GSA Data Repository item 2011260

GEOCHEMICAL MAPPING OF THE KINGS-KAWEAH OPIOLITE BELT, CALIFORNIA-EVIDENCE FOR PROGRESSIVE MELANGE FORMATION IN A LARGE OFFSET TRANSFORM-SUBDUCTION INITIATION ENVIRONMENT-*SUPPLEMENTARY DATA AND TEXT*

J. Saleeby Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125

CONTENTS

Tables:

Supplementary Text:

Analytical facilities:

New radiogenic isotopic and ID-TIMS U-Pb zircon data reported here were generated in the author's isotopic geochemistry laboratory at the California Institute of Technology between 1989 and 2007. Mass spectrometry was performed on VG Sector multi-collector and Lunatic I (JGW) TIMS instruments. Information on standards and blanks are given below under analytical procedures.

Mineral chemistry studies for determination of pressure and temperature of equilibration were performed at the California Institute of Technology Geological, Geological and Planetary Sciences Division Analytical Facility. Confirmation of phase identifications and quantitative analysis of select points at three phase contacts between garnet, hornblende and plagioclase were performed on a JEOL JXA-8200 Electron Probe Micro-analyzer, with the former in EDS mode and later in WDS mode.

Major and trace element data on bulk rock samples were performed by X-ray fluorescence (Tables SD3, 6 and 8), and by ICP-MS (Table SD 3) at the Washington State University GeoAnalytical Laboratory. Laser ablation ICP-MS analyses of zircon for U/Pb ages were performed at the University of Arizona, Tucson, Laserchron Center.

Analytical procedures for Nd-Sr isotopic studies:

Bulk rock powders were prepared from ~100 g fragments of fine-grained rocks and ~500 g fragments of coarse-grained rocks by initial fragmentation in a small stainless steel jaw crusher. Granules with visible alteration effects were discarded. All washing procedures were performed in closed PFA Teflon screw top vials of various sizes with ultra-clean water and acids prepared in house by multiple sub-boiling distillation procedures. The bulk rock fragments chosen for analysis were given a 30 min. wash cycle by water in ultrasonic bath followed by a 30 min. wash in warm ultra-clean 1 N HCl, followed by multiple water rinses. Individual coarse clinopyroxene, plagioclase and hornblende grains (2-5 cm diameter) were separated from recrystallized rock matrix materials by rock saw, and then entire grains were given similar ultra-sonic and warm HCl washes prior to further processing. Garnet porphyroblasts from sample M9 readily broken free from the rock matrix upon jaw crushing. The cleanest, unbroken grains were hand picked under binocular microscope, and then likewise given ultrasonic water and warm dilute HCl washes prior to powdering. Washed bulk rock and mineral separates were then powdered a WC shatterbox. The hornblende-rich matrix from sample M9 was given additional initial wash cycles for 30 min. in warm 2 N HCl, followed by a warm water rinse, and then a 1 hr. hot wash in conc. H_2SO_4 as a means to leach out calcite altered apatite grains. The wash products were not analyzed.

Samples for which Nd and Sr isotopic studies were performed were spiked with ^{87}Rb and ^{84}Sr, and with mixed ^{147}Sm-^{150}Nd tracers, and the remainder of samples with only the mixed ^{147}Sm-^{150}Nd tracer. Spike and calibration shelf solutions used during the course of this study were the same as those used in Shaw et al., (1987). Bulk rock and mineral separate dissolutions were performed in screw-top PFA Teflon vials using a concentrated HF solution with a few drops of concentrated HNO_3 on a hot plate. Samples for which solid residues or "milky" solutions remained after one week were evaporated and re-dissolved in concentrated HF with a few drops of concentrated $HClO_4$ and left warm in open beaker under clean laminar flow air. Dissolution was usually complete after a few days. A few samples required drying down, and an additional cycle in HF-$HClO_4$. After final evaporation the samples were re-dissolved in 1 N HCl, and separation of Rb, Sr, and bulk REE were performed via HCl elution in cation columns. Separation of Sm and Nd was carried out using LNSpec^R resin. The highest procedural blanks measured during the course of the study were: 12 pg Rb, 175 pg Sr, 7 pg Sm and 16 pg Nd.

Mass spectrometric filament loading procedures for Nd consisted of loading in an AG50W-X8, 100-200 mesh resin bead with H_3PO_4 on a single Re filament, with ionization at ~1600° C typically yielding an ion beam current of 5 x 10^{-11}A. Analysis was of Nd ions in a five-cup dynamic mode. Nd isotopic ratios were normalized to $^{146}Nd/^{144}Nd$ = 0.7219. Sm was loaded in platinized carbon and HCl on a single Re filament, and ionized at ~1500°C yielding a typical ion beam current of 5 x 10^{-12}A, and run in static mode as Sm ions. Long-term external precisions on La Jolla Nd standard, including the time interval covered in this study, are ~10 ppm, and periodic runs of Caltech nNdβ standard during the course of this study were at ~15 ppm, the value obtained by Shaw et al., (1987). Mass spectrometric filament loading procedures for Sr consisted of loading in TaO on a single Ta filament, with ionization at ~1700° C yielding a typical ion beam current of 5 x 10^{-11}A. Sr was run by a four-cup dynamic mode. Sr isotopic ratios were normalized to $^{86}Sr/^{88}Sr$ = 0.1194. Rb was loaded in silica gel and H_3PO_4 on a single Re filament and ionized at ~900° C, yielding a typical ion beam current of 5 x 10^{-11}A. Rb was run in static multicollector mode. Long-term external precisions for Sr, including the time interval covered in this study, on NBS Sr987 are ~10 ppm.

Analytical procedures for Pb isotopic studies:

Splits from powdered bulk rock or feldspar samples used for Nd-Sr analysis were weighed into a TFE bomb capsule and given a warm wash for 15 minutes in ultrapure 4 N HNO_3. Bomb dissolution was complete in concentrated HF with 1 drop of concentrated HNO_3 at 225°C in 24 hours. The solution was evaporated and sample cakes were treated with several drops of $HClO_4$ and warmed in the open capsule, evaporated, re-dissolved in 6 N HCl, and then aliquoted into PFA screw top capsules. One aliquot was spiked with a mixed ^{208}Pb-^{235}U-^{230}Th tracer and equilibrated on a hot plate over night. Both aliquots were evaporated, and then re-dissolved in 6 N HCl-1 N HBr solution. Lead extractions were performed by standard HCl and HBr cycles, and U-Th extractions were performed for spiked aliquots in HNO_3-HCl cycles. Pb was loaded in H_3PO_4 and silica gel on a single Re filament and ionized at ~1400°C yielding typical ion beam currents of 1 to 5 x 10^{-11} A. Pb was analyzed in a dynamic multicollector peak switching mode with typical precisions of <0.1 per cent. A mass fractionation factor of 0.12±0.05/amu was applied based on multiple runs of NBS 982 standard. U and Th were loaded in H_3PO_4 and graphite on a single Re filament and ionized at ~1900°C yielding typical ion beam currents of 1 x 10^{-11} A for U, and 2-5 x 10^{-12} for Th. U and Th were analyzed in multicollector static mode with typical precisions of ~0.1 percent for U and <0.25 percent for Th. A mass fractionation factor of 0.13±0.06/amu was applied to the U data based on multiple runs of NBS U500, and was also applied to the Th data.

Analytical procedures for U/Pb Zircon studies:

Zircon separates from samples M4b, M5c, M6b, and M7a were weighed into a Savillex screw top vial and then given an additional 15-minute warm wash with ultrapure concentrated HNO_3. 500 ml of concentrated ultrapure HF with one drop of ultrapure HNO_3 were added to the vial, and the lid was sealed tight. The loaded vial was heated on a hot plate at 80°C for 6 days. Following cool down the solution was evaporated in a laminar flow clean hood, and then 500 ml ultraclean 3.1 N HCL was added to the cake, the vial sealed and then cooked overnight at 80°C. After cooling the solution was extracted out and added to a separate Savillex screw top vial. Then 200 ml of ultraclean concentrated HNO_3 was added to the zircon solid residue, the vial sealed and set into an ultrasonic bath for 30 min. The HNO_3 solution was extracted and added slowly to the early leach cycles. Then 100 ml of ultraclean concentrated HNO_3 was added to the zircon residue, the vial sealed, set on a hot plate and heated for 15 min at 50°C. After cool down the HNO_3 was extracted and added to the leach vial. The leaches were spiked with a mixed ^{205}Pb-^{238}U tracer, sealed, and set on a hot plate overnight. Following the HNO_3 cycles the vial with the zircon solid residue was loaded with 500 ml ultraclean concentrated HF and a drop of ultrapure concentrated HNO_3 , sealed in a stainless steal bomb jacket and heated at 225°C for 3 days. Following dissolution, the samples were evaporated and re-bombed overnight in ultrapure 6N HC1 prior to spiking. Samples were then spiked with a mixed ^{205}Pb-^{235}U tracer, and equilibration was obtained in hot 6N HCL within a sealed PFA container overnight on a hotplate.

