Appendix G

Neodymium Isotope Geochemistry

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To prepare the samples, any weathered surfaces or hydrothermal alteration zones along fractures were removed, and the remainder of the sample was crushed to fine-gravel consistency using a jaw crusher. The crushed pieces were pulverized to a fine powder in an aluminum-oxide shatter box. The powder was split into two vials. One vial was sent to MURR for chemical analysis, and the other was retained at the Department of Geological Sciences, University of North Carolina at Chapel Hill, for isotopic analysis.

For Sm-Nd isotopic analysis, approximately 200 mg of a mixed ^{147}Sm-^{150}Nd tracer solution (to determine absolute concentrations of Sm and Nd) was added to an equal mass of sample powder. The samples were dissolved with an hydrofluoric/nitric acid mixture in precleaned teflon high pressure dissolution vessels by heating in an oven for seven days at approximately 180°C. Conversion from fluoride to chloride solution is achieved by drying the hydrofluoric acid solution on a hot plate in a clean air environment and redissolution in 6M hydrochloric acid.

Sample preparation procedures for Phase 1 and Phase 2 samples deviate from one another slightly here, but this deviation has no impact on the final results. For Phase 1 samples, separation of bulk rare-earth elements followed standard cation exchange procedures. Rare-earth element separation was achieved by reverse-phase chromatography using 2-methyllactic acid on cation exchange resin. For Phase 2, the samples were dried and redissolved in nitric acid for separation of bulk rare-earth elements using RE-Spec™ resin. Rare-earth element separates were then dried and redissolved in hydrochloric acid for isolation of Sm and Nd using LN-Spec™ resin. Analytical procedural contamination is less than 20 pg for Sm and Nd, which is negligible considering the Sm and Nd concentrations of analyzed samples.

Isotopic analyses were performed on a VG Sector 54 magnetic sector, thermal ionization mass spectrometer with eight Faraday collectors operating in dynamic multicollector mode. Typical ^{144}Nd beam intensities were 5.0E^{-12} to 1.0E^{-11} volts relative to a 10E^{-11} ohm resistor. External precision is assessed by replicate analyses of the JNdi-1 standard (Tanaka et al. 2000) and yields ^{143}Nd/^{144}Nd = 0.512108 ± 0.000007 (n = 20). Neodymium isotopic compositions are normalized to ^{146}Nd/^{144}Nd = 0.7219 assuming exponential fractionation behavior. Internal run precision for the critical isotopic composition measurement, ^{143}Nd/^{144}Nd, is better than ± 0.000005, 1σ absolute. Internal run precision for measurement of ^{147}Sm/^{152}Sm is better than ± 0.00001, 1σ absolute. Total uncertainties in isotopic ratios are the quadratic sum of individual sample measurement errors, uncertainties in spike weight and concentration, sample weight, and the reproducibility of standards and are reported as 2σ, absolute (Table G.1).

Table G.1. Neodymium (Nd) and Samarium (Sm) Isotope Ratios.

Sample [c]	Measured Ratios [a, b]			
	$^{147}Sm/^{144}Nd_{(now)}$ [d]	$^{143}Nd/^{144}Nd_{(now)}$ [e]	$eNd_{(now)}$ [f]	$^{143}Nd/^{144}Nd_{(550\ Ma)}$ [g]
FBL001	0.1427	0.512570	-1.33	0.512056
FBL002	0.1466	0.512578	-1.17	0.512050
FBL003	0.1497	0.512595	-0.84	0.512056
FBL004	0.1455	0.512576	-1.21	0.512052
FBL005	0.1466	0.512586	-1.01	0.512058
FBL006 (1)	0.1452	0.512550	-1.72	0.512027
FBL006 (2)	0.1470	0.512568	-1.37	0.512038
FBL006 (3)	0.1472	0.512578	-1.17	0.512048
FBL007	0.1511	0.512594	-0.86	0.512050
FBL008	0.1522	0.512611	-0.53	0.512063
FBL009	0.1533	0.512604	-0.66	0.512052
FBL010	0.1534	0.512606	-0.62	0.512053
FBL011	0.1496	0.512599	-0.76	0.512060
FBL012	0.1516	0.512613	-0.49	0.512067
FBL013	0.1536	0.512607	-0.60	0.512054
FBL014	0.1430	0.512548	-1.76	0.512033
FBL015 (1)	0.1441	0.512548	-1.76	0.512029
FBL015 (2)	0.1440	0.512537	-1.97	0.512018
FBL016	0.1438	0.512544	-1.83	0.512026
FBL017	0.1451	0.512596	-0.82	0.512073
FBL018	0.1427	0.512553	-1.66	0.512039
FBL019	0.1430	0.512540	-1.91	0.512025
FBL020 (1)	0.1324	0.512484	-3.00	0.512007
FBL020 (2)	0.1323	0.512495	-2.79	0.512018
FBL021	0.1393	0.512689	0.99	0.512187
FBL022	0.1403	0.512685	0.92	0.512179
FBL023	0.1463	0.512518	-2.35	0.511990
FBL024	0.1388	0.512571	-1.31	0.512071
FBL025	0.1270	0.512458	-3.51	0.512000
FBL026	0.1282	0.512468	-3.32	0.512006
FBL027	0.1484	0.512244	-7.69	0.511709
FBL028	0.1320	0.512227	-8.02	0.511751
FBL029	0.1266	0.512197	-8.60	0.511741
FBL030	0.1576	0.512275	-7.08	0.511707
FBL031	0.1315	0.512623	-0.29	0.512149
FBL032	0.1270	0.512622	-0.31	0.512164
FBL033	0.1284	0.512613	-0.49	0.512150
FBL034	0.1331	0.512609	-0.57	0.512129
FBL035	0.1308	0.512601	-0.72	0.512130
FBL036	0.1289	0.512611	-0.53	0.512147
FBL037	0.1222	0.512560	-1.52	0.512120
FBL038	0.1272	0.512630	-0.16	0.512172
FBL039	0.1637	0.512783	2.83	0.512193
FBL040	0.1579	0.512655	0.33	0.512086
FBL041	0.1582	0.512618	-0.39	0.512048
FBL042	0.1689	0.512743	2.05	0.512134
FBL043	0.1189	0.512648	0.20	0.512220
FBL044	0.1354	0.512558	-1.56	0.512070
FBL045	0.1204	0.512652	0.27	0.512218
FBL046	0.1290	0.512640	0.04	0.512175

