the transformation treatment[2].

With the demonstration that stable transformation of gramineous species by direct gene transfer is possible, the prospect of genetic engineering of cereal food crops is much closer. In principle, there is no host range limitation because bacterium-mediated introduction is not involved. But systems for the isolation, culture and regeneration of plants from protoplasts are required. The major problem in experiments on cereals is the regeneration of entire transformed plants from protoplasts. In addition, transformation frequencies reported so far for direct gene transfer, for tobacco at least, are much lower than those obtained by cocultivation with *Agrobacterium* (about 0.01 per cent compared with 10 per cent), and there may be multiple copies or other modifications to the directly introduced DNA[5]. The development of methods to increase transformation frequencies and of techniques to transform totipotent cereal cells must be the next step. In other words, this is now a problem of plant cell biology and tissue culture, rather than a fundamental problem of molecular biology. □

1. Lörz, H. *et al. Molec. gen. Genet.* **199**, 178 (1985).
2. Potrykus, I. *et al. Molec. gen. Genet.* **199**, 183 (1985).
3. Paszkowski, J. *et al. EMBO J.* **3**, 2717 (1984).
4. Potrykus, I. *et al. Molec. gen. Genet.* **199**, 169 (1985).
5. Hain, R. *et al. Molec. gen. Genet.* **199**, 161 (1985).
6. North, G. *Nature News and Views* **311**, 706 (1984).
7. Hooykaas-Van Slogteren G.M.S. *et al. Nature* **311**, 763 (1984).
8. Hermalsteens, J.-P. *et al. EMBO J.* **3**, 3039 (1984).
9. Krens, F.A. *et al. Nature* **296** 72 (1982).

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Palaeoecology

Holocene evolution of lakes

from F. Alayne Street-Perrott

By using a well-chosen combination of palaeoecological and isotopic studies, J.-C. Fontes and colleagues have been able to trace the Holocene evolution of three small, closed lake basins on the borders of the Great Western Erg, in northern Sahara. Their paper, published on page 608 of this issue[1], is the latest in a lineage that can be traced back to 1715 when, eleven years after he had identified 'his' comet, Edmund Halley presented to the Royal Society a paper "On the cause of the saltness of the ocean, and of the several lakes that emit no rivers; with a proposal, by help thereof, to discover the age of the world"[2]. In this short but imaginative essay, he laid the basis for the interpretation of variations in the level of closed lakes (lakes without surface outlets) in terms of changes in climate; he also postulated that such lakes increased in salinity as the inflowing waters were concentrated by evaporation.

The links between climate and lakes were elucidated further by Julian Jackson, an eccentric retired Indian Army colonel, who identified three types of 'affluents' into a lake — direct precipitation, surface runoff and groundwater; and three types of outputs — evaporation, surface outflow and groundwater seepage . He contrasted the different inputs and outputs in terms of salinity and sediment load, and debated the origin of salt lakes, concluding that some were "formed originally by the universal ocean" whereas others owed their salinity to evaporative concentration.

In the century and a half since Jackson's treatise was published, the study of lake-level fluctuations has become an accepted source of information about past climatic changes[4]. Variations in the water level of closed lakes can be reconstructed both from direct evidence (historical documents, dated shorelines, buried soils in lake-sediment cores, lakeside archaeological sites) and indirectly, using the assumption that the salinity of closed lakes varies inversely with volume. Since many lacustrine organisms, notably diatoms, charophytes, chrysophytes, ostracodes and molluscs, are sensitive to salinity and alkalinity, fossils are often used to infer past hydrological changes. Supporting evidence can be derived from the analysis of stable isotopes (^{18}O and ^{13}C) in lacustrine carbonates.

When radiocarbon dating became generally available in the early sixties, it was soon apparent that the closed lakes in regions such as the Sahara had experienced similar histories[5]. By 1979, it was clear that lakes and swamps had expanded in many tropical regions north of the Equator between 12,000 and 3,000 yr BP (ref. 6). This wet phase has recently been attributed to an increase in monsoon rains induced by the early Holocene maximum of summer insolation that is predicted by the Milankovitch theory[7].

The three Saharan basins that form the subject of the study by Fontes *et al.* are dry. The water table lies far below the basin floors, although in the past it may have intersected the surface. The dates for the basins obtained from the lacustrine period span the range 9,000 – 3,000 yrs BP. Significant discrepancies, however, emerge when records for individual basins are compared. Fontes *et al.* attribute these differences to local hydrological factors rather than dating problems.

This conclusion confirms fears that the fine details of the Holocene climate record may prove hard to reconstruct from groundwater-fed lakes. Lakes in which groundwater forms a substantial proportion of the water budget tend to suffer from two serious defects as palaeoclimatic indicators. First, their response to climatic fluctuations may be damped, delayed, or perturbed by the sudden opening and closing of underground conduits. Second, lengthy aquifer-residence times may result in the introduction of dead carbon into surface waters, giving rise to anomalously old radiocarbon dates.

Another important finding is that, during phases of low lake levels, the fossil assemblages and isotopic values mimicked marine conditions, although the sites lie more than 500 km inland. The lake deposits contain 'marine' foraminifera, diatoms and molluscs, showing that great caution is needed when interpreting evaporitic sequences in arid areas[8,9]. One giveaway in this case is that individual beds often display a mixture of freshwater and saltwater organisms. Based on the ^{18}O results, this situation is thought to have resulted from rapid evaporative concentration of seasonal or intermittent influxes of fresh groundwater, a situation that may have been common in the central and northern Sahara[10].

The initial phase of euphoria about the value of lake-level fluctuations as an indicator of past climatic changes has been replaced by a more cautious and critical mood resulting from the discovery of various complications, notable those associated with groundwater and anthropogenic effects. Nevertheless, the multidisciplinary approach adopted by Fontes *et al.* holds great promise for tackling some of the searching questions about the hydrological and chemical evolution of lakes posed by Jackson over 150 years ago, over a century after Halley's paper. □

1. Fontes, J.-C. *et al. Nature* **317**, 608 (1985).
2. Halley, E. *Phil. Trans. R. Soc.* **29**, 296 (1715).
3. Jackson, Col. J. *Observations on Lakes, Being an Attempt to Explain the Laws of Nature Regarding Them: The Cause of their Formation and Gradual Diminution: The Different Phenomena They Exhibit, etc. With a View to the Advancement of Useful Science* (Bossange, Barthes and Lovell, London, 1833).
4. Hecht, A.D. *Paleoclimate Analysis and Modeling* (ed.) (Wiley, New York, 1985).
5. Faure, H. *Mitt. internat. Verein. theor. angew. Limnol.* **17**, 131 (1969).
6. Street, F.A. & Grove, A.T. *Quat. Res.* **12**,83 (1979).
7. Kutzbach, J.E. *Science* **214**, 59 (1981).
8. Gaven, C., Hillaire-Marcel, C. & Petit-Maire, N. *Nature* **290**, (1981).
9. Richards, G.W. & Vita-Finzi, C. *Nature* **295**, 54 (1982).
10. Ritchie, J.C., Eyles, C.H. & Haynes, C.V. *Nature* **314**, 352 (1985).

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100 years ago

The third International Congress of Geologists, postponed last year on account of the spread of cholera in southern Europe, has just been held at Berlin. The use of French as the language of discussion was no doubt one effective cause of silence on the part of many members who would otherwise only too readily have made themselves heard. Under such circumstances the Latin races have of course a considerable advantage over the Teutonic.

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