INTERNATIONAL GEOLOGICAL CONGRESS

Report of the Twenty-Third Session Czechoslovakia 1968

PROCEEDINGS OF SECTION 5

Geological Results of Applied Geophysics

Geological Results of Applied Geophysics

GENERAL EDITOR

MIROSLAV MALKOVSKÝ

EDITED BY

JAN MAŠÍN

INTERNATIONAL GEOLOGICAL CONGRESS

Report of the Twenty-Third Session Czechoslovakia 1968

PROCEEDINGS OF SECTION 5

Geological Results of Applied Geophysics

ACADEMIA

PRAGUE 1968

Printed in Czechoslovakia

Contents

Editorial

The Organizing Committee of the XXIII International Geological Congress has received a great number of papers for the different sections and symposia. Consequently, the selection of the papers to be printed was very difficult, as for technical and financial reasons, not all the papers presented at the Congress could be published.

In the papers of this volume the Organizing Committee has made practically no editorial or linguistic alterations. Only in the case of evident formal or grammatical imperfections, there have been done minimal corrections by the editorial staff. It means that almost all the papers have been reprinted in the form in which they were submitted.

The Organizing Committee
of the XXIII I. G. C.

Studies on Curie-Temperatures of Rocks

H. VOLLSTÄDT and F. FRÖLICH
D. D. R.

Introduction

The Curie-values of rock forming magnetic minerals, marking the transition from the ferrimagnetic to the paramagnetic state, are generally influenced by impurities which rocks commonly contain. Besides, the distribution of lattice-disorders of such a kind is (as one expects) arbitrary. Therefore during heating, those crystallites will be changed in its behaviour first of all which have the lowest Curie-value. On such a way the ferrimagnetic state shrinks by steps and at least there exist only ferrimagnetic "isles" within paramagnetic surroundings. Hence it follows that rocks generally show a Curie-temperature-region instead of a Curie-point.

Proceedings

For studying these Curie-temperature-regions, three methods are used (in the main) which base on quite different principles and what are therefore independent one from another:

(i) a magnetothermic balance of precision
(ii) an arrangement for determination of thermodynamical coefficients by means of ballistic galvanometer-measurements
(iii) a differential-thermo-analyzer.

These methods and the results, obtained by them, will be described and discussed in the following. On this way it will be shown that such complex studies enable to obtain secured statements about the present real situation within the rock concerned.

(i) Firstly the standard temperature-characteristics of pure minerals (magnetite, maghemite, hematite, ilmenite, titanomagnetite, pyrrhotite, siderite, ...) were recorded by the aid of the magnetothermic balance of precision. The purity of these mineral specimens was controlled by X-ray powder diagrams. By this means, the deviations of Curie-temperatures*, caused by the impurities of ordinary rock sam-

* Resp. Néel-temperatures for antiferromagnetic minerals.

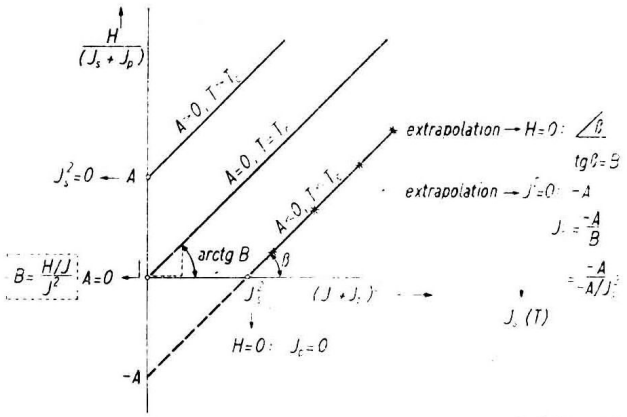

Fig. 1 — Plotting of the dependence: H/J on J^2 corresponding to the method of thermodynamical coefficients: $A + BJ^2 = H/J$

J_s: spontaneous magnetization
J_p: para-process magnetization
A, B: thermodynamical coefficients
*: first measuring points

