DATA REPOSITORY ITEM 2009017

ANALYTICAL TECHNIQUES

U-Pb Geochronology

Approximately 5–10 kg of sample were crushed using a jaw crusher and disc grinder and processed for mineral separations using a Gemeni water table. Zircons were concentrated using methylene iodide (MEI) and magnetic separation with a Frantz. Errors on spot ages of individual zircons grains are reported at 1σ, and weighted mean ages were calculated and reported in the text and figures at the 2σ level.

LA-MC-ICPMS. For LA-MC-ICPMS, all material that sank in MEI and was non-magnetic at 1.8 A was put on 2.5 cm epoxy mounts for analysis. Beam diameter was 50 μm for detrital zircons and 30 or 35 μm for igneous zircons. The ablated material was transported in an Ar-He carrier gas into the plasma source of a Micromass Isoprobe, which is equipped with a flight tube of sufficient width to allow simultaneous analysis of U, Th, and Pb isotopes. All measurements were 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 were ~1 mv per ppm. Each analysis consisted of an integrated 20-second background measurement on the peak positions, 20 one-second integrations with the laser firing, and a 30 second delay to purge the previous sample and prepare for the next analysis.

Common Pb corrections were made using measured ^{204}Pb concentrations 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. Prior analyses have demonstrated that the Ar-He carrier gas contains negligible ^{204}Hg and we corrected for isobaric ^{204}Hg interferences on ^{204}Pb as part of the background measurements.

Element and isotopic fractionation for LA-MC-ICPMS vary with pit depth and the accepted isotope ratios were determined by least-squares projection through the measured values back to the initial determination. Inter-element fractionation of Pb/U was generally <20%, whereas fractionation of Pb isotopes was generally <5%. Each analysis was normalized to the University of Arizona "SL" zircon standard with an age of 564 ± 4 Ma (G. Gehrels, unpublished data), which was analyzed after every fifth sample analysis for detrital zircons and every fourth analysis for igneous zircons. The uncertainty resulting from the calibration correction (together with the uncertainty from decay constants and common Pb composition) is generally 3% (2σ) for $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ages of >1.2 Ga.

Errors from the measurement of $^{206}Pb/^{238}U$, $^{206}Pb/^{207}Pb$, and $^{206}Pb/^{204}Pb$ are reported at the 1σ level. Additional errors that affect all ages include uncertainties from (1) U decay constants; (2) the composition of common Pb; and (3) calibration correction. These systematic errors (SE) are not included in the tables and add an additional uncertainty to $^{207}Pb/^{206}Pb$ ages. Interpreted ages for igneous rocks incorporate the systematic errors into the weighted mean ages so that the total 2σ uncertainties that are quoted are equal to the square root of the squares of the random error plus the systematic error. U and Th concentrations have approximately 25% uncertainty. Analyses with >6% 1σ uncertainty, >30% normal discordance, or >5% reverse discordance are excluded from the plots and interpretations. Relative probability diagrams and weighted mean calculations were created using the Isoplot program (Ludwig, 2003). For other details of analytical methods see Gehrels et al. (2006).

SHRIMP. For SHRIMP analysis, zircons were hand picked from material that sank in MEI and was non-magnetic at 1.8 A. About 30–50 zircons were put on 2.5 cm epoxy mounts for individual analysis. A 30-μm diameter, 8–12 nA O_2 primary beam was used to sputter the zircon grains for analysis, following 90 seconds of rastering to remove potential surface contamination. CL images were obtained for all zircons analyzed. U, Th, and Pb concentrations were standardized against RG-6 and VP-10 zircons that were analyzed after every four unknown analyses. Data was reduced using the SQUID program (Ludwig, 2001). Pb/U ratios were corrected for common Pb using the model Pb evolution curve of Stacey and Kramers (1975). Errors on spot ages of individual zircons grains are reported at 1σ, and weighted mean ages were calculated and reported in the text and figures at the 2σ level. The weighted mean of $^{207}Pb/^{206}Pb$ ages derived using the SQUID and Isoplot programs (Ludwig, 2003) incorporates uncertainties in the standards and decay constants into the reported errors and thus the total uncertainties reported are comparable in scope to those reported from the LA-ICPMS data.