Chemical extraction techniques for U and Pb from both the zircon residue and the leach mixes entailed cycles of 2N, 3N and 6N HCl, similar to those described in Krogh (1973). Mass spectrometry was performed on a VG Sector multicollector instrument. Pb and U were run on outgassed Re single filaments with silica gel and graphite loads, respectively. Pb was ionized at ~1400°C and U at ~2000°C, yielding typical ion beam currents of 1 to 5 x 10^{-11} A. Regular inter-calibrations of the multiple detector system yielded stabilities at the 10-ppm level for time periods typically in excess of several hours, and thus Pb and U were run in a static multicollector mode. $^{206}Pb/^{204}Pb$ ratios were measured with the ^{204}Pb beam directed into a Daly deflection knob-photomultiplier system. The gain factor was stable within 5 per mil over the course of the Pb runs. A 0.13±0.05/amu mass fractionation correction was applied to both U and Pb runs based on replicate analyses of NBS 982, 983 and U500 standards.

Select zircon grains from the coarse fraction of sample C3b (63-80μ) and sample C9 (100-180μ) were mounted in 2.5 cm epoxy mounts and ablated with a New Wave DUV193 Excimer laser, operating with a wavelength of 193 nm and a spot diameter of 35–50 microns. CL images were made for all grains of all mounts and used as a means to screen out grains with clear resorbed or rounded cores or dense inclusion clusters. Each grain analysis consisted of a single 20-second integration on isotope peaks without laser-firing to obtain on-peak background levels, 20 one-second integrations with the laser firing at the center of each grain, followed finally by a 30-second purge with no laser firing to deliver the remaining evacuated sample. Hg contributions to ^{204}Pb were removed by taking on-peak backgrounds. Each excavation pit is ~20 microns in depth.

The ablated material is carried via argon gas into a Micromass Isoprobe, which is equipped with a flight tube of sufficient width that U and Pb isotopes are measured simultaneously. The measurements are made in static mode, using Faraday detectors for ^{238}U, ^{232}Th, $^{208–206}Pb$, and an ion-counting channel for ^{204}Pb. Ion yields are ~1 millivolt per ppm. Analyses of zircon grains of known isotopic and U-Pb composition were conducted in most cases after each set of five or ten unknown measurements to correct for elemental isotopic fractionation. In some cases, the standard analyses were sufficiently stable to measure ten unknowns between standards. $^{207}Pb^*/^{206}Pb^*$ ratios for all samples were corrected for 2%–5% ± ~3% fractionation. Common Pb correction is performed by using the measured ^{204}Pb and assuming an initial Pb composition from Stacey and Kramers (1975) (with uncertainties of 1.0 for $^{206}Pb/^{204}Pb$ and 0.3 for $^{207}Pb/^{204}Pb$). Measurement of ^{204}Pb is unaffected by the presence of ^{204}Hg because backgrounds are measured on peaks (thereby subtracting any background ^{204}Hg and ^{204}Pb), and because very little Hg is present in the argon gas.

For each analysis, the errors in determining $^{206}Pb/^{238}U$ and $^{206}Pb/^{204}Pb$ result in a measurement error of several percent (at 2-sigma level) in the $^{206}Pb/^{238}U$ age. The errors in measurement of $^{206}Pb/^{207}Pb$ are substantially larger for younger grains due to low intensity of the ^{207}Pb signal. The $^{207}Pb/^{235}U$ and $^{206}Pb/^{207}Pb$ ages for younger grains accordingly have large uncertainties, beyond the level of geologic meaning for samples of this study. Inter-element fractionation of Pb/U is generally <20%, whereas isotopic fractionation of Pb is generally <5%. The uncertainty resulting from the calibration correction is generally ~3% (2-sigma) for both $^{207}Pb/^{206}Pb$ and $^{206}Pb/^{238}U$ ages.

The pooled crystallization ages reported in this paper are weighted averages of individual spot analyses. The weighted mean of individual analyses is calculated according to Ludwig (2003). The mean considers only the measurement or random errors (errors in $^{206}Pb/^{238}U$ and $^{206}Pb/^{204}Pb$ of each unknown). Age of standard, calibration correction from standard, composition of common Pb, decay constant uncertainty are the other sources that contributed to the error in the final age determination. These uncertainties are grouped and are treated as the systematic error. The error in the age of the sample is calculated by adding quadratically the two components (random or measurement error and systematic error). All age uncertainties are reported at 2σ.

Additional References:

Chen, J.H., and Wasserburg, G.J., 1981, Isotopic determination of uranium in picomole and subpicomole quantities: Analytical Chemistry, v. 53, p. 2060-2067.

Jaffey, A.H., Flynn, K.F., Glendenin, L.E., Bentley, W.C., and Essling, A.M., 1971, Precision measurement of the half-lives and specific activities of ^{235}U and ^{238}U: Physics Reviews., v. C4, p. 1889-1906.

Krogh, T.E., 1973, A low-contamination method for hydrothermal decomposition of zircon and extraction of U and Pb for isotopic age determinations: Geochimica et Cosmochimica Acta, v. 37, p.637-679.

Ludwig, K.R., 2001, Users Manual for Isoplot/Ex (rev. 2.49): A geological toolkit for Microsoft Excel: Berkeley Geochronology Center Spec. Pub. 1a, 56p.

Stacey, J.S., and Kramers, J.D., 1975, Approximation of terrestrial lead isotopic evolution by a two-stage model: Earth and Planetary Science Letters, v. 26, p. 207-221.

Table SD 1. Sm/Nd and Rb/Sr data for Kings-Kaweah ophiolite belt and cover strata mafic volcanic rocks (O = Kings River ophiolite; M = ophiolitic ductile shear zones and Kaweah serpentinite mélange; C = cover strata volcanic rocks).

Sample	$^{143}Nd/^{144}Nd$[a]	$^{147}Sm/^{144}Nd$[b]	ppm Nd	$^{87}Sr/^{86}Sr$[a]	$^{87}Rb/^{86}Sr$[b]	ppm Sr	Sr_i[c]
O1 Basalt[d]	0.51245 ±0.00003	0.2014	9.15	0.70300 ±0.00002	0.0065	235.2	0.70296
O2 Basalt	0.51244 ±0.00001	0.2083	10.38	--	--	--	--
O3 Basalt	0.51242 ±0.00002	0.2094	10.04	--	--	--	--
O4 Basalt	0.51240 ±0.00002	0.2001	10.15	--	--	--	--
O5a Basalt	0.51243 ±0.00003	0.2110	5.03	--	--	--	--
O5b Diabase[d]	0.51241 ±0.00002	0.2039	6.10	0.70296 ±0.00003	0.0036	170.6	0.70294
O6 Basalt	0.51240 ±0.00001	0.1952	9.21	0.70287 ±0.00002	0.0091	140.5	0.70281
O7 Gabbro[d]	0.51244 ±0.00003	0.2168	2.16	0.70232 ±0.00003	0.0061	131.6	0.70228
O7 Plagioclase[d]	0.51212 ±0.00002	0.1060	0.67	--	--	--	--
O8 Clinopyroxene	0.51262 ±0.00002	0.2701	2.11	--	--	--	--
O8 Plagioclase	0.51208 ±0.00001	0.1018	0.59	0.70225 ±0.00002	0.0002	351.1	0.70250
O9 Gabbro[d]	0.51244 ±0.00002	0.2128	3.02	0.70274 ±0.00003	0.0030	161.7	0.70272

O10 Clinopyroxene	0.51268 ±0.00001	0.2821	3.21	--	--	--	--
O10 Plagioclase	0.51213 ±0.00001	0.1135	0.71	0.70226 ±0.00002	0.0008	297.8	0.70225
O11 Clinopyroxene	0.51269 ±0.00001	0.2953	2.93	--	--	--	--
O11 Plagioclase	0.51207 ±0.00001	0.0991	0.78	--	--	--	--
O12 Pl-Ol Clinopyroxenite[d]	0.51254 ±0.00003	0.2433	1.57	--	--	--	--
O13 Troctolite	0.51234 ±0.00001	0.1751	0.50	--	--	--	--
M1 Basalt	0.51246 ±0.00001	0.2363	8.70	0.70277 ±0.00001	0.0076	241.7	0.70274
M2 Basalt	0.51245 ±0.00001	0.2281	6.20	0.70294 ±0.00002	0.0059	131.2	0.70290
M3 Diabase[d]	0.51240 ±0.00002	0.2233	3.51	0.70330 ±0.00003	0.0080	169.3	0.70327
M4a Gabbro mylonite	0.51232 ±0.00001	0.1861	4.29	--	--	--	--
M4b Diorite mylonite	0.51229 ±0.00001	0.1584	11.08	--	--	--	--
M5a Anorthositic gabbro mylonite	0.51236 ±0.00001	0.2061	4.93	--	--	--	--
M5b Gabbro mylonite[d]	0.51235 ±0.00003	0.1950	11.91	--	--	--	--

