41. OXYGEN AND STRONTIUM ISOTOPIC COMPOSITIONS AND THORIUM AND URANIUM CONTENTS OF BASALTS FROM DSDP 37 CORES

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INTRODUCTION

The analyses reported are from 26 samples supplied as uncrushed core, weighing between 17 and 70 g. These samples were sectioned and dried in an oven for 24 hr at 60°C, crushed in a steel mortar and pestle, and ground to a fine powder either in a tungsten carbide swing-mill (larger samples) or by hand in an agate mortar (small samples). Aliquots of these powders were used for Sr and Pb isotopic analysis by Yamaguchi et al. at the University of British Columbia (this volume) and for whole-rock XRF analysis by Lambert and Holland (this volume). Further analyses will be reported elsewhere and the data from the three groups will be integrated.

STRONTIUM ISOTOPES

Thirteen analyses for Rb, Sr, and Sr^{87}/Sr^{86} are available (Table 1, Figures 1 and 2), the range of figures being almost identical to those of Yamaguchi et al. (this volume) including having the lowest Sr^{87}/Sr^{86} at the bottom of each hole. The range of figures from 0.70315 ±7 to 0.70450 ±7 is on the high side for a set of rocks from one oceanic area, and the values themselves are generally higher than those from Icelandic and Atlantic ocean-floor basalts (Hart et al., 1973; O'Nions and Pankhurst, 1974), but are similar to those from Leg 17 (Bass et al., 1973). Analytical error seems to be most unlikely as a cause of these differences.

The range of the figures appears to be related to exchange with seawater strontium (and perhaps rubidium) as illustrated in Figures 1 and 2. In Figure 2 we note the presence of calcite and state CO_2 figures from the nearest portions of core, where available. There is a broad but by no means perfect correlation between the visible presence of carbonate, association with CO_2-rich portions of core, and high Sr^{87}/Sr^{86} and δO^{18}. We conclude that the apparent 100-150 m.y. "isochron" of Figure 1 is spurious. However, if so, it is curious that the samples with higher Sr^{87}/Sr^{86} in the low Sr^{87}/Sr^{86} series (e.g., 332A 21-1 and 332B 21-1) have correspondingly higher Rb/Sr. The "isochron" implies uptake of Rb or loss of Sr in proportion to gain of Sr^{87} from seawater. Loss of Sr seems most unlikely, but detailed discussion must await analysis of individual minerals.

If it is assumed that unaltered basalt has $\delta O^{18} = 6.0$, then extrapolation along the crude linear trend seen in Figure 2 gives an intercept of Sr^{87}/Sr^{86} of 0.7030 for the composition of the primary Sr in these rocks. O'Nions and Pankhurst (1974) gave 0.70314 ±4 for ridge samples at 63°N and 0.70294 ±4 from 58°N to 52°N.

OXYGEN ISOTOPES

The data for 24 samples are given in Table 2 and Figure 2. The two figures for each of 334-24-3 and 335-8-3 are from separate powders from two fragments of core, broken from one piece during sample preparation. Apart from the low values from the serpentinized plagioclase peridotite 334-24-3, the remainder range from $\delta O^{18} = 6.5$ to 9.9. There is a crude correlation between high δO^{18} and the presence of carbonate, but our data are too incomplete to permit a quantitative evaluation. If solely due to carbonate precipitated from seawater in veins and vesicles, rocks such as 332B-35-2 should contain ~10% calcite with $\delta O^{18} = +40$. However, this basalt contains only ~1% calcite in thin section and larger-scale exchange with silicates is implied. Enough exceptions also exist in this set of specimens to the suggested correlation of secondary carbonate with high δO^{18} (e.g., the samples from 332A-12-1 with $\delta O^{18} = 8.2$ and 8.8 have no carbonate in thin section) for it to be essential that some other minerals be involved in this O^{18} enrichment.

