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Key Points:

- Statistical analysis of three previous MORB data sets and one comprehensive compilation assembled here provides objective insight into the nature of the MORB source
- We reveal different partitioning behaviors of K and U and document fractionation of K/U as a function of differentiation
- The K/U value of the MORB source is higher than that of global MORB and may extend above 15,500

Supporting Information:

- Supporting Information S1
- Data Set S1

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K/U of the MORB Source and Silicate Earth

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Abstract Potassium (K) informs on the radiogenic heat production, atmospheric composition, and volatile element depletion of the Earth and other planetary systems. Constraints on the abundance of K in the Earth, Moon, and other rocky bodies have historically hinged on K/U values measured in planetary materials, particularly comparisons of the continental crust and mid-ocean ridge basalts (MORBs), for developing compositional models of the bulk silicate Earth (BSE). However, a consensus on the most representative K/U value for global MORB remains elusive despite numerous studies. Here, we statistically analyze a critical compilation of MORB data to determine the K/U value of the MORB source. Covariations in the log-normal abundances of K and U establish that K is 3–7 times less incompatible than U during melting and/or crystallization processes, enabling inverse modeling to infer the K/U of the MORB source region. These comprehensive data have a mean K/U for global MORB = $13,900 \pm 200$ ($2\sigma_m$; $n = 4,646$), and define a MORB source region with a K/U between 14,000 and 15,500, depending on the modeled melting regime. However, this range represents strictly a lower limit due to the undefined role of fractional crystallization in these samples and challenges preserving the signatures of depleted components in the MORB mantle source. This MORB source model, when combined with recent metadata analyses of ocean island basalt (OIB) and continental crust, suggests that the BSE has a K/U value $>12,100$ and contains $>260 \times 10^{-6}$ kg/kg K, resulting in a global production of ~ 3.5 TW of radiogenic heat today and 1.5×10^{17} kg of ^{40}Ar over the lifetime of the planet.

Plain Language Summary Radioactive elements are a major source of heat, and they provide atmospheric gas to a planet. Specifically, the decay of potassium, thorium, and uranium over billions of years has driven mantle convection and plate tectonics and added argon and helium gas to the atmosphere. Thus, knowing how these elements are distributed throughout a planet's surface and interior is critical to our understanding of the Earth and its dynamics. The release of potassium and uranium from the mantle during melting was thought to be equal. However, we found that the relative concentrations of these two elements change from the interior to the surface, because uranium is more efficiently introduced into magma. With this new insight, we determine the amount of potassium in the whole Earth. This new estimate helps us to understand how the Earth's interior separated into layers (e.g., crust or mantle), determine how much heat is generated inside Earth today, and calculate how much argon has been produced over the Earth's lifetime.

1. Introduction

Potassium (K) is a critical variable in compositional models for the Earth, Moon, and other planetary systems. The rarest isotope of K, ^{40}K (atomic abundance of 0.01167%), which follows a branched decay scheme to ^{40}Ca (89.44%) and ^{40}Ar (10.56%), provides radiogenic heat and produces atmospheric Ar, ultimately influencing prospects for habitability. As a lithophile element with minimal affinity for metallic iron (Corgne et al., 2007) and an intermediate condensation temperature (Lodders, 2003), the abundance of K in the silicate Earth largely defines the bulk planet's depletion in volatile elements relative to chondrites (e.g., Allègre et al., 1995; McDonough & Sun, 1995).

Despite the attention K attracts as a multifaceted geochemical proxy, the abundance of K in the silicate Earth, and by extension the bulk planet, remains poorly constrained. Abundances of refractory lithophile elements, such as La, Th, and U, in the bulk silicate Earth (BSE) may be inferred directly from chondritic relative abundances (Clark & Ringwood, 1964; Wasserburg et al., 1964), thereby enabling the abundance of K to be extrapolated through empirically observed ratios. Traditionally, the Earth's K content has been

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estimated from K/La, K/Th, and/or K/U values in terrestrial rocks. Because K, Th, and U are radioactive and concentrated in the crust due to their highly incompatible geochemical behaviors, we can measure K/Th and K/U on the surfaces of other rocky planetary bodies via gamma ray spectroscopy from orbit, enabling comparisons in volatile element depletions across the inner solar system (Peplowski et al., 2011, and references therein). The amount of ^{40}Ar in the BSE provides an independent validation on the inferred budget of K; for example, a minimum of 120×10^{-6} kg/kg K is needed to account for the 66×10^{15} kg of ^{40}Ar currently residing in the atmosphere (Turekian, 1959). In contrast, higher levels of K inferred in the BSE (e.g., $>200 \times 10^{-6}$ kg/kg, as predicted by several models described below) require a deep undegassed reservoir (Allègre et al., 1996).

