

# Geological Society of London

## Reporting standards for $^{40}\text{Ar}$ - $^{39}\text{Ar}$ and U-Pb geochronometric data

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### Common to all datasets

- Provide the location of each sample in latitude/longitude format, with datum.
- Although separately formatted tables may be included, data should also be included in digital spreadsheet format, with each value in a separate column. This will allow for easier validation of data by reviewers and editors.
- All units of measure must be explicitly stated.
- Appropriate significant figures on all presented data.
- All uncertainties must be explicitly stated ( $1\sigma$ ,  $2\sigma$ , 95 % confidence, etc.).
- Petrological context for all analysed minerals should be provided, ideally in the form of an equilibrium/retrogression assessment, but at the very least by cathodoluminescence/backscattered electron imaging of the samples.

### $^{40}\text{Ar}$ - $^{39}\text{Ar}$

#### *Data required in main body of text*

- Explicitly stated confidence level for all uncertainties.
  - Recommendation 1:  $2\sigma$  for all uncertainties quoted in body of text.
  - Recommendation 2: Explicit restatement of confidence level used in associated tables, appendices or repository items containing data.
- Name of laboratory providing analytical data.
- Reference to source of decay constant values.
  - Recommendation: Steiger & Jäger (1977).
- Minerals or materials analysed
- Name, apparent age and associated uncertainties of neutron fluence monitor used, and reference to source of primary calibration or intercalibration data
  - Recommendation: The following monitors are considered to be internationally accepted and their use is encouraged:
    - FCT-San
    - Hb3gr hornblende
    - TCR-San
    - GA1550 Biotite
    - AC-San
- Analytical technique (e.g. furnace step-heat on single grains)

#### *Data required for data table*

- Sample identifier (as used in main body of text) and analysis identifier (for step-heating data, this would be laser power or heating temperature).
- J-factor and uncertainty.
- One of the following formats:
  1. Relative abundances and uncertainty (and volume, atomic or mass units) of  $^{40}\text{Ar}$ ,  $^{39}\text{Ar}$ ,  $^{38}\text{Ar}$ ,  $^{37}\text{Ar}$ ,  $^{36}\text{Ar}$  or
  2. Ratio to common denominator with uncertainty, and relative abundance of denominator with its uncertainty (e.g.  $^{36}\text{Ar}/^{39}\text{Ar}$ ,  $^{37}\text{Ar}/^{39}\text{Ar}$ ,  $^{38}\text{Ar}/^{39}\text{Ar}$ , and  $^{40}\text{Ar}/^{39}\text{Ar}$  and  $^{39}\text{Ar}$ ).Recommendation: Format (1) because any ratio can then be directly derived.
- Fraction of total sample  $^{39}\text{Ar}$  released (for step heat analyses).
- $^{40}\text{Ar}^*/^{39}\text{Ar}$  and uncertainty
- Apparent age and uncertainty.
  - Recommendation: J-factor uncertainty is to be propagated only into the final age.
- Footnote stating corrections and their magnitude that are applied to abundances.
  - Recommendation: Abundances should be corrected for background, mass discrimination, and radioactive decay and interfering nuclear isotopes.

- Either by footnote, column header or combination of both, state confidence level for all uncertainties and whether they are fractional or absolute values.
- Optionally, other parameters such as %<sup>40</sup>Ar\*, Ca/K, or Cl/K, may be included

*The following data must appear in at least one of main body of text, methodology section in appendix or as footnote in data table*

- Description of data reduction methodology, either explicitly or by reference.  
*Note:* This should include or reference at a minimum (1) basis of data reduction and associated statistical methods, (2) basis for calculation of J-factor, (3) basis for calculation of backgrounds (blank), (4) basis for calculation of mass discrimination.
- Reactor name.
- Value and uncertainty of mass discrimination.
- Values of nuclear interfering reactions and uncertainties for (<sup>40</sup>Ar/<sup>39</sup>Ar)<sub>K</sub>, (<sup>39</sup>Ar/<sup>37</sup>Ar)<sub>Ca</sub>, and (<sup>36</sup>Ar/<sup>37</sup>Ar)<sub>K</sub> and either explicitly or by reference, methodology used for their determination.
- Background (blank) levels and uncertainties for <sup>40</sup>Ar, <sup>39</sup>Ar, <sup>38</sup>Ar, <sup>37</sup>Ar, <sup>36</sup>Ar.
  - Recommendation: The measured range of each value may be given if the variability is reasonably low.

