Mantle plumes and hotspots

HARRISON AND LINDH[1] have recently reported a new determination of the relative motion between the geomagnetic frame of reference and the hotspot frame of reference. While I do not disagree with their approach, I would like to point out that the hotspot frame of reference is not necessarily the same as the mantle plume frame of reference which is the frame of more fundamental geophysical significance. As pointed out by Harrison and Lindh, a hotspot is the surface manifestation of a mantle plume. Recent work by Whitehead[2] has shown that when a rising plume passes through a region of shear, the plume can be deflected by as much as 60° from the vertical. For the Earth, where shear in the mantle may be occurring at a depth of 100–200 km, the geological features which are interpreted as the hotspot may be displaced 175–350 km from the location of the corresponding plume in the mantle. This displacement of 1.5–3.0° will not be important if the plate moves uniformly over the mantle plume. However, in their analysis, Harrison and Lindh dealt with data from the past 200 Myr. During this time, major reorganizations of plate motion have occurred so that significant errors can arise if the location of a mantle plume is assumed to be the same as its associated hotspot. For example, in the case of a plate whose direction of motion changed by 90°, the hotspot associated with a stationary mantle plume would exhibit an apparent displacement of 2.5–5.0° with respect to the geomagnetic frame of reference.

While these considerations do not alter the conclusions of Harrison and Lindh, they do emphasize the fact that there can be significant differences between the frame of reference defined by the location of hotspots and the frame of reference of the mantle plumes which give rise to them.

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HARRISON AND LINDH REPLY—The mechanism suggested by Verosub is certainly possible, and as he indicates would tend to degrade the information about mantle plume movements, especially during times of changing patterns of plate motion. However, it is possible that plumes may rise much faster than the simple Stokes' law equivalents used by Whitehead[1]. This can happen if there is significant heat transfer between the rising hot blob and the higher viscosity mantle material surrounding it, causing the mantle material close to the blob to become less viscous. In this case, the hot blob may rise at a rate much greater than that calculated from the simple Stokes' law equation. What is more, it is possible for the hot blob to ascend a large distance through the mantle while remaining essentially molten. These conclusions were reached recently by Ribe[2].

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Two cubic phases in monoolein–water system

LONGLEY AND MCINTOSH[1] have given convincing evidence for the existence of a cubic phase with a primitive lattice in the monoolein–water system, the structure proposed consists of a lipid bilayer forming a tetrahedral periodic minimal surface which separates two water channel networks. According to earlier work[2] the cubic monoolein–water phase forms a body-centred lattice. I now show that there are, in fact, two cubic phases in this binary system, one with a body-centred lattice at low water content and another with a primitive lattice at high water content.

Our structure analysis in the monoolein–water system was based on NMR diffusion measurements and X-ray diffraction changes at the transition from a lamellar liquid–crystalline phase to a cubic phase obtained by heating at a low water content[2]. The X-ray diffraction lines observed there were in agreement with a body-centred lattice, and as all cubic samples prepared over the whole composition range appeared homogeneous, the other X-ray data were indexed according to the same lattice. The demonstration of the existence of a primitive lattice[1] has initiated a more thorough analysis of the X-ray data, and the new indexing of our earlier published X-ray data[2] is given in Table 1. The X-ray data of samples with 34.93 and 39.87% (wt/wt) of water are in perfect agreement with the data reported by Longley and McIntosh[1]. Note that the spacings and intensities at 20.05 and 29.79% (wt/wt) of water are in agreement with the data of the body-centred cubic phase described by Luzzati *et al.*[3]. The transition between the body-centred and primitive lattice at 22 °C takes place at a composition in the range 30–35% (wt/wt) of water.

Table 1 New indexing of the X-ray diffraction lines recorded at 22 °C from cubic monoolein–water phases of different compositions.

Body-centred lattice[2]						Primitive lattice[4]					
25.05% (wt/wt) water			29.79% (wt/wt) water			34.93% (wt/wt) water			39.87% (wt/wt) water		
d 1(Å)	(*hkl*)	a_{calc} (Å)	*d* 1(Å)	(*hkl*)	a_{calc} (Å)	*d* 1(Å)	(*hkl*)	a_{calc} (Å)	*d* 1(Å)	(*hkl*)	a_{calc} (Å)
48.9	211	119.8	54.5	211	133.5	59.8	110	84.6	64.2	110	90.8
42.2	220	119.4	47.0	220	132.9	49.3	111	85.4	52.2	111	90.4
32.8	321	122.7	36.1	321	135.1	43.4	200	86.8	46.0	200	92.0
30.8	400	123.2	33.9	400	135.6	35.2	211	86.2	32.6	220	92.2
27.3	420	122.1	30.1	420	134.6	30.3	220	85.7	30.7	221	92.1
26.1	332	122.4	29.1	322	136.5	28.7	221	86.1	29.3	310	92.7
25.0	422	122.5				27.1	310	85.7			
24.1	431	122.9									

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