DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2011/120

Conceptual models for the geological architecture of the Archaean crust and gold occurences in southern West Greenland and South-West Greenland 64° – 61°30'N

Nynke Keulen, Jochen Kolb, Thomas F. Kokfelt,
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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

GEUS

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G E U S

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Introduction

Background

The Geological Survey of Denmark and Greenland (GEUS) and the Bureau of Minerals and Petroleum (BMP) co-financed the following three projects in southern West and South-West Greenland ”Strukturelt kontrolleret hydrotermal omdannelse og mineralisering på regional skala og detaljestudie af udvalgte grønstensbælter”, ”Integrative dataanalyse til karakterisering af økonomiske metaller” and ”Homogenisering og konceptuel modernisering af geologiske kort i Sydvestgrønland 61º30’ - 64 º00’” between 2008 and 2010. In order to extract extra information out of the results that were obtained in these projects and to present these data to the scientific world, it was agreed between GEUS and BMP in the early winter 2010 to co-finance an extra year of scientific work on the three listed topics.

Aims

Several previously unknown gold occurrences were documented on Qilanngaarsuit, near Kangiata Nunaa, NW of Buksefjorden, N of Sermilik, W of Bjørnesund, and in the Paamiut area within the framework of the “hydrothermal gold” project. Here, we compare these data to known gold occurrences in the Godthåbsfjord area (Isua, Storø, Qussuk, Store Malene, Sadelø and Bjørneøoen) and compile all data on these gold occurrences into one comprehensive genetic model. These data are connected to the structural, geochemical, metamorphic, geophysical and geochronological data, which were delivered on a seamless digital geological 1:100.000 map. Here, we expand the dataset to a cross section through the Archaean crust of southern West and South-West Greenland, where different kinds of geological data are integrated into an integrated geological history, including a cross section through the area SE of the Bjørnesund and incorporating an area with gold occurrences.

This report further aims at (i) giving an overview over the visited conferences, where we promoted the work of BMP and GEUS in Greenland, (ii) distribute the newly produced data, (iii) give an update on contributions from external partners, and (iv) to deliver the draft versions of the scientific contributions (on a confidential CD).

Presentation of the scientific results at international scientific conferences

EGU conference, Vienna, Austria

GEUS presence at this meeting has been reported earlier in GEUS Notat 11-MI-11-02, sent to Henrik Stendal on 15th May 2011. This Notat is added as Appendix 1. Here we will give a short summary.

The session GMPV22/TS1.5 "Geology of the North-Atlantic Craton" was convened by N. Keulen, with T.F. Kokfelt and J. Kolb as co-conveners. The session hosted six oral presentations and 13 poster presentations as listed below:

Oral session:

Jochen Kolb, Denis M. Schlatter, Annika Dziggel, and Alexander F.M. Kisters: Orogenic gold mineralisation in the Archean North Atlantic craton, southern West and South West Greenland.

Tomas Næraa, Minik Rosing, Anders Scherstén, Elis Hoffmann, Thomas F. Kokfelt, and Tony Kemp: Eo- to Mesoarchaean crust formation in the Nuuk region, southern West Greenland. Constrains from combined U/Pb, Hf and O isotopes in zircon.

Hugh Rollinson: LILE-depletion in the Archaean lower continental crust: the Lewisian granulites revisited.

Kristoffer Szilas, Vincent J. van Hinsberg, Alexander F.M. Kisters, Thomas F. Kokfelt, Anders Scherstén, and Brian F. Windley: Remnants of Mesoarchaean oceanic crust in the Tartoq Group, North Atlantic Craton, SW Greenland.

John C. Schumacher, Nynke Keulen, Charlotte Stamper, Gemma Sherwood, and Vincent van Hinsberg: Metamorphism in southern West Greenland and South-West Greenland.

Nicolas Benjamin Stoltz, Annika Dziggel, and Jochen Kolb: Formation of garnet coronas during high-P retrogression in mafic granulites of the Mesoarchaean Tasiusarsuaq terrane, southern West Greenland.

Poster session:

Martin B. Klausen, Thomas F. Kokfelt, Nynke Keulen, Alfons Berger, and John C. Schumacher: Tholeiitic 'komatiite'-basalt and calc-alkaline andesite-dacite succession in the Archaean Kvanefjord Area (South-West Greenland): A composite oceanic and volcanic arc suite?

Thomas Kokfelt, Anders Scherstén, and Tomas Næraa: New geochronological evidence for a c. 3.1-3.2 Ga old cratonic core in the Fiskenæsset area, South-West Greenland.

Thomas Kokfelt, Nynke Keulen, Tomas Næraa, Anders Scherstén, and Tjerk Heijboer: New zircon U/Pb age data from the Archaean craton, South-West and southern West

Greenland (61º30'N - 64º00'N).

Timothy Johnson: Evidence for partial melting in the central region of the Lewisian complex, Scotland.

Alfons Berger, Thomas F. Kokfelt, and Martin B. Klausen: Geochemistry and petrology of border zones between mafic/ultramafic bodies and surrounding TTG gneisses (SW Greenland).

Martin Koppelberg, Annika Dziggel, Jochen Kolb, Denis Martin Schlatter, and Robert Flock: Alteration systematics and petrology of gold-bearing quartz veins on the island Qilanngaarssuit, southern West Greenland.

Denis Martin Schlatter, Jochen Kolb, and Sara Edith Hoffritz: Characterization of host rocks and hydrothermal alteration of the Nuuluk gold occurrences in the Sermiligaarsuk Fjord area, South West Greenland.

Vincent van Hinsberg, Alex Kisters, and Kristoffer Szilas: Constraining the geotectonic setting for the Archaean Tartoq Group (SW Greenland) from its metamorphic and structural history.

Kristoffer Szilas, Adam A. Garde, Anders Scherstén, Jeroen A.M. van Gool, and Claus Østergaard: Mesoarchaean premetamorphic hydrothermal alteration of tholeiitic basalt resulting in aluminous lithologies, Storø supracrustal belt, Nuuk region, southern West Greenland.

Kristoffer Szilas, Anders Scherstén, J. Elis Hoffmann, Thomas F. Kokfelt, Vincent J. van Hinsberg, Brian F. Windley, and Carsten Münker: Linking the Ravns Storø and Bjørnesund supracrustal belts (SW Greenland) using Lu-Hf and Sm-Nd isotopic data and whole-rock geochemistry.

Nynke Keulen, John C. Schumacher, Vincent J. van Hinsberg, Kristoffer Szilas, Brian F. Windley, Thomas F. Kokfelt, Denis M. Schlatter, and Anders Scherstén: The Bjørnesund anorthosite-greenstone belt - a link between the Fiskenæsset complex and the Ravns Storø metavolcanic belt, southern West Greenland.

Nynke Keulen, Thomas F. Kokfelt, Alfons Berger, and John C. Schumacher: Archaean tectonics in the Paamiut region, South-West Greenland.

Bo M. Stensgaard, Jochen Kolb, Troels F.D. Nielsen, and Kristine Thrane: The Archaean craton and Palaeoproterozoic mobile belt in South-East Greenland: an overview of our current understanding.

Nynke Keulen, Thomas F. Kokfelt and the Homogenisation Team. A 1:100 000 web-accessible geological map of southern West and South-West Greenland (61°30' - 64°N).

Emma F. Rehnström (compiler): 64 V.2 Syd. Kapisillit: A new geological 1:100 000 map sheet in the Nuuk area, SW Greenland.

11th SGA biennial meeting, Antofagasta, Chile

The SGA Council and the SGA2011 Local Organizing Committee invited all professionals and students who work in the field of economic geology to participate in the 11th SGA Biennial Meeting, which was held in the coastal city of Antofagasta, Chile, at the Enjoy Resort and Casino. The goal is to promoting the exchange of knowledge and experience among geoscientists. The SGA2011 conference represents an exceptional opportunity for the exchange of information and experiences among international lecturers, exploration and research geologists and students in economic geology. The main technical program was held over four days from Monday, September 26 to Thursday, 29 September, 2011, with the following daily structure: Monday, 26 and Tuesday, 27 September: Morning plenary sessions, afternoon concurrent technical sessions. Wednesday, 28 and Thursday, 29 September: Concurrent technical sessions.

Plenary sessions Keynote speakers

- Sergio Rivera (Exploraciones Mineras Sociedad Anónima, filia CODELCO)
- Christoph Heinrich (Institut für Geochemie und Petrologie, ETH Zurich)
- Martin Reich (Departamento de Geología, Universidad de Chile)
- Noel White (Consulting Geologist)
- Richard Sillitoe (Consulting Geologist, London)
- Constantino Mpodozis (Antofagasta Minerals)
- Lluis Fonbote (Département de Minéralogie, Université de Géneve)
- Bernd Lehmann (Mineral Resources, Technical University of Clausthal)
- Stuart Bull (CODES, University of Tasmania)
- Sergei Cherkasov (IAGOD, Vernadsky State Geological Museum of Russian Academy of Sciences)
- Fernando Tornos (presidential address)(Instituto Geológico y Minero de España)

Sessions

S1 ORE FORMING PROCESSES

S1.1 Large Scale Controls on Ore Genesis

S1.2 Dating Ore Deposits

S1.3 Geochemistry of Ore Systems

S1.4 New Advances in the Study of Mineral Deposits

S2 STYLES OF MINERALIZATION

S2.1 Porphyry Systems and Related Mineralization Styles

S2.2 IOCG and Magnetite-Apatite Deposits

S2.3 Orogenic Gold Deposits

S2.4 Upper Mantle to Weathered Surface: Mineral Deposits in Mafic-Ultramafic Terranes

S2.5 Epithermal Systems

S2.6 Sedimentary- and Volcanic-hosted Ore Deposits

S2.7 The Cherry on Top - Supergene Ore Formation During Climate and Land scape Evolution

S2.8 Lithium, Salars and Industrial Mineral Deposits

S3 ORE DEPOSITS IN SOUTH AMERICA

S3.1 New Developments in Cordilleran Evolution and Metallogeny

S3.2 Ore Deposits in South American Shields

S3.3 New Discoveries in South America

S4 APPLIED GEOLOGY

S4.1 Energy Resources

S4.2 Geometallurgy

S4.3 Sustainability in Mining and Related Environmental Issues

J. Kolb held a talk ”Metamorphosed and orogenic gold-quartz veins of the Paamiut gold province, South-West Greenland: a genetic model for prograde metamorphism of orogenic gold deposits” in session S2.3. Colleagues from all over the world were attending, and with some possible future projects in Greenland were discussed. D. Schlatter and J. Kolb presented a poster with the title “Host rock composition and hydrothermal alteration as tools for exploration in the Nanortalik gold district” in the same session.

The next SGA meeting, 12th SGA biennial meeting, will be held in Uppsala, Sweden, the 12-15 August 2013. J. Kolb will be responsible of organizing a special session on Greenland and look into possibilities of organizing a field trip to Greenland for interested participants.

In connection to the SGA meeting, D. Schlatter visited the “Structural-lithological controls on porphyry and epithermal mineralization. The Porphyry-epithermal transitions of Northern Peru” workshop at the University of Cajamara on the 1st of Oktober. Here he held a talk with the titel: "The Proterozoic Nalunaq, narrow high grade gold deposit in South Greenland".

New results produced in 2011

New geochronological data

An extensive reporting and interpretation of the geochronological data is found in GEUS report 2011/12: Kokfelt, T.F., Keulen, N., Næraa, T., Nilsson, M., Scherstén, A., Szilas, K. & Heijboer, T.: Geochronological characterisation of the felsic rocks of the Archaean craton in South-West Greenland and southern West Greenland, 61°30′ - 64°N. Here we give the new data produced in 2011. 21 additional samples were analysed in preparation for the scientific articles produced in relation to this report (see Tabel 1).

GGU #		coordinates	rock type
510135	N 62.951165 W 49.761513	Pegmatite	**main age peak**
510138	N 62.953273 W 49.760642	Pegmatite	2686 ± 12 Ma
510169	N 62.944282 W 49.769422	Granite	2916 ± 7 Ma
510170	N 62.951165 W 49.761513	Pegmatite	2898 ± 2 Ma
511530	N 61.80175167, W 48.431815	Granite	2711 ± 8 Ma
511539	N 61.905315, W 48.591575	Tonalitic gneiss	2551± 6 Ma
511586	N 61.723368 W 48.223253	Tonalitic gneiss	2853±3 Ma
511609	N 61.94415 W 48.39569	Tonalitic gneiss	2904 ± 11 Ma
511622	N 61.884162 W 48.223243	Aplite	2903 ± 5 Ma
511899	N 61.813192 W 48.778295	Orthogneiss	no peak
513832	N 63.346317 W 49.282887	Metaleucogabbro	2907 ± 13 Ma
513856	N 63.346223 W 49.275968	Granite	2777 ± 7 Ma
519410	N 61.82869 W 48.33367	Bt-gt-gneiss	2777 ± 35 Ma
519425	N 61.822522 W 48.347143	tonalic gneiss	2881 ± 7 Ma
519431	N 61.862987 W 48.622212	tonalic gneiss	2890 ± 5 Ma
519440	N 62.091700 W 49.195090	granite	2922 ± 5 Ma
519443	N 62.091057 W 49.166758	granite	2721 ± 11 Ma
519454	N 62.108117 W 49.154833	granite	2735 ± 10 Ma
519921	N 62.651957 W 49.569628	Tonalitic gneiss	2728 ± 4 Ma
519939	N 62.625123 W 49.930262	Tonalitic gneiss	3039 ± 9 Ma
519945	N 62.716860 W 49.848030	Pegmatite	2808 ± 6 Ma

Tabel 1: Dated zircon samples (Appendix 2)

Here, we give a summary of the applied analytical procedure, for more details, the reader is referred to the report above:

All geochronological data were analysed at GEUS by Laser Ablation Sector Field Inductively Coupled Plasma Mass Spectroscopy (LA-SF-ICPMS). Pb/Pb and U/Pb ages, as well as, absolute U and Th concentrations were determined from single spot analyses of zircon grains. The method uses a focused laser to ablate minute quantities of a sample contained in an air-tight sample chamber. The ablated material is transported in a helium carrier gas via a tygon plastic tubing to the mass spectrometer for isotopic determination. For the spot diameter of 30 µm and ablation times of 30 s the amount of ablated material approximates ca 200-300 ng. The reported analytical uncertainties related to the ages are on the 2σ level. A large number of zircon grains (i.e., 50-150, usually about 100) were analysed per sample in order to obtain a sufficient statistical basis for identifying individual age peaks in samples exhibiting multiple age components. Interpretation of zircon ages was in part based on visual inspection of zircon types from back-scattered electron images, which allowed for distinguishing primary magmatic from metamorphic zircons, and in part from the measured Th/U ratio in the zircons, which further allowed to identify magmatic zircons from metamorphic zircons, as the latter often have lower Th/U ratios.

After initial data reduction of the data, which was done in GEUS' data U/Pb reduction software 'Zirchron', further data handling and plotting was carried out in an off-line Excel sheet utilising the add-on macro program 'Isoplot' by Ludwig (Ludwig, K.R. 2003: Mathematical-statistical treatment of data and errors for Th-230/U geochronology. Uranium-Series Geochemistry, Reviews in Mineralogy and Geochemistry 52, 631–656). For the unravelling of distinct age populations in samples showing complex age patterns the 'unmix' function of 'Isoplot' program was applied; with the 'unmix' function it is possible to quantify the number and relative size of individual age components in a sample using a least squares residual approach.