The mean δO^{18} for 332A is 7.3, for 332B it is 7.8, and for 335 it is 9.0. These figures correspond to altered basalts with 1 to 3 weight percent H_2O (Muehlenbachs and Clayton, 1972, fig. 1): data on H_2O so far available (26 March 1974 listing) show similarly high levels of H_2O in Leg 37 basalts. Thus it is provisionally concluded that these basalts have suffered O^{18} enrichment, probably via formation of "clays" rather than via carbonates (Muehlenbachs and Clayton, 1972), to the extent of up to 15% "clay" in the case of the samples with highest δO^{18}. Such a high degree of alteration will presumably be sufficient to make assessment and use of minor and trace element geochemistry (particularly the alkalies) rather uncertain.

THORIUM AND URANIUM

Th and U analyses by the delayed-neutron method are given in Table 3, and U is compared with Zr and K in Figures 3 and 4. With the exception of 332B-14-1, which has anomalously low U by comparison with similar rocks from 332B (Figures 3 and 4), the U data fall neatly into groups following the geochemical classification of Lambert and Holland (this volume). However, K/U ratios vary widely, averaging 33,000 in 334, 22,500 in the "low Zr, high Mg" subset of 332A and B, and 11,000 in the "high Zr, low Mg" subset, excluding the one anomalous Sample 332B-14-1 (K data from Lambert and Holland). These high ratios immediately raise the question of U loss, particularly in 335 and the low-Zr subset. At Site 335, the possibility of

TABLE 1
Strontium Isotope Data from Leg 37

Sample (Interval in cm)	Rb[a]	Sr[a]	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
332A-8-1, 98-100 (#11)	6.77 ±0.37[b]	118.3 ±0.7	0.165 ±0.009	0.70328 ±7[c]
332A-12-1, 123 (#12D)	5[d]	120[d]	0.12	0.70351 ±7
332A-21-1, 57-59 (#4)	4.31 ±0.20	108.2 ±0.4	0.115 ±0.005	0.70338 ±7
332A-28-1, 34-36 (#4)	5.19 ±0.24	116.2 ±0.5	0.129 ±0.006	0.70328 ±7
332A-29-1, 37-39 (#5)	6.60 ±0.20	111.6 ±1.0	0.171 ±0.005	0.70329 ±7
332A-40-3, 37-39 (#4B)	2.08 ±0.20	94.8 ±0.5	0.063 ±0.006	0.70318 ±7
332B-6-1, ~100 (#11A)	8.10 ±0.20	114.5 ±0.4	0.204 ±0.005	0.70363 ±7
332B-13-1, 70-72 (#6)	3.42 ±0.25	123.7 ±1.0	0.080 ±0.006	0.70410 ±7
332B-21-1, 27-30 (#1B)	3.01 ±0.20	62.1 ±0.1	0.140 ±0.009	0.70338 ±7
332B-35-2, 105-108 (#1N)	3.42 ±0.46	85.8 ±0.6	0.115 ±0.016	0.70450 ±7
332B-47-2, 67-70 (#P5)	0.87 ±0.27	108.7 ±0.3	0.023 ±0.007	0.70315 ±7
335-7-2, 95-97? (#7B)	6.95 ±0.20	102.7 ±0.5	0.195 ±0.005	0.70449 ±7
335-10-6, 28-30 (#2)	3.38 ±0.20	95.3 ±0.3	0.102 ±0.006	0.70407 ±7

[a]Rb and Sr determined by X-ray analysis; 4 replicates. Corrected for interferences from U, Th, Pb, Rb, and Sr.

[b]Errors are S.D. of replicate analyses, increased to 0.20 where smaller values were obtained. Errors indicate position.

[c]Error quoted is mean of internal errors, and the same as A.N.U. laboratory error estimate.

[d]From Lambert and Holland (this volume).

[e]Sr ratios must be decreased by 0.00021 on the basis of replicate analysis on NBS SRM 987 which yielded 0.71035 ±0.0002 when measured on the instrument used for these analyses, W. Compston (personal communication).

a threefold depletion must be regarded as real in view of $\delta O^{18} = 9$ as discussed above. In the "low-Zr" rocks, however, the situation is much less clear, because these have low Fe_2O_3/MgO (but show no petrographic evidence for loss of Fe_2O_3 or gain of MgO) and are consistently and uniformly low in Ti, Y, Zr, and Nb elements usually regarded as inert in alteration processes (Cann, 1970; Pearce and Cann, 1973). Also, the "low-Zr" basalt 332A-40-3, 37-39 cm (#4B) has comparatively low Sr^{87}/Sr^{86} (Figure 1) accompanying its K/U of 24,000, suggesting lack of exchange, although it has $\delta O^{18} = 7.4$.

