Dana (*Syst. Min.*, 1944, p. 402) suggests that "warthaite" is identical with "goongarrite" but that adequate data are lacking to establish the relationship. These observations confirm this suggestion and indicate that both are intimate mixtures of cosalite and galena.

LIQUID INCLUSIONS IN GEOTHERMOMETRY

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It was with considerable interest that I read the paper on "Liquid inclusions in halite as a guide to geologic thermometry" by Dreyer, Garrels and Howland in the January–February, 1949, issue of this Journal, but I am at variance with the interpretation put upon the results and the conclusions arrived at by the authors.

Some time ago a technique was developed in this department whereby the noise made by the breaking out (decrepitation) of liquid inclusions in minerals when heated, is used to indicate the point of complete filling by the liquid phase. This technique was described by Scott (*Econ. Geol.*, **43,** 637, 1948). Modifications have been made to the apparatus, particularly to the method of recording the onset of decrepitation, in an attempt to attain greater precision. In effect a curve is drawn, automatically, of the frequency of decrepitation against temperature. The inflection point in this curve is taken to indicate the temperature at which the fluid inclusions have just been completely filled by the liquid phase. This is described more fully elsewhere in this issue. In calibrating the apparatus and technique, synthetic mineral crystals grown under controlled conditions were used so far as possible, surprisingly close correspondence being obtained between the calculated temperatures of complete filling and those given by the apparatus. Among the minerals used was sodium chloride crystallized from a saturated aqueous solution at the temperature of the boiling point of the solution. Decrepitation gave a temperature in excess of this by 0.5° C. which is well within experimental error. Subsequently sodium chloride was grown from saturated aqueous solutions at temperature of 45° C. ± 2° C. and 80° C. ± 2° C. In both these cases decrepitation indicated temperatures of complete filling substantially the same as those of formation, certainly well within the possible experimental error.

In their paper, Dreyer, Garrels and Howland suggest that, since they obtained temperatures of formation of 70 to 100° C. for natural halite, using the direct observation-heating stage technique described by Inger-

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son (*Am. Mineral.*, **32,** 375, 1947), and since "it is obvious, that the bodies of water from which the sedimentary halite was deposited could not have had a general temperature of 70–100° C.," the use of liquid inclusions in geologic thermometry may not give a true indication of the general temperature of the solution from which the material was crystallised.

In view of the close correspondence between the temperature of the solution from which artificial halite was crystallised and the experimentally determined temperature of complete filling of the inclusions, as described above, an alternative conclusion to that of Dreyer, Garrels, and Howland is suggested.

It is possible that the crystals examined were not those individual crystals initially precipitated from a subaerial body of water. The only evidence given that the halite had not suffered reworking was that the specimens came from dry, well stratified, undistorted strata. It is very unsafe however to assume that, because the beds show no distortion, recrystallisation has not taken place. In view of the high solubility of sodium chloride in water it would seem likely that recrystallisation, not only once but many times, would be the rule rather than the exception during the compaction of the original sediment. The connate water would be saturated with respect to sodium chloride and as the temperature rose with depth of burial it would tend to take more into solution. Nevertheless there must be a constant interchange of ions between the crystals and solution, the larger crystals growing at the expense of the small ones, material going into solution at points of high pressure and being precipitated at points of low pressure. Thus while the second of the criteria of primary inclusions, namely a good correlation between the volume of the inclusion and the volume of the gas phase, certainly indicates a primary nature for the inclusion with respect to the enclosing crystal, there is nothing to indicate that the crystal itself is primary to the deposit.

Therefore when using liquid inclusions to determine conditions of temperature and pressure of formation of a mineral, care must be exercised to examine the possibilities of recrystallisation subsequent to initial deposition, particularly where the mineral examined has a high solubility in water. If there is evidence that recrystallisation can have taken place, then the primary liquid inclusions can only indicate the temperature/pressure conditions prevailing during the last cycle of recrystallisation.