SHRIMP-RG U-Pb isotopic systematics of zircon from the Angel Lake orthogneiss, East Humboldt Range, Nevada: Is this really Archean crust? REPLY

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The comments from McGrew and Snoke are well received and their concerns for the interpretations in our paper (Premo et al., 2008), which questions the original contention that the Angel Lake orthogneiss is an Archean rock, are many and varied—all of which we will attempt to address. As they point out, this issue is an important one as this particular crustal exposure may delimit the southwestern extent of the Archean Wyoming province (Foster et al., 2006; Mueller and Frost, 2006), which has implications for the true crustal evolution of this region of the Great Basin and perhaps more importantly its relationship (if any) to the location of the world-class gold deposits of north-central Nevada (e.g., Howard, 2003).

Before receiving this comment, we had already embarked on collecting more age data from sample RM-9, mostly of zircon cores, in hopes of providing more information regarding inherited zircon ages. We take this opportunity to show these results. In addition, we have received and processed several other samples from McGrew and Snoke that will hopefully help resolve not only this particularly important issue, but provide age information on several other rock samples from the Angel Lake and Winchell Lake areas.

This discrepancy can be summed up with two major points: (1) Our interpretations in Premo et al. (2008) were based on the fact that sample RM-9 had been described as a biotite monzogranitic orthogneiss (Lush et al., 1988; Wright and Snoke, 1993). McGrew and Snoke's new sample description of RM-9 as a migmatitic rock certainly requires a re-interpretation of our data. (2) With the exception of numerous Cretaceous ages from magmatic rims and one Late Archean age from the center of one zircon, all other analyses from sample RM-9 are discordant, and the majority of other analyses contain significant amounts of common Pb that require a correction to the data that can only be approximately estimated. In essence, RM-9 is not the sample we need to provide the important answer to our question: Is there Archean crust in the East Humboldt Range? Arguing about these dubious results still will not provide the answer.

THE CHARACTER OF RM-9 AND FIELD RELATIONSHIP(S)

McGrew and Snoke in their discussion point out that we do not provide "any significant discussion of the field relationships of this rock unit." We admit that we have not mapped these rocks and we therefore have relied heavily on information and descriptions from the literature by these authors and others (Lush et al., 1988; McGrew, 1992; Wright and Snoke, 1993; Snoke et al., 1997; McGrew et al., 2000). It was our intention from the beginning of this study that we would hopefully better resolve the Archean age of this sample of orthogneiss.

McGrew and Snoke describe the "orthogneiss of Angel Lake as a rather distinctive coarse-grained, biotite monzogranitic orthogneiss with a distinctive striped appearance due to alteration of biotite-rich seams with more feldspathic domains (see their fig. 1). Locally, it contains distinctive large augen porphyroclasts, and in general appearance it strikingly resembles Archean augen orthogneissic rocks observed throughout the Archean Wyoming province." They continue to point out that the original collectors, Snoke and J.E. Wright, were "well aware of the migmatitic character of the rock (their fig. 1), sought to avoid obviously younger leucogranitic dikes, veins, and seams, by picking through the rock fragments to sample those domains they judged to be most representative of the host gneiss. Despite the best efforts of Snoke and Wright to avoid younger rock, the ubiquitous character of leucogranite penetration throughout this terrain makes it unsurprising that there would be a zircon fraction grown in equilibrium with younger melt that Premo et al. (2008) have now documented to be Late Cretaceous in age."

Rechecking the literature for descriptions of RM-9 and the Angel Lake orthogneiss, we find that this sample and rock unit are nowhere described as migmatitic in nature (Lush et al., 1988; Snoke et al., 1997) until Sullivan and Snoke (2007), who state that the orthogneissic unit is in fact migmatitic. The fact that RM-9 is from a migmatitic rock certainly alters our original interpretation. And we would agree with McGrew and Snoke in that our results could be interpreted as dating the Late Cretaceous leucosome portion of the migmatite. This possibility would indicate that the host rock is most likely not Cretaceous as well, although we do note that additional Late Cretaceous age data ranges between 72 and 98 Ma (weighted mean age = 82 Ma), which does offer the possibility of a slightly older Cretaceous component (see below).

Zircons from sample RM-9 were provided to us by those who had collected and presumably mapped the area in detail. As stated in our paper, our SHRIMP-RG results originally sought to better resolve the Archean age of the orthogneiss. In doing so, we found that the zircon population contained up to 50% new growth of Late Cretaceous age, much of which was magmatically-zoned and euhedral. Bearing in mind the description of the sample and the collectors' attempt to minimize the "melt" fraction, we can only conclude that this particular sample is close to being mostly Late Cretaceous material, despite their attempts to minimize it. This observation begs the question: At what point does a migmatized rock cease to be the age of the host or melanosome portion and become the age of the new material or leucosome? Or should it be

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both? Does 50% or more new material make it a new rock with a subordinate portion of inherited material? While we do not intend to enter into the arguments of such a subject, we do intend to raise the question and make the point that the situation becomes a semantical one. In other words, even if this rock had once been an Archean rock, although we still have reservations based on the evidence shown below, we can believe that it is now one of mostly new material and could certainly be considered by some to be Late Cretaceous in age.

AMPHIBOLITIC BODIES

McGrew and Snoke point out that one of their "main reasons for inferring an older age for the gneiss complex of Angel Lake is that both the orthogneiss and paragneiss contain widespread bodies of amphibolite that are absent from the surrounding, inferred miogeoclinal metasedimentary sequence."

