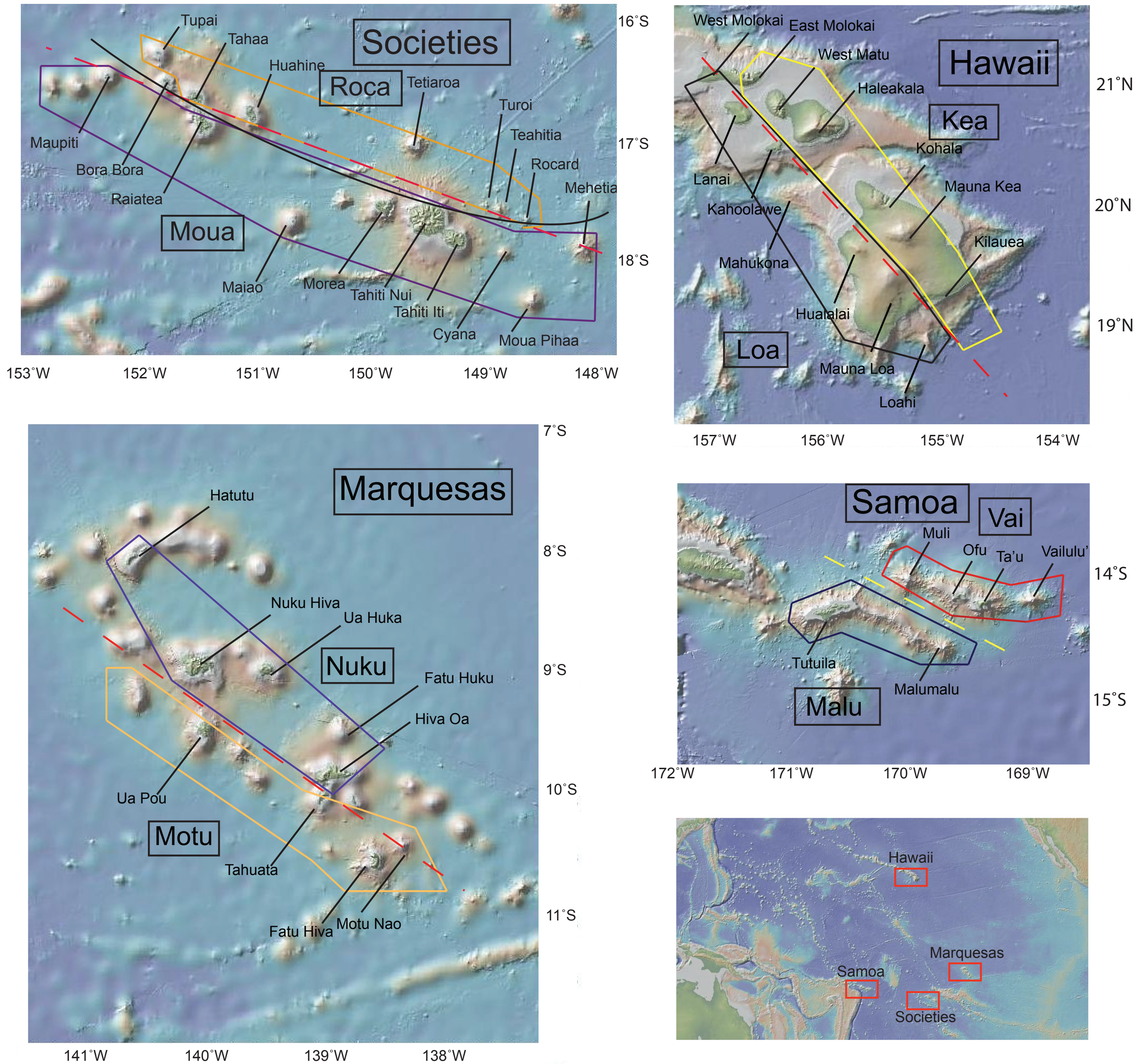
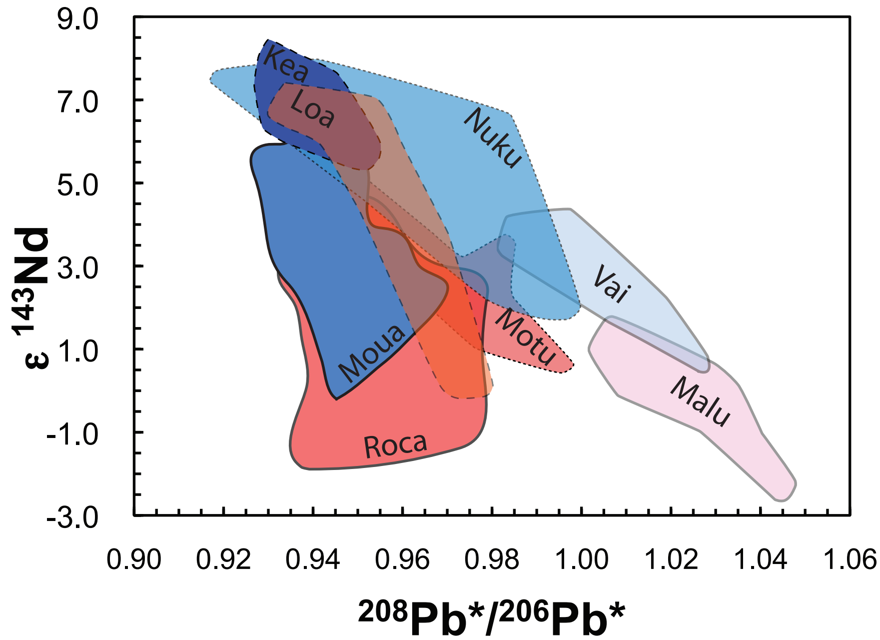


