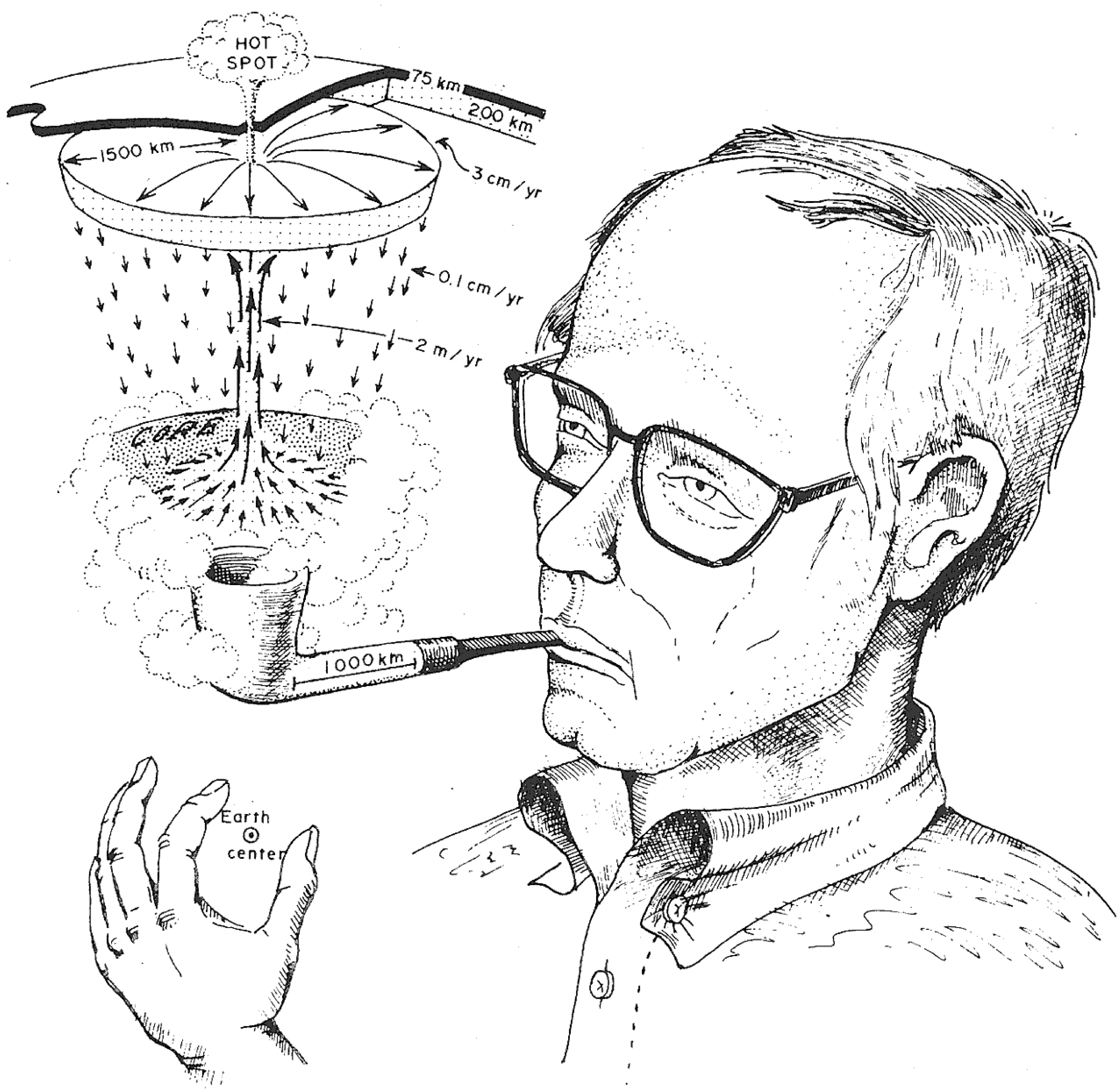

Fig. 1. Conception of the mantle plume theory, adapted liberally from W. J. Morgan (unpuffed data, 1977).

Graphic Solutions to Problems of Plumacy

John C. Holden and Peter R. Vogt

Preface

The mantle plume is just the youngest member of a big and colorful family of geological fads and fashions: diluvialisms and catastrophisms, earths expanding and contracting, global tectonics new and old. Some of these fads have become bandwagons rolling from theory to fact. Others are intellectual white elephants gathering library dust. We do not know yet how the mantle plume will fare; certainly it has not quite attracted the bandwagon that the new global tectonics did.

Since plumes are better hidden from observation than plates, it may take years to prove or disprove their existence. This is just as well—one cannot write a research proposal to prove that the earth is round or that the continents drift.

