# TEMPERATURES OF FORMATION OF THE CHISEL LAKE SULPHIDE DEPOSIT, SNOW LAKE, MANITOBA

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During the winter of 1961–62 a study was made of the ore mineralogy of the Chisel Lake Mine by A. E. Bence working under the supervision of L. C. Coleman. This mine is located in central Manitoba at 54° 50′ N. Lat., 100° 07′ W. Long. Specimens for this work were provided by the Hudson Bay Mining and Smelting Company.

The sulphides: arsenopyrite, pyrite, sphalerite, chalcopyrite, galena, pyrrhotite, gudmundite, marcasite, and the sulphosalts: meneghinite, tetrahedrite, and a bournonite-seligmannite solid solution, were observed as well as small amounts of native gold.

On the basis of textural relationships the following general sequence of events for the formation of the metallic components of the ore body is postulated: the crystallization of arsenopyrite followed by deformation; crystallization of pyrite; introduction of gold; crystallization of pyrrhotite, sphalerite, and chalcopyrite, generally in that order but with some reversals and overlapping relationships; fracturing followed by the emplacement of galena, the sulphosalts, gudmundite, and pyrite; and finally, the formation of marcasite by the alteration of pyrrhotite.

Two geothermometers were employed to determine temperatures of formation. These were the FeS-ZnS geothermometer of Kullerud (1953) and Skinner & Barton (1958) and the pyrrhotite geothermometer of Arnold (1962).

All measurements were made with a Norelco wide angle diffractometer using filtered Cu radiation for the sphalerite samples and Fe radiation for the pyrrhotite samples. An external silicon standard was employed and the $2\theta$ values measured are believed to be accurate to ±0.005°. Corrections for MnS and CdS* in solid solution in sphalerite were made based on the curves of Coleman (1957). The amounts of Co and Ni* present in the pyrrhotite are less than 400 p.p.m. and their effects on the unit cell dimensions are negligible.

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*Mn and Cd analyses of sphalerite and Co and Ni analyses of pyrrhotite were done by Dr. R. G. Arnold of the Saskatchewan Research Council using *x*-ray fluorescence techniques.

Sphalerites from fourteen specimens were analyzed. These samples had been taken at regular intervals along the plunge of the orebody to see if a temperature gradient existed during its formation.

The corrected unit cell dimensions (Table 1) vary from 5.4131 Å to 5.4158 Å which indicate FeS contents of the sphalerites ranging from about 8.4–14.3 mol%. Using data from Kullerud (1953), a range of minimum temperatures of formation of the sphalerite was determined as having been from 275° C. to 425° C.

TABLE 1. TEMPERATURES OF FORMATION OF SPHALERITE

| Sample No. | Measured $a_0$ (Å) | Wt. % MnS | Wt. % CdS | MnS and CdS Correction | Corrected $a_0$ (Å) | Mol % FeS | Minimum formation Temp. °C. |
|---|---|---|---|---|---|---|---|
| 1 | 5.4153 | .67 | .08 | −.0006 | 5.4147 | 11.85 | 370 |
| 2 | 5.4140 | .69 | .13 | −.0007 | 5.4133 | 8.80 | 285 |
| 3 | 5.4160 | .40 | .10 | −.0004 | 5.4156 | 13.80 | 415 |
| 4 | 5.4157 | .27 | .14 | −.0003 | 5.4154 | 13.35 | 405 |
| 5 | 5.4160 | .59 | .13 | −.0006 | 5.4154 | 13.35 | 405 |
| 6 | 5.4151 | .48 | .12 | −.0005 | 5.4146 | 11.60 | 360 |
| 7 | 5.4157 | .29 | .17 | −.0003 | 5.4154 | 13.35 | 405 |
| 8 | 5.4163 | .48 | .12 | −.0005 | 5.4158 | 14.25 | 425 |
| 9 | 5.4161 | .29 | .17 | −.0003 | 5.4158 | 14.25 | 425 |
| 10 | 5.4140 | .48 | .13 | −.0005 | 5.4135 | 9.20 | 300 |
| 11 | 5.4145 | .54 | .12 | −.0005 | 5.4140 | 10.30 | 330 |
| 12 | 5.4161 | .73 | .14 | −.0007 | 5.4154 | 13.35 | 405 |
| 13 | 5.4152 | .73 | .17 | −.0007 | 5.4145 | 11.40 | 360 |
| 14 | 5.4135 | .36 | .17 | −.0004 | 5.4131 | 8.35 | 275 |