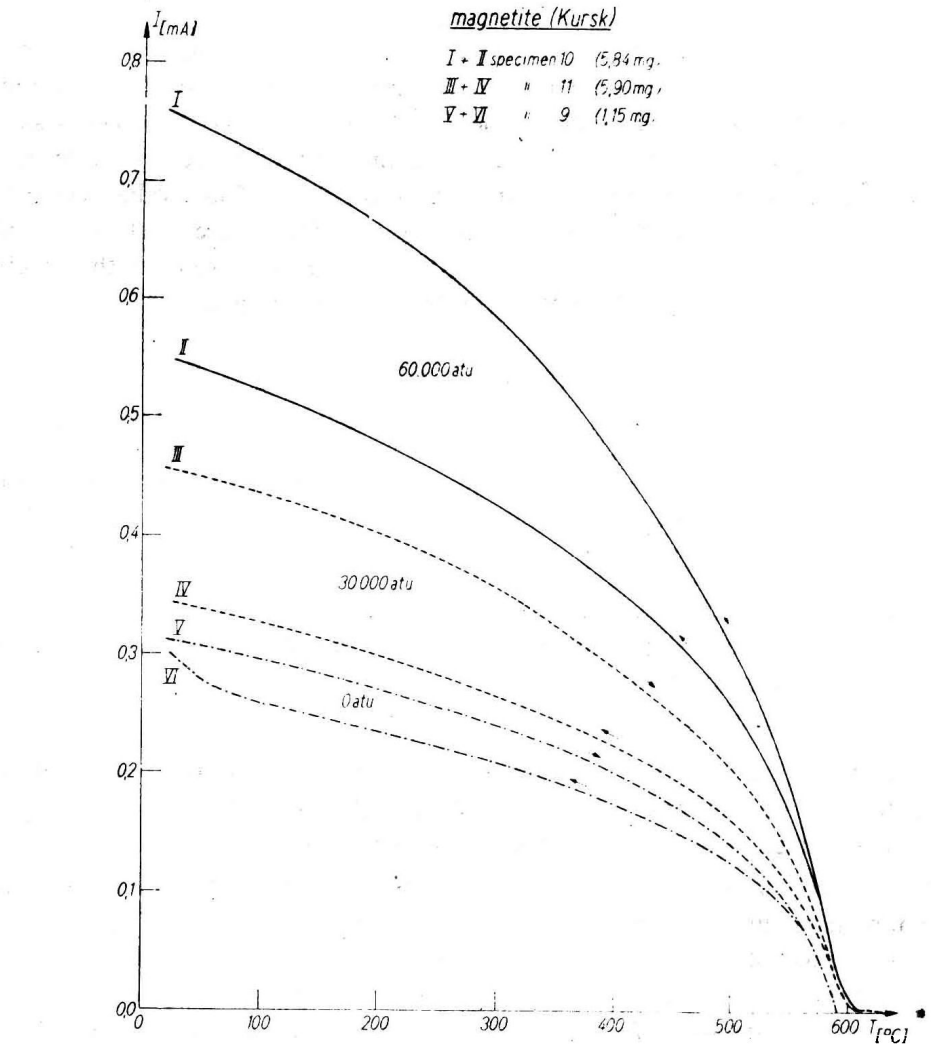

Fig. 2 — Temperature-dependence of magnetization*: *natural* magnetite (Kursk) and pressure effects on its

ples, could be recognized, where upon the foreign elements were pointed out by spectrochemical methods. By paying regard to the situation of exchange-interactions within the respective lattice,

(iα) the decrease of Curie-temperature by participation of diamagnetic (Ti^{4+}, Al^{3+}, Mg^{2+}, Mn^{2+}, ...) in rocks and

(iβ) the increase of Curie-value as consequence of cobalt (Co^{3+}) proportions in rocks

can be understood in detail.