In this paper we hope to cut through the hullaballoo surrounding mantle plumes by offering a graphic commentary on the 'hot' topic. Any resemblance between persons or deities depicted here and those living or dead may or may not be coincidental. If kings and statesmen fall to the cartoonist's pen, why not scientists, their students, instruments, and Mother Earth herself?

Introduction

It was *Wilson* [1963] who first suggested that hot spots were fixed in the upper mantle and created aseismic ridges as crustal plates moved over them. This idea was expanded to include a mechanism that would also

Order of authors is alphabetical.

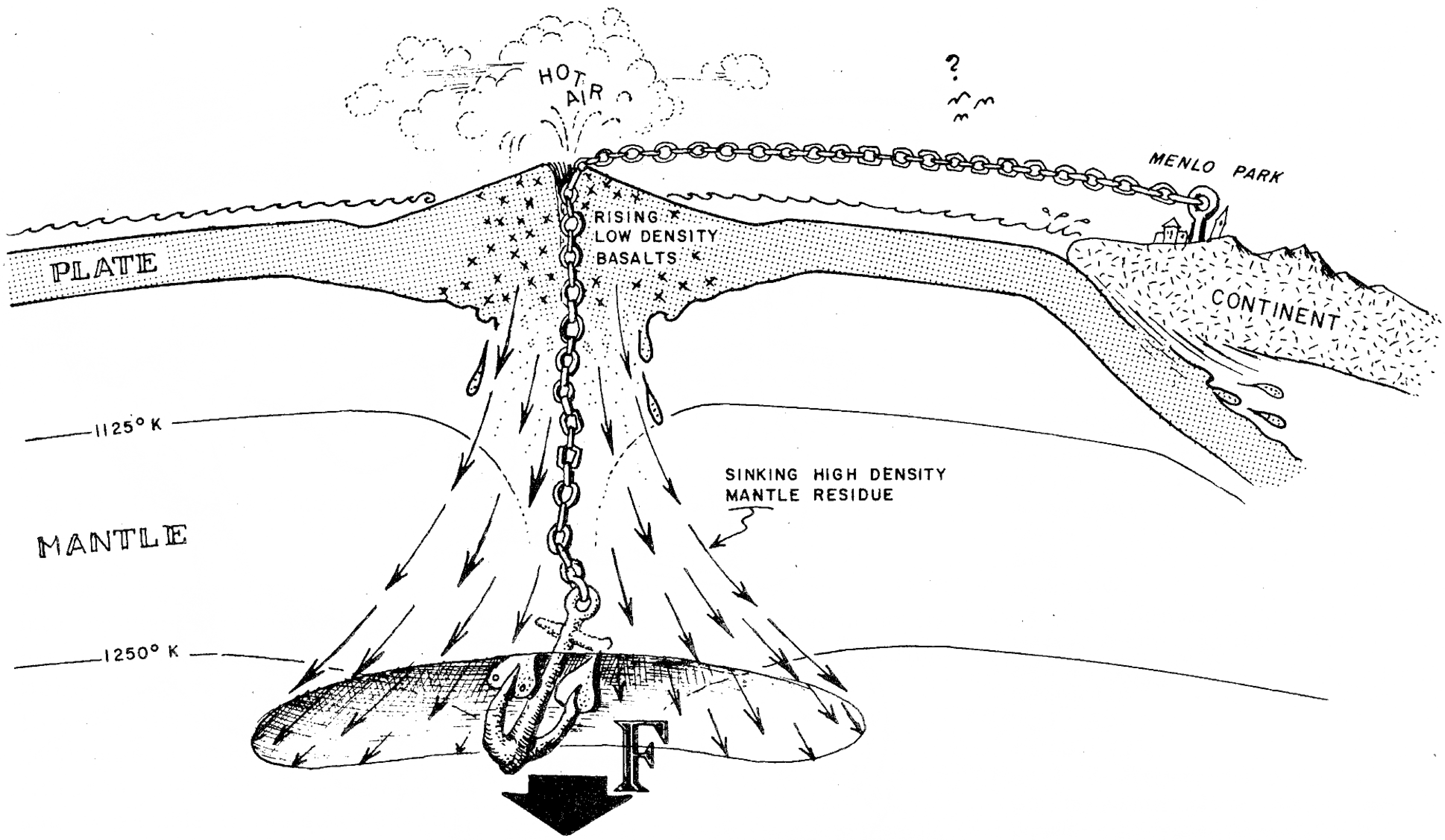

Fig. 2. Gravitational anchor theory, showing the origin of Hawaii [*Shaw and Jackson*, 1973]. According to this hypothesis, even the motion of California can be explained (although the motions of Californians remain as mysterious as ever).