## U–Pb ID-TIMS

*Data required in main body of text*

- Explicitly stated confidence level for all uncertainties.
  - Recommendation 1: 2σ for all uncertainties quoted in body of text.
  - Recommendation 2: Explicit restatement of confidence level used in associated tables, appendices or repository items containing data.
- Name of laboratory providing analytical data.
- Minerals or materials analysed
- Reference to source of decay constant values.
  - Recommendation: Steiger & Jäger (1977).

*Data required for data table*

- Sample identifier (as used in main body of text) and fraction identifier.
- Either by footnote, column header or combination of both, state confidence level for all uncertainties and whether they are fractional or absolute values.
- Fraction weight in micrograms.
  - Optional: number of grains analysed
- Concentration of radiogenic U and Pb in ppm.
- Measured <sup>206</sup>Pb/<sup>204</sup>Pb corrected for spike and fractionation.
- <sup>208</sup>Pb\*/<sup>206</sup>Pb\* or model Th/U
  - Optional: To also include uncertainty.
- Isotopic ratios <sup>206</sup>Pb\*/<sup>238</sup>U, <sup>207</sup>Pb\*/<sup>235</sup>U and uncertainties.
- One of the following formats:
  1. Isotopic ratio <sup>207</sup>Pb\*/<sup>206</sup>Pb\* and uncertainty or
  2. Isotopic ratio <sup>207</sup>Pb\*/<sup>206</sup>Pb\* and associated correlation coefficient
 Recommendation: Format (1) because of explicit statement of uncertainty.
- Calculated age and uncertainty derived from each of <sup>206</sup>Pb\*/<sup>238</sup>U, <sup>207</sup>Pb\*/<sup>235</sup>U and <sup>207</sup>Pb\*/<sup>206</sup>Pb\*
- Optionally, other parameters such as percent discordance or calculated common Pb content may be included.

*The following data must appear in at least one of main body of text, methodology section in appendix, or as footnote in data table*

- Description of data reduction methodology, either explicitly or by reference.  
*Note:* This should include or reference at a minimum
  - basis of data reduction and associated statistical methods
  - basis for calculation of blanks or
  - basis for calculation of mass discrimination.
- Description of mineral or material preparation, either explicitly or by reference.  
*Note:* This should include or reference at a minimum
  - methodology for concentration of analysed material
  - selection criteria for analysed material
  - any modification to material, such as air or chemical abrasion.
- Description of chemical preparation techniques, either explicitly or by reference.
- Spike composition and uncertainty on calibration of main isotopic U/Pb ratio (e.g. <sup>235</sup>U/<sup>205</sup>Pb)
- Description of instrumentation and its analytical protocols, either explicitly or by reference.

- Value and uncertainties of applied common  $^{206}\text{Pb}/^{204}\text{Pb}$ ,  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $^{208}\text{Pb}/^{204}\text{Pb}$  corrections, along with methodology of determination, either explicitly or by reference.
- Blank levels for Pb and U (in pg).
  - Recommendation: The measured range of the blank levels may be given if the variability is reasonably low.
- Pb isotopic composition of blank with uncertainty stated as  $^{206}\text{Pb}/^{204}\text{Pb}$ ,  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $^{208}\text{Pb}/^{204}\text{Pb}$ .