The earliest attempts to determine the amount of K in the BSE reported only limited variances in K/U measured between felsic and mafic rocks, with most K/U estimates for the BSE falling between 10,000 and 13,000 (Jochum et al., 1983; Urey, 1955; Wasserburg et al., 1964), although some BSE models suggested K/U values up to 17,000 (Clark & Ringwood, 1964). However, these findings were based on small sample collections. Later studies have added considerably larger amounts of data and uncovered measurable distinctions between K/U values, as recorded in rocks from the continental crust and oceanic basalts (e.g., Arevalo et al., 2009; Lassiter, 2004). Perhaps more surprisingly, independent surveys that focused exclusively on mid-ocean ridge basalts (MORBs) also show statistically significant K/U variations (Arevalo et al., 2009; Gale et al., 2013; Jenner & O'Neill, 2012). As a result, a wide range of K/U values for the BSE have been reported, resulting in anywhere from 120×10^{-6} kg/kg to more than 300×10^{-6} kg/kg K in the silicate Earth (assuming ~ 2.8 CI1 chondrite abundances for the refractory elements; e.g., McDonough & Sun, 1995; Palme & O'Neill, 2014). The K/La ratio has also been employed to constrain the Earth's K content, given a relatively constant MORB K/La value of ~ 330 (Lyubetskaya & Korenaga, 2007; Palme & O'Neill, 2014). The problem with this approach is that the relative difference in the incompatibilities (as measured by partition coefficients) of K and La are greater than for K and U; consequently, relying on K/La correlations leads to skewed estimates of the K content of the BSE.

2. Attempts to Constrain the K/U Value of Global MORB

Access to fresh samples from reliable curation facilities (e.g., Smithsonian Institute), streamlined acquisition of chemical analyses via in situ methods (e.g., laser ablation inductively coupled plasma mass spectrometry, LA-ICPMS), and the emergence of publicly available online databases (e.g., PetDB) provide robust avenues to determine the K/U value for MORB. However, even with a growing number of analyses to interrogate, independent statistical evaluations of the same sample collection and/or data compilation may derive different representative K/U values. For example, the application of means and standard deviations to describe a sample set assumes a normal distribution, which may not reflect the population. Although the distribution of K/U in MORB approximates a Gaussian curve (e.g., Jenner & O'Neill, 2012), K and U abundances are skewed in mantle-derived materials (e.g., Arevalo & McDonough, 2010), requiring that log-normal abundances be considered for traditional statistical treatments. Consequently, the composition of the MORB source may be (and has been) inferred from (i) the distribution of K/U values measured in each individual specimen and/or (ii) log-normal distributions of K and U abundances. The former approach requires that both K and U be measured in each sample under investigation, potentially limiting the size of available data sets but ensuring a uniform number of samples and an equal global distribution. The latter approach allows for decoupling between sample sets that characterize K and U distributions, supporting larger databases, but at risk of unequal sample sizes, discrepant geographical coverage, and analytical biases, particularly the underrepresentation of samples depleted in U due to challenging detection limits and/or counting statistics.

Within the course of only a few years, several studies that attempted to determine a representative K/U value for the source of MORB arrived at statistically distinct answers, albeit through different approaches. Arevalo et al. (2009) analyzed both K and U in a limited but global suite of MORB glasses ($n = 75$) by high-precision LA-ICPMS within a single laboratory (thereby eliminating the risk of inter-laboratory bias), indicating a mean K/U value $>18,000$ (Table 1). Depleted MORB ($[\text{La}/\text{Sm}]_n < 0.63$) were linked to higher K/U values than more enriched samples ($[\text{La}/\text{Sm}]_n \geq 0.63$), reflecting multiple source components with distinct compositions and/or disparate partitioning behavior between K and U during mantle melting and fractional crystallization of basalts.

