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ZIRCON U-Pb AGE DATA, RAY MOUNTAINS AREA, BETTLES QUADRANGLE, ALASKA

by
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by

Amy L. Tuzzolino[1], Paul B. O'Sullivan[2], Lawrence K. Freeman[3], and Rainer J. Newberry[1]

SUMMARY

U-Pb analyses were performed on igneous rocks from the Ray Mountains area of west-central Alaska. The plutonic samples have ages ranging from 98.0 ± 0.9 Ma to 111.6 ± 1.0 Ma.

INTRODUCTION

In 2012, the State of Alaska established its Strategic and Critical Minerals (SCM) Assessment project, a State-funded Capital Improvement Project (CIP), to evaluate Alaska's statewide potential for SCM resources. The project is being implemented by the Alaska Division of Geological & Geophysical Surveys (DGGS), and involves obtaining new airborne-geophysical, geological, and geochemical data.

DGGS conducted a multi-year project, from 2012 through 2013, to study the geology and economic potential of rare-earth elements (REE) and other metals in the Ray Mountains in the Beaver, Bettles, Livengood, and Tanana quadrangles (Bachmann and others, 2013; Tuzzolino and others, 2014a). To better understand the granitic rocks that are associated with REE and tin–polymetallic occurrences in the area, four samples were collected for U-Pb geochronologic analyses. These new age analyses will allow us to better evaluate the geochronology of the granitic rocks that are the apparent source of the alluvial REE and tin resources.

The purpose of this DGGS Raw Data File is to present the U-Pb age results of the Ray Mountains study. Analyses were performed by the Apatite to Zircon, Inc. (A2Z) laboratory. Additional $^{40}Ar/^{39}Ar$ ages for the Ruby batholith were published in a separate release (Tuzzolino and others, 2014b).

The sample location coordinates and analytical data tables associated with this report are available in digital format as comma-separated value (CSV) files. Additional details about the organization of information are noted in the accompanying metadata file. All files can be downloaded from the DGGS website (doi:10.14509/29662).

METHODOLOGY

Field Methods

DGGS field geologists collected rock samples from the surface or within 0.5 m of the surface. Care was taken to collect fresh, unweathered rock samples representative of igneous rock types in the map area. Locations were recorded using handheld, WAAS-enabled GPS devices. WAAS-enabled GPS devices have a reported error of about 1 m (NSTB/WAAS T&E Team, 2006). Depending on degradation of the WAAS and GPS signals, the horizontal position error of sample locations in this report is in the range of 1–10 m. The originating coordinate system for samples collected in 2012 (2012CW033A, 2012RN364A and 2012RN418A) was NAD27, UTM zone 5. Sample 2013AT135A was collected using WGS1984 Web Mercator Auxiliary Sphere coordinate system as specified by the settings of the collectors used. To provide a consistent coordinate system for all samples, all location coordinates of the samples collected in 2012 were transformed to WGS1984 Web Mercator Auxiliary Sphere using NAD_1927_To_NAD_1983_Alaska+WGS_1984_(ITRF00)_To_NAD_1983 transformation. Latitude and longitude

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coordinates of the samples are provided in the accompanying .csv file. This file also contains brief descriptions of each sample based on field observations.

Analytical Methods

DGGS submitted selected rock samples to A2Z in 2014. Paul O'Sullivan directed the processing and analyses of the samples in the A2Z laboratory in Viola, Idaho, where laser-ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) analyses were performed on an Agilent 7700x quadrapole mass spectrometer attached to a Resonetics RESOlution M50 Excimer laser. Detailed discussion of the laboratory techniques is provided in Donelick and others (2005) and Solie and others (2014).

ANALYTICAL RESULTS

Four plutonic rocks, consisting of monzogranites and a syenogranite, were analyzed. The mean error-weighted $^{206}Pb/^{238}U$ and mean U-Pb concordia-calculated ages (Ma) from zircons in each sample are recorded in the accompanying .csv table. All four ages fall within a span of about 14 million years, between 98.0 Ma (2012RN364A) and 111.8 Ma (2012CW033A). U-Pb concordia diagrams, histograms, and mean error-weighted probability plots for each sample are provided in Appendix A, from youngest to oldest.

U-PB DATA ANALYSIS

The raw data received from A2Z were reviewed and processed at DGGS. First, the failed and peak-background-corrected (pbc) analyses were excluded from the age calculations. These initial criteria are noted in the accompanying data tables for individual samples. Next, the analyses for each sample were plotted on concordia plots using Isoplot v. 3.7 (Ludwig, 2008). In two cases, samples 2013AT135A and 2012RN418A, the datasets yielded poorly defined chords, with mid-Cretaceous lower intercepts and early Paleozoic to late Proterozoic upper intercepts. The data quality are not sufficient to use the ages so defined, but they do indicate a small amount of contamination from older, inherited zircon.

To further reduce the data, the relative $^{206}Pb/^{238}U$ age error was calculated using the $^{206}Pb/^{238}U$ age and the quoted error (2σ). All analyses with greater than 10 percent relative error were excluded. The excluded data consistently included those samples with anomalously old ages.

Histograms of $^{206}Pb/^{238}U$ ages were constructed to identify age populations well outside of the means. For sample 2012RN418A, a single, anomalously old age was excluded. The mean error-weighted ages for the remaining $^{206}Pb/^{238}U$ ages were calculated (table 1).

Next, the percent deviation from the concordia was calculated. The equation that was used calculates the extent that the measured $^{207}Pb/^{235}U$ deviates from the concordia, assuming the measured $^{206}Pb/^{238}U$ ratio lies on the concordia. In several cases, data that plots increasingly farther from the concordia gives increasingly older ages, again indicating a physical mixing of Pb and U from early Paleozoic to late Proterozoic and from Cretaceous zircon.

Following the elimination of data deviating more than 2–3 percent from the concordia, a mean concordia age (table 1) was calculated using Isoplot software (Ludwig, 2008). In general, the mean $^{206}Pb/^{238}U$ age and the mean concordia age are indistinguishable, within error, with a smaller error for the concordia age. The authors prefer the resulting mean concordia age, as generally having smaller error and fewer inherited components.

Table 1: U-Pb ages (Ma) for the four granite samples.

Sample	Lab Sample Number	Latitude	Longitude	Pluton	Mean Error-Weighted $^{206}Pb/^{238}U$ Age ± 2σ	Mean Concordia Age ± 2σ
2012RN364A	12RN364A	66.35686	-150.4650	Hot Springs	98.6 ± 1.0 Ma	98.0 ± 0.9 Ma
2013AT135A	13AT135A	66.10740	-150.0470	No Name Creek	107.0 ± 1.2 Ma	106.6 ± 1.3 Ma
2012RN418A	12RN418A	66.05439	-150.5030	Ray River	111.0 ± 1.3 Ma	110.6 ± 1.1 Ma
2012CW033A	12CW033A	66.51191	-150.2000	Kanuti	111.7 ± 1.0 Ma	111.6 ± 1.0 Ma

DISCUSSION OF RESULTS

The samples are presented in chronological order, from youngest apparent age to oldest.

2012RN364A—Zircon from the interior of the Hot Springs pluton: 60 analyses were attempted; 50 analyses were used to calculate a mean error-weighted $^{206}Pb/^{238}U$ age of 98.6 ± 1.0 Ma. Seventeen analyses were used to calculate a mean concordia age of 98.0 ± 0.9 Ma.

2013AT135A—Zircon from the southern boundary of the No Name Creek pluton: 60 analyses were attempted; 49 analyses were used to calculate a mean error-weighted $^{206}Pb/^{238}U$ age of 107.0 ± 1.2 Ma. Eighteen analyses were used to calculate a mean concordia age of 106.6 ± 1.3 Ma.