Figure DR1. Maps showing the proposed dual volcanic trends at Hawaii, Samoa, Marquesas (Huang et al., 2011) and Societies (this study). Excluding the Pacific regional map, all four maps of the individual hotspot tracks are at the same scale.

Figure DR2



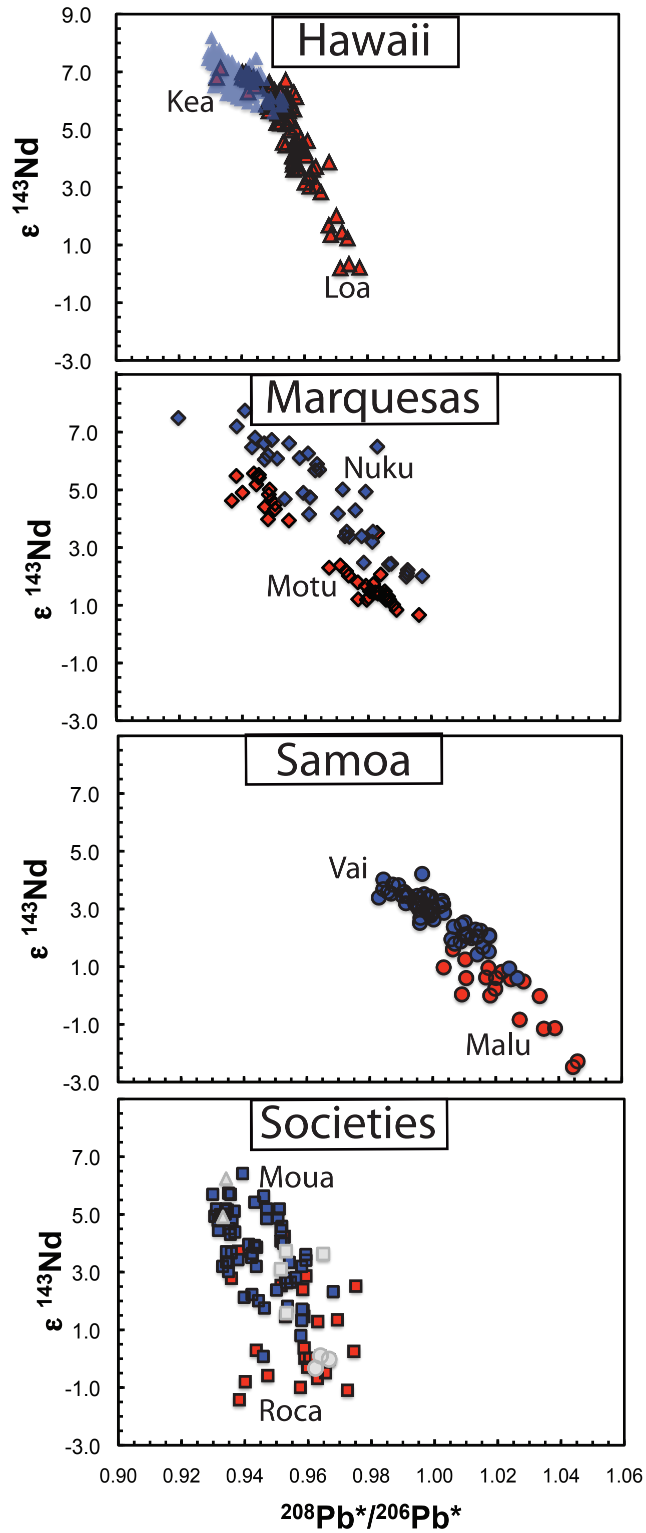


Figure DR2. The $^{143}Nd/^{144}Nd$ vs. $^{208}Pb^*/^{206}Pb^*$ for the Societies hotspot compared with Hawaii, Samoa and Marquesas hotspots. All four hotspots are shown together in the large panel. However, to facilitate examination of the geochemical data at each hotspot, the data for each of the four hotspots are shown separately in the four small panels. Bora Bora lavas plot geographically and geochemically between the two Societies trends and are shown with grey squares (i.e., they are not assigned to one of the two trends). Rejuvenated lavas are excluded from this study, but are shown as grey triangles. We consider several highly evolved lavas (mugearites) from Moorea to have experienced crustal contamination (see Figure DR3), and these three lavas are plotted as grey circles in the figure.

