U-Pb Zircon Geochronology Results for the Granite Peak and Granite Peak SE Quadrangles, Utah

by

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INTRODUCTION

This open-file report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during geologic mapping funded or partially supported by the Utah Geological Survey (UGS). Table 1 summarizes the ages of the samples and provides additional information such as sample location and rock type. Christiansen and others (2007), Jensen and others (2007), Clark and others (2008), and Clark and others (in press) explain the geologic setting of these rocks and the significance of the Late Jurassic ages for the magmatic rocks and how they relate to the tectonic evolution of the western United States. These data are highly technical in nature and proper interpretation requires considerable training in the applicable geochronologic techniques.

GEOCHRONOLOGIC TECHNIQUES

New U-Pb zircon ages were acquired for three samples from the Granite Peak and Granite Peak SE quadrangles—a porphyritic granite from the granite of Granite Peak (Jg on the map of Clark and others, in press), a granodiorite from the foliated granodiorite of Granite Peak (Jgd), and a biotite-muscovite schist from the metasedimentary rocks of Granite Peak (PzZm2) that are intruded by the granitic rocks (table 1). To avoid problems associated with slow cooling of plutonic rocks, hydrothermal alteration, and zircon inheritance from older rock units, we obtained U-Pb ages on zircons by laser-ablation inductively coupled-mass spectrometry (LA-ICP-MS) at the GeoAnalytical Lab at Washington State University. All samples were processed and zircon grains separated using standard gravimetric and magnetic techniques at Brigham Young University. Zircon grains, both standards and unknowns, were mounted in a 1 inch-diameter epoxy puck that was ground and polished to expose the interiors of the grains. Cathodoluminescence images acquired at the University of Idaho were used as base maps for recording laser spot locations and to reveal growth and compositional zonation, inclusions, and to look for inherited cores.

Chang and others (2006) present a comprehensive overview of the laser-ablation techniques and a brief overview is given below. Zircon ages were determined using a New Wave UP-213 laser ablation system in conjunction with a Thermo Scientific Element2 single collector, double-focusing magnetic sector ICP-MS. Zircons were analyzed using a 30 μm diameter beam operating at 10 Hz. The ablated material was delivered to the torch by a mixed He and Ar gas. Laser-induced time-dependent fractionation was corrected by normalizing measured ratios in standards and samples to the beginning of the analysis using the intercept method. Static fractionation, including that caused by laser ablation and due to instrumental discrimination, was corrected using external zircon standards. In our case, we used FC1 and Peixe (Paces and Miller, 1993; Dickinson and others, 2003). Weighted average ages and Tera-Wasserburg concordia were calculated using IsoPlot 3.0 (Ludwig, 2003).

Total uncertainty for each spot analysis of an unknown was combined quadratically with the uncertainty in the measured isotope ratios and the uncertainty in the fractionation factors calculated from the measurement of standards. For individual analyses we estimate that the accuracy and precision are better than 4% at the two-sigma level, with the largest contribution in uncertainty from the measurement of the standards. Based on a comparison of LA-ICP-MS ages with ages determined by thermal ionization mass spectrometry, Chang and others (2006) estimated the accuracy of age determinations using this technique to be on the order of 1% or better. However, there are unresolved contributions to uncertainty from the lack of a common Pb correction and from potential matrix effects between standards and unknowns. Consequently, we analyzed the Temora zircon as an independent check on the accuracy and precision. The Temora zircon has been proposed as a zircon standard by Black and others (2003), who reported a weighted average $^{206}Pb/^{238}U$ age of 416.8 ± 1.1 Ma based on 21 isotope dilution-thermal ionization mass spectrometric (ID-TIMS) analyses and 416.8 ± 1.8 Ma based on 50 sensitive-high resolution ion microprobe (SHRIMP) analyses. Chang and others (2006), using the same instrument and analytical conditions as used here, report an age of 416 ± 9 Ma for Temora. During the course of our analyses, 12 LA-ICP-MS analyses on seven grains of Temora were collected in two separate analytical sessions. All analyses, corrected for fractionation and incorporating fractionation factor uncertainty, give a weighted mean $^{206}Pb/^{238}U$ age of 416.9 ± 5.6 Ma (MSWD = 0.49), which is within error of the ID-TIMS age. In

order to account for all sources of uncertainty, including unknown matrix effects between zircon samples and standards, we suggest that a more realistic uncertainty for the LA-ICP-MS U-Pb method is no less than 2%. Therefore, all ages reported here are subject to a minimum uncertainty of 2%.

