5. A Method of Mounting Mineral Grains for Statistical Microscopic Study

By

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1. Introduction

In connection with an investigation of the mineralogical composition of till, it has been a problem to the author to find a suitable method of mounting mineral grains for statistical microscopic study. Existing methods summarized by KRUMBEIN and PETTIJOHN (1938) are not suitable for the present investigation, and therefore the author, in cooperation with Dr. O. MELLIS from the Mineralogical Institute in Stockholm, has constructed a device, called a *Microsieve*, to solve the problem.

The method is worked out with a view that the manual work should take a minimum of time, but give a substratum of full value to the statistical determination of the several mineral components in the sample examined. The Microsieve and the testing of it is described in this paper.

The writer is indebted to Mr. W. PLAN and Mr. S. NORBERG, Upsala, for assisting me in building the device and solving the mechanical problems.

2. Description of the Microsieve

The device is reproduced in the photo, Fig. 1, and by the drawing of Fig. 2, to which the capital letters in the following description refer. The building-material is nickel-plated brass.

The hopper (A) into which the sample is to be poured opens into a rectangular box (B, B^1). Two spreaders (C, C^1) rotating in opposite directions and driven by a 4.5-volt battery motor (D, D^1) spread the grains in the box. The hopper can be turned aside to facilitate the cleaning of the box.

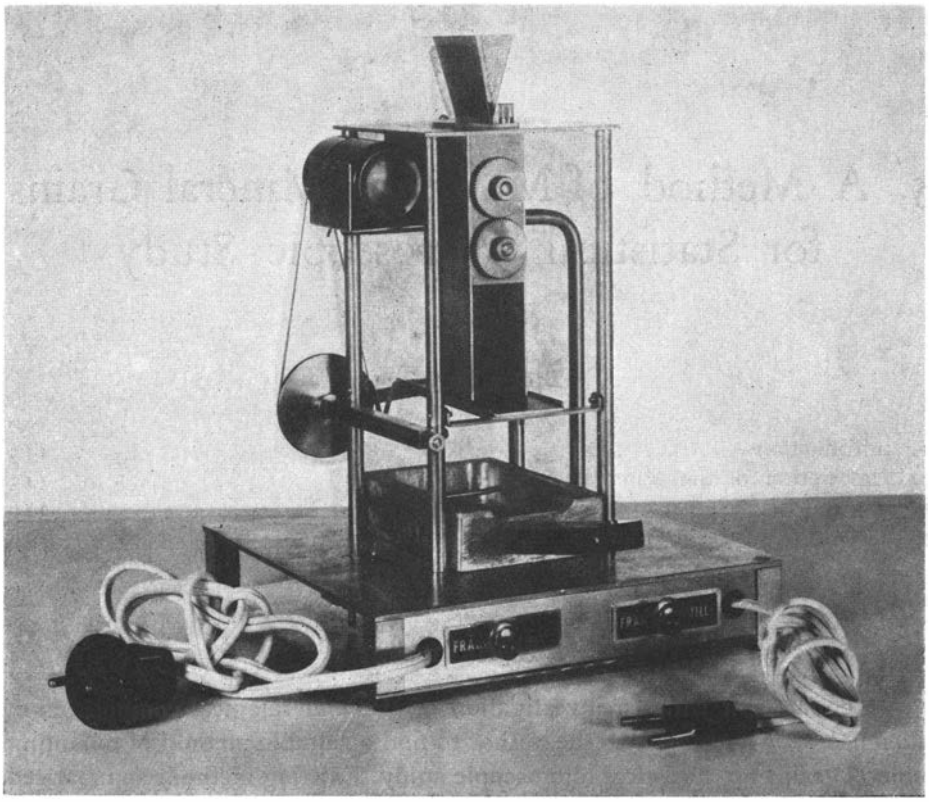

Fig. 1 The Microsieve. Photo N. Hjort.

In the front-side of the box there is a window of plexi-glass (E), and the insides of the walls are covered with smooth paper to prevent grains from adhering.

