A brief introduction into the Greenland U-Pb Geochronology Database

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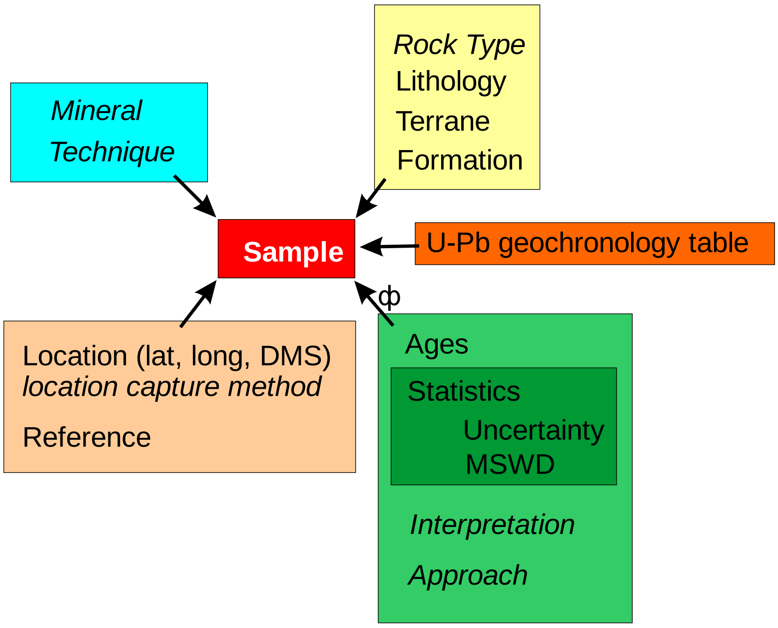
Geochronology aims to establish the age of rocks, minerals, and geological events including fluid movement and mineralization, within a specific degree of uncertainty, using signatures inherent in the rocks themselves. Absolute dating is only accomplished through the use of naturally-occurring radioactive isotopes found within geological samples. The U–Th–Pb isotopic system is the benchmark for determining the ages of geological materials because, unlike other chronometers, it exploits three independent isotopic decay schemes for which the decay constants are well known: ^{235}U to ^{207}Pb, ^{238}U to ^{206}Pb, and ^{232}Th to ^{208}Pb. The ability to use more than one independent chronometer in the same sample allows open-system behaviour (i.e. radiogenic-Pb loss) to be detected. This helps to evaluate whether analyses represent the time of mineral growth or the time of a younger disturbance, and greatly enhances the reliability of age determinations. In principle any mineral that contains sufficient quantities of uranium can be dated. However, those minerals whose crystal structure expels lead are preferable because they will only (or to a great extent) contain radiogenic lead produced from insitu decay and thus will not be compromised with lead from outside the crystal that would contaminate the time signal. Zircon is by far the most commonly utilized mineral for U–Pb dating, monazite, apatite, xenotime, titanite, rutile, baddeleyite, allanite, and perovskite can also be dated using the U-Pb method. As each of these minerals will close to lead diffusion at different temperatures or have different susceptibilities to fluids they provide a broad range of geochronologic and thermochronologic applications. Such applications include not only directly dating igneous, metamorphic, hydrothermal, and epithermal processes but also potentially constraining the timing of exhumation.

There are two categories of U–Pb measurements: thermal ionization mass spectrometry and in situ microanalysis. Isotope dilution thermal ionization mass spectrometry generally requires a crystal or crystals to be dissolved prior to measurement of the U, Th, and Pb (Krogh, 1982). Although able to yield very precise measurements, this method requires that the crystals are homogeneous otherwise the measured result will represent a mixture of age domains. Alternatively, microanalytical techniques use a focused ion (Ireland and Williams, 2003) or laser beam (Jackson et al., 2004) to ablate material from small areas within a crystal, and therefore can determine ages from different growth domains within individual crystals although with lower analytical precision.