M5c Quartz diorite mylonite[d]	0.51225 ±0.00002	0.1402	5.96	0.70278 ±0.00003	0.0022	446.0	0.70277
M6a Gabbro mylonite	0.51235 ±0.00001	0.1880	1.75	--	--	--	--
M6b Quartz diorite mylonite	0.51226 ±0.00001	0.1524	7.96	--	--	--	--
M7a Plagiogranite	0.51215 ±0.00001	0.0838	4.94	--	--	--	--
M7b Diabase	0.51233 ±0.00002	0.1805	3.09	--	--	--	--
M8 Hornblende	0.51245 ±0.00002	0.2579	3.09	--	--	--	--
M8 Plagioclase	0.51217 ±0.00001	0.1068	4.94	--	--	--	--
M9 Hornblende-rich matrix	0.51218 ±0.00002	0.1391	17.07	--	--	--	--
M9 Garnet porphyroblast	0.51249 ±0.00002	0.3251	3.91	--	--	--	--
C3a Basalt	0.51222 ±0.00003	0.1749	4.95	0.70416 ±0.00003	0.1761	117.3	0.70362
C8 Basalt	0.51219 ±0.00002	0.1879	3.81	0.70448 ±0.00003	0.1602	173.4	0.70399

[a] Normalized to $^{146}Nd/^{142}Nd=0.636151$, $^{86}Sr/^{88}Sr=0.1194$. Errors are 2σ mean
[b] Uncertainty <0.2%
[c] Sr_i for T=484 Ma (O samples), T=295 Ma (M samples), and T=215 Ma (C Samples) with $\lambda^{87}=1.42 \times 10^{-11}$ yr^{-1}
[d] Data previously reported in Shaw et al. (1987; Shaw, H.F., Chen, J.H., Saleeby, J.B., and Wasserburg, G.J., 1987, Nd-Sr-Pb systematics and age of the Kings River ophiolite, California: Contributions to Mineralogy and Petrology, v. 96, p. 281–290, doi:10.1007/BF00371249.)

Table SD 2. (U, Th)/Pb data for Kings-Kaweah ophiolite belt (O=Kings River ophiolite; M=ophiolitic ductile shear zones and Kaweah serpentinite melange).

Sample	ppm Pb[b]	$^{238}U/^{204}Pb$[c]	$^{232}Th/^{238}U$[d]	Measured ratios[a]			Initial ratios[e]		
				$^{204}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
O1 Basalt [f]	2.134	10.789	3.072	0.05500	0.8520	2.0718	17.338	15.444	36.863
O5b Diabase [f]	0.920	7.797	7.321	0.05426	0.8438	2.0689	17.821	15.518	36.743
O6 Basalt	0.630	0.384	3.204	0.05737	0.8896	2.1167	17.402	15.481	36.812
O7 Gabbro[f]	0.058	5.214	2.423	0.05699	0.8781	2.1147	17.139	15.384	36.799
08 Plagioclase	0.294	0.905	1.402	0.05772	0.8928	2.1328	17.253	15.406	36.782
O9 Gabbro [f]	0.363	1.725	5.405	0.05575	0.8640	2.0970	17.801	15.489	37.384
O10 Plagioclase	0.261	0.054	1.447	0.05793	0.8920	2.1307	17.256	15.399	36.779
M1 Basalt	2.546	0.564	1.333	0.05544	0.8613	2.1004	18.013	15.536	37.825
M2 Basalt	0.934	0.256	3.750	0.05564	0.8630	2.0971	17.962	15.511	37.663
M3 Diabase [f]	1.154	1.000	5.750	0.05394	0.8414	2.0656	18.493	15.600	38.211
M5b Diorite [f]	2.514	2.784	2.027	0.05477	0.8520	2.0802	18.132	15.549	37.898

[a] Corrected for blank and spike composition, and mass fractionation of 0.1% per AMU (2σ~ ±0.3%)
[b] Uncertainty ~0.1%
[c] Uncertainty ~0.5%
[d] Uncertainty ~1.5%
[e] Calculated for T=484 Ma (O samples), T=295 Ma (M samples), $\lambda^{238}=1.55125 \times 10^{-10}$ yr^{-1}, $\lambda^{235}=9.8485 \times 10^{-10}$ yr^{-1}, $\lambda^{232}=4.990 \times 10^{-11}$ yr^{-1}
[f] Data previously reported in Shaw et al. (1987; Shaw, H.F., Chen, J.H., Saleeby, J.B., and Wasserburg, G.J., 1987, Nd-Sr-Pb systematics and age of the Kings River ophiolite, California: Contributions to Mineralogy and Petrology, v. 96, p. 281–290, doi:10.1007/BF00371249.).

Table SD 3. ICP-MS trace element data for Kings-Kaweah ophiolite belt metabasalts.

Sample	La ppm	Ce ppm	Pr ppm	Nd ppm	Sm ppm	Eu ppm	Gd ppm	Tb ppm	Dy ppm	Ho ppm	Er ppm	Tm ppm	Yb ppm	Lu ppm
O1	4.38	11.68	1.86	9.34	2.98	1.25	4.08	0.73	4.72	1.03	2.85	0.41	2.49	0.38
O1 dup	4.28	11.57	1.85	9.21	2.98	1.26	3.96	0.73	4.79	1.01	2.81	0.40	2.47	0.39
O2	4.93	13.11	2.08	10.45	3.39	1.31	4.47	0.80	5.22	1.13	3.07	0.45	2.74	0.42
O2 dup	5.00	13.20	2.12	10.46	3.36	1.33	4.42	0.82	5.28	1.12	3.12	0.44	2.75	0.43
O3	4.77	12.71	2.03	10.13	3.29	1.25	4.33	0.80	5.24	1.10	3.03	0.45	2.67	0.42
O4	4.90	12.65	2.03	10.14	3.29	1.27	4.31	0.78	5.10	1.10	3.07	0.44	2.65	0.42
O5a	2.01	5.77	0.97	5.23	1.91	0.84	2.60	0.49	3.26	0.73	2.04	0.28	1.77	0.29
O5b	1.44	3.99	0.69	3.62	1.36	0.66	1.91	0.37	2.45	0.53	1.46	0.20	1.25	0.20
O6	3.77	10.51	1.75	9.11	3.02	1.16	3.99	0.73	4.74	1.00	2.80	0.41	2.44	0.37
M1	4.76	12.52	1.99	9.80	3.17	1.27	4.15	0.78	5.14	1.09	3.01	0.42	2.64	0.40
M2	2.09	5.97	1.03	5.42	1.98	0.84	2.57	0.51	3.41	0.73	2.04	0.28	1.75	0.28
M3	2.91	8.46	1.45	7.69	2.73	1.13	3.73	0.72	4.81	1.02	2.84	0.40	2.48	0.39
M7b	8.17	20.68	3.11	14.29	4.11	1.46	4.74	0.87	5.58	1.17	3.25	0.49	3.08	0.48

Sample	Ba ppm	Th ppm	Nb ppm	Y ppm	Hf ppm	Ta ppm	U ppm	Pb ppm	Rb ppm	Cs ppm	Sr ppm	Sc ppm	Zr ppm
O1	42	0.30	3.37	25.36	2.19	0.23	0.21	2.63	1.8	0.10	235	36.8	89
O1 dup	40	0.29	3.36	25.64	2.17	0.22	0.20	2.58	1.5	0.08	237	37.1	88
O2	47	0.29	3.85	28.08	2.45	0.26	0.21	1.63	1.4	0.01	230	43.1	99
O2 dup	46	0.25	3.74	28.05	2.45	0.25	0.19	1.57	1.3	0.01	227	37.9	98
O3	40	0.27	3.74	27.79	2.37	0.26	0.18	3.15	1.3	0.01	215	42.5	99
O4	67	0.29	4.10	27.45	2.31	0.28	0.10	1.19	2.0	0.02	247	41.7	96
O5a	36	0.11	1.52	18.10	1.26	0.11	0.04	0.82	0.3	0.02	144	27.9	46
O5b	30	0.08	1.05	12.93	0.86	0.07	0.04	1.42	0.7	0.04	174	39.7	30
O6	19	0.16	1.78	25.19	1.83	0.13	0.05	0.63	0.6	0.04	140	33.2	66
M1	80	0.32	3.34	26.82	2.32	0.22	0.24	2.55	2.2	0.04	261	39.5	91
M2	32	0.15	1.56	18.30	1.25	0.10	0.04	0.93	0.5	0.03	142	28.1	46
M3	13	0.16	2.27	25.47	1.92	0.16	0.06	0.68	0.3	0.02	171	40.1	69
M7b	109	0.41	8.81	30.38	3.37	0.47	0.16	1.46	0.5	0.03	142	28.1	46

Table SD4. XRF major and trace element data for Kings River ophiolite.