By means of a thin rubber-pulley and an eccentric disk (F, F^1) the motor also transmits a vibration to the holder of an exchangeable sieve (G, G^1). The sieve in the device will further spread the grains dumping down from the box, and prevent them from lumping together.

In the fundament of the device a 250-watt heating-plate (H) for heating Canada-balsam is built-in. The pan (K, K^1) of silumin, the bottom of which is ground into a plane surface, has inside of it three bars to fix the position of a glass slide. The switch of the heating-plate and its cable are placed on the right, and that of the motor on the left.

3. Mounting

For mounting mineral grains for statistical microscopic study, a quantity of 10 to 30 mg. of a representative fraction of the sample that is to be examined is required. To obtain this small representative fraction, the

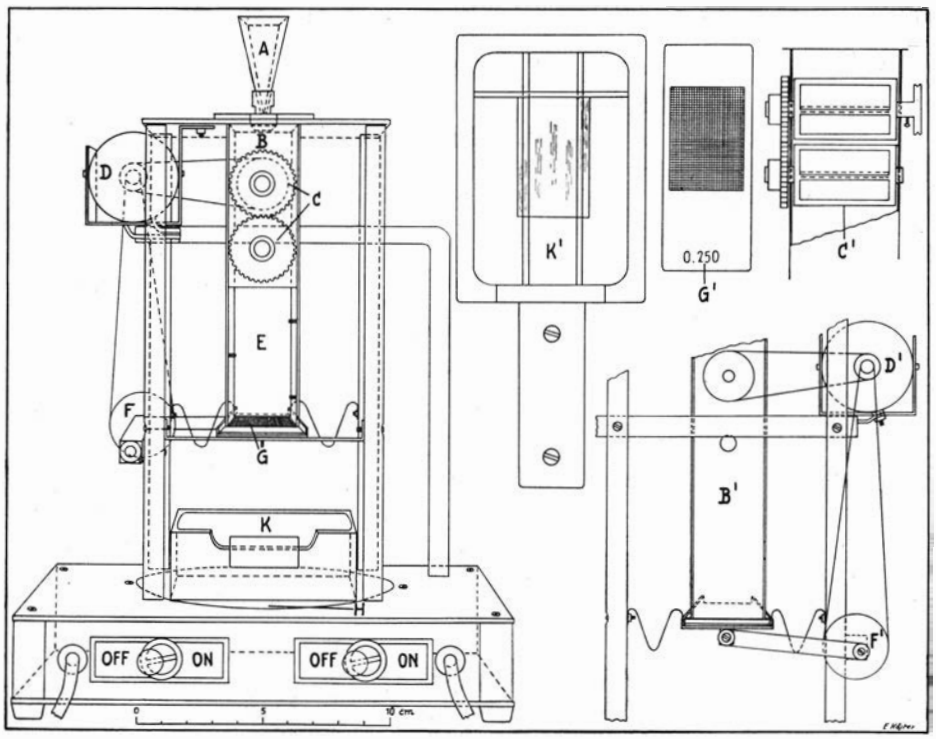

Fig. 2. Sketch of the Microsieve.

sample must in most cases be split down, and one can with advantage use an OTTO's Microsplit (1933).

If the sample is separated into different fractions by sieving, a suitable grade size is 125—62 μ also with regard to a microscopic determination of the several mineral components. Then the sieve in the device must have twice the mesh-width of the upper grade limit of the fraction to be investigated, i.e. in this case about 250 μ. Materials larger than 500 μ in diam. are not suitable for mounting, because the grains hold the cover-glass up.

As in existing methods (PETTIJOHN, *loc. cit.*, p. 359) the residue thus split down can be mounted in some temporary fashion, or permanently. When using immersion liquids for temporary mounts the method of gelatin-coated slides (FAIRBAIRN 1943) can be used to give the grains a fixed position after dumping down from the sieve.