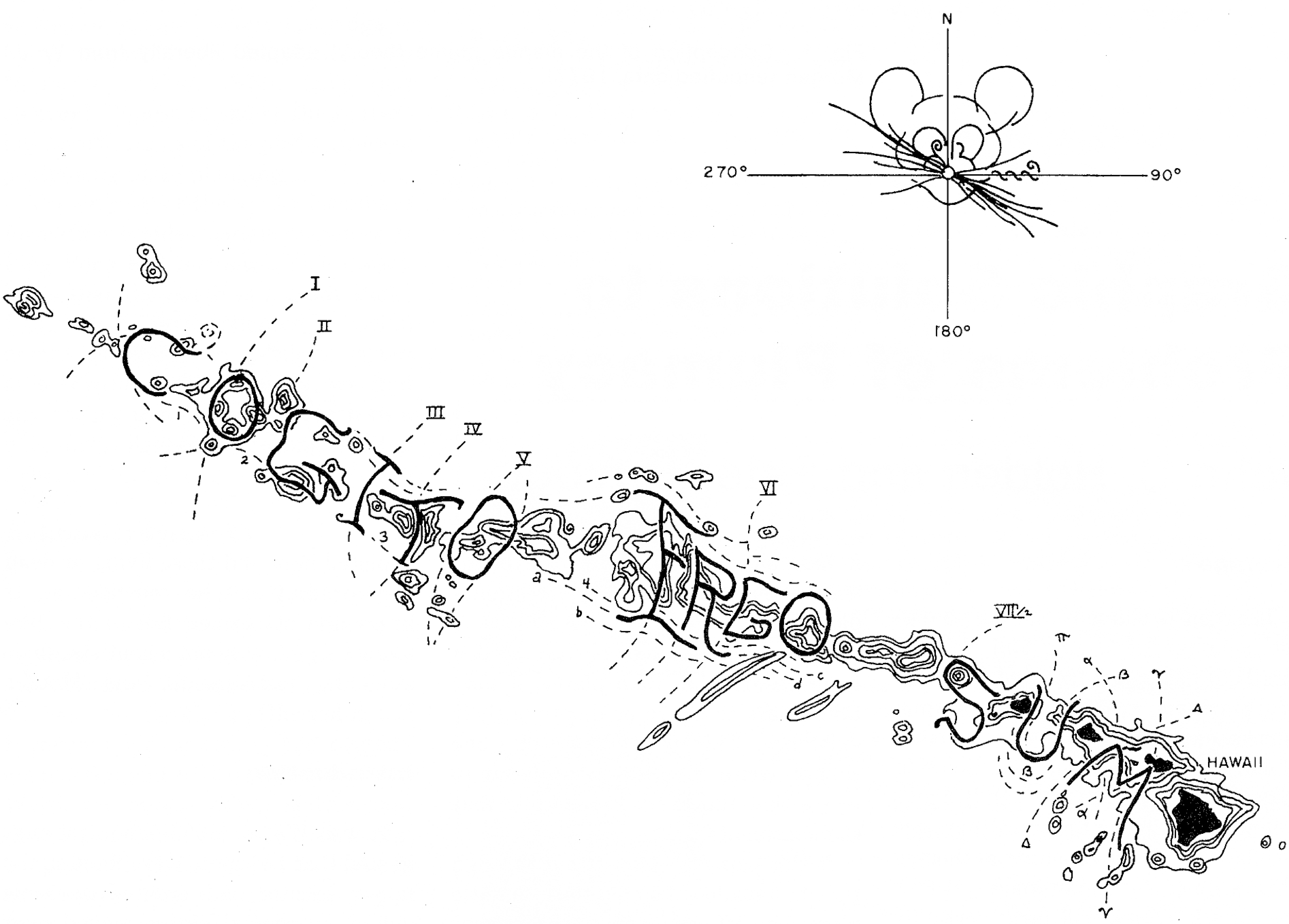

Fig. 3. Stress field lineations plotted from volcano distribution along the Hawaiian chain. The geophysical relevance of the message spelled out is a matter of intense debate.

account not only for hot spots but also for the causal forces of plate tectonics and continental drift. In short, it was proposed that ascending convection plumes exist in the deep mantle below active hot spot volcanism [*Morgan*, 1971, 1972]. Geometrically, these features are toroidal cells with narrow (200–300 km wide) vertical axes through which hot material is transferred from the lower to the higher regions in the mantle.