Sample	O1	O2	O2 dup	O3	O4	O5a	O5b	O6	O7	O8	O9	O10	O11	O12	O13
	Major Elements (Weight %):														
SiO_2	50.03	50.01	50.00	49.51	50.31	49.56	52.14	51.39	50.97	51.31	51.21	51.77	52.69	46.83	44.91
TiO_2	1.187	1.299	1.301	1.284	1.247	0.751	0.526	0.981	0.218	0.217	0.254	0.363	0.381	0.142	0.093
Al_2O_3	16.37	16.50	16.51	16.29	16.15	18.80	17.27	16.55	20.80	21.06	17.26	15.91	18.16	13.36	23.22
FeO*	8.38	9.34	9.33	9.55	8.90	7.24	6.16	7.87	3.31	3.22	4.21	5.46	5.91	4.62	4.92
MnO	0.155	0.147	0.146	0.148	0.161	0.137	0.116	0.133	0.065	0.063	0.086	0.118	0.118	0.094	0.091
MgO	7.06	6.16	6.17	6.37	7.50	8.46	8.91	8.34	8.33	8.11	11.05	10.33	7.49	19.71	8.37
CaO	13.71	12.44	12.38	12.38	11.37	12.14	12.37	11.36	12.70	12.82	13.18	12.51	11.44	11.12	16.84
Na_2O	2.81	3.60	3.60	3.50	3.58	2.40	2.50	2.81	2.98	3.03	2.65	2.82	3.62	1.88	0.64
K_2O	0.25	0.24	0.24	0.24	0.34	0.06	0.09	0.07	0.06	0.06	0.06	0.07	0.08	0.06	0.09
P_2O_5	0.146	0.158	0.159	0.154	0.148	0.070	0.045	0.095	0.011	0.011	0.014	0.024	0.015	0.012	0.006
Sum	100.10	99.89	99.84	99.42	99.69	99.62	100.12	99.61	99.47	99.90	99.98	99.39	99.92	97.84	99.19
LOI	0.50	0.44	0.44	0.42	0.49	0.76	0.66	0.57	0.77	0.80	0.64	0.53	0.62	2.22	1.40

*** total Fe as FeO**

Trace Elements (ppm):

Ni	66	51	55	54	51	109	92	120	132	128	159	118	84	613	89
Cr	266	271	271	268	259	304	490	321	378	359	469	226	87	1583	305
Sc	39	41	41	41	41	29	40	34	23	24	36	43	37	23	29
V	205	218	221	219	207	156	154	208	84	85	118	151	152	84	80
Ba	43	43	45	41	68	33	27	19	14	17	7	6	22	23	13
Rb	1	2	2	2	3	0	1	1	1	0	1	1	1	0	2
Sr	231	220	226	207	236	140	168	134	201	202	169	161	216	25	337
Zr	92	102	102	100	99	47	31	67	7	6	9	16	12	5	2
Y	24	27	28	27	26	17	13	25	6	5	6	11	9	5	2
Nb	3.0	2.9	2.4	2.6	3.4	0.3	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ga	14	13	14	14	12	12	11	13	10	10	9	9	13	6	11
Cu	39	11	11	13	62	34	2	70	53	51	38	60	44	32	22
Zn	52	66	66	72	56	55	37	31	19	20	26	38	35	34	28
Pb	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0
La	6	5	5	8	6	4	2	3	0	3	1	3	1	2	0
Ce	10	14	13	13	6	0	5	11	0	0	0	2	4	0	0
Th	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nd	7	10	13	9	8	4	6	10	3	4	1	4	5	1	0
U	1	2	2	1	1	0	1	1	1	1	1	1	1	0	0

Table SD5. ID-TIMS U/Pb zircon isotopic age data for ophiolitic plagiogranite and mylonitic diorites§

Sample	Fraction† (μm)	Amount Analyzed (mg)	ppm ^{238}U	ppm $^{206}Pb*$	$\frac{^{206}Pb}{^{204}Pb}$	$\frac{^{206}Pb*}{^{238}U}$	$\frac{^{207}Pb*}{^{206}Pb*}$	Ma $\frac{^{206}Pb*}{^{238}U}$	Ma $\frac{^{207}Pb*}{^{235}U}$	Ma $\frac{^{207}Pb*}{^{206}Pb*}$
M4b	$<100^{ZR}$	0.6	124	4.51	7429	0.04199(07)	0.05204(04)	265.2	267.4	287
	$<100^{L}$	0.6	493	8.78	439	0.02053(09)	0.04910(11)	131.1	132.4	157
M5c	<44^	3.0	378	8.11	5340	0.02479(17)	0.05006(09)	157.9	160.4	198
	44-74^	3.1	342	7.46	5901	0.02521(17)	0.05015(12)	160.5	163.1	202
	44-74^	2.6	267	6.01	1345	0.02603(16)	0.05022(13)	165.6	169.0	206
	74-179^	2.7	232	5.59	3237	0.02784(17)	0.05032(10)	177.0	179.2	210
	$100\text{-}180^{ZR}$	0.9	211	7.15	9973	0.03913(08)	0.05168(05)	247.5	249.8	271
	$100\text{-}180^{L}$	0.9	515	9.93	783	0.02227(10)	0.04963(08)	142.0	144.1	178
M6b	$<100^{ZR}$	0.7	193	6.95	8207	0.04159(07)	0.05185(05)	262.7	264.3	279
	$<100^{L}$	0.7	278	8.63	1263	0.03585(08)	0.05129(07)	227.1	229.5	254
M7a	<45^	1.9	731	17.72	1031	0.02802(16)	0.05079(14)	178.1	181.8	231
	45-74^	2.5	595	15.40	1146	0.02991(17)	0.05076(12)	190.0	192.9	230
	74-179^	3.2	523	13.69	1249	0.03025(17)	0.05110(13)	192.1	196.1	246
	>179^	1.8	453	15.19	788	0.03876(16)	0.05167(13)	245.1	247.5	271
	$100\text{-}180^{ZR}$	0.8	239	9.01	4998	0.04356(08)	0.05213(06)	274.9	276.6	291
	$100\text{-}180^{L}$	0.8	591	14.06	959	0.02750(10)	0.05043(08)	174.9	177.5	215

^ Data previously reported in Saleeby and Sharp (1980) for which reported blank dominated nonradiogenic correction. Nonradiogenic correction on other samples based on 25 pg blank Pb (1:18.78:15.61:38.50) and initial Pb approximations of 1:17.962:15.511:37.663 (Table SD2, sample M2).
ZR zircon solid residue, L mixture of leach steps modified after Mattinson (1994).

† Fractions separated by grain size and magnetic properties. All fractions shown are non-magnetic splits except M5c second 44-74μ fraction which is diamagnetic. Samples handpicked to 99.9% purity prior to dissolution. Dissolution and chemical extraction techniques modified from Krogh (1973).

* Radiogenic, parentheses show ± uncertainty in last figures.

§ Decay constants used in age calculations: $\lambda^{238}U = 1.55125 \times 10^{-10} a^{-1}$ and $\lambda^{235}U = 9.8485 \times 10^{-10} a^{-1}$ (Jaffey and others, 1971): $^{238}U/^{235}U$ atom = 137.88 (Chen and Wasserburg, 1981). All isotopic ratios corrected for 0.13±0.05/amu for mass fractionation. Uncertainties are 2σ of mean.

REFERENCES

Chen, J.H., and Wasserburg, G.J., 1981, Isotopic determination of uranium in picomole and subpicomole quantities: Analytical Chemistry, v. 53, p. 2060-2067.

Krogh, T.E., 1973, A low-contamination method for hydrothermal decomposition of zircon and extraction of U and Pb for isotopic age determinations: Geochimica et Cosmochimica Acta, v. 37, p.637-679.Mattinson, J.M., 1994, A study of complex discordance in zircons using step-wise dissolution techniques: Contributions to Mineralogy and Petrology, v. 116, p. 117–129, doi:10.1007/BF00310694.

Saleeby, J.B., and Sharp, W.D., 1980, Chronology of the structural and petrologic development of the southwest Sierra Nevada Foothills, California: Geological Society of America Bulletin, pt. 1, v. 91, p. 317–320; pt. 2, v. 91, p. 1416–1535.

Table SD6. XRF major and trace element data for ophiolitic ductile shear zones and Kaweah serpentinite melange.

