

grade regional metamorphism dated using the U–Pb method on sphenes<sup>3</sup>. This is consistent with the uppermost Jurassic–lowermost Cretaceous age of the subaerial to shallow marine sediments which unconformably overly the Dongqiao ophiolites<sup>4</sup>. In addition, Jurassic radiolaria have been found in these ophiolites<sup>5</sup>. Finally, the ages of granites associated with this suture range from Upper Jurassic to Lower Cretaceous<sup>3</sup>. Thus, the Lhasa block must have been accreted to Eurasia before the end of the Jurassic and, if its origin is to be sought amidst austral continents, its separation from Gondwana must have been considerably older. This is also indicated by combining the palaeomagnetic results<sup>6</sup> and the ages discussed here, along the lines of reasoning in Audley-Charles' last paragraph.

The Palaeozoic history of the Lhasa block is still very poorly known. Indeed, one must explain the simultaneous occurrence of Carboniferous pebbly slates and a Permian Cathaysian flora, in an association which is strongly suggestive of that described in northern Tibet<sup>7,8</sup>. The cautionary note in our paper<sup>1</sup> was due to the fact that the interpretation of pebbly

slates found in southeastern Asia is controversial, particularly regarding those found in the Phuket Group. They have been interpreted as rift infill<sup>9</sup>, as tillites or, as suggested by Cameron *et al.*<sup>10</sup>, as the consequence of reworking and turbiditic redeposition of inrafted subglacial or fluvioglacial debris. On the other hand, one must recall that the Cathaysian flora is traditionally interpreted as being typical of an equatorial climate, indicative of a long period of optimal climate between the Carboniferous and the Permian. Audley-Charles' interpretation implies a progressive change of flora from the South Pole to the northern margin of Gondwana. However, this appears to be contradicted by the discovery of typical Gondwanian flora in the Himalayan Tibet<sup>11</sup> which according to Audley-Charles' reconstruction was only about 10°S of the Permo-Carboniferous Lhasa block. Actually, the sole action of warming invoked by Audley-Charles can be replaced or complemented by an early northward migration of the Lhasa block.

The description of Permian brachiopod fauna, which are identical in Australia, western Thailand and New Guinea, argues

strongly for a close geographical connection of the three land masses at the time. On the other hand, available data of Permian fauna from the Lhasa block rather favour the hypothesis of an early northward migration of the block.

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## Oxygen isotope ratios in plants

IN the comprehensive account of their work, Förstel and Hützen<sup>1</sup> state that the different isotope ratios in leaves and fruits on the grape vine are due to their different rates of exchange with the atmosphere. They state that this exchange is more rapid in the leaf than the grape because the leaf has a much greater surface area per unit volume of water. However, gaseous exchange only occurs within the leaf between the cells of the spongy tissues where the anatomical structure is adapted for this purpose, and the grape is not so adapted<sup>2</sup>. The leaf has internal airways with walls that are always wet, allowing gaseous exchange; they do not possess the waxed and cutinized surfaces found on

the exterior of the leaf and fruit. There is no measurable exchange through the outer surface of the mature leaves and fruits—this has been proved by blocking the stomatal pores of the leaves, thus stopping transpiration, etc.

The fruits receive food (sugars dissolved in leaf water) from the leaves via the phloem. In transit, and in the grape itself, this leaf water mixes with the stem water transporting nutrient minerals from the soil through the xylem, thus the final isotope value in the fruit is lower than the average diurnal value of the leaf water (Fig. 2 of ref. 1).

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FÖRSTEL REPLIES—The idea that gaseous exchange only occurs inside the leaf is not sufficient to describe the fractionation of H<sub>2</sub><sup>18</sup>O and H<sub>2</sub><sup>16</sup>O between the leaf water and water vapour of the surrounding air. If one takes into account merely internal processes in the leaf, only a simple phase transition from the wet cell walls to a water vapour-saturated gas space must be assumed. The diurnal variation of the relative air humidity surrounding the leaf exterior cannot be expected to have any effect, as has been observed<sup>1</sup>. On the other

hand, tracer experiments using enriched water showed that the label from the root zone is transported unaltered through the stem and the stalk<sup>2</sup>; dilution occurs only in the leaves. Finally, the steady-state tracer concentration in the leaves lies between the <sup>18</sup>O content of the water from the roots and that of the air humidity.

The supply of sugar from the leaves to the fruits is an active process which does not depend on the movement of water. There may be a continuous dilution of the water in the fruit by the inflow of water from the stem or stalk, but the enrichment of H<sub>2</sub><sup>18</sup>O (compared with H<sub>2</sub><sup>16</sup>O) must be largely due to a water/vapour phase transition between the liquid in the fruit and the surrounding air. Fluid, which moves via the phloem, is diluted rapidly by the root–leaf water flow down to the groundwater level. We have not experimentally observed any influence from an internal leaf–fruit water cycle. Rather, the following conclusion must be valid: the H<sub>2</sub><sup>18</sup>O content of grapes remains constant because of the small surface/volume ratio of the fruits, in contrast to the leaves where the H<sub>2</sub><sup>18</sup>O content changes quickly during the day. The H<sub>2</sub><sup>18</sup>O content of fruit water cannot be due solely to the water supply via the xylem.

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