An entire science has developed around the study of plumes, albeit perhaps no more scientific than social, spiritual, or political science. If the concept is valid, then most first-order features of the earth's surface may be attributed directly or indirectly to plumes. We term this discipline 'plumacy,' its practioners 'plumatics' (also 'plume freaks'). Recognizing the parallels between religious and geological faiths, we also propose the term 'aplumatics' for those who do not believe that mantle plumes exist; we carry over the term 'agnostic' to apply to all those fainthearted earth scientists who refuse to debate the issue on grounds that the existence or nonexistence of mantle plumes cannot be proved since the terms are not defined. This position is untenable, since the definition and etymology of the word plume has been published in the geological literature [*Anderson*, 1975]. Because he is a little-known author (just one of the numerous Andersons in earth science) publishing in an obscure journal, it is worthwhile to reproduce his definition here.

Tozer [1973] has objected to the use of the word 'plume' because of prior usage and connotations. However, the various definitions of 'plume' and its antecedents in French, Latin, and German seem to provide enough flexibility to describe the phenomenon, its implications, and its raison d'être on the one hand and its inventors, supporters, and detractors on the other: *Plume* (English, from French and Latin, pluma)—a feather, a long handsome feature, a token of honor or prowess; a prize, to pride or congratulate; to preen. *Plombe* (Germanic)—a plug. *Plombe* (Old English from West Germanic)—something especially desirable, as a good position. panache (French)—trail, stripe, swagger; fumée (French)—smoke, fumes, steam; fumer (verb)—to fume, to dung, to manure; plumitif (familiar)—scribbler, pen-pusher.

We leave the definition of hot spots (also called melting spots and melting

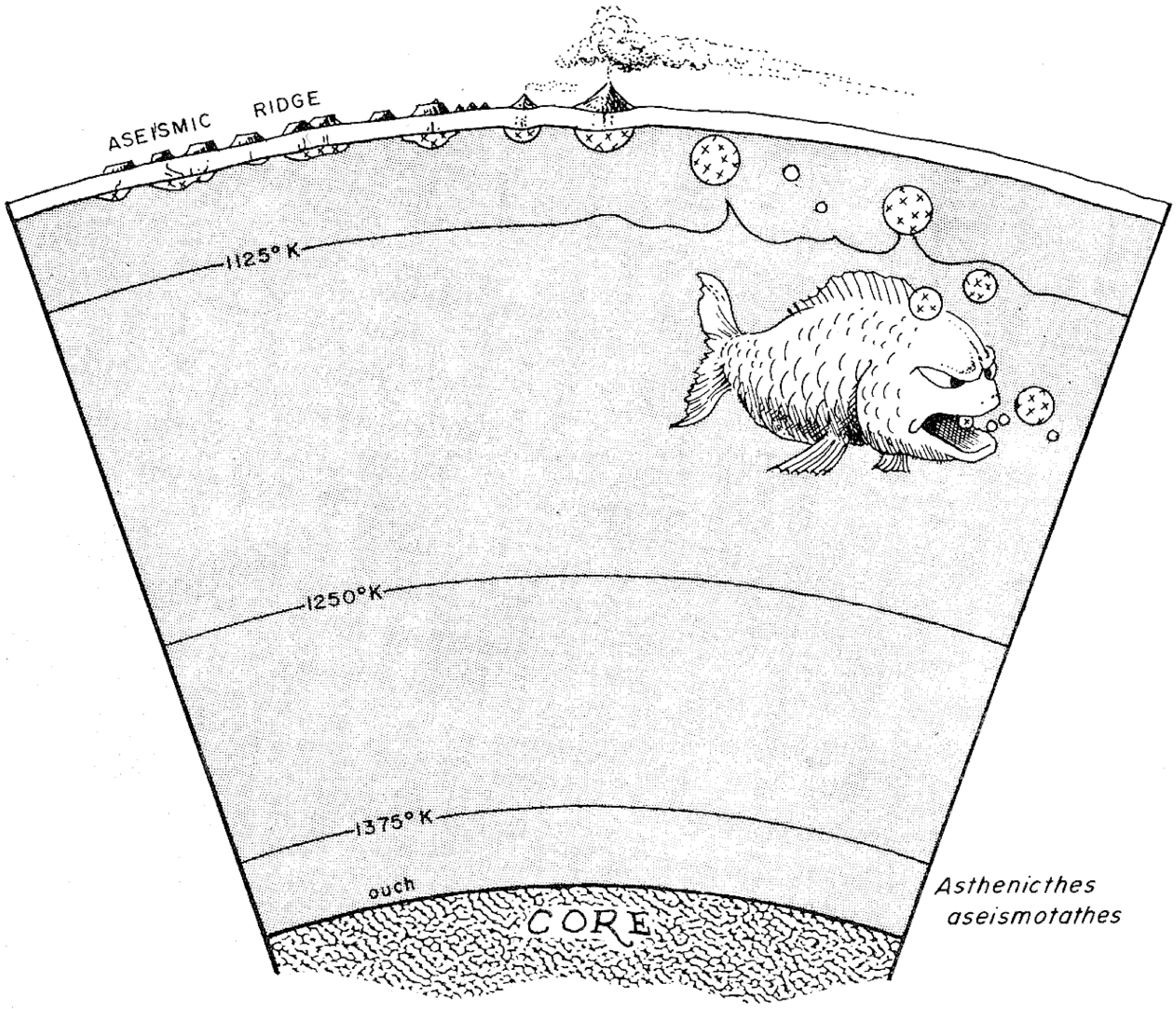

Fig. 4. Alternative to the mantle plume theory (based on an ancient Japanese legend).