RESULTS

The analytical results for the rocks from the Granite Peak and Granite Peak SE quadrangles are summarized in table 1, and the complete data set is given in table 2. Both samples of the intrusive units and the schist from the wallrocks of the pluton yield Late Jurassic U-Pb ages. We analyzed eight grains in the granodiorite, 17 grains in the granite, but we were only able to separate and analyze one grain from the schist. We prefer the weighted mean $^{206}Pb/^{238}U$ ages, but the other types of ages are all similar—148.2 ± 1.2 (for the granite), 149.8 ± 1.3 Ma (for the granodiorite), and 149.9 ± 3.9 Ma for one grain in the schist (table 1; figure 1). We interpret these to represent the age of crystallization of the granitic rocks because zircon has such a high closure temperature. The age of the zircon in the schist may be related to thermal metamorphism of the country rocks caused by emplacement of the hot granitic magma. However, because we recovered only one zircon from the schist sample, this age should be treated with suspicion, since there is the possibility that this is a "rogue" grain from one of our other samples.

Relatively large MSWDs (mean square of the weighted deviates) indicate scatter in the ages beyond that attributable solely to analytical errors and could be related to a protracted crystallization history for the magma. However, the weighted means of the U-Pb ages are indistinguishable from one another; all overlap within the two-sigma uncertainties (table 2). Consequently, we grouped all of the zircon analyses together to reduce the uncertainty and calculated an age of 148.7 ± 0.9 Ma. To incorporate other sources of error, beyond those produced by analytical variabilities, we suggest that a better estimate of the age and its associated uncertainty is 148.7 ± 3.0 based on the application of a blanket 2% uncertainty noted above.