Nd Isotope Geochemistry

Sr and Nd isotope analyses were obtained by dissolving rock powder in HF and perchloric acid in Teflon beakers and Rb, Sr, Sm, and Nd were separated and their isotopic compositions were determined using the techniques described in Farmer et al. (1991).

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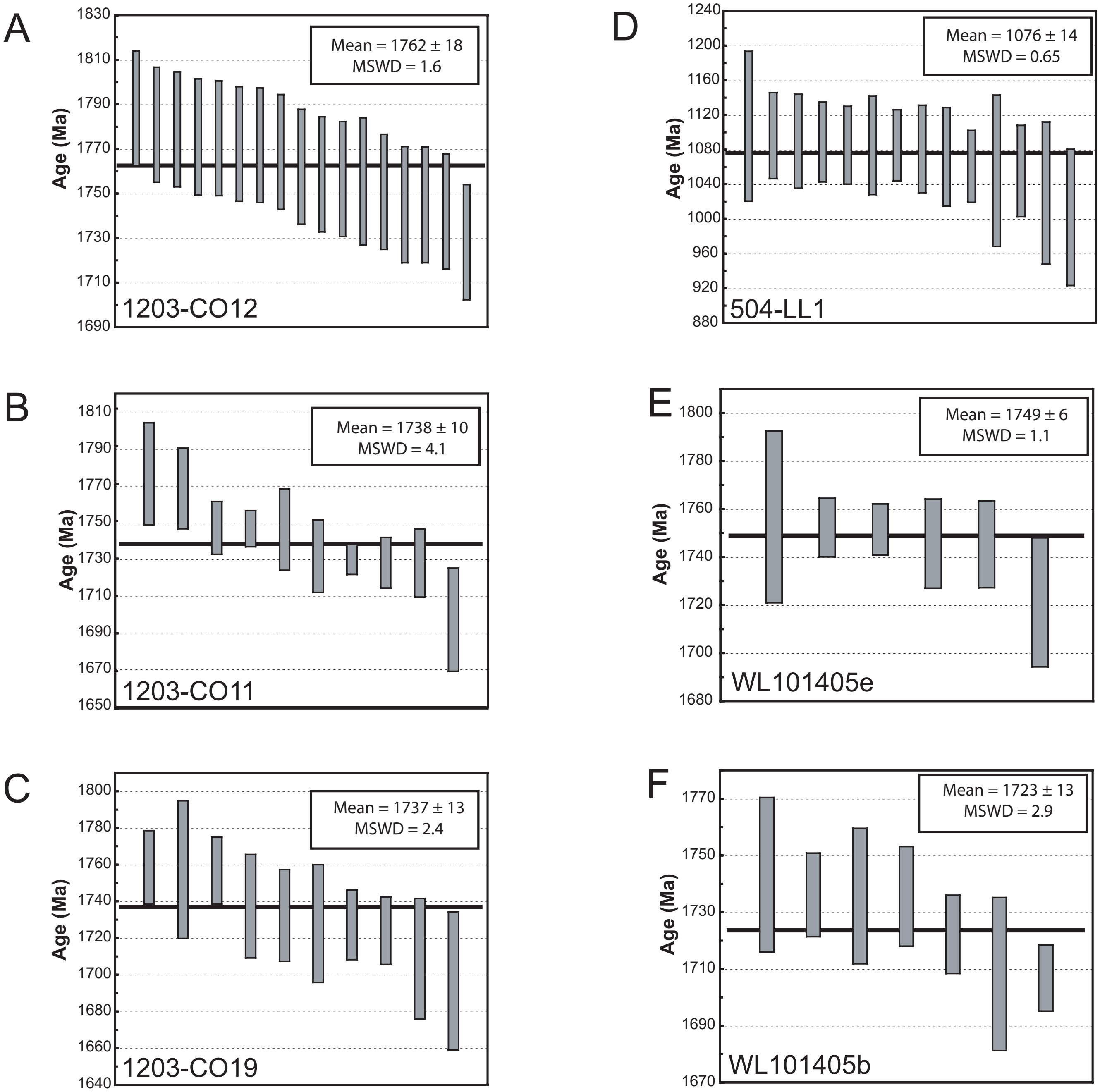