For permanent mounts a very viscous medium of a low refractive index is suitable; for testing the device Canada balsam ($n = 1.54$) has been used.

Some drops of Canada balsam may be put on a clean standard petrographic slide, which is placed in the pan. The pan is placed on the heating-plate, so that the slide may be fixed just below the sieve. Then the slide is slowly

heated until the balsam flows out over the glass. Care should be taken to heat slowly in order to prevent the formation of bubbles.

The motor driving the spreaders and the sieve is started, and then the sample is poured into the hopper from one of the pans of a microsplitter, and the grains will dump down into the balsam. The slide is then removed from the pan of the device, and after it has cooled a little, a hot cover-glass (18 × 18 mm.) is gently pressed down.

If a sample containing a very great frequency of extremely flaky mineral grains, e.g. muscovite, is to be examined, special arrangements must be made. After removing the sieve, a slide with heated balsam is placed on the sieve-holder, and the pulley driving the eccentric disk is disconnected. (If the sieve is used in this case, the flaky minerals will lump together owing to electrostatic forces.) A suitable size of the sample is 5—10 mg. Care must be taken that the spreaders do not rotate too fast. In these cases a cover glass cannot generally be used, because the flaky grains will flow to the edges of the glass.

It is not necessary to dry the mounts in a thermostat. If one has a very small sample, the mineral grains remaining in the pan of the Microsieve and in the excess balsam at the edges of the cover glass can be removed and reserved for further study. The mounting requires some manual training for a good result.

4. Testing of the Microsieve

In order to test the device, two artificial mixtures of mineral grains crushed into a particle size of 125—62 μ are used: a) quartz and fluorite, and b) magnetite and muscovite. These minerals are chosen because they are easily separated from each other under the microscope, and have different forms and specific gravities. The quartz grains are in most cases sharply angular (sp. gr. 2.65); the fluorite has an irregular to cleavage-controlled (octahedral) form (sp. gr. 2.15); the magnetite occurs in angular and well-rounded grains (sp. gr. 5.17); and the muscovite in flakes with a mean thickness of 6 μ according to measurements (sp. gr. 2.93).

The test samples are weighed on an analytical balance with a sensitivity of 0.1 mg. After mounting, the grains are counted under the microscope by means of a mechanical stage in such a way that every grain passing into the centre of the cross-hair of the ocular is counted. The distance between every section is 1—3 mm. apart, depending on the number of grains in the mount. The values thus obtained are then multiplied by the specific gravity of the respective minerals, and the whole is reduced to percentage by weight.[1]

[1] Owing to the great difference in volume between a flake and a sphere of muscovite, the values of muscovite must also be multiplied by the ratio between these two volumes, which is easily found when one knows the grade size and the mean thickness of the flakes.