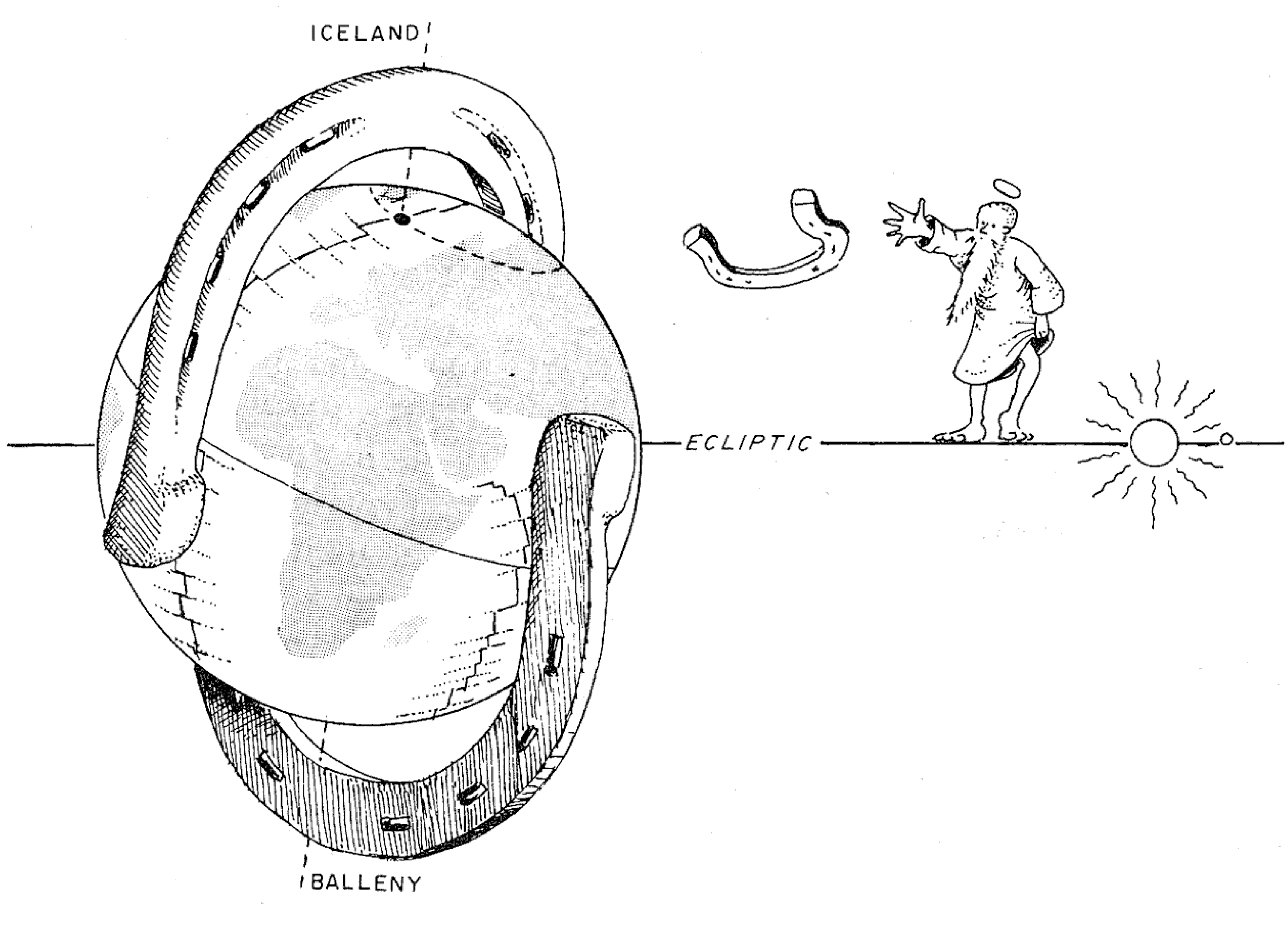

Fig. 5. Schematic of a theory for the origin of midoceanic rifts, hot spots, the solar system, creation, and God.

anomalies) as an exercise for the reader.

