

trick of posture to make their backs more compliant. The idea is attractive, but a crude calculation is discouraging. People usually take about two steps per second, so the back would have to be compliant enough to bring the natural frequency of the load below about 1 Hertz to reduce its vertical movements significantly. The standard formula for the frequency of spring-mass systems shows that the spring of the back would have to be soft enough to be compressed 0.25 metres by the load. Such compliance does not seem feasible, even if the back were allowed to bow out in an unusual curve. In any case, carrying a large head-load with the back bent seems dangerous. Flexible columns carrying loads are apt to collapse by buckling, and the danger is worse if the column is bent initially.

It would be interesting to attach accelerometers to the head-loads to find out how steadily they are carried. It would

also be interesting to know whether there is anything unusual about the curve of the women's backs. Meanwhile, there is something more to wonder about. Taylor *et al.* (*J. exp. Biol.* **86**, 9; 1980) have argued that most of the energy cost of running is associated with the generation of force in muscles, rather than with performance of work. Therefore, an animal carrying a load of x per cent of body mass must increase its energy consumption by x per cent. The evidence available at the time seemed to support this conclusion, but the authors have now discovered that Luo and Kikuyu women can carry 20 per cent of body mass without increasing their oxygen consumption. Is there a lesson to be learned from these women about the fundamentals of muscle energetics in locomotion? □

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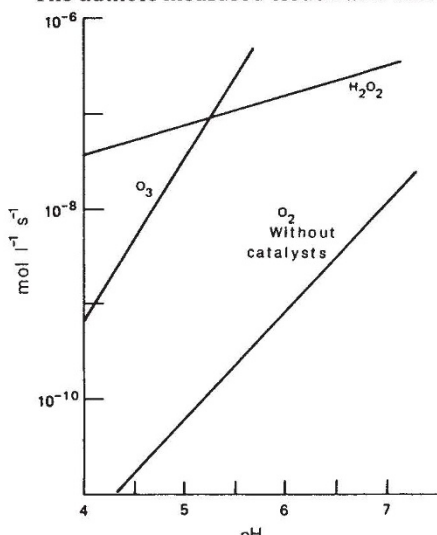
Atmospheric chemistry

Hydrogen peroxide in cloudwater

from S.A. Penkett

HYDROGEN peroxide is perhaps best known as an aid to pulchritude, although it occurs naturally and has now been shown to be a common constituent of cloudwater. Older chemistry textbooks refer to the presence of H_2O_2 in the atmosphere almost as a piece of folklore, and ascribe its presence to atmospheric electricity. In fact, a recent study using highly specific analytical methods shows that it is much more likely to be formed as a result of photochemistry of atmospheric trace gases (Kelly, T.J., Daum, P.H. & Schwartz, S.E. *J. geophys. Res.* **90**, 7861; 1985).

The authors measured cloudwater sam-



Conversion of S(IV) to S(VI). The pH dependence of the reaction rates is for the systems H_2O_2 , O_3 and O_2 .

ples collected in free air by aircraft; they found that the H_2O_2 concentration varies from less than 0.3 to 72 μM , corresponding to gas-phase concentrations up to 0.9 p.p.b.v. (parts per 10^9 by volume) with an average of 0.1 p.p.b.v. These values are roughly equivalent to a much more extensive series of measurements made on cloudwater samples collected on a mountain top by Mohen and co-workers (*NATO Advanced Study Institute Conference*, 1983), who show a substantial seasonal dependence of H_2O_2 , with larger values in the summer. The gas-phase concentrations estimated from cloudwater, however, are significantly less than those observed directly at the same time of year (October) at a similar location (Calvert, J.G. *et al. Nature* **317**, 27; 1985).

Interest in atmospheric H_2O_2 has increased substantially since it was realized that this substance could be the most efficient droplet-phase oxidant for SO_2 , leading to the production of SO_4^{2-} in cloud and rainwater (see figure). At cloudwater pH, which is typically less than 5, peroxide oxidizes dissolved SO_2 more rapidly than ozone or oxygen in the absence of large concentrations of metal catalysts.

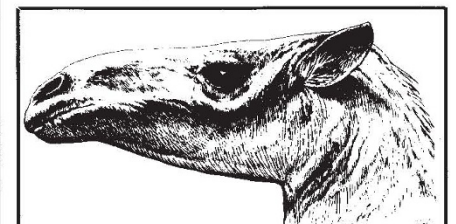
Kelly *et al.* measured samples of cloudwater with specific detectors because previous attempts to estimate H_2O_2 in the gas phase had resulted in analytical artefacts (see Lazrus, A. *et al. Analyt. Chem.* **57**, 917; 1985). The new results show that the presence of gas-phase SO_2 inside clouds and cloudwater containing H_2O_2 is mutually exclusive, and that the sum of H_2O_2 and sulphate ions in the

aqueous phase is much closer to the newer, artefact-free gas-phase H_2O_2 concentration measured by Calvert's group at the same time of year (about 2 p.p.b.v.). Measured gas-phase concentrations agree closely with the values calculated by Calvert *et al.* who used a sophisticated model of atmospheric photochemistry, and moreover they often exceed measured concentrations of gaseous SO_2 . All these findings strongly implicate H_2O_2 as the predominant oxidant for SO_2 in many circumstances.

Other oxidation mechanisms for SO_2 are also possible and oxidation by hydroxyl radicals in a homogeneous gas-phase process is probably of equal efficiency to the H_2O_2 droplet process. Oxidation in droplets by free radicals collected from the gas phase (see Chameides, W. & Davis, D. *J. geophys. Res.* **87**, 4863; 1982) appears to be a rare phenomenon, although according to Kelly *et al.*'s data, so is oxidation by ozone. Both of these conclusions may be modified when further data are collected. It is quite possible that slower oxidation of SO_2 by ozone in the winter clouds may be relatively more important when the concentrations of other oxidants are low.

Recent understanding of the role of peroxides has led to the suggestion that atmospheric oxidation, and therefore acidification, may often be oxidant-limited. This has certainly complicated the issue on the best course to be adopted in addressing the acid-rain problem, as it is possible that reductions in acid deposition in remote areas may not be a linear function of emissions of gases such as SO_2 in highly populated areas. To add a further complication, many scientists now believe that oxidant damage to forests in Germany can be more significant than damage caused by acid deposition. This includes damage by H_2O_2 at the sort of levels measured in Kelly *et al.*'s cloudwater studies. It is clear we need to understand the mechanisms responsible for the production of such oxidants. □

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Reconstruction of the head of the giant camel *Megacamelus merriami* which lived in North America about 2 million years ago. From *Smithsonian Contributions to Paleobiology* No. 57 (Washington DC; 1985), by Jessica Harrison.