MODERN ASPECTS & ANALYTIC TECHNIQUE FOR ACCURATE DETERMINATION OF MAGNETIC SUSCEPTIBILITY USING DOLGINOV ASTATIC MAGNETOMETER

By

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ABSTRACT

The Dolginov astatic magnetometer has been used as a main instrument for measuring the magnetic susceptibility of rock specimens. Using the Dolginov special equation, it was found different contradictory values of the mangetic property for the same specimen. A study of this complication of data has revealed the various parameters resulting in these errors. A new approach based on some concepts, mainely the instantaneous constant, has been revealed for accurate determination of magnetic susceptibility. Experimental verification is given for the new method which proved to be reproducible.

INTRODUCTION

The field of earth magnetics (1), (2) has been widely used, beside other geological methods, in petrolium and mining exploration. Magnetic methods are most important in their assistance to geological reconnaissance and mapping. Therefore great attemps are tried to develop the methods of measuring magnetic properties.

The Working Equation :

Dolginov astatic magnetometer, (Fig. 1), has been used as an important instrument for measuring the magnetic susceptibility of rock specimens. The working equation used in this magnetometer (3) is as follows :

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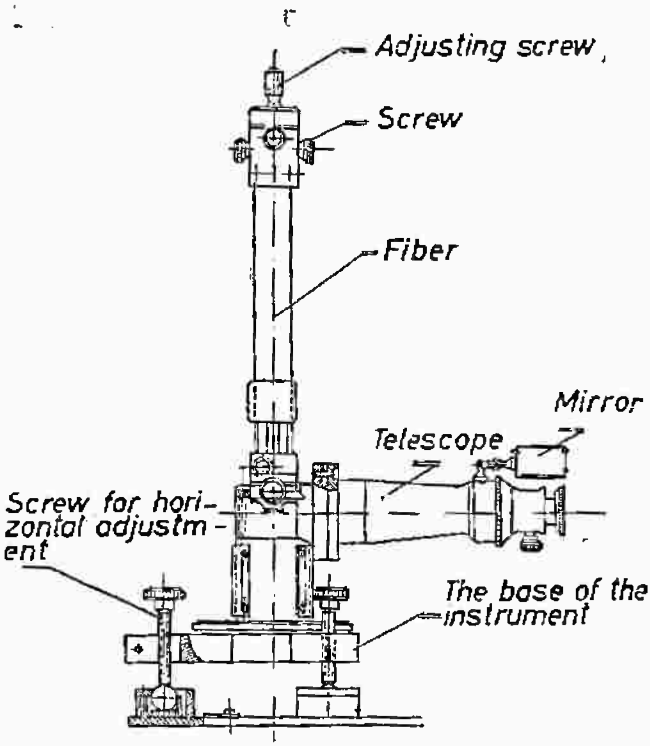
$$\chi = \frac{V}{P} \cdot \theta \cdot K \quad , \qquad (1)$$

where χ = the magnetic susceptibility,

V = volume of the tube = 1.15 cm^3,

P = weight of specimen, Θ = deflection of the coil,

K = constant at a special distance on the two arms of the magnetometer.



(Fig. 1)

The constants (K) for different distances on the two arms of the magnetometer, can be determined by using the following equation (3) :

$$K = \frac{i_c \ N}{2 \ l \times 1000 \times 10} \cdot \frac{1}{\theta_2 \ H_x} \qquad (2)$$

where K = constant at a certain distance,

i_c = current measured in milli-amperes,

N = number of turns in one centimeter (N = 18 turns),

θ_c = the average deflection of the coil,

H_x = magnetic field of the system at a given point on the arm (given in the catalogue of the magnetometer),

2l = height of the coil in cm, (given in the catalogue)

Complications in the Data :

Measurements were made on many samples among which is sample No. 45. The deflections in the magnetometer at different distances can be arranged in Table 1 :

TABLE 1

Distances (a) cm	3	4	5	6	7	8	9	10
Deflections (Θ)	—	—	14.250	8.75	6.0	4.00	3.0	2.000
	—	—	11.625	7.625	5.5	2.75	2.5	1.875
	21.75	13.625	6.625	5.0	3.0	2.125	1.75	1.121
	20.875	12.750	8.25	5.25	4.0	2.625	2.125	1.500