Plumes, Antiplumes, and Other Explanations for Hot Spots

Plumes are often invoked to explain the source of the force causing sea floor spreading and plate motion. Unfortunately, no airtight case has been made for the cause of the plumes themselves, and the original problem of where it all begins is not solved but merely pushed deeper into the earth's interior. Therefore we must in all fairness discuss not only mantle plumes but alternate theories put forth to explain hot spots.

One wonders what was being smoked when the plume concept was formed (Figure 1). It is a well-known dictum in geopolitics that for popular acceptance the terms one chooses are equally as important as the ideas themselves. Therefore when the plume concept was under construction, the stem of the plume was cleverly dubbed a pipe, which immediately brings to mind kimberlite pipes of mantle origin. . . Bingo, a winner! After all, it is much more propitious for material to move 'up the pipes' than to go 'down the tubes.' However, to suggest that the term pipe was picked only for its public relations value is not entirely fair. After all, when geophysicists conceptualize, they habitually use the stems of their pipes as a scale for relative proportions. So it is only logical that the stem of a plume should be called a pipe; Q.E.D.

A few years after the plume idea was out, *Shaw and Jackson* [1973] proposed a slight modification of it in their gravitational anchor theory (Figure 2). According to this scheme, dense crustal residues are sinking beneath Pacific hot spots at the eastern ends of the Hawaiian, Tuamoto, and Austral chains as low-density basaltic magmas are distilled out and up to form the spot on the hot spot. The geometry of this specialized convection cell is that of an upside-down plume, or antiplume as it were. Shaw and Jackson are absolutely correct in assuming that these anchors do not drive the plates but rather act as pinning points. We presume that the chain (not the volcanic chain) attached to the anchor (and nowhere discussed by the original authors) extends out of the orifice of the volcano. Where it goes after that is uncertain; perhaps it