Figure DR3

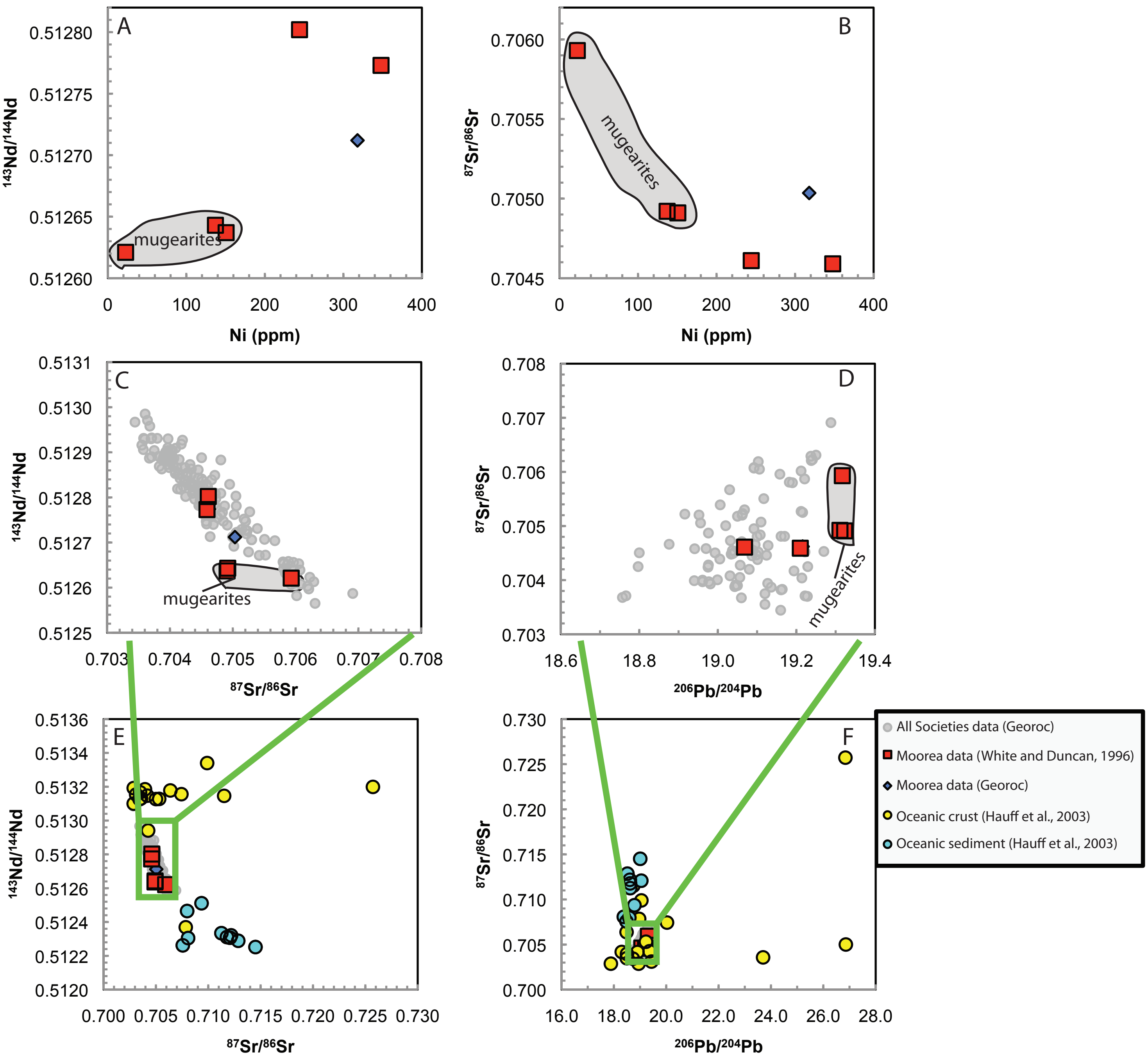


Figure DR3. Highly evolved mugearite lavas from Moorea exhibit evidence for assimilation of crustal materials. White and Duncan (1996) reported Sr-Nd-Pb isotopic and trace element geochemistry for five lavas from Moorea. **Panels A and B.** The Moorea mugearites become increasingly enriched isotopically with increasing degrees of magmatic evolution, an observation that may be explained by crustal assimilation with increasing magmatic evolution. **Panels C and D**. The three Moorea mugearites have extreme isotopic signatures, including the most radiogenic $^{206}Pb/^{204}Pb$ isotopic compositions reported for Societies lavas. White and Duncan (1996) argued that this is not an assimilation signature, and suggested "assimilation of basalt or sediment from the oceanic crust would lower $^{206}Pb/^{204}Pb$." However, we note that the three Moorea mugearites are also shifted to enriched $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios, consistent with assimilation. **Panels E and F.** Contrary to the statement made by White and Duncan (1996), Hauff et al. (2003) identified extremely radiogenic $^{206}Pb/^{204}Pb$ in the basaltic portions of drill cores from sites 1149 and 801 in the ODP Leg 185, and assimilation is therefore a concern in the Moorea mugearites. While we do not provide a specific assimilation model here, the