that correspond to the expanded DAPI image are used to represent background fluorescence and are used as the intensity origin.

7. GMO1723 (45,XO), GM08399 (46,XX), GMO4626 (47,XXX), GMO1415E (48,XXXX), and GMO5009B (49,XXXXX) from the National Institute of General Medical Sciences (NIGMS) repository (Camden, NJ).
8. H. S. Smith *et al.*, *J. Natl. Cancer Inst.* **78**, 611 (1987). According to the published karyotype, 600PE contains only one normal copy of chromosomes 1, 9, 11, 13, 16, and 17 and has five marker chromosomes: t(1q:13q), 1p-(p22), inv(11)(p15q13), t(9q:17q), and inv(1)(p36q21). FISH of 600PE interphase nuclei and metaphase chromosomes (*9*) showed two signals with 16p cosmid probes and one signal with 16q cosmids. The other 16p signal was located on the second marker chromosome, which indicates that this marker had been misclassified by conventional cytogenetic analysis and was actually a t(1q:16p).
9. M. Sakamoto, personal communication.
10. GMO5877 and GMO1142A come from the NIGMS repository (Camden, NJ).
11. K. W. Kinzker *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **83**, 1031 (1986).
12. C. Saint-Ruf *et al.*, *Genes Chrom. Cancer* **2**, 18 (1990); S. Bruderlein, K. van der Bosch, P. Schlag, M. Schwab, *ibid.*, p. 63.
13. We thank H. S. Smith and L. Chen for supplying 600PE DNA, M. Sakamoto for mapping the chromosome 16 deletion in 600PE cells, P. Kyrölä for technical assistance, and the Los Alamos National Laboratory for chromosome 16 cosmids. This work was funded by the Office of Health and Environmental Research, Department of Energy, under contract DE-AC-03-76SF00098, and NIH grants CA 45919, CA 44768, and CA 47537 as well as by Imagenetics Inc. (Naperville, IL). A.K. and O.-P.K. have received support from the Finnish Science Academy, Finnish and Pirkanmaa Cancer Societies, Lahtikari Foundation, and Pirkanmaa Cultural Foundation (Finland).

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TECHNICAL COMMENTS

Mantle Plumes and Mantle Sources

Basalts from many ocean islands define elongate arrays in Sr-Nd-Pb isotopic space; these likely reflect the dominance of binary mixing of mantle sources in intraplate volcanism. S. R. Hart *et al.* (*1*) observe that when these arrays are projected onto a ternary diagram bounded by mantle end-members DMM [depleted mid-ocean ridge basalt (MORB) mantle], HIMU (high U/Pb mantle), and EM1 (enriched mantle 1), they are subparallel and point toward a composition on the DMM-HIMU join. Hart *et al.* suggest this composition is associated with a high $^3He/^4He$ ratio (>30 R_A) and therefore cannot be a ubiquitous upper-mantle mixture of DMM and HIMU (both of which have $^3He/^4He$ < 9 R_A). They instead argue in favor of a new isotopic component, resident in a deep mantle "Focus Zone" (FOZO), which is characterized by a high $^3He/^4He$ ratio or which acquires helium with a high $^3He/^4He$ signature from the core.

There is an alternative interpretation of the He data. On the basis of binary isotope diagrams involving He, we (*2*) have suggested that the highest $^3He/^4He$ ratios are associated with intermediate $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ rather than with the highly depleted FOZO values. Mantle He-Sr-Nd-Pb systematics are consistent with five compositional endmembers—our finding of high $^3He/^4He$ Primitive Helium Mantle (PHEM) (*2*) and DMM-HIMU-EM1-EM2.

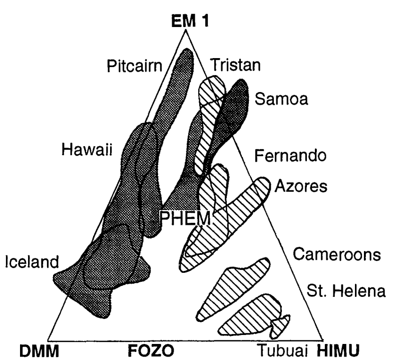

Fig. 1. Helium isotope affinity of some ocean island localities trending toward FOZO. Helium data are from standard sources [referred to in (*2*, *3*)] and our unpublished results. Striped areas indicate low ^3He; solid areas indicate high ^3He.