The reproducibility of the age determinations was evaluated from analysing secondary standards along with the samples and from replicated analyses of individual samples. Two different zircon standards were used during the data acquisition period in this project, each representing different age ranges. First and foremost, we used the Plesovice zircon standard (Carboniferous age), which has been described in the literature; the obvious disadvantage of using the Plesovice in this context is that it is considerably younger than the rocks generally dated in this project, which are Archaean (ca. 2.5-3.2 Ga). To compensate for the latter, and in lack of an adequate international standard of Precambrian age, a second 'in house standard' was introduced in this study; this was zircons separated from a sample of the Archaean 'Ilivertalik granite' (2.80 Ga).

The new zircon U/Pb age data are reported in Appendix 2 as a series of crafted display sheets, one sheet for each sample, also providing an interpretation of the obtained age data. An example of a sheet is given in Figure 1. Each age display sheet provides as standard, a Tera-Wasserburg diagram, a probability density distribution diagram (and/or an averaged age plot) and a Th/U vs. age diagram. Also shown are SEM images (by back-scattered electrons) of representative zircon grains for each sample – to give an impression of the material dated. To each sample sheet the basic information is provided concerning the sample number, coordinates, collector, Ganfeld station, aim of the dating and an interpretation of the age(s) obtained.

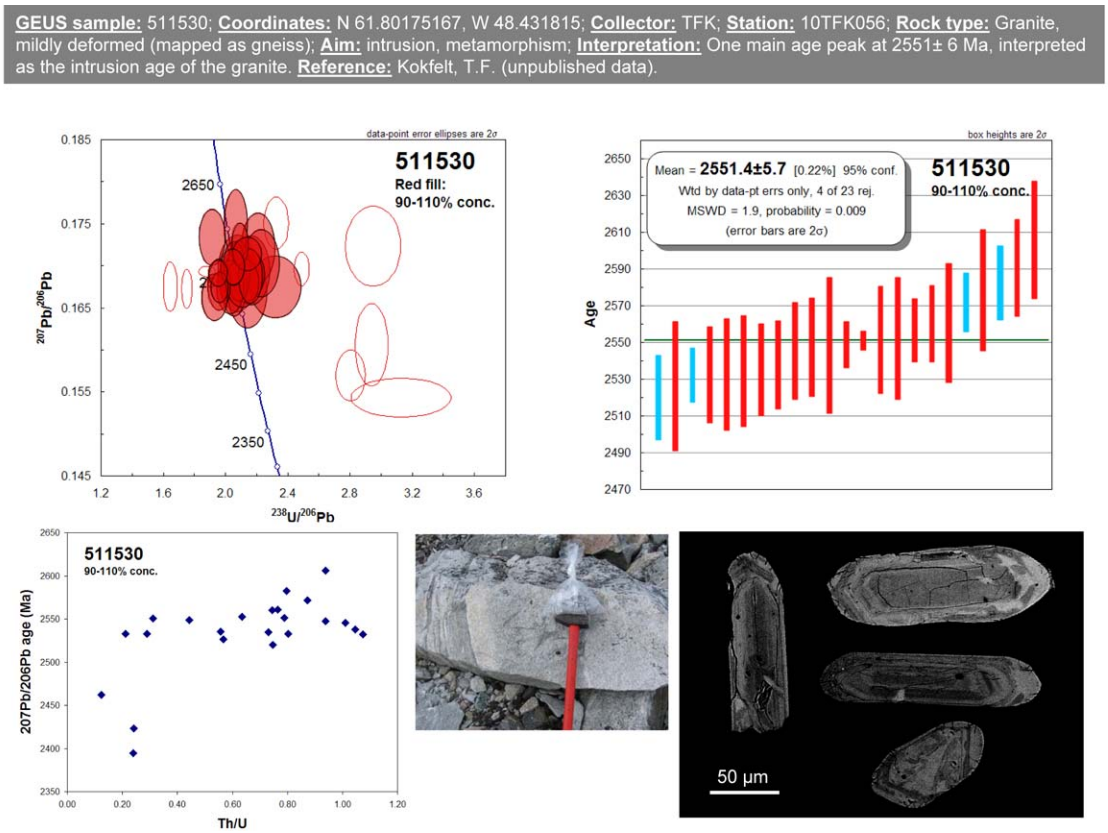


Figure 1: Example of a zircon age data report sheet, here showing sample 511530.

New predictive mineral potential for gold in southern West Greenland and South-West Greenland

Based on established characteristic of gold occurrences in the Nuuk region, southern West Greenland and South-West Greenland, and the identified data signatures for gold occurrences in the Nuuk region a predictive artificial neural network analysis for the favourability for gold was carried out. The work that is presented here will be described in detail in the GEUS report: Stensgaard, B.M., Steenfelt, A., & Rasmussen, T.M. (in prep): Gold potential in South-West Greenland through integrative data analysis by empirical, neural network and self-organising maps methods.

Artificial neural network is a mathematical structure modelled on the human neural network that is able to tackle statistical problems such as pattern recognition, multivariate analysis learning and memory. The essential feature of such a structure is a network of simple processing elements (artificial neurons) coupled together so that they can cooperate.

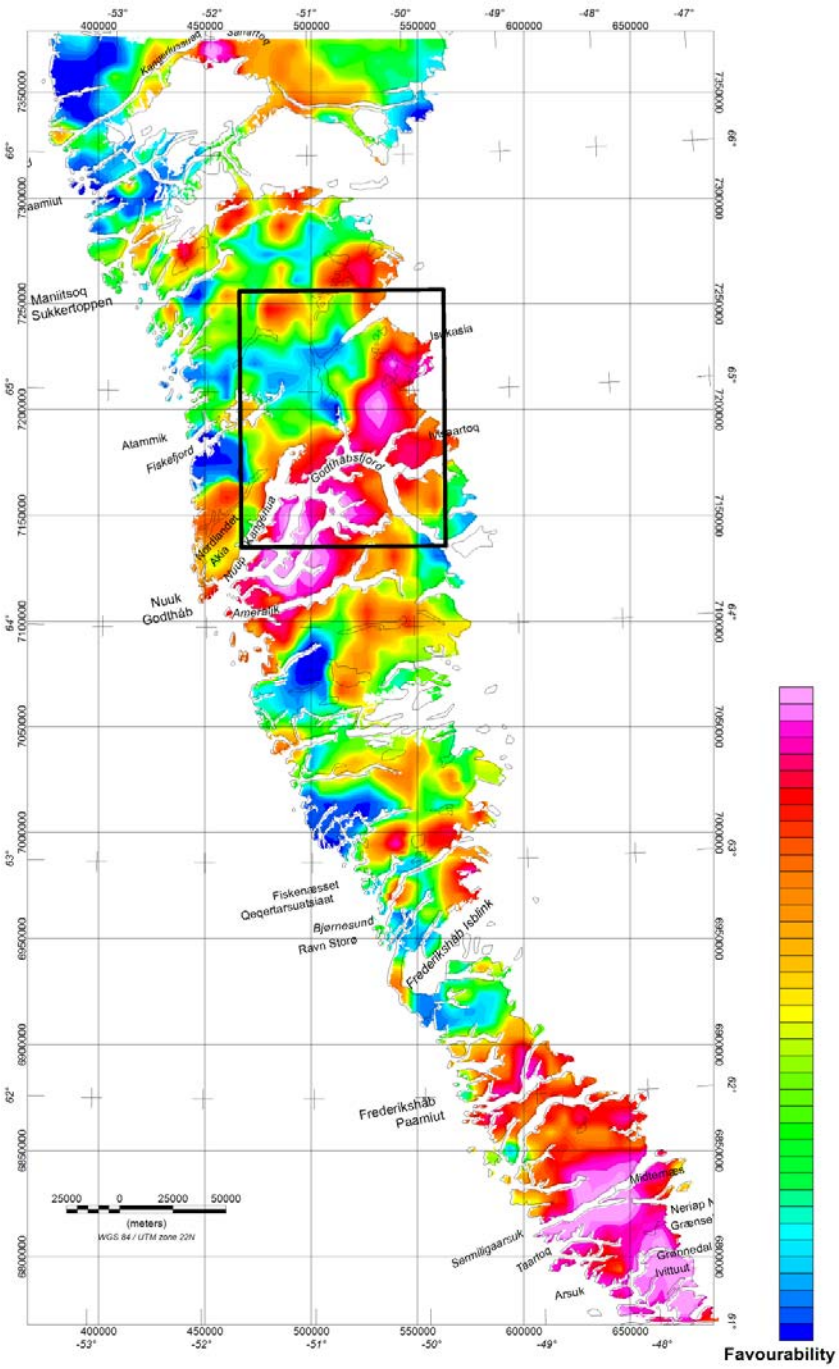


Figure 3: Neural network predictive results for gold potential in southern West Greenland based on stream sediment geochemistry distribution of As, Cs, Sb, U and Rb. Predicted lowest gold favourable are shown in blue, highest are shown in pink.

Basically, different datasets and sites with known gold occurrences (targets) are used to train the neural network to recognise the sites with the gold occurrences. The training is carried out for a number of gold occurrences within a training area, which in this case stretches from central part of Storø, central Godthåbsfjord, in the southwest to north of Isukasia in the northeast (see black box in Fig. 3). The neural network then applies what it has learned from the datasets to a second dataset (a simulation area), which in this case

covers entire southern West Greenland from just north of Kobberminebugt in the south (~61°15'N) to just north of Sukkerkappen (66°35'N) in the north (Fig. 3). The 42 gold occurrences, which are used as targets for the training of the neural network, are defined as 200 × 200 m areas in which one or more rock samples yielded more than 1 g/t Au. The rock samples are extracted from GEUS rock sample data base and various publicly released company reports. The extraction is based on samples collected before 2004.

The datasets that are used as inputs have previously been established from empirical distribution function analysis of a large number of different datasets to have characteristic data signatures of the gold occurrences in the Nuuk region. The input dataset are stream sediment geochemistry distribution for the geochemical elements As, Cs, Sb, U, Rb. These elements are well-known pathfinder elements for gold. The results from the neural network predictive analysis for gold based on the above stream sediment geochemistry distribution are shown in Figure 3. Well-known areas, outside the training area, with gold are outlined clearly by the results, e.g. at Paamiut, Tartoq and Grænseland. However, other areas, with lesser-known or unknown gold mineralisations, are also outlined. These areas are e.g. areas north of Isukasia, Bjørnesund, east of Fiskenæsset, outer Fiskefjord, a corridor from Maniitsoq to the Inland Ice and an area north of the north-western part of Sukkertoppen Iskappe (Fig. 3).

It has been shown earlier that the majority of gold occurrences in the Nuuk region and rest of southern West Greenland and South-West Greenland is strongly correlated with geological lineaments; e.g. structural lineaments (fault/shear/thrust zones), lithological/rheological contacts/contrasts (e.g. Kolb et al 2009, 2010; GEUS reports 2009/58; 2010/47). Lineaments extracted from aeromagnetic total magnetic intensity field data by a combination of image analysis and discontinuity analysis of the magnetic field. The extraction is based on two steps. Firstly, based on a texture analysis-based image enhancement that highlights local intensity variations which enhances regions of discontinuity within the magnetic dataset. The regions of magnetic discontinuity correspond with, and can identify, lithological boundaries, faults/structures, and dykes. Secondly, discontinuity structure detection is carried out on the output of the texture analysis. This detects the skeletal structure of the regions of the magnetic discontinuity. The output of this detection is a set of a binary skeletal line segments that belong to each of the discontinuity regions, showing the changes of orientations and offsets within the structures. As the geological lineament seldom represent only a thin line, but ussually a zone, and as possible gold mineralized sites can be found in the near vicinity of the lines representing the geological lineaments a buffer zone of 100 m on both sides of the extracted lineaments have afterwards been added. The resulting buffered lineaments are shown in Figure 4.

The results from the neural network predictive analysis for gold based on the As, Cs, Sb, U, Rb stream sediment geochemistry distribution and the lineaments extracted from the aeromanetic data are shown in Figure 5 and 6. The same areas, as for the analysis of stream sediment geochemistry only, are outlined, but the inclusion of the lineaments gives better details to the results.

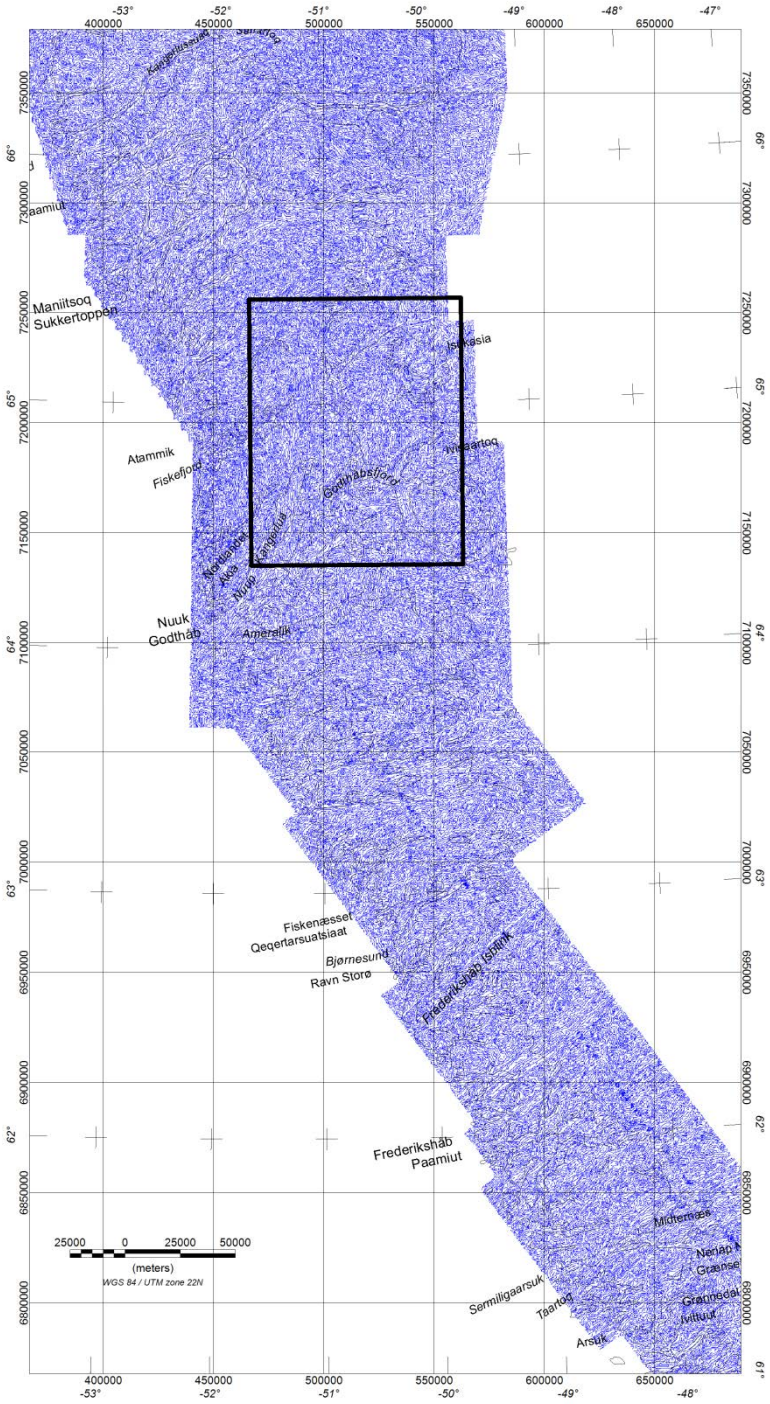


Figure 4: Lineaments extracted from aeromagnetic total magnetic intensity field data by image analysis and discontinuity analysis of the magnetic field.

