EarthChem Workshop on Geochronology for U-Pb

University of Kansas, Lawrence, Kansas 66045
April 9, 2007, 8:30am to 5:30 pm

Report compiled by Doug Walker, Mark Schmitz, Samuel Bowring, and George Gehrels.

<u>Participants:</u>
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<u>Background</u>
EarthChem is a community driven project to facilitate the compilation and dissemination of geochemical data of all types. The project is active at building a home for future data contributions by working with authors, societies, and publishers as well as government organization. In addition, the EarthChem project responds to community needs to facilitate compiling and serving data.

A recently identified community need is in the area of geochronology. At the GeoEarthScope town hall meeting held in association with the 2006 GSA National Meeting in Philadelphia, attendees discussed the necessity of a home for geochronology data collected by that project. Consensus opinion of attendees and organizers was that EarthChem should be the group to provide data management for data collected in association with GeoEarthScope, storing and serving geochronological data submitted by participating facilities. Such a management system would be useful to other workers in geochronology. EARTHTIME, for example, strongly endorses EarthChem's leadership in this regard and will work to encourage members to contribute data. This emphasis was endorsed by the EarthChem advisory board at its 2006 annual meeting.

To move this effort forward, several small workshops are planned for 2007 to ensure that the proper standards for data and metadata reporting are enforced. To this end, EarthChem is working with experts in the field of U-Pb geochronology (who are also connected with the EarthTime effort) in an April meeting, and experts at (U-Th)/He geochronology/thermochronology at a May meeting. Additional meetings for Ar-Ar and cosmogenic nuclide dating are in the planning stages. This report gives the results of the U-Pb workshop.

<u>Goals</u>
Goals of the meeting were to address important issues for creating a home for geochronology data related to U-Pb.

a. Establish reporting requirements including metadata and classes of measure values.
b. Identify and evaluate methods of data entry and output that will work for the geochronology community.
c. List the important requirements of a geochronology website.
d. Plan approaches and actions for moving forward with the effort.

Workshop Summary

The workshop group focused a large amount of effort on identifying the important items that must be reported for U-Pb geochronology results. This is presented as a large table at the end of the report. The preparation of this was greatly aided through previous work by the PaleoStrat and EARTHTIME groups. It was felt that the list of critical metadata, data, and data reduction parameters was appropriate for both ID-TIMS and LA-ICPMS geochronology. In the few areas where the two methods differ, separate parameters are identified.

The group addressed the need for an easy path for data entry. Although contributors to a database (either in EarthChem or PaleoStrat) can enter parameters directly into a spreadsheet, the group considered that the most appropriate route would be to take output directly from data reduction programs. PbMacDat (existing) and U-Pb-Redux (in development by the EARTHTIME effort) were identified as the programs with the widest potential user base. Participants also defined numerous features important to a geochronology website. These features include data display, data download, and query functions. Visualization using maps and standard diagrams are important to users and to making the data accessible.

Participants created several different *approaches* to making progress on the creation of a geochronology database within EarthChem. These approaches are general goals and aspects of the effort. These approaches were then fit into a plan of *next steps* to be taken over the rest of 2007 and the first half of 2008 to move the effort forward.

Approaches

A basic requirement of data reporting should be an IGSN for each sample and subsample (mineral separate, grain mount, etc.). To this end, the data entry system will call for the IGSN identifier. This can be done with a link to the SESAR site during data entry/upload if the IGSN is not present. It is important that users be able to establish their own IGSN for host samples in the field. This may take some work with the SESAR group, but was deemed very desirable so that users/collectors do not create multiple sample identifiers (field vs. IGSN).

One of the most arduous tasks for contributors is to enter data into any system. This is especially true for U-Pb geochronology because of the extensive amount of information (basic ratios to data reduction parameters) that must be listed. For that reason, the group recommended emphasizing data entry directly from data reduction programs. This will be done for the current PbMacDat program. This is a data reduction is done via VB macros in Excel. Data entry into the geochronology database will be done by shredding the worksheet directly into the database. A system will also be created for the U-Pb-Redux program that is under development. U-Pb-Redux is a Java-based application. The group developing this will create an XML output option, and this XML can be read directly into the database.

