RELATIONSHIP BETWEEN PARTICLE SIZE AND THE EFFICIENCY OF SEPARATION OF MINERALS BY HEAVY MEDIA

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Heavy media separations are commonly employed both in mineral dressing laboratories and in industry to separate the heavier from the lighter minerals by using a fluid medium whose specific gravity lies between those of the minerals concerned. The first successful commercial plant for heavy media separation was installed in the year 1936 at Mascot by the American Zinc Company of Tennessee[1] to separate sphalerite from dolomitic limestone. Since then, heavy media separation plants are increasing in number. The proper working of the heavy media process is dependent not only on the difference in specific gravity but also on the particle size. A minimum difference of about 0.02 in specific gravity is preferred[2]. A statistical review[3] of fifty plants in operation and about thirty under construction reveals that in almost all the plants, the size of the feed is 10 mesh and above.

On a laboratory scale, however, particles of + 65 mesh are generally used for heavy media analysis. Tyler and Twenhofel[4] suggest that heavy media separation can be employed for particles of 100-200 mesh in size, and Krumbein and Pettijohn[5] also state similarly that heavy media separation is satisfactorily applicable only in the case of particles larger than 200 mesh. Twenhofel[6,7] mentions that heavy media separation is not satisfactory if the particle size is less than 50 microns (about 285 mesh) and that it cannot generally, be employed for particles smaller than 10 microns (about 1300 mesh). It therefore appears desirable to obtain further information concerning the efficiency of heavy media separation at lower particle sizes.

Our own observations in separating silica from pyrolusite in a low grade pyrolusite ore indicated that in the case of minus 200 mesh fraction, the separation of silica from the pyrolusite could not be carried out effectively by the heavy media method. Microscopic examination, however, indicated that pyrolusite and silica were in a liberated condition. A detailed investigation was, therefore, undertaken to find out the relationship between the particle size and the effectiveness of heavy media separation, employing synthetic mixtures of finely divided pyrolusite and quartz in presence of aqueous and non-aqueous heavy liquids.

Experimental and Results

The heavy liquids employed were bromoform (sp. gr. 2.89) and an aqueous saturated solution of potassium mercuric iodide (sp. gr. 3.16). The bromoform used was freshly distilled and free from moisture.

A high grade quartz powder (— 40 mesh) was wet ground and the sample after grinding was digested with concentrated hydrochloric acid to remove any iron contamination during the grinding. The washed quartz was wet sieved using Tyler standard sieves upto 325 mesh. Below this size, sedimentation method[8] had to be employed for further fractionation into various sizes. Twenty grams of the minus 325 mesh quartz were placed in a tall 300 c.c. beaker and water was added into it upto a height of 10 cms. The contents were thoroughly stirred and allowed to stand for a definite period to allow the coarse particles to settle. The velocity of settling (v) was calculated making use of Stoke's law for unhindered settling. Since the height of the water column was 10 cm. the period of settling for any particle size was $\frac{10}{v}$. At every period, the suspended solids were decanted off into a second beaker. The process was repeated five to six times with the residue, till the decanted liquid was free from solid suspension. The residue was finally filtered and dried. The size was verified by microscopic examination using a micrometer disc. The solid which was collected with the washings in the second beaker was subjected to the same process with longer intervals of settling to get fractions smaller in size. The process was repeated till a sample of 5 microns in size (and lower) was obtained. A high grade crystalline pyrolusite (Mn = 58.59%, MnO_2 = 86.54% and silica less than 0.3%) was wet ground and fractionated into different sizes by a process similar to the one described.

For every size, the samples of quartz and pyrolusite were mixed in the ratio of 1 : 1 by weight and the mixtures were subjected to heavy media separation.

Two grams of the mixture were put into a long form separating funnel having a taper of about 30°. Ten c.c. of the heavy liquid were then added, the contents were shaken vigorously and allowed to stand, till the two layers of solids separated out. The upper and the lower layers were drawn off separately and retreated similarly. The heavy and light fractions so obtained were dried and weighed. A weighed amount of the lighter fraction (mostly quartz) that separated was treated with acidified ferrous sulphate to dissolve out the pyrolusite. The residue was washed well, dried and weighed.

The percentage separation at each particle size has been given in Fig. I. Curves I and II indicate the results with bromoform and aqueous potassium mercuric iodide respectively. It is clear from these that the separation depends not only upon the size of the particles but also on the liquid employed. In the case of bromoform, complete separation is possible only upto 70 microns, below which the separation of silica from pyrolusite falls off and at a particle size of about 30 microns there is practically no separation. With the aqueous solution of potassium mercuric iodide, on the other hand, complete separation is possible upto a size of about 50 microns (Curve II) after which the curve follows a similar steep path as in I. This indicates that even when there are discrete individual particles, simple heavy media process cannot be employed for the separation of very small particles.

