sequent authentication through, for example, pigment analysis has in general confirmed van Danzig's analysis. The heart of this method is the identification of at least 100 characteristics in well-authenticated works of a given artist. If a dubious painting contained 75% of these, van Danzig concluded that it was authentic. Storm van Leeuwen reported a high rate of success in applying pictological analysis to objects as diverse as bookbindings, but cautioned that the method is difficult to learn.

In the general discussion the view that connoisseurship must remain the ultimate test of a work of art was put forward. But this traditional view had clearly received a strong challenge from the more objective methods presented. □

Continental drift changes climate

from Peter J. Smith

THE annual mean temperature difference between the equator and the north pole is at present about 41 °C (equatorial 27 °C to polar −14 °C). But evidence from the fossil record makes it clear that temperatures during the Mesozoic, for example, were generally higher than they are now and that the large equator–north pole temperature drop currently observed is probably atypical of the past few hundred million years of geological time. So why has the temperature gradient increased? Why is late Caenozoic climate abnormal? One possibility is that since at least the Palaeozoic the Earth has been influenced by extraterrestrial effects such as variations in solar luminosity, as suggested by Ulrich (*Science* **190**, 619; 1975). However, Donn and Shaw (*Geol. Soc. Amer. Bull.* **88**, 390; 1977) now claim that the appeal to external processes is unnecessary and that climatic changes in the northern hemisphere during the Mesozoic–Caenozoic may be attributed entirely to changing terrestrial geography.

Their evidence comes from the application of a modified form of the thermodynamic meteorological model of Adem (*Tellus* **14**, 102; 1962 and subsequent papers), the purpose of which is to estimate the temperature of the Earth's surface and atmosphere from the radiation balance. The details are complex and can barely be summarised. Suffice it to say that the model involves such factors as the solar radiation received at the Earth's surface, the surface albedo (reflectivity), latent heat loss from the surface by evaporation, heat of condensation in the atmosphere, cloudiness, heat storage in the oceans and atmosphere, the horizontal eddy diffusion of heat, and heat added to the atmosphere by short-wave and long-wave radiation. What emerges from a consideration of these thermal effects is an equilibrium temperature distribution; and the model can certainly be said to work insofar as it has been used successfully to describe the present climate.

The crucial element as far as Donn and Shaw are concerned, however, is the change in the Earth's albedo with time. The present albedo of the Earth as a whole is about 30%; that is, about 30% of the incident solar radiation is reflected back into space and is thus unavailable for warming the Earth's surface and atmosphere. But this average conceals large variations, for whereas the albedo of clouds is about 90%, that of ice and snow is 60–80% and that of certain land and water areas is less than 10%. Moreover, because of its transparency and mobility, water transports heat to a greater depth than does land and is thus more capable of storing heat. The amount of heat absorbed by the Earth's surface, and thus available for later warming of the atmosphere, is therefore dependent upon the relative proportions and positions of the different types of surface cover.

And the proportions and arrangement of continents and oceans in the northern hemisphere have changed considerably over the past 200 Myr because of continental drift and possibly polar wandering. The albedo and heat storage characteristics must likewise have changed. To see if such changes are sufficient to account for the observed climatic changes, Donn and Shaw have therefore used their modified Adem model to determine the surface temperature distribution for the early Triassic (200 Myr ago), the mid-Jurassic (150), the Palaeocene (65), the Oligocene (35) and the present. The point of beginning with the early Triassic is that this epoch preceded the separation of Europe, America and Africa and marked a time when much of the northern hemisphere was water. (Of course, much of the northern hemisphere was also under water during the Cretaceous, when large continental areas were submerged. This period has not been considered in order to avoid having to distinguish between the thermal effects of land and large epeiric seas.)

What the analysis shows is that during the early Triassic the temperature difference between equator and pole over most of the northern hemisphere was only about 20 °C. But as more and more land moved in from the southern hemisphere and drifted towards the north pole over the succeeding 200 Myr, the equator–pole temperature drop rose to about 40 °C, which agrees well with the currently observed value of 41 °C. Throughout this period, however, the tropics remained at 25–30 °C. In other words, the increasing temperature gradient was brought about by a gradual decrease in polar temperature unaccompanied by any significant change in equatorial temperature.

The increasing gradient tied to a nearly constant equatorial temperature inevitably led to a decrease in the overall mean northern hemisphere temperature—in fact, a more or less uniform fall of about 3 °C throughout the 200 Myr. But temperature reductions in the higher latitudes were not only greater but also less uniform. In the 60–70°N band, for example, the annual mean temperature fell by about 5 °C during the first 165 Myr and by about the same over the remaining 35 Myr. During the same intervals the proportion of land in that latitude band rose 0–50% and 50–100% respectively, emphasising again the importance of 'continentality' in producing temperature decline. Incidentally, the model analysis shows that the mean 60–70°N temperature fell below freezing point 10–15 Myr ago, which is in good agreement with the onset of North American glaciation.

In summary, then, it would seem that continental drift is capable of explaining fully the gross changes in northern hemisphere temperature for the past 200 Myr. Whether the same can be said for the southern hemisphere, where the present equator–pole temperature drop is even higher at 77 °C, remains to be seen. Donn and Shaw promise that analysis later. □

100 year ago

BERLIN dealers in delicacies have recently received from the south, and especially from Upper Italy, immense quantities of edible birds which have been captured there in their flight northwards. Unfortunately there were not only snipe, fieldfare, and larks, or so-called "delicacies" among the birds sent, but also singing birds, that are never eaten in Germany, such as goldfinch, thrush, and nightingales. The animals were caught on their migratory flight by means of nets, or surprised during the night and indiscriminately killed. A new indication of the importance of an international law for bird protection!

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