The Greenland Geochronology database compiles published U-Pb geochronology from a wide range of literature sources and normalizes and recasts the data into consistent ratios and uncertainty levels; specifically all errors are given at the 1 sigma level. Importantly, this normalization provides coherence across the dataset. Additionally, ratios are verified against ages and have, if necessary, been corrected to ensure an internally consistent dataset. Systematic collation and assessment of geochronological data can be best achieved by means of a database which holds information within a structured and consistent framework which permits querying to extract relevant data and minimises difficulty in cross comparison of age information where different standards have been used. Additionally, the database collates information scattered widely across published sources making this information vastly more accessible.

Data is captured from a wide range of published literature sources and stored in multiple linked tables using a Globally Unique IDentifier (GUID) for each sample, a unique reference number used as a means of directly locating a specific record. The primary level of information for each sample is sample identification (as provided by the referenced literature source), source reference, location, lithological features, mineral type, analytical technique, pooled age information and individual analysis-level age information. All original data sources are referenced in the database using the Harvard referencing style to allow easy location of the original data source through internet searching. If a specific ratio, age, or other variable has not been provided in the original source it is not derived in this database. In all cases the information captured has aimed to remain faithful to the original source geological interpretation and information, the only exception being sample location where samples with a missing location or otherwise mis-located have been assigned a grid reference through Google Earth™. The table structure is designed to ensure referential integrity i.e. to ensure that typographic errors are minimised through the use of lookup tables for specific fields.



Schematic representation of the simplified structure of the Greenland Geochronology Database. Those fields in italics are looked up from established listings (see Eglington, 2004). The green "ages" box refers to pooled ages where means or other statistical aggregations of individual analyses have been performed. The orange "U-Pb geochronology table" box refers to spot or grain level analytical data including ratios, concentrations and ages.

Two levels of age information are held within the database, namely Pooled Ages and Individual Ages. Pooled Ages refer to weighted mean ages or other statistical age groupings where multiple analyses are considered together to define the age of a geological event. A single sample can have multiple Pooled Ages and hence multiple interpretations thereof. For example, a single sample may yield younger metamorphic overgrowths on older igneous crystals, and therefore a Pooled Age of each crystal domain is possible and would yield more information from this sample than just a single date.

For consistency with the Geoscience community, lookup fields aim to follow Eglington (2004). The database is designed such that samples are linked to:

Location

Location is either captured from the source itself, or where not given is captured via Google Earth™. Locations are given in decimal degrees.

Reference

Reference of the original data source in Harvard format.

Lithological information

Lithology; a free text field as defined by the source author describing the sampled rock.

Rock type; a pre-defined choice of rock classification e.g. igneous, metamorphic and sedimentary and derivatives thereof. Terrane and unit information based on spatial join with a terrane map of Greenland based in large part on Dawes (2009).

Mineral

A lookup value from a list of minerals used for U-Pb geochronology (Eglington, 2004).

Technique

A lookup value from a list of techniques used to determine U-Pb ratios (Eglington, 2004).

Pooled ages and statistical information

A one-to-many relationship with the sample, this structure holds the statistical information about a pooled age (e.g. age, uncertainty and MSWD) along with interpretation of the pooled age (looked up) and the approach (looked up). The approach defines the isotopic ratio or the ratios used to calculate the pooled age.

Individual ages and ratios

This structure holds the spot level or grain level isotopic information (U-Pb, Pb-Pb ratios and corresponding uncertainties at the 1 sigma level) and derived dates. We have applied a simple analysis-level classification system which aims to be consistent with the original interpretation; this scheme aids in the utility of datasets and allows easy compilation. D = outside discordance threshold or age information regarded as geologically meaningless; M = metamorphic; I = magmatic; X = xenocryst / inheritance; S = detrital. The spot level ID is a simplified scheme as discussed in Spencer et al., (2015) and used by the Geological Survey of Western Australia (Wingate and Kirkland, 2015). All analyses are common Pb corrected.

Referencing

For referencing the Geochronology Database the following citation should be used Kirkland, CL, Hollis, J and Gardiner, N, 2016, Greenland U-Pb Geochronology Database, www.greenmin.gl. For referencing any ages within the database the relevant reference fields should be consulted.

Disclaimer

The information provided is interpretive. The information is made available in good faith and derived from sources believed to be reliable and accurate at the time of release. Every effort has been made to make the information a useful reference. However, you should not rely solely on this information when making commercial decisions.

References

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