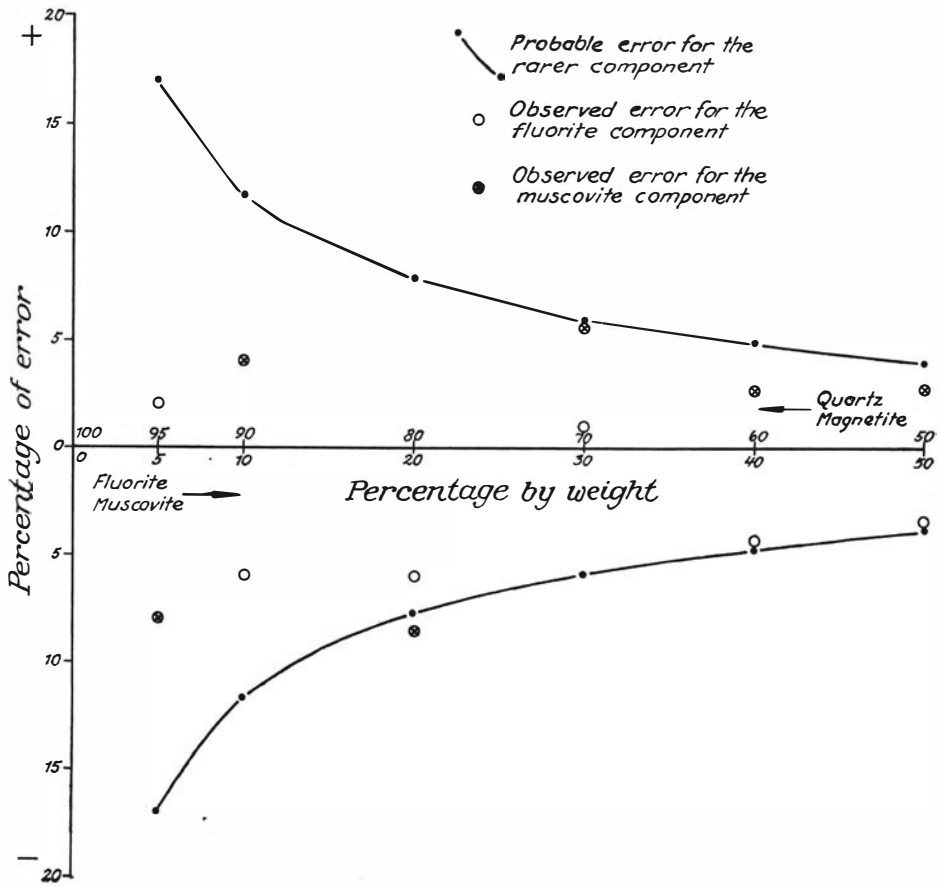

Fig. 3. Diagram showing the relation between a probable and an observed error for the rarer component.

A question of great importance to this method of mounting is how many grains in the mount must be counted in order to give a substratum of full value for the statistical determination of the various mineral components in the sample examined. As discussed by DRYDEN (1931) and PETTIJOHN (*loc. cit.*, pp. 469—472), the question arises as to what error will be made concerning each mineral species if some number n, less than the total number of grains in the mount, is counted.

DRYDEN has given the formula

$$\text{P.E. (the probable error in no. of grains)} = 0.6745\sqrt{npq}$$

where n is the number of grains counted, p the probability of a given grain being a particular mineral, and q the chance that such a random grain is not the mineral in question. The probable error in percentage is (P.E./a) 100, in which a is the "true" frequency of the species present

Fig. 4.

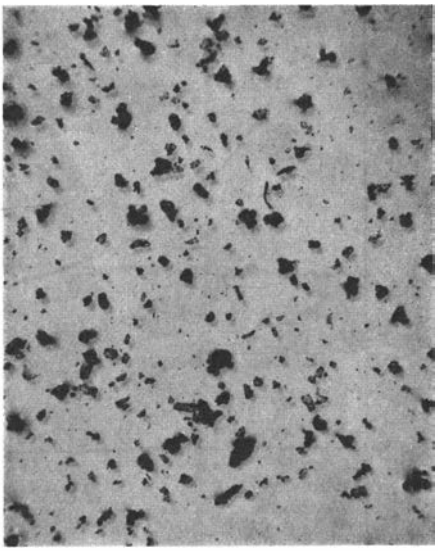

Fig. 5.

Fig. 4. Quartz and fluorite grains in weight-proportion 70/30 (mount No. 3 in table 1). Parallel nicols, × 12.

Fig. 5. Magnetite and muscovite grains in weight-proportion 70/30 (mount No. 9 in table 1). Parallel nicols, × 12

Graphically summarized (DRYDEN, *loc. cit.*, p. 236), these relations show that the larger the number of grains counted, the smaller the probable error, and that the probable error is greatest in the rarer constituents and lowest in the abundant components. But from about 300 grains counted and upwards, the accuracy increases very slowly. Both DRYDEN and PETTIJOHN seem to be of the opinion that "perhaps 300 will suffice for most ordinary work". In order to test the device in the present investigation, exactly 300 grains were counted.