Figure DR1. Weighted mean calculations of $^{207}Pb/^{206}Pb$ ages determined using LA-MC-ICPMS (1203-CO12) or SHRIMP (all others). Uncertainties on weighted mean ages are reported at the 2σ level. Height of each bar reflects 2σ uncertainty. Samples are from granitoids in the La Lamina region (A-D) and from two clasts in Lower Jurassic conglomerate south of La Lamina (E-F).

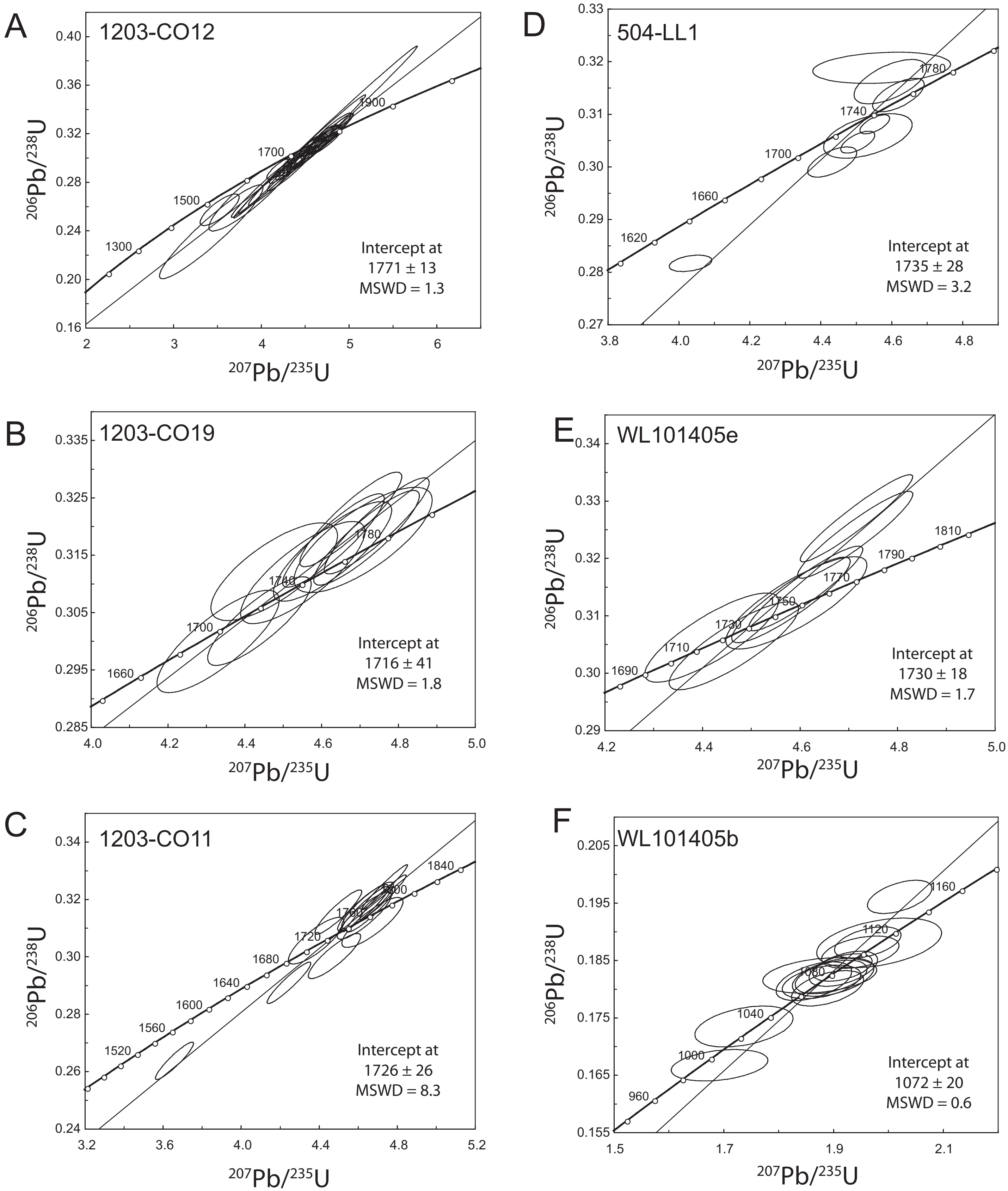