Sample	M1	M2	M3	M4a	M4b	M5a	M5b	M5c	M6a	M6b	M7a	M7b	M9
Major Elements (Weight %):													
SiO_2	49.93	49.34	50.88	49.45	55.20	48.47	52.04	58.22	51.20	56.70	64.85	53.54	42.39
TiO_2	1.208	0.736	1.079	0.444	0.991	0.761	0.402	0.970	0.231	0.982	0.116	1.300	2.401
Al_2O_3	16.65	18.39	16.40	17.84	18.29	20.88	16.44	21.43	20.43	21.39	21.80	16.77	16.14
FeO*	8.30	6.99	8.44	6.15	5.49	7.01	5.83	2.91	3.33	2.93	0.19	7.26	14.76
MnO	0.160	0.133	0.146	0.107	0.096	0.127	0.106	0.060	0.066	0.064	0.004	0.127	0.301
MgO	6.41	8.29	7.60	9.38	5.13	5.32	10.20	2.19	8.60	2.48	0.25	6.24	7.56
CaO	12.64	11.97	12.03	11.17	8.24	14.76	11.42	6.32	12.82	6.73	3.01	9.17	11.02
Na_2O	3.33	2.41	2.80	4.58	6.19	2.29	3.75	7.68	2.92	7.30	10.02	5.50	1.99
K_2O	0.25	0.06	0.08	0.10	0.12	0.33	0.09	0.08	0.07	0.14	0.11	0.17	0.37
P_2O_5	0.137	0.068	0.104	0.043	0.133	0.081	0.013	0.337	0.011	0.328	0.055	0.176	0.983
Sum	99.01	98.39	99.55	99.26	99.87	100.03	100.30	100.18	99.67	99.04	100.41	100.24	97.93
LOI	0.52	0.68	0.53	1.05	0.54	0.53	0.54	0.43	0.75	0.88	0.43	0.59	1.59

*** total Fe as FeO**

Trace Elements (ppm):

Ni	60	110	66	120	56	66	132	15	134	24	0	51	73
Cr	268	299	313	590	198	290	131	2	407	14	4	182	121
Sc	41	28	41	35	25	29	45	4	27	5	1	32	60
V	204	153	219	136	147	149	178	73	92	77	3	205	421
Ba	70	26	11	92	115	62	56	138	14	153	146	111	96
Rb	2	1	0	1	1	3	3	1	1	2	3	2	7
Sr	252	138	168	524	410	239	217	562	194	570	230	279	263
Zr	92	47	71	25	123	51	12	136	8	128	76	132	140
Y	26	17	25	11	25	17	11	10	6	10	2	29	64
Nb	2.3	1.0	1.1	0.0	6.3	0.9	0.0	5.1	0.0	4.6	0.0	8.4	4.3
Ga	13	12	13	10	16	13	11	15	10	16	14	16	16
Cu	62	32	81	173	75	43	29	153	56	166	0	126	35
Zn	72	54	68	42	37	37	36	18	20	19	1	55	139
Pb	1	0	0	0	1	1	0	4	0	4	13	0	2
La	7	1	6	2	5	1	3	5	4	5	10	9	10
Ce	5	3	7	0	12	2	0	14	0	11	16	16	15
Th	0	0	0	0	0	0	0	0	0	0	0	0	0
Nd	4	6	9	4	11	3	2	12	3	8	5	13	15
U	2	2	1	0	0	1	1	0	1	0	0	1	1

Table SD 7. Electron microprobe compositions determined at two three-grain contacts in sample M9 garnet amphibolite used in THERMOCALC.

Analysis	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
hbl	46.83	0.37	11.31	0.01	0.00	13.69	0.09	12.16	9.29	3.14	0.43
grt	38.51	0.05	21.24	0.02	0.00	26.59	1.37	5.17	8.09	0.01	0.00
plag	68.39	0.00	19.41	0.01	0.00	0.17	0.00	0.02	0.80	11.80	0.04
hbl	46.75	0.44	11.50	0.03	0.00	12.67	0.04	12.05	9.54	3.57	0.49
grt	38.72	0.08	21.04	0.03	0.00	26.38	0.53	4.90	8.79	0.03	0.00
plag	68.02	0.00	19.51	0.01	0.00	0.33	0.00	0.02	0.23	11.95	0.06

THERMOCALC results:

T = 802 ˚C, σ= 65 ˚C

P = 15.9 kbars, σ= 2.3 kbars, cor = 0.919

Table SD 8: XRF major and trace element data for early Mesozoic cover strata volcanic-hypabyssal rocks.

Sample Group	C1	C2	C3a	C3b	C4	C5	C6	C7	C8
Major elements (weight %):									
SiO_2	55.60	52.00	51.20	70.50	52.40	54.70	53.70	52.20	51.90
TiO_2	0.74	0.31	0.40	0.51	0.46	0.79	0.63	0.75	0.81
Al_20_3	15.60	10.20	12.90	14.10	13.30	14.80	18.30	15.00	14.80
FeO*	9.08	8.56	10.00	4.60	10.30	9.77	8.41	10.10	10.40
MnO	0.16	0.20	0.20	0.15	0.19	0.19	0.18	0.19	0.17
MgO	5.69	12.80	9.77	0.77	9.23	6.14	4.36	6.85	6.88
CaO	12.00	12.00	8.92	4.04	7.52	9.89	8.74	6.92	11.00
Na_2O	1.22	1.78	3.16	4.69	3.01	2.77	2.88	4.42	2.53
K_2O	0.06	0.14	0.15	0.12	0.21	0.06	1.32	0.26	0.43
P_20_5	0.11	0.03	0.06	0.21	0.07	0.15	0.15	0.13	0.08
sum	100.60	99.20	99.90	99.70	100.30	99.80	100.80	99.70	100.00
Loi	0.39	1.16	3.16	0.00	3.54	0.62	2.23	2.93	1.00

*** total Fe as FeO**

Trace Elements (ppm):

Ni	101	191	103	5	138	27	39	61	28
Cr	351	516	623	11	738	142	146	301	264
Sc	41	39	40	21	32	49	29	55	40
V	399	226	237	132	263	329	296	369	301
Ba	37	29	21	59	34	31	61	78	42
Rb	1	5	7	22	9	4.1	3	7	7
Sr	158	123	112	101	134	136	189	160	157
Zr	35	17	12	43	21	39	41	33	29
Y	13	15	9	9	7	12	11	14	10
Nb	0.36	0.41	0.93	0.89	0.91	0.63	1.07	0.68	0.89
Ga	12	5	9	1	7	14	13	14	11
Cu	88	91	79	109	107	128	96	57	71
Zn	73	79	85	87	98	51	103	89	112
Pb	3	1	2	3	1	2	1	3	2
La	1	1	1	3	2	2	3	2	3
Ce	3	2	1	1	2	4	3	4	3
Th	1	0	1	2	0	1	1	1	0
Nd	3	3	5	6	4	3	7	3	5
U	2	1	2	3	1	1	2	0	1

Table SD 9a. Laser Ablation ICP-MS U/Pb zircon data for sample C3 dacite clast.

Analysis	U (ppm)	206Pb 204Pb	U/Th	207Pb* 235U	± (%)	206Pb* 238U	± (%)	error corr.	206Pb* 238U	± (Ma)	207Pb* 235U	± (Ma)	206Pb* 207Pb*	± (Ma)	Best age (Ma)	± (Ma)
KSM73-1	1425	2899	6.2	0.16804	18.2	0.02055	7.0	0.39	131.1	9.1	157.7	26.5	578.3	366.2	131.1	9.1
KSM73-2	775	20150	4.6	0.22424	6.0	0.03270	4.7	0.79	207.4	9.7	205.4	11.1	182.7	84.8	207.4	9.7
KSM73-3	1897	28258	3.5	0.22391	5.1	0.03186	4.9	0.95	202.1	9.7	205.2	9.5	239.8	36.3	202.1	9.7
KSM73-4	2138	27158	2.0	0.21679	9.1	0.03137	9.0	0.99	199.1	17.7	199.2	16.5	200.5	36.6	199.1	17.7
KSM73-5	1435	35900	3.2	0.24511	4.2	0.03531	4.1	0.97	223.7	9.0	222.6	8.5	210.9	24.5	223.7	9.0
KSM73-6	1378	25520	2.9	0.25291	3.4	0.03627	2.8	0.82	229.7	6.2	228.9	6.9	221.5	45.2	229.7	6.2
KSM73-7	370	8441	3.7	0.25092	6.9	0.03619	3.8	0.55	229.2	8.5	227.3	14.1	208.3	134.4	229.2	8.5
KSM73-8	968	22629	3.9	0.24349	3.1	0.03474	2.5	0.80	220.2	5.4	221.3	6.2	232.9	42.8	220.2	5.4
KSM73-10	967	23319	5.7	0.22819	5.1	0.03316	4.5	0.88	210.3	9.3	208.7	9.6	190.6	55.3	210.3	9.3
KSM73-11	982	13869	4.1	0.21309	8.9	0.03093	7.7	0.86	196.4	14.9	196.1	15.9	193.3	104.9	196.4	14.9
KSM73-12	1169	10151	1.7	0.20199	8.8	0.02782	8.1	0.92	176.9	14.2	186.8	15.0	314.1	76.6	176.9	14.2
KSM73-13	1497	15706	4.8	0.22141	7.8	0.03129	7.3	0.94	198.6	14.3	203.1	14.3	254.9	60.6	198.6	14.3
KSM73-14	1612	3056	3.8	0.21427	6.6	0.02865	5.3	0.80	182.1	9.5	197.1	11.8	381.4	88.0	182.1	9.5
KSM73-15	896	19687	5.9	0.22749	3.0	0.03238	2.2	0.74	205.4	4.5	208.1	5.6	238.6	46.2	205.4	4.5
KSM73-16	866	18033	5.2	0.21892	10.7	0.03143	9.8	0.91	199.5	19.3	201.0	19.6	218.9	100.3	199.5	19.3