Bearing in mind their field observations concerning these amphibolitic bodies, we would agree that they indicate it is unlikely that the Angel Lake metamorphic suite is any younger than Cambrian. Because we have unpublished detrital zircon data from several of the paragneiss units, we know that the amphibolite bodies are younger than ~900 Ma and are probably related to latest Neoproterozoic to Cambrian mafic dike intrusions that are well documented throughout western North America (e.g., Karlstrom and Humphreys, 1998; Harlan et al., 2003). If this is indeed the case, then the "orthogneiss" host rock must be older than ~900 Ma. We don't deny that the "orthogneiss" unit may have been a unit within these sedimentary sequences, which would explain why it is not observed to intrude the surrounding metasedimentary sequences.

NEW DATA FROM RM-9: "ORTHOGNEISS OF ANGEL LAKE"

New SHRIMP-RG data from zircon grains of sample RM-9 are given in Table 1 and shown in Figures 1–4. Analytical methods are the same as those given in Premo et al. (2008). Data were reduced using SQUID ver. 1.02 (Ludwig, 2002), and age information was determined and plotted using ISOPLOT/Ex ver. 3 (Ludwig, 2003).

In short, our additional data do not conclusively illustrate the presence of Proterozoic zircon cores in the RM-9 zircon population, but instead reinforce the prevalence of Archean or near-Archean aged cores. However, a major point to be made here is the fact that, with the exception of one analysis at 2511 ± 6 Ma (a rounded grain) and of course the Late Cretaceous rims, there are absolutely no concordant data from this sample (Fig. 1)—out of 111 analyses. Needless to say, this sample is not a good one to use to evaluate this issue.

The complete data sets (original data from Premo et al. [2008] combined with our new data; Table 1) for RM-9 indicate: (1) U-rich, low Th/U, outer portions of these zoned zircons are Late Cretaceous in age, ranging from 72 to 98 Ma with a weighted mean age of 82.5 Ma (Fig. 2); (2) a predominant Late Archean population that ranges between ~2480 and 2580 Ma for data that are 10% or less discordant, although only one is actually concordant (Figs. 3 and 4); and (3) a sub-population of intermediate ages, ranging in ^{207}Pb/^{206}Pb age between ~1317 and 2380 Ma, although all of these are more than 10% discordant except one analysis that is 8% discordant and has a ^{207}Pb/^{206}Pb age of 2190 Ma (Table 1 and Fig. 3).

Much concern is made of the fact that the vast majority of the older analyses (^{206}Pb/^{238}U ages > 125 Ma) contain substantial amounts of common Pb (e.g., ^{206}Pb > 1%; see Table 1). Because substantial amounts of common Pb require significant corrections in order to obtain usable radiogenic U-Pb data, an accurate and precise common Pb composition must be known. In the case of RM-9, we don't have an accurate and precisely known composition for the common Pb correction. To circumvent the problem, if we eliminate all the analyses with ^{206}Pb > 1%, we obtain a small cluster of analyses with ^{207}Pb/^{206}Pb ages between roughly 2510 and 2580 Ma with an upper-intercept age of 2562 ± 40 Ma (MSWD = 7.4; Fig. 4A) and a mean ^{207}Pb/^{206}Pb age of 2552 ± 21 Ma (Fig. 4B) that is slightly older than the age results with the high common Pb analyses included (e.g., 2516 ± 17 Ma; Premo et al., 2008).

DISCORDANCE OF APPARENT PROTEROZOIC ZIRCONS

We agree with McGrew and Snoke that the apparent presence of Proterozoic grains is weak at best—a point that was well stated in Premo et al. (2008). As pointed out by Premo et al. (2008) and McGrew and Snoke, there is a strong correlation between these Proterozoic ^{207}Pb/^{206}Pb ages and degree of discordance (Fig. 3). Despite the fact that many of these analyses may lie near the discordia for the Archean component, many do not lie near enough and in fact clearly define some other U-Pb isotopic behavior (Fig. 3). However, we do concede that these zircon populations may have undergone more than one Pb-loss event and that the Proterozoic ^{207}Pb/^{206}Pb ages reflect that possibility. On the other hand, they may not. McGrew and Snoke do not recognize the zircon groupings that Premo et al. (2008) document. Although very discordant, many of the analyses that exhibit intermediate ages not only do not lie on the Archean discordia, but are exclusively from metamict, rounded cores within the Late Cretaceous magmatic grains. We believe this is strong evidence that these particular cores/grains were transported in with the Late Cretaceous melt fraction and do not have much if anything to do with the Late Archean zircon population.

With these new realizations, we believe there is no argument regarding the apparent correlation with the discordant Proterozoic ages and "prevalent" magmatic events within the Laurentian southwest, although it is worth mentioning that the "time window in the mid- to early Paleoproterozoic (~1.95–2.5 Ga)" is not "largely barren of zircon ages in the western U.S. Cordillera (e.g., Stewart et al., 2001)." If a new compilation of the detrital zircon populations from Paleoproterozoic through Neoproterozoic sediments of southwestern North America were created, it would easily show peaks, however small, within this range (e.g., Gehrels, 2000).

However, it is also worth emphasizing that McGrew and Snoke's contention that "the complete absence of a Grenville-aged peak seems especially problematic for any likely Neo-Proterozoic source rock, such as the McCoy Creek Group" is not impossible. It simply means that erosional processes were not active on sources of that age at the time of deposition, however unlikely that might seem.