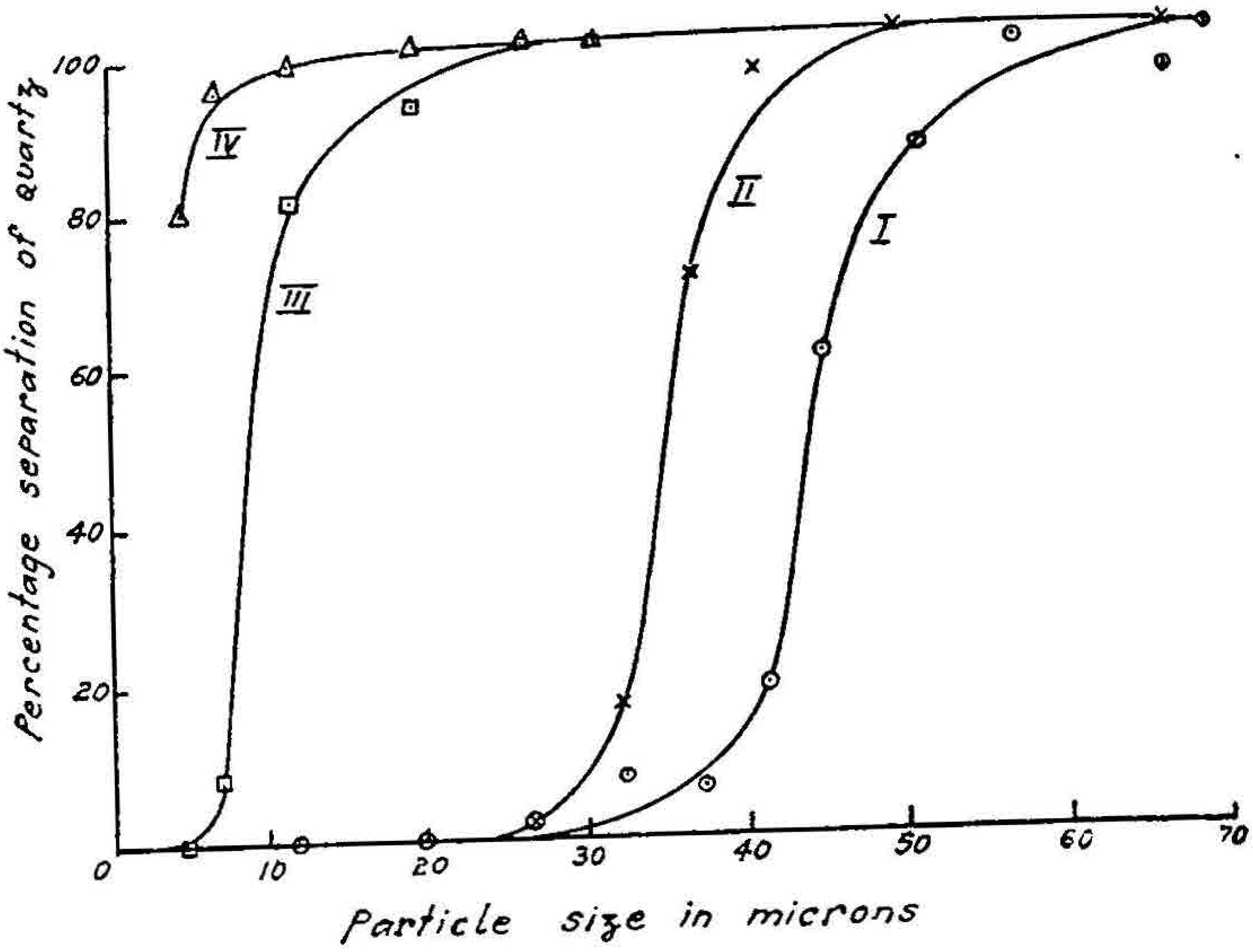

FIG. I

⊙ Bromoform ... ... I } without centrifuge
× Pot. Mercuric Iodide saturated solution ... II }

□ Bromoform ... ... III } with centrifuge
Δ Pot. Mercuric Iodide saturated solution ... IV }

The use of a centrifuge is often recommended for separation of the particles by heavy media separation[9]; but, even in this case there is very little information regarding the efficiency of separation at various particle sizes. It is seen from the Curves III and IV, that the separation of silica from pyrolusite improves on centrifuging. In the case of bromoform, complete separation of the constituents is possible upto about 30 microns. The separation then falls off till 5 microns, after which there is no separation at all. In the case of aqueous solution of potassium mercuric iodide, the separation is complete upto a size of 12 microns and even at a size of 5 microns, there is 80% separation. Here again, the aqueous liquid is better than the non-aqueous.

The higher efficiency of the aqueous solution in the separation of small particles is perhaps due to the high penetrating power of the aqueous solution between the solid particles. Bromoform gives a finite contact angle and consequently its penetrating power into the thin capillary spaces between the two solids would be comparatively less. It is also probable that there is a greater diminution of free energy when aqueous layers wet the solid surface than in the case of non-aqueous media.

The authors are thankful to Prof. K. R. Krishnaswami for his keen interest in the work.

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