Molluscan extinction rates in question

SIR—The Palaeogene molluscan record of the North American Gulf Coastal Plain rivals that of the Paris Basin and provides an excellent database for studies of extinction and speciation events. Palaeocene and Eocene molluscs of this basin are documented in the catalogue of Palmer and Brann[1]. Recent monographs on Early Oligocene molluscs[2,3] provide a basis for studying faunal changes across the Eocene/Oligocene boundary. In their review, Hut *et al.* cite[4] stepwise extinction of molluscs across the Gulf Coast Eocene/Oligocene boundary as evidence for multiple cometary impacts. But they overstate the significance of these 'stepwise' extinctions, which occur between successive formations, in view of Palaeogene extinction rates in the northern gulf as a whole.

The average molluscan extinction rate between successive formations in the northern gulf Palaeogene is 70% (on the average 50% of a formation's fauna are known only from that formation). This rate increases to 95% at group/stage boundaries. The first and third steps of the Hut *et al.* molluscan extinctions correspond respectively to the Claiborne/Jackson and Jackson/Vicksburg group boundaries. Extinction rates cited within the Jackson Group between the Moodys Branch and Yazoo Formations were 72% for gastropods and 63% for bivalves. These rates are in line with the Palaeogene interformational average.

High molluscan extinction rates occurring at group/stage boundaries in the North American Gulf Coastal Plain are associated with major marine regressions[5] that subdivide the Palaeogene sequence. These regressions were accompanied by periods of delta progradation and increased shelf turbidity. A change in the shelf environment from a clear-water, sandy-bottom shelf to a turbid, muddy-bottom shelf adversely affected most of the molluscan species and was a probable cause of their demise.

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HANSEN REPLIES—Dockery is correct in that average interformational extinction rates in the Gulf Coast Palaeogene are high, but they are probably lower on average than the figures he cites. I have based my calculations on the sources cited by Dockery but I have also 'filtered' the data by including only species from the clastic sedimentary provinces of the Gulf Coast (specimens from carbonate facies are usually poorly preserved, fossiliferous formations in the Atlantic states are patchy and represent a different biogeographic province making it difficult to correlate with the Gulf Coast), eliminating all unnamed species (such as *Nuculana* sp.), and omitting all species named from a single poorly preserved specimen or in which the sole type specimen has been lost. All these criteria reduce the number of 'short-lived' species, reduce the average extinction rate and make the species more equivalent to true biological species. These adjustments reduce the mean interformational extinction rate to around 50% (from 70% cited by Dockery). In addition, it is misleading to compare the Late Eocene extinction rates with the average rate because Palaeogene extinction rates are not uniformly high. Rather they are high during the Early Palaeocene (60–70%), possibly because of high faunal turnover in the wake of the Cretaceous–Tertiary extinctions[1], high near the Palaeocene–Eocene boundary (around 80%), low through most of the Middle Eocene (around 25%) and high approaching and during the Late Eocene (70–90%). The fact that extinctions tend to be particularly high near some group/stage/epoch boundaries is not surprising because these boundaries have been named in part precisely because of high extinctions and the resulting faunal changes.

The Late Eocene molluscan extinctions have not yet been studied in the microstratigraphic detail characteristic of the Cretaceous–Tertiary boundary, but they are 'stepwise' in that rather than a single abrupt extinction at the Eocene–Oligocene boundary (a common impression given by literature studies of this extinction[2]), the molluscs undergo a series of accelerated (higher than average) extinction episodes starting at the Mid–Late Eocene boundary and continuing to the Eocene–Oligocene boundary[3]. The immediate cause of these extinctions has been debated already[3–6]. Dockery's choice of local shelf turbidity as a primary control is a poor one because the molluscan extinctions tend to be selective for warm-water taxa, and not for taxa intolerant of high turbidity, and they broadly correlate with stepwise extinctions among the planktonic foraminifera from deep-sea Atlantic cores[1,6,7].

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Cometary organics

SIR—Chyba and Sagan write[1] "Hoyle and N. Wickramasinghe compare the 3–4 μm spectrum of comet Halley obtained at the Anglo-Australian telescope by D. Wickramasinghe and Allen with the prediction of a bacterial model. We believe that the agreement between the two provides no evidence of cometary bacteria".

When a pre-existing theory turns out to fit very well to later observations is this really "no evidence"? If so, science is nowadays being prosecuted according to principles very different from those used in the past, when such an agreement was construed as positive evidence for the theory, although whether could be considered to prove the theory was of course another question.

Chyba and Sagan ask for a more explicit statement of our "modelling procedure". Our emission curve[2,3] was essentially calculated from the formula $A\tau(\lambda)B_{\lambda}(T)$, where A is a normalization constant adjustable to fit the quantity of material around comet Halley, $\tau(\lambda)$ is the measured emissivity of bacteria already published several times[4], and $B_{\lambda}(T)$ the Planck function, with T given as 320 K.

Subsequent refinements to this model have taken account of a size distribution of grains and used the Mie formulae to calculate both the scattering background and the distribution of grain temperature under various conditions[5]. The correspondences shown earlier were not significantly altered by these later refinements.

Other points raised by Chyba and Sagan are based on the conception that a particular unchangeable grain model should be capable of explaining observations made at different times. Because of the sporadic activity of the comet, however, no one grain model can be expected to explain all the observations at all times. Our initial arguments applied specifically to the situation on 31 March 1986. On that occasion the observations of D. Wickramasinghe and Allen emphasized those particles that had the best ability to absorb sunlight in the visible region of the spectrum, as only particles that become heated through absorption in the main part of the solar spectrum would have been able to radiate appreciably in the 3–4 μm region of the infrared. Such absorption would be conveniently explained quantitatively by pigments, which could vary considerably between different particles (especially between organic and inorganic particles), and which would probably change with time as the pigments were exposed progressively to solar ultraviolet light.

Chyba and Sagan say that an attempt "to explain the spectrum of comet Halley with living organisms or their products seems an extravagant departure from Occam's razor". Why? We know that some 10^{14}–10^{15} kg of organic material is produced

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