The values from the testing of the device are shown in Table 1, and graphically summarized in the diagram of Fig. 3. Column I in the table gives the number of mounts (1—12) produced in the device, column II the mineral species present (Q = quartz, F = fluorite, Ma = magnetite, Mu = muscovite).

In the test samples of artificial mixtures, the "true" frequency value (in weight-percentage) of the mineral components is known (column III), and can be compared with the observed frequency in the mounts (column IV). As the probable error of each component and frequency (column VI) is the chance of deviation either way (positive or negative) from the true frequency, a calculation can also be made between which frequency values the observed percentage would by chance lie (column VII). The "true" or observed percentage of error is given in column V.

Table 1. Testing of the Microsieve.

I. Number of mounts	II. Mineral species present	III. "True" frequency	IV. Observed frequency	V. Observed error	VI. Probable error	VII. Deviation of probable error	VIII. Levelness (see text)
1	Q	50.0	51.7	3.4	3.9	48.0—52.0	21.8
	F	50.0	48.3	3.4	3.9	48.0—52.0	
2	Q	60.0	61.7	2.8	3.2	58.1—61.9	45.8
	F	40.0	38.3	4.3	4.8	38.1—41.9	
3	Q	70.0	69.7	0.2	2.5	68.2—71.8	16.4
	F	30.0	30.3	1.0	5.9	28.2—31.8	
4	Q	80.0	81.2	1.5	2.0	78.4—81.6	21.6
	F	20.0	18.8	6.0	7.8	18.4—21.6	
5	Q	90.0	90.6	0.7	1.3	88.8—91.2	9.8
	F	10.0	9.4	6.0	11.7	8.8—11.2	
6	Q	95.0	94.9	0.1	0.9	94.1—95.9	14.6
	F	5.0	5.1	2.0	17.0	4.1—5.9	
7	Ma	50.0	48.7	2.6	3.9	48.0—52.0	23.4
	Mu	50.0	51.3	2.6	3.9	48.0—52.0	
8	Ma	60.0	59.0	1.7	3.2	58.1—61.9	20.5
	Mu	40.0	41.0	2.5	4.8	38.1—41.9	
9	Ma	70.0	68.3	2.4	2.5	68.2—71.8	41.7
	Mu	30.0	31.7	5.7	5.9	28.2—31.8	
10	Ma	80.0	81.7	2.1	2.0	78.4—81.6	18.9
	Mu	20.0	18.3	8.5	7.8	18.4—21.6	
11	Ma	90.0	89.6	0.4	1.3	88.8—91.2	15.6
	Mu	10.0	10.4	4.0	11.7	8.8—11.2	
12	Ma	95.0	95.4	0.4	0.9	94.1—95.9	13.5
	Mu	5.0	4.6	8.0	17.0	4.1—5.9	
13	Q	80.0	70.7	13.3	2.0	78.4—81.6	36.3
	F	20.0	29.3	46.5	7.8	18.4—21.6	
14	Ma	80.0	66.8	16.5	2.0	78.4—81.6	21.6
	Mu	20.0	33.2	66.0	7.8	18.4—21.6	

So as to obtain an idea of the levelness of the spread of the grains in the mounts, the values in columm VIII give the mean deviation in percentage as computed from the mean number of grains in the sections. For statistical reasons all values in the table are given with an accuracy of 0.1 per cent.

As shown graphically in Fig. 3, the values of the observed percentage of error of the rarer components (the case in which the probable error is greatest) would lie in an irregular way between the two curves of the probable error. Only one value occurs a little distance outside the area of the probable error.

For comparison two mounts (No. 13 and 14 in the table) have been prepared in the way recommended by PETTIJOHN (*loc. cit*,. pp. 360—361, 471). The poor conformity between the true and the observed frequency in the mounts must partly be explained by the great difference in specific gravity between the mineral species, and the disposition of the grains of muscovite to lump together. Thus it is obvious that, by means of the method presented by the author, errors arising from the above causes can be eliminated to a great extent.

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