2012RN418A—Zircon from the western portion of the Ray River pluton: 60 analyses were attempted; 46 analyses were used to calculate a mean error-weighted $^{206}Pb/^{238}U$ age of 111.0 ± 1.3 Ma. Twenty-one analyses were used to calculate a mean concordia age of 110.6 ± 1.1 Ma.

2012CW033A—Zircon from the interior of the Kanuti pluton: 60 analyses were attempted; 55 analyses were used to calculate a mean error-weighted $^{206}Pb/^{238}U$ age of 111.7 ± 1.0 Ma. Twenty-six analyses were used to calculate a mean concordia age of 111.6 ± 1.0 Ma.

U-Pb analyses of zircons ideally yield the same $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ages, indicating concordance. Lack of concordance indicates partially inherited thermal disturbance. Because the samples are not entirely concordant (figs. 1b, 2b, 3b, 4b), we prefer to take a subset of ages approximately concordant and use the average of these ages—the mean concordia age (Ma). The smaller sample size used to calculate the mean concordia age minimizes the effects of inherited zircons, and thus yields slightly smaller uncertainties.

ACKNOWLEDGMENTS

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APPENDIX A: DATA PLOTS FOR INDIVIDUAL SAMPLES

2012RN364A

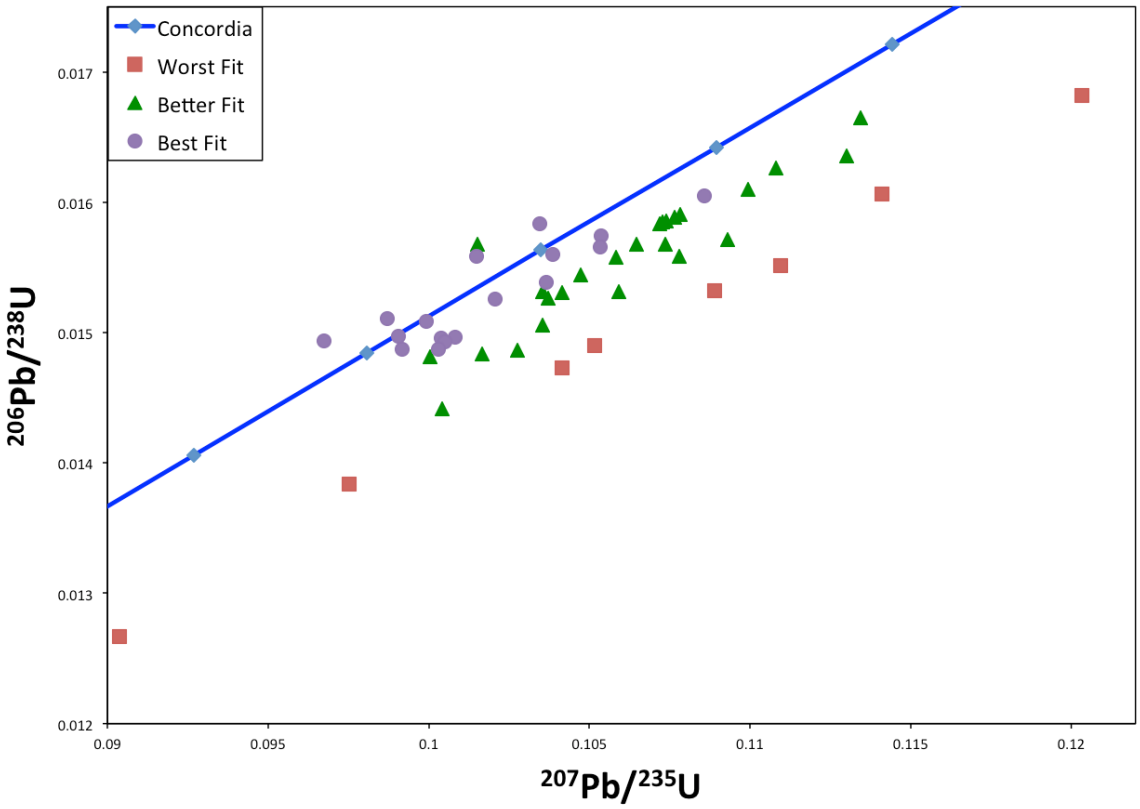


Figure 1a. 50 sets of analyses with relative error <10 percent, plotted to express relation to concordia.

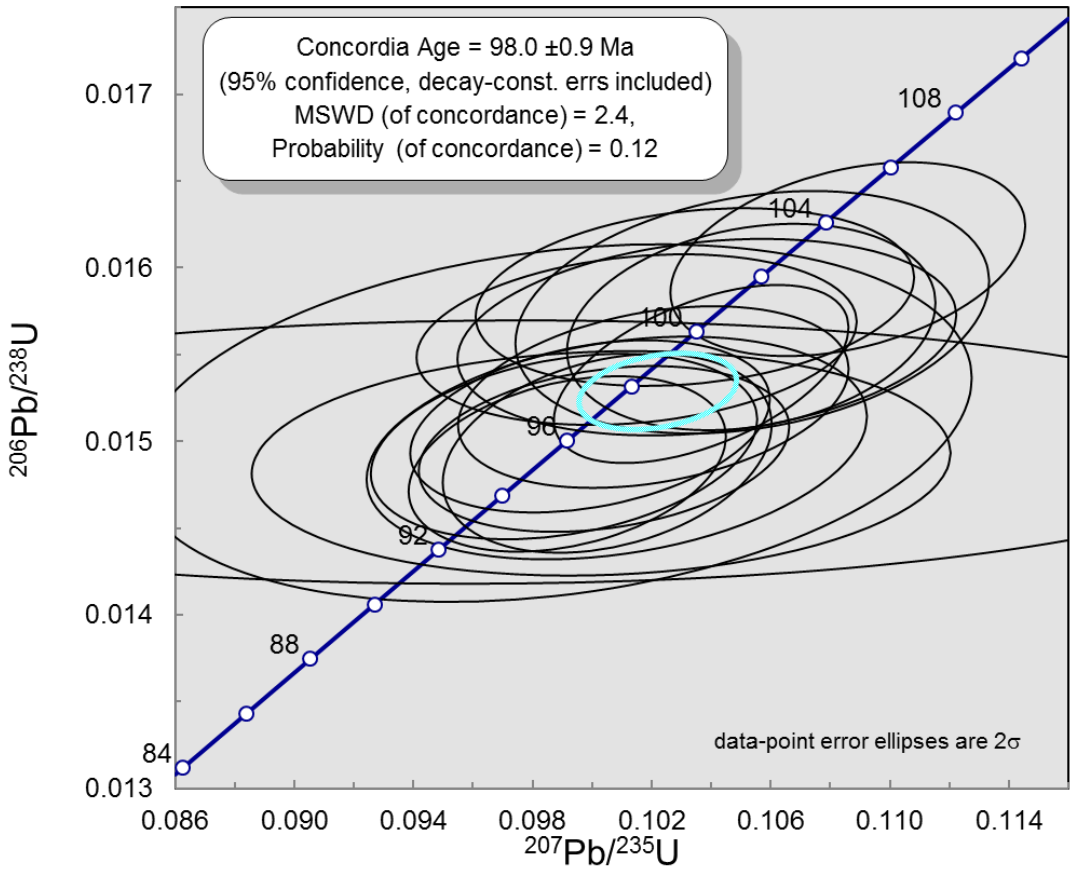


Figure 1b. U-Pb concordia-calculated age based upon 17 analyses, with $^{207}Pb/^{235}U$ deviating from the concordia by <2 percent.