The database itself should be built on XML using a schema that preserves the critical data and metadata (see attached table). This will allow other parties to access the data through the XML. This is especially critical to the involvement of PaleoStrat. The working group envisioned the schema would be created by collaboration of the EarthChem, EarthTime, U-Pb-Redux, and PaleoStrat groups.

The creation of the XML schema is critical to maintaining interoperability. The group envisioned the U-Pb geochronology database to be one of many such geochronology systems. The interoperability of these systems is important for future inquiry. In addition, the enforcement of the IGSN requirement will ensure that samples can be tied together in the future. For example, the participants considered the time between high- and low-temperature chronometers especially appealing to making powerful new interpretations for locations and regions.

Lastly, the user interface needs to allow complex queries and tailor the output of such queries to the need of the user. For this reason, the interface must allow for simple display and download for casual/non-geochronologist users (probably the vast majority) and complete and rich interactions for experts.

Next Steps

Considering the approaches listed above, the participants recommended the following next steps to move the process of creating a geochronology database forward. We anticipate that these steps will be done over the next 12 months.

1) Prepare and circulate the report of this workshop. The report will be posted on the EarthChem, EARTHTIME, LaserChron, PaleoStrat, and NAVDAT websites as well as being emailed to a list of critical data providers (including the EarthChem, EARTHTIME, and PaleoStrat advisory boards). Results may be presented at the next GSA and EARTHTIME meetings. Doug Walker will take the lead on this effort with help from Mark Schmitz and George Gehrels.

2) Start developing the XML schema. This will be done by taking the list of critical items (see table) combined with some sample data and creating a structure. The schema should allow for efficient search and retrieval. The schema will be normalized to the extent needed by the amount and complexity of potential data. Exploration of existing schemas (such as OGC, GeoSciML, and GfG) will be done to further foster interoperability. Jason Ash and Jim Bowring will start this effort, and will ensure coordination between the XML and output from U-Pb-Redux.

3) Review the current EARTHTIME XML schema for tracers. EARTHTIME has already created a database and XML schema for tracer information. Because these data must be available to any new database, this schema must be reviewed in light of the results of this workshop. Noah McLean, Jason Ash, and Jim Bowring will do this task.

4) Contact Ken Ludwig about his plans for Isoplot. It is clear that Isoplot is the tool of choice for analyzing most geochronological data, especially that of U-Pb. This is currently an Excel addin. Any possibility of making this web-based or any other changes are critical to the geochronology community. Serving this addin from the geochronology database would be desirable. Mark Schmitz will contact Ludwig on this matter.

5)   Prototype a U-Pb geochronology website. This will start building a website for exploration of the U-Pb geochronology database. This may be stand-alone or, more likely, be part of an integrated geochronology website. Many components may be built off existing components of the EarthChem site. Eileen Jones and Jason Ash will start this.

6) Determine how U-Pb-Redux can interface with LA-ICPMS U-Pb data. At present, U-Pb-Redux is being optimized for ID-TIMS dating. It could also work with LA-ICPMS and possibly Ion Probe data. Jim Bowring and George Gehrels will evaluate this possibility.

7) Consider the possibility of porting U-Pb-Redux over to ion probe data. This would allow for universal use of the program and streamlined the process of getting U-Pb data of all sorts into a database system. George Gehrels will discuss this possibility with Marty Grove (UCLA) and Joe Wooden (Stanford/USGS).

8) Expand possibilities of metadata and other supporting information for samples. At present, the PaleoStrat projects ties age information to stratigraphic context in a complete way. No similar ties exist for tectonic relations, such as how the age of dated material relates to deformation fabrics, faults, etc. This will require expansion or creation of a new schema/database for other types of information. As yet, no one is identified to take this task. This may present an opportunity for advanced interoperability with other database efforts.

Supporting Materials

Nature of website output and user interaction.

1. Present concordia diagrams, ranked age plots, probability-density plots, Tera-Wasserburg diagrams, and interpreted ages plots with sample queries. Such plots should be printable and appropriate for presentations (e.g., for PowerPoint). Avoid complex mathematical treatments such as those done in Isopolot.
2. Support clicking on point on concordia diagram or other plot and linking to sample image (live link).
3. Be able to download a file that can be taken directly into Isoplot. Ensure that this field contains links to data. Explore the possibility of having Isoplot run directly from the website.
4. Generate other file formats as needed for other user tools.
5. Be able to explore all data in an advanced output mode.
6. Create output at the level of a complete sample or age interpretation. Create publication ready output if possible and appropriate.
7. Support a "tree" representation of all ages connected with a sample or set of samples (using an IGSN application/approach). Explore ways to create links between samples.