## U–Pb HR-SIMS

### *Data required in main body of text*

- Explicitly stated confidence level for all uncertainties.
  - Recommendation 1:  $2\sigma$  for all uncertainties quoted in body of text.
  - Recommendation 2: Explicit restatement of confidence level used in associated tables, appendices or repository items containing data.
- Name of laboratory providing analytical data. Description of minerals or materials analysed
- Description of imaging techniques, such as CL, BSE, etc., if they were used for characterization of the analysed material.
- Reference to source of decay constant values.
  - Recommendation: Steiger & Jäger (1977).
- Name of U/Pb calibration reference, age used for Pb/U calibration (specify whether this is based on  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  or  $^{206}\text{Pb}^*/^{238}\text{U}$  age), resultant external uncertainty on the calibration and reference to source of primary calibration or intercalibration data.

### *Data required for data table*

- Sample identifier (as used in main body of text) and analysis identifier.
- Either by footnote, column header or combination of both, state confidence level for all uncertainties and whether they are fractional or absolute values.
- Concentration of U, Pb (total or radiogenic) in ppm.
  - Recommendation: To also include Th in ppm or Th/U ratio.
- Measured  $^{204}\text{Pb}/^{206}\text{Pb}$  and/or calculated fraction of common  $^{206}\text{Pb}$  ( $f_{206}$ ) with statement in footnotes.
- Composition assumed for common Pb, presented either as explicit  $^{207}\text{Pb}/^{206}\text{Pb}$  and  $^{206}\text{Pb}/^{204}\text{Pb}$  ratios or with reference to a model composition of specified age, e.g. Stacey & Kramers (1975). This can be a footnote statement if common to all analyses.
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- Isotopic ratios: common Pb corrected  $^{206}\text{Pb}^*/^{238}\text{U}$ ,  $^{207}\text{Pb}^*/^{235}\text{U}$ , (optional  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ ) and uncertainties together with error correlation ( $\rho$ ) when plotting conventional (Wetherill concordia) or  $^{206}\text{Pb}^*/^{238}\text{U}$  and  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  when plotting inverse (Tera–Wasserburg) concordia.
  - Recommendation: Tabulated data should at a minimum match plot axes used in figures (i.e. conventional or inverse Concordia).
- Calculated age and uncertainty derived from each of: Common Pb corrected  $^{206}\text{Pb}^*/^{238}\text{U}$ , (optional  $^{207}\text{Pb}^*/^{235}\text{U}$ ),  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  and uncertainties. Where appropriate  $^{207}\text{Pb}$  corrected ages and uncertainties calculated from combined uncorrected  $^{206}\text{Pb}/^{238}\text{U}$ ,  $^{207}\text{Pb}/^{206}\text{Pb}$  ratios may also be presented.
- Optionally, other parameters such as % discordance,  $^{208}\text{Pb}^*/^{206}\text{Pb}^*$  (with uncertainties) or calculated common Pb content may be included, but are not required.

### *The following data must appear in at least one of main body of text, methodology section in appendix, or as footnote in data table*

- Description of data reduction methodology, either explicitly or by reference.
 

*Note:* This should include or reference at a minimum

  - basis of data reduction and associated statistical methods
  - basis for assumption of common Pb composition
  - basis for estimation of mass fractionation (if applied).
- Description of mineral or material preparation, either explicitly or by reference.
 

*Note:* This should include or reference at a minimum

  - methodology for concentration of analysed material
  - selection criteria for analysed material
  - any modification to material, such as annealing or chemical abrasion
  - mount preparation procedures or
  - description of any electroconductive coating applied to mount.
- Description of instrumentation and its analytical protocols, either explicitly or by reference.
 

*Note:* This should include or reference, at a minimum

  - primary ion beam type and size
  - isotopes/species measured
  - mass resolution
  - detection settings (e.g. mono- or multi-collection).