Combined He-Sr-Nd-Pb data are lacking for most ocean islands. However, many studies have demonstrated that ocean islands may be either "high ^3He" (all measured $^3He/^4He$ ratios ≥ MORB values) or "low ^3He" ($^3He/^4He$ ≤ MORB) (*3*). We know of no single ocean island that has $^3He/^4He$ ratios both greater and less than MORB (this also holds for most hot spot chains). Thus we can easily identify ocean islands that are tapping high $^3He/^4He$ material; if FOZO is characterized by a high $^3He/^4He$ ratio, then arrays trending toward it should be from high $^3He/^4He$ islands. We have replotted the mantle ternary (*1*) in Fig. 1 to indicate He affinities and the projection of the PHEM component into DMM-EM1-HIMU space. Many of the arrays tending toward FOZO are from low $^3He/^4He$ localities (Fig. 1), indicating that FOZO may not have a high $^3He/^4He$ ratio. We propose that some arrays mix to PHEM, and others to FOZO; isotopic relationships in DMM-HIMU-EM1-EM2-PHEM space are difficult to visualize in a ternary projection.

If FOZO does not have a high $^3He/^4He$ ratio, the need for a core or lower mantle helium source for FOZO is eliminated, and the component may be a DMM-HIMU mixture residing in the upper mantle. This has important implications for the origin and entrainment dynamics of mantle plumes. Additional studies of ocean islands, in which He is integrated with Sr-Nd-Pb, are required to accurately interpret $^3He/^4He$ ratios within the framework of the Sr-Nd-Pb mantle end-members.

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3. H. Craig, *EOS* **71**, 1669 (1990); *Caltech Plume Symposium Abstract Volume 1* (Plumacy Press, California Institute of Technology, Pasadena, CA 1991).

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Response: In our paper on evidence for lower mantle plume entrainment, we stressed the potential role that He isotopes could play in supporting or rejecting our theory. We noted the lack of published He data on many key islands, so we welcome the comment by Farley and Craig.

Unfortunately, data are needed for He *and* Sr, Nd, and Pb isotopes on the same samples, and figure 1 of the comment by Farley and Craig does not help in this respect. Pitcairn shows enormous variations

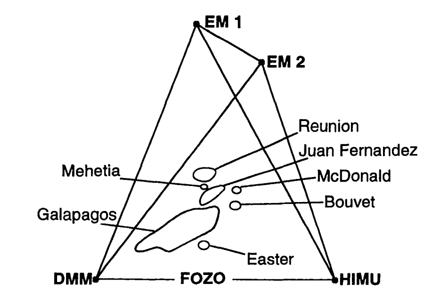

Fig. 1. Mantle tetrahedron from our report showing locations of additional high He 3/4 islands not shown in figure 1 of the comment by Farley and Craig. References for heavy isotope data may be found in (*3*); He data are from standard sources, Farley and Craig, and (*1*).

in Sr, Nd, and Pb, and we need to know if all basalts from Pitcairn are high He 3/4 and if there is a correlation such that He increases in one direction or the other along the Sr, Nd, Pb array. The Cameroon line is marked by volcanoes stretching for 1500 km, yet it is labeled "low He" by Farley and Craig, with no reference to which volcanoes were samples or where the data can be found (the data are not in their references 2 or 3, nor is the Fernando data to be found there). There are additional high He islands (Fig. 1) that extend the high He domain more toward our FOZO component.

Farley and Craig locate their PHEM mantle component from the array which their Samoa (Tutuila) data (*1*) makes on He-Sr, He-Nd, and He-206/204 Pb plots. The observed data scatter and possible curvature in these arrays would seem to allow a PHEM location near our FOZO component.

Finally, we address what appear to be several remarkable features touched on by Farley and Craig. The first is that no single island shows He isotope values both higher and lower than the typical value of 8 Ra inferred for the upper mantle from MORB. If this finding holds as additional He data are generated, it may implicate mixing of upper mantle as an important plume entrainment process. The second is the general left-right division of the DMM-EMI-HIMU mantle plane (figure 1 of the comment by Farley and Craig) into high and low He regions. If this feature "holds up," it may argue not only for the low He 3/4 signature for HIMU, established by Graham *et al.* (*2*), but also for a relatively high He concentration in HIMU, so that this component is able to overwhelm the He from other mixing end-members.

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"Thousands of years ago, herbivorous animals wandered into these tar-pits, got stuck and were followed in by predators who also found themselves mired, eventually attracting paleontologists such as ourselves."