MORPHOLOGY OF "ARCHEAN-AGED" ZIRCON GRAINS

McGrew and Snoke note that "one of the chief lines of evidence cited by Premo et al. (2008) is the apparent detrital character of some of the Archean zircon grains." In response, it has been interpreted that zircon can undergo metamorphic restructuring and perhaps attain a rounded morphology during metamorphic processes (e.g., Hoskin and Schaltegger, 2003). However, during those processes it is likely if not unavoidable that they also undergo destructuring in that their internal igneous-related structures (e.g., oscillatory zoning) are typically disrupted or even destroyed—a feature that is not evident from the majority of rounded grains in this sample. We need to point out that of the 100+ grains analyzed, ~26% are subrounded to rounded, and whereas many have secondary overgrowths of presumed Late Cretaceous age, their internal structures are not typically disturbed, let alone destroyed. In addition, we note that the geochemistry of the Cretaceous and

TABLE 1. SHRIMP U-Th-Pb ANALYTICAL DATA FOR ZIRCONS FROM SAMPLE RM-9, THE ORTHOGNEISS OF ANGEL LAKE, EAST HUMBOLDT RANGE, NEVADA

Spot Name	Spot Location	Common ^{206}Pb (%)	U (ppm)	Th (ppm)	^{232}Th/^{238}U	Total ^{238}U/^{206}Pb	Error (%)	Total ^{207}Pb/^{206}Pb	Error (%)	^{207}Pb-corr. ^{206}Pb/^{238}U Age	Error (1σ)	^{207}Pb/^{235}U*	Error (%)	^{206}Pb/^{238}U*	Error (%)	Error correlation	^{204}Pb-corr. ^{207}Pb/^{206}Pb Age	Error (1σ)	Discordance (%)
RM-9: Orthogneiss of Angel Lake																			
Session Two																			
RM9-1	1 - mag core	5.17	614	286	0.48	2.5852	0.39	0.1694	0.30	2015	8	9.0281	0.50	0.3868	0.39	0.786	2551	5	20
RM9-2.1	2 - center	8.15	1132	868	0.79	3.6581	0.30	0.1607	0.44	1444	5	6.0527	0.53	0.2733	0.30	0.565	2462	7	41
RM9-3.1	2 - mag center	6.72	600	439	0.76	3.0328	0.43	0.1642	0.37	1729	8	7.4608	0.57	0.3297	0.43	0.763	2499	6	30
RM9-4.1	2 - mag zone	3.48	911	553	0.63	2.4359	0.36	0.1648	0.32	2152	8	9.3297	0.48	0.4106	0.36	0.741	2506	5	14
RM9-5.1	2 - mag center	8.05	749	223	0.31	3.7610	0.39	0.1581	0.36	1410	6	5.7868	0.53	0.2658	0.39	0.730	2433	6	42
RM9-6	3A - mag core	0.05	1774	69	0.04	16.2299	0.89	0.1209	0.46	354	3	1.0236	1.01	0.0616	0.89	0.881	1964	9	83
RM9-7	3A - mag core	0.18	442	1011	2.36	4.7126	0.96	0.1661	2.21	1121	12	4.8125	2.44	0.2118	0.96	0.393	2505	38	56
RM9-8	2 - center	0.01	489	522	1.10	2.1577	0.92	0.1700	1.24	2425	24	10.8584	1.55	0.4634	0.92	0.596	2557	21	5
RM9-9	2 - mag zone	0.08	1500	62	0.04	6.0486	0.88	0.1396	0.29	909	8	3.1658	0.93	0.1652	0.88	0.945	2215	5	60
RM9-10	2 - mag center	0.22	963	308	0.33	5.4297	0.92	0.1576	0.42	987	9	3.9518	1.04	0.1838	0.93	0.888	2412	8	59
RM9-11	1 - mag core	0.02	238	278	1.21	2.1280	1.01	0.1664	0.44	2472	27	10.7688	1.10	0.4698	1.01	0.916	2520	7	2
RM9-12	2 - mag zone	0.02	493	222	0.47	2.6859	0.92	0.1601	0.76	1961	18	8.2109	1.19	0.3723	0.92	0.773	2455	13	20