The mean U figure, 0.180 ppm, is rather higher than the mean of 0.08 for three samples from Leg 17 (Bass et al., 1973) and 0.15 for six samples from Leg 15 (Donnelly et al., 1973; excepting two K-rich samples). These other sets had mean K/U of 48,000 and 10,000, respectively. Th is unfortunately comparatively poorly determined by the delayed neutron method when in low concentrations, but the arithmetic mean is 0.48 ppm (if the below detection limit figures average 0.15 ppm) and mean Th/U = 2.7. For those samples with Th above the detection limit, excluding the anomalous sample 332B-14-1, 33-35 cm (#1), Th/U = 3.0.

CONCLUSIONS

The strontium isotope measurements combined with oxygen isotope data indicate contamination and/or reaction by seawater, probably via the formation of clay minerals and perhaps also by addition of secondary carbonate. An "initial" Sr^{87}/Sr^{86} of 0.7030 is suggested for these samples, with the actual present-day range being 0.70315 to 0.70450, and the arithmetic mean 0.70363. The mean δO^{18} for basalts is +7.75. Uranium and thorium data show below-average contents with average U = 0.180 ppm, K/U = 20,000, and Th/U = 3.0, although the latter figure is not accurately defined. Some recent U loss may have occurred, but other geochemical parameters suggest that the quantity lost has not been large.

ACKNOWLEDGMENTS

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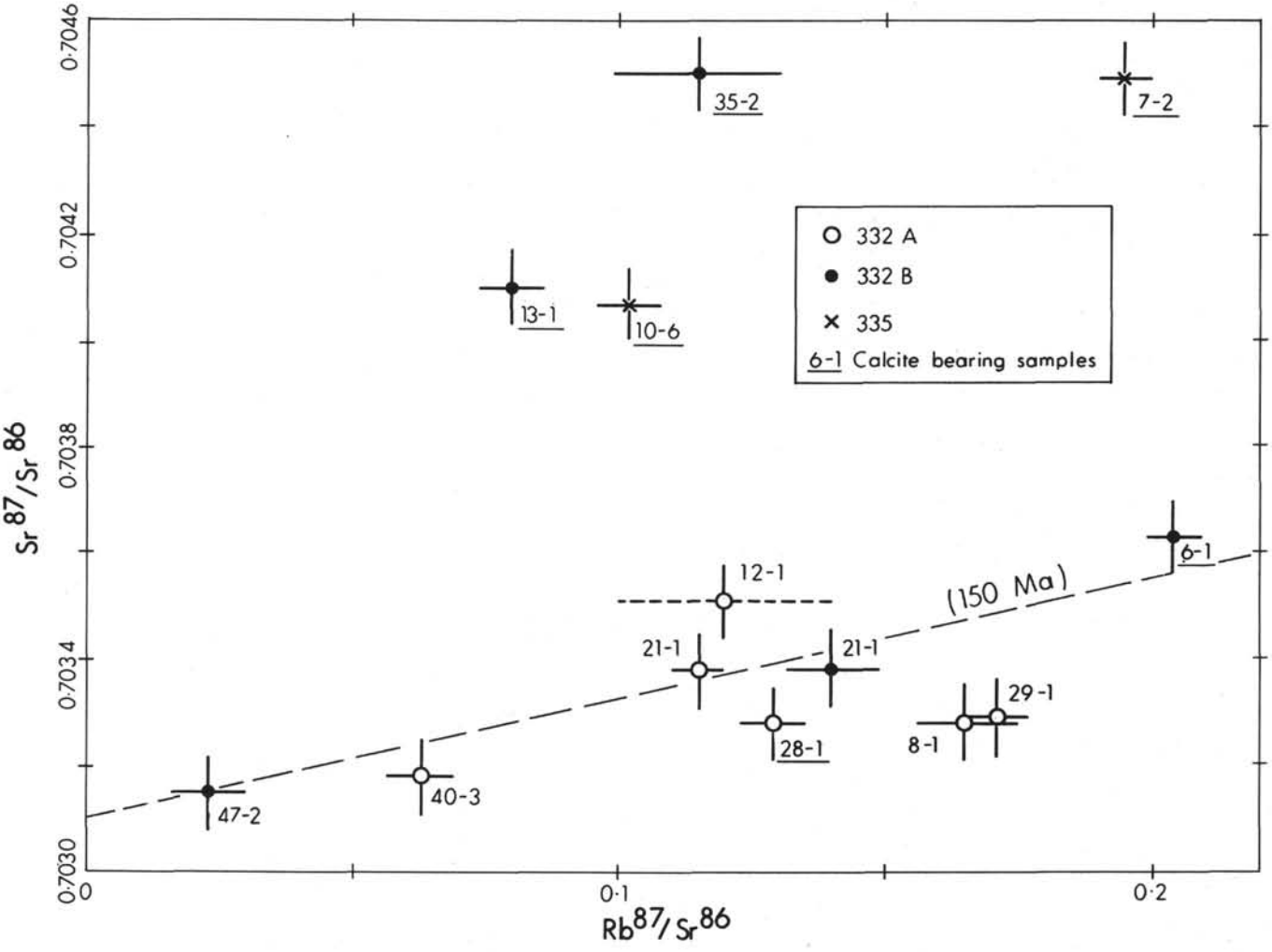