## U (Th)–Pb LA-ICPMS<sup>a</sup>

The following data must appear in at least one of main body of text, methodology section in appendix, or as footnote in data table

- Minerals or materials analysed
- Name of laboratory providing analytical data.
- Description of mineral or material preparation, either explicitly or by reference.  
*Note:* This should include or reference at a minimum
  - methodology for concentration of analysed material, unless analysed in situ
  - selection criteria for analysed material
  - any modification to material, such as annealing or chemical abrasion
  - mount preparation procedures
  - description of imaging techniques, such as CL, BSE, etc., in case they were used for characterization of the analysed material
- Description of instrumentation and its analytical protocols, either explicitly or by reference  
*Note:* This should include or reference at a minimum
  - type of laser and ICPMS used
  - laser parameters (e.g. wavelength, fluence, spot size, repetition rate, mode of sampling, laser sample gas)
  - ICPMS parameters (e.g. plasma power and plasma gas flows, type of detector and detection mode (sequential or simultaneous), isotopes/species measured, measurement dwell and settling times, number of measurements/readings per analysis, length of blank/sample measurements).
- Description of data reduction methodology, either explicitly or by reference.  
*Note:* This should include or reference at a minimum
  - basis of data reduction, including all corrections applied to the raw data (e.g. blank, laser-induced fractionation, mass discrimination, interference, common Pb and basis for assumption of common Pb composition<sup>b</sup>)
  - calibration strategy
  - used calibration standards and their  $^{206}\text{Pb}^*/^{238}\text{U}$  and  $^{207}\text{Pb}^*/^{235}\text{U}$  ( $^{208}\text{Pb}^*/^{232}\text{Th}$ ) ages and associated uncertainties
- Description or reference to calculation of analytical uncertainties and explicitly stated confidence level for all uncertainties.  
*Note:* This should include or reference at a minimum
  - basis of uncertainty calculation
  - list of all sources of uncertainties included in the estimate of isotopic ratio/age uncertainties,
  - estimate of precision and accuracy (e.g. based on analysis of reference sample) of the technique.
    - Recommendation 1:  $2\sigma$  for all uncertainties quoted in body of text.
    - Recommendation 2: explicit statement of confidence level used in the text, figures, associated tables, appendices or repository items containing data.
- Description of U/Pb (Th/Pb) reference sample.  
*Note:* This should include name and source, U (Th) and Pb contents,  $^{206}\text{Pb}^*/^{238}\text{U}$  and  $^{207}\text{Pb}^*/^{235}\text{U}$  ( $^{208}\text{Pb}^*/^{232}\text{Th}$ ) ages and associated uncertainties, results achieved by repeat measurement of the reference sample and their uncertainties.
- Description of age calculation and reference to source of decay constant values.  
*Note:* This should include or reference the calculation procedure used for age calculation and source/values of decay constants.
  - Recommendation: Steiger & Jäger (1977).

### Data required for data table

- Sample identifier (as used in main body of text) and analysis identifier.
- Either by footnote, column header or combination of both, state confidence level for all uncertainties and whether they are fractional or absolute values.
- Optional: concentration of U (Th), Pb (total or radiogenic) in ppm.
- Measured  $^{204}\text{Pb}/^{206}\text{Pb}^b$
- Isotopic ratios: common Pb corrected<sup>b</sup>  $^{206}\text{Pb}^*/^{238}\text{U}$ ,  $^{207}\text{Pb}^*/^{235}\text{U}$ , ( $^{208}\text{Pb}^*/^{232}\text{Th}$ ),  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  and uncertainties together with error correlation.  
*Note:* Explanation or reference to error correlation formula should be given in the footnote or in the main body of the text.
- Calculated age and uncertainty derived from each of: common Pb corrected<sup>b</sup>  $^{206}\text{Pb}^*/^{238}\text{U}$ ,  $^{207}\text{Pb}^*/^{235}\text{U}$ , ( $^{208}\text{Pb}^*/^{232}\text{Th}$ ),  $^{207}\text{Pb}^*/^{206}\text{Pb}^*$  and uncertainties.
- Optionally, other parameters such as % discordance,  $^{208}\text{Pb}^*/^{206}\text{Pb}^*$  (with uncertainties) or calculated common Pb content may be included, but are not required.  
*Note:* Explanation or reference to % discordance calculation formula should be given in the footnote or in the main body of the text.

<sup>a</sup>Th–Pb data should be reported when available.

<sup>b</sup> Where applicable