DENSITIES AND PHYSICAL MIXTURES

JOSEPH A. MANDARINO

Department of Mineralogy & Geology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6

and

Department of Geology, University of Toronto, Toronto, Ontario M5S 1A1

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 densitites 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 ΣM 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.

SOMMAIRE

On peut mesurer la densité d'une phase x d'un mélange à partir de la densité du mélange si la masse et la densité des autres phases sont connues. Contrairement à une opinion courante, la densité n'est pas additive. La densité D_x de la phase x est égale à

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

Dans cette expression, D_m est la densité du mélange, D_1, D_2, D_n, la densité des impuretés dans le mélange, M_x la masse de la phase x, M_1, M_2, M_n, celle des autres phases, et ΣM la masse totale de l'échantillon. On obtient le même résultat en employant des proportions pondérales au lieu des masses.

(Traduit par la Rédaction)

Mots-clés: densité, mélange physique, propriété non additive, erreurs.

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 densitites 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.% SiO_2. They then calculated the density of the robinsonite to be 5.63 g/cm³ assuming the additive relationship, $D_m = (W_q \times D_q) + (W_r \times D_r)$, 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

AYORA, C. & GALI, S. (1981): Additional data on robinsonite. Can. Mineral. 19, 415-417.

JAMBOR, J.L. & OWENS, D.R. (1982): Re-examination of robinsonite from Vall de Ribes, Spain. Can. Mineral. 20, 97-100.

JOHAN, Z., SLANSKY, E. & POVONDRA, P. (1983): Vashegyite, a sheet aluminum phosphate: new data. Can. Mineral. 21, 489-498.