Table A1 Protactinium-uranium, radium-thorium and thorium-uranium data.

	MgO	$(^{231}Pa/^{235}U)^*$	Error†	^{231}Pa fmol/g	Error	$(^{226}Ra/^{230}Th)$	Error	^{226}Ra fmol/g	Error	$(^{226}Ra/^{230}Th)_i$§	Error	$(^{230}Th/^{238}U)$	Error	U/Th
MB-5 Phil	7.29	1.506	14	48.29	45	1.607	50	2.13	5	1.63	5	0.917	8	0.28
CY-3	6.02	1.464	39	40.43	108	1.220	40			1.34	6	0.936	11	0.28
B-4	5.95	1.451	14	49.81	48	1.215	40			1.34	6	0.945	8	0.28
CAL-1	5.65	1.435	29	46.06	93	1.176	39			1.29	6	0.924	21	0.27
BAL-1-1						1.085	28	5.72	12	1.19	5			
BAL-1-2						1.079	24	5.61	11	1.19	4			
BAL-1-D						1.047	29	5.46	10	1.15	5			
BAL-1 Aver.	1.97	1.312	11	11.59	10	1.071	43	5.60	30	1.18	6	0.941	6	0.29
BM-8-1						1.028	20	4.99	9	1.13	4			
BM-8-D						1.021	24	4.98	11	1.12	4			
BM-8 Aver.	1.50	1.282	25	11.82	23	1.025	16	4.98	7	1.13	3	0.951	12	0.29
TML-1						1.000	19	16.29	28					
TML-2						0.995	35	16.03	53					
TML-3D						0.989	21	16.35	30					
TML-4D						1.006	18	16.26	27					
Aver.						1.000	10	16.27	15					

Th-Ra and U-Th isotopic analyses were done at the University of New Mexico. Our Ra separation method was modified from the method described by Chabaux et al. (1994)*. See Asmerom (1999) for U-Th procedures. We purified a ^{228}Ra spike an old analytical Th standard. The ^{228}Ra was calibrated using NIST SRM 4966 ^{226}Ra standard. The spike calibration was tested using Table Mountain Latite (TML), a secular equilibrium [$(^{226}Ra/^{230}Th) = 1.00$] standard. U-Pa isotopic analysis was done at the University of Minnesota following the method of See Pickett et al. (1994) and Edwards et al. (1997). The ^{233}Pa spike was calibrated against TML. *Values in parenthesis are activity ratios; activity is equal to the number of atoms multiplied by the decay constant for that nuclide. †Errors are 2-σ analytical errors. § Initial activity ratios; uncertainties in initial ratios (values at time of eruption) reflect uncertainties in age estimates, 0.250 ka, and analytical uncertainty, except for the 1968 eruption (MB-5). For historical lavas initial corrections for U, Pa and Th are insignificant. Values for the secular equilibrium standard, Table Mountain Latite (TML), are measured values.*

APPENDIX 1.

Both Model I and Model II are based on the magma replenishment model of Hughes and Hawkesworth (1999), here referred to as H&H, for change in ($^{230}Th/^{238}U$) due to magma mixing. We adopted their approach to deal with changes in ($^{231}Pa/^{235}U$) and ($^{236}Ra/^{230}Th$). Changes in ($^{231}Pa/^{235}U$) and ($^{236}Ra/^{230}Th$), concentration of U, Th, ^{231}Pa and ^{226}Ra due to radioactive decay (Equation 1 of H&H), fractional crystallization (Equation 2 of H&H) and magma or fluid mixing (in the case of Model II) (Equation 3 of H&H) are calculated. The radioactive decay and fractional crystallization steps are calculated in alternating small sub-steps in order to simulate the simultaneous and continuous process of radioactive decay and fractional crystallization. Element fractionation is calculated based on melt/solid distribution for each element (listed below). Magma or fluid mixing was treated as a discrete event with reoccurrence intervals of 200 years for magma addition and 370 years for fluid addition (best model fit).

If ***f*** is the fraction of magma crystallized, the number of iteration is set to 1/***f***, until the initial volume of magma is completely replaced. In the case of Model II, the amount of fluid added to the melt is coupled to degree of fractional crystallization. Thus, we can use the same equations as in the case of Model I, except substituting the change in activities and concentrations due to addition of fresh magma with the changes in activities and concentrations due to fluid addition. The duration of replenishment is equal to (1/***f***)***t,*** where ***t*** is the replenishment interval. The parameters for Model I and Model II are listed in Table A2. See H&H for complete detail.

TABLE A2. PARAMETERS FOR MODEL I AND MODEL II

	Model I (melt)	Model II (fluid)	
f	0.0036	0.01	
t	200 yr	370 yr	
$^{235}U_{Initial}$ concentration	1	1	(Dimensionless)
$^{230}Th_{initial}$ concentration	1	0.01	(Dimensionless)
($^{226}Ra/^{230}Th$)	10 (melt)	70 (fluid)	
($^{231}Pa/^{235}U$)	1.528	1.57	
Partition coefficients:			
D_U =0.05*	D_{Th} = 0.05*	D_{Ra} = 0.25*	D_{Pa} = 0.005

*From Hughes and Hawkesworth (1999).

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