TRACE ELEMENTS AND SR-ISOTOPIC GEOCHEMISTRY OF THE CONSTITUENT MINERALS IN ULTRAMAFIC XENOLITHS FROM SAN QUINTIN, BAJA CALIFORNIA

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We report the abundances of K, Rb, Sr and Ba and the $^{87}Sr/^{86}Sr$ ratios of separated silicate minerals in a suite of ultramafic xenoliths, their host basalts, and plagioclase megacryst from San Quintin, Baja California, (Table 1).

Although the xenoliths are enriched in modal diopsides (up to 35%), the trace element abundances are extremely low in all the silicate phases. For example, the diopsides contain as low as 10.7 ppm K, 0.01 ppm Rb, 1.7 ppm Sr and 0.6 ppm Ba. The diopsides from the pyroxenite layers usually show slightly higher abundances, such as 107 ppm K, 0.07 ppm Rb, 22 ppm Sr and 33 ppm Ba.

In four lherzolites, the coexisting olivines, orthopyroxenes and clinopyroxenes were analyzed after separation by hand-picking. In three of these samples, each mineral fraction was analyzed twice - without washing and after washing in 2N add HCl for 3 minutes. In the acid washed minerals (AW), K, Rb, Sr and Ba abundances are reduced by about half from the unwashed abundances. In addition, $^{87}Sr/^{86}Sr$ ratios are also lowered by the acid washing. In one of these samples, the acid washed minerals and the acid washed whole rock reveal an isochron of $T = 3.41 \pm 0.3$ AE (2σ) and $I = 0.70057 \pm 0.004$ (2σ). In the other three samples the coexisting silicates show clear disequilibrium in their $^{87}Sr/^{86}Sr$ ratios.

The green chrome-diopsides in the spinel lherzolites, except in specimen 2-13, show $^{87}Sr/^{86}Sr$ ratios lower than 0.7030, whereas the more iron-rich black clinopyroxenites show much higher $^{87}Sr/^{86}Sr$ ratios. Therefore, these two groups of pyroxenes are not genetically related.

The extremely fine-grained (CPX+glass) whole rock vein, interpreted as a partially molten layer in the spinel lherzolite no. 2-68, show a $^{87}Sr/^{86}Sr$ ratio of 0.7030 - possibly the same ratio in the refractory chrome-diopside in the host rock.

In the plagioclase peridotite, no. 1-6-1, both plagioclase and clinopyroxene show the same $^{87}Sr/^{86}Sr$ ratios; possibly, this peridotite formed by crystal settling in an alkali basaltic magma chamber in the mantle with higher $^{87}Sr/^{86}Sr$ ratios than the surficial lava flows in San Quintin.

Plagioclase megacryst of andesine composition, Sp. No. 3-1, show essentially the same $^{87}Sr/^{86}Sr$ ratios as its host basalt. This plagioclase is, therefore, a true phenocryst. On this basis the partition coefficients between plagioclase/basalt for K, Rb, Sr and Ba are 0.688, 0.355, 4.09 and 0.916, respectively. These estimates are 2 to 10 times higher than the values commonly used. However, the andesine megacryst is likely to be a high pressure phenocryst, and the above distribution coefficients may be valid only at high pressures.

The clinopyroxenes from the different xenoliths show the lowest and the most variable $^{87}Sr/^{86}Sr$ ratios of all the silicates, from .70196±11 to .70445±5. Thus the data indicate that at least part of the vertical mantle profile beneath San Quintin, represented by the xenoliths studied here, is heterogeneous in its Sr-isotopic ratios. This heterogeneity must reflect complex processes in the mantle, such as partial melting, removal of melt, cumulus processes, recrystalization, etc.

Finally, the extreme depletion of the trace elements in the silicate phases of the lherzolites, as reported here, contrasts remarkably with the diopside-rich nature of the xenoliths. No simple scheme of partial melting of these xenoliths can produce any normal basalt with its appropriate trace elemental abundances and ratios.

Table 1

Sample	Mineral	K ppm	Rb ppm	Sr ppm	Ba ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
	OL	13.6	.042	.380	.424	.3195	.70709±25
2-82	OL(AW)	4.6	.018	.233	.114	.2233	-
Spinel	OPX	33.3	.059	.556	.280	.3068	.70680±18
Lherzolite	OPX(AW)	22.4	.034	.322	.172	.3053	-
	CPX	15.5	.049	1.951	1.490	.0726	.70340±12
	CPX(AW)	12.39	.038	1.703	.650	.0645	.70261±8
	OL	42.6	.100	2.643	16.00	.1094	.70723±5
2-13	OL(AW)	17.5	.044	1.301	9.71	.0978	.70555±12
Spinel	OPX	52.2	.110	3.552	13.02	.0895	.70765±10
Lherzolite	OPX(AW)	28.7	.083	2.976	9.98	.0806	.70717±14
	CPX	50.9	.090	2.857	9.6	.0911	.70528±12
	CPX(AW)	23.9	.050	2.136	7.07	.0677	.70484±10
	OL	39.3	.063	4.32	13.0	.0422	.70684±11
	OL(AW)	21.2	.035	.953	8.48	.1062	.70585±18
2-41	OPX	204.4	.186	5.74	8.82	.1094	.70702±7
Spinel	OPX(AW)	43.6	.057	1.51	6.34	.1091	.70579±7
Lherzolite	CPX	92.2	.123	11.17	12.72	.0318	.70545±12
	CPX(AW)	38.7	.054	5.295	12.58	.0295	.70196±11
	Whole Rock(AW)	33.6	.043	1.591	8.10	.0781	.70452±8
2-67	OL(AW)	22.06	.050	.189	.321	.7648	.70644±16
Spinel	OPX(AW)	4.00	.003	.338	.827	.0256	.70302±13
Lherzolite	CPX(AW)	10.70	.011	7.353	.597	.0043	.70230±6
1-7-28 Spinel Lherzolite	Cr-Diopside (AW)	63.14	.059	5.643	.732	.0302	.70275±9

Sample	Mineral	K ppm	Rb ppm	Sr ppm	Ba ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
2-68 Pxite layer in Spinel Lherzolite	CPX + glass (AW)	43.70	.050	32.83	.666	.0044	.70303±8
2-30 Cpxite layer	Cr-Diopside (AW)	107.9	.073	21.99	1.005	.0096	.70295±7
1-8-5 Black Cpxite (augite)	CPX (AW)	64.38	.049	18.707	-	.0076	.70413±8
2-81 Black Cpxite (augite)	CPX (AW)	31.61	.049	22.144	33.58	.0064	.70445±5
2-36 Sp-Lh W/ Opxite layer	OPX (AW)	94.96	.070	.449	.242	.4541	-
1-6-1	Plag (An_{98}) (AW)	36.80	.042	342.32	16.65	.00035	.70407±7
Plag - Peridotite	CPX (AW)	18.03	.046	13.04	4.03	.0102	70425±13
2-19 Plag-peridotite	Plag (AW)	143.61	.255	406.40	16.43	.0018	.70337±8
3-1 Plag Megacryst Andesine	Plag (AW)	10591	12.776	2503	348.7	.0148	.70317±9
1-2-6 Host Basalt	Whole Rock (AW)	15390	35.96	611.7	380.6	.1699	.70311±8
SQB Host Basalt	Whole Rock (AW)	13853	26.58	560.7	315.8	.1371	.70314±7