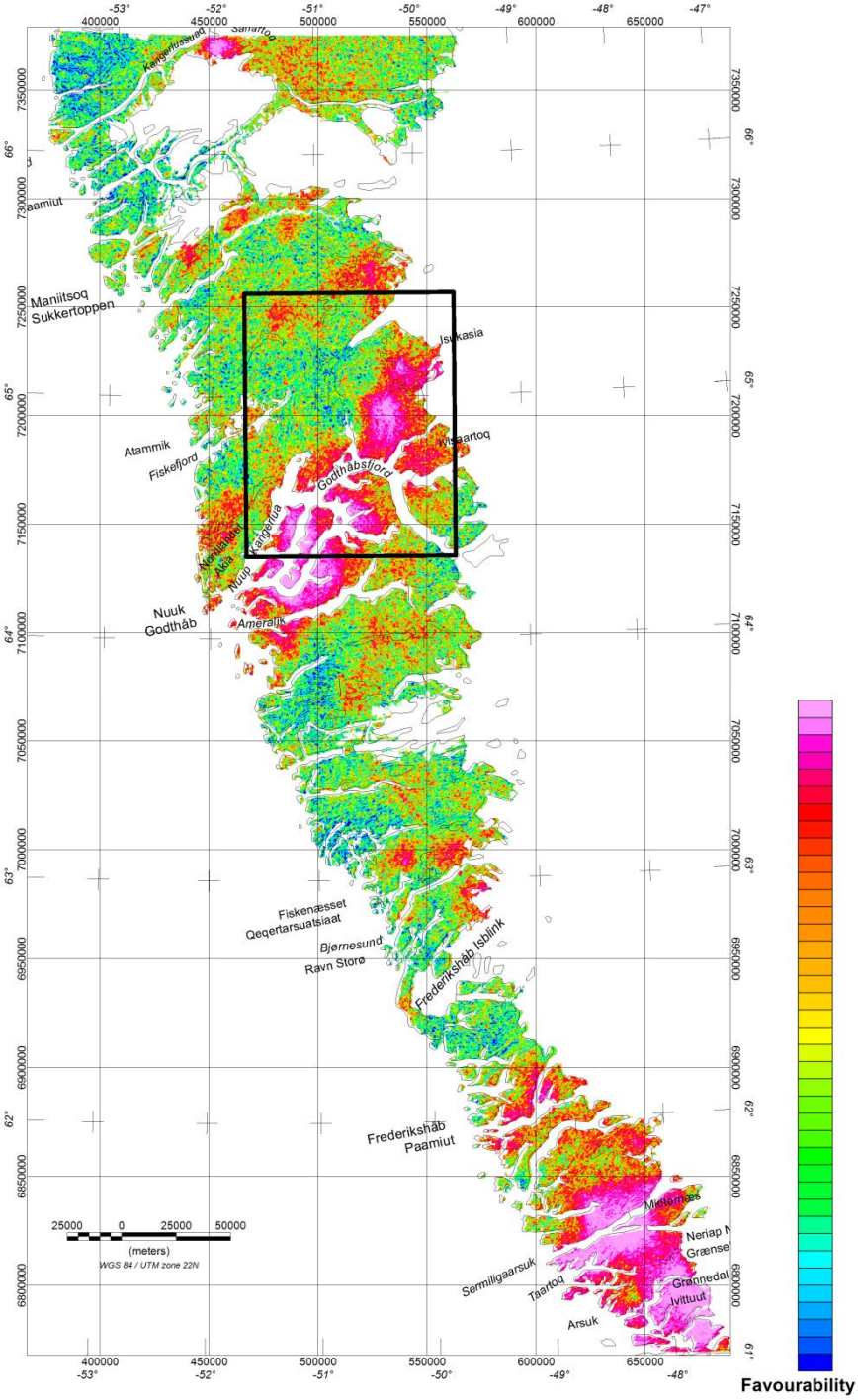


Figure 5: Neural network predictive results for gold potential in southern West Greenland based on stream sediment geochemistry distribution of As, Cs, Sb, U and Rb and extracted lineaments from aeromagnetic total magnetic intensity field data. Predicted lowest gold favourable are shown in blue, highest are shown in pink.

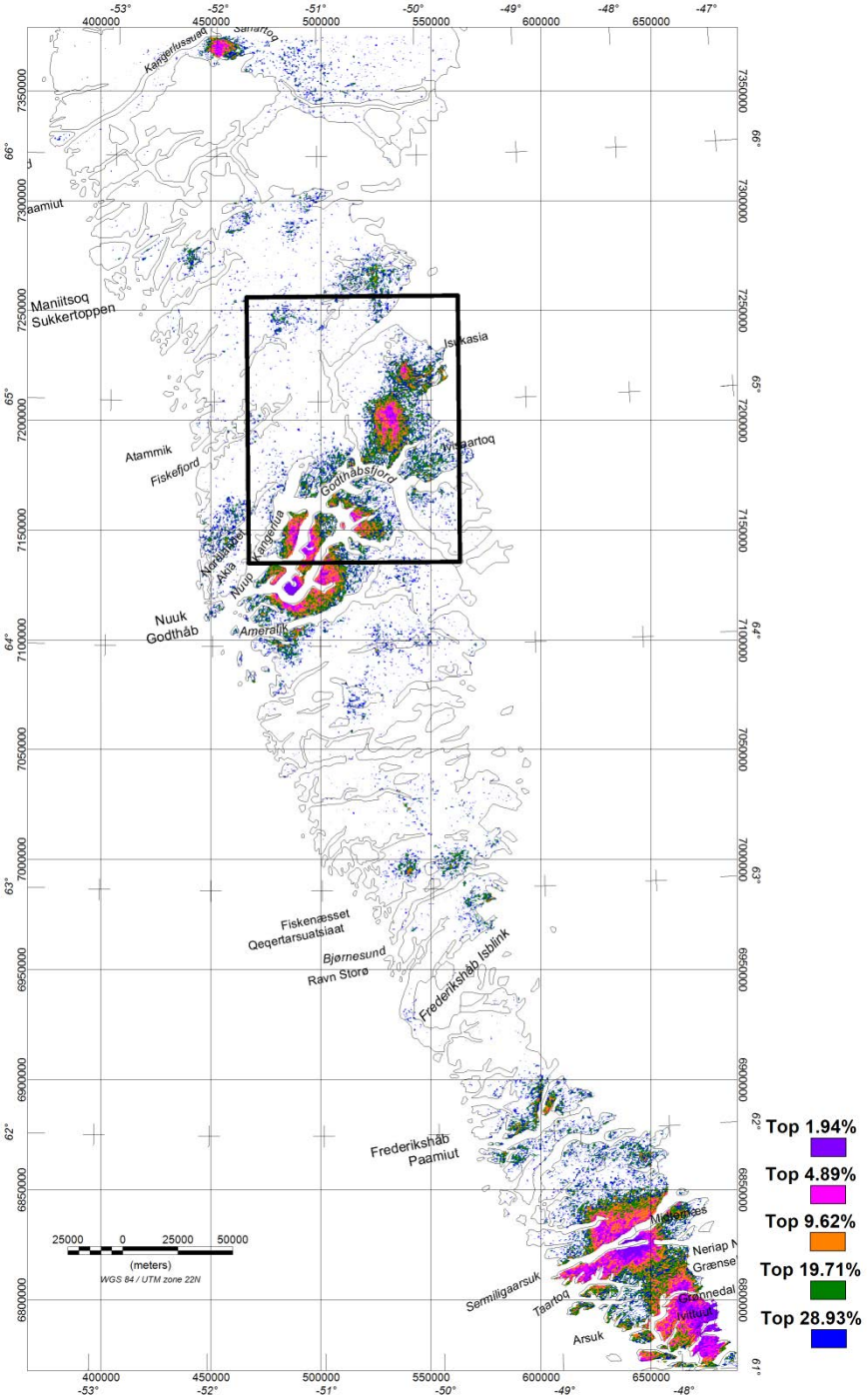


Figure 6: Outline of different top percentile areas in entire southern West Greenland with highest favourability for gold based on the neural network predictive results of stream sediment geochemistry distribution of As, Cs, Sb, U and Rb and extracted lineaments from aeromagnetic total magnetic intensity field data. The top 1.95% most favourable area is shown in purple with the top 4.98%, 9.62%, 19.71% and 28.93% areas outlined below.

Digitised maps

For the scientific publications, a range of geological maps needed to be digitised. Additionally, technical drawing skills of GEUS' in-house professionals were used to produce Figures for the scientific publications. This digitisation and drawing has been paid for by GEUS, as a part of GEUS' contribution to the project.

- Schematic geological map of (a) southern West and (b) South-West Greenland
- Schematic geological map showing the Qilanngaarsuit Island.
- Schematic geological map of the Bjørneø supracrustal belt.
- Schematic geological map of central Storø.
- Schematic geological map of Qussuk.
- Geological map of the Isua, Ivisaartoq, and Ujarassuit greenstone belts.
- Geological maps of the Tasiusarsuaq area.
- Sketch illustrating the structural control of quartz veins and alteration halos.
- Sketch of a cliff wall south of Grædefjord.
- Schematic geological map of the folded supracrustal belt north of Sermilik.
- Schematic geological map of the Sioraq and Paamiut blocks.
- Schematic geological map of the Tartoq gold province.
- Schematic northwest-southeast cross section showing the northern contact of the Tasiusarsuaq terrane.
- Schematic sketch of the structural situation for the Paamiut and Tartoq gold provinces.
- Sketch of the proposed tectonic setting of the Paamiut gold province.
- Sketch of the proposed tectonic setting during gold mineralization in the Godthåbsfjord and Tasiusarsuaq gold provinces.
- Schematic geological map of the Bjørnesund and Ravns Storø area
- Geological map of the northern outer Bjørnesund fjord area
- Geological map of the part of the Bjørnesund Greenstone Belt
- Lithological profile for the eastern part of the Bjørnesund Greenstone Belt
- Lithological profile for the northern outer Bjørnesund fjord area
- Lithological profile for the northeastern coast of Ikkattup Nunaa.

Ar-Ar dating of three pseudotachylyte samples

Three samples of pseudotachylytes were dated with $^{40}Ar/^{39}Ar$ at the University of Lund, Sweden, by Anders Scherstén and Laurence Page with a Micromass-5400 Gas Source Mass Spectrometer with a faraday and an electron multiplier. The samples were collected during the fieldwork in 2008 from brittle fault rock outcrops in the Bjørnesund and Ravns Storø areas.

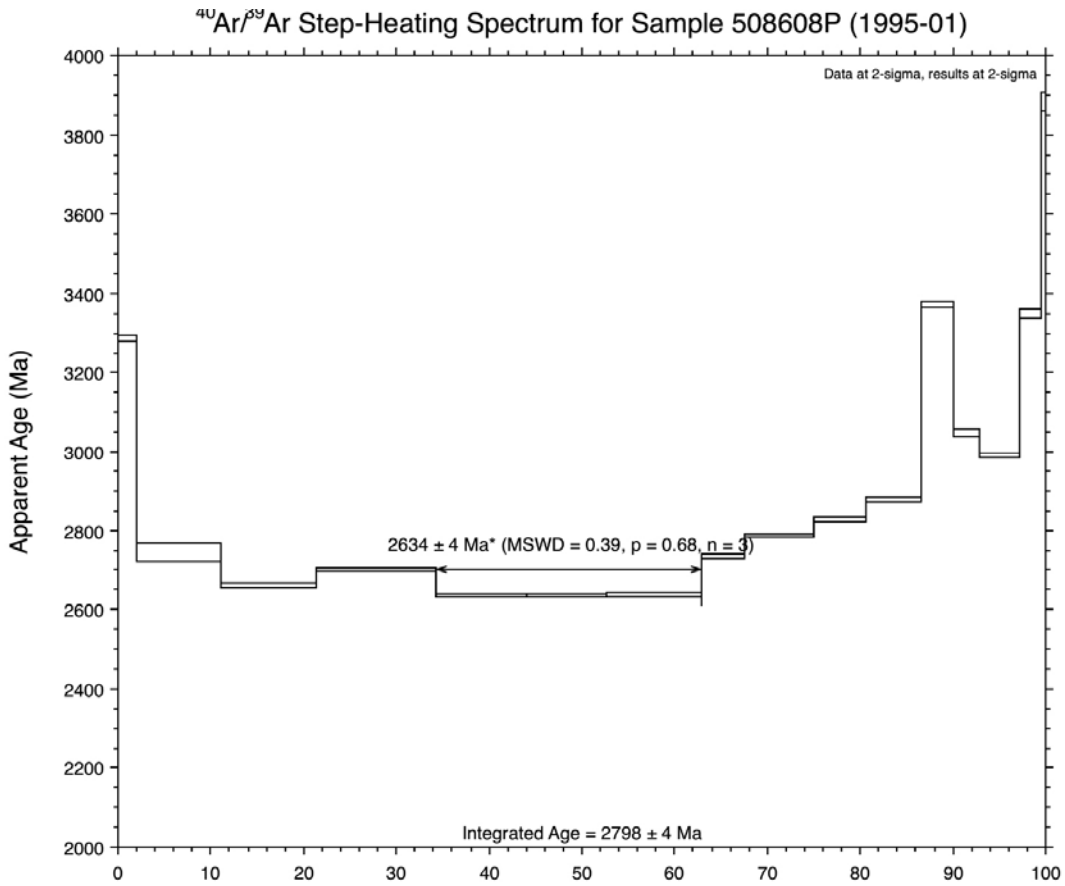
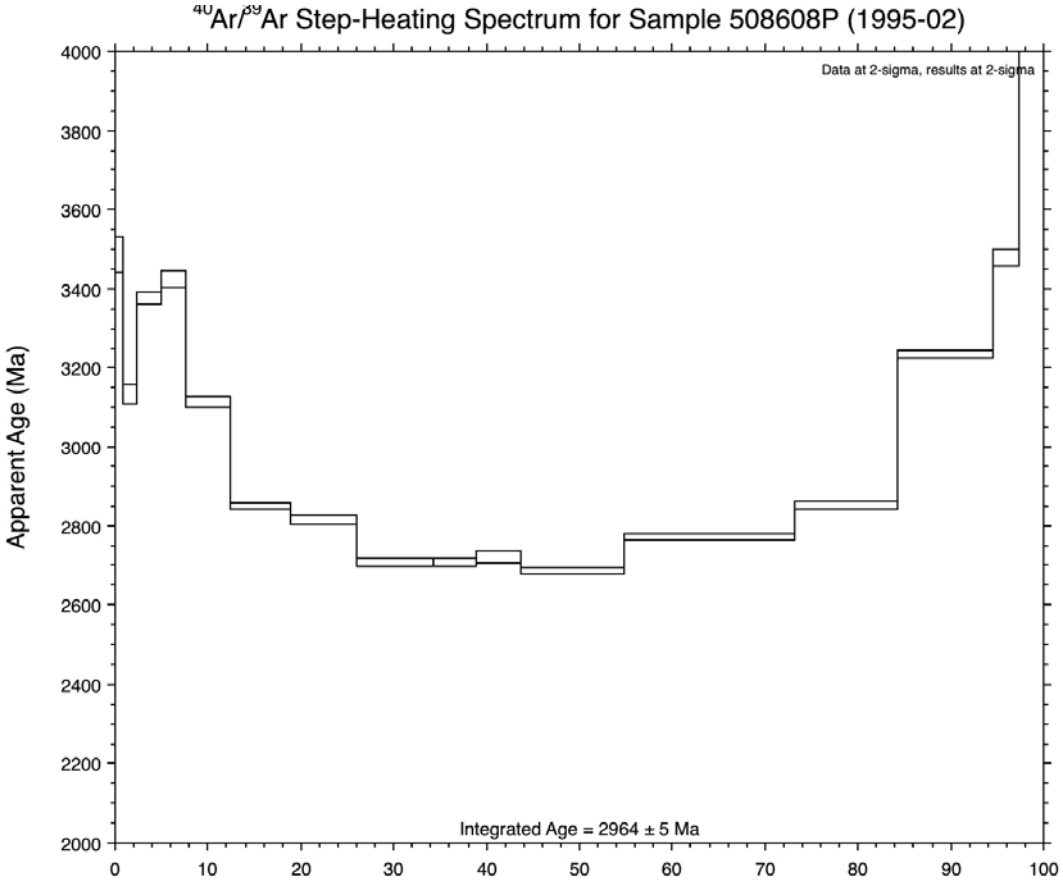
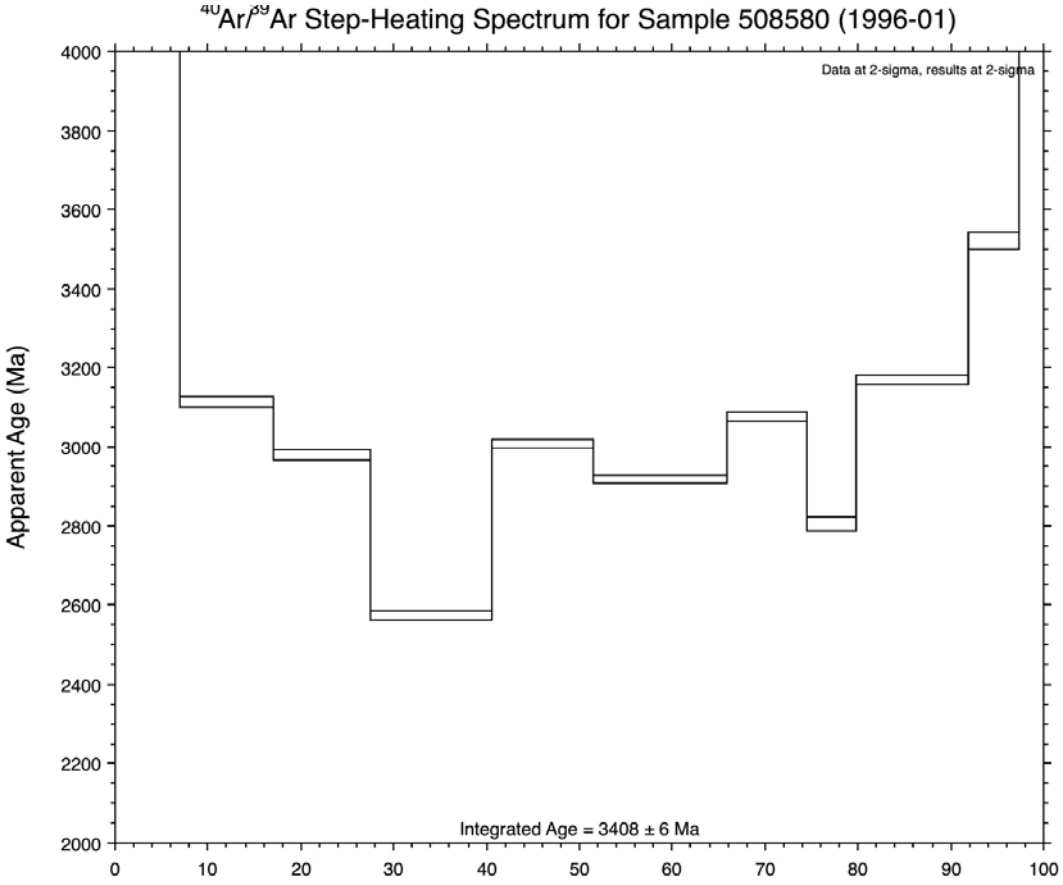


