ratios for connate waters are: Sr/Cl, 0·003–0·010; Br/Cl, 0·0035–0·008; I/Cl, 0·00005–0·0005 (ref. 7). It would be interesting to extend the comparison to include these ionic ratios.

The temperature of connate waters *in situ* is a function of the geothermal gradient at the sub-surface area from which they are sampled. A value of 44° C, comparable with the Red Sea bottom brine, may represent a relatively shallow depth of origin from a sedimentary sequence in a tectonically active area like the Red Sea basin. The temperature of the Red Sea brines is then in keeping with the proposed connate origin.

It is proposed that the 200-m thick layer of warm saline brine found at the bottom of a basin in the Central Red Sea is derived from the release of connate water from a nearby outcrop of sedimentary rock. Other anomalous waters showing less extreme values have been reported in adjacent regions[2,3,5]. Speculation on the origin of these waters awaits determination of the ionic ratios.

Thick sedimentary sequences are not a common geological feature of the immediately adjacent land areas, yet the elongate Red Sea basin is most probably a down-faulted region, and this trough would accumulate a sedimentary sequence in the course of its subsidence. Waters buried with the sediments of the trough would become connate waters and could re-emerge if faulting or some other tectonic process provided access to the surface.

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PHYSICS

Linear Temperature Scale

In a recent communication[1] Groves and Lielmezs express the absolute temperature scale in a form symmetrical about the arbitrary zero, with the absolutely highest and lowest temperatures placed at $+\infty$ and $-\infty$, respectively. As a mathematical transformation, this is of course trivial—one can always turn something into nothing by making it a unit and taking its logarithm. However, Groves and Lielmezs seem to be unaware that the scale they describe was in fact the first absolute scale proposed by W. Thomson (later Lord Kelvin), not as a mathematical possibility but on physical grounds[2].

Thomson defined equal-temperature steps as those in which a given quantity of caloric produced equal amounts of work in descending through them, and since at that time he followed Carnot in supposing that 'caloric' was conserved in the process, there was no terminus to its descent, and the absolute zero was therefore represented by $-\infty$. When later it was realized that heat (which had then taken the place of caloric as the relevant concept) was destroyed when work was produced, there was a limit to its descent and the absolute zero was therefore represented by a finite number—the now familiar $-273·16°$ C. It is easily seen that temperature on Thomson's original scale is proportional to the logarithm of the present absolute temperature, and so is identical with that proposed by Groves and Lielmezs.

More than 20 years ago[3], I proposed a scale based on a different physical conception—namely, the relativity of temperature radiation, which was treated mathematically in the same way as the relativity of motion in the special relativity theory. This gives a scale which, like Thomson's first conception, is symmetrical about the arbitrary zero, but the limiting values are represented by finite quantities, $\pm\zeta$, analogous to the limiting values, $\pm c$, of velocity in special relativity kinematics. These limits are inaccessible in the same sense as the velocity of light is inaccessible. Groves and Lielmezs might find it worth while to consider whether this scale might be of use to them in their enquiries.

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GROVES and LIELMEZS have directed attention to certain properties of a temperature ψ defined as the logarithm of the usual Kelvin temperature[1]. It can also be shown that ψ has a very simple interpretation in terms of the efficiency of an ideal reversible heat engine, such as was discussed by Kelvin in establishing his thermodynamic scale.

Consider a series of ideal heat engines operating in Carnot cycles, such that the waste heat discharged by one engine is supplied reversibly to the next. By Carnot's theorem the efficiency of each engine is a function of the input and output temperatures only, hence the efficiencies can be used to define scales of temperature. There are two obvious simple possibilities: (*a*) The differences between input and output temperatures for the various engines are defined to be equal if their efficiencies are equal. (*b*) The temperature differences are defined to be equal if each engine does the same amount of work.

The scheme (*b*) defines the usual Kelvin scale. Since the engines do equal amounts of work the scale must terminate at some finite value below any arbitrary starting point at which a finite amount of heat is supplied. Hence the Kelvin scale has an absolute zero at a finite number of degrees below the ice-point. It might be thought that absolute zero could then be regarded as the temperature of the heat sink of the last engine of the series. However, for this to be meaningful it is necessary that some heat should be discharged. Thus we must imagine that the last engine has a heat sink at a temperature infinitesimally above absolute zero. This engine will then have an efficiency which tends to unity as the sink temperature tends to absolute zero. Hence absolute zero necessarily appears as an unattainable limit in the ordinary Kelvin scale, contrary to the supposition of Groves and Lielmezs.

A consideration of the efficiencies of the last few engines in the series leads immediately to the well-known law for the efficiency ε in terms of the Kelvin temperatures T_1 and T_2 of the heat source and sink :

$$\varepsilon = 1 - T_2/T_1 \qquad (1)$$

Substituting the temperature ψ defined by $T = e^{\psi}$ gives:

$$(1 - \varepsilon) = \exp[-(\psi_1 - \psi_2)] \qquad (2)$$

Equation (2) shows that the efficiencies of the engines will be equal for equal temperature differences measured on this scale. Hence the temperature ψ satisfies the requirements of scheme (*a*) above.

For dimensional consistency the temperature ψ should properly be defined by the equation :

$$\psi = \psi_0 \ln (T/T_0)$$

where ψ_0 and T_0 are constants which can be determined arbitrarily. Hence by calibration at the ice and steam points the temperature ψ can be expressed in degrees Celsius. Clearly, on this scale absolute zero is at minus infinity degrees Celsius.

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