RM9-13	2 - mag center	0.01	1203	518	0.44	4.4296	0.88	0.1620	0.65	1197	11	5.0405	1.10	0.2257	0.88	0.805	2476	11	52
RM9-14	2 - mag center	0.02	855	158	0.19	4.1503	0.90	0.1566	0.33	1284	11	5.1971	0.96	0.2409	0.90	0.938	2418	6	47
RM9-15	2 - mag center	0.01	1087	493	0.47	2.8077	0.88	0.1660	0.39	1864	16	8.1465	0.96	0.3561	0.88	0.915	2517	7	26
RM9-16	1 - mag core	0.22	2193	279	0.13	15.5145	0.88	0.1153	4.90	373	4	1.0083	5.07	0.0643	0.88	0.174	1859	90	81
RM9-17	2 - mag core	0.09	1460	852	0.60	4.3888	0.87	0.1646	1.09	1204	11	5.1441	1.40	0.2276	0.87	0.622	2496	19	52
RM9-18	2 - mag core	0.04	1537	398	0.27	6.8044	0.88	0.1522	0.56	798	7	3.0757	1.04	0.1469	0.88	0.840	2367	10	67
RM9-19	2 - mag center	0.03	649	333	0.53	3.0193	0.90	0.1613	0.38	1744	16	7.3507	0.98	0.3311	0.90	0.919	2466	7	29
RM9-20	2 - mag center	0.00	830	801	1.00	2.1312	0.89	0.1706	0.22	2456	23	11.0356	0.92	0.4692	0.89	0.970	2563	4	4
RM9-21	3A - mag core	0.00	950	481	0.52	4.5552	0.90	0.1655	0.32	1160	10	5.0103	0.95	0.2195	0.90	0.941	2513	5	54
RM9-22	2 - mag zone	0.03	541	143	0.27	3.2205	0.92	0.1481	0.65	1662	15	6.3306	1.13	0.3104	0.92	0.815	2322	11	28
RM9-23	2 - mag center	0.00	637	448	0.73	2.5708	0.90	0.1706	5.42	2024	29	9.1524	5.49	0.3890	0.90	0.164	2564	91	20
RM9-24	2 - mag core	0.02	406	237	0.60	3.1816	0.94	0.1670	1.97	1645	17	7.2275	2.19	0.3142	0.94	0.431	2526	33	35
RM9-25	3A - mag core	0.02	1931	75	0.04	7.8175	0.87	0.1438	0.27	704	6	2.5328	0.91	0.1279	0.87	0.955	2271	5	70
RM9-26	2 - mag center	0.00	935	685	0.76	2.4391	0.88	0.1688	0.22	2139	19	9.5385	0.91	0.4100	0.88	0.970	2545	4	15
Session Three																			
RM9-1.1	2 - mag zone	4.34	981	201	0.21	2.8849	0.34	0.1508	0.44	1846	7	7.1914	0.56	0.3465	0.35	0.616	2352	8	21
RM9-2.1	2 - mag zone	8.07	1242	142	0.12	5.5480	0.32	0.1396	0.35	988	3	3.4646	0.48	0.1802	0.32	0.671	2220	6	56
RM9-3.1	2 - mag zone	2.99	875	188	0.22	2.4004	0.37	0.1633	0.28	2188	8	9.3693	0.46	0.4165	0.37	0.793	2489	5	12
RM9-4.1	2 - mag zone	0.89	168	248	1.53	2.0941	0.85	0.1720	1.25	2498	24	11.3246	1.51	0.4775	0.85	0.564	2577	21	3
RM9-5.1	2 - mag zone	2.77	784	508	0.67	2.3165	0.40	0.1671	0.93	2259	10	9.9460	1.01	0.4317	0.40	0.393	2529	16	10
RM9-6.1	2 - rim	1.56	758	135	0.18	2.6946	0.41	0.1372	0.46	2007	8	7.0159	0.62	0.3711	0.41	0.664	2191	8	8
RM9-7.1	2 - mag zone	5.72	687	147	0.22	2.7954	0.44	0.1646	0.35	1874	8	8.1040	0.57	0.3576	0.44	0.776	2501	6	24
RM9-8.1	2 - mag zone	7.38	1166	749	0.66	3.2818	0.34	0.1626	0.30	1603	6	6.8203	0.46	0.3046	0.34	0.746	2481	5	35
RM9-9.1	2 - mag zone	2.69	962	223	0.24	2.3820	0.36	0.1623	0.53	2208	9	9.3827	0.65	0.4197	0.36	0.561	2478	9	11
RM9-10.1	3A - core	7.60	2636	91	0.04	17.9556	0.34	0.1140	1.48	323	1	0.8552	1.65	0.0555	0.34	0.208	1828	29	83
RM9-10.2	3B - clear rim	0.01	3488	38	0.01	85.7467	0.52	0.0476	1.39	75	0	0.0738	2.17	0.0116	0.53	0.243	–1	51	
RM9-11.1	3B - clear rim	0.04	6292	25	0.00	64.9050	0.35	0.0483	1.26	99	0	0.1021	1.38	0.0154	0.35	0.253	102	32	4