Table 1
Summary of K, U, and K/U Statistics From Previous Studies

	Arevalo et al. (2009) ^a	Jenner and O'Neill (2012) ^b	Gale et al. (2013) ^c
<i>K/U statistics</i>			
Minimum	10,700	5,800	1,600
Quartile 1	15,400	11,300	13,700
Median	18,500	13,800	16,200
Quartile 3	20,600	16,700	19,800
Maximum	43,400	34,400	43,500
Count	75	458	608
K/U average	18,300	14,000	17,000
σ	4,800	4,000	5,600
$2\sigma_m$	1,100	400	500
<i>Log-normal statistics</i>			
K average ($\times 10^{-6}$ kg/kg)	1,100	990	1,300
σ	200	110	100
Count	75	464	746
$2\sigma_m$	40	10	10
U average ($\times 10^{-6}$ kg/kg)	0.061	0.078	0.087
σ	0.026	0.027	0.027
Count	75	491	693
$2\sigma_m$	0.006	0.002	0.002
K/U average	17,700	12,800	15,300
σ	7,900	4,700	4,900
$2\sigma_m$	1,800	400	400

Note. The bolded values are averages, and thus preferred values that best represent the sample sets described.

^aData reported for both "normal-type" and "enriched-type" MORB, as defined in the text. ^bData reported for all MORB samples derived from recognized spreading centers. ^cData reported for new (i.e., previously unpublished) MORB measurements provided in Gale et al. (2013).

Jenner and O'Neill (2012) measured the compositions (including both K and U) of more than 600 basaltic glasses collected from the ocean floor, including 497 MORB samples from recognized spreading centers, by similar high-precision LA-ICPMS techniques; these data support a MORB K/U value closer to 14,000 (Table 1). Although the variances in K/U determined by these two independent studies are nearly identical, an unpaired Welch's *t* test, which conservatively assumes heteroscedasticity, indicates that these distributions are statistically distinct at the >99.9% confidence level.

Gale et al. (2013) also characterized a limited collection of MORB, but they further combined these data with thousands of published measurements of K and U (including Jenner & O'Neill, 2012, but not limited to high-precision methods) from a global array of MORB glasses and whole rock samples compiled from the PetDB online database and unpublished data from multiple sources. Rather than treating the composite data set as a subsampling of a single population, Gale et al. (2013) instead employed the data to estimate average compositions of 771 segments of the mid-ocean ridge network, relying on log-normal means to define representative abundances of highly incompatible trace elements, such as K and U. The spreading rate and length of each segment were used to define and apply a weight factor to each segment, leading Gale et al. (2013) to argue for a global MORB K/U value closer to 12,000. Interestingly, the new data published in this study ($n = 273$, primarily from the Mid-Atlantic and Gakkel Ridges), which were collected by LA-ICPMS techniques, indicate (i) a substantively higher mean K/U value of 17,000 (Table 1) and (ii) a distribution that is statistically indistinguishable from Arevalo et al. (2009), as determined by an unpaired Welch's *t* test at the >99.9% confidence level.

Although these studies attempted to solve the same problem objectively, variations between their respective compositional models highlight the importance of statistical data treatments as well as potential sources of error, including the following:

- analytical artifacts (e.g., systematic errors, different approaches in calibration strategy, and/or disproportionate characterization of more enriched samples due to instrument detection limits) and/or
- inequivalent geographical sampling (e.g., asymmetrical spatial coverage between samples with available K and U measurements).

Through a metadata analysis, in this study we attempt to circumvent controversial normalization schemes and weighting functions and simply rely on statistical variances to describe the uncertainties of global MORB chemistry. We explore potential links between K/U statistics and specific measurement techniques to evaluate critically analytical biases. To limit geographical inequalities, we focus only on samples that have been analyzed for both K and U. We also examine correlations between K/U and other geochemical indices that provide insights into distinct source contributions and partitioning behaviors. Fractionation between K and U is characterized quantitatively as a function of partial melting and/or crystallization processes to build a compositional model of the MORB source region, thereby enabling a reconstruction of the K/U value and K abundance of the BSE.