Table G.1. Neodymium (Nd) and Samarium (Sm) Isotope Ratios (continued).

Sample [c]	Measured Ratios [a, b]			
	$^{147}Sm/^{144}Nd_{(now)}$ [d]	$^{143}Nd/^{144}Nd_{(now)}$ [e]	$eNd_{(now)}$ [f]	$^{143}Nd/^{144}Nd_{(550\ Ma)}$ [g]
FBL047	0.1240	0.512621	-0.33	0.512174
FBL048	0.1227	0.512659	0.41	0.512217
FBL049	0.1123	0.512612	-0.51	0.512207
FBL050	0.1139	0.512616	-0.43	0.512206
FBL051	0.1213	0.512424	-4.17	0.511987
FBL052	0.1209	0.512398	-4.68	0.511962
FBL053	0.1231	0.512418	-4.29	0.511974
FBL054	0.1267	0.512412	-4.41	0.511955
FBL055	0.1417	0.512472	-3.24	0.511961
FBL056	0.1287	0.512372	-5.19	0.511908
FBL057	0.1282	0.512146	-9.60	0.511684
FBL058	0.1278	0.512602	-0.70	0.512141
FBL059	0.1330	0.512603	-0.68	0.512124
FBL060	0.1348	0.512666	0.55	0.512180
FBL061	0.1355	0.512683	0.88	0.512195
FBL062	0.1351	0.512654	0.31	0.512167
FBL063	0.1331	0.512699	1.19	0.512219
FBL064	0.1337	0.512689	0.99	0.512207
FBL065	0.1352	0.512675	0.72	0.512188
FBL066	0.1168	0.512606	-0.62	0.512185
FBL067	0.1217	0.512627	-0.21	0.512188
FBL068	0.1301	0.512474	-3.20	0.512005
FBL069	0.1247	0.512613	-0.49	0.512164
FBL070	0.1408	0.512668	0.59	0.512161
FBL071	0.1564	0.512696	1.13	0.512132
FBL072	0.1470	0.512553	-1.66	0.512023
FBL073	0.1472	0.512697	1.15	0.512167
FBL074	0.1294	0.512337	-5.87	0.511871
FBL075	0.1511	0.512687	0.96	0.512143
FBL076	0.1352	0.512431	-4.04	0.511944
FBL077	0.1326	0.512442	-3.82	0.511964
FBL078	0.1390	0.512489	-2.91	0.511988
FBL079	0.1400	0.512428	-4.10	0.511924
FBL080	0.1456	0.512549	-1.74	0.512024

[a] All Nd data normalized to $^{146}Nd/^{144}Nd = 0.7219$.

[b] Replicate analyses of JNdi-1 yield $^{143}Nd/^{144}Nd = 0.512108 \pm 0.000007$ (n = 20).

[c] Samples FBL006, FBL015, and FBL020 were each measured multiple times; the ratios for each measurement are listed separately.

[d] Error in measured $^{147}Sm/^{144}Nd$ is the quadratic sum of run precision, external reproducibility of the standards, and uncertainty in the Sm/Nd ratio of the spike. For the samples in this study, this error is consistently < 0.0010 in the measured ratio (absolute 2s).

[e] Error in measured $^{143}Nd/^{144}Nd$ is dominated by external reproducibility error and is estimated at ± 0.000010 (absolute 2s).

[f] eNd calculated using $^{143}Nd/^{144}Nd_{ChUR} = 0.512638$ and $^{147}Sm/^{144}Nd_{ChUR} = 0.1967$.

[g] Error in the calculated $^{143}Nd/^{144}Nd$ at 550 Ma is a combination of errors in the measured ratios. For the samples in this study, this error is consistently < 0.000040 in the initial ratio (absolute 2s).