geochemical diversity identified in the altered oceanic crust (AOC) and sediments by Hauff et al. (2003) permit a host of assimilation scenarios (i.e., magmatic assimilation of both AOC and sediments) that may explain the unusual geochemistry of the Moorea mugearites. The geochemical trends in the Societies lavas, together with the enormous isotopic diversity in altered oceanic crust and sediments, are consistent with assimilation of crustal materials in the most evolved lavas from Moorea.

Figure DR4

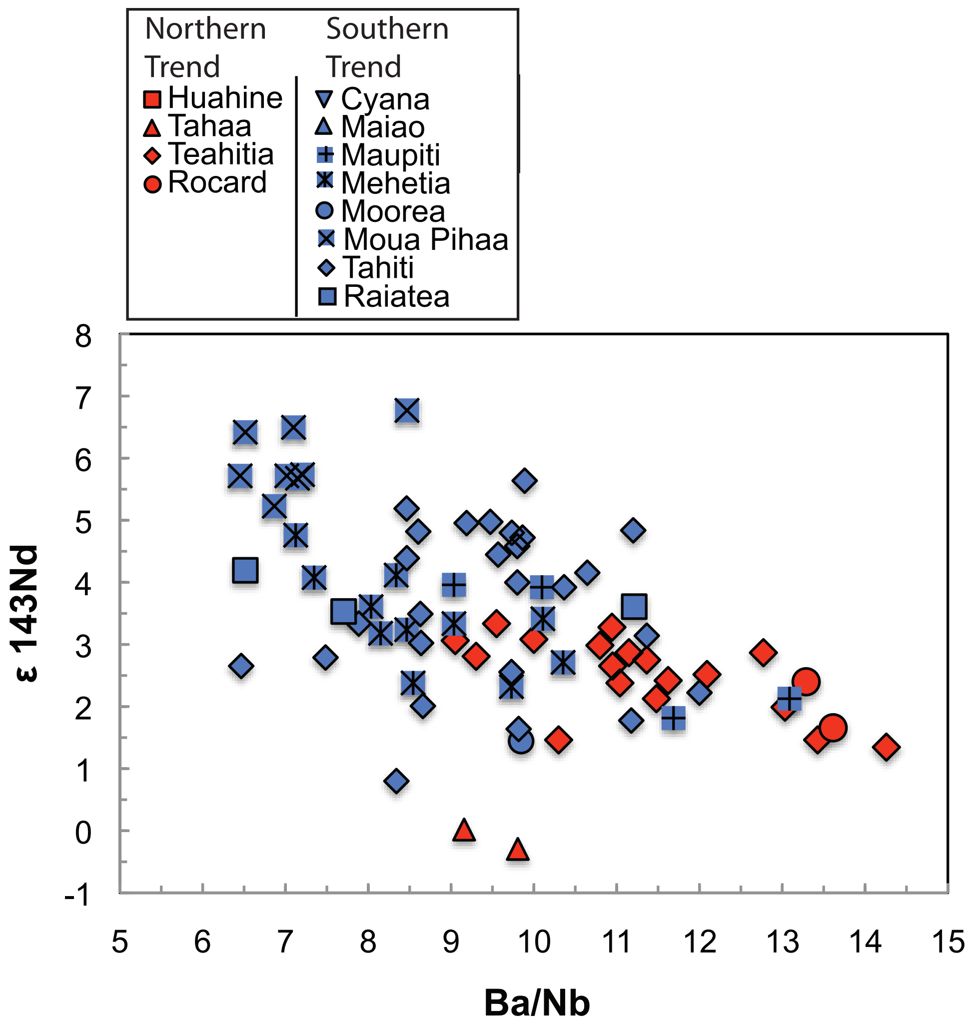


Figure DR4. The Ba/Nb ratio can also be used to geochemically resolve the two volcanic trends. Societies lvas with high Ba/Nb ratios are often associated with geochemical and isotopic enrichment. Samples from the geochemically-enriched northern islands tend to have higher Ba/Nb and lower $^{143}Nd/^{144}Nd$ than the southern trend volcanoes. Lavas with MgO < 4.0 wt.% were excluded, as trace phases that occur in highly evolved lavas can fractionate Ba/Nb ratios. Where Pb-isotopic data is absent (e.g., Raiatea), this plot can be used to evaluate whether a volcano has northern or southern trend geochemical affinities. In the absence of a complete isotopic dataset for Raiatea, a southern trend island, paired Ba/Nb and $^{143}Nd/^{144}Nd$ data suggest that this island exhibits geochemical affinities with other southern trend volcanoes.