DISCLAIMER

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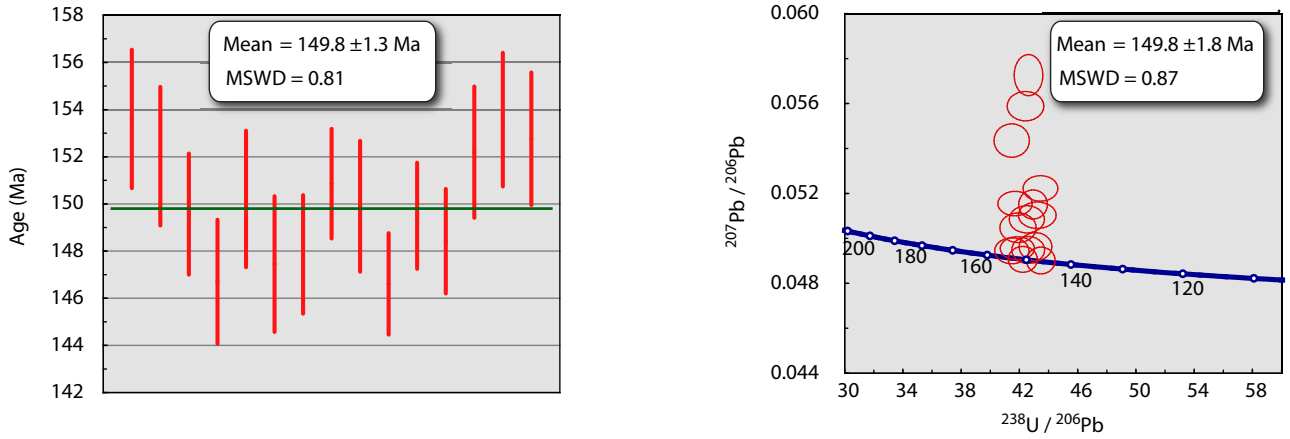
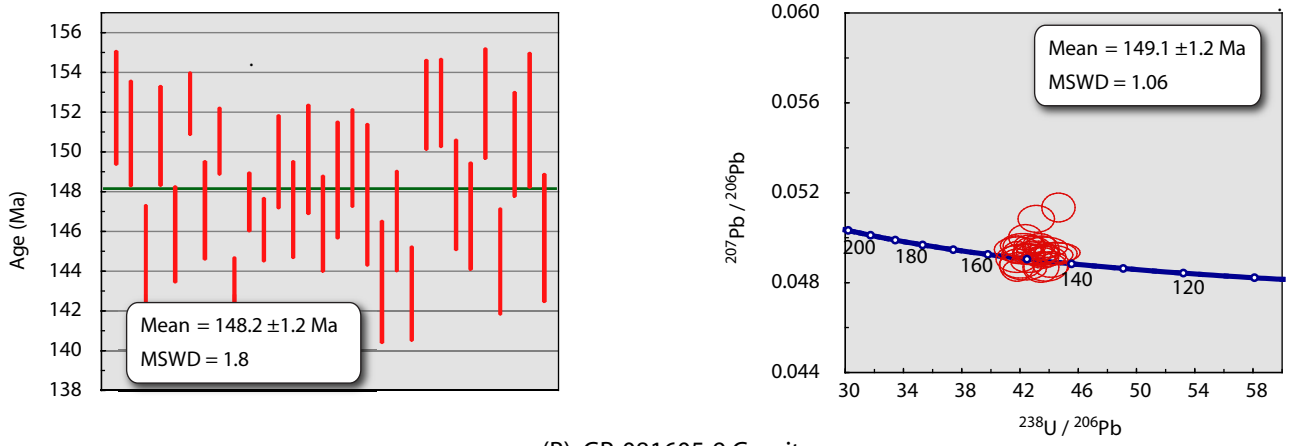
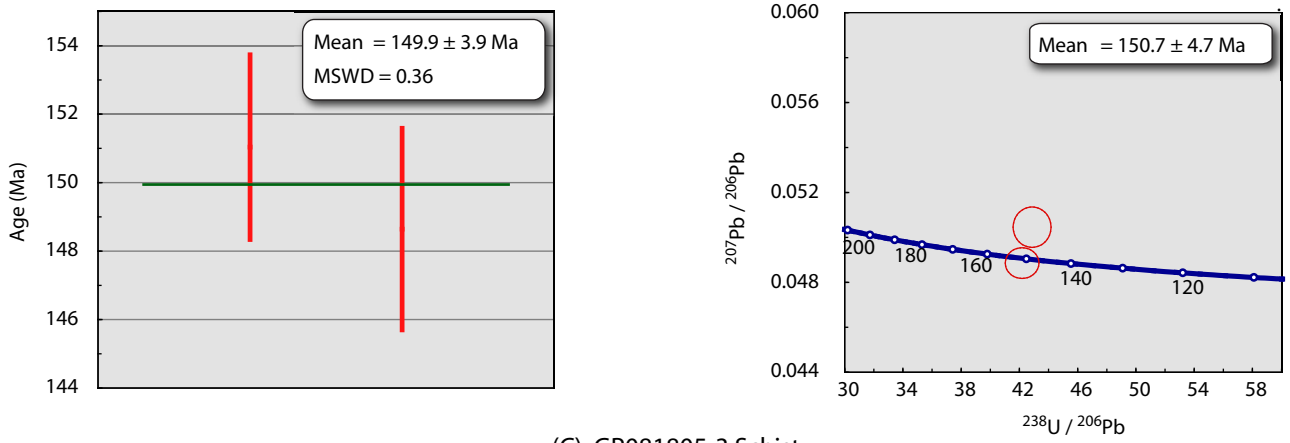