Items for queries by users:

1. Sample age
    a. Preferred age
    b. Age type
    c. Hf model age
    d. Discordance
    e. Filter by Discordance
    f. Other compositional information such as REE and TE
2. Mineral and sample type
3. IGSN
4. Rock type
5. Location
6. Filter by technique (TIMS vs. ICPMS [quad, HR, MC] vs. SHRIMP vs. Cameca)
7. Filter by number of grains
8. Date
9. Search at level of mineral fraction

EarthChem Workshop on Geochronology – U-Pb

Nichols Hall, University of Kansas – April 9, 2007

Agenda

8:30	Overview of Geoinformatics and examples. Demonstration of NAVDAT and EarthChem systems.
9:30	Discussion of reporting requirements for U-Pb data. What are the critical items that must be reported? Can we link to IGSN/SESAR for sample information?
11:00	Demonstration of NAVDAT data entry.
11:15	Discussion of how data entry and submission should work for geochronology. Do we need digital lab books? How do legacy data and new data differ? Do data reduction programs contain enough metadata? What level/depth of data documentation is needed or desirable?

Lunch (12:00 – 1:00) Demonstration of Tripoli and PB-Redux

1:00	Continue discussion
2:00	Demonstration of NAVDAT plotting and maps.
2:15	Nature of U-Pb geochronology website and geochronology websites in general. What ways do providers and users want to interact with the data? Is it critical to allow reprocessing of data at some level? What sorts of age calculation utilities are needed?
4:00	Discussion of how the website should link to the rest of geoinformatics. What links are needed? What other groups should be involved? How integrated must this be with the main site?
4:30	Wrap up and listing of goals. Identify next steps and key providers/users to move the effort forward.
6:00	Group dinner at a local restaurant

General Comments on Table:
Applicability: an entry in these columns indicates whether or not the item is applicable to a given instrumental method;
C = common parameter applicable to all analyses in an experiment (or batch); I = individual parameter applicable only to one analysis

Item	Type	Units	Applicability			Comment
			TIMS	ICPMS	Ion Probe	
General Information about host sample						
Sample Name (IGSN)	text		C	C	C	The sample name refers to the primary sample for which positional, lithologic and other metadata were established
Sample Metadata (IGSN)	text		C	C	C	The metadata for a sample name include positional, lithologic data, etc. which is captured with the original IGSN designation, or by the host database
Experiment/Batch Name	text		C	C	C	The ***experiment*** is a sub-sample of the primary ***sample*** name
Experiment/Batch Reference	text		C	C	C	Literature reference for the experiment
Laboratory	text		C	C	C	Laboratory in which the experiment was conducted
Analyst	text		C	C	C	Investigator conducting the experiment
Instrumental Method	text		C	C	C	Choices include (ID-TIMS, SHRIMP Ion Probe, Cameca Ion Probe, Quad-ICPMS, HR-ICPMS, MC-ICPMS)
Instrumental Method Reference	text		C	C	C	Literature reference for the instrumental method
Comment	text		C	C	C	Text string accommodating a description of any aspect of the sample or experiment
Interpreted Sample Age Information						
Preferred Age Type	text		C	C	C	The preferred Age Type for the experiment sub-sample as intrepreted and stated by the author; Age Types include the list to the right -->
Preferred Age	numeric	Ma	C	C	C	The preferred Age for the experiment sub-sample as intrepreted and stated by the author
Preferred Age Error	numeric	Ma, absolute 2-sigma	C	C	C	The error on the preferred age
Preferred Age Explanation	text	string	C	C	C	A text string describing the details of the preferred age interpretation
Age Type	text		C	C	C	There can be more than one Age Type per Experiment; Age Types include the list to the right -->
Age	numeric	Ma	C	C	C	"Age" combines one or more analyses into an age interpretation for the Experiment; there can be more than one Age per Experiment
Age Error (Analytical)	numeric	Ma, absolute	C	C	C	Analytical error includes counting statistic uncertainties, mass