Table DR1. Geochemical data for the Societies lavas, dowloaded from Georoc (georoc.mpch-mainz.gwdg.de/georoc) in the summer of 2011

Name of volcano	Sample name	$\varepsilon^{143}Nd$	$^{87}Sr/^{86}Sr$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{208}Pb^*/^{206}Pb^*$	$\Delta\ ^{207}Pb/^{204}Pb$	$\Delta\ ^{208}Pb/^{204}Pb$	Ba/Nb
Roca trend volcanoes:										
Huahine	s HHN-8			19.10	15.61	38.94	0.967	4.999	22.7	13.4
Huahine	s USNM101211	2.5	0.705270	19.21	15.61	38.90	0.951	3.142	4.5	
Huahine	s USNM101198	0.4	0.705800	19.19	15.64	38.95	0.959	6.480	12.2	
Huahine	s 73-111	0.0	0.706070	19.09	15.61	38.87	0.960	4.643	16.4	
Huahine	s 73-56		0.705620							
Huahine	s 73-72		0.704860							
Huahine	s 73-83	4.2	0.704280	18.98	15.57	38.68	0.952	2.600	11.5	
Huahine	s 73-95	1.3	0.705670	19.03	15.60	38.84	0.963	4.615	20.5	
Tahaa	s 7X	0.3	0.705811							
Tahaa	s 8B	3.3	0.704723							
Tahaa	s TAA-B-7	0.0	0.705958	19.16	15.63	38.92	0.959	6.227	13.3	9.2
Tahaa	s 7Y		0.706078							
Tahaa	s TAA-B-26	-0.3	0.706226	19.24	15.66	39.01	0.960	8.028	12.1	9.8
Tahaa	s 73-185	-1.0	0.706910	19.29	15.66	39.03	0.958	7.418	8.6	
Tahaa	s 73-186	3.2	0.705050							
Tahaa	s 73-189	0.7	0.705520							
Tahaa	s 73-190	-0.7	0.706190	19.10	15.62	38.91	0.963	6.023	18.5	
Tahaa	s 73-192	-0.5	0.706290	19.24	15.66	39.06	0.966	8.771	17.8	
Tahaa	s 73-196		0.706380							
Tahaa	s TA-1D	-1.4	0.706310	19.25	15.59	38.80	0.938	1.630	-9.6	
Tahaa	s TA-2J	2.8	0.704870	18.98	15.53	38.52	0.936	-1.900	-4.6	
Tahaa	s TA-3F	0.3	0.706050	19.11	15.57	38.72	0.944	0.691	-0.5	
Tahaa	s TA-4H	-0.6	0.706080	19.09	15.57	38.74	0.947	1.243	3.5	
Tahaa	s TA-8B	3.7	0.704580	18.94	15.53	38.51	0.938	-1.320	-1.5	
Tahaa	s TA-8G	-0.8	0.706210	19.24	15.59	38.81	0.940	1.060	-7.5	
Teahitia	s 9-3	3.1	0.704395							10.0
Teahitia	s 3-101	2.8	0.704624							11.4
Teahitia	s 3-8	3.3	0.704575							10.9
Teahitia	s 3-3	2.9	0.704547	19.04	15.59	38.81	0.959	3.439	16.6	11.1
Teahitia	s TEAH-3	3.1	0.704630							9.1
Teahitia	s 3-7	2.4	0.705024							11.6
Teahitia	s TEAH-2	3.3	0.704358							9.5
Teahitia	s 9-1CD	2.1	0.704577							11.5
Teahitia	s 3-113	2.0	0.704691							13.0
Teahitia	s 9-2CD	2.9	0.704707							12.8
Teahitia	s 9-1	1.3	0.705506	19.12	15.62	38.98	0.969	6.072	24.4	14.3
Teahitia	s 3-100	2.8	0.704508							9.3
Teahitia	s 3-1	1.5	0.704640	19.13	15.59	38.89	0.959	2.952	13.7	10.3
Teahitia	s 20-1	2.7	0.704590							11.0
Teahitia	s 5-5	3.0	0.704659							10.8
Teahitia	s 5-1	2.4	0.704559							11.0
Teahitia	s 3-5	2.5	0.704836	19.11	15.61	39.03	0.975	4.969	30.3	12.1
Teahitia	s 22-1	1.5	0.705006	19.02	15.58	38.73	0.953	2.723	10.8	13.4
Teahitia	s 9DS-3			19.14	15.61	38.94	0.963	4.422	17.3	
Rocard	s 4-123	2.4	0.704806	19.10	15.59	38.86	0.958	2.856	14.1	13.3
Rocard	s 34-1	1.7	0.705073	19.11	15.59	38.87	0.958	2.748	13.9	13.6