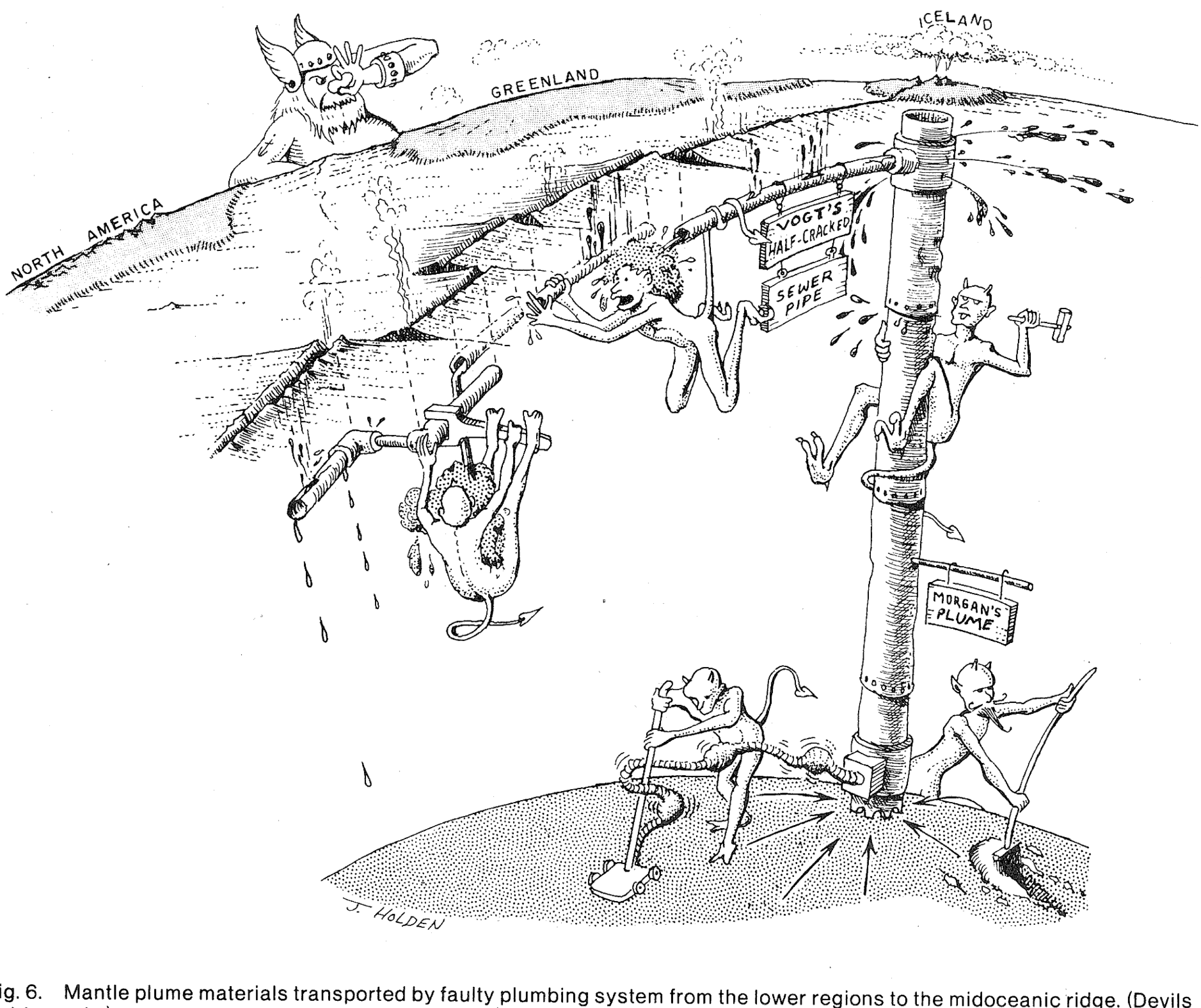

Fig. 6. Mantle plume materials transported by faulty plumbing system from the lower regions to the midoceanic ridge. (Devils not to scale.)

is attached to the nearest continent, and if it does not drive the oceanic plate, it pulls the continent over it. Because this theory accounts for the large shield volcanoes at Hawaii and elsewhere, gravitational anchors are associated with an abundance of tephra-laden hot air that often tends to obfuscate a clear understanding of these features.

On occasions when the clouds do clear somewhat, some authors can identify stress fields in the Hawaiian chain (not the anchor chain) indicating the stress of the anchor [*Jackson and Shaw*, 1975]. They define two stress fields, a Polynesian and a Hawaiian field. We see that a third pattern and a reassessment of all three fields yields a remarkable phenomenon (Figure 3). Carefully plotting the three lineation sets actually spells out this fact, and in Latin, no less. We misinterpret these data to read, 'We think, therefore they exist.' The mouse diagram showing trend bearings about an imaginary center marks the overall trend of the Hawaiian chain (the volcanic chain, not the anchor chain).

Plumes, antiplumes, and propagating fractures are certainly not the only possible explanations for features such as the Hawaiian chain. Ancient legend has it that the island of Japan is situated atop a giant carp and that every time the beast shifts position Mount Fuji erupts. As most legends have some basis in fact, we propose that this creature also finds its home throughout the viscous asthenosphere (Figure 4). Could it be that as it swims, at a rate of only a few centimeters per year within the mantle, it leaves behind a buoyant trail of tholeiitic bubbles which rise ponderously to create aseismic ridges? We name this fish *Asthenicthes aseismotathes*, or the asthenospheric fish that makes aseismic ridges. No doubt there are some who would question our taxonomy and would want to call the species a form of crappie. Readers may find something fishy about this theory, but then there is at least something fishy about the other theories as well.

How plumes are oriented, orifice up or orifice down, awaits future adjudication. On the other hand, we can make some definite statements