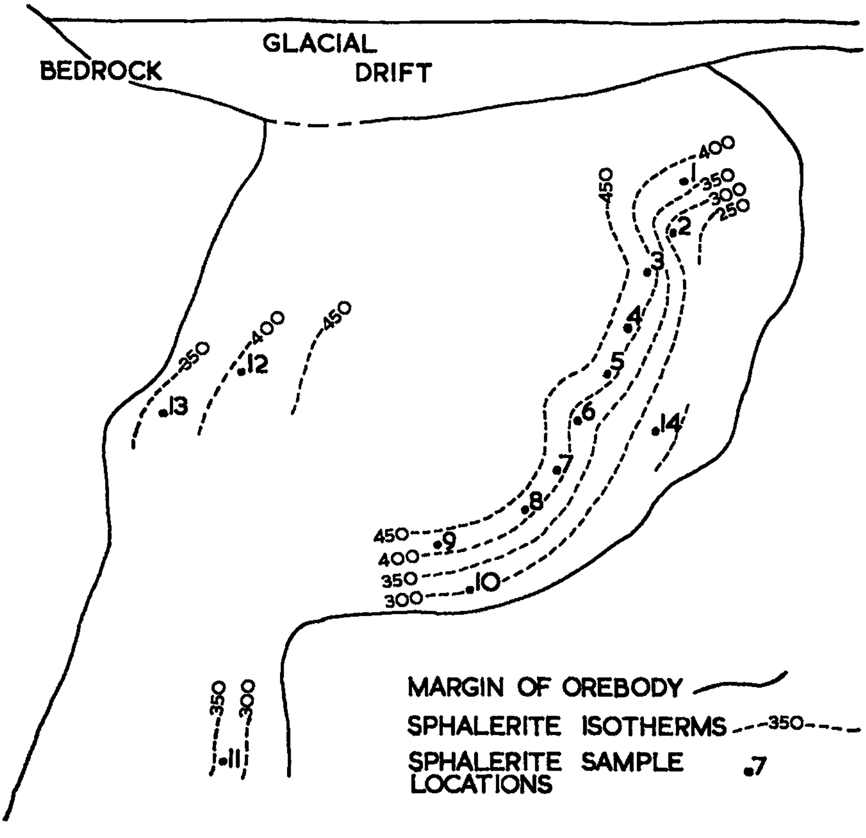
Pyrrhotite from two specimens was analysed in the present study and $d(102)$ spacings of 2.0565 Å and 2.0558 Å were measured (Table 2). These indicate pyrrhotite compositions containing about 46.5 atomic percent metals and a temperature of formation for the pyrrhotite from both specimens of 510±10° C. This is a minimum temperature of formation but, since in both specimens the pyrrhotite is closely associated with pyrite, the results are probably very close to the true temperature of formation.

TABLE 2. TEMPERATURES OF FORMATION OF PYRRHOTITE

| Sample No. | $d(102)\alpha$ Ångstrom units | Atomic % metals | Temperature of formation °C. |
|---|---|---|---|
| 12 | 2.0558 | 46.45 | 515 |
| 13 | 2.0565 | 46.50 | 510 |

The results of this work suggest the following possibilities: first, that either a temperature gradient existed during the formation of the sphalerite or that there was a time-space relationship for sphalerite formation, and second that the temperature of formation of the pyrrhotite was higher than that of the sphalerite and that, therefore, the physical conditions were changing during the formation of the deposit.

The FeS content of the sphalerites as determined by the unit cell dimensions appears to be a function of the distance from the margins of the ore body (Table 1, Fig. 1). This feature could be accounted for if



LONGITUDINAL SECTION

CHISEL LAKE MINE

LOOKING N.67°E.

SCALE: 1 INCH = 200 FEET

the deposit had formed as the result of hydrothermal solutions which were introduced along some "channelway" located near its centre and if such introduction had created a thermal gradient diminishing outwards from the locus of introduction. An alternative explanation is that the formation of sphalerite extended over a period of time during which temperatures in the region were progressively changing. In this case, sphalerite toward the centre of the orebody would, presumably, have been formed earliest and the formation of sphalerite would have progressed outwards, with time, towards the margins of the deposit.

This study has shown that the pyrrhotite formed at a higher temperature than the sphalerite. On this basis, assuming what is considered the normal sequence of events (i.e. decreasing temperature with time), the pyrrhotite formed earlier than the sphalerite. Age relationships of these minerals deduced from textural evidence support this idea.

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