DENSITIES AND PHYSICAL MIXTURES

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ABSTRACT

The density of a mineral physically attached to other phases can be determined, by measuring the density of the mixture, if the amounts and densities of the other constituents are known. The density is not an additive property, although this seems to be a common misconception. The equation for the density $D_x$ of the mineral in question is:

$$ D_x = \frac{D_m M_x}{\Sigma M - D_m (M_1/D_1 + M_2/D_2 + \ldots + M_n/D_n)} $$

where $D_m$ is the density of the mixture, $D_1, D_2, D_n$ represent the densities of the admixed phases, $M_x$ is the mass of the mineral, $M_1, M_2, M_n$ are the masses of the other phases, and $\Sigma M$ is the total mass. The same numerical result is obtained if weight percentages are used instead of masses.

Keywords: density, physical mixtures, nonadditive property, errors.

INTRODUCTION

In measuring the density of a mineral, it is commonly difficult to obtain monomineralic grains. If one must use grains that are made up largely of the mineral in question with one or more adhering phases, the correct density of the mineral can be determined from the measured density of this mixture if the amounts and densities of each of the other phases are known.

Although the calculation is rather straightforward, the author has noticed some recent instances where this has been done incorrectly and decided that this short note might be of value for mineralogists faced with this problem.

The first example of the wrong procedure for correcting the measured density noted by the author was in the study of robinsonite by Ayora & Gali (1981). They measured the density of a robinsonite-quartz mixture by means of a pycnometer and obtained the value of 5.11 g/cm³. Subsequently they analyzed the mixture for silica and found 17.3 wt.% SiO₂. They then calculated the density of the robinsonite to be 5.63 g/cm³ assuming the additive relationship, $D = (W_o \times D_o) + (W_r \times D_r)$, where $D$ is density, $W$ is weight % and the subscripts are: $m$ for the mixture, $q$ for quartz and $r$ for robinsonite. The correct relationship is not additive, and the error in the paper by Ayora & Gali (1981) was pointed out to the editor of this journal by Mandarino (written comm.). At that time, Jambor & Owens (1982) were preparing their paper on the re-examination of the Spanish robinsonite and, citing this author’s written communication, they pointed out the correct relationship between the densities of a mixture and its components and gave the corrected density for robinsonite (6.31 g/cm³).

More recently, Johan et al. (1983) studied vashegyite and “corrected” the measured densities of some mixtures using the additive relationship. The densities that they obtained, 1.926 and 1.933 g/cm³, should be, respectively, 1.950 and 1.954 g/cm³.

PROCEDURE

In the case of a physical mixture, the usual equation relating mass $M$ and volume $V$ to density $D$, $D = M/V$, becomes:

$$ D_m = \frac{M_x + M_1 + M_2 + \ldots + M_n}{V_x + V_1 + V_2 + \ldots + V_n} $$
where $M_x$ and $V_x$ are, respectively, the mass and volume of the mineral whose density is required, $M_1$, $M_2$, $M_n$ are the masses of the other constituents, $V_1$, $V_2$, $V_n$ are the volumes other constituents and $D_m$ is the density of the mixture. Because the volumes are not known, the equation must be recast so that only masses and densities appear in it. This is easily done by substituting $M/D$ for each $V$. The equation becomes:

\[
D_m = \frac{\Sigma M}{M_x/D_x + M_1/D_1 + M_2/D_2 + \ldots + M_n/D_n}
\]

Solving for $D_x$ gives:

\[
D_x = \frac{D_m M_x}{\Sigma M - D_m (M_1/D_1 + M_2/D_2 + \ldots + M_n/D_n)}
\]

One need not have the actual masses of the phases because use of their weight percentages will give the same numerical answer.

The precision of the density value given by the equation will depend on the precision of the weight percentages and densities of the various phases as well as on the precision of the measured density of the mixture. The use of rough estimates of weight percentages is not advised; weight percentages of all the phases should be calculated from reliable chemical and analytical data for best results. In addition, if the weight percentage of the mineral under study is very low, large errors can be expected in its calculated density. In cases where the contaminants may show wide variations in density because of chemical and crystallographic variations, their densities should be measured rather than selected from the literature.

**REFERENCES**


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