KSM73-17	625	14826	5.4	0.23302	3.3	0.03304	2.2	0.66	209.5	4.5	212.7	6.3	247.6	56.6	209.5	4.5
KSM73-18	881	8428	5.0	0.22679	8.7	0.03109	5.6	0.64	197.4	10.8	207.5	16.3	324.8	151.4	197.4	10.8
KSM73-20	548	7365	3.8	0.26875	5.1	0.03629	4.5	0.90	229.8	10.3	241.7	10.9	358.8	49.7	229.8	10.3
KSM73-21	1374	19580	3.3	0.26339	5.7	0.03846	4.8	0.84	243.3	11.5	237.4	12.1	179.5	72.0	243.3	11.5
KSM73-22	1287	16095	4.6	0.22264	3.9	0.03159	3.5	0.89	200.5	6.9	204.1	7.3	245.8	41.4	200.5	6.9
KSM73-23	1330	25839	3.8	0.24856	2.4	0.03522	1.9	0.79	223.1	4.1	225.4	4.8	249.2	33.7	223.1	4.1
KSM73-24	1388	25411	3.8	0.26004	6.1	0.03745	5.3	0.86	237.0	12.2	234.7	12.8	211.7	72.9	237.0	12.2
KSM73-26	464	11910	4.8	0.25696	10.1	0.03817	5.3	0.53	241.4	12.6	232.2	20.9	139.7	201.5	241.4	12.6
KSM73-27	1170	20986	4.6	0.21727	4.1	0.03169	2.7	0.67	201.1	5.4	199.6	7.4	182.2	70.4	201.1	5.4
KSM73-28	969	20770	2.2	0.23298	2.7	0.03354	1.5	0.56	212.7	3.2	212.7	5.3	212.6	52.7	212.7	3.2
KSM73-29	963	21588	4.3	0.24154	2.3	0.03448	2.0	0.86	218.5	4.3	219.7	4.6	231.9	27.8	218.5	4.3
KSM73-30	1840	30970	2.0	0.25150	2.7	0.03568	1.9	0.72	226.0	4.2	227.8	5.4	246.4	42.3	226.0	4.2
KSM73-31	1280	23996	4.0	0.23975	1.8	0.03445	1.3	0.75	218.3	2.8	218.2	3.4	217.2	26.7	218.3	2.8
KSM73-32	1187	21301	5.4	0.24042	7.7	0.03494	5.9	0.77	221.4	12.9	218.8	15.1	190.7	113.7	221.4	12.9
KSM73-33	1462	29620	3.3	0.23738	2.2	0.03369	1.1	0.52	213.6	2.4	216.3	4.3	245.7	43.7	213.6	2.4
KSM73-34	1911	20798	2.0	0.22289	4.7	0.03177	4.5	0.96	201.6	9.0	204.3	8.8	235.2	31.1	201.6	9.0
KSM73-35	1452	25359	3.3	0.23011	3.8	0.03330	3.3	0.88	211.2	6.9	210.3	7.1	200.2	41.6	211.2	6.9
KSM73-36	1106	11295	3.1	0.22451	6.0	0.03166	5.6	0.94	200.9	11.1	205.7	11.1	260.2	44.8	200.9	11.1

KSM73-37	1156	18180	3.7	0.24879	4.8	0.03465	4.2	0.87	219.6	9.1	225.6	9.8	288.9	54.1	219.6	9.1
KSM73-38	1266	30276	2.3	0.24318	2.5	0.03466	1.8	0.74	219.7	3.9	221.0	4.9	235.5	38.3	219.7	3.9
KSM73-39	466	13496	4.4	0.23649	10.6	0.03427	9.5	0.89	217.2	20.2	215.5	20.5	197.4	110.0	217.2	20.2
KSM73-40	950	19552	3.6	0.24567	3.3	0.03446	2.6	0.79	218.4	5.7	223.1	6.7	272.7	46.4	218.4	5.7
KSM73-41	531	13447	4.2	0.24921	3.5	0.03518	2.1	0.61	222.9	4.7	225.9	7.1	257.9	64.4	222.9	4.7
KSM73-42	1030	11921	2.8	0.23015	3.9	0.03315	3.6	0.92	210.3	7.4	210.3	7.4	211.0	35.7	210.3	7.4
KSM73-43	1950	10958	0.9	0.13299	4.5	0.01958	4.2	0.93	125.0	5.2	126.8	5.4	160.6	38.3	125.0	5.2
KSM73-44	1559	28763	3.2	0.23670	1.9	0.03385	1.2	0.64	214.6	2.6	215.7	3.7	227.9	33.9	214.6	2.6
KSM73-45	1599	26218	3.8	0.24504	4.6	0.03591	3.3	0.72	227.4	7.3	222.5	9.1	171.0	74.2	227.4	7.3
KSM73-46	920	19287	3.6	0.25261	7.1	0.03709	5.9	0.83	234.7	13.6	228.7	14.5	167.0	92.4	234.7	13.6

Table SD 9b. Laser Ablation ICP-MS U/Pb zircon data for sample C9 siliciclastic turbidite.

				Isotope ratios							Apparent ages (Ma)							
Analysis	U (ppm)	206Pb 204Pb	U/Th	206Pb* 207Pb*	± (%)	207Pb* 235U*	± (%)	206Pb* 238U	± (%)	error corr.	206Pb* 238U*	± (Ma)	207Pb* 235U	± (Ma)	206Pb* 207Pb*	± (Ma)	Best age (Ma)	± (Ma)
KK1009-1	501	70410	5.2	12.2323	3.5	2.2502	4.0	0.1996	2.0	0.51	1173.3	21.9	1196.8	28.3	1239.5	68.0	1239.5	68.0
KK1009-2	276	40320	2.9	9.4163	2.6	3.7906	9.5	0.2589	9.1	0.96	1484.1	121.0	1590.7	76.4	1735.2	47.3	1735.2	47.3
KK1009-3	68	25887	2.0	5.5193	1.9	12.5984	3.2	0.5043	2.6	0.81	2632.3	55.8	2650.1	30.2	2663.7	31.5	2663.7	31.5
KK1009-4	279	21744	1.4	16.6565	1.5	0.8050	2.5	0.0972	2.0	0.80	598.3	11.5	599.6	11.4	604.9	32.5	598.3	11.5
KK1009-5	426	6849	0.9	19.8019	4.4	0.1828	4.6	0.0262	1.3	0.28	167.0	2.1	170.4	7.2	218.1	101.2	167.0	2.1
KK1009-6	71	20148	2.0	8.9111	1.1	4.7859	6.2	0.3093	6.1	0.98	1737.3	92.3	1782.4	51.7	1835.6	19.4	1835.6	19.4
KK1009-7	94	21465	1.7	8.8599	2.2	4.6766	9.1	0.3005	8.8	0.97	1693.8	131.4	1763.1	76.1	1846.1	39.5	1846.1	39.5
KK1009-8	120	36705	1.3	8.5939	1.3	5.4863	1.7	0.3420	1.0	0.60	1896.1	16.4	1898.4	14.2	1901.0	23.7	1901.0	23.7
KK1009-9	209	40335	5.2	13.0388	2.4	1.9187	5.6	0.1814	5.1	0.91	1074.8	50.4	1087.6	37.5	1113.2	47.3	1113.2	47.3
KK1009-10	118	30735	0.7	8.7881	2.5	5.1930	2.7	0.3310	1.0	0.37	1843.2	16.0	1851.5	23.1	1860.8	45.5	1860.8	45.5
KK1009-11	360	87078	2.5	9.4285	2.3	4.3690	2.5	0.2988	1.2	0.46	1685.2	17.2	1706.5	21.0	1732.8	41.5	1732.8	41.5
KK1009-12	147	35445	2.3	9.4832	5.5	4.2070	5.6	0.2894	1.2	0.21	1638.3	17.1	1675.4	45.8	1722.2	100.2	1722.2	100.2
KK1009-13	545	18645	2.6	19.4832	27.2	0.2741	27.2	0.0387	1.0	0.04	244.9	2.4	245.9	59.5	255.5	635.8	244.9	2.4
KK1009-14	311	49791	2.8	12.6721	2.6	2.0817	2.8	0.1913	1.0	0.36	1128.5	10.4	1142.8	19.2	1170.0	51.7	1170.0	51.7
KK1009-15	227	4215	2.0	20.0810	6.5	0.1863	6.5	0.0271	1.0	0.15	172.6	1.7	173.5	10.4	185.6	150.6	172.6	1.7
KK1009-16	402	52341	4.4	12.5368	2.0	2.1300	2.3	0.1937	1.1	0.48	1141.2	11.5	1158.6	15.8	1191.2	39.7	1191.2	39.7
KK1009-18	133	30606	1.1	9.5659	2.5	4.1881	2.7	0.2906	1.0	0.37	1644.3	14.5	1671.7	22.3	1706.2	46.6	1706.2	46.6
KK1009-19	374	11889	1.9	19.8980	3.5	0.2565	3.7	0.0370	1.1	0.29	234.3	2.5	231.8	7.7	206.8	82.1	234.3	2.5

