matters arising

Was Venus born retrograde?

INGERSOLL AND DOBROVOLSKIS[1] have disputed my theory[2] of the atmosphere of Venus. The key quantity in both analyses is the accelerating atmospheric torque T_A, evaluated in equations (2) and (22) of refs 1 and 2 respectively. The latter expression is determined from observations to within some 30%, while the former contains the unknown 'thermal response time' τ for mass transport in the atmosphere, for which the authors suggest values between some weeks and infinity. But sound waves can travel around the planet within some 10^5 s, hence I expect τ to be about a day; and for this value, both determinations of T_A give the same answer.

The other important quantity is the braking solid body tidal torque T_B which depends on the average value of the quality factor Q divided by the tidal Love number k_2. Estimates for $Q/4k_2$ range from 30 to $\gtrsim 10^5$ (refs 3, 2). In view of the different spin rate, chemistry and thermal history of Venus, a comparison with Earth need certainly not be trusted. An equality $T_A \approx T_B$ can therefore at best be conjectured. In ref. 1, this equality is suggested to hold within less than 2%, an unlikely event without independent justification.

For this and the other reasons put forward in ref. 2, I still believe in the law of isochronism: that all Solar System secondaries were born with a prograde spin period between 5 and 10 h.

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INGERSOLL AND DOBROVOLSKIS REPLY—The questions which have been raised concerning the tidal torque on the atmosphere of Venus[1] deserve some clarification.

The atmospheric torque evaluated in equation (22) of ref. 2 depends on the coefficient of viscosity in the upper atmosphere of Venus. Because this is undoubtedly dominated by eddy momentum transport instead of molecular diffusion, the coupling between the upper and lower atmosphere is uncertain by orders of magnitude, not by 30% as claimed by Kundt.

The thermal response time τ is introduced in ref. 1 to parameterise unmodelled effects which tend to damp the atmospheric tides. It is not necessarily related to mass transport, and has nothing to do with the speed of sound waves (an entirely separate phenomenon). The main conclusions of ref. 1 (see our Fig. 2) are based on the undamped case $\tau \to \infty$.

Regarding the solid body torque, a value for Q of the order of 30 is not only suggested by analogy with the Earth, Moon and Mars, but is required (on the average) if Venus has despun from an originally rapid rotation, whether prograde or retrograde. Nevertheless, it is true that the near-equality (in the opposite sense) of the atmospheric and body tidal torque ($T_A \approx T_B$) is a conjecture. This hypothesis was originally advanced by Gold and Soter[3] to explain the nonsynchronous rotation period of Venus.

These and similar questions are dealt with in greater depth in a forthcoming series of paper, as well as in ref. 4.

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An alternative hypothesis for the origin of West African kimberlites

MARSH[1] suggested in 1973, that the alkaline intrusives along the coast of southwestern Africa occurred where oceanic fracture zones extended under the adjacent continents. Recently Williams and Williams[2] have used this suggestion to attempt to explain the origin of the West African kimberlites. Their interpretation rests heavily on the accuracy of kimberlite and transform fault locations in their Fig. 1, on the assumption of Mesozoic ages for all of their kimberlites, and ignores the important occurrences in the same region of pre-Mesozoic kimberlites and alluvial diamond deposits.

Williams and Williams' hypothesis assumes West African diamond deposits to be Mesozoic, whereas the deposits in Ghana, Upper Volta, the Ivory Coast and Mali are Proterozoic or Infracambrian[3–8]. Their reference to kimberlites in Ghana is incorrect. Their location of a 'kimberlite' in Ghana fits the location of a few diamonds in a stream panning exercise[3] while the largest diamond fields of West Africa (placer), located in southern Ghana, are omitted. Their 'kimberlite' in Nigeria is a lamprophyre dyke located between Zaria and Sokoto (P. J. T. Verheijen, personal communication). Likewise, their postulated inland continuations of transform fault zones contradict without explanation the generally accepted trends[9] of these zones: the Chain and Charcot into the Benue trough,[9] the Romanche into the Keta basin bearing toward Ibadan,[9,10] and the St Paul entering the Ivory Coast east of Sassandra bearing ENE[9,10]. Thus the ages and locations of kimberlites as well as the positions of transform faults and their postulated landward continuations used by Williams and Williams[2] disagree with those established in the literature, with no explanation for this disagreement.

The geographical pattern of kimberlite pipes and the larger diamond placers can be more accurately interpreted (Fig. 1) as occurring along a primary arc running from Ghana through the Ivory Coast and Liberia to Sierra Leone[11]. In such a case the occurrence of young kimberlites is brought into coincidence with all of the much older kimberlites and alluvial deposits in the same general region. In addition there is a possibility of a second, roughly parallel arc extending from northern Ghana through Upper Volta, the Ivory Coast, Mali and Senegal. Known ages of major deposits along the primary arc include the diamonds contained in and above Birimian meta-sediments (2,200 Myr) in Ghana[3,4], the Seguela and Kanangono kimberlites (1,429 Myr) in the Ivory Coast[5,7], and the Sefadu and Koidu kimberlites (140–92 Myr) in Sierra Leone[6]. Along the second arc, the Kenieba kimberlites of Mali have been dated at 1,072 Myr (ref. 5). The geology of these deposits and the age determination techniques and results are discussed elsewhere[3–8]. Such a long history of progressive east to west arcuate diamond-bearing belts requires more than an association between Mesozoic kimberlites and post-Palaeozoic ocean fractures.

An equally viable explanation might be the existence of a long-lived mantle

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