(A) GP-102605-3 Granodiorite



(B) GP-081605-9 Granite



(C) GP081805-3 Schist

Figure 1. Laser-ablation inductively coupled mass spectrometry (LA-ICP-MS) data for zircons from Granite Peak, Utah. $^{206}Pb/^{238}U$ ages plotted along with the weighted mean age (left) and Tera Wasserburg diagrams with concordia shown as a blue line (right). One sigma uncertainties, error bars, and error ellipses are shown. However, in order to account for all sources of uncertainty, including those in the age of the standards and unknown matrix effects between zircon samples and standards, a more unrealistic uncertainty for the LA-ICPMS U-Pb method is no less than 2%--±3 m.y. for these Late Jurassic rocks.

Table 1. Dated samples from the Granite Peak and Granite Peak SE quadrangles, Utah

Sample	Rock type	Latitude (N)	Longitude (W)	Age (Ma)	Unc1 (Ma)	Unc2 (Ma)
GP102605-3	Granodiorite (Jgd)	40° 05' 16.2"	113° 16' 46"	149.8	± 1.3	± 3.0
GP081605-9	Granite (Jg)	40° 07' 40"	113° 18' 23"	148.2	± 1.2	± 3.0
GP081805-3	Schist (PzZm2)	40° 04' 31"	113° 16' 03"	149.9	± 3.9	± 3.0

Notes: Weighted mean age is given. For details, see Tables 2 and 3
Rock type: basic lithology of sample and in parentheses the unit abbreviation used by Clark and others (in press)
Locations given in NAD 1927 reference datum
Unc1 = two sigma uncertainty for the weighted mean age
Unc2 = Uncertainty based on application of a blanket 2% error (see text for explanation)

Table 2. Summary of U-Pb laser ablation ICP-MS ages of rocks from the Granite Peak and Granite Peak SE quadrangles, Utah

Sample	Unit	Type	Age (Ma)	Unc1 (Ma)	Unc2 (Ma)	MSWD	Grains	Used	Rejected	Not used
GP102605-3	Granodiorite (Jgd)	Weighted mean	149.8	± 1.3	± 3.0	0.81	8	15	0	2
		Concordia	149.8	± 1.8	± 3.0	0.87	8	15	0	2
		Concordia 2	149.5	± 1.4	± 3.0	0.83	8	15	0	2
		TuffZirc	149.9	+2.3 -2.0	± 3.0		8	15	0	2
GP081605-9	Granite (Jg)	Weighted mean	148.2	± 1.2	± 3.0	1.8	17	30		5
		Concordia	149.1	± 1.2	± 3.0	1.06	17	30		5
		TuffZirc	148.2	+2.3 -1.5	± 3.0		17	28	2	5
GP081805-3	Muscovite schist (PzZm2)	Weighted mean	149.9	± 3.9	± 3.0		1	2	0	0
		Concordia	150.7	± 4.7	± 3.0		1	2	0	0
Combined		Weighted mean	148.7	± 0.9	± 3.0	1.5	26	47		7
		Concordia	149.0	± 0.9	± 3.0	1.05	26	47		7
		Concordia2	148.9	± 0.9	± 3.0	1.04	26	47		7
		TuffZirc	149.5	+0.9 -2	± 3.0		26	47		7

Notes: Uncertainty at two sigma; MWSD = Mean square of weighted deviates; Grains = Number of zircon grains analyzed;
Spots = Number of analyses: Rejected = Number of analyses rejected by age calculation routine;
Not used = analyses not used, poor quality, complex spectra, or very young or old age
Unc1 = Uncertainty as calculated by IsoPlot 3.0 (Ludwig, 2003)
Unc2 = Uncertainty based on application of a blanket 2% error (see text for explanation)
Concordia2 = age calculated with regression forced through an assumed common Pb of 0.86 ± 0.1
Ages and Unc1 calculated using IsoPlot 3.0 (Ludwig, 2003)