Figure 7: $^{40}Ar/^{39}Ar$ step heating spectrum for samples 508608 and 508580 (above and next page). Plateau ages and integrated ages are indicated.

Sample 508608 (1995-01) shows a plateau age of 2634 ± 4 Ma (Figure 7), which might indicate a late Archaean brittle overprint of the earlier Meso- and Neo-Archaean geological history. The age either indicates the true age or the maximum age of the sample. The other run of this sample 508608 (1995-02) hints at similar results, but no plateau was reached, possibly due to contamination of the pseudotachylyte with tiny host rock fragments. Sample NTK508608 was collected at the brittle fault zone east of the Bjørnesund fjord.


$^{40}Ar/^{39}Ar$ Step-Heating Spectrum for Sample 508608P (1995-02)
Data at 2-sigma, results at 2-sigma
Apparent Age (Ma)
Integrated Age = 2964 ± 5 Ma


$^{40}Ar/^{39}Ar$ Step-Heating Spectrum for Sample 508580 (1996-01)
Data at 2-sigma, results at 2-sigma
Apparent Age (Ma)
Integrated Age = 3408 ± 6 Ma

Theses, abstracts, reports, and articles in 2011

Theses, abstracts, and reports produced in 2011

In cooperation with external participants, the following articles, theses, abstracts and reports were produced in relation to the project in 2011. Abstracts for the EGU conference were listed earlier in this report.

Coetzee, M.: Frederikshåb Isblink lamprophyre sheets and dykes: probing the petrogenesis of a sub-glacial igneous centre. BSc Honours Thesis Stellenbosch University (to be submitted November 2011).

Flock, R., 2010, Petrographie und Mineralchemie hydrothermaler Quarzgang-Systeme in Amphiboliten des Færingehavn Terrans, SW Grönland. BSc thesis, RWTH Aachen University, 86 pp.

Hoffritz, S. E., 2011, Modellering af hydrotermale omdannelser og Au mineraliseringer i Nuuluk området, Tartoq guldprovins, Copenhagen University, 54 p.

Keulen, N., Schumacher, J.C. & Kokfelt, T.F. 2011:.Notes on established structural profiles related to the 1:100 000 digital geological map of southern West and South-West Greenland, 61°30′ - 64°N. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2011/13, 68pp.

Kokfelt, T.F., Keulen, N., Næraa, T., Nilsson, M., Scherstén, A., Szilas, K. & Heijboer, T. in prep: Geochronological characterisation of the felsic rocks of the Archaean craton in South-West Greenland and southern West Greenland, 61°30′ - 64°N. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2011/12.

Kolb, J. (ed.), 2011, Controls of hydrothermal quartz vein mineralisation and wall rock alteration in the Paamiut and Tartoq areas, South-West Greenland, Geological Survey of Denmark and Greenland Rapport 2011/114, 176pp.

Kolb, J.: Metamorphosed and orogenic gold-quartz veins of the Paamiut gold province, South-West Greenland: a genetic model for prograde metamorphism of orogenic gold deposits. SGA 2011 Abstract volume, 547-549p.

Koppelberg, M., 2011, Geochemische und petrologische Charakterisierung einer goldführenden hydrothermalen Alterationszone auf der Insel Qilanngaarsuit, SW Grönland. Diploma thesis, RWTH Aachen University, 70 pp + Anhang. (submitted in September 2011).

Klausen, M.B., Kokfelt, T.F., Keulen, N., Berger A., & Schumacher, J.C. 2011, Geochemistry of Archaean serpentinites, tholeiitic amphibolites and calc-alkaline schists across the Nigerlikasik section in the Kvanefjord Region, South-West Greenland (~62°S). Geological Survey of Denmark and Greenland Rapport 2011/11, in review.

Klausen M.B., Berger, A. Kokfelt, T.F., 2011, Archaean structures around the proposed tectonic boundary along Frederikshåb Isblink, southern West Greenland (62°25′ - 62°45′N). Geological Survey of Denmark and Greenland Rapport 2011/14.

Pieters, J.: Formation of an intrusive meta-gabbro suite in the TTG's of the Kangaarsuup Nunaa (South-West Greenland). BSc Honours Thesis Stellenbosch University (to be submitted November 2011).

Reynolds, K., 2011, Chemical mass transfer during alteration and gold mineralization of the Tartoq Group greenstones, Sermiligaarsuk Fjord, SW Greenland, Imperial College, 48 p.

Schlatter, D.M., Kolb, J.: Host rock composition and hydrothermal alteration as tools for exploration in the Nanortalik gold district. SGA 2011 abstract 65.

Schlatter, D.M. and Stensgaard, B.M. 2011 (in prep./2011): Gold potential in the Buksefjord area, southern West Greenland: results from field work and follow-up on remote sens-ing and predictive mineral potential anomalies. Danmarks og Grønlands Geologiske Undersøgelse Rapport.

Stensgaard, B.M., Steenfelt, A., and Rasmussen, T.M. 2011 (in prep./2011): Gold potential in South-West Greenland through integrative data analysis by empirical, neural network and self-organising maps methods. Danmarks og Grønlands Geologiske Undersøgelse Rapport.

Stoltz, N.B., 2011, Metamorphe Entwicklung von mafischen Granuliten des Tasiusarsuaq Terrans, SW Grönland. Diploma thesis, RWTH Aachen University, 108 pp. (submitted in August 2011).

Szilas, K., van Hinsberg, V.J., Kisters, A.F.M., Kokfelt, T.F., Scherstén, A. & Windley, B.F. 2011. Remnants of Mesoarchaean oceanic crust in the Tartoq Group, North Atlantic Craton, SW Greenland. Geological Survey of Denmark and Greenland Bulletin 23, p57-60.

Szilas, K., van Hinsberg, J., Kisters, A.F.M., J. Hoffmann, E., Kokfelt, T.F., Scherstén, A., Windley, B.F. & Münker, C. Geochemistry of the Tartoq Group, SW Greenland. Gondwana Research (in review).

Szilas, K., van Hinsberg, V.J. & Kisters, A.F.M. 2011. Mesoarchaean suprasubduction zone ophiolite in the Tartoq Group, SW Greenland. Mineralogical Magazine, Goldschmidt Conference abstract, p 1977.

The finished theses were sent to Råstofdirektoratet earlier as paper copies. On-going research projects will be reported subsequently by sending copies of the publications.

Scientific contributions

The following scientific contributions were produced in this project:

Kolb J., Kokfelt T.F., Dziggel A.: Geodynamic setting and deformation history of an Archaean terrane at mid-crustal level: the Tasiusarsuaq terrane of southern West Greenland. Precambrian Research, in review.

Kolb J., Dziggel A., Schlatter D.M.: Gold Occurrences of the Archean North Atlantic Craton, Southern West and South West Greenland: A Review and First Approach to a Comprehensive Genetic Model. Planned for Ore Geology Reviews, in prep.

Keulen, N., Schumacher, J.C., Szilas, K., Schlatter, D.M., Kokfelt,T.F., Scherstén, A. & van Hinsberg, V.J., Windley, B.F.: Late Archaean geological history of the Bjørnesund greenstone belt, southern West Greenland – tectonometamorphic conditions favouring gold enrichment and sapphirine formation. Planned Precambrian Research, in prep.

These scientific contributions are submitted or to be submitted in the nearest future. As scientific journals require that the material in the publications is not published before (see a copy below), we provide the drafts of the papers on a CD delivered to RD, which is confidential until publication of the papers.

Statement Elsevier:

“Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.”

A further publication is expected to be finished in 2012. A draft will be deposited to RD on a (confidential) CD, following the same conditions:

Thomas F. Kokfelt, Nynke Keulen, Tomas Næraa, Mimmi Nilsson, Anders Scherstén, Kristoffer Szilas, and Tjerk Heijboer: Geochronological characterisation of the felsic rocks of the Archaean craton in South-West Greenland and southern West Greenland, 61°30′ - 64°N.

Appendix 1: EGU conference Vienna

Til: Henrik Stendal, RD

Fra: Thomas Kokfelt, NTK; JKOL

Kopi til: FGC, KHA, LTH, GEUSJ

Fortroligt: NEJ Dato: 11/05/2011

GEUS-NOTAT nr.: 11-MI-11-02 J.nr. GEUS: 49-0001/43-439

Emne: Præsentation af videnskabelige forskningsresultater fra SV Grønland ved EGU-mødet i Wien, 3-8. april, 2011.

Dette notat dokumenterer de faglige bidrag som GEUS' Afdeling for Petrologi & Malmgeologi leverede ved det årlige European Geosciences Union møde, som fandt sted i Wien fra d. 3-8/5 2011. På baggrund af den intense aktivitet som GEUS har haft i Sydvestgrønland de seneste tre år, tog Petrologi & Malmgeologi afdelingen initiativ til at udbrede den indhøstede nye viden ved at arrangere en speciel session ved EGU 2011 mødet. Sessionens tema var det Nordatlantiske arkæiske kraton med særlig fokus på Sydvestgrønland med sessionsbetegnelse "GMPV22/TS1.5 / Geology of the North-Atlantic Craton". Convenors var Nynke Keulen, Thomas Kokfelt og Jochen Kolb, alle fra GEUS' afdeling for Petrologi & Malmgeologi.

GEUS's aktiviteter i SV Grønland de seneste tre år har overordnet fokuseret på at reevaluere mineralpotentialet i området mellem 64N og 61.5N og har bl.a. resulteret i flere nye guldfund samt et nyt digitalt geologisk kort (skala 1:100.000), som nu er offentligt tilgængeligt på internettet. Aktiviteterne har gennem hele perioden været støttet finansielt af Råstofdirektoratet i Grønland og af GEUS og arbejdet har involveret geologer fra GEUS samt en lang række internationale institutioner og universiteter. Råstofdirektoratet støttede endvidere EGU mødedeltagelsen for fire GEUS ansatte (Nynke Keulen, Jochen Kolb, Thomas Kokfelt og Denis Schlatter) samt to eksterne deltagere (John Schumacher, Bristol Universitet og Annika Dziggel, Achen Universitet). To ph.d. studerende fra Petrologi & Malmgeologi afdelingen deltog også i mødet med foredrag (Kristoffer Szilas og Tomas Næraa), begge finansieret af GEUS.

Der blev oprindeligt tilmeldt 21 abstacts til sessionen; præsentationerne fordelte sig på 6 foredrag og 13 posters (to abstracts blev tilbagekaldt før mødet). På de følgende sider er programmet for EGU11 session GMPV22/TS1.5 / "Geology of the North-Atlantic Craton" vist efterfulgt af de tilmeldte bidrag i form af abstracts. Sessionsbidragene i form af posters kan findes på EGU's hjemmeside som uploadede PDF-filer (se http://meetingorganizer.copernicus.org/EGU2011/poster_programme/7300). Alternativt kan præsentationer fra mødet rekvireres ved at rette e-mail henvendelse til relevante forfattere eller til én af de tre ovennævnte convenors.

De Nationale Geologiske Undersøgelser
for Danmark og Grønland (GEUS)
Klima- og Energiministeriet

Øster Voldgade 10
1350 København K

Telefon 38 14 20 00
Telefax 38 14 20 50
E-mail geus@geus.dk

European Geosciences Union

General Assembly 2011

Vienna | Austria | 03 – 08 April 2011

Session GMPV22/TS1.5
Geology of the North-Atlantic Craton

GMPV22/TS1.5
Geology of the North-Atlantic Craton

Convener: Nynke Keulen
Co-Conveners: Thomas F. Kokfelt, Jochen Kolb
Convener Login

Oral Programme / Room 31 / Tue, 05 Apr, 08:30–10:00

Poster Programme / Halls X/Y / Attendance Tue, 05 Apr, 17:30–19:00 / Display 08:00–19:30

The conveners of this sessions welcome contributions on all aspects of geology of the North-Atlantic Craton, especially on southern West Greenland, including geochronology, ore geology, structural geology, igneous and metamorphic petrology, geochemistry, geophysics and more.