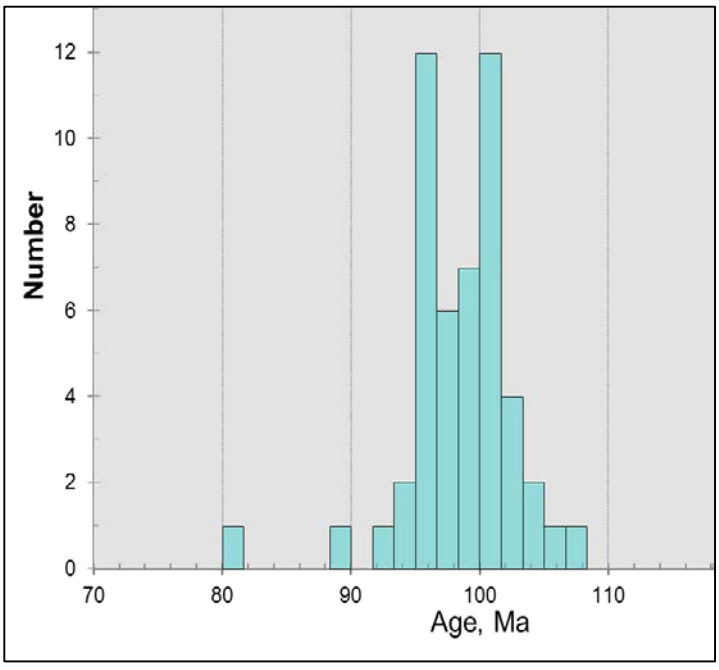


Figure 1c. 50 age measurements with relative error <10 percent.

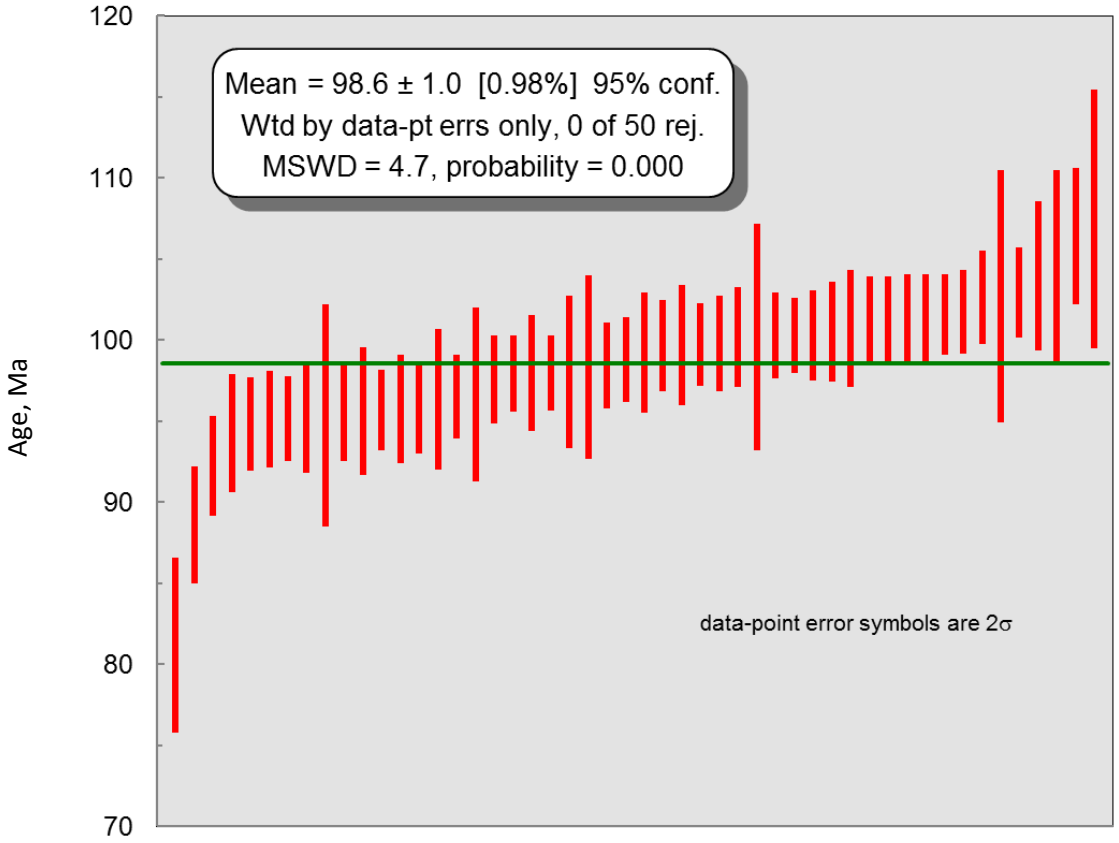


Figure 1d. Mean error-weighted $^{206}Pb/^{238}U$ ages for 50 analyses, all with <10 percent relative error.

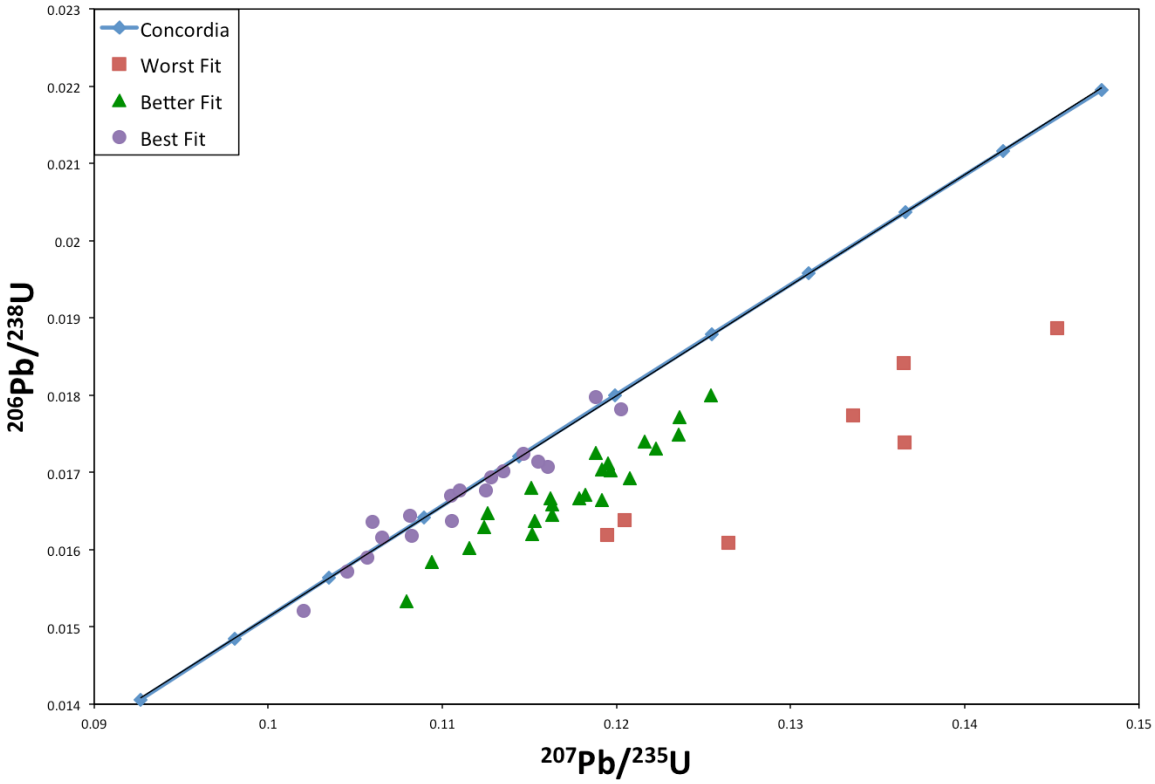


Figure 2a. 49 sets of analyses with relative error <10 percent, plotted to express relation to concordia.