3. Data Compilation and Analytical Methods

We compiled compositional data for >29,000 MORB samples from the PetDB database. The raw data were filtered to comprise samples with $\text{SiO}_2 = 41\text{--}57 \text{ wt.\%}$ to reflect the International Union of Geological Sciences (IUGS) classification of basaltic lithologies. Samples indicative of excessive olivine accumulation (i.e., MORB with $\text{MgO} > 16 \text{ wt.\%}$) were extracted, and only samples with $\text{Al}_2\text{O}_3 < 18 \text{ wt.\%}$ were included, encompassing the highest estimates of near-primary melt MgO and Al_2O_3 contents for MORB (e.g., Falloon & Green, 1988). Only samples with major element oxides summing to $100 \pm 2 \text{ wt.\%}$ were admitted. Of this pared data set, only samples with both K and U measurements were considered in order to enforce an equal spatial distribution across the global ridge system. After applying these chemical filters, 4,740 MORB sample analyses remained from the initial compilation. Aqueous alteration is not expected to affect the K/U results reported here because only analyses of fresh MORB glasses were considered, as demonstrated by a cohesive linear correlation between Th and fluid-mobile Ba ($r^2 = 0.85$) in the data set (see the supporting information).

4. A Representative K/U Value for Global MORB

The MORB samples critically evaluated here are globally distributed (Figure 1) and include 2,877 glasses, 1,545 whole rock samples, and 318 unlabeled rock types. Nearly all samples ($n = 4,713$) have K abundances reported as K_2O , collected primarily via electron probe microanalysis (EPMA), and to a lesser extent X-ray fluorescence (XRF) and/or instrumental neutron activation analysis (INAA). However, 734 samples report K as a trace element (Table 2), measured almost exclusively by LA-ICPMS, supporting an investigation into putative biases in reported K abundances determined by different analytical techniques.

Two independent log-normal distributions of K may be defined: (1) K determined as K_2O via EPMA, XRF, and/or INAA techniques; and (2) K treated as a trace element and measured by LA-ICPMS. Because both distributions are Gaussian in shape (Figure 2), parameterized statistical treatments may be applied. An unpaired t test with unequal variance indicates that the means of the two distributions are statistically distinct (>99.9% confidence level), with the distribution of K measured as a trace element (via ICPMS) defined by a lower geometric mean.

Unfortunately, we cannot investigate analytical biases in the reported values of U because the specific techniques used to measure U in each sample are not provided. However, an unpaired t test with unequal variance reveals that the distribution of K/U recorded by global MORB is insensitive to the method used to measure K. Thus, these findings fail to substantiate analytical biases as a root cause of conflicting K/U reported by previous surveys of MORB (Arevalo et al., 2009; Gale et al., 2013; Jenner & O'Neill, 2012).

As inferred from K/U measured in each individual sample, the inclusive metadata compiled here indicate that global MORB are characterized by a mean K/U value of $13,900 \pm 200$ ($2\sigma_m$, Figure 3), most closely aligned with the value previously reported by Jenner and O'Neill (2012). Alternatively, using the log-normal K and U distributions from the same data set, global MORB could arguably be represented by a K/U value of $12,800 \pm 500$ ($2\sigma_m$), approximating the model MORB composition based on the integration of ridge segment averages (Gale et al., 2013). However, the drawbacks to the latter treatment, mainly unequal K and U

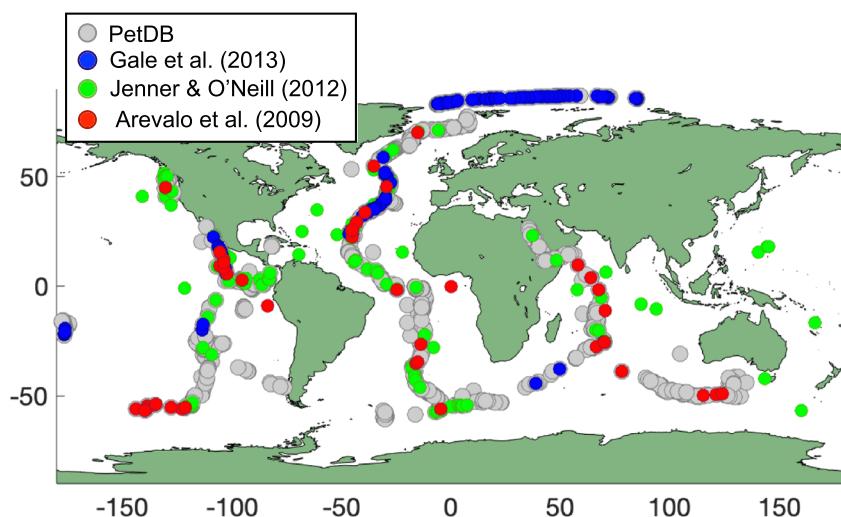


Figure 1. Geographic distribution of MORB samples investigated here and in previous studies. Samples from Gale et al. (2013) represent new analyses with both K and U measurements first published in that specific study.

sample sizes, discrepant geographical coverage, and analytical biases, are discussed above. Although geographical inequalities inevitably persist in MORB data sets due to incomplete and uneven sampling across the entire mid-ocean ridge network, sampling biases may be attenuated by focusing on samples with both K and U measurements (as demonstrated here). Nonetheless, these two distinct K/U values for MORB, derived from the same data set, highlight the sensitivity of statistical treatments to the construction of global compositional models.