Figure 1. *Sr^{87}/Sr^{86} and Rb^{87}/Sr^{86} in basalts from Leg 37. The apparent isochron is meaningless, because of secondary isotopic exchange.*

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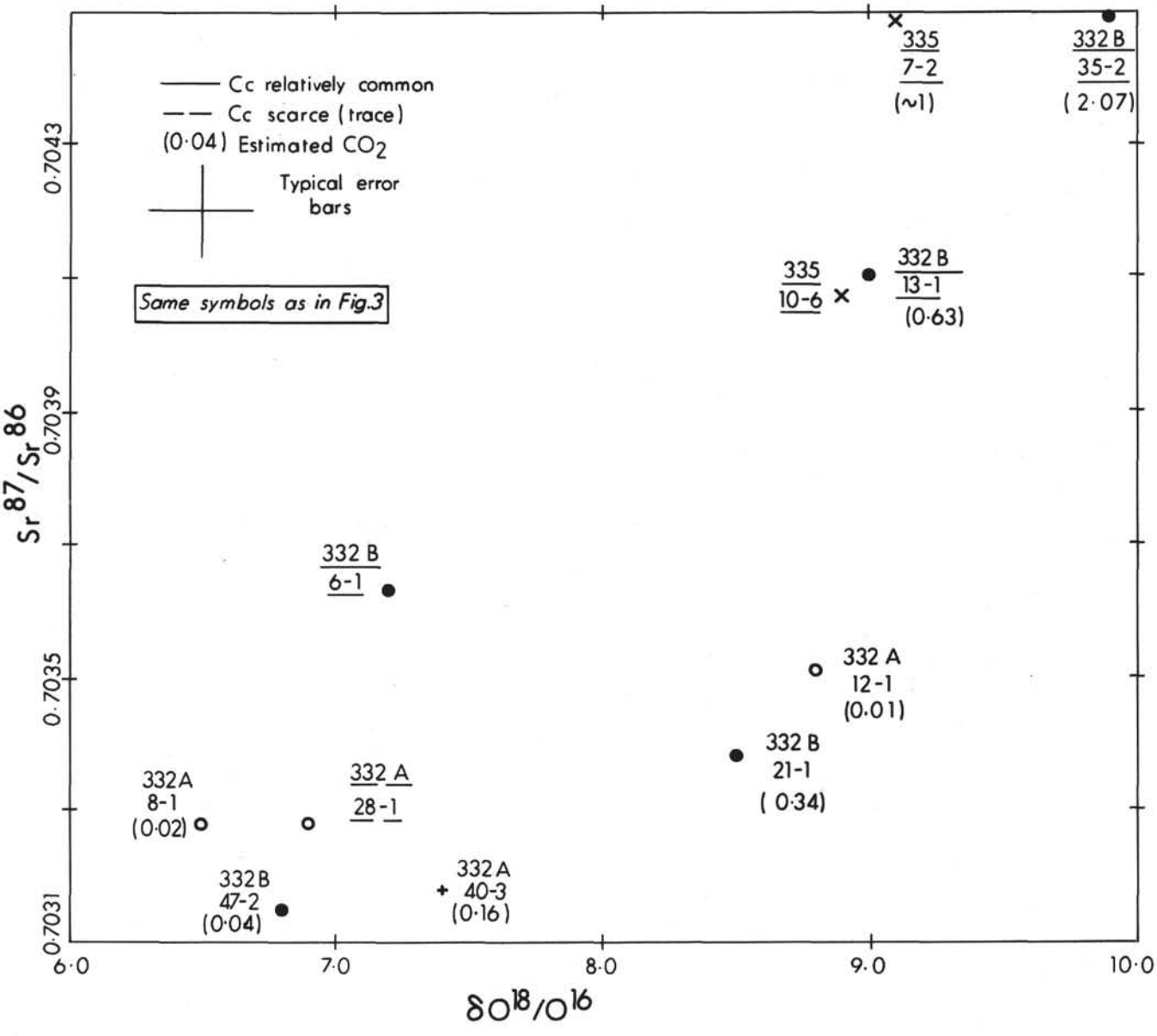