Oral Programme GMPV22/TS1.5
Geology of the North-Atlantic Craton
Convener: Nynke Keulen
Co-Conveners: Thomas F. Kokfelt, Jochen Kolb
Session Details Poster Programme

Add Session to Personal Programme

Tuesday, 05 Apr 2011
Room: 31
Chairperson: Keulen, Kokfelt, Kolb

08:30–08:45 EGU2011-8427
Jochen Kolb, Denis M. Schlatter, Annika Dziggel, and Alexander F.M. Kisters
Orogenic gold mineralisation in the Archean North Atlantic craton, southern West and South West Greenland

08:45–09:00 EGU2011-13670
Tomas Næraa, Minik Rosing, Anders Scherstén, Elis Hoffmann, Thomas F. Kokfelt, and Tony Kemp
Eo- to Mesoarchaean crust formation in the Nuuk region, southern West Greenland. Constrains from combined U/Pb, Hf and O isotopes in zircon

09:00–09:15 EGU2011-2183
Hugh Rollinson
LILE-depletion in the Archaean lower continental crust: the Lewisian granulites revisited

09:15–09:30 EGU2011-3170
Kristoffer Szilas, Vincent J. van Hinsberg, Alexander F.M. Kisters, Thomas F. Kokfelt, Anders Scherstén, and Brian F. Windley
Remnants of Mesoarchaean oceanic crust in the Tartoq Group, North Atlantic Craton, SW Greenland

09:30–09:45 EGU2011-10078
John C. Schumacher, Nynke Keulen, Charlotte Stamper, Gemma Sherwood, and Vincent van Hinsberg
Metamorphism in southern West Greenland and South-West Greenland

09:45–10:00 EGU2011-10042
Nicolas Benjamin Stoltz, Annika Dziggel, and Jochen Kolb
Formation of garnet coronas during high-P retrogression in mafic granulites of the Mesoarchaean Tasiusarsuaq terrane, southern West Greenland.

Poster Programme GMPV22/TS1.5
Geology of the North-Atlantic Craton
Convener: Nynke Keulen
Co-Conveners: Thomas F. Kokfelt, Jochen Kolb
Session Details Oral Programme

Add Session to Personal Programme
Display Time: Tuesday, 05 Apr 08:00–19:30
Attendance Time: Tuesday, 05 Apr 17:30–19:00
Halls X/Y
Chairperson: Kolb, Kokfelt, Keulen

XY435 EGU2011-10661
Martin B. Klausen, Thomas F. Kokfelt, Nynke Keulen, Alfons Berger, and John C. Schumacher
Tholeiitic ‘komatiite'-basalt and calc-alkaline andesite-dacite succession in the Archaean Kvanefjord Area (South-West Greenland): A composite oceanic and volcanic arc suite?

XY436 EGU2011-13662
Thomas Kokfelt, Anders Scherstén, and Tomas Næraa
New geochronological evidence for a c. 3.1-3.2 Ga old cratonic core in the Fiskenæsset area, South-West Greenland

XY437 EGU2011-14038
Thomas Kokfelt, Nynke Keulen, Tomas Næraa, Anders Scherstén, and Tjerk Heijboer
New zircon U/Pb age data from the Archaean craton, South-West and southern West Greenland (61º30'N - 64º00'N)

XY438 EGU2011-7335
Timothy Johnson
Evidence for partial melting in the central region of the Lewisian complex, Scotland

XY439 EGU2011-7403
Alfons Berger, Thomas F. Kokfelt, and Martin B. Klausen
Geochemistry and petrology of border zones between mafic/ultramafic bodies and surrounding TTG gneisses (SW Greenland)

XY440 EGU2011-10089
Martin Koppelberg, Annika Dziggel, Jochen Kolb, Denis Martin Schlatter, and Robert Flock
Alteration systematics and petrology of gold-bearing quartz veins on the island Qilanngaarssuit, southern West Greenland.

XY442 EGU2011-7359
Denis Martin Schlatter, Jochen Kolb, and Sara Edith Hoffritz
Characterization of host rocks and hydrothermal alteration of the Nuuluk gold occurrences in the Sermiligaarsuk Fjord area, South West Greenland

XY443 EGU2011-10026
Vincent van Hinsberg, Alex Kisters, and Kristoffer Szilas
Constraining the geotectonic setting for the Archaean Tartoq Group (SW Greenland) from its metamorphic and structural history

XY444 EGU2011-12125
Kristoffer Szilas, Adam A. Garde, Anders Scherstén, Jeroen A.M. van Gool, and Claus Østergaard
Mesoarchaean premetamorphic hydrothermal alteration of tholeiitic basalt resulting in aluminous lithologies, Storø supracrustal belt, Nuuk region, southern West Greenland

XY445 EGU2011-11114
Kristoffer Szilas, Anders Scherstén, J. Elis Hoffmann, Thomas F. Kokfelt, Vincent J. van Hinsberg, Brian F. Windley, and Carsten Münker
Linking the Ravns Storø and Bjørnesund supracrustal belts (SW Greenland) using Lu-Hf and Sm-Nd isotopic data and whole-rock geochemistry

XY446 EGU2011-8525
Nynke Keulen, John C. Schumacher, Vincent J. van Hinsberg, Kristoffer Szilas, Brian F. Windley, Thomas F. Kokfelt, Denis M. Schlatter, and Anders Scherstén
The Bjørnesund anorthosite-greenstone belt - a link between the Fiskenæsset complex and the Ravns Storø metavolcanic belt, southern West Greenland

XY447 EGU2011-8660
Nynke Keulen, Thomas F. Kokfelt, Alfons Berger, and John C. Schumacher
Archaean tectonics in the Paamiut region, South-West Greenland

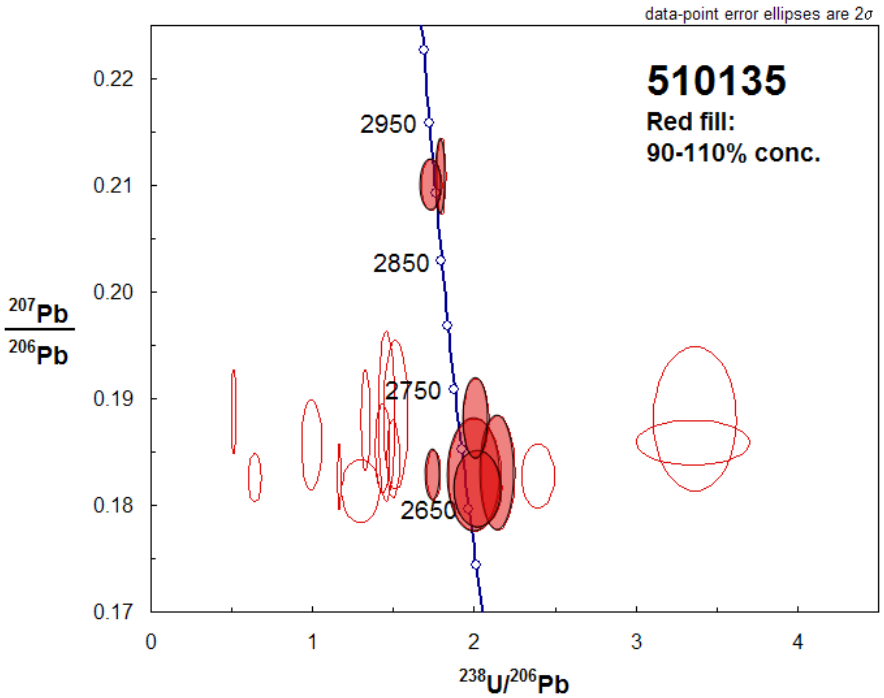
XY448 EGU2011-14021
Bo M. Stensgaard, Jochen Kolb, Troels F.D. Nielsen, and Kristine Thrane
The Archaean craton and Palaeoproterozoic mobile belt in South-East Greenland: an overview of our current understanding

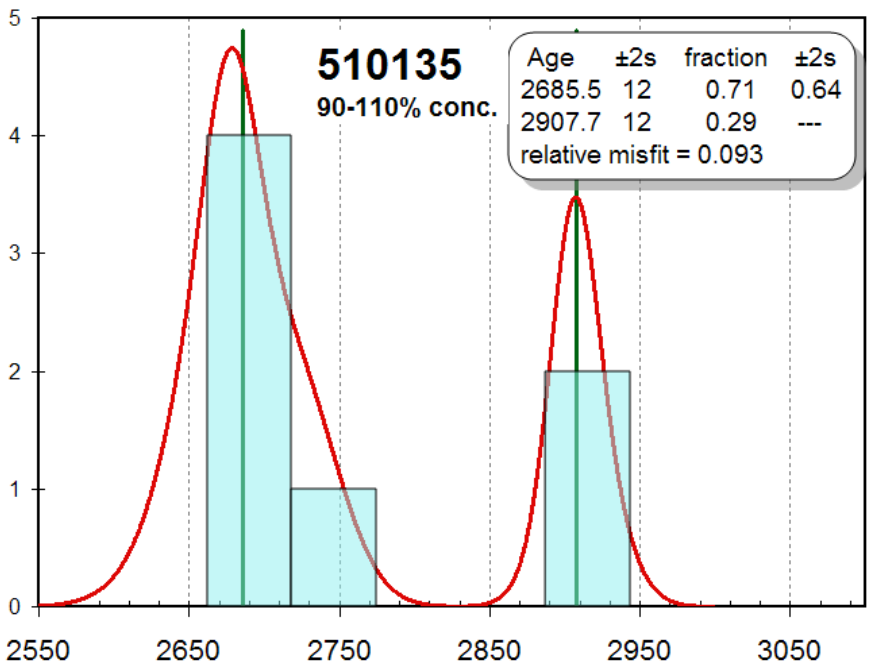
XY449 EGU2011-12336
Nynke Keulen, Thomas F. Kokfelt and the Homogenisation Team.
A 1:100 000 web-accessible geological map of southern West and South-West Greenland (61°30' - 64°N)

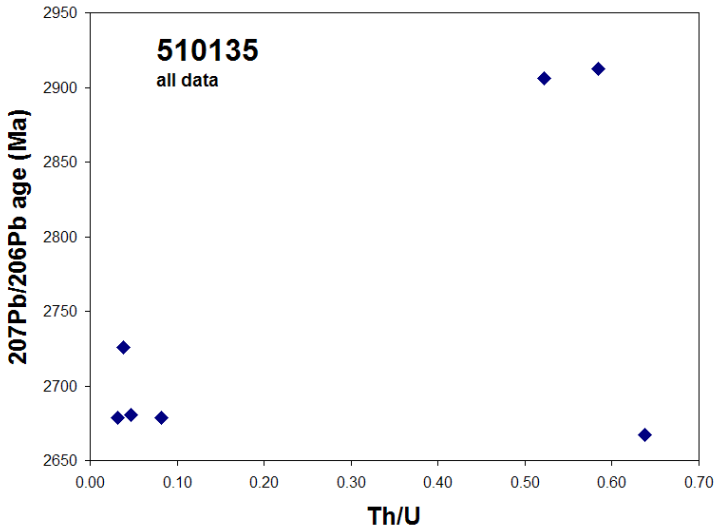
XY450 EGU2011-13675
Emma F. Rehnström (compiler)
64 V.2 Syd. Kapisillit: A new geological 1:100 000 map sheet in the Nuuk area, SW Greenland

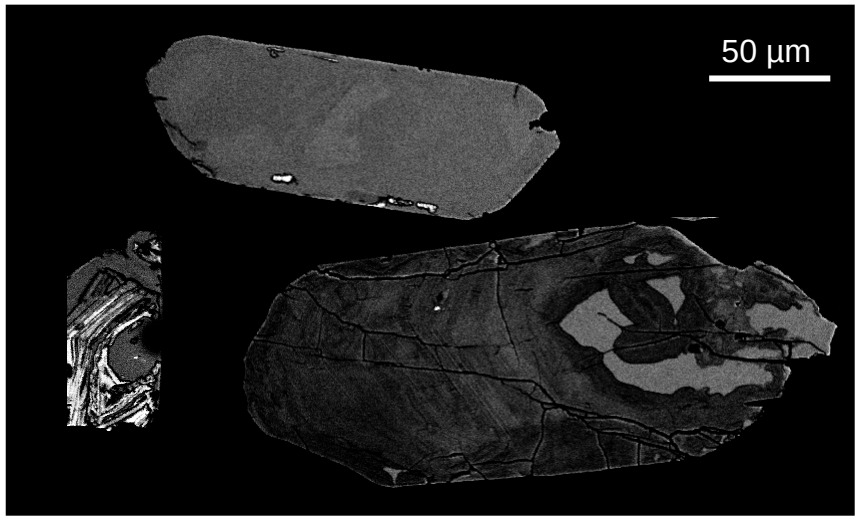
Appendix 2: Zircon U/Pb geochronology

GEUS sample: 510135; **Coordinates:** N 62.951165 W 49.761513; **Collector:** NTK; **Station:** 09NTK036; **Rock type:** Pegmatite, late stage, granitic; **Aim:** intrusion; **Interpretation:** A main peak at 2686 ± 12 Ma interpreted as the intrusion age of the pegmatite. Two concordant zircons form an age peak at 2908 ± 12 Ma interpreted as being inherited. **Reference:** Kokfelt, T.F. (unpublished data).