5. Fractionation of K and U During Magmatic Processing

The metadata evaluated here comprise 2,961 enriched-type MORBs (E-MORBs; $[La/Sm]_n \geq 1.0$), 1,535 normal-type MORBs (N-MORBs; $[La/Sm]_n < 1.0$), and 244 samples with unknown chemical enrichment/depletion due to insufficient rare earth element (REE) analyses. A negative correlation between K/U and $[La/Sm]_n$ (see the supporting information) indicates that U is more incompatible than K during partial melting and/or fractional crystallization, corroborating observations reported previously (e.g., Arevalo et al., 2009; Hauri et al., 1994; Palme & O'Neill, 2014; Sun & McDonough, 1989). Quantitative constraints on the partitioning behavior of these two elements (i.e., $D_U^{solid/liquid}$ vs. $D_K^{solid/liquid}$) may be informed by a log-log

Table 2
Statistics of K/U and Log-Normal K and U Abundances Determined by Different Analytical Techniques

Statistics	K/U (K from K_2O) ^{a,b}	K/U (K as trace) ^{a,c}	K/U (synthesis) ^{a,d}	log K (K from K_2O) ^{b,e}	log K (K as trace) ^{c,e}	log K (synthesis) ^{d,e}	log U abundance ^a
Mean	14,000	13,700	13,900	3.11	3.07	3.11	-1.00
StDev	6,300	4,000	6,200	0.37	0.37	0.37	0.42
Count	4,616	733	4,646	4,713	734	4,740	4,732
$2\sigma_m$	200	300	200	0.01	0.03	0.01	0.01
Minimum	33	1300	33	1.92	2.16	1.92	-2.70
Quartile 1	10,000	11,000	10,000	2.87	2.83	2.87	-1.26
Median	13,300	13,700	13,300	3.10	3.07	3.10	-1.00
Quartile 3	17,200	16,300	17,000	3.34	3.27	3.34	-0.74
Maximum	39,400	30,000	39,400	4.60	4.52	4.60	0.55

Note. The bolded values are averages, and thus preferred values that best represent the sample sets described.

^aOutliers with values outside 3 times the interquartile range were isolated from the statistical assessment. ^bK measured as a major element (K_2O) primarily via EPMA, XRF, or INAA methods. ^cK measured as a trace element almost exclusively via laser ablation ICPMS techniques. ^dSynthesis of K measurements, with trace element analyses treated as a default over major element analyses. ^eNo outliers fell outside 3 times the interquartile range; thus, no data points were isolated for statistical assessment