(*continued*)

TABLE 1. SHRIMP U-Th-Pb ANALYTICAL DATA FOR ZIRCONS FROM SAMPLE RM-9, THE ORTHOGNEISS OF ANGEL LAKE, EAST HUMBOLDT RANGE, NEVADA (*continued*)

Spot Name	Spot Location	Common ^{206}Pb (%)	U (ppm)	Th (ppm)	^{232}Th/^{238}U	Total ^{238}U/^{206}Pb	Error (%)	Total ^{207}Pb/^{206}Pb	Error (%)	^{207}Pb-corr. ^{206}Pb/^{238}U Age	Error (1σ)	^{207}Pb/^{235}U*	Error (%)	^{206}Pb/^{238}U*	Error (%)	Error correlation	^{204}Pb-corr. ^{207}Pb/^{206}Pb Age	Error (1σ)	Discordance (%)
RM-9: Orthogneiss of Angel Lake																			
Session Three (*continued*)																			
RM9-11.2	3A - mag core	7.58	1894	77	0.04	9.4297	0.30	0.1220	0.41	603	2	1.7511	0.58	0.1058	0.31	0.523	1957	9	70
RM9-12.1	2 - mag center	1.00	666	696	1.08	2.1006	0.45	0.1721	0.48	2489	12	11.2904	0.66	0.4760	0.45	0.683	2577	8	3
RM9-13.1	2 - rim	7.64	2049	78	0.04	8.6290	0.29	0.1242	0.56	655	2	1.9786	0.66	0.1158	0.29	0.443	2013	10	68
RM9-14.1	1 - core	9.98	1748	520	0.31	11.1401	0.34	0.1384	1.71	501	3	1.7054	1.76	0.0897	0.34	0.193	2201	30	78
RM9-15.1	3B - clear rim	0.03	5249	68	0.01	76.1491	0.42	0.0479	1.11	84	0	0.0863	1.22	0.0131	0.42	0.343	83	27	–1
RM9-16.1	2 - mag zone	4.65	3186	65	0.02	49.0488	0.44	0.0855	0.87	124	1	0.2402	0.98	0.0204	0.44	0.453	1326	17	91
RM9-17.1	2 - rim	9.96	1877	1664	0.92	5.9949	0.30	0.1520	1.15	902	4	3.4894	1.19	0.1668	0.30	0.255	2366	20	62
RM9-18.1	2 - mag zone	4.10	746	415	0.58	2.5334	0.42	0.1640	0.42	2070	9	8.9165	0.60	0.3947	0.42	0.705	2496	7	16
RM9-19.1	2 - mag zone	3.71	698	369	0.55	2.5315	0.41	0.1612	0.32	2078	9	8.7692	0.52	0.3949	0.41	0.783	2467	5	15
RM9-20.1	2 - mag zone	4.25	500	95	0.20	3.0051	0.53	0.1460	0.58	1783	10	6.6779	0.80	0.3326	0.53	0.669	2295	10	22
RM9-21.1	2 - rim	6.50	238	269	1.16	2.9490	0.79	0.1652	0.63	1775	14	7.6699	1.04	0.3387	0.79	0.763	2500	11	29
RM9-22.1	2 - mag zone	1.67	685	133	0.20	2.2420	0.43	0.1647	0.51	2344	11	10.1071	0.67	0.4459	0.43	0.637	2501	9	6
RM9-23.1	2 - mag zone	8.13	457	965	2.18	3.2757	0.52	0.1686	0.43	1594	9	7.0669	0.71	0.3051	0.53	0.745	2538	8	37
RM9-24.1	2 - mag core	8.71	3032	1513	0.52	15.8688	0.32	0.1240	2.51	361	2	1.0699	2.56	0.0630	0.32	0.124	2004	45	83
RM9-25.1	3B - clear rim	–0.12	3125	19	0.01	79.4158	0.53	0.0467	1.42	81	0	0.0792	1.99	0.0126	0.53	0.268	–19	46	
RM9-26.1	3B - convoluted	4.76	3641	200	0.06	50.4051	0.40	0.0863	0.81	121	1	0.2323	1.06	0.0198	0.41	0.385	1317	19	91
RM9-27.1	2 - mag zone	2.20	966	205	0.22	2.2816	0.37	0.1655	0.55	2300	9	9.9951	0.67	0.4382	0.37	0.554	2512	9	8
RM9-28.1	2 - mag zone	4.42	831	444	0.55	2.4812	0.39	0.1692	0.54	2101	9	9.3863	0.67	0.4029	0.39	0.580	2547	9	17
RM9-29.1	2 - mag zone	2.32	1062	393	0.38	2.2760	0.35	0.1668	0.26	2302	8	10.1027	0.43	0.4393	0.35	0.802	2526	4	9
RM9-30.1	2 - mag zone	8.45	1579	721	0.47	5.4117	0.30	0.1435	0.57	1007	3	3.6553	0.65	0.1848	0.30	0.463	2270	10	56
RM9-31.1	2 - mag core	0.07	512	273	0.55	2.1034	0.50	0.1654	0.36	2506	14	10.8363	0.62	0.4754	0.50	0.810	2511	6	0
RM9-32.1	2 - mag core	0.60	1007	489	0.50	2.1195	0.37	0.1676	0.70	2479	10	10.8863	0.79	0.4717	0.37	0.463	2532	12	2
RM9-33.1	2 - mag core	1.54	1077	670	0.64	2.1773	0.35	0.1690	0.25	2405	9	10.6978	0.43	0.4592	0.35	0.812	2547	4	6
RM9-34.1	2 - mag zone	–0.93	762	763	1.04	1.9814	0.42	0.1718	0.29	2654	13	11.9481	0.52	0.5046	0.42	0.818	2574	5	–3
RM9-35.1	2 - mag core	1.01	95	125	1.37	2.0644	1.08	0.1757	2.14	2525	32	11.7824	2.40	0.4847	1.08	0.450	2618	36	3
RM9-36.1	2 - rim	8.31	1901	79	0.04	6.8217	0.27	0.1350	0.55	813	3	2.7233	0.62	0.1466	0.27	0.429	2161	10	63
RM9-37.1	2 - mag core	4.79	817	608	0.77	2.5515	0.41	0.1683	0.85	2044	9	9.0905	0.94	0.3919	0.41	0.434	2540	14	19
RM9-38.1	2 - mag core	9.53	1724	218	0.13	8.8926	0.33	0.1386	0.42	625	2	2.1416	0.54	0.1124	0.33	0.603	2205	8	72
RM9-39.1	2 - mag zone	3.55	1110	284	0.26	2.4079	0.33	0.1670	0.29	2172	8	9.5471	0.45	0.4152	0.33	0.749	2525	5	14
RM9-40.1	2 - mag zone	3.01	533	127	0.25	2.3957	0.47	0.1638	1.32	2191	12	9.4099	1.41	0.4173	0.47	0.336	2493	22	12
RM9-41.1	2 - mag zone	0.67	1006	638	0.66	2.1098	0.35	0.1690	0.57	2487	10	11.0384	0.67	0.4739	0.35	0.523	2547	10	3
RM9-42.1	2 - mag core	9.83	1304	1150	0.91	5.7337	0.33	0.1525	0.36	942	4	3.6588	0.49	0.1744	0.33	0.671	2371	6	61
RM9-43.1	2 - mag core	10.75	2233	449	0.21	9.4124	0.29	0.1473	0.35	584	2	2.1515	0.46	0.1062	0.29	0.617	2311	6	75
RM9-44.1	2 - mag zone	9.37	1326	590	0.46	4.9868	0.32	0.1541	0.32	1076	4	4.2351	0.48	0.2003	0.32	0.669	2383	6	55
RM9-45.1	2 - mag center	3.96	1169	953	0.84	2.4431	0.34	0.1679	0.26	2137	8	9.4724	0.43	0.4093	0.34	0.794	2536	4	15
RM9-46.1	2 - mag core	2.19	989	676	0.71	2.2191	0.34	0.1702	0.25	2354	9	10.5650	0.42	0.4506	0.34	0.805	2558	4	8
RM9-47.1	2 - mag core	1.75	1122	535	0.49	2.2118	0.34	0.1677	0.95	2369	10	10.4458	1.01	0.4521	0.34	0.340	2534	16	6
RM9-48.1	2 - convoluted	5.79	2521	115	0.05	9.7536	0.26	0.1071	0.37	594	2	1.5087	0.48	0.1025	0.26	0.546	1745	7	67