Figure DR2. Concordia diagrams of U-Pb data determined using LA-MC-ICPMS (1203-CO12) or SHRIMP (all others). Error ellipses are plotted at the 2σ level. Samples are from granitoids in the La Lamina region (A-D) and from two clasts in Lower Jurassic conglomerate south of La Lamina (E-F).

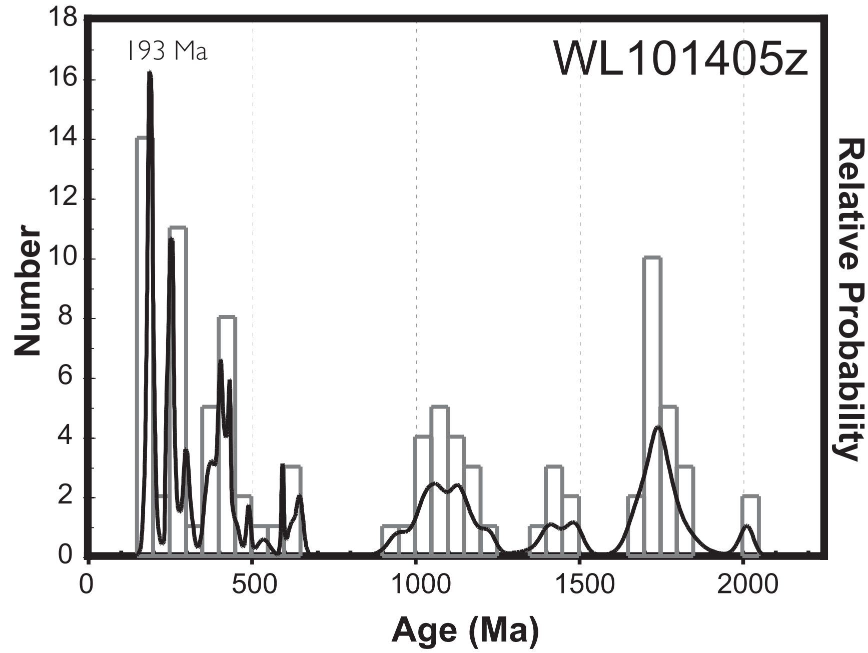

Figure DR3. U-Pb relative probability distribution and histogram for matrix from conglomerate with Proterozoic clasts.