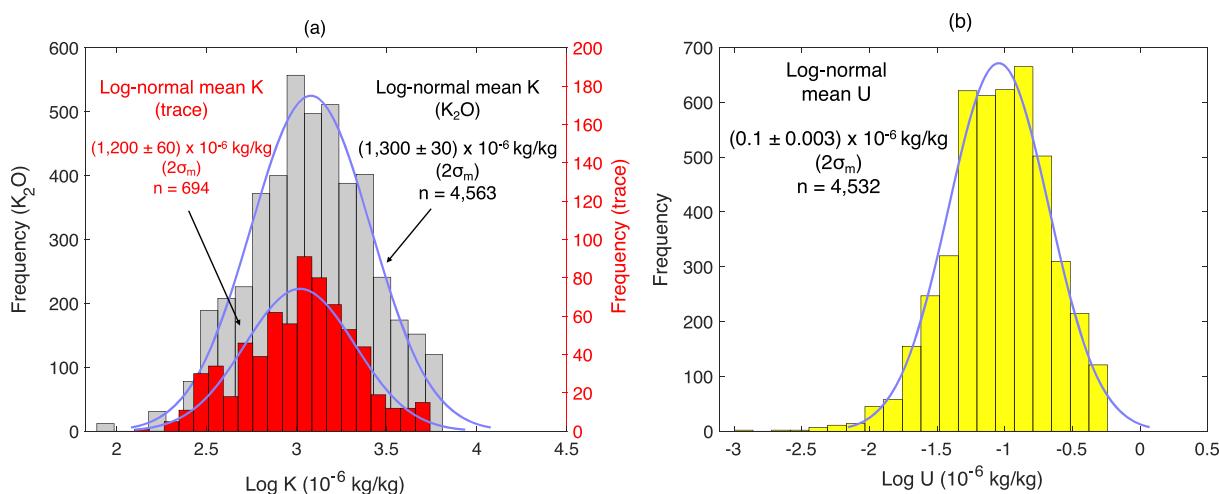


Figure 2. Histograms of log-normal K and U abundances recorded in the MORB data set investigated here. (a) Comparison of log-normal distributions and statistics of K reported as K_2O and as a trace element, reflecting different analytical techniques. (b) Log-normal distribution of U.

covariation diagram (e.g., Arevalo et al., 2009; Hofmann, 2014; Sims & DePaolo, 1997) if we assume that silicate differentiation is the primary control on K/U fractionation. Using this diagnostic approach, equal partitioning behavior between two elements would manifest as a slope of unity ($m = 1.00$). However, the role of different mass contributions from mantle sources with distinct compositions cannot be dismissed (e.g., more melt contribution for an enriched mantle source).

Bivariate linear regression analyses of the log-normal U (ordinate) versus K (abscissa) data presented here confirm that U is more incompatible than K; however, the exact slope (and by extension inferred magnitude of fractionation) is sensitive to the analytical technique used to measure K (Figure 4). The regression best fit to the ICPMS data, which has a lower mean square weighted deviation (MSWD) than the regression for the complete data set, indicates a slope of 1.18 ± 0.04 (95% confidence) in agreement with previous evaluations (Arevalo & McDonough, 2010). Although the dynamics of MORB genesis are complicated by magma replenishment, mixing, extraction, and crystallization (among other processes; e.g., O'Neill & Jenner, 2012, 2016; O'Neill et al., 2018), this quantitative log-log relationship can be used to infer $D_K^{solid/liquid}$

based on a given $D_U^{solid/liquid}$, which is more tightly constrained due to studies of Pb isotope systematics and U-series disequilibria. For more details on our calculation of D_K from log-log regression, see the supporting information.

Here, we assume $D_U^{solid/liquid} = 0.001$, in line with partitioning experiments (e.g., Salters et al., 2002), natural observations of ultramafic systems (Hauri et al., 1994), and previous literature compilations (Workman & Hart, 2005). Given this assumption, if we treat the composition of the most depleted sample in the ICPMS data (i.e., lowest U abundance) as a proxy for the primary melt, and the most enriched sample (i.e., highest U abundance) as the last solid to crystallize, $D_K^{solid/liquid} \approx 0.007$, or $7 \times D_U^{solid/liquid}$, according to the bivariate linear regression. Similarly, if the most depleted sample approximates the composition of the mantle, consistent with a host of previous MORB source models (e.g., Arevalo et al., 2013, and references therein), and the most enriched sample represents the smallest fractional melt of the source, $D_K^{solid/liquid} \approx 0.003$, or $3 \times D_U^{solid/liquid}$, according to the regression (see the supporting information). Although both of these scenarios are inherently oversimplified, such inverse models place quantitative bounds on the inferred $D_K^{solid/liquid}$ based on a statistical analysis of the empirical data set compiled here.

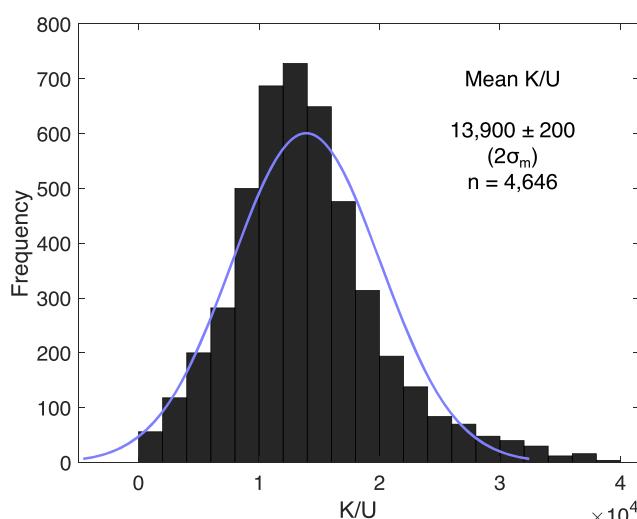


Figure 3. Gaussian distribution of K/U values for the inclusive MORB data set (for samples with K reported as both K_2O and a trace element, the trace element abundance served as the default values).