Table 3. LA-ICP-MS data and calculated U-Pb zircon ages of rocks from the Granite Peak and Granite Peak SE quadrangles, Utah

GP102605-3
Granodiorite

	Ratios						Ages (Ma)					
Spot Analysis	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ
GP3_1a	0.18071	0.00417	0.02411	0.00047	0.05435	0.00049	168.7	3.6	153.6	2.9	385.6	20.1
GP3_1b	0.16608	0.00389	0.02386	0.00047	0.05047	0.00043	156.0	3.4	152.0	2.9	216.9	19.8
GP3_2a	0.16017	0.00340	0.02347	0.00041	0.04948	0.00039	150.8	3.0	149.6	2.6	170.9	18.5
GP3_2b	0.16575	0.00354	0.02302	0.00042	0.05222	0.00037	155.7	3.1	146.7	2.6	295.2	16.3
GP3_2c	0.18165	0.00408	0.02358	0.00046	0.05588	0.00043	169.5	3.5	150.2	2.9	447.7	17.0
GP3_3a	0.16279	0.00368	0.02314	0.00046	0.05103	0.00039	153.1	3.2	147.4	2.9	242.2	17.4
GP3_3b	0.15879	0.00337	0.02320	0.00040	0.04963	0.00041	149.6	2.9	147.9	2.5	177.8	19.2
GP3_5a	0.16018	0.00307	0.02368	0.00037	0.04907	0.00038	150.9	2.7	150.9	2.3	150.9	18.0
GP3_6a	0.16494	0.00361	0.02353	0.00044	0.05085	0.00040	155.0	3.1	149.9	2.8	233.9	18.0
GP3_6b	0.15550	0.00297	0.02300	0.00034	0.04901	0.00039	146.8	2.6	146.6	2.2	148.5	18.6
GP3_7a	0.18530	0.00395	0.02346	0.00036	0.05726	0.00061	172.6	3.4	149.5	2.3	501.7	23.1
GP3_7b	0.16546	0.00323	0.02329	0.00035	0.05151	0.00043	155.5	2.8	148.4	2.2	263.7	18.9
GP3_8a	0.16324	0.00344	0.02389	0.00044	0.04956	0.00034	153.5	3.0	152.2	2.8	174.2	15.9
GP3_8b	0.16437	0.00357	0.02411	0.00045	0.04945	0.00038	154.5	3.1	153.6	2.8	169.0	17.9
GP3_9b	0.17044	0.00362	0.02398	0.00045	0.05155	0.00036	159.8	3.1	152.8	2.8	265.4	15.9

