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Abstract

Full Text

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GEOPHYSICS

G. I. KRUGLYAKOVA

DEPENDENCE OF THE MAGNETIC SUSCEPTIBILITY OF SALTS ON THEIR WATER CONTENT

(Presented by Academician N. V. Belov on 10 VI 1958)

One of the most widely used instruments for determining the magnetic susceptibility of rocks is the astatic magnetometer of S. Sh. Dolginov. It is recommended that this instrument be calibrated for determining the magnetic susceptibility of rocks not by the absolute method with current, but by a relative method—using paramagnetic salts. In calibrating the instrument a series of salts and oxides is used; the salts may be anhydrous or hydrated.

Among the paramagnetic compounds that are common in chemical laboratories and therefore widely used in the calibration of instruments by field and stationary magnetic laboratories are (1):

Anhydrous salts: CoCl_2 , CoSO_4 , NiSO_4 , NiCl_2 , MnSO_4 , MnCl_2 , $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4$.

Crystal hydrates: $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$.

All the listed anhydrous salts can be obtained by drying crystal hydrates at a certain temperature; crystal hydrates can likewise be obtained by hydrating anhydrous salts.

When calibrating a magnetometer with paramagnetic compounds, we had to deal with the nonconstancy of the magnetic susceptibility of salts, which depends on the percentage of water contained in them. In view of the absence of corresponding data in the literature, we present here the results of our investigations.

The law of variation of the magnetic susceptibility of a salt as a function of its water content is not represented by a straight line connecting the maximum value of the magnetic susceptibility of the anhydrous salt with the zero value of the magnetic susceptibility corresponding to 10% distilled water. To establish

the law of variation of the magnetic susceptibility of a salt as a function of water content, we carried out the following investigations.

Anhydrous salts CoCl_2 , CoSO_4 , NiSO_4 , MnSO_4 , Mohr's salt $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$, and others were obtained by drying at an elevated temperature specified for each salt in the work (2). Some anhydrous salts differ sharply in appearance from their crystal hydrates. Thus, anhydrous CoCl_2 is a light-blue powder, whereas $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ consists of red monoclinic crystals; anhydrous NiSO_4 is light yellow, while $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ forms green crystals, etc.

Four grams of each salt, in identical porcelain vessels, were placed in a desiccator with distilled water, and over a period of 1 to 5 weeks, for different salts, the increase in the weight of the salt caused by the addition of water and the corresponding changes in the values of the magnetic susceptibility of the hydrating salt were recorded. Observation was stopped as the salt became moist, which usually occurs soon after all the crystallization water has been taken up.

lization water. The further change in the magnetic susceptibility of the salt as a function of water content was observed in solutions consisting of the anhydrous salt with a definite amount of distilled water.

The obtained law of the change in the magnetic susceptibility of a salt as a function of its water content is represented by a broken line. The nature of the break in the line determines the magnitude of the magnetic susceptibility of the anhydrous salt, and the greater it is, the more sharply the breaks in the lines are marked. In individual cases, for small values of the magnetic susceptibility of the anhydrous salt, the breaks are almost imperceptible.

Fig. 1. Magnetic susceptibility of the salts CoCl_2 and NiSO_4 as a function of their water content

The first segment of the curve (see Fig. 1) connects the value of the magnetic susceptibility of the anhydrous salt with the value of the magnetic susceptibility of its crystalline hydrate and characterizes their mechanical two-phase mixture with different percentage ratios of the two phases. When the salt passes from the anhydrous state into the crystalline hydrate, water enters the crystal lattice of the salt and changes its structure. Of course, not all of the anhydrous salt is converted at once into the crystalline hydrate. There is a gradual mixing of molecules of the anhydrous salt, which has a higher magnetic susceptibility, with molecules of its crystalline hydrate, which has a lower magnetic susceptibility. As the amount of added water increases, an ever greater number of molecules of the anhydrous salt become hydrated, and the magnetic susceptibility decreases to the value of the magnetic susceptibility of the complete crystalline hydrate.

The second segment of the curve characterizes a two-phase mixture of the crystalline hydrate with a saturated solution of the salt. It connects the value of the magnetic susceptibility of the crystalline hydrate with the value of the magnetic susceptibility of the saturated solution of the given salt, characterizing their mechanical mixture.

The last, third segment connects the value of the magnetic susceptibility of the saturated solution with the value of the magnetic susceptibility

distilled water—with zero. The character of the curve determines the percentage content of the components of the mixture and the degree of hydration of the ions.

The investigations carried out make it possible to draw an important conclusion about the nature of the change in the magnetic susceptibility of salts as a function of the presence of water in them—both in the structure of the salt molecule and as a mechanical admixture—and make it possible to determine, from the magnetic susceptibility of a solution, the concentration of salt in it.

The values of the magnetic susceptibility of salts reported in the literature should be accompanied by an indication of the state of the salt to which the given value of magnetic susceptibility refers.

When selecting standards for calibrating magnetometers, salts should first be dried at a definite temperature and definitely anhydrous compounds with magnetic-susceptibility values established for them should be used, or stable compounds that practically do not take up water should be chosen as standards.

Such compounds include anhydrous manganese dioxide, MnO_2 —a black crystalline or amorphous powder which, under ordinary conditions, does not take up moisture and does not change its composition on ignition and, consequently, does not change its magnetic susceptibility, equal to $38 \cdot 10^{-6}$ CGSM.

A fairly stable aqueous compound is $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ —Mohr's salt, which over a number of years under normal storage conditions does not change its moisture content or its magnetic susceptibility, equal to $27 \cdot 10^{-6}$ CGSM.

The discovery of other stable compounds that do not change their moisture content under ordinary conditions and, consequently, preserve their magnetic susceptibility is a subject for further research.

The least suitable of the standards now used is MnCl_2 , which, on the one hand, is readily moistened and, on the other, on ignition in air passes into Mn_3O_4 with liberation of HCl.

The established regularities in the change of the magnetic susceptibility of a salt as a function of the water content in it, or of the salt content in water in the case of a solution, may be used not only in selecting standards for calibrating magnetometers in the study of the magnetic properties of rocks, but may also find application in the chemical industry for determining the moisture content of salts and in determining the concentration of salt solutions.

Institute of Geology of Mineral Deposits Academy of Sciences of the Ukrainian SSR

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