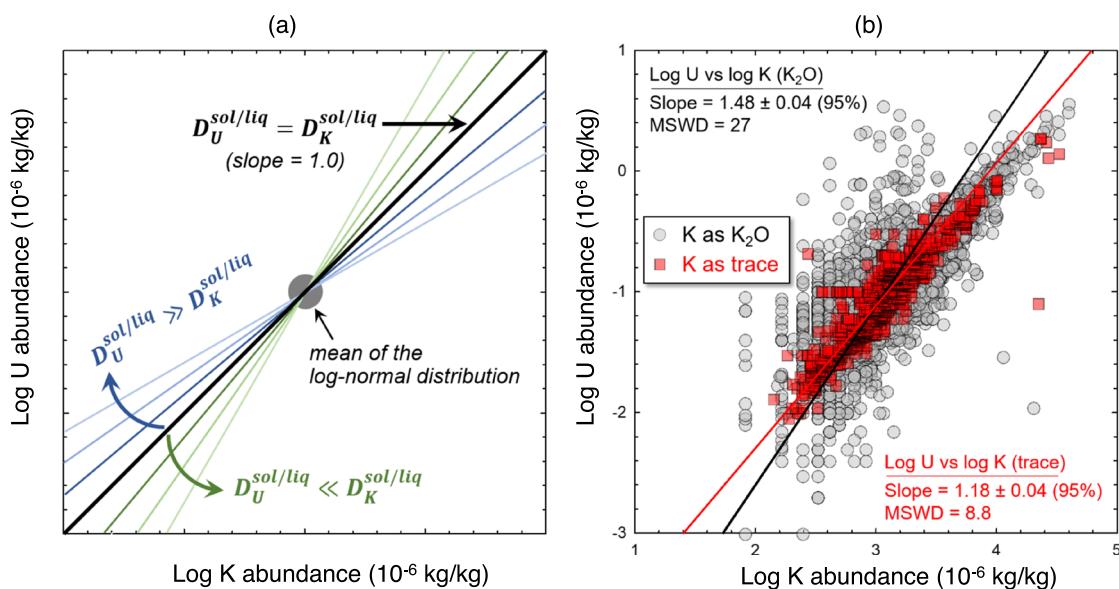


Figure 4. (a) Schematic showing the effect of unequal element incompatibility on the slope of log-log regression analyses. (b) Log-log bivariate linear regressions for K and U abundances, with K measured as an oxide (multiple techniques) compared with K measured as a trace element (primarily via LA-ICPMS) in the data set compiled here. Regression slopes for both sets of data are distinct from 1, indicating an unequal incompatibility between K and U.

6. The K/U of the MORB Source and Bulk Silicate Earth

The quantitative constraints on $D_K^{solid/liquid}$ provided here enable new insights into the K/U value of the MORB source region, and by extension the BSE. The comprehensive database compiled here (not limited to the ICPMS sample set) defines the mean K/U value of global MORB as $13,900 \pm 200$ ($2\sigma_m$; Table 2). As with the derivation of $D_K^{solid/liquid}$, we need to consider the type(s) of differentiation process(es) involved in the genesis of MORB in order to model the fractionation of K/U between source and melt. For example, if the bulk of the population of MORB samples evaluated here represent 8–20% equilibrium melting of the source, and assuming $D_U^{solid/liquid} \sim 0.001$ and $D_K^{solid/liquid} \sim 0.003$ –0.007, the mean K/U value of the MORB source region falls between 14,000 and 15,500. Alternatively, models of mantle melts derived from an equivalent range of 8–20% of fractional melting, as opposed to equilibrium melting, would attenuate K/U fractionation, implying a mean MORB source with a K/U value between 14,000 and 14,200. Considering most samples in the compilation have less than 10 wt.% MgO, they have also experienced significant fractional crystallization, which would require an even higher K/U of the MORB source than what is estimated from inverse modeling of low degree melting alone. Equilibrium and fractional melting models and data on K/U fractionation due to fractional crystallization are found in the supporting information.