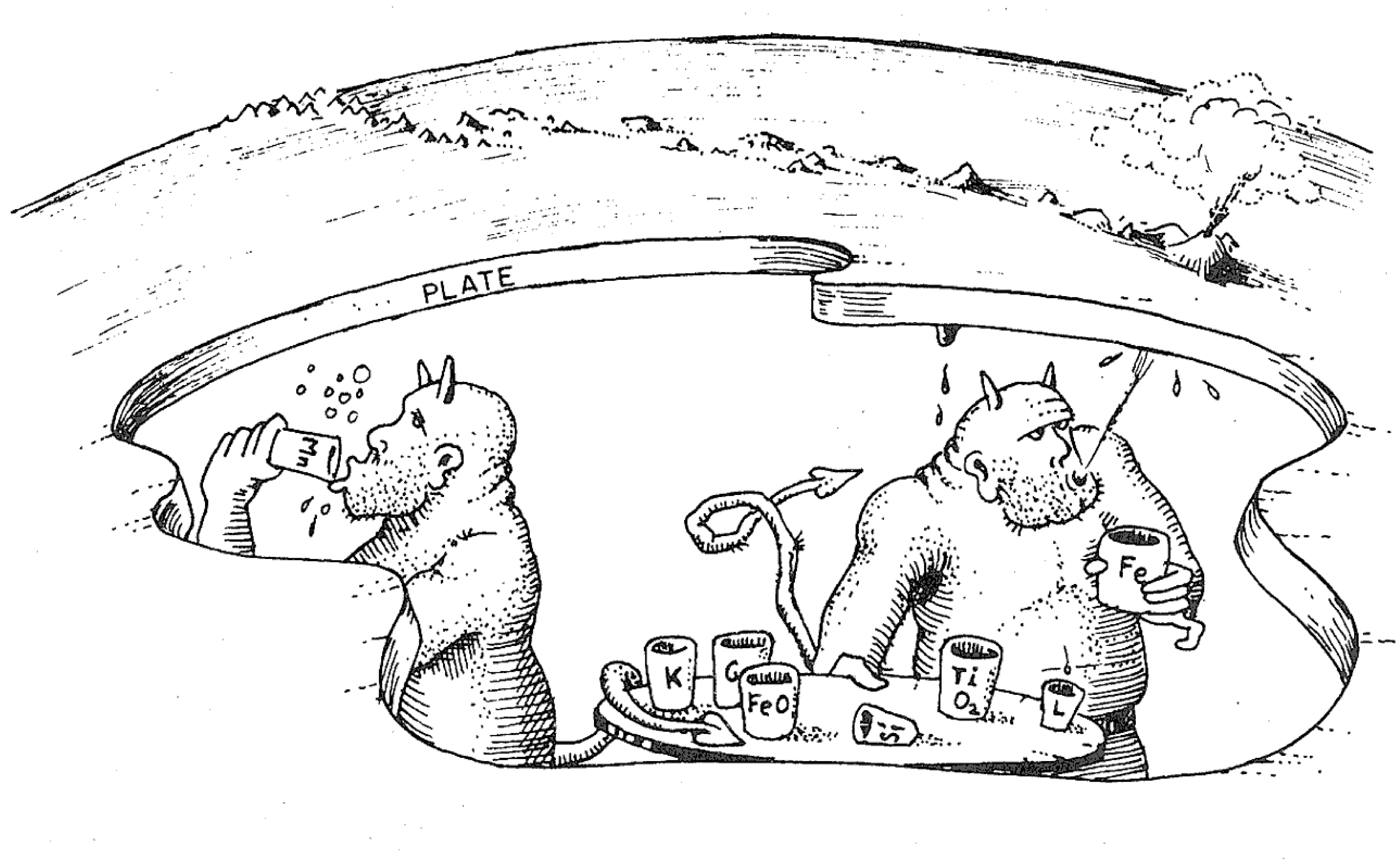

Fig. 7. Strange chemistry of ocean island tholeiites, hawaiites, balonites, and similar hot spot generated rocks, attributed to the culinary habits of X. Vulcan et al. (regurgitated material, in preparation, 1977).

about the distributions of plumes. There are, for example, two plumes on the Arctic and Antarctic circles, namely, Iceland and Balleny Islands, respectively. If Balleny Islands are, in fact, a plume, as *Morgan* [1972] predicted, it is nearly perfectly antipodal to the Iceland plume [*Holden*, 1976*a*]. If these two hot spots are taken as midpoints of the two world rift systems, the rifts have an interesting relationship to each other, as shown in Figure 5. One supposes that this proves the athletic excellence of the Creator, for the game is certainly horseshoes, and He has scored two perfect ringers. It would seem that this particular game has been going on for at least 200 m.y. if the rift margins of Antarctica are any indication. This continent has been located at the south pole since Pangaea broke apart, and its rift margins are all close to the Antarctic Circle [*Holden*, 1976*b*]. Unfortunately, this only accounts for two plumes; we leave it up to the reader to devise explanations for the distribution of the remaining 120.

How Many Plumes?

Mantle plumes are in the midst of a population explosion that threatens to engulf the earth in a volcanic catastrophe [*Vogt*, 1972]. The facts speak eloquently for themselves—no need to consult the Club of Rome. In 1971 there were 20 plumes [*Morgan*, 1971, 1972]; in a mere half decade the population has risen to no less than 122 [*Burke and Wilson*, 1976]. Our extrapolations from these data show that there will be 1,000,000 hot spots by the year 2000. We hope someone proves that hot spots do not exist, before it is too late.

Cracked Sewer Pipes

If mantle material rises below Iceland, it must somehow spread out from the top (head) of the plume. Presumably, the flow occurs primarily in the asthenosphere below the plate. *Vogt* [1971, 1974] and *Schilling* [1973, 1975] have suggested that this flow is concentrated in the bidirectional pipe formed below the spreading axis as a result of extensive partial melting and lowered viscosity there (Figure 6). This slightly tilted 'cracked sewer pipe' flushes away the material rising in the stem of the vertical pipe.

The sewer pipe is cracked (or, more exactly, half-cracked like its author) in the sense that tholeiitic magmas must rise vertically to feed the constantly accreting oceanic crust. To further complicate matters, transform faults offsetting the spreading axis also offset the subaxial conduit, thus creating transform dams [*Vogt and Johnson*, 1975]. Despite all this faulty plumbing the conduit can do it, beHolden though it is to numerous mantle demons (Figure 6). Fluctuations in plume discharge down the cracked sewer pipes are thought to