entire North Atlantic was not warranted. In contrast, PCB concentrations have been measured regularly in the North American Basin during 1972–75. As this is the closest ocean basin downwind of the US industrial complex the large decrease observed there between 1972 and 1973 may only reflect changes in the North American PCB input and may have been the most rapid in the North Atlantic.

We intend to measure PCB concentrations north of 50°N during 1975 in waters more within the influence of European PCB losses.

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Avian vision

IN an article[1] on the visual control of head movements by walking birds, Friedman quotes me as maintaining that a bird's head moves backwards as well as forwards during walking. This is not so. In 1931 observation of hens had shown me that, as Friedman has proved for pigeons, the head of a walking hen is thrust forwards as rapidly as possible and then remains stationary while the body of the bird catches up. It seemed to me quite clear that this enables the hen to have a succession of sharply defined pictures of its environment rather than the continuously slightly fuzzy picture which would be obtained from steadily moving eyes.

Humans circumvent this problem differently. They fix visually upon a succession of points for varying times according to their momentary interest, and use a reflex capacity to control eye positions to compensate for bodily movement.

Most birds have a much larger area of high definition than humans, backed by a much less versatile data processor, and may find it advantageous to attend only to those objects in their environment that are moving independently. These can be distinguished from a complex background only when the eyes are stationary with respect to that background and are not confused by the apparent backward displacement of the nearer objects which will occur as a result of parallax while the eyes are moving.

In my article[2] I was not concerned at all with the head movements of walking birds but with the frequent up and down movements of the heads of stationary birds. This, I suggested would not only give feeding birds longer ranges of vision—which it by no means always does—but would enable birds to use parallax to obtain a three-dimensional picture of their surroundings.

Binocular stereopsis is available to most birds, with their sideways-looking eyes, only over a very narrow field of forward vision, and with an extremely short 'baseline' between the eyes. Observation of the changes of the retinal image as a bird raises and lowers its head, however, provides the bird with a much longer baseline and gives the possibility of three-dimensional vision over the whole field of view of both eyes—often nearly 360°.

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Plume spacing and source

SINCE the average distance between island-arc volcanic centres (~70 km) is approximately equal to the depth to the magma source (~100 km), Lingenfelter and Schubert[1,2] have suggested that the typical distance between hot spots (~3,000 km) is approximately equal to the depth to their source. Thus, they infer that the region of instability giving rise to the initially solid plumes of mantle material is near the core–mantle boundary. Certain fluid dynamic results may show this inference to be untenable.

In the case of island-arc volcanism[3], andesitic magma is generated along the Benioff Zone at a depth of about 100 km. The magma is much less dense than the overlying peridotitic mantle material and this two layer system, andesitic magma beneath peridotitic mantle, is gravitationally unstable. This situation is analogous to that of a layer of oil underlying a layer of water, and represents a type of fluid instability commonly known as Rayleigh–Taylor instability[4–6].

When perturbed from equilibrium, the less dense, lower fluid penetrates the overlying fluid at discrete and, ideally, evenly spaced points. This is the case in both two and three dimensions[4,5]. The characteristic wavelength of instability is dependent on the depth to the source layer (or thickness of the upper layer) only if the thickness of the source layer is greater than one tenth of the depth to the source[7]. That is, once the upper layer is 10 times thicker than the lower buoyant layer the dominant wavelength of instability is independent of the depth to the buoyant layer. In island arcs, judging from the exceedingly small quantity of lava observed at the surface, the thickness of the magmatic layer is, surely, much less than 10 km. For those cases, the spacing of the volcanic centres is given by[4]

$$\lambda = (2\pi h_2/2.15)(\eta_1/\eta_2)^{1/3}, \text{ for } h_1 > 10h_2$$

where: λ = the dominant wavelength or spacing of volcanic centres; h_1 = the thickness of higher density layer; h_2 = the thickness of lower density layer; η_1 = the viscosity of denser layer (mantle); η_2 = the viscosity of lighter layer (andesitic magma).

By estimating roughly the contrast in viscosities ($\eta_1/\eta_2 = 10^9$), and from the observed spacing of the volcanic centres (~70 km), the magma layer in the case shown was probably a few tens of metres thick at the time of instability.

In the case of plumes, assuming, as did Lingenfelter and Schubert[1], that the process of instability is similar to that operative in island arcs, if the source layer is near the core–mantle boundary it must be greater than about 300 km thick for the plume spacing to reflect the depth to the source (that is, 3,000 km). Seismic evidence seems to indicate that a low density layer of this thickness cannot be present in the lowermost mantle. On the other hand, if it is assumed that the depth to the buoyant layer, wherever it is, is greater than 10 times the thickness of the buoyant layer itself, the thickness of that layer can be calculated from the relationship given already. For λ = 3,000 km and $\eta_1/\eta_2 = 10^3$, the buoyant layer thickness is about 100 km, whereas for $\eta_1/\eta_2 = 10^6$ it is about 10 km. A layer 10–100 km thick could be located seismically. Since the existence of a low density layer is a necessary condition for this type of fluid instability, which seems inherent in the plume theory as envisaged by Morgan, it is of paramount importance to ascertain its presence.

In conclusion, the distance between island-arc volcanic centres tells us little about the depth to the magma source and this is also probably true for the spacing between plumes if they arise from a Rayleigh–Taylor type fluid instability.

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