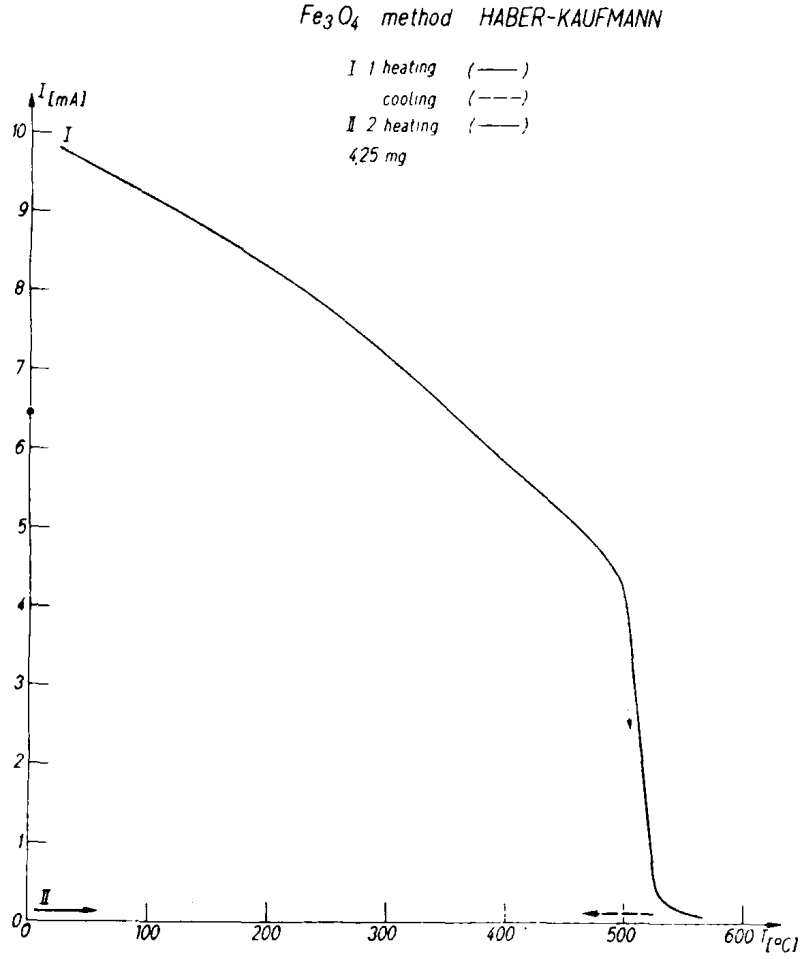

Fig. 3 — Temperature-dependence of magnetization*: *synthetic* magnetite (method: Haber-Kaufmann)

* The ordinate of the diagram marks the compensation-current of the magnetothermic balance. By gauging with purest Ni-powder, hence it follows the specific magnetization. The conversion-relation: 1 [mA/mg] ≙ 34,158 [Gcm^3/g]. During heating up to 700°C, a complete transition is passed through from ferrimagnetic magnetite to antiferromagnetic hematite.

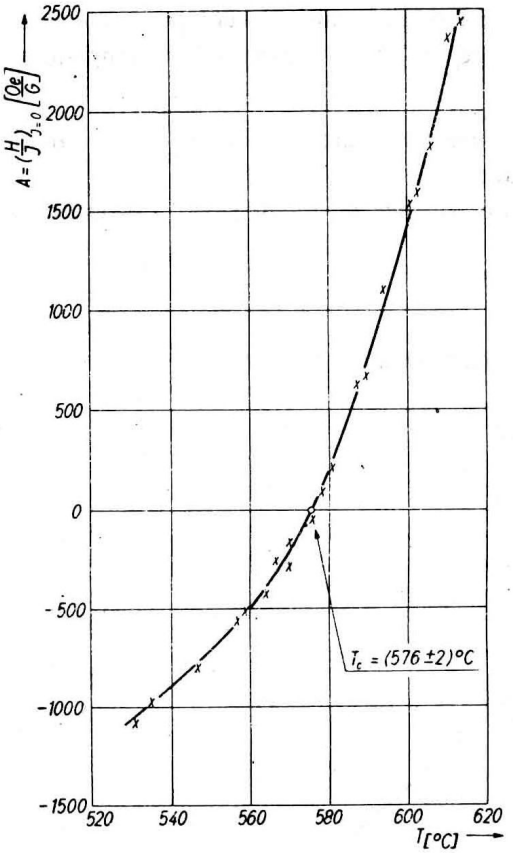

Fig. 4 — Thermodynamical coefficient A: using its null-passage to evaluate the Curie-temperature (of magnetite in this case)