TABLE DR1. COMPLETE U/PB ZIRCON DATA

Spot	U (ppm)	Th (ppm)	Th/U	204Pb† (%)	238U/206Pb	err (%)	207Pb*/206Pb*	err (%)	206Pb*/238U age (Ma)	1s	206Pb*/207Pb* age (Ma)	err 1s	Conc.‡ (%)
1203-CO11: La Lamina gabbro (12R, 518363, 3366615): SHRIMP													
2	211	76	0.36	<0.01	3.2053	1.1	0.1086	0.8	1747	19	1777	14	98
11	364	142	0.39	<0.01	3.3302	1.1	0.1082	0.6	1684	18	1769	11	95
5	797	194	0.24	0.01	3.1594	1.0	0.1069	0.4	1776	18	1747	7	102
4	1664	1225	0.74	<0.01	3.1177	1.0	0.1069	0.3	1799	18	1747	5	103
12	364	138	0.38	0.05	3.1811	1.1	0.1069	0.6	1764	18	1746	11	101
14	910	79	0.09	<0.01	4.1925	1.0	0.1061	0.4	1778	18	1734	7	103
23	481	194	0.40	<0.01	3.1448	1.0	0.1060	0.5	1786	18	1732	10	103
7	2721	2112	0.78	0.02	3.0837	1.0	0.1059	0.2	1820	18	1730	4	105
8	919	791	0.86	0.00	3.4371	1.0	0.1058	0.4	1638	16	1728	7	95
3	502	188	0.37	0.04	3.1538	1.0	0.1058	0.5	1781	18	1728	9	103
22	278	84	0.30	0.05	3.2718	1.1	0.1040	0.8	1722	18	1698	14	101
6	1385	207	0.15	<0.01	3.1685	1.0	0.1034	0.4	1778	17	1686	8	105
10	2275	109	0.05	0.05	3.7914	1.0	0.1006	0.4	1498	15	1635	8	92
15	1450	188	0.13	0.00	4.0465	1.0	0.0895	0.4	1424	14	1416	7	101
13	2166	215	0.10	0.01	4.2527	1.0	0.0892	0.3	1358	13	1408	6	96
19	2347	162	0.07	0.01	4.0504	1.0	0.0891	0.3	1424	14	1406	5	101
18	1599	163	0.10	0.03	3.9934	1.0	0.0890	0.3	1443	14	1404	6	103
9	2397	168	0.07	0.04	4.0691	1.0	0.0890	0.3	1417	14	1404	6	101
16	2218	105	0.05	0.08	4.5656	1.0	0.0890	0.5	1269	12	1404	9	90
17	1649	147	0.09	0.01	3.9806	1.0	0.0890	0.3	1448	14	1404	6	103
20	1638	178	0.11	0.03	4.0799	1.0	0.0885	0.3	1415	14	1394	6	101
13	2274	154	0.07	0.01	3.1580	1.0	0.0884	0.4	1378	13	1391	7	99
21	2470	143	0.06	0.01	4.1387	1.0	0.0884	0.8	1395	13	1390	15	100
1203-CO12: La Lamina weakly foliated granite (12R, 518370, 3366581): LA-MC-ICPMS													
15	228	113	0.49	<0.01	3.1829	1.4	0.1093	0.7	1761	22	1788	13	98
4	606	173	0.29	<0.01	3.1342	0.7	0.1089	0.7	1785	11	1781	13	100
9	343	115	0.34	<0.01	3.1741	1.6	0.1088	0.7	1766	24	1779	13	99
5	453	195	0.43	<0.01	3.2471	1.2	0.1086	0.7	1731	18	1776	13	97
28	422	168	0.40	<0.01	3.1780	2.9	0.1085	0.7	1764	44	1775	13	99
18	707	102	0.14	<0.01	3.2053	3.2	0.1085	0.7	1750	49	1774	13	99
30	671	519	0.77	<0.01	3.2297	0.7	0.1084	0.7	1739	11	1772	13	98
2	1169	171	0.15	<0.01	3.3186	1.2	0.1084	0.7	1698	18	1772	13	96
10	882	567	0.64	<0.01	3.4386	2.5	0.1083	0.7	1646	36	1772	13	93
25	978	482	0.49	<0.01	3.1551	1.3	0.1082	0.7	1775	20	1769	13	100
20	1056	154	0.15	<0.01	3.2233	0.8	0.1081	0.7	1742	12	1768	13	99
7	635	85	0.13	<0.01	3.1069	0.7	0.1079	0.7	1799	11	1764	13	102
19	873	726	0.83	<0.01	3.1064	1.9	0.1078	0.7	1799	30	1762	13	102
12	1696	70	0.04	<0.01	3.4408	0.7	0.1077	0.7	1645	10	1761	13	93
6	488	206	0.42	<0.01	3.4297	1.3	0.1076	0.7	1649	20	1759	13	94
24	1563	585	0.37	<0.01	3.3520	1.5	0.1075	0.7	1683	21	1757	13	96
3	720	3936	5.47	0.01	3.5245	3.3	0.1074	0.8	1610	47	1756	14	92
26	1119	149	0.13	<0.01	3.2277	1.1	0.1072	0.7	1740	17	1752	13	99
29	881	249	0.28	<0.01	3.1823	0.7	0.1071	0.7	1762	11	1751	13	101
17	911	382	0.42	<0.01	3.1116	9.0	0.1068	0.7	1796	141	1745	13	103
22	943	386	0.41	<0.01	3.2989	6.6	0.1068	0.7	1707	99	1745	13	98
13	1593	117	0.07	<0.01	3.4113	2.0	0.1067	0.7	1657	29	1744	13	95
11	788	152	0.19	<0.01	3.2973	1.9	0.1066	0.7	1708	28	1742	13	98
21	1309	103	0.08	<0.01	3.3613	1.7	0.1065	0.7	1679	26	1741	13	96
27	1282	448	0.35	<0.01	3.6440	3.5	0.1058	0.7	1563	48	1729	13	90
16	1131	84	0.07	<0.01	3.4282	1.2	0.1046	0.7	1650	18	1708	13	97
14	1036	99	0.10	<0.01	3.7112	4.5	0.1043	2.2	1538	61	1701	40	90
1	2125	2321	1.09	<0.01	4.1792	6.6	0.1040	2.4	1383	82	1696	45	82
8	585	51	0.09	<0.01	3.8855	2.1	0.0993	1.5	1476	27	1612	29	92