Although the K/U value of the MORB source is thus shown to be model dependent, the empirical data compiled here highlight that the MORB source region must be characterized by a K/U value higher than that preserved in the global MORB population. Further, because melts derived from the most depleted source components contributing to MORB genesis are unequivocally overprinted by more enriched domains (e.g., Stracke et al., 2019), the K/U value of the composite MORB source likely falls even higher than these simple model calculations suggest. If the enriched domains in the MORB source contain a higher proportion of pyroxenite (Yang et al., 2020), which has a lower solidus than peridotite (e.g., McKenzie & Bickle, 1988), they may be preferentially melted at mid-ocean ridges and thus introduce a sampling bias (Hirschmann & Stolper, 1996), further implicating a higher source K/U value than that defined by global MORB. Nonetheless, the range of MORB source compositions defined here may be used to corroborate previous studies (e.g., Jenner & O'Neill, 2012) and contradict the higher (Arevalo et al., 2009) and lower values proposed by others (e.g., Gale et al., 2013; Jochum et al., 1983).

To evaluate how the MORB source model constrained here impacts the inferred heat production and noble gas budget of the BSE, we need to consider other appreciable sources of K and U; in the simplest scenario, the silicate Earth may be reconstructed by the MORB source, the source(s) of ocean island basalt (OIB), and the continental crust. A global compilation of OIB (Arevalo et al., 2013), including samples representing

endmembers defined by extreme radiogenic isotope signatures (e.g., Zindler & Hart, 1986), shows that OIB samples exhibit a significant variance in K/U. In particular, samples from Gough (mean K/U = 18,900 ± 1,800, $2\sigma_m$; $n = 23$) and Society (mean K/U = 7,200 ± 400, $2\sigma_m$; $n = 12$) represent the highest and lowest K/U values of this data set, respectively. Taken together, this inclusive OIB data set implies a mean OIB K/U value = 11,000 ± 500 ($2\sigma_m$; $n = 322$). Although OIB derive from intraplate volcanic centers and thus reflect melting conditions distinct from MORB, trace element systematics suggest that K is similarly less incompatible than U during the genesis of OIB (e.g., Arevalo & McDonough, 2010; Sun & McDonough, 1989); therefore, the mean OIB source region should be modeled with a K/U value >11,000.

Historically, compositional estimates of the bulk continental crust have suggested a K/U value between 7,700 (Taylor, 1964) and 15,900 (Gao et al., 1998); however, a more recent synthesis of these models coupled with a progressive evaluation of new empirical constraints have resulted in a preferred K/U value of 11,600 for the continental crust (Rudnick & Gao, 2014, and references therein). Thus, the MORB source is defined by a markedly higher K/U value than both global OIB and the bulk continental crust.

If we combine the K/U values for the MORB and OIB sources and the continental crust, weighted according to the mass fraction of U proposed for each domain (e.g., Arevalo et al., 2013; Rudnick & Gao, 2014, and references therein), the preferred mean K/U value for the BSE falls around 12,100 (assuming a chondritic bulk Earth). Of course, this again represents a lower limit for the silicate Earth, given the potential for chemical overprinting (Stracke et al., 2019), distinct source mineralogies (Yang et al., 2020), and melt sampling biases (Hirschmann & Stolper, 1996), resulting in difficulties in characterizing the most depleted components of MORB and OIB sources (Stracke et al., 2019). Nonetheless, assuming 20×10^{-9} kg/kg U in the bulk silicate Earth (McDonough & Sun, 1995), this K/U value suggests $>260 \times 10^{-6}$ kg/kg K in the BSE, indicating ~3.5 TW of radiogenic heat production from K today (10% lower than previous estimates Arevalo et al., 2009), contributing to 20 TW of total radiogenic power produced globally. This K content would produce 1.5×10^{17} kg of ^{40}Ar over the lifetime of the planet.

Conflict of Interest

There are no financial or other conflicts of interest with this work.

Data Availability Statement

Geochemical data were provided by Earthchem.org (<https://www.EarthChem.org/>). The data used in this manuscript were downloaded from the EarthChem PetDB portal and are freely available online (<https://search.earthchem.org/advancedoptions.php?pkey=3245826>). Data are also accessible in the supporting information.

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