		2-sigma				fractionation uncertainties, blank and tracer subtraction uncertainties
MSWD	numeric		C	C	C	Mean Squared Weighted Deviation
Age Error (Systematic)	numeric	Ma, absolute 2-sigma	C	C	C	Systematic error includes decay constant uncertainties, initial common Pb subtraction uncertainties, tracer calibration uncertainties (ID-TIMS), calibration uncertainty, and uncertainty in the age of the calibration standard,
Included Analyses	text		C	C	C	Those analyes included in a given Age
Comment	text		C	C	C	Text string accommodating a description of any aspect of the interpreted sample age information
Decay Constant Parameters						
238U Decay Constant	numeric		C	C	C	
238U Decay Constant Error	numeric	% 1-sigma	C	C	C	
235U Decay Constant	numeric		C	C	C	
235U Decay Constant Error	numeric	% 1-sigma	C	C	C	
232Th Decay Constant	numeric		C	C	C	
232Th Decay Constant Error	numeric	% 1-sigma	C	C	C	
230Th Decay Constant	numeric		C	C	C	
230Th Decay Constant Error	numeric	% 1-sigma	C	C	C	
235U/238U	numeric		C	C	C	
Decay Constant Reference	text		C	C	C	Literature reference for the utilized decay constants
Comment	text		C	C	C	Text string accommodating a description of any aspect of the utilized decay constants
Data Reduction Parameters						
U Blank	numeric	pg, moles	C			Amount of uranium subtracted from an ID-TIMS analysis as a contribution from blank
U Blank Error	numeric	% 1-sigma	C			
Pb Blank	numeric	pg, moles	C			Amount of common lead subtracted from an ID-TIMS analysis as a contribution from blank
Pb Blank Error	numeric	% 1-sigma	C			
Blank 206Pb/204Pb	numeric		C			Isotopic composition of blank common Pb assumed in ID-TIMS analysis for purposes of radiogenic isotope ratio calculation
Blank 206Pb/204Pb Error	numeric	% 1-sigma	C			
Blank 207Pb/204Pb	numeric		C			Isotopic composition of blank common Pb assumed in ID-TIMS analysis for purposes of radiogenic isotope ratio calculation
Blank 207Pb/204Pb Error	numeric	% 1-sigma	C			
Blank 208Pb/204Pb	numeric		C			Isotopic composition of blank common Pb assumed in ID-

						TIMS analysis for purposes of radiogenic isotope ratio calculation
Blank 208Pb/204Pb Error	numeric	% 1-sigma	C			
Spike Type	text		C			Isotope dilution tracer used in ID-TIMS analysis
Standard Mineral	text		C	C	C	Mineral standard used to calibrate isotopic ages from isotopic ratios (ICPMS, Ion Probe), or as an external check on accuracy (ID-TIMS)
Standard Mineral Reference	text		C	C	C	Literature reference for the age standard
Standard True Age	numeric	Ma	C	C	C	Accepted (true) age of mineral standard
Standard True Age Error	numeric	abs. 2-sigma	C	C	C	Uncertainty in accepted (true) age of mineral standard
Standard Measured Age	numeric	Ma	C	C	C	Measured age of mineral standard
Standard Measured Age Error	numeric	abs. 2-sigma	C	C	C	Uncertainty in accepted (true) age of mineral standard
206Pb/238U Calibration Error	numeric		C	C	C	Systematic error associated with calibration of 206Pb/238U age from measured 206Pb/238U ratio (tracer composition for ID-TIMS; sample-standard comparison for ICP; Pb/U-U/UO2 calibration for Ion Probe)
208Pb/232Th Calibration Error	numeric		C	C	C	Systematic error associated with calibration of 208Pb/232Th age from measured 208Pb/232Th ratio (tracer composition for ID-TIMS; sample-standard comparison for ICP; Pb/U-U/UO2 calibration for Ion Probe)
207Pb/206Pb Calibration Error	numeric			C	C	Systematic error associated with calibration of 207Pb/206Pb age from measured 207Pb/206Pb ratio (sample-standard comparison for ICP; Pb/U-U/UO2 calibration for Ion Probe)
Comment	text		C	C	C	Comment on the data reduction parameters used in the experiment
Analysis Information						
General						
Analysis (Grain/Spot) Name	text		I	I	I	An ***analysis*** is a sub-sample of the ***experiment*** sample name, and is thus a sub-sub-sample of the primary ***sample*** name
Image	file	(CL, BSE, Optical, etc.)	I	I	I	Link to image file illustrating the grain/spot comprising the analysis
Time Stamp	date		I	I	I	Time of analysis
Mineral	text		I	I	I	e.g. zircon, xenotime, monazite, apatite, titanite, rutile, calcite, whole rock, other
Setting	text	(in situ, grain mount, loose grain)	I	I	I	e.g. in situ, grain mount, loose grain
Number of Grains	numeric		I			Number of grains dissolved for ID-TIMS analysis; useful for queries of "single-grain" analyses