Rocard	s 4-8	0.4	0.705886							
Rocard	s 4-113	0.4	0.705965							
Rocard	s 4-115	-0.1	0.705839							
Rocard	s 4-2	-1.1	0.706017	19.21	15.64	39.11	0.972	6.942	25.3	
Rocard	s 4-124	-0.5	0.705981							
Rocard	s 4-126	-0.6	0.705929							
Rocard	s 4-3	0.3	0.705870	19.22	15.65	39.14	0.974	7.444	27.1	
Rocard	s PN20-5	3.5								
Rocard	s PN20-13	-0.7								
Moua trend volcanoes:										
Cyana	s 81-3	4.9	0.704504	18.99	15.56	38.68	0.950	1.316	9.1	
Maiao	s MAO-6	5.7	0.703700	19.23	15.53	38.70	0.930	-4.932	-17.4	
Maiao	s MAO-13	5.1	0.703940	19.13	15.53	38.65	0.935	-3.537	-10.0	
Maiao	s MAO-27	3.3	0.704810	19.16	15.55	38.69	0.935	-1.705	-10.6	
Maiao	s MAO-61	4.8	0.704810	19.17	15.54	38.71	0.936	-2.903	-9.8	
Maiao	s MAO-65	4.5	0.703830	19.16	15.53	38.69	0.935	-3.938	-10.3	
Maiao	s MAO-113	4.4	0.703870	19.14	15.54	38.68	0.937	-2.234	-7.9	
Maiao	s MAO-114	4.9	0.703820	19.16	15.54	38.64	0.930	-3.205	-14.9	
Maupiti	s MU5	1.8	0.705391	19.01	15.59	38.72	0.954	4.275	11.8	11.7
Maupiti	s MU24	3.9	0.704663	18.88	15.55	38.50	0.943	1.684	5.1	10.1
Maupiti	s MU6A	2.1	0.705204	18.95	15.58	38.54	0.940	3.260	-0.1	13.1
Maupiti	s MU20	4.0	0.704505	18.80	15.56	38.41	0.941	2.708	5.4	9.0
Maupiti	s MU11	2.8	0.705056	18.96	15.59	38.67	0.953	4.717	12.4	
Maupiti	s 73-201	1.3	0.705300							
Maupiti	s 73-204	1.7	0.705230	19.06	15.62	38.82	0.958	5.757	14.8	
Maupiti	s 73-207	1.3	0.705300	19.07	15.59	38.83	0.958	2.803	14.6	
Mehetia	s P3-101	3.4	0.704548	19.09	15.59	38.86	0.959	2.964	15.3	10.1
Mehetia	s P3-115	2.7	0.704539							10.4
Mehetia	s P3-5	3.3	0.704466							9.0
Mehetia	s MEAH-6	4.8	0.703962							7.1
Mehetia	s M-2	4.1	0.704714							8.3
Mehetia	s MEAH-2	3.2	0.704507							8.1
Mehetia	s P3-1	2.4	0.704622	19.07	15.56	38.75	0.950	0.181	6.7	8.5
Mehetia	s P2-5	3.6	0.704600	19.08	15.59	38.85	0.959	3.073	15.5	8.0
Mehetia	s P1-1	2.3	0.704655	19.10	15.57	38.95	0.968	0.610	23.6	9.7
Mehetia	s P3-3	3.2	0.704597							8.5
Mehetia	s P3-4	4.1	0.704276	19.06	15.56	38.75	0.951	0.422	8.4	7.3
Mehetia	s MEH-A1	3.1	0.704634							
Mehetia	s MEH-DR1	3.5	0.704121							
Mehetia	s MEAH-3	3.6	0.704215							
Mehetia	s MHT-101	4.9	0.703900	19.05	15.53	38.57	0.933	-2.202	-9.3	
Mehetia	s MHT-103	5.0	0.703910	19.05	15.53	38.55	0.932	-2.948	-9.9	
Mehetia	s MHT-120	3.2	0.704250	18.80	15.52	38.33	0.933	-1.359	-2.4	
Mehetia	s MHT-121	3.2	0.704490	19.04	15.55	38.66	0.944	-0.172	1.3	
Mehetia	s MHT-151	3.6	0.704520	19.04	15.55	38.65	0.942	-0.826	0.0	
Mehetia	s MHT-155	4.8	0.703880	19.04	15.53	38.54	0.931	-3.026	-10.6	
Moorea	s MOOR1	1.4	0.705035							9.8
Moorea	s 93MO-1	2.6	0.704590	19.21	15.59	38.92	0.953	1.464	6.4	
Moorea	s 93MO-4	0.1	0.704920	19.31	15.64	39.12	0.964	5.269	14.4	
Moorea	s USNM101159	-0.3	0.705930	19.32	15.63	39.11	0.962	4.604	12.7	
Moorea	s 73-211		0.705000							