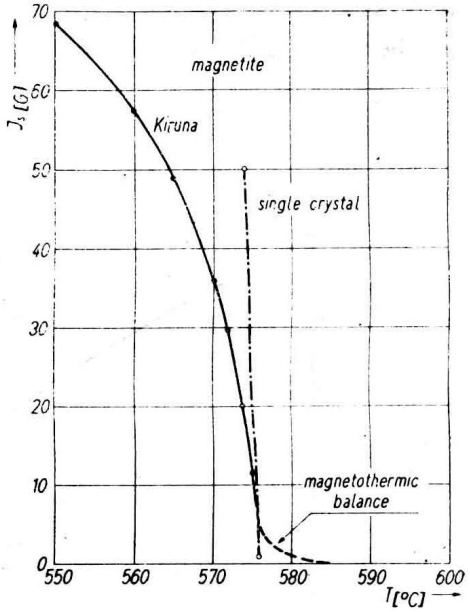

Fig. 6 — Temperature-dependence of magnetization following from method of thermodynamical coefficients

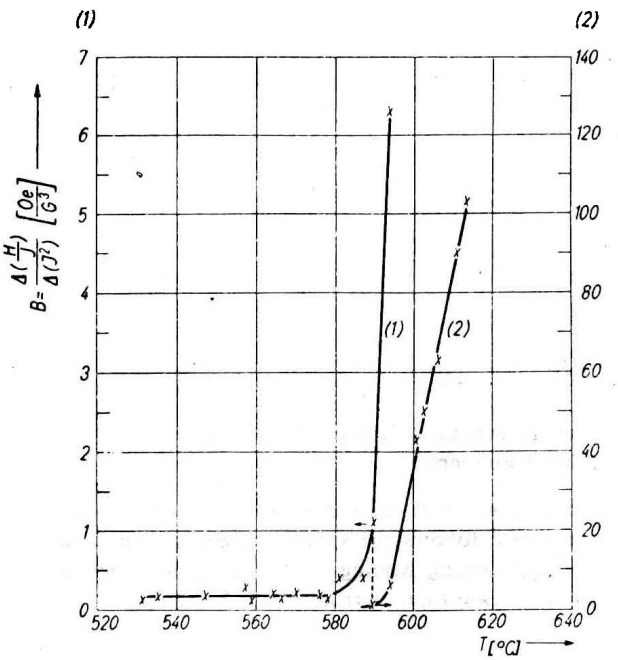

Fig. 5 — Thermodynamical coefficient B (magnetite)

(ii) In connection herewith, the method of ascertaining the thermodynamical coefficients yields a very sensitive control. Fig. 1 illustrates the proceeding.

Disappearance of the first coefficient (A = 0) indicates the Curie-value (T_C).