1203-CO19: La Lamina granite gneiss (12R, 517802, 3366617): SHRIMP

1	403	226	0.56	<0.01	3.1443	1.1	0.1076	0.5	1783	19	1759	10	101
6	166	74	0.44	<0.01	3.1480	1.2	0.1075	1.0	1781	21	1757	19	101
2	465	309	0.67	<0.01	3.1240	1.1	0.1075	0.5	1794	19	1757	9	102
10	228	102	0.44	0.05	3.1679	1.1	0.1063	0.8	1772	20	1738	14	102
7	553	186	0.34	0.02	3.2946	1.0	0.1060	0.7	1706	17	1733	12	98
3	177	173	0.98	0.06	3.2053	1.2	0.1058	0.9	1753	20	1728	16	101
8	481	180	0.37	0.00	3.1489	1.0	0.1058	0.5	1784	18	1727	9	103
5	482	390	0.81	0.00	3.1130	1.0	0.1056	0.5	1804	19	1724	9	105
4	196	99	0.51	<0.01	3.3337	1.2	0.1047	0.9	1689	20	1709	16	99
9	329	234	0.71	0.12	3.2038	1.1	0.1040	1.0	1757	19	1697	19	104

504-LL1: La Lamina Pozito micrographic granite (12R, 520112, 3366521): SHRIMP

10	115	48	0.41	<0.01	5.3172	0.9	0.0765	2.2	1111	10	1107	43	100
4	155	79	0.51	0.07	5.5500	0.7	0.0761	1.2	1067	7	1096	25	97
9	276	159	0.57	0.25	5.3634	0.6	0.0758	1.3	1103	7	1090	27	101
13	207	109	0.53	0.00	5.4476	0.7	0.0758	1.1	1086	7	1089	23	100
6	213	120	0.56	0.10	5.3100	0.6	0.0756	1.1	1113	6	1086	22	102
8	190	98	0.52	0.08	5.4914	0.7	0.0756	1.4	1078	8	1086	28	99
1	253	123	0.49	0.10	5.4400	0.5	0.0756	1.0	1088	6	1085	20	100
3	174	91	0.52	0.10	5.4900	0.7	0.0755	1.2	1079	7	1081	25	100
2	172	74	0.43	0.11	5.5200	0.7	0.0751	1.4	1074	7	1072	28	100
14	255	61	0.24	0.06	5.0996	0.6	0.0747	1.0	1159	7	1061	21	109
5	160	90	0.56	0.39	5.4800	0.7	0.0745	2.2	1081	7	1056	43	102
12	162	59	0.36	0.00	5.5127	0.8	0.0745	1.3	1075	8	1056	26	102
11	239	196	0.82	0.21	5.9968	0.7	0.0736	2.0	993	6	1030	41	96
7	157	60	0.38	0.27	5.7634	0.8	0.0726	1.9	1033	8	1003	39	103