Note: All data collected on the SHRIMP-RG at the Stanford University ion probe lab. Data reduced using Squid 1.02 (Ludwig, 2002) and age information calculated using ISOPLOT/Ex, ver. 3 (Ludwig, 2003). Group numbers and spot locations are given in second column; see original paper, Premo et al. (2008), for explanation of group numbers. "mag" refers to a zone with oscillatory zoning indicatiive of magmatic zircon growth. All errors are given at 1σ.

*Radiogenic.

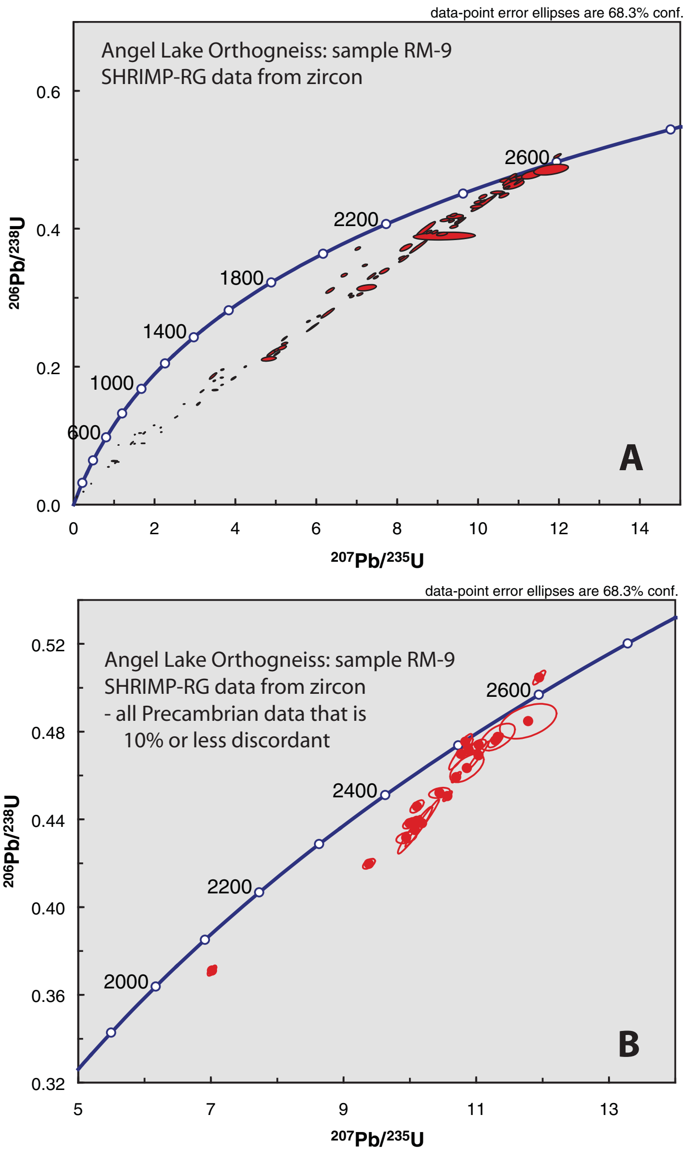

Figure 1. (A) Conventional concordia diagram showing distribution of SHRIMP-RG data (solid ellipses) from this study and Premo et al. (2008) combined. (B) Conventional concordia diagram showing only the least discordant (10% or less) analyses at the upper end of the discordia shown in A.