N.B. This table is one from many others not mentioned in this paper. Applying equaton (1) for calculating magnetic susceptibility of the sample No. 45 at distance (a = 5) and by using the special constant (K) from graduation in equation 2, and by substitution for the different deflections (Θ) from table 1, we obtained for the same sample No. 45 and for the same V and P, four different values for magnetic susceptibility : 364.93 ; 297.77 ; 169.25 ; 211.27 x 10^{-6}. We are herin opposed by a question « which is the right value from these results ?. The aim of this paper is to solve this discrepency in the data obtained. The authers have deduced a new approach for accurate determination of the magnetic susceptibility by putting some concepts, of which is the instantaneous constant.

The Previous Work :

A crytical analysis of the results obtained by Dolginov's astatic magnetometer is introduced by Avehyan (4) who suggested a correction formula for computing the calibration coefficients since the field pattern of the specimen and of the calibrating coil are not identical.

EXPERIMENTATION

The rock samples were collected from different areas of Egypt (Eastern Desert, Wadi Safaga — Abu Chalaga). After grinding, the samples are packed in the powder state in the plastic tubes of the magnetometer. After numerating the tubes filled with the samples, they are set on the arms of the magnetometer at different distances and deflections are observed. By this routine work of Dolginov astatic magnetometer, 7 to 9 readings were taken for every specimen every day. Measurements were repeated four days. So, nearly, about 28 to 30 readings for every specimen were accomplished at four days. The effect of temperature and time were also investigated by repeating the measurements at different temperatures and at different days. In this connection the data obtained for two samples, No. 45 and 46 proved that the temperature and time of observations are not the dominent effect on the value of the magnetic susceptibility The results have been arranged in many tables, some of which are tables, 1, 2 and 3.

RESULTS AND DISCUSSIONS

Contradictory Results :

From the series of observations and tables, we found a very curious remark where we got different values of deflections for the same sample at the same distance. Hence by using the constant (K) for every special distance in equation (1), we obtained many different values of magnetic susceptibility for one sample. This result is in great discrepency with the basic concept that every sample should have one value for magnetic susceptibility.

New Concepts :

The unreliable results obtained by applying Dolginov's method can be attributed to the presence of other parameters affecting the constant (K), and in turn leading to these contradictions. These parameters are assumed to be as follows : a) Weight and the process of packing. b) Grain size. c) Personal error. d) The error in the apparatus itself. In order to get rid of these parameters, they should be kept constant by using the same tubes packed always with the same samples having the same grain size. An intestive study of the constant (K) in equation (1) revealed a new concept. If we consider the stability of magnetic susceptibility for a reasonable time, and we still have various deflections, so for balancing these variations, the constant (K) must vary according to these variations. So, we adopted a new concept «Instantaneous Constant» including instantaneous variations to avoid the disturbances in the final result. Coinciding with this, a new definition called «standard specimen» must be used also.

Concerning the instantaneous constant, we suppose that the convolution of many factors is influencing upon this constant. Some of these factors arise from our planet earth ; (5), (6) namely its magnetic field and the subsequent daily or secular variation. Other factor is that related to magnetic variation caused by the outer-spaced cosmic particles which change its charges under the continuous activities of the sun. Consequently from the electrodynamics (7) of the charged particles is produced a new magnetic field which in turn affects instantaneously the magnetic field of the earth. It is worth to mention that our concepts herin include not only the mangetic element of the earth but also the magnetic effect from the outer space which had been neglected by Avehyan (4) in his critical analysis. As a result of the importance of careful observations, cleverness in applying the previous assumed concepts, we expect that prediction and observation would agree. So, we can arrange these scientific concepts as follows :

1. Special datum level of measurement.
2. Stability of mass susceptibility for a reasonable time.
3. Standard specimen.
4. Instantaneous constant.