WL-101405b: Lower Jurassic Conglomerate clast1 (12R, 520010, 3359342): SHRIMP

7	218	80	0.37	0.06	3.2000	1.1	0.1067	0.7	1753	18	1743	14	101
4	713	391	0.55	0.00	3.1800	1.0	0.1063	0.4	1767	17	1736	7	102
10	379	184	0.49	0.02	3.2800	1.0	0.1062	0.6	1713	17	1736	12	99
2	522	196	0.38	0.04	3.2000	1.0	0.1062	0.5	1757	17	1736	9	101
3	741	455	0.61	0.01	3.0900	1.0	0.1055	0.4	1821	17	1722	7	106
5	243	68	0.28	0.06	3.2700	1.0	0.1047	0.7	1724	17	1708	13	101
6	959	203	0.21	0.02	3.0600	0.9	0.1046	0.3	1838	17	1707	6	108
8	815	74	0.09	0.00	3.4700	1.0	0.1010	0.4	1629	15	1642	7	99
9	732	12	0.02	0.01	3.6300	1.0	0.0956	0.8	1572	15	1539	15	102
1	1478	15	0.01	0.01	3.9900	0.9	0.0897	0.3	1444	13	1420	6	102

WL101405e: Lower Jurassic Conglomerate clast2 (12R, 520010, 3359342): SHRIMP

4	317	88	0.28	0.22	3.2700	0.6	0.1075	1.0	1716	9	1757	18	98
9	1155	302	0.26	0.01	3.2800	0.3	0.1072	0.3	1710	5	1752	6	98
2	1687	378	0.22	0.02	3.2500	0.2	0.1072	0.3	1729	4	1752	5	99
3	600	230	0.38	0.07	3.3200	0.4	0.1068	0.5	1690	6	1746	9	97
7	556	164	0.29	0.02	3.1900	0.4	0.1068	0.5	1760	7	1746	9	101
8	315	124	0.39	0.06	3.1600	0.5	0.1054	0.7	1777	10	1721	13	103
6	908	82	0.09	0.04	3.1400	0.4	0.1040	1.7	1794	8	1696	31	106
5	2649	261	0.10	0.03	3.5500	0.2	0.1038	0.6	1591	4	1694	10	94

Note: All locations reported as UTM coordinates (Zone, Easting, Northing) determined using the NAD27 datum.

Pb* indicates corrected for common Pb using measured 204Pb.

†Common Pb component (%) of total 206Pb determined using measured 204Pb.

‡Concordance (%) calculated as (6-8 age/6-7 age)*100.

Additional note on Table DR1 data:

Several zircon ages for Sample 1203-CO11 have a weighted mean of 1404 Ma, or over 300 m.y. younger than the interpreted intrusive age (see text). These zircons have Th/U values that are generally very low (<0.1), a feature often associated with metamorphic zircon growth (Hoskin and Schaltegger, 2003). We interpret this to indicate that this sample has experienced metamorphic zircon growth at this time, but this was not put into the manuscript for space considerations.

Reference

Hoskin, P.W.O., and Schaltegger, U., 2003, The composition of zircon and igneous and metamorphic petrogenesis, *in* Hanchar, J.M., and Hoskin, P.W.O., eds., Reviews in Mineralogy and Geochemistry Volume 53: Zircon, Volume 53: Washington, D.C., Mineralogical Society of America, p. 27-62.