Figure 2. *Sr^{87}/Sr^{86} and $\delta O^{18}/O^{16}$ in basalts from Leg 37. Note the general positive correlation.*

TABLE 2
Oxygen Isotope Data from Leg 37

Sample (Interval in cm)	$\delta O^{18}/O^{16}$ SMOW
Hole 332A	
7-2, 15-17 (#9)	+7.2[a]
8-1, 98-100 (#11)	+6.5
12-1, 93-97 (#11A)	+8.2
12-1, 123 (#12D)	+8.8
14-1, 127-129 (#12)	+6.8
26-1, 43-45 (#2)	+7.3
28-1, 34-36 (#4)	+6.9[a]
28-2, 57-59 (#9)	+7.0[a]
32-1, 106-108 (#14B)	+6.9
40-3, 37-39 (#4B)	+7.4[b]
Hole 332B	
2-5, 103-106 (#10)	+7.7[b]
6-1, ~100 (#11A)	+7.2[a]
9-3, 14-16 (#3)	+6.5
13-1, 70-72 (#6)	+9.0[a]
14-1, 33-35 (#1)	+7.5
21-1, 27-30 (#1B)	+8.5[b]
27-2, 56-58 (#6)	+6.9
35-2, 105-108 (#1N)	+9.9[a,b]
46-3, 36-38 (#3A)	+7.7
47-2, 67-70 (#P5)	+6.8
Site 334	
24-3, 136-140 (#12)	+4.7
24-3, 136-140 (#12)	+5.4
Site 335	
7-2, 95-97? (#7B)	+9.1[a]
8-3, 61-63 (#5B)	+8.9
8-3, 61-63 (#5B)	+9.3
10-6, 28-30 (#2)	+8.9[a]

[a]Calcite-bearing samples.
[b]"Low Zr" geochemical type.