KK1009-20	783	15639	1.8	20.0237	1.9	0.1737	2.1	0.0252	1.0	0.47	160.6	1.6	162.6	3.2	192.2	43.5	160.6	1.6
KK1009-21	586	69780	3.7	9.6144	2.9	3.0636	4.3	0.2136	3.2	0.74	1248.1	36.1	1423.6	33.1	1696.9	54.0	1696.9	54.0
KK1009-22	114	13305	2.2	13.6689	3.7	1.6613	3.8	0.1647	1.1	0.27	982.8	9.6	993.9	24.4	1018.3	75.0	1018.3	75.0
KK1009-23	149	46323	2.8	6.1634	2.4	9.1315	2.7	0.4082	1.2	0.45	2206.6	22.8	2351.3	24.9	2479.2	41.0	2479.2	41.0
KK1009-24	132	33507	2.3	8.6113	1.6	5.0854	1.9	0.3176	1.0	0.54	1778.1	15.8	1833.7	16.0	1897.4	28.6	1897.4	28.6
KK1009-25	111	25047	1.6	8.3346	2.9	5.4653	3.1	0.3304	1.0	0.33	1840.2	16.0	1895.2	26.3	1955.9	51.6	1955.9	51.6
KK1009-26	806	204729	1.1	5.9754	1.8	10.3115	2.6	0.4469	1.9	0.72	2381.3	37.6	2463.1	24.3	2531.3	30.5	2531.3	30.5
KK1009-28	196	28713	1.7	12.2716	4.7	2.2208	6.0	0.1977	3.7	0.63	1162.7	39.8	1187.6	41.8	1233.3	91.3	1233.3	91.3
KK1009-29	161	10593	0.8	16.9022	2.7	0.7778	3.6	0.0954	2.4	0.66	587.1	13.3	584.2	15.9	573.1	58.0	587.1	13.3
KK1009-30	1107	18558	3.2	19.4561	3.1	0.2509	3.2	0.0354	1.0	0.31	224.3	2.2	227.3	6.6	258.7	71.1	224.3	2.2
KK1009-31	367	76224	10.9	9.6899	1.2	3.7543	4.2	0.2638	4.0	0.96	1509.5	53.7	1583.0	33.5	1682.4	22.7	1682.4	22.7
KK1009-32	347	44250	1.3	13.2865	1.6	1.9309	2.2	0.1861	1.5	0.68	1100.0	15.6	1091.8	15.1	1075.6	32.9	1075.6	32.9
KK1009-33	398	29046	10.3	16.4905	2.2	0.8140	2.4	0.0974	1.1	0.45	598.9	6.3	604.7	11.1	626.5	46.8	598.9	6.3
KK1009-35	101	2736	2.3	17.5080	5.7	0.2841	5.8	0.0361	1.0	0.17	228.5	2.2	253.9	13.1	496.0	126.3	228.5	2.2
KK1009-36	478	10911	1.9	19.8225	2.0	0.2207	3.0	0.0317	2.3	0.76	201.4	4.5	202.5	5.5	215.7	45.5	201.4	4.5
KK1009-37	168	13398	3.8	17.0525	3.7	0.7811	3.8	0.0966	1.0	0.26	594.4	5.7	586.1	17.1	553.8	81.1	594.4	5.7
KK1009-38	66	26361	1.6	5.8335	1.8	11.5750	2.5	0.4897	1.8	0.70	2569.5	37.5	2570.7	23.7	2571.6	30.4	2571.6	30.4
KK1009-39	226	32820	1.3	9.6560	1.4	3.7878	2.5	0.2653	2.0	0.82	1516.7	27.2	1590.2	19.8	1688.9	26.2	1688.9	26.2
KK1009-40	759	19389	2.3	19.5874	3.5	0.2521	3.6	0.0358	1.0	0.28	226.9	2.2	228.3	7.4	243.2	80.6	226.9	2.2
KK1009-41	234	15045	1.7	16.6416	4.5	0.8172	4.6	0.0986	1.0	0.22	606.4	5.8	606.5	21.0	606.8	97.2	606.4	5.8
KK1009-42	1222	32319	2.4	19.1947	2.2	0.2590	2.9	0.0361	2.0	0.67	228.4	4.4	233.9	6.1	289.7	49.3	228.4	4.4
KK1009-43	115	5373	1.6	19.0622	32.7	0.2847	32.8	0.0394	1.6	0.05	248.9	3.8	254.4	73.9	305.5	764.1	248.9	3.8
KK1009-44	63	35166	1.4	5.1941	2.9	14.3041	3.0	0.5389	1.0	0.33	2778.6	22.6	2770.1	28.8	2763.9	47.0	2763.9	47.0

KK1009-45	510	45864	5.4	16.4801	2.4	0.8531	2.8	0.1020	1.4	0.49	626.0	8.2	626.4	13.1	627.9	52.4	626.0	8.2
KK1009-46	91	11883	1.8	13.2820	3.5	1.8835	3.6	0.1814	1.0	0.28	1074.8	9.9	1075.3	24.0	1076.2	69.9	1076.2	69.9
KK1009-47	318	16869	7.3	18.2423	3.0	0.5091	3.5	0.0674	1.8	0.51	420.2	7.4	417.8	12.1	404.8	68.1	420.2	7.4
KK1009-48	244	50214	1.7	9.6275	2.2	4.3039	2.4	0.3005	1.0	0.42	1693.9	14.9	1694.1	19.8	1694.4	40.2	1694.4	40.2
KK1009-49	630	15069	4.8	19.6397	3.2	0.1880	3.5	0.0268	1.4	0.40	170.3	2.3	174.9	5.6	237.1	74.0	170.3	2.3
KK1009-50	222	4770	1.4	19.7706	7.3	0.1984	8.1	0.0284	3.5	0.43	180.8	6.2	183.8	13.7	221.7	170.0	180.8	6.2
KK1009-51	67	9057	0.8	13.3105	2.8	1.7451	3.0	0.1685	1.0	0.33	1003.7	9.3	1025.4	19.5	1071.9	57.2	1071.9	57.2
KK1009-52	824	21690	1.4	19.4605	5.6	0.2507	5.8	0.0354	1.7	0.29	224.2	3.8	227.2	11.9	258.2	128.1	224.2	3.8
KK1009-53	152	24996	1.1	12.1981	2.1	2.3052	2.3	0.2039	1.0	0.43	1196.4	10.9	1213.9	16.3	1245.0	40.6	1245.0	40.6
KK1009-54	1504	31560	2.3	18.5170	7.4	0.2772	8.1	0.0372	3.4	0.41	235.6	7.8	248.4	17.9	371.2	166.2	235.6	7.8
KK1009-55	360	25941	1.8	16.1719	3.3	0.8686	3.7	0.1019	1.6	0.43	625.4	9.3	634.8	17.3	668.4	71.1	625.4	9.3
KK1009-56	401	64134	3.8	13.0862	1.3	1.8158	1.7	0.1723	1.0	0.60	1025.0	9.5	1051.2	10.8	1106.0	26.4	1106.0	26.4
KK1009-57	998	60183	2.1	16.8999	3.5	0.6923	4.3	0.0849	2.5	0.58	525.1	12.6	534.2	17.8	573.4	75.9	525.1	12.6
KK1009-59	205	12519	4.5	17.3598	2.1	0.6228	2.3	0.0784	1.0	0.43	486.6	4.7	491.6	9.0	514.7	45.7	486.6	4.7
KK1009-59A	115	21984	1.3	9.1657	1.9	4.3081	2.2	0.2864	1.1	0.52	1623.4	16.2	1694.9	17.9	1784.5	33.9	1784.5	33.9
KK1009-60	188	54405	1.4	5.3674	3.0	10.2718	5.0	0.3999	4.0	0.80	2168.4	73.5	2459.6	46.4	2709.9	50.2	2709.9	50.2
KK1009-61	141	45861	2.0	6.9386	2.1	7.7537	3.0	0.3902	2.1	0.69	2123.7	37.1	2202.8	26.6	2277.3	36.7	2277.3	36.7
KK1009-62	501	16557	1.5	18.9802	3.1	0.3037	3.3	0.0418	1.2	0.35	264.0	3.0	269.3	7.9	315.3	71.5	264.0	3.0
KK1009-63	1693	24351	2.7	18.8689	2.2	0.2894	2.4	0.0396	1.0	0.42	250.4	2.5	258.1	5.5	328.7	49.6	250.4	2.5
KK1009-64	160	8442	1.7	18.2327	3.9	0.5139	4.0	0.0680	1.0	0.25	423.9	4.1	421.1	13.8	405.9	86.8	423.9	4.1
KK1009-65	55	11592	2.2	12.0969	1.5	2.4695	1.8	0.2167	1.0	0.55	1264.2	11.5	1263.2	13.2	1261.3	29.8	1261.3	29.8
KK1009-67	260	68739	1.9	8.2598	2.3	5.9244	4.0	0.3549	3.3	0.82	1958.0	54.9	1964.8	34.6	1972.0	41.0	1972.0	41.0
KK1009-66	184	15663	3.7	16.7314	2.5	0.7615	2.7	0.0924	1.0	0.37	569.8	5.5	574.9	12.0	595.2	55.0	569.8	5.5
KK1009-68	294	39651	1.3	12.8281	1.9	2.0429	4.0	0.1901	3.5	0.88	1121.8	36.4	1129.9	27.3	1145.7	37.4	1145.7	37.4