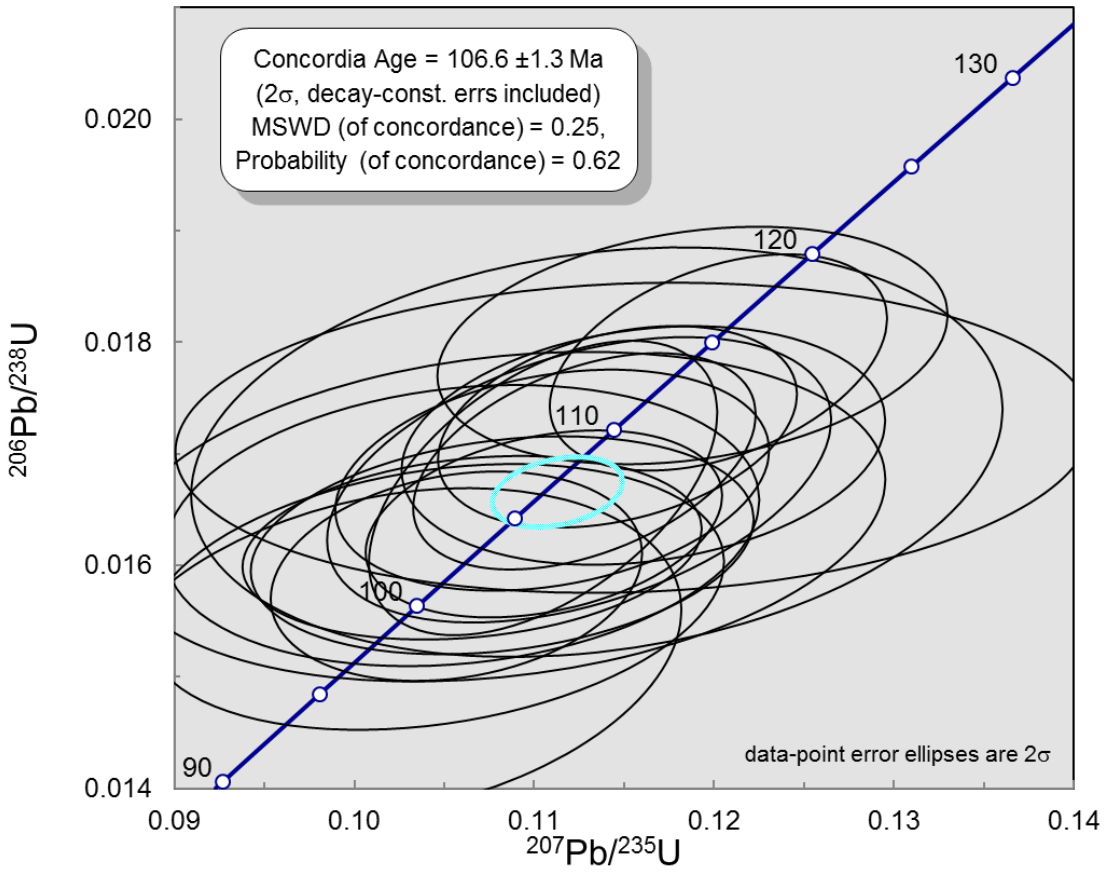
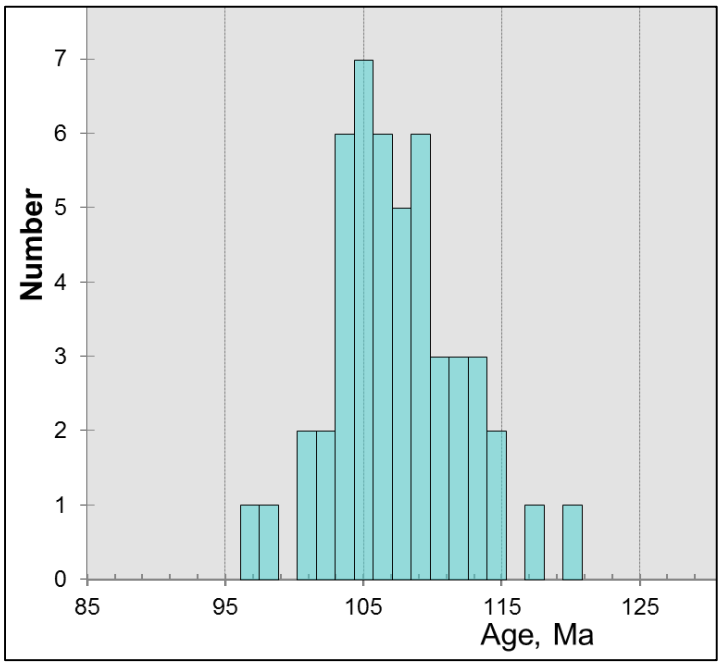


Figure 2b. U-Pb concordia-calculated age based upon 18 analyses, with $^{207}Pb/^{235}U$ deviating from the concordia by <2 percent.



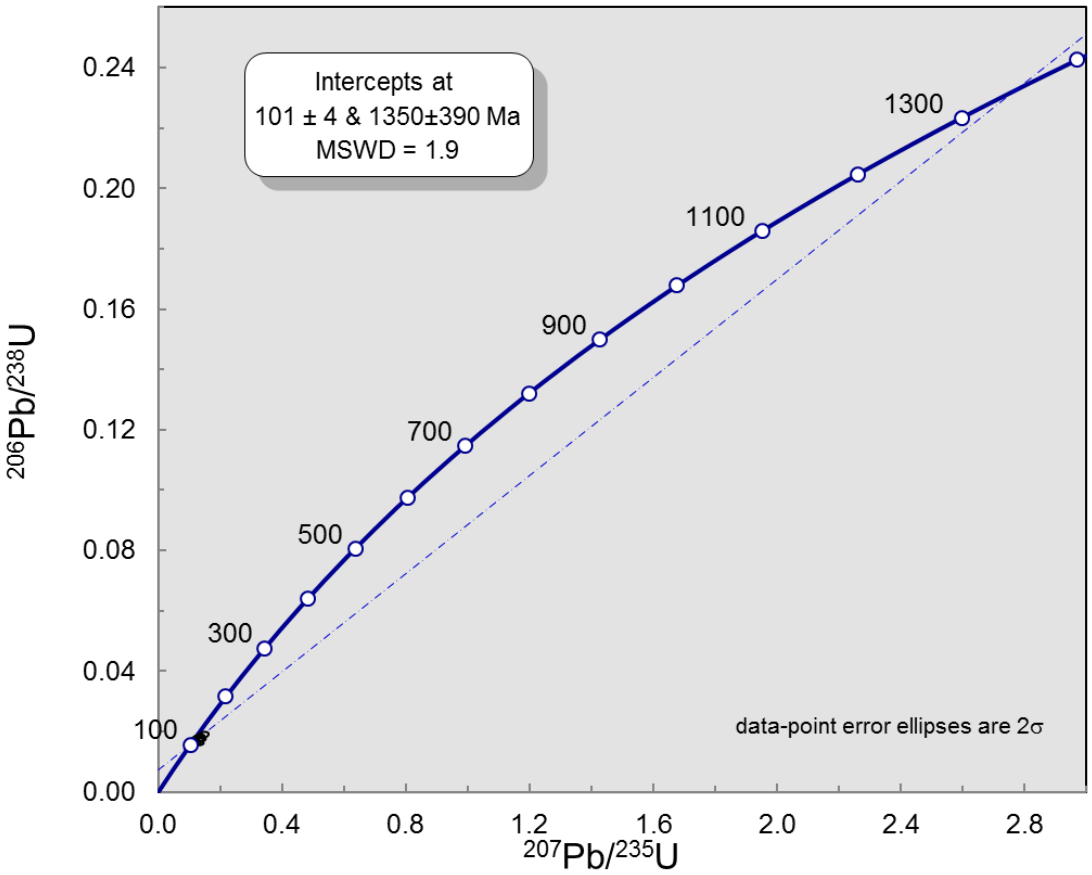


Figure 2d. All 55 measurements (including those with relative error >10 percent) define a two-point isochron with a Proterozoic upper-age intercept and a Middle Cretaceous lower-age intercept, indicating physical contamination of magmatic zircon with older, inherited zircon.