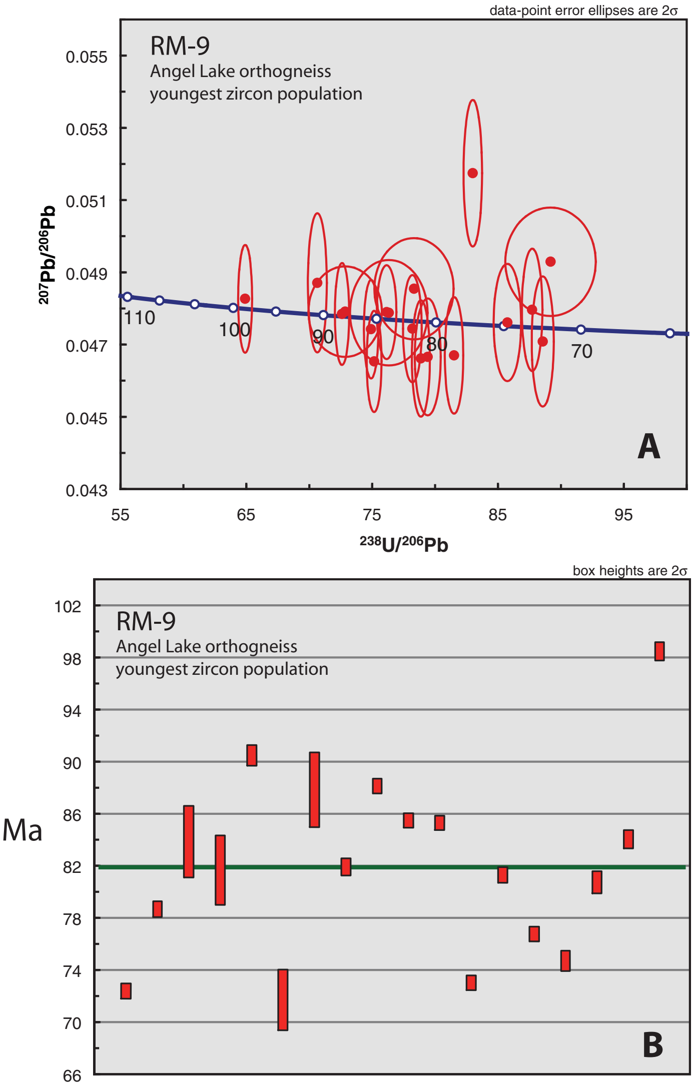

Figure 2. (A) Tera-Wasserburg plot of SHRIMP-RG analyses from oscillatory-zoned magmatic rims indicating a range of near-concordant ^{206}Pb/^{238}U ages between 98 and 72 Ma. High U concentrations (>3000 ppm) are likely to have disturbed the U-Pb systematics of some grains, resulting in inconsistent U-Pb age results. (B) Distribution of ^{206}Pb/^{238}U ages for the data shown in A. A weighted mean age can be calculated at 82.5 Ma, but we have little confidence that this age is the true age.

Tertiary melts is peraluminous (McGrew et al., 2000), a chemical affinity that does not support the resorption of inherited zircon (Watson, 1979; Watson and Harrison, 1982).

However, we would agree with McGrew and Snoke that many of the Late Archean grains do not appear to be detrital, although anyone who has done this kind of work knows that the lack of rounding can indicate: (1) the likelihood that some detritus did not breakdown for a longer time period, or (2) a local source that did not allow the time or distance to produce rounded grains.

We would also concede that our grain 9 (Premo et al., 2008), with one of the oldest ^{207}Pb/^{206}Pb ages of 2543 Ma, could be a slightly older detrital zircon incorporated with many other slightly older Archean zircons, except that grain 9 is not a core within a slightly younger zircon growth, nor are many of the other grains. Knowing that Wright and Snoke went through great pains to segregate the “orthogneissic” component in this sample, we find it highly unlikely that they would have included detrital inclusions.

PROBLEMS WITH THE REE DATA

McGrew and Snoke note that if the Precambrian U-Pb ages are disturbed, then it should follow that the REE systematics of the Archean grains would also be disturbed. In fact, Premo et al. (2008) do not argue that the U-Pb ages nor the REE systematic of the Archean grains are disturbed. We make the case that the lack of uniformity in both the age distribution and the REE patterns from the near-Archean grains argues that they are not genetically related and therefore are

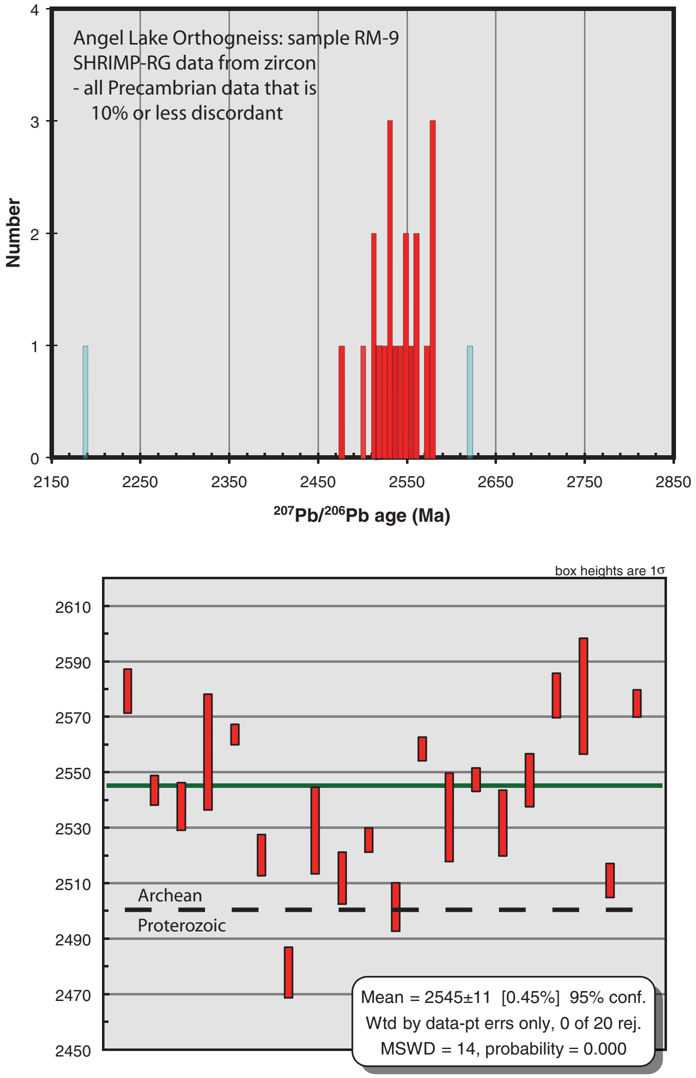

Figure 3. Distribution of ^{207}Pb/^{206}Pb ages for analyses that are 10% or less discordant. The bulk of these analyses range from ~2480–2580 Ma, with the exception of two analyses shown in blue in the upper diagram. These two have ^{207}Pb/^{206}Pb ages of ~2190 and 2618 Ma.