Weight	numeric	mg, µg	I			Weight of the grain(s) dissolved for ID-TIMS analysis
Physical Abrasion?	boolean		I			Was the grain(s) used for analysis physically abraded prior to dissolution?
HF Leaching?	boolean		I			Was the grain(s) used for analysis leached in HF acid prior to dissolution?
Anneal & Chem. Abr.?	boolean		I			Was the grain(s) used for analysis annealed and chemically abraded prior to dissolution?
Ion Exch. Chem. Sep.?	boolean		I			Were Pb and U chemically purified prior to ID-TIMS analysis?
Comment	text		I	I	I	Text string accommodating a description of any aspect of the analysis
Compositional						
U	numeric	ppm, pg, moles/g	I	I	I	U concentration of analysis
Th	numeric	ppm, pg, moles/g	I	I	I	Th concentration of analysis
Th/U	numeric		I	I	I	Th/U ratio of analysis, obtained by direct measurement or by inference from 208Pb*/206Pb* and age
Pb (total)	numeric	ppm, pg, moles/g	I			Amount of total analysis Pb (e.g. radiogenic, blank and initial sample Pb)
Pb (rad.)	numeric	ppm, pg, %, moles/g	I			Amount of radiogenic Pb in analysis
Pb (com.)	numeric	ppm, pg, %, moles/g	I			Amount of common Pb in analysis (e.g. blank and initial sample Pb)
206Pb (total)	numeric	ppm, pg, moles/g	I			Amount of total analysis 206Pb (e.g. radiogenic, blank and initial sample Pb)
206Pb (rad.)	numeric	ppm, pg, %, moles/g	I			Amount of radiogenic 206Pb in analysis
206Pb (com.)	numeric	ppm, pg, %, moles/g	I			Amount of common 206Pb in analysis (e.g. blank and initial sample Pb)
Pb*/Pbc	numeric		I			Radiogenic/common Pb ratio (spike-stripped, fractionation corrected)
Sample Isotope Ratios						
238U/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
238U/204Pb Error	numeric	(% 1-sigma)	I	I	I	
206Pb/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
206Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 238/204-206/204	numeric		I	I	I	Correlation coefficient between sample 238U/204Pb and

						206Pb/204Pb ratios for the purposes of isochrons
235U/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
235U/204Pb Error	numeric	(% 1-sigma)	I	I	I	
207Pb/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
207Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 235/204-207/204	numeric		I	I	I	Correlation coefficient between sample 235U/204Pb and 207Pb/204Pb ratios for the purposes of isochrons
232Th/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
232Th/204Pb Error	numeric	(% 1-sigma)	I	I	I	
208Pb/204Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
208Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 232/204-208/204	numeric		I	I	I	Correlation coefficient between sample 232Th/204Pb and 208Pb/204Pb ratios for the purposes of isochrons
238U/206Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
238U/206Pb Error	numeric	(% 1-sigma)	I	I	I	
207/206Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
207Pb/206Pb Error	numeric	(% 1-sigma)	I	I	I	
204Pb/206Pb	numeric		I	I	I	"Sample" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, but not corrected for initial common Pb
204Pb/206Pb Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 238/206-207/206	numeric		I	I	I	Correlation coefficient between sample 238U/206Pb and 207Pb/206Pb ratios for the purposes of Semi-Total and Total Pb isochrons
Corr. Coef. 207/206-204/206	numeric		I	I	I	Correlation coefficient between sample 207Pb/206Pb and 204Pb/206Pb ratios for the purposes of Semi-Total and Total Pb isochrons
Radiogenic Isotope Ratios						
208Pb*/206Pb*	numeric		I	I	I	"Radiogenic" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, and correccted for initial common Pb
206Pb*/238U	numeric		I	I	I	"Radiogenic" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, and correccted for initial common Pb
206Pb*/238U Error	numeric	(% 1-sigma)	I	I	I	
207Pb*/235U	numeric		I	I	I	"Radiogenic" ratio, e.g. spike stripped, fractionation corrected

