Air pressure and methane fluxes

SIR — Mattson and Likens found [1] that sporadic methane bubble releases (ebullition) from lake sediments were correlated with changes in the local air pressure. A similar phenomenon has been known to colliery ventilation engineers in the United Kingdom for more than 250 years.

Saxton, in a series of articles[2] on the history of coal mine ventilation, has documented several accounts of investigations of the phenomenon of methane emission from underground cavities coincident with a falling barometric pressure. The first refers to investigations by Brownrigg prompted by the explosion of methane at the Corporal pit in Whitehaven in 1737. Brownrigg is said to have linked the possibility of such explosions with a rapidly falling barometer. The explosion at Haswell colliery, Durham in 1844 was investigated by Michael Faraday and Charles Lyell. The report suggested that a fall in the barometer resulted in the emission of methane into the airstream of the mine. Scott and Galloway[3] investigated the statistical evidence for the linkage between methane explosions and the state of the weather, concluding that of the 525 explosions between 1868 and 1870, 49 per cent could be connected with disturbance of the barometer.

Following some disastrous explosions, a Royal Commission was set up in 1879 to inquire and report "whether, with respect to the influence of fluctuations in atmospheric pressure upon the issue of firedamp (methane) from coal, ... the resources of science furnish any practicable expedients that are not now in use and are calculated to prevent the occurrence of accidents, or limit their disastrous consequences". The Commission concluded that variations of atmospheric pressure exercise an undoubted effect on accumulations of gas in mines but noted widespread conflict of opinion as to the connection between atmospheric pressure and the occurrence of explosions.

The significance of changes in barometric pressure is recognized in the Acts and Regulations under which mines have to be operated. It is a statutory requirement that a barometer must be provided where it can be easily seen and read by people employed at the mine.

Even with modern ventilation standards, a rapid fall in barometric pressure can still cause serious problems. Hinchliffe[4] describes the high gas emission at Allerton Bywater Colliery, Yorkshire in March 1986. This was the direct result of a severe drop in barometric pressure, which fell at approximately 3 millibars per hour for about 12 hours. High concentrations of methane were measured in the mine ventilation air and it was necessary to suspend some operations until the barometer rose again.

In all the above incidents, methane was emitted from cavities of various kinds. Changes in barometric pressure will not affect the adsorption/desorption of gas from the coal itself, as the pressure associated with these processes are of the order of two or more atmospheres[5]. It is the time rate of change of air pressure that matters[5]. Mattson and Likens refer only to the changes in air pressure with no indication of the periods over which they took place: it would be interesting if they re-examined their data to see where the best correlation lies.

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In defence of Fourier

SIR — Maddox[1] and Malone and Wheatley[2] raise questions about the validity of Fourier's analysis of heat conduction and its equivalent for molecular diffusion. A particular point of dissatisfaction concerns the infinite speed of propagation of the diffusing property implied by the partial differential equation model.

We wish to draw attention to an early discussion of this problem by P. Frank[3], who carefully points out that this diffusion theory is based on the assumption of a continuous distribution of matter in space and does not account for a finite number of discrete molecules. So we must interpret solutions to the diffusion equation in a probabalistic sense, representing the mean number of molecules in a certain region at a given time. Starting with a discrete number of molecules N at $x = 0$ diffusing on the infinite x-axis, one can easily show that in time t, on average at most one particle will have diffused a distance at least

$$\xi = \xi(N,t) = 2f(N)\sqrt{Dt}$$

where D is the diffusion constant and $f(N)$ is the solution of

$$\psi(f(N)) = 1/N$$

here $\psi(x)$ denotes the complementary error function, and therefore $f(N)$ increases to infinity as N goes to infinity[3]. Thus, $\xi(N,\tau)/\tau$, where τ is an arbitrary unit of time, may be defined as the propagation speed of diffusion, infinite only in the limit as the number of molecules, N, goes to infinity. The concentration maximum in a variety of diffusion settings also occurs at distances of order $\sqrt{Dt}$ after t units of time[4], a rule of thumb equally suitable for defining a finite speed of propagation of diffusion[3].

In view of this interpretation it seems to us that the current debate[1,2] is about a rather small can of worms. Fourier's approach will retain its prominent place in our thinking of diffusion problems, and school teachers will wait for better reasons to change their curriculum.

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A natural classification

SIR — Ernst Mayr criticizes [1] the new natural system we propose[2], and offers an alternative. Mayr has written of the need for consistency between phylogeny and taxonomy, and for precise measures of relationship among the higher taxa[3], so we had anticipated his support.

Our system[2] is an attempt to bring taxonomic classification into line with the recent understanding of phylogeny that stems from molecular studies. It replaces the conventional 'default' system — an inconsistent amalgam of the five-kingdom classification of Whittaker and the modern version of Chatton's prokaryote–eukaryote dichotomy — which is phylogenetically incorrect. Mayr faults our system, however, for not reflecting the structural disparity between eukaryotes and prokaryotes — the latter having "relatively small differences between [them]"[1]. Although he makes some minor terminological and relational rearrangements of categories, his alternative system is merely a return to what we consider to be the flawed conventional view that divides the living world into eukaryotes and prokaryotes.

Even if it is true, as Mayr says, that "the difference in structural organization between prokaryotes and eukaryotes is an order of magnitude greater than the relatively small difference between the Archaebacteria and the Eubacteria"[1], this does not reflect an aboriginal phylogenetic division between prokaryotes and eukaryotes, nor does it mean that the archaea are related to the (eu)bacteria rather than the eukaryotes. Phylogenetically, the archaea's most recent common ancestor (determined by sequence comparisons using several unrelated pairs of paralogous protein genes) appears to have been with the eukaryotes, not with the bacteria[4,5]. Thus, any system that divides the living world initially into prokaryotes and eukaryotes cannot be natural.

Many biologists tend to see morphological