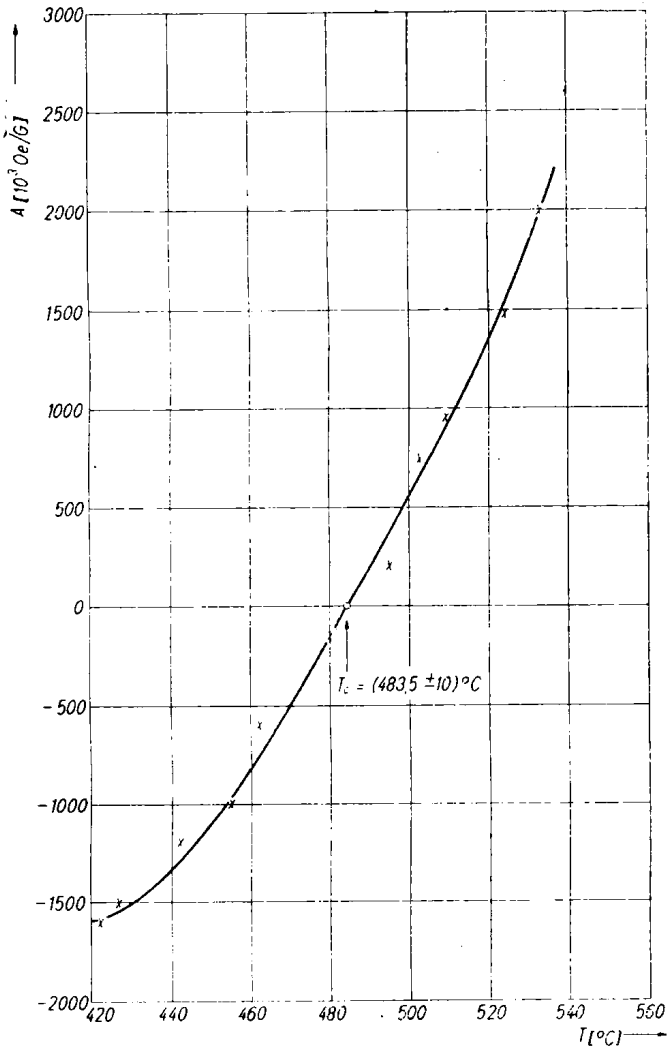

Fig. 7 — Thermodynamical coefficient A: using its null-passage to evaluate the Curie-temperature (of titanomagnetite)

(iii) Additional to these two methods, the differential-thermo-analysis (DTA) gives informations about the progressing processes within Curie-temperature-region: The transition from ferrimagnetic to paramagnetic state is indicated by an endothermic peak in the DTA-diagram, whereas structural changes (phase changes) discover themselves by exothermic peaks. In the first case, thermic energy is needed for loosening the