KK1009-69	90	6504	0.7	16.8370	3.9	0.7414	4.2	0.0905	1.6	0.37	558.7	8.3	563.2	18.2	581.5	85.0	558.7	8.3
KK1009-70	387	8103	1.4	20.2845	2.6	0.1751	2.8	0.0258	1.1	0.40	164.0	1.8	163.8	4.3	162.0	60.7	164.0	1.8
KK1009-70A	606	10845	1.8	20.3552	2.5	0.1672	2.7	0.0247	1.0	0.37	157.2	1.6	157.0	4.0	153.9	59.2	157.2	1.6
KK1009-71	675	57288	3.6	13.6055	2.2	1.6699	2.5	0.1648	1.3	0.50	983.3	11.4	997.1	15.9	1027.7	43.9	1027.7	43.9
KK1009-72	343	6921	1.0	20.2520	5.4	0.1868	5.5	0.0274	1.0	0.18	174.5	1.7	173.9	8.7	165.8	125.4	174.5	1.7
KK1009-73	380	13488	1.7	19.4640	5.9	0.2654	6.0	0.0375	1.0	0.17	237.1	2.3	239.0	12.8	257.8	136.5	237.1	2.3
KK1009-74	194	46980	1.5	8.5131	1.0	5.2714	3.4	0.3255	3.2	0.95	1816.4	50.8	1864.2	28.8	1918.0	18.3	1918.0	18.3
KK1009-75	335	56349	2.4	10.6813	3.8	3.4829	4.8	0.2698	3.0	0.61	1539.9	40.5	1523.3	38.2	1500.5	72.4	1500.5	72.4
KK1009-76	106	27096	1.2	9.1888	1.9	4.7615	2.2	0.3173	1.0	0.46	1776.6	15.5	1778.1	18.2	1779.9	35.2	1779.9	35.2
KK1009-77	501	8205	2.8	19.3560	3.4	0.2202	4.3	0.0309	2.7	0.62	196.2	5.2	202.0	7.9	270.5	77.7	196.2	5.2
KK1009-78	504	84369	6.4	9.0373	3.4	4.1159	4.4	0.2698	2.8	0.63	1539.7	38.3	1657.5	36.2	1810.1	62.3	1810.1	62.3
KK1009-79	280	13458	1.9	16.9844	4.3	0.5358	4.6	0.0660	1.6	0.35	412.0	6.4	435.7	16.2	562.5	93.5	412.0	6.4
KK1009-80	49	17010	2.5	7.7217	5.2	6.9743	5.3	0.3906	1.0	0.19	2125.5	18.1	2108.2	47.2	2091.3	91.8	2091.3	91.8
KK1009-81	212	62082	1.6	8.3977	1.1	5.2368	1.5	0.3189	1.0	0.67	1784.6	15.6	1858.6	12.7	1942.5	19.7	1942.5	19.7
KK1009-82	106	318	1.2	12.6905	6.4	0.2654	6.6	0.0244	1.6	0.24	155.6	2.4	239.0	14.1	1167.1	127.6	155.6	2.4
KK1009-83	232	15279	4.1	14.5331	3.2	0.8781	3.5	0.0926	1.4	0.40	570.6	7.6	639.9	16.5	893.0	65.9	570.6	7.6
KK1009-84	173	22899	1.4	13.6349	3.3	1.5180	6.7	0.1501	5.8	0.87	901.6	48.7	937.7	40.9	1023.4	67.4	1023.4	67.4
KK1009-85	220	30267	1.2	10.6406	2.7	3.0619	2.8	0.2363	1.0	0.35	1367.4	12.3	1423.2	21.7	1507.7	50.1	1507.7	50.1
KK1009-85A	30	2817	1.9	12.1746	4.3	1.8768	4.4	0.1657	1.0	0.23	988.5	9.2	1072.9	29.2	1248.8	83.9	1248.8	83.9
KK1009-86	1037	17430	1.3	20.0668	3.1	0.2096	3.9	0.0305	2.4	0.61	193.7	4.5	193.2	6.8	187.2	71.5	193.7	4.5
KK1009-88	430	7935	2.0	19.7531	3.2	0.1978	3.6	0.0283	1.6	0.44	180.1	2.8	183.3	6.0	223.8	73.9	180.1	2.8
KK1009-87	490	35112	5.8	13.8372	1.6	1.5411	1.9	0.1547	1.0	0.53	927.0	8.6	946.9	11.7	993.5	32.9	993.5	32.9
KK1009-89	519	9111	1.1	20.1234	2.8	0.1790	3.0	0.0261	1.1	0.36	166.2	1.8	167.2	4.6	180.6	64.7	166.2	1.8
KK1009-90	471	22704	181.5	18.0898	2.1	0.4818	2.3	0.0632	1.0	0.43	395.1	3.8	399.3	7.6	423.5	46.3	395.1	3.8

KK1009-90A	390	54240	1.9	13.1903	2.5	1.9101	2.7	0.1827	1.0	0.37	1081.8	10.0	1084.6	17.9	1090.1	49.9	1090.1	49.9
KK1009-91	52	21006	1.4	5.9907	3.0	10.4560	3.2	0.4543	1.0	0.32	2414.3	20.1	2476.0	29.2	2527.0	50.2	2527.0	50.2
KK1009-93	224	4935	2.5	19.8726	7.5	0.2008	8.0	0.0289	3.0	0.37	183.9	5.4	185.8	13.7	209.8	173.5	183.9	5.4
KK1009-94	160	33174	2.5	9.9707	3.5	3.8476	3.6	0.2782	1.0	0.27	1582.5	14.0	1602.8	29.3	1629.5	65.1	1629.5	65.1
KK1009-95	332	57567	5.2	9.3870	2.0	4.2246	2.2	0.2876	1.0	0.45	1629.6	14.4	1678.8	18.1	1740.9	35.9	1740.9	35.9
KK1009-96	767	122082	4.8	11.4323	3.6	2.2782	6.2	0.1889	5.0	0.81	1115.4	51.3	1205.6	43.5	1370.9	69.1	1370.9	69.1
KK1009-97	257	26367	2.6	10.6488	4.3	2.4189	4.6	0.1868	1.7	0.38	1104.1	17.5	1248.2	33.0	1506.2	80.3	1506.2	80.3
KK1009-98	200	58974	1.3	8.2350	2.2	5.5279	2.4	0.3302	1.0	0.41	1839.1	16.0	1904.9	20.9	1977.4	39.5	1977.4	39.5
KK1009-99	216	50202	2.3	6.2926	3.5	8.2630	3.7	0.3771	1.0	0.27	2062.8	17.7	2260.3	33.2	2444.1	59.8	2444.1	59.8
KK1009-100	297	45345	4.4	13.7144	2.7	1.6492	3.2	0.1640	1.8	0.56	979.2	16.3	989.3	20.3	1011.6	53.9	1011.6	53.9
KK1009-101	137	19308	2.0	11.3150	3.3	2.7838	3.4	0.2285	1.0	0.29	1326.4	12.0	1351.2	25.4	1390.7	62.4	1390.7	62.4
KK1009-102	162	4884	2.6	19.6356	7.8	0.2656	7.9	0.0378	1.0	0.13	239.4	2.3	239.2	16.8	237.5	181.1	239.4	2.3
KK1009-103	103	26406	1.7	5.9683	1.3	8.3238	2.8	0.3603	2.5	0.89	1983.6	43.0	2266.9	25.8	2533.3	22.0	2533.3	22.0
KK1009-104	98	20979	1.5	5.3746	2.8	8.8540	3.1	0.3451	1.3	0.42	1911.3	22.0	2323.1	28.6	2707.6	46.9	2707.6	46.9
KK1009-105	208	4125	2.0	19.7263	11.5	0.2201	11.5	0.0315	1.0	0.09	199.9	2.0	202.0	21.1	226.9	266.1	199.9	2.0
KK1009-106	340	60588	3.3	9.4707	3.4	4.4703	3.7	0.3071	1.5	0.40	1726.2	22.3	1725.5	30.4	1724.6	61.7	1724.6	61.7
KK1009-107	198	38037	2.2	9.2750	1.8	4.7412	2.2	0.3189	1.2	0.56	1784.5	19.0	1774.6	18.3	1762.8	33.1	1762.8	33.1
KK1009-108	319	8436	3.0	18.0637	3.4	0.5066	3.7	0.0664	1.3	0.34	414.3	5.1	416.2	12.5	426.8	76.8	414.3	5.1
KK1009-109	352	6627	4.9	19.7633	16.8	0.1816	17.0	0.0260	2.5	0.15	165.7	4.1	169.4	26.6	222.6	391.6	165.7	4.1