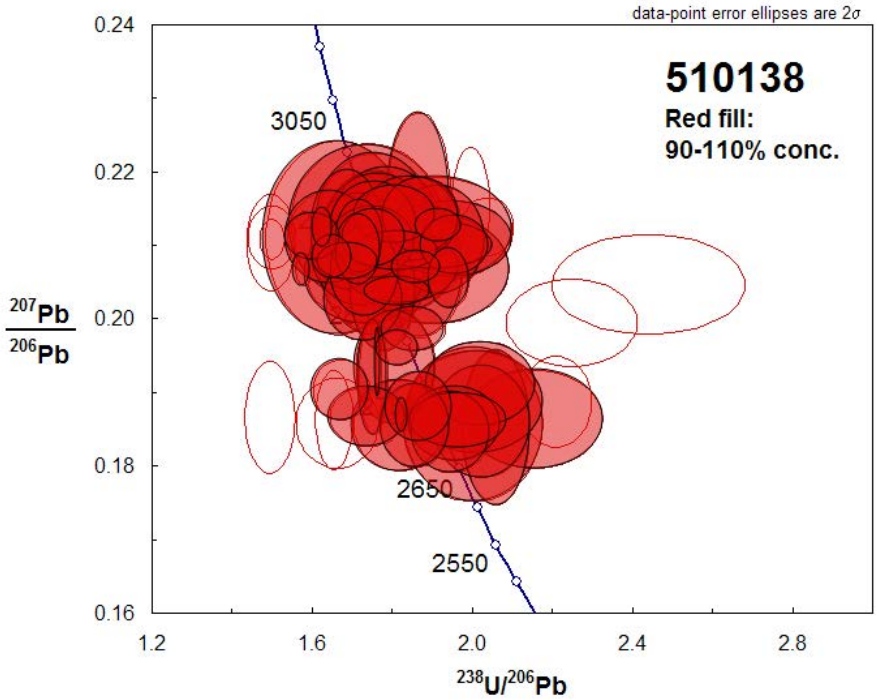


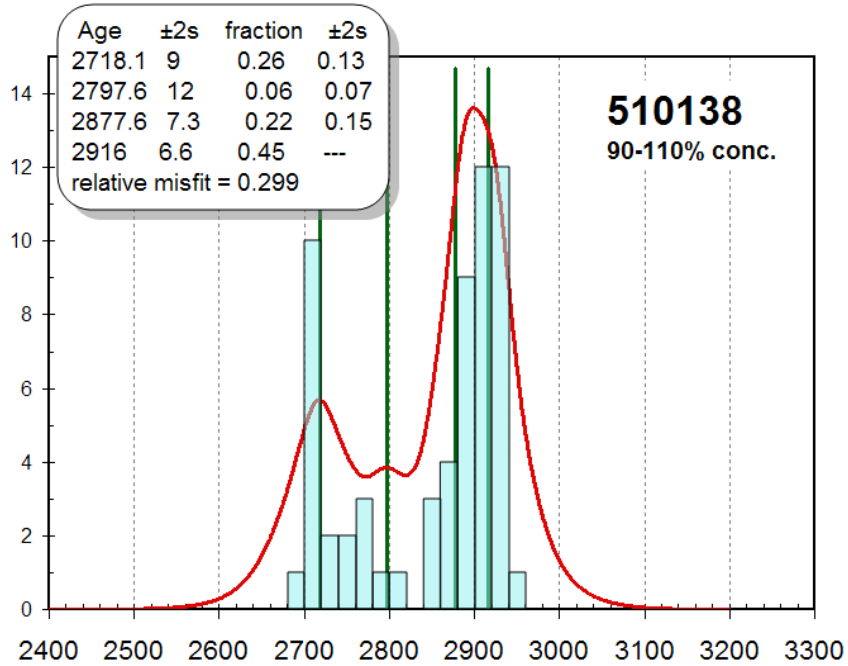


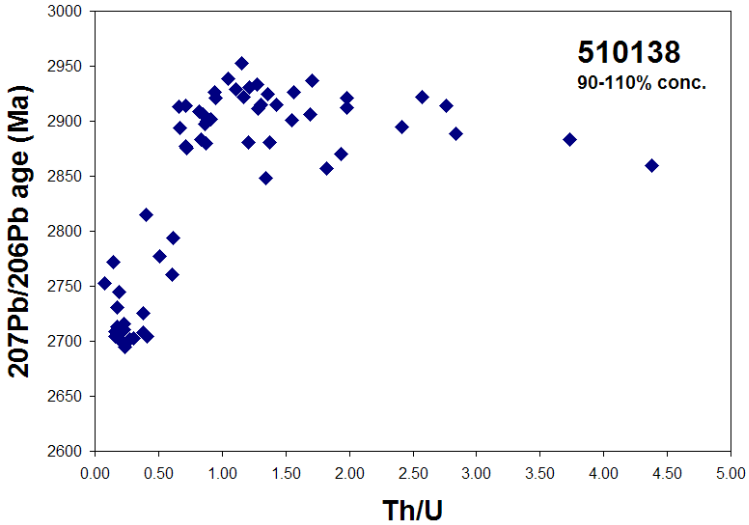


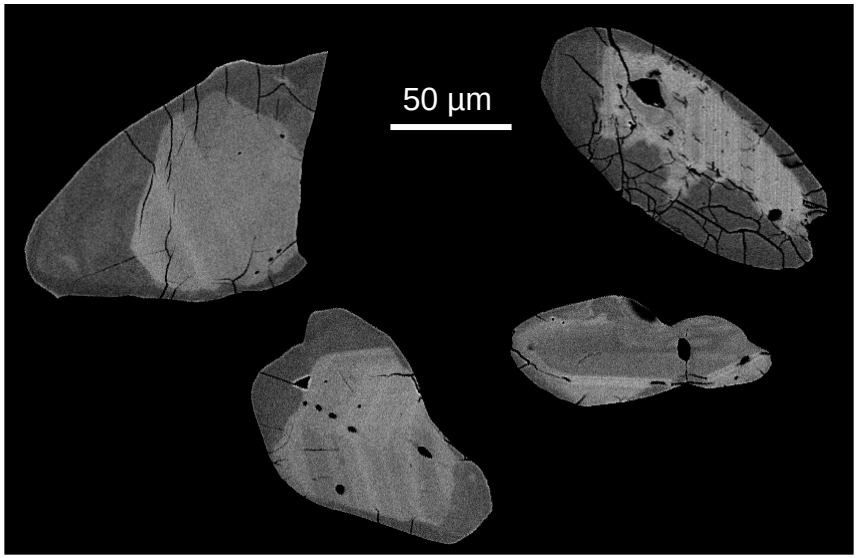


GEUS sample: 510138; **Coordinates:** N 62.953273 W 49.760642; **Collector:** NTK; **Station:** 09NTK038; **Rock type:** Pegmatite, cross-cutting main foliation; **Aim:** intrusion; **Interpretation:** A main peak at 2916 ± 7 Ma interpreted as the intrusion age of the pegmatite (alternatively as an inherited age). A distinct peak at 2718 ± 9 Ma reflects rim growth during metamorphism in the area. **Reference:** Kokfelt, T.F. (unpublished data).

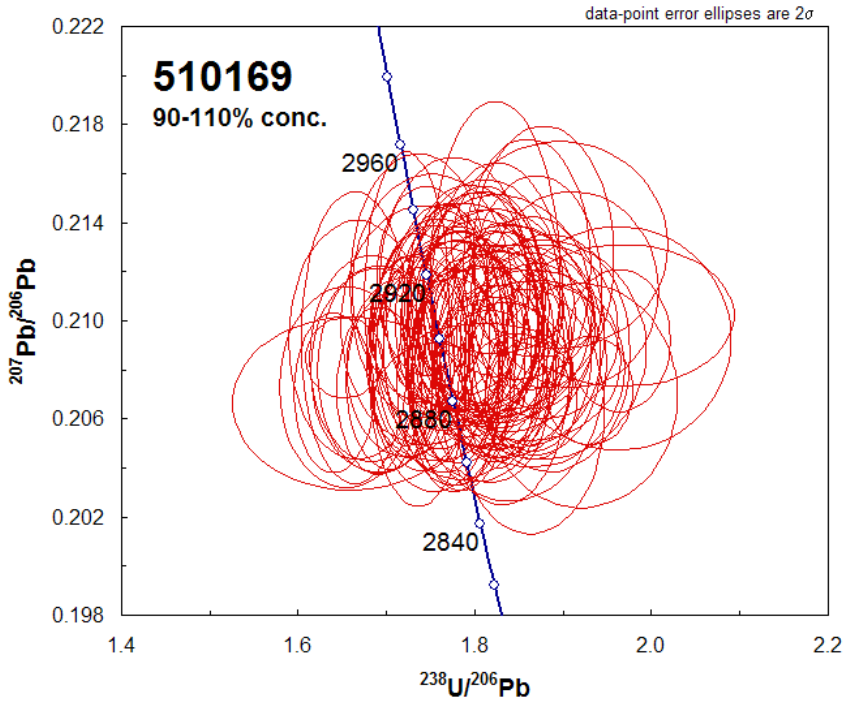


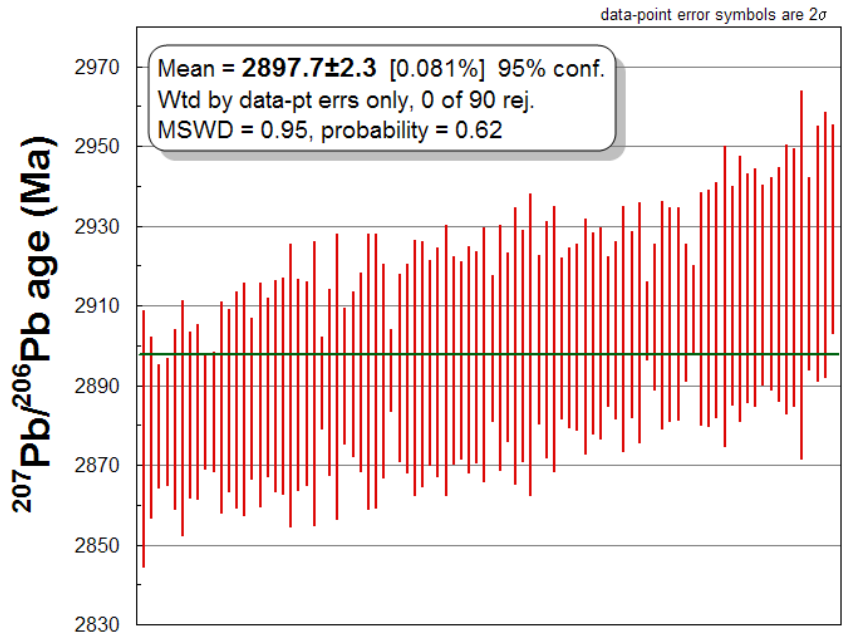


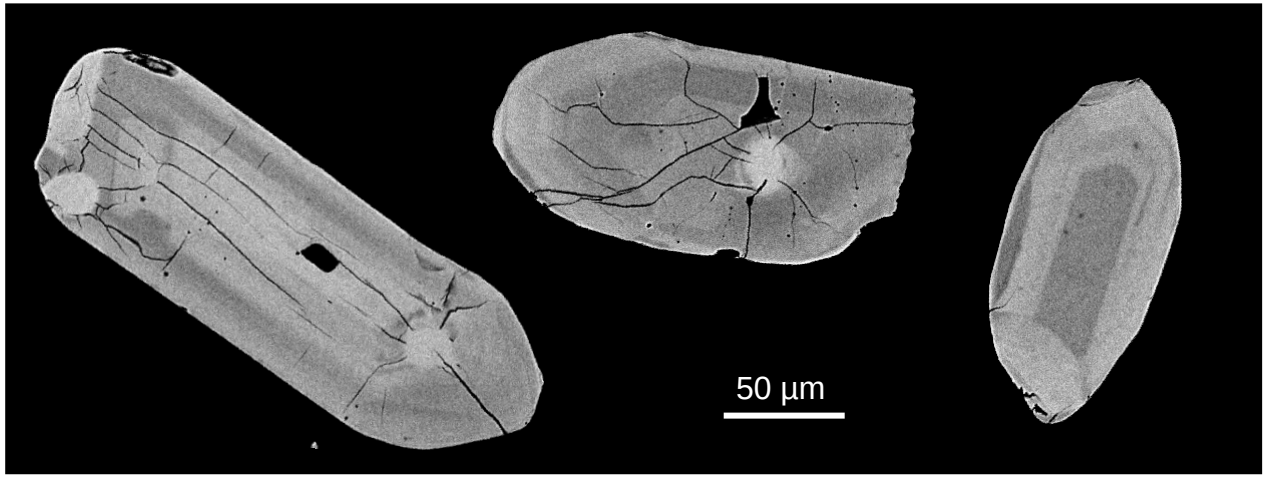




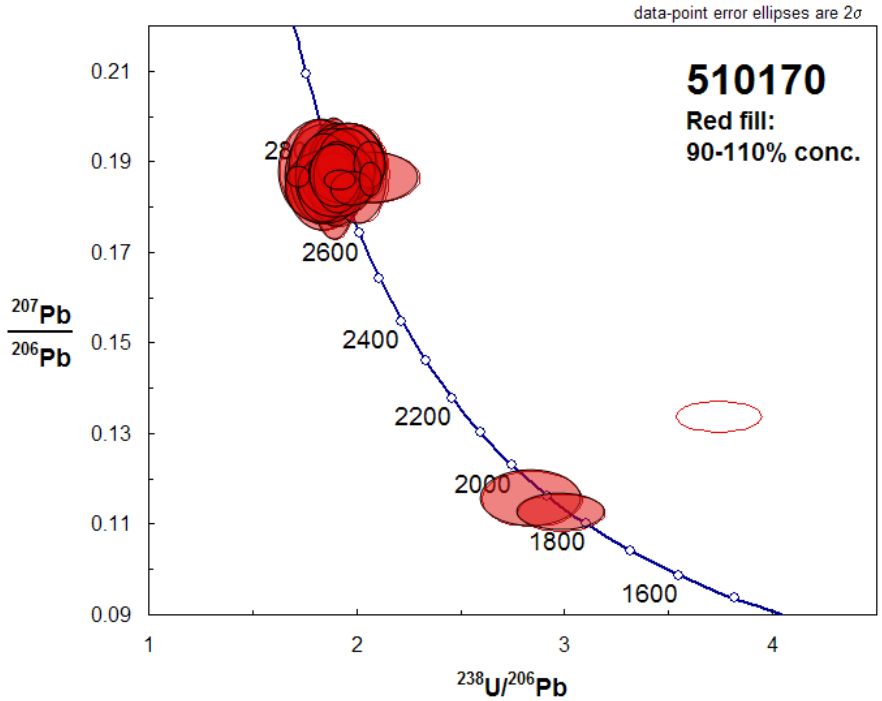
GEUS sample: 510169; **Coordinates:** N 62.944282 W 49.769422 ; **Collector:** NTK; **Station:** 09NTK063; **Rock type:** Granite, syn-tectonic (diorite on map); **Aim:** intrusion; **Interpretation:** A well defined age peak at 2898 ± 2 Ma interpreted as the intrusion age of the granite. **Reference:** Kokfelt, T.F. (unpublished data).

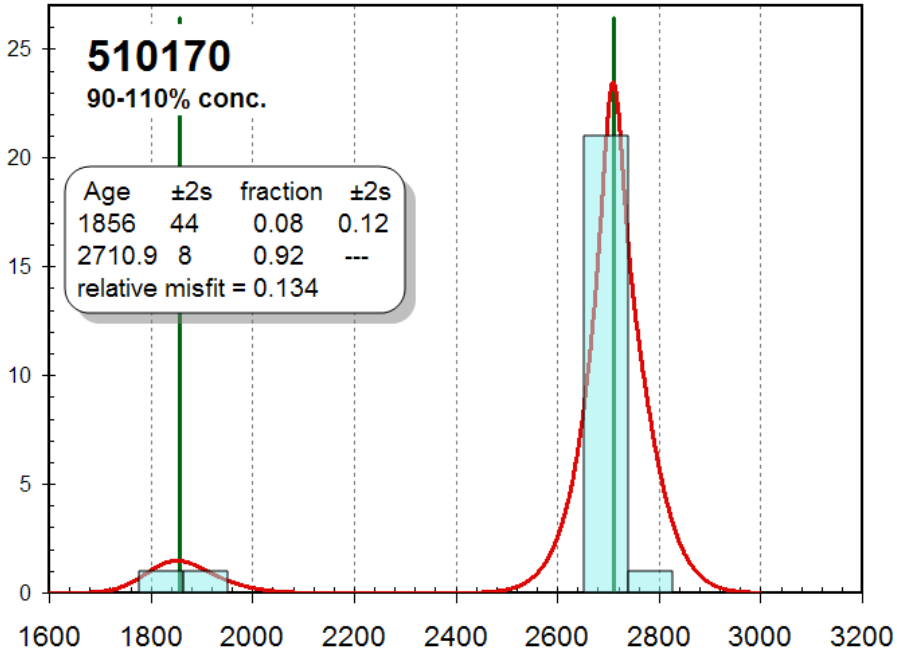


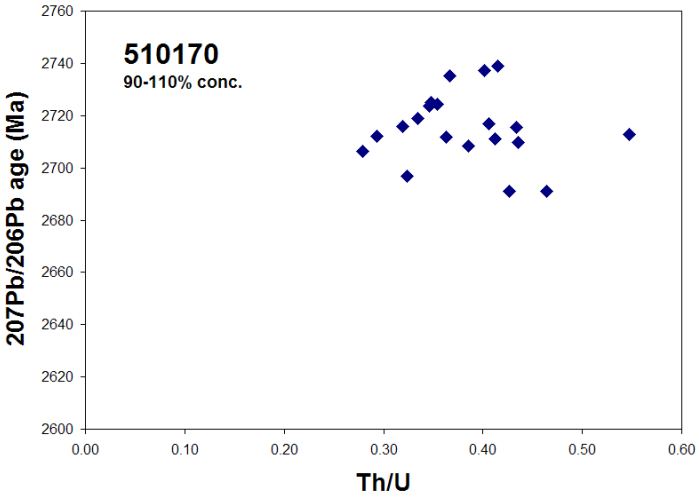


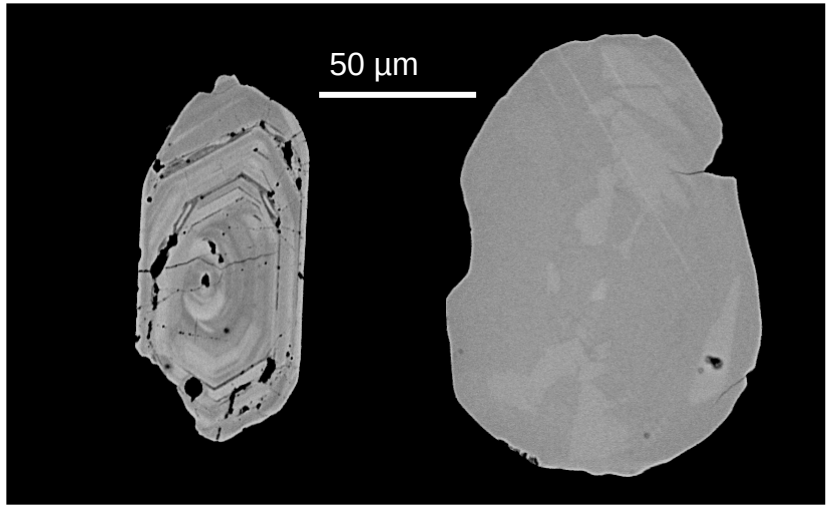


GEUS sample: 510170; **Coordinates:** N 62.951165 W 49.761513; **Collector:** NTK; **Station:** 09NTK036; **Rock type:** pegmatite, relatively undeformed; **Aim:** intrusion; **Interpretation:** A main peak at 2711 ± 8 Ma interpreted as the intrusion age of the granite. Two concordant grains yield Palaeoproterozoic ages of ~1.85 Ga **Reference:** Kokfelt, T.F. (unpublished data).