Experimental Vertification of the New Approach :

We compare here between Dolginov's method and our new method by interpreting data on two samples

Dolginov's Calculation :

We take specimen numerated 49 as shown in Table 2

V = 1.15 c.c. ; P = 2.09 gm ; V/p = 0.520597 c.c/gm

TABLE 2

Distance (a) cm	Average deflection Θ °	Constant K x 10^{6}	Magnetic Susceptibility x 10^{5}
10	2.15	—	—
9	2.5	156.6	20.38
8	3.75	113.0	22.03
7	6.25	79.81	25.93
6	9.00	64.67	30.30
5	15.00	47.45	37.00
4	23.75	47.45	—

Thus the average (χ) for sample 49 = 27 x 10^{-5}. It is worth to note that the magnetic susceptibilities in Table 2 are calculated by substitution in equation (1) using the constant (K). Measurements were taken for another sample 46 and the results were arranged in a table from which we found also very different values of magnetic susceptibility for sample 46 and with an average value (χ) of 20 x 10^{-5}.

The New Approach Calculations :

Measurements were repeated on the same two sample No. 49 & 46. The results were arranged in Table 3. We could determine the magntic susceptibility for sample No. 46 by taking sample No. 49 as a standard specimen and using the instantaneous constant method.

TABLE 3

Sample No. 46		Sample No. 49	
Distance (a)	Average deflection Θ	Average Distance (a)	deflection Θ
10	3.00	10	1.875
9	4.00	9	3.000
8	5.50	8	4.125
7	8.75	7	6.250
6	12.00	6	8.750
5	19.50	5	14.000

Taking the value of mass susceptibility of specimen No. 49 (considered as a standard one) = 27 x 10^{-5} and using the new deflections of specimen No. 49 of Table 3 and applying equation (1), we found that K (Instantaneous constants) are as follows :

$K = 942.96 \times 10^{-7} \ (a = 8)$

$\quad = 265.95 \times 10^{-7} \ (a = 5)$

$K = 1296.58 \times 10^{-7} \ (a = 9)$;

$\quad = 592.75 \times 10^{-7} \ (a = 7)$;

$\quad = 432.19 \times 10^{-7} \ (a = 6)$

Using the average deflections in Table 3 and the last corresponding instantaneous constants in equation (1), the values of magnetic susceptibility for specimen No. 46 are of the same order of magnitude as follows :

$\chi = 21.42 \times 10^{-5} \ (a = 9)$;

$\quad = 20.26 \times 10^{-5} \ (a = 7)$;

$\quad = 20.45 \times 10^{-5} \ (a = 5)$

$\chi = 21.37 \times 10^{-5} \ (a = 8)$

$\quad = 20.64 \times 10^{-5} \ (a = 6)$

The average value of $\chi \cong 20.8 \times 10^{-5}$. Comparing the two results of specimen 46, we find that they are the same approximately but the method of instantaneous constant does not give great contradictory results for the same sample. It gives about the same value of magnetic susceptibility for one sample whatever be the distance (a) on the arms of the magnetometer.

The Reproducibility of the New Method :

It is clear that specimen 46 is measured at a certain datum level of measurement during a special standard specimen No. 49. Also, we got reproducable results when we considered specimen No. 46 as a standard specimen for another sample No. 48. The results for the two samples 46 & 48 were obtained and arranged in such a way as Table 3. Using the new method, we calculated the instantaneous constants from which we obtained for 48 the average magnetic susceptiblity $= 5.4 \times 10^{-5}$. Measurements were repeated after a time nterval of six days on the same two samples 46 & 48. Comparing he two results of susceptibility of specimen 48 in a time interval of ix days, we found that the difference between the two values is very mall and is of the order of 10^{-5}. It is interesting that this is an utstanding result generated from different values of deflections.

CONCLUSION

The constant (K) in the equation used for the determination of magnetic susceptibility by Dolginov Astatic mangetometer leads to non-reproducible results for the same specimen.

The authers adopted the new concept of instantaneous constant, by which they could realise reproducible and reliable results.

3. Our criticism concerning Dolginov working equation and the correct results obtained are in good agreement with the critical analysis suggested by Avehyan.

4. From the economic point of view, our new method would save much labour and time spent in the interpretation and application of unreliable results based on the instructions proposed by Dolginov for the constant (K).

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