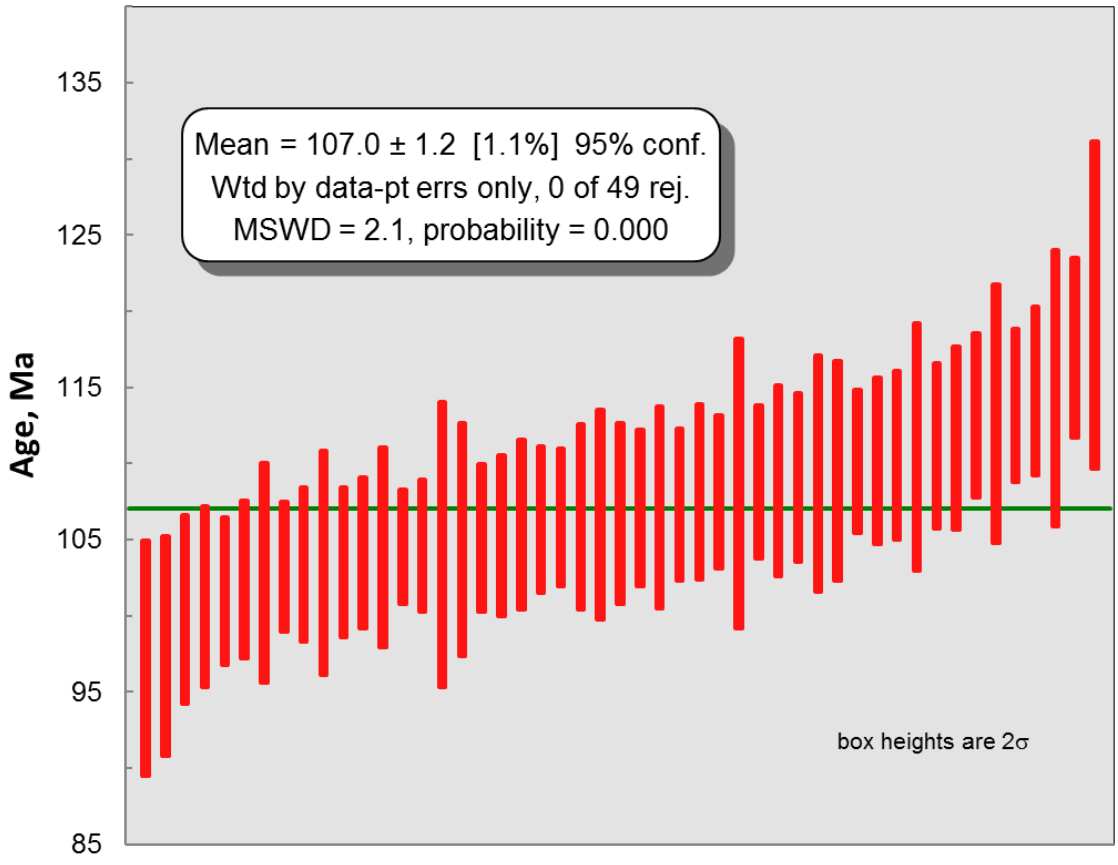


Figure 2e. Mean error-weighted $^{206}Pb/^{238}U$ ages for 49 analyses, all with <10 percent relative error.

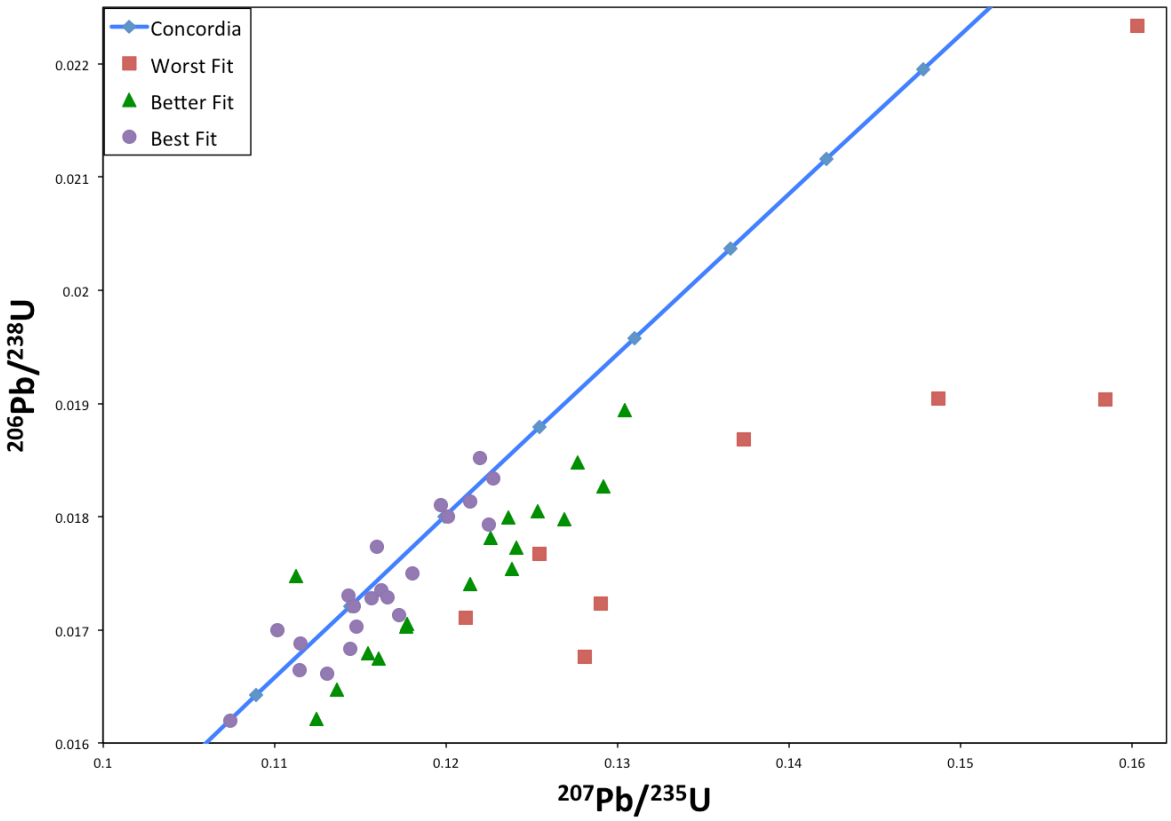


Figure 3a. 46 sets of analyses with relative error <10 percent, plotted to express relation to concordia.