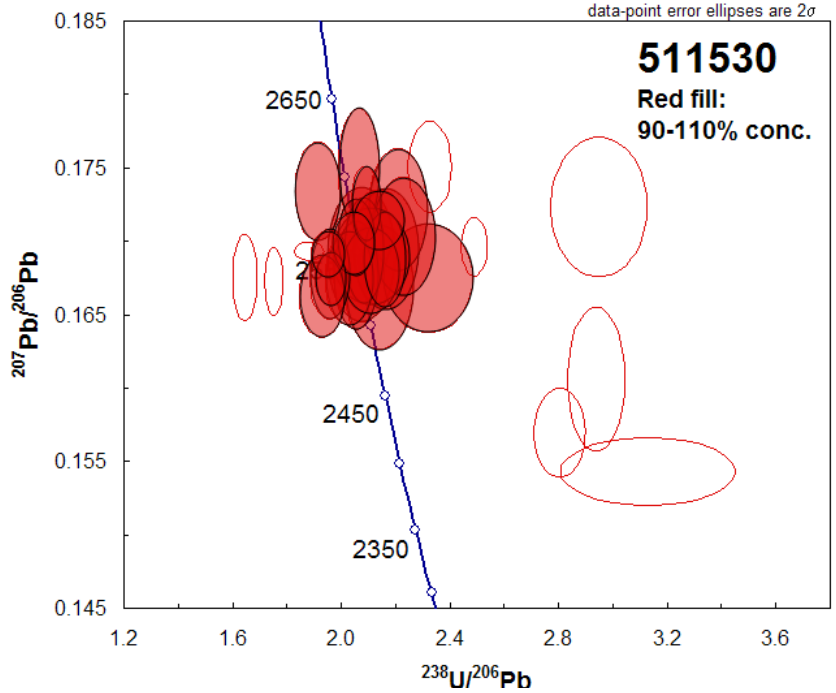


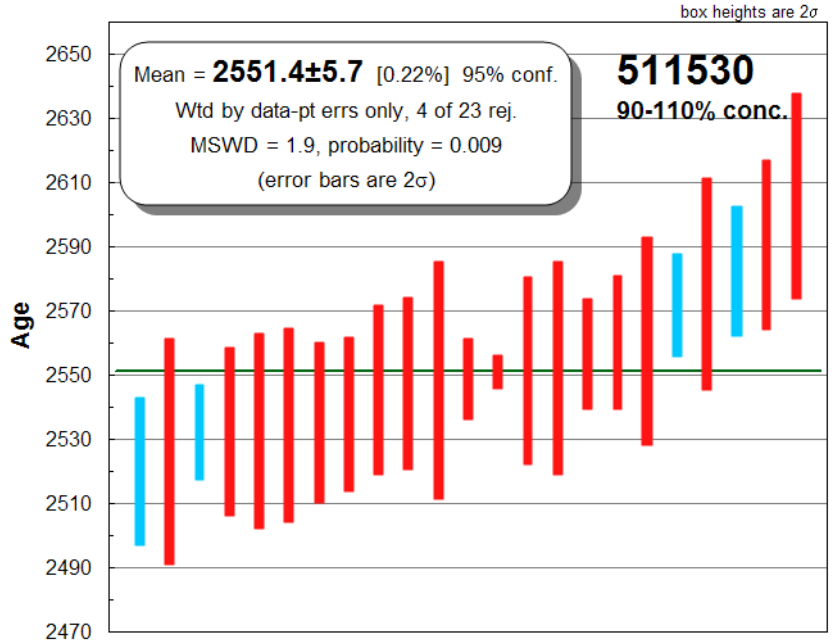


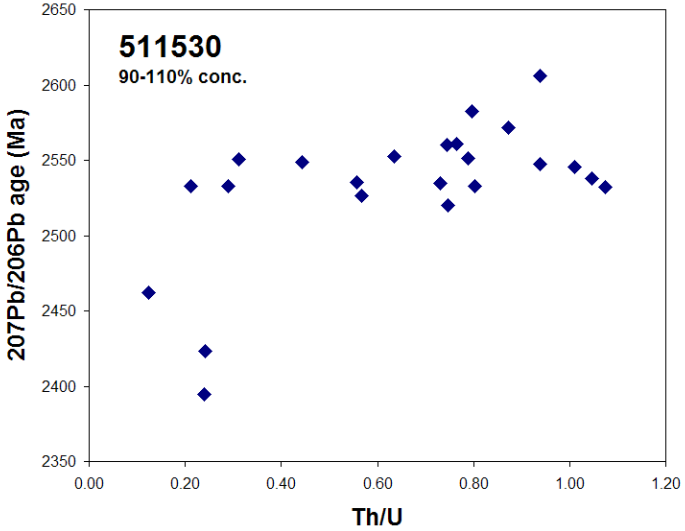


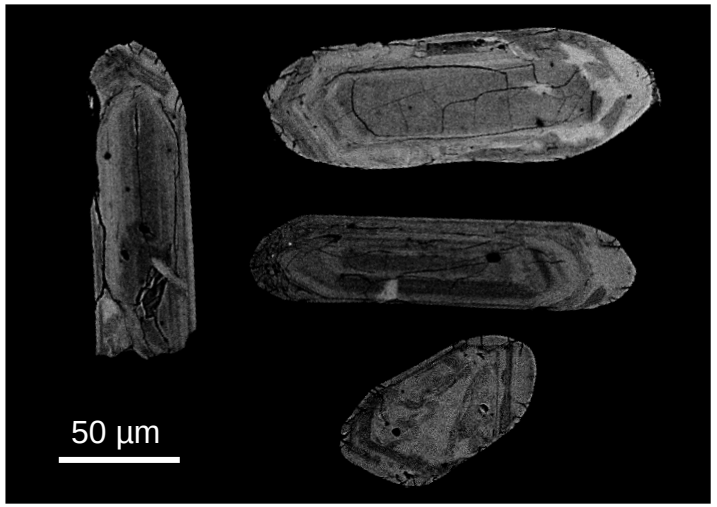


GEUS sample: 511530; **Coordinates:** N 61.80175167, W 48.431815; **Collector:** TFK; **Station:** 10TFK056; **Rock type:** Granite, mildly deformed (mapped as gneiss); **Aim:** intrusion, metamorphism; **Interpretation:** One main age peak at 2551± 6 Ma, interpreted as the intrusion age of the granite. **Reference:** Kokfelt, T.F. (unpublished data).

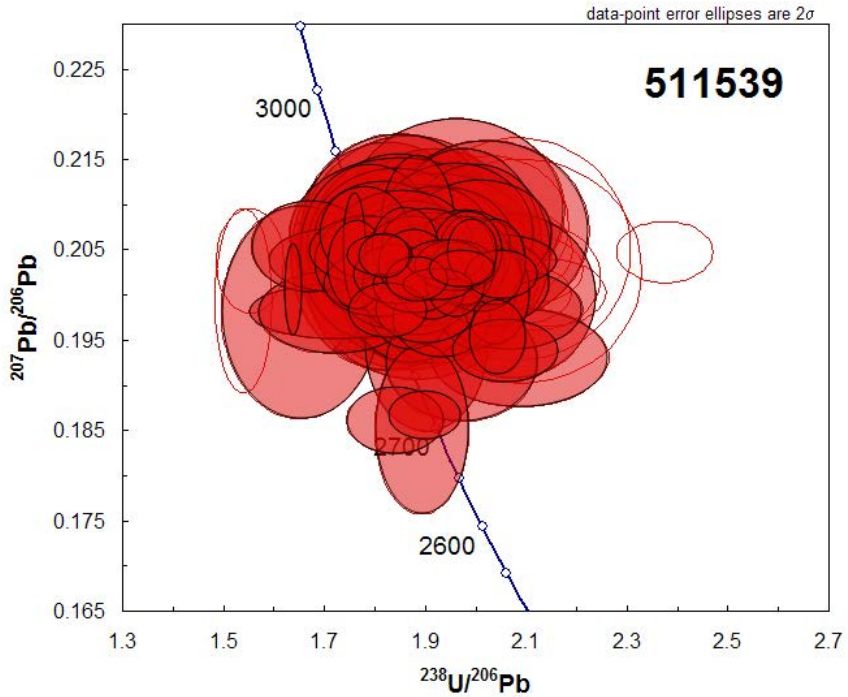


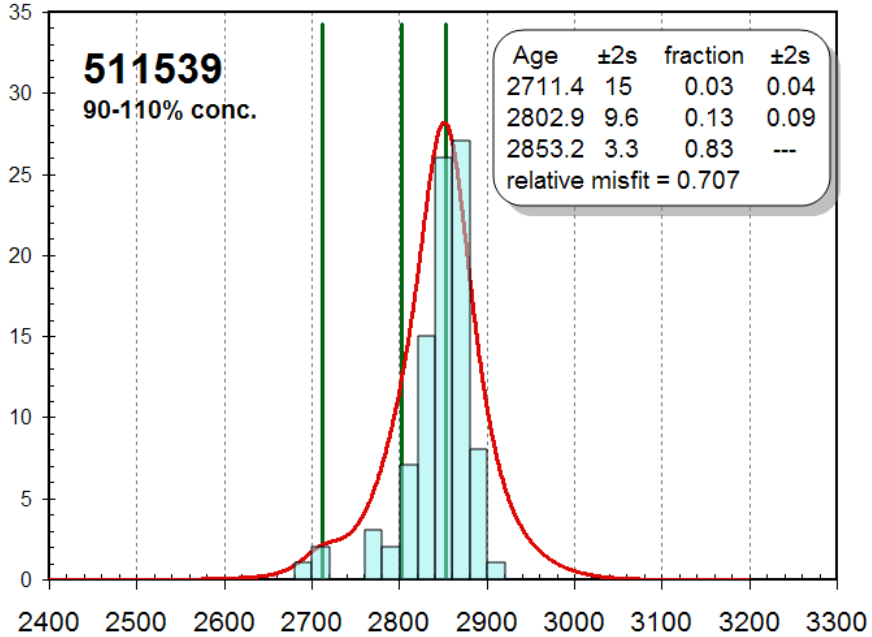


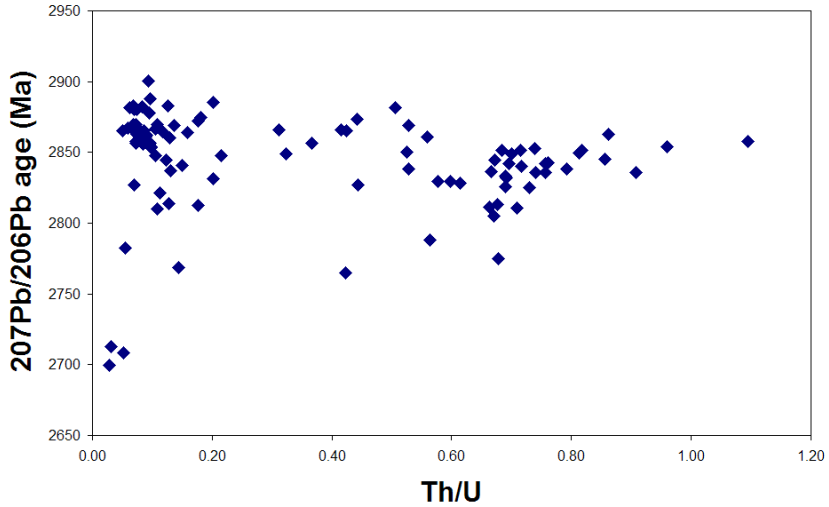


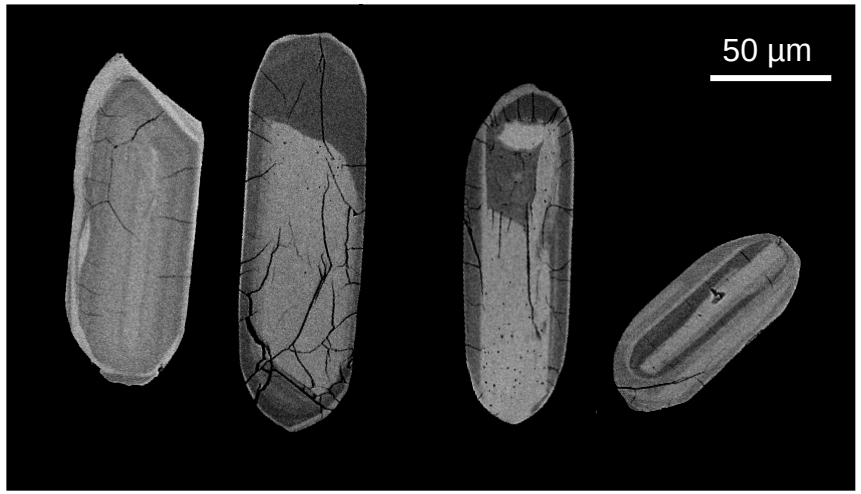


GEUS sample: 511539; **Coordinates:** N 61.905315, W 48.591575; **Collector:** NTK; **Station:** 10NTK011; **Rock type:** Tonalite gneiss; **Aim:** intrusion, metamorphism; **Interpretation:** One main age peak at 2853±3 Ma, interpreted as the intrusion age of the gneiss protolith. Ages scattering down to ~2.80 Ga likely reflect ancient Pb-loss, whereas the minor peak at ~2.71 Ga (low Th/U) could reflect a metamorphic event. **Reference:** Kokfelt, T.F. (unpublished data).