Moorea	s 73-215		0.704700								
Moorea	s 73-225		0.704470								
Moorea	s 73-233	0.0	0.704910	19.32	15.65	39.16	0.967	6.539	16.8		
Moorea	s 73-234	3.2	0.704610	19.07	15.59	38.83	0.958	2.803	14.6		
Moorea	s 73-248		0.704850								
Moorea	s MO01-01	2.7	0.704621	19.22	15.60	38.93	0.954	2.899	7.4		
Moua Pihaa	s TH24-9	6.4	0.703444	19.16	15.56	38.73	0.939	-0.794	-6.1	6.5	
Moua Pihaa	s TH24-1	5.4	0.703553	19.12	15.56	38.73	0.943	-0.361	-1.3	0.0	
Moua Pihaa	s 28-1	5.7	0.703798							6.5	
Moua Pihaa	s TH24-10	5.7	0.703581							7.0	
Moua Pihaa	s 29-2CD			19.30	15.61	38.96	0.949	2.688	-0.1	7.5	
Moua Pihaa	s 29-2CD	6.8	0.703605							8.5	
Moua Pihaa	s 29-1	5.7	0.703709	19.22	15.54	38.74	0.935	-3.466	-12.2	7.2	
Moua Pihaa	s TH24-4	4.9	0.703673	19.06	15.57	38.71	0.947	1.290	3.9	0.0	
Moua Pihaa	s TH24-7	5.7	0.703600							7.1	
Moua Pihaa	s 28-1CD	6.5	0.703642							7.1	
Moua Pihaa	s TH24-5	5.2	0.703577							6.9	
Moua Pihaa	s TH24-9	6.4									
Tahiti	s T85-41	2.2	0.705180	19.05	15.56	38.66	0.942	-0.102	-0.3	12.0	
Tahiti	s T85-43	3.4	0.704710	19.06	15.53	38.59	0.934	-2.921	-8.5		
Tahiti	s T85-44	0.1	0.705810	19.18	15.57	38.82	0.946	-0.533	-0.3		
Tahiti	s THG-10B	2.7	0.704566							6.5	
Tahiti	s TH-68	1.6	0.705055							9.8	
Tahiti	s TH-14	5.2	0.704006	19.00	15.57	38.69	0.951	1.851	9.4	8.5	
Tahiti	s 62Y	4.5	0.704055								
Tahiti	s 56L	4.0	0.704160								
Tahiti	s 56C	2.8	0.704468								
Tahiti	s THG-1A	1.8	0.705143							11.2	
Tahiti	s TH-65	3.5	0.704456							8.6	
Tahiti	s 56AA	0.7	0.705422								
Tahiti	s TH-66	0.8	0.705251	19.22	15.62	38.97	0.958	4.699	10.6	8.3	
Tahiti	s 56N	2.1	0.704851								
Tahiti	s 62A	2.3	0.704757								
Tahiti	s 56AB	3.5	0.704363								
Tahiti	s T85-19	3.0	0.704480	19.03	15.54	38.57	0.935	-1.229	-7.1	8.6	
Tahiti	s THG-14	5.0	0.703964							9.5	
Tahiti	s THG-10C1	2.6	0.704659							9.7	
Tahiti	s THG-3A	4.7	0.703965							9.9	
Tahiti	s 62CH	2.0	0.704913								
Tahiti	s 56Z	1.0	0.705017								
Tahiti	s THG-15A	3.1	0.704485							11.4	
Tahiti	s THG-13A	4.8	0.704147							9.7	
Tahiti	s THG-18B	5.0	0.703954							9.2	
Tahiti	s THG-9E1	5.0	0.703971								
Tahiti	s THG-2C	4.8	0.703963								
Tahiti	s THG-4	4.8	0.703937								
Tahiti	s 62BZ2	4.6	0.703962								
Tahiti	s THG-3B	4.9	0.703958								
Tahiti	s THG-9B	2.8	0.704532								
Tahiti	s 65G2	1.5	0.704996								
Tahiti	s 62AF1	4.9	0.704062								
Tahiti	s T85-102	5.7	0.703970	18.98	15.52	38.52	0.935	-3.211	-4.9		
Tahiti	s T85-12	5.0	0.704000	18.96	15.52	38.49	0.934	-2.237	-6.1		