TABLE 3
U and Th from Leg 37

Sample (Interval in cm)	U (ppm)	Th (ppm)
Hole 332A		
7-2, 15-17 (#9)	0.406 ±0.011	0.6 ±0.4
8-1, 98-100 (#11)	0.205 ±0.008	0.4 ±0.3
12-1, 123 (#12D)	0.158 ±0.007	0.6 ±0.3
21-1, 57-59 (#4)	0.166 ±0.011	0.9 ±0.5
26-1, 43-45 (#2)	0.202 ±0.008	0.8 ±0.3
28-1, 34-36 (#4)	0.285 ±0.009	0.6 ±0.3
28-2, 57-59 (#2)	0.212 ±0.008	0.7 ±0.3
29-1, 37-39 (#5)	0.169 ±0.007	0.6 ±0.3
32-1, 106-108 (#14B)	0.185 ±0.008	1.0 ±0.3
40-3, 37-39 (#4B)	0.064 ±0.005	bdl
Hole 332B		
2-5, 103-106 (#10)	0.048 ±0.004	bdl
6-1, ~100 (#11A)	0.276 ±0.010	0.4 ±0.3
9-3, 14-16 (#3)	0.256 ±0.009	0.8 ±0.4
13-1, 70-72 (#6)	0.228 ±0.009	0.5 ±0.4
14-1, 33-35 (#1)	0.055 ±0.005	1.1 ±0.3
21-1, 27-30 (#1B)	0.082 ±0.005	bdl
27-2, 56-58 (#6)	0.252 ±0.009	0.4 ±0.3
35-2, 105-108 (#1N)	0.126 ±0.006	bdl
46-3, 36-38 (#3A)	0.243 ±0.009	bdl
47-2, 67-70 (#P5)	0.307 ±0.010	bdl
Site 334		
24-3, 136-140 (#12)	0.038 ±0.004	bdl
Site 335		
7-2, 95-97 (#7B)	0.094 ±0.006	0.5 ±0.3
8-3, 1-61-63 (#5B)	0.130 ±0.009	bdl
8-3, 61-63 (#5B)	0.089 ±0.006	bdl
10-6, 28-30 (#2)	0.075 ±0.006	0.7 ±0.3

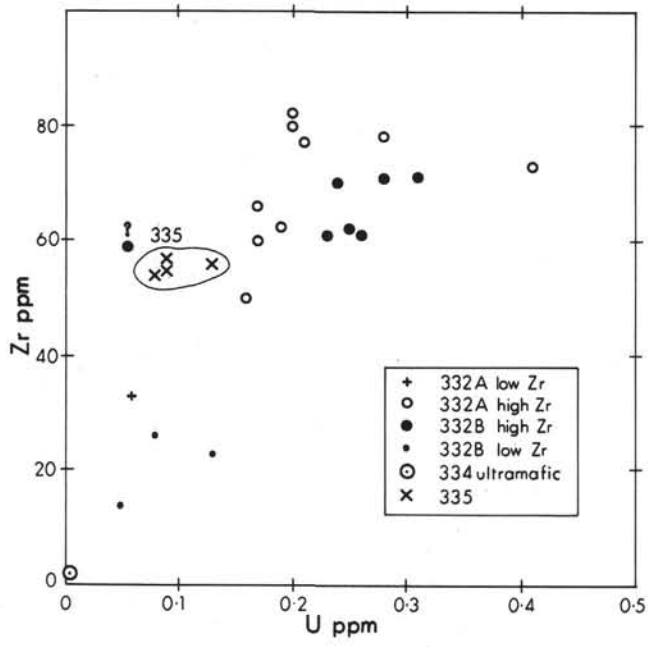

Figure 3. *U and Zr in Holes 332A, 332B, and Sites 334, 335, showing systematic variation of U with other geochemical parameters exemplified by Zr.*

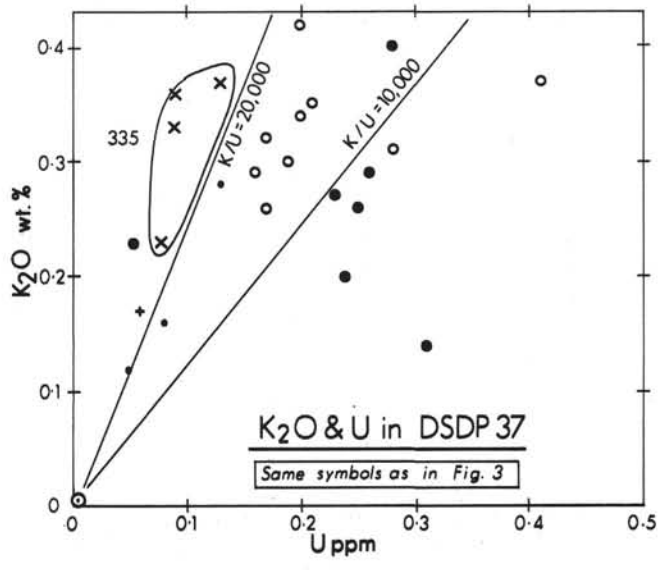

Figure 4. *K_2O and U in Holes 332A, 332B, and Sites 334, 335.*