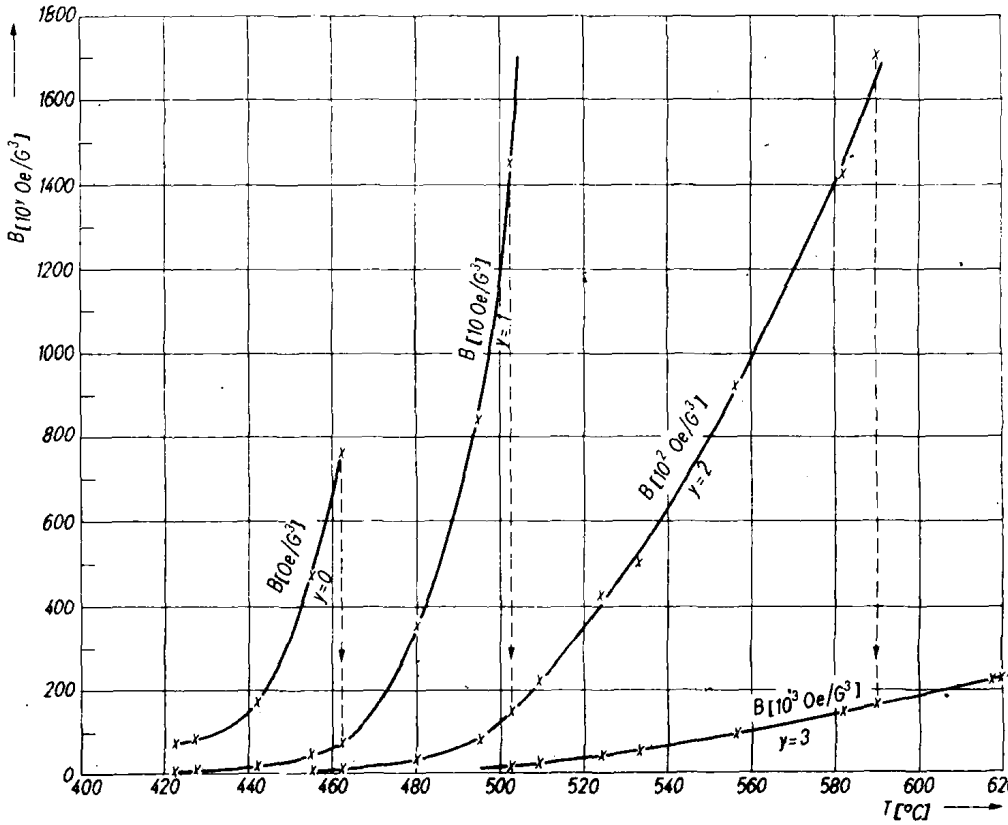

Fig. 8 — Thermodynamical coefficient B (titanomagnetite)

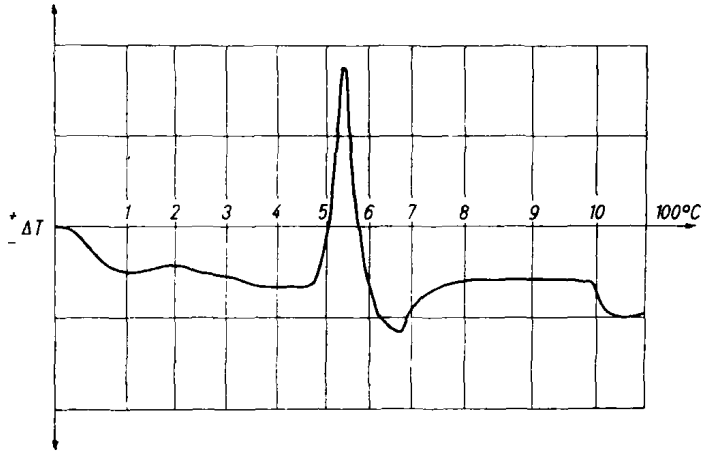

Fig. 9 — Differential-thermo-analysis of maghemite:

(v = 10°C/min; T → 1,050°C)

exothermic peak at 545°C: phase change maghemite → hematite
endothermic peak at 675°C: Néel-temperature of antiferromagnetic hematite

magnetic longrange ordering within the crystal structure, whereas structural-changes set energy free.

Results

Fig. 2, 3 show diagrams of magnetothermic balance, fig. 4–8 give some results, gained by the method of thermodynamical coefficients and fig. 9 and 10 illustrate differential-thermo-analysis.

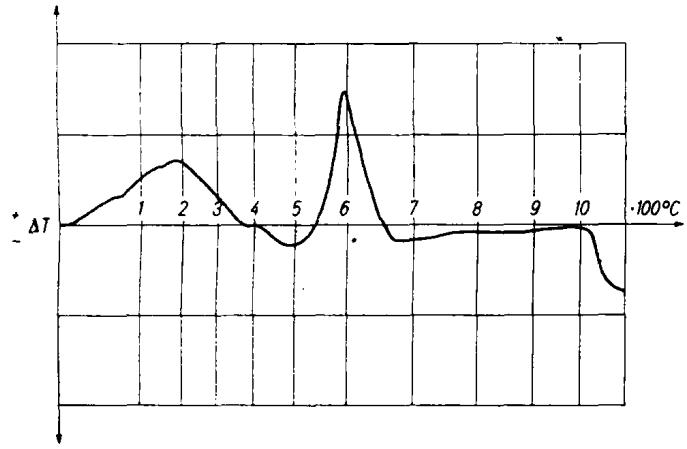

Fig. 10 — Differential-thermoanalysis of maghemite with 3% Co contents:
(v = 10°C/min; T → 1,050°C).
The exothermic peak is shifted to 590°C as consequence of the Co contents

The comparison between the behaviour of single crystals of magnetite and natural magnetite (Kiruna) shows that the absence of impurities (single crystals) leads to a larger angle of inclination and to an Curie-point, whereas the presence of impurities (Kiruna-magnetite) yields diminished inclination and a Curie-temperature-region.

[*Manuscript received July 20th, 1967*]