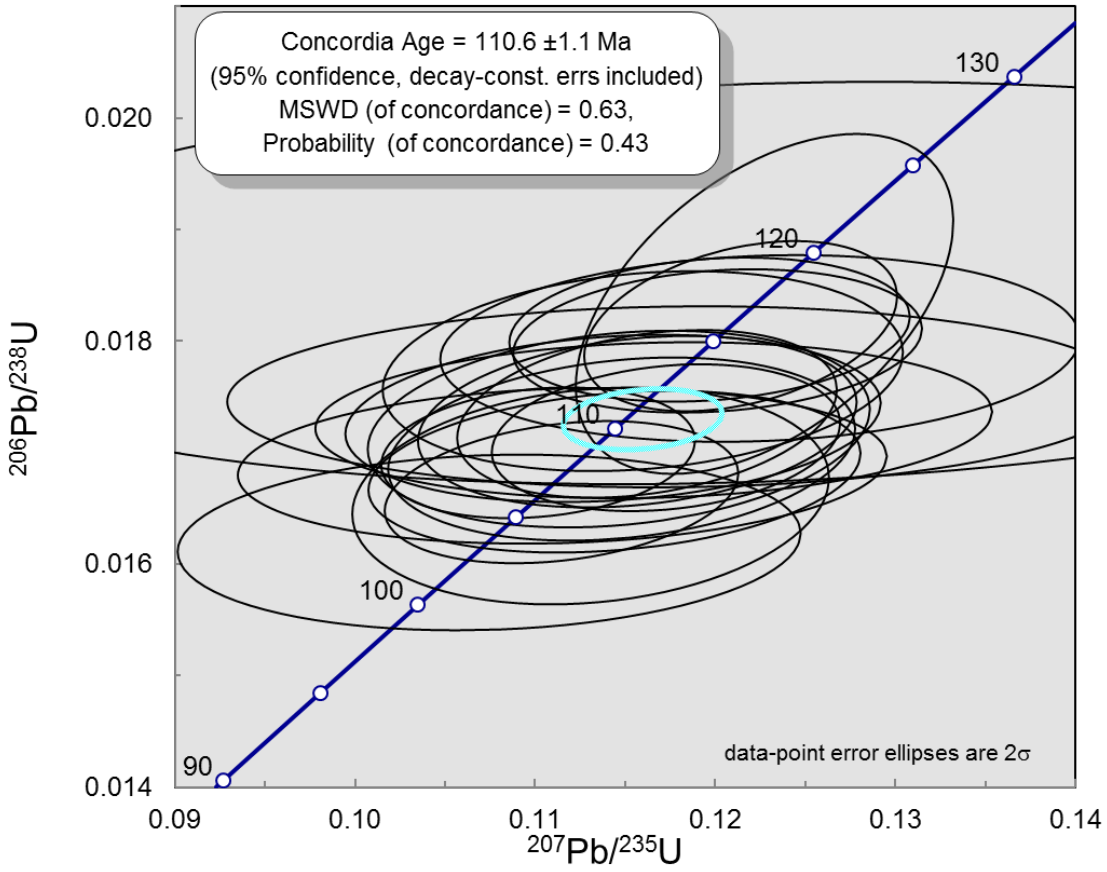


Figure 3b. U-Pb concordia-calculated age based on 21 analyses, with $^{207}Pb/^{235}U$ deviating from the concordia by <3 percent.

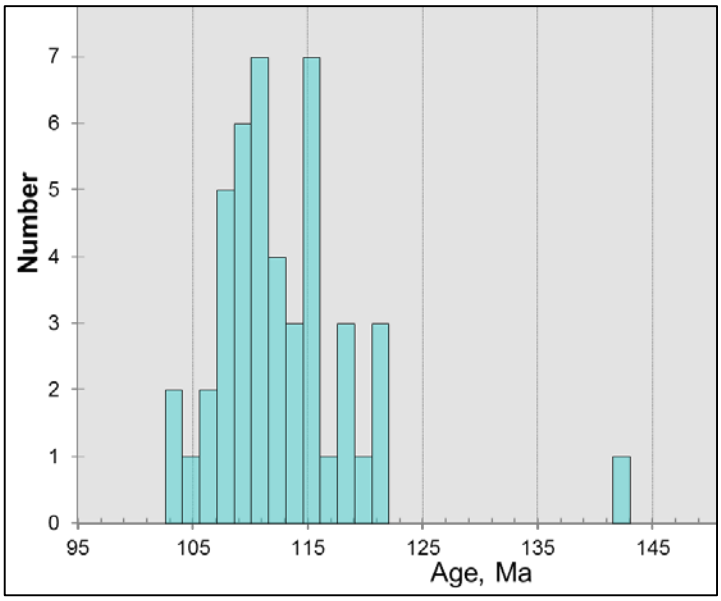


Figure 3c. 46 age measurements with relative error <10 percent. Note the outlier 144 Ma, which is not part of the main population.

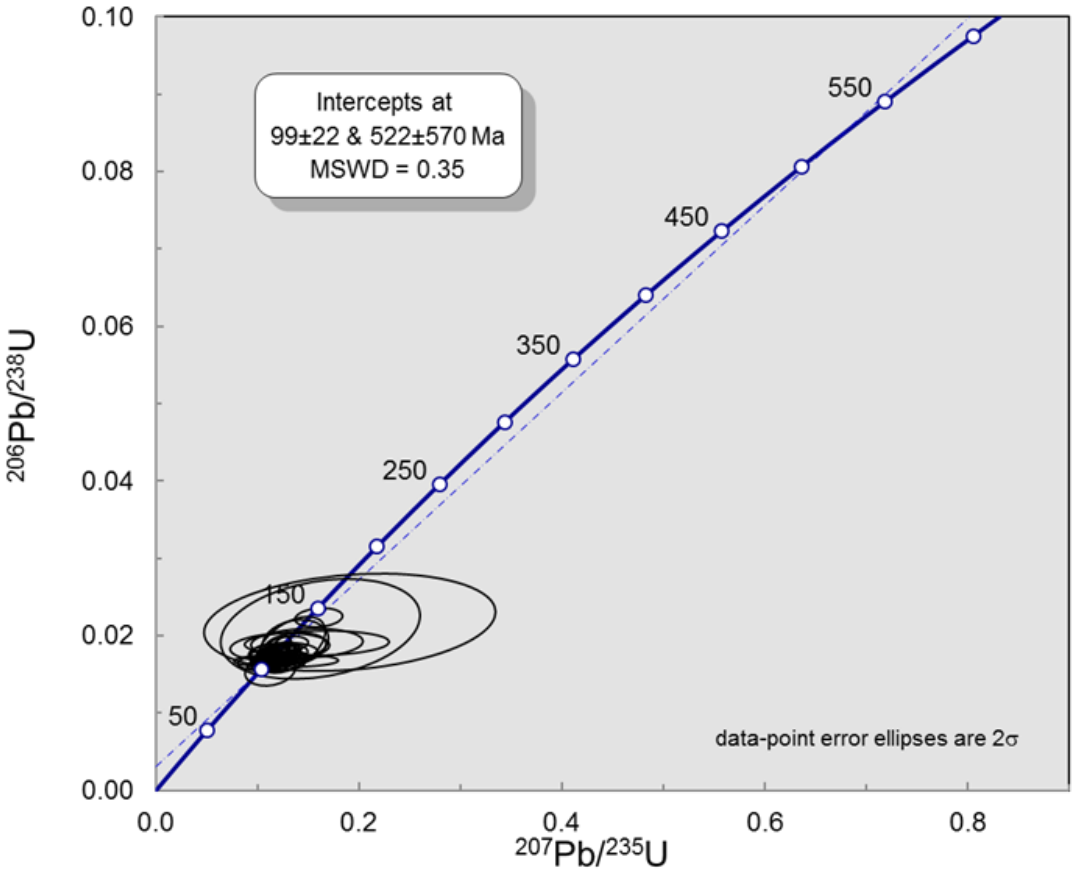


Figure 3d. All 52 measurements (including those with relative error >10 percent) poorly define a two-point isochron with an Early Paleozoic upper-age intercept and a Middle Cretaceous lower-age intercept, indicating physical contamination of magmatic zircon with older, inherited zircon.