						ratio, blank subtracted, and correccted for initial common Pb
207Pb*/235U Error	numeric	(% 1-sigma)	I	I	I	
207Pb*/206Pb*	numeric		I	I	I	"Radiogenic" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, and correccted for initial common Pb
207Pb*/206Pb* Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 207/235-206/238	numeric		I	I	I	Correlation coefficient between ratios
208Pb*/232Th	numeric		I	I	I	"Radiogenic" ratio, e.g. spike stripped, fractionation corrected ratio, blank subtracted, and correccted for initial common Pb
208Pb*/232Th Error	numeric	(% 1-sigma)	I	I	I	
Corr. Coef. 207/235-208/232	numeric		I	I	I	Correlation coefficient between ratios
206Pb*±230Th/238U	numeric		I	I	I	"Radiogenic" ratio additionally corrected for initial 230Th disequilibrium
206Pb*±230Th/238U Error	numeric	(% 1-sigma)	I	I	I	
Radiogenic Isotope Ages						
206Pb/238U Age	numeric		I	I	I	"Radiogenic" isotopic age calculated from the radiogenic 206Pb/238U ratio of the analysis
206Pb/238 Age Error	numeric	(abs. 2-sigma)	I	I	I	
207Pb/235U Age	numeric		I	I	I	"Radiogenic" isotopic age calculated from the radiogenic 207Pb/235U ratio of the analysis
207Pb/235U Age Error	numeric	(abs. 2-sigma)	I	I	I	
207Pb/206Pb Age	numeric		I	I	I	"Radiogenic" isotopic age calculated from the radiogenic 207Pb/206Pb ratio of the analysis
207Pb/206Pb Age Error	numeric	(abs. 2-sigma)	I	I	I	
208Pb/232Th Age	numeric		I	I	I	"Radiogenic" isotopic age calculated from the radiogenic 208Pb/232Th ratio of the analysis
208Pb/232Th Age Error	numeric	(abs. 2 sigma)	I	I	I	
Discordance	numeric	(%)	I	I	I	
206Pb±230Th/238U Age	numeric		I	I	I	"Radiogenic" isotopic age calculated from the 230Th-disequilibrium corrected radiogenic 206Pb/238U ratio of the analysis
206Pb±230Th/238U Age Error	numeric	(abs. 2-sigma)	I	I	I	
Analysis Data Reduction Parameters						
Initial Common Pb Method	text		I	I	I	e.g. feldspar, model, isochron, 207-concordance, 208-concordance
Initial 206Pb/204Pb	numeric		I	I	I	Isotopic composition of initial common Pb assumed for purposes of radiogenic isotope ratio calculation
Initial 206Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Initial 207Pb/204Pb	numeric		I	I	I	Isotopic composition of initial common Pb assumed for purposes of radiogenic isotope ratio calculation

Initial 207Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Initial 208Pb/204Pb	numeric		I	I	I	Isotopic composition of initial common Pb assumed for purposes of radiogenic isotope ratio calculation
Initial 208Pb/204Pb Error	numeric	(% 1-sigma)	I	I	I	
Pb Collector Type	text		I			Collector (e.g. Faraday cup, Daly, SEM) used for Pb isotope measurements
Pb Fractionation	numeric	%/amu	I			Mass fractionation per atomic mass unit applied to Pb isotope ratios measured on Faraday cups
Pb Fractionation Error	numeric	% 1-sigma	I			
U Collector Type	text		I			Collector (e.g. Faraday cup, Daly, SEM) used for U isotope measurements
U Fractionation	numeric	%/amu	I			Mass fractionation per atomic mass unit applied to U isotope ratios measured on Faraday cups
U Fractionation Error	numeric	% 1-sigma	I			