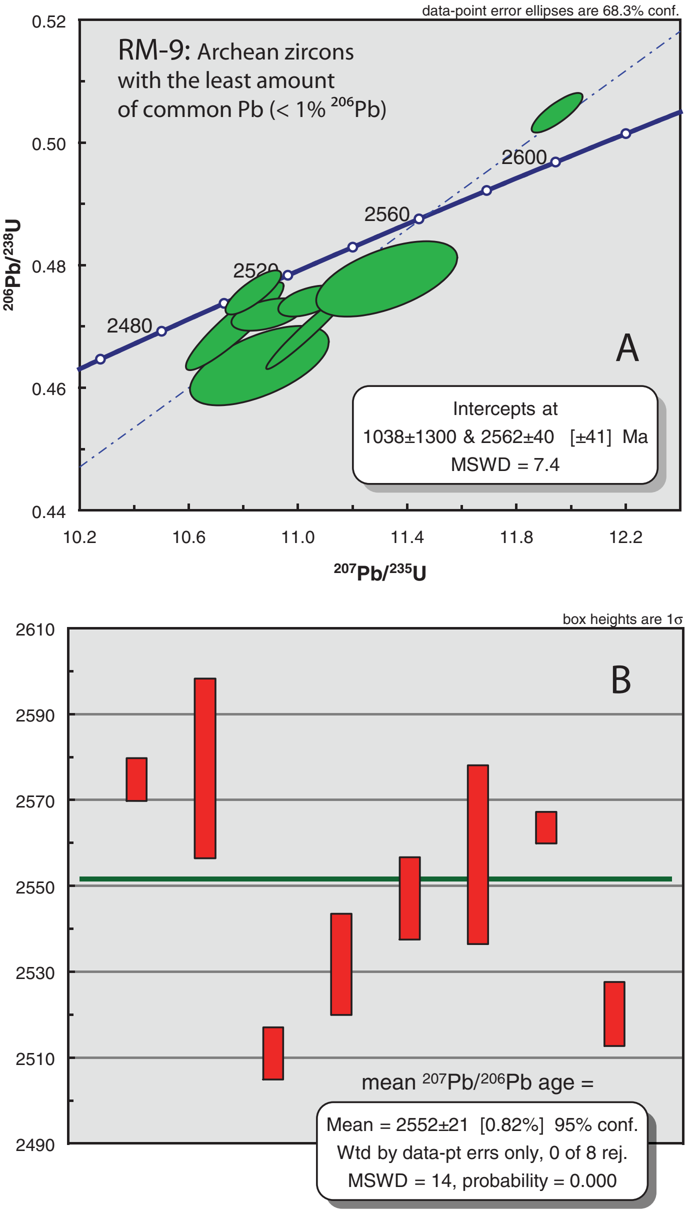

Figure 4. (A, B) Distribution of ^{207}Pb/^{206}Pb ages for "older" analyses with the lowest common Pb values (^{206}Pb < 1%). (B) These analyses range in age from ~2510–2580 Ma, with a mean ^{207}Pb/^{206}Pb age of 2552 ± 21 Ma (MSWD = 14).

not likely from the same igneous source. Their statement that this "likely (indicates that these are) inherited Archean detrital grains," is correct, in our opinion. However, if that is true, then which grains indicate the actual crystallization age of the original "Archean" monzogranite?

SO, WHAT'S IT ALL MEAN?

(1) McGrew and Snoke "conclude that none of the lines of evidence advanced by Premo et al. (2008) definitively indicates a Late Cretaceous age for the orthogneissic host rock of Angel Lake." We would agree with this statement under the realization that RM-9 was actually a migmatitic sample that we feel is not adequately conveyed under the description "biotite monzogranitic orthogneiss." They further maintain that "when interpreted within the context of the field relationships, the geochronological data favor the original Archean interpretation for the age of the orthogneiss of Angel Lake." With this statement, we cannot agree. Particularly, as we are currently aware that the enveloping paragneisses in the Winchell Lake nappe are actually Neoproterozoic (W.R. Premo, 2009, personal observ.), the unit that RM-9 came from could also be a metasedimentary horizon within the sequence, though largely fed from an Archean source as opposed to the other horizons thus far measured. The fact that a quarter of the zircon population are rounded and not metamorphic (not recrystallized), exhibit non-uniform REE patterns, and exhibit a range of ages (~100 m.y.) from data that are 10% or less discordant supports the idea that RM-9 is from a metasedimentary horizon.

(2) We concede that the Late Cretaceous component is likely the age of the melt fraction within the migmatitic gneiss and that the highly discordant Proterozoic ages are problematic and may be meaningless. However, dating a sample of the melt fraction or leucosome would certainly help to resolve this question.

(3) We conclude that RM-9 is a difficult sample from which to find much definitive information. As the original title "Is this really Archean crust?" of Premo et al. (2008) implies, this sample produced inconclusive yet highly suggestive information. And we would agree with McGrew and Snoke that better samples and additional work are needed to resolve this issue. Thankfully, that process has already begun.

(4) A very important point is added at the end of McGrew and Snoke's comments: "The orthogneiss is observed only from the core of the Winchell Lake fold nappe. It is at least somewhat allochthonous and this interpretation does not necessarily require the directly underlying crust to be Archean in age." With this realization is the idea that despite our arguments regarding RM-9, the answer to our original question, "How far does the Archean crust extend into the Great Basin?" remains elusive.

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