Tahiti	s T85-24	4.4	0.704240	18.98	15.51	38.48	0.932	-3.589	-8.6	
Tahiti	s T85-33	4.3	0.704080	19.03	15.53	38.57	0.935	-1.996	-6.4	
Tahiti	s T85-34	5.1	0.703930	18.98	15.52	38.54	0.937	-2.854	-3.9	
Tahiti	s T85-67	5.2	0.703970	18.96	15.51	38.49	0.934	-4.137	-6.0	
Tahiti	s T85-7	3.7	0.704380	19.10	15.53	38.62	0.934	-3.055	-9.6	
Tahiti	s T85-72	5.2	0.703750	19.12	15.52	38.61	0.931	-4.461	-13.2	
Tahiti	s T85-93	3.4	0.704390	19.01	15.53	38.57	0.938	-2.114	-3.4	
Tahiti	s T85-95	4.9	0.704027							
Tahiti	s TC-92	3.9	0.704527							
Tahiti	s TH-1	4.4	0.704340							8.5
Tahiti	s TC-11	4.8	0.704028							8.6
Tahiti	s TH-63	4.6	0.704320							9.8
Tahiti	s TH-57	3.9	0.704228							10.4
Tahiti	s TH-70	3.3	0.704521	19.22	15.62	38.94	0.954	4.434	6.9	7.9
Tahiti	s TH-18	5.3	0.703966							
Tahiti	s TAH-31	2.7	0.704745							
Tahiti	s TAH-47	4.1	0.704253							
Tahiti	s T83-12X	4.2	0.704150							
Tahiti	s T83-PAP	4.4	0.704112							
Tahiti	s T87-6	3.7	0.704319							
Tahiti	s USNM100793	2.8	0.704460	19.12	15.61	38.86	0.956	4.196	11.3	
Tahiti	s USNM100801	4.6	0.704050	19.06	15.59	38.75	0.952	2.833	8.7	
Tahiti	s USNM101044	3.9	0.704250	19.23	15.60	38.84	0.944	2.758	-3.6	
Tahiti	s THT-15	4.0	0.704450	19.09	15.58	38.79	0.952	2.297	8.5	9.8
Tahiti	s TAH2	5.6	0.704200	19.08	15.57	38.72	0.946	1.073	2.5	9.9
Tahiti	s TAH4	4.4	0.703990	18.94	15.52	38.64	0.951	-2.410	11.5	9.6
Tahiti	s TAH3	2.0	0.704583	18.97	15.56	38.60	0.944	1.265	3.8	8.7
Tahiti	s TAH1	2.8	0.704567							7.5
Tahiti	s TH-5	4.8	0.703986							11.2
Tahiti	s TH-4	4.2	0.704130							10.6
Tahiti	s USNM101030	5.2	0.704040	19.21	15.61	38.86	0.947	3.520	-0.1	
Tahiti	s 73-423		0.703980							
Tahiti	s 73-422		0.703730							
Tahiti	s 1		0.704200							
Tahiti	s 2		0.704700							
Tahiti	s 3		0.704100							
Tahiti	s 4		0.704600							
Tahiti	s 5		0.704400							
Tahiti	s 6		0.703900							
Tahiti	s 7		0.704300							
Tahiti	s 8		0.704200							
Tahiti	s 9		0.704300							
Tahiti	s 10		0.705600							
Tahiti	s 11		0.704300							
Tahiti	s 73-396		0.704540							
Tahiti	s 74-416	4.1	0.704340							
Tahiti	s 74-422	5.5	0.704180							
Tahiti	s 73-362		0.703990							
Tahiti	s 73-367		0.704820							
Tahiti	s 73-419		0.703600							
Tahiti	s 74-437	3.7	0.704520	19.10	15.54	38.64	0.936	-2.377	-8.2	
Tahiti	s T85-35	3.5	0.704170	19.19	15.58	38.79	0.942	0.337	-4.3	
Tahiti	s T85-40	1.8	0.705200	19.06	15.57	38.71	0.946	1.268	3.2	

Inconclusive (no trend assigned)										
Bora Bora	s USNM101282	1.6	0.705220	18.92	15.59	38.63	0.953	5.151	13.8	
Bora Bora	s USNM101286	3.6	0.704530	19.27	15.64	39.09	0.965	5.713	16.3	
Bora Bora	s USNM101287	5.3	0.704090							
Bora Bora	s USNM101288	4.4	0.704450							
Bora Bora	s 73-257	3.1	0.704730	19.03	15.60	38.73	0.951	4.493	9.0	
Bora Bora	s 73-295		0.704000							
Bora Bora	s 73-318		0.704670							
Bora Bora	s 73-332	3.7	0.704950	19.09	15.61	38.80	0.953	5.043	9.1	
Rejuvenated lavas:										
Tahaa Post Erosiona	s TA-2R	6.2	0.703680	18.76	15.48	38.30	0.934	-4.526	-0.2	
Tahaa Post Erosiona	s TA-2V	4.9	0.703710	18.77	15.47	38.30	0.933	-5.523	-1.4	
Isotopic Data Incomplete or Absent:										
Raiatea	s RIG-3B	3.5	0.704433							7.7
Raiatea	s RIG-1B	3.6	0.704367							11.2
Raiatea	s RIG-4C	4.2	0.704085							6.5
Raiatea	s RI-28	3.6	0.704434							
Raiatea	s 73-124		0.704020							
Raiatea	s 73-140		0.704100							
Raiatea	s 73-153		0.704090							
Tupai	s TU134T	No isotopic data								
Tupai	s TU134T	No isotopic data								
Turoi	s 19-1	No isotopic data								3.0
Turoi	s TH03-10	No isotopic data								
Turoi	s TH03-09	No isotopic data								
Un-named	s 2-1	3.6	0.704466	19.10	15.59	38.88		2.578	16.0	9.1
Un-named	s 2-7	8.7	0.702839							

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