rock slabs for several rock types is described by Jackson and Ross (1956, p. 649). After the slab is prepared, a polygonal figure is scribed just inside the edge of the rock slab. Counting is done only within this line to avoid a bias caused by one mineral occurring more frequently at the fractured edge of the sample. Traverses are made with the "east-west" cross feed which has the clicking spring and these traverses are spaced by the "north-south" cross feed which has a calibrated sleeve. The traverses can be spaced at some regular distance and if this method of counting is intended, a second clicking spring can be added to the "north-south" cross feed. The writer prefers, however, to use a stratified-random sampling pattern and eliminate biases which arise from any periodic relationship between stratification within the rock and the transverse interval. This type of sampling is described by Chayes (1956, p. 29).

As a test of the reproducibility of data obtained from macro point counting, several slabs of the McAfee adamellite from the northern Inyo Mountains of California were each counted four times. This rock is

TABLE I. DATA FROM FOUR MACRO POINT COUNTS OF A STAINED SLAB OF MCAFEE ADAMELLITE

Mineral	Mean	Standard deviation of the means	Calculated binomial standard deviation
	$\bar{x}$	$s_{\bar{x}}$	σ
Plagioclase	37.7%	1.6	1.5
K-feldspar	30.3%	1.0	1.4
Quartz	29.0%	1.3	1.4
Other	3.0%	0.6	0.5

equigranular with an average grain size of about 5 mm. and a maximum grain size of 10 mm. Plagioclase, sodium cobaltinitrite-stained microcline, quartz, and "others" were the items counted. A thousand points were counted for each determination and after each count the slab was rotated and the next count was started from a different corner. Table I shows the results of a test based on the duplicate analysis of one of these slabs. The analyses of the other slabs yielded essentially the same information.

The calculated binomial standard deviation from the equation,

$$\sigma = 100\sqrt{\frac{p(1-p)}{n}}$$

where $p = \bar{x}/100$ and $n = 1000$, is seen to be a good approximation of the observed standard deviation ($s_{\bar{x}}$). Two of the observed values slightly exceed the theoretical values and two are smaller. The evidence from this slab and from five others, all of which show the same relationships, is that the counting error from this macro point counting stage is very close to binomial expectation.

These replication tests indicate that the macro point counting stage is capable of reproducible results from stained rock slabs. The relationship between macro and micro point counted modes still remains to be determined. Reliable modal mineral percentages can be determined by the macro point counting stage which permits the rapid sampling of a sufficient area of the coarser-grained and porphyritic rocks.

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