GP-081605-9
Granite

	Ratios						Ages (Ma)					
Spot Analysis	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ
GP0816059_1a	0.16230	0.00468	0.02390	0.00061	0.04947	0.00037	152.7	3.2	152.2	2.9	170.3	17.3
GP0816059_1b	0.16099	0.00447	0.02369	0.00058	0.04965	0.00035	151.6	3.0	150.9	2.7	178.5	16.6
GP0816059_1c	0.15277	0.00410	0.02271	0.00055	0.04924	0.00029	144.4	2.7	144.8	2.5	159.2	13.6
GP0816059_2b	0.15902	0.00417	0.02367	0.00055	0.04928	0.00029	149.8	2.7	150.8	2.5	161.1	13.9
GP0816059_2c	0.15637	0.00400	0.02288	0.00053	0.04957	0.00030	147.5	2.8	145.8	2.4	175.1	14.0
GP0816059_3a	0.16162	0.00426	0.02393	0.00054	0.04905	0.00039	152.1	3.4	152.4	1.6	150.4	18.7
GP0816059_4a	0.15700	0.00322	0.02307	0.00039	0.04923	0.00032	148.1	2.8	147.0	2.5	158.7	15.1
GP0816059_4b	0.15902	0.00408	0.02363	0.00055	0.04860	0.00031	149.8	3.2	150.5	1.7	128.4	15.2
GP0816059_5a	0.15401	0.00387	0.02244	0.00052	0.04934	0.00029	145.5	3.1	143.0	1.6	163.9	13.5
GP0816059_6a	0.15811	0.00396	0.02314	0.00052	0.04929	0.00033	149.1	3.1	147.5	1.5	161.4	15.4
GP0816059_6c	0.15577	0.00393	0.02292	0.00052	0.04917	0.00030	147.0	3.1	146.1	1.6	155.9	14.1
GP0816059_7a	0.16071	0.00307	0.02346	0.00038	0.04967	0.00029	151.3	2.7	149.5	2.4	179.5	13.8
GP0816059_8a	0.15817	0.00320	0.02308	0.00039	0.04969	0.00033	149.1	2.8	147.1	2.5	180.5	15.2
GP0816059_8b	0.15840	0.00340	0.02348	0.00044	0.04891	0.00030	149.3	3.0	149.6	2.8	143.4	14.2
GP0816059_10a	0.15555	0.00308	0.02296	0.00039	0.04910	0.00030	146.8	2.7	146.4	2.4	152.7	14.3
GP0816059_11a	0.15893	0.00381	0.02331	0.00047	0.04942	0.00041	149.8	3.3	148.6	3.0	167.8	19.5
GP0816059_11b	0.15965	0.00315	0.02349	0.00039	0.04926	0.00030	150.4	2.8	149.7	2.5	160.5	14.2
GP0816059_12b	0.15789	0.00426	0.02320	0.00057	0.04933	0.00034	148.9	3.7	147.8	3.6	163.7	16.0
GP0816059_14a	0.15300	0.00374	0.02250	0.00049	0.04930	0.00033	144.6	3.3	143.4	3.1	162.0	15.4
GP0816059_14b	0.15712	0.00328	0.02299	0.00040	0.04955	0.00035	148.2	2.9	146.5	2.5	173.7	16.2
GP0816059_14c	0.15869	0.00335	0.02240	0.00038	0.05134	0.00042	149.6	2.9	142.8	2.4	256.3	18.8
GP0816059_16a	0.16283	0.00302	0.02392	0.00036	0.04934	0.00032	153.2	2.6	152.4	2.3	164.2	15.1
GP0816059_17a	0.16388	0.00296	0.02393	0.00035	0.04963	0.00030	154.1	2.6	152.5	2.2	177.7	14.1
GP0186059_18a	0.16258	0.00367	0.02319	0.00044	0.05084	0.00039	153.0	3.2	147.8	2.8	233.5	17.8
GP0186059_18b	0.15457	0.00357	0.02302	0.00043	0.04869	0.00044	145.9	3.1	146.7	2.7	133.0	21.3
GP0186059_6d	0.16094	0.00376	0.02393	0.00044	0.04878	0.00047	151.5	3.3	152.4	2.8	137.3	22.6
GP0186059_8c	0.15249	0.00339	0.02266	0.00043	0.04881	0.00038	144.1	3.0	144.4	2.7	138.7	18.0
GP0186059_7b	0.16279	0.00346	0.02360	0.00042	0.05003	0.00037	153.1	3.0	150.4	2.7	196.2	17.0
GP0186059_9a	0.16002	0.00412	0.02379	0.00054	0.04878	0.00038	150.7	3.6	151.6	3.4	137.1	18.1
GP0186059_9b	0.15345	0.00400	0.02285	0.00052	0.04871	0.00042	145.0	3.5	145.6	3.3	133.8	20.2

GP102605-3
Schist

	Ratios						Ages (Ma)					
Spot Analysis	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ	$^{207}Pb/^{235}U$	± 1σ	$^{206}Pb/^{238}U$	± 1σ	$^{207}Pb/^{206}Pb$	± 1σ
GP8_1a	0.15978	0.00358	0.02371	0.00043	0.04886	0.00045	150.5	3.1	151.0	2.7	141.0	21.4
GP8_1b	0.16237	0.00418	0.02333	0.00047	0.05046	0.00059	152.8	3.6	148.6	2.9	216.0	26.9