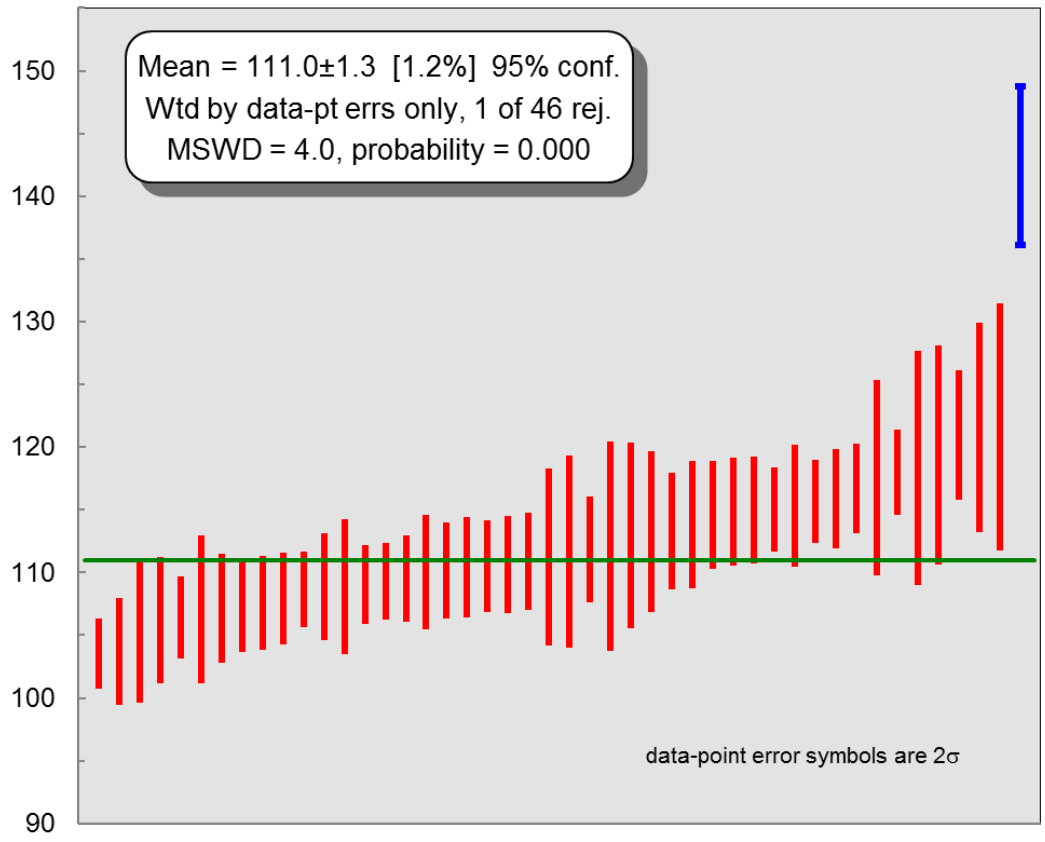


Figure 3e. Mean error-weighted $^{206}Pb/^{238}U$ ages for 46 analyses, all with <10 percent relative error. The outlier at 144 Ma was rejected as statistically (95 percent confidence) not part of the main population.

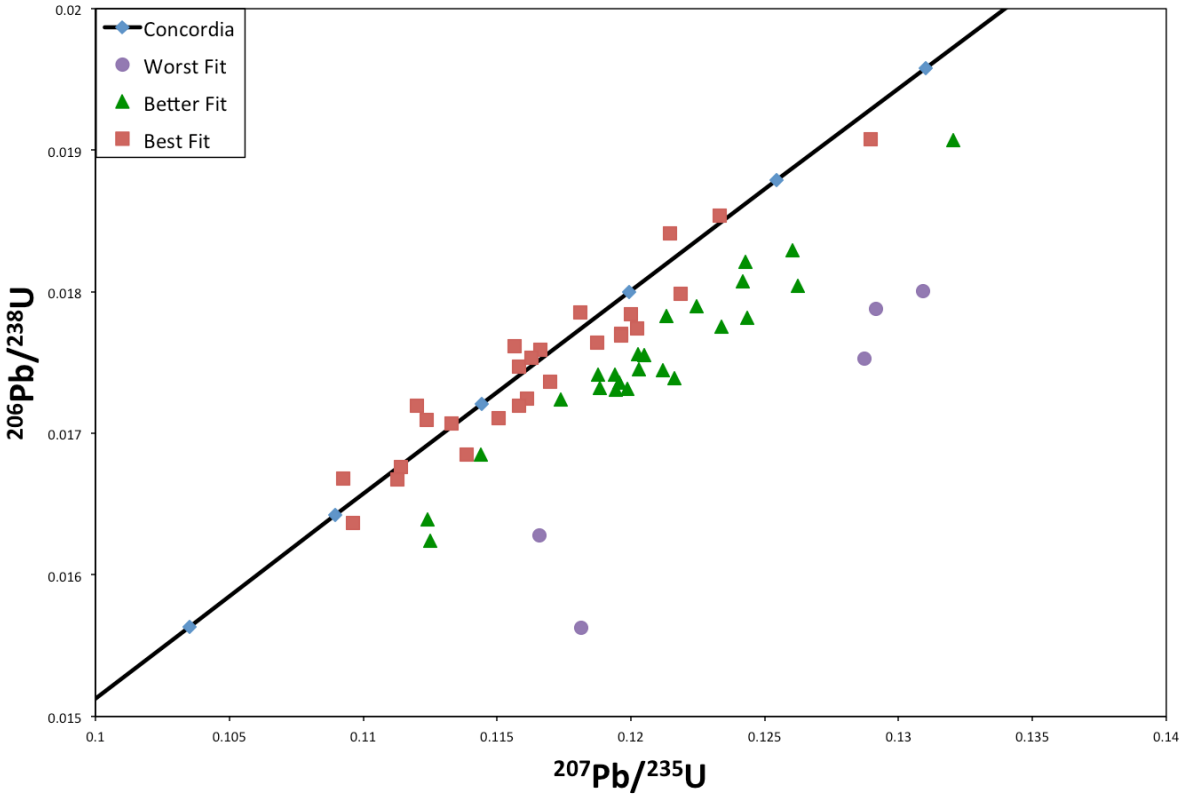


Figure 4a. 55 sets of analyses with relative error <10 percent, plotted to express relation to concordia.