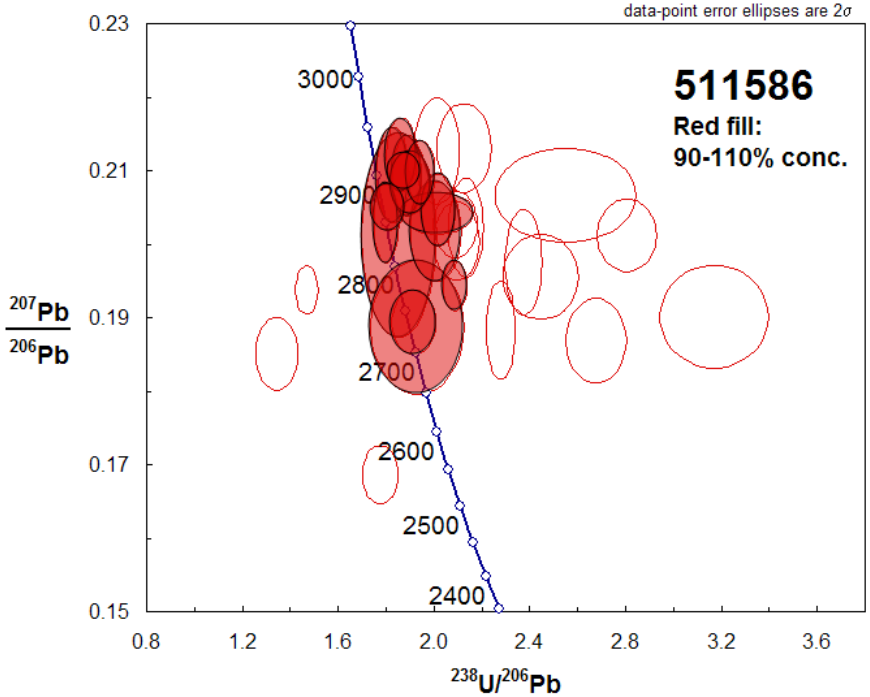


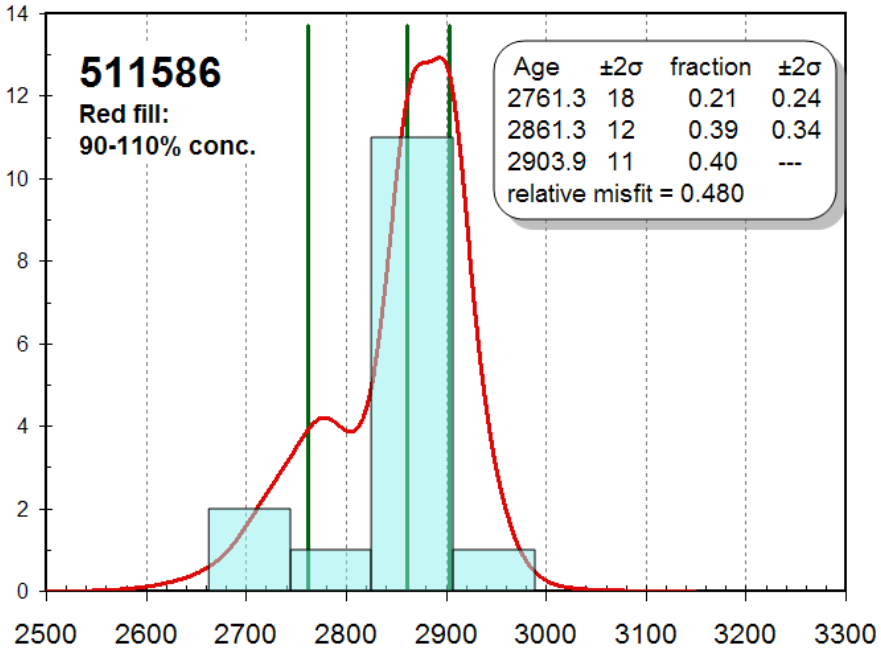


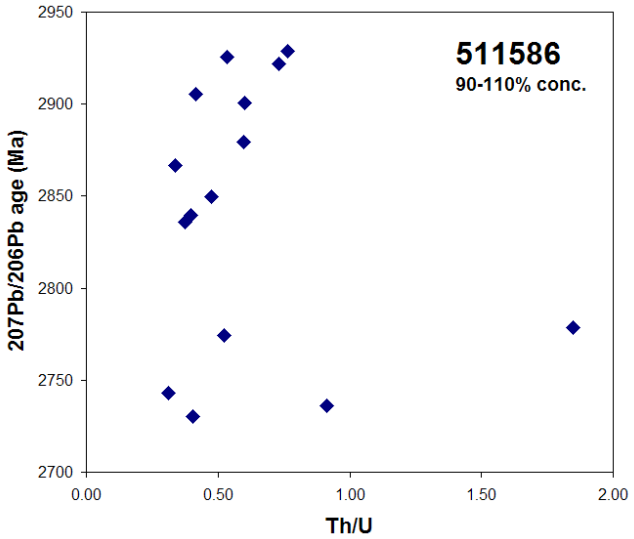


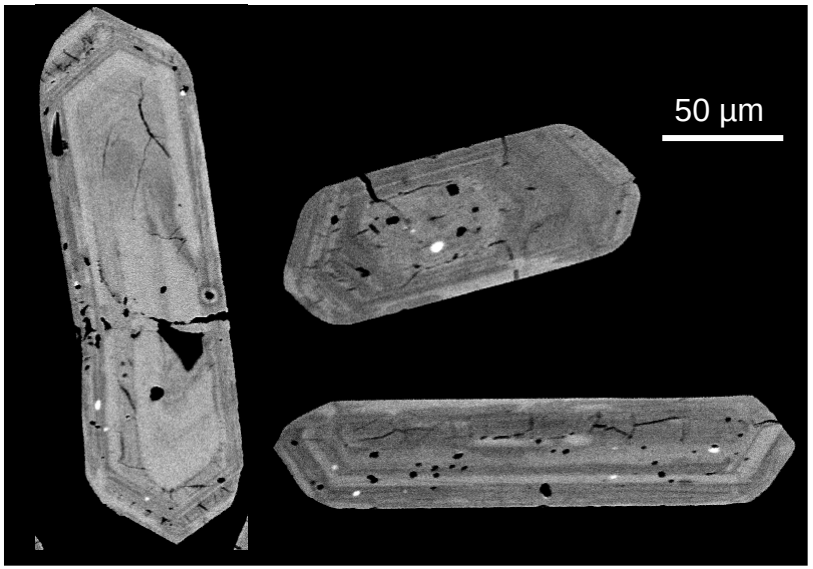


GEUS sample: 511586; **Coordinates:** N 61.723368 W 48.223253; **Collector:** NTK; **Station:** 10NTK215; **Rock type:** Orthogneiss, tonalitic; **Aim:** protolith intrusion; **Interpretation:** Weakly defined main peak at 2904 ± 11 Ma interpreted as the intrusion age of the gneiss protolith. A few younger ages down to 2.7 Ga may reflect later metamorphism or ancient Pb-loss. **Reference:** Kokfelt, T.F. (unpublished data).

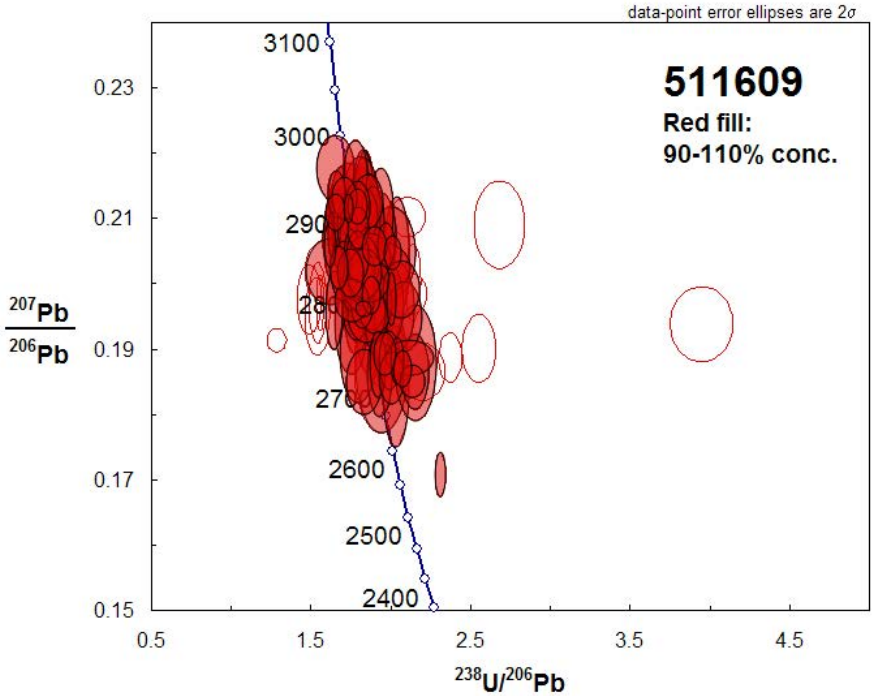


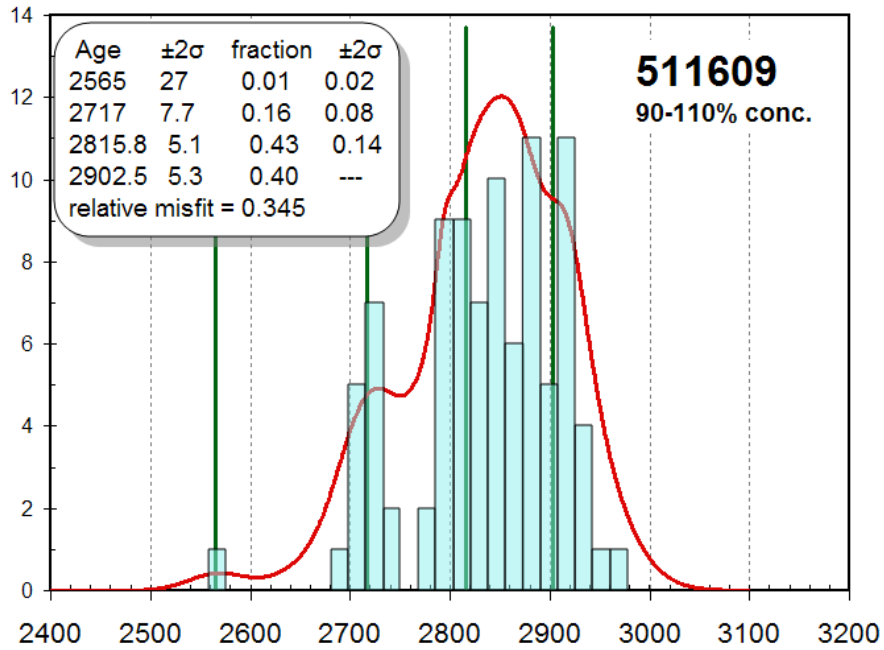


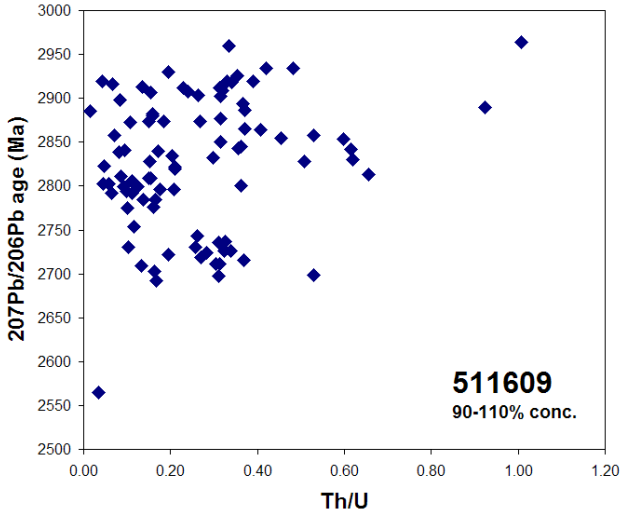


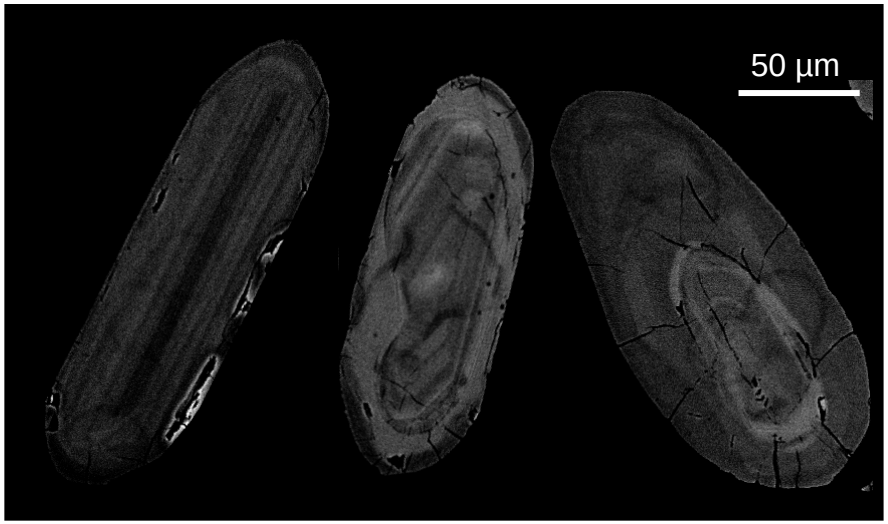


GEUS sample: 511609; **Coordinates:** N 61.94415 W 48.39569; **Collector:** NTK; **Station:** 10NTFK319; **Rock type:** Orthogneiss, tonalite, cataclastically deformed; **Aim:** protolith intrusion, deformation; **Interpretation:** Complex age pattern with two main peaks at 2903 ± 5 Ma and 2816 ± 5 Ma interpreted as the intrusion age of the gneiss protolith and peak metamorphism, respectively. A minor peak at 2717 ± 8 Ma reflects late stage deformation and zircon growth. A single zircon grain yields an age of ~2.56 Ga reflecting the latest stage of Archaean magmatism in the area. **Reference:** Kokfelt, T.F. (unpublished data).

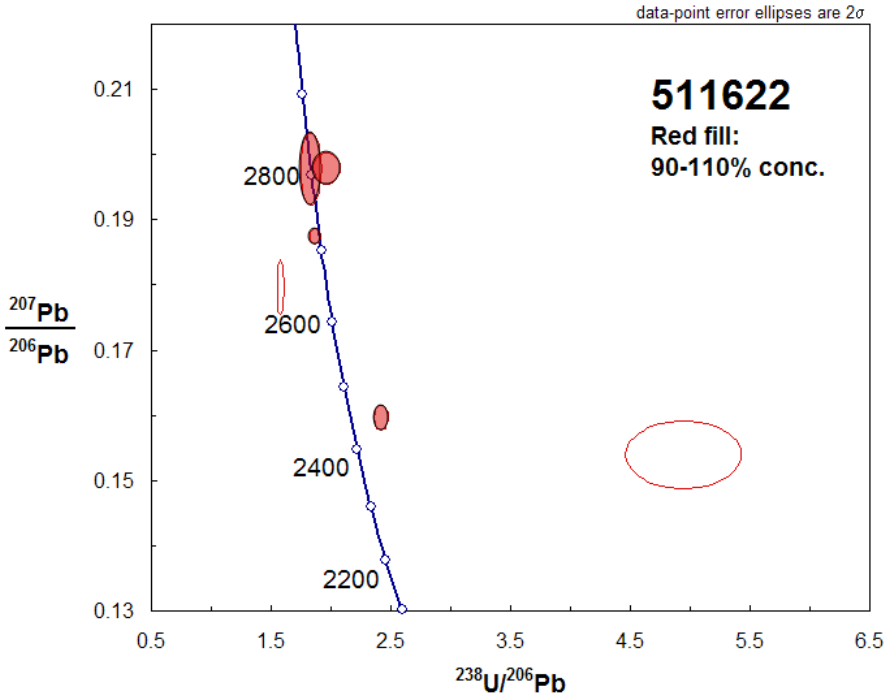