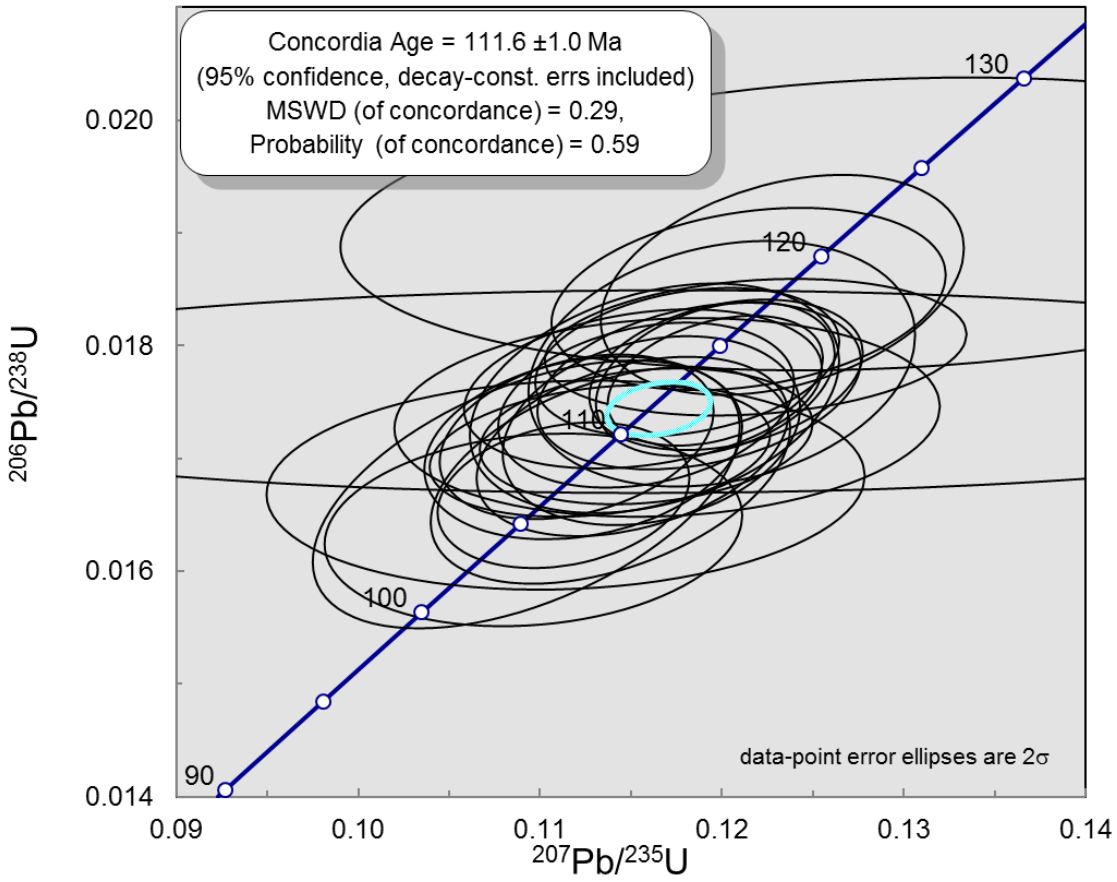


Figure 4b. U-Pb concordia-calculated age based upon 26 analyses, with $^{207}Pb/^{235}U$ deviating from the concordia by <2 percent.

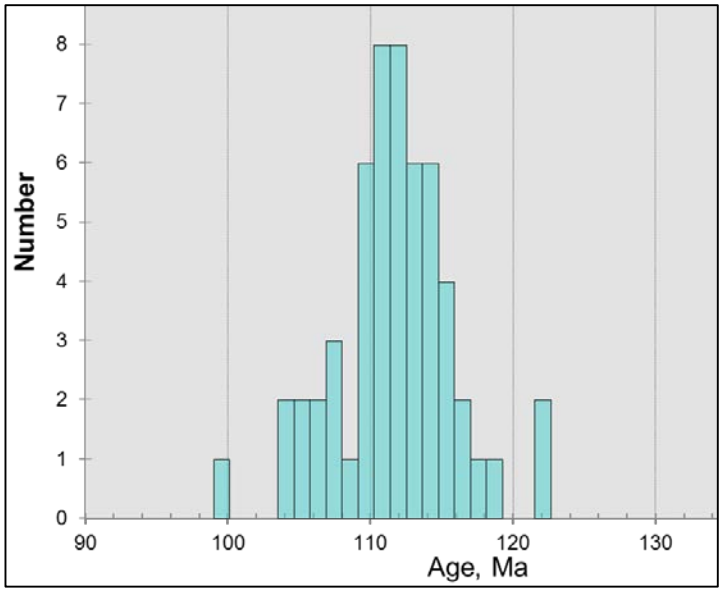


Figure 4c. 55 age measurements with relative error <10 percent.

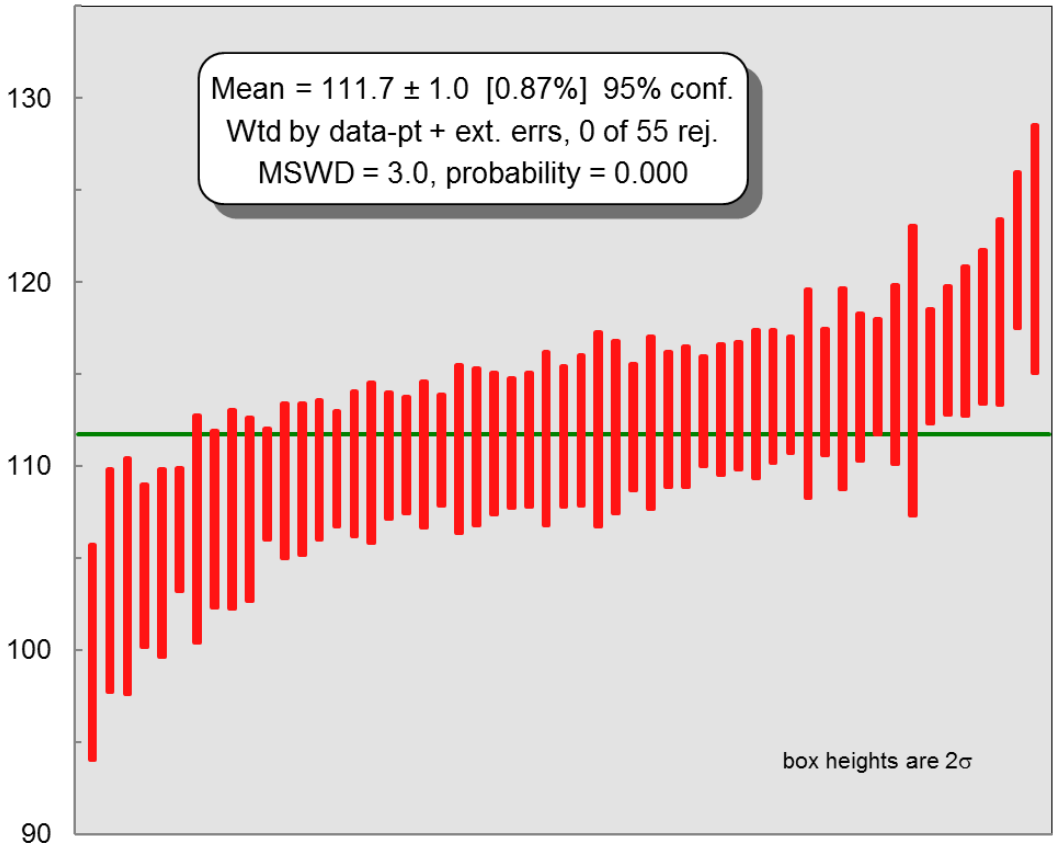


Figure 4d. Mean error-weighted $^{206}Pb/^{238}U$ ages for 55 analyses, all with <10 percent relative error.

APPENDIX B: ZIRCON AGE STANDARDS

Standard	Standard	U-Pb Age (± 2σ)	Reference
F5	Duluth Complex	1,099.0 ± 0.6 Ma (assumed equal to FC-1)	Paces and Miller, 1993
FC	Duluth Complex	1,099.0 ± 0.6 Ma	Paces and Miller, 1993
IF	Fish Canyon Tuff	28.201 ± 0.012 Ma	Lanphere and Baadsraard, 2001; Kuiper and others, 2008
MD	Mount Dromedary	99.12 ± 0.14 Ma	Renne and others, 1998
MT	Mud Tank Carbonatite	732 ± 5 Ma	Black and Gulson, 1978
T2	Temora 2, Middledale Gabbroic Diorite	416.9 ± 0.33 Ma	Black and others, 2004
T1	Temora 1, Middledale Gabbroic Diorite	416.75 ± 0.24 Ma	Black and others, 2003
TR	Tardree Rhyolite	61.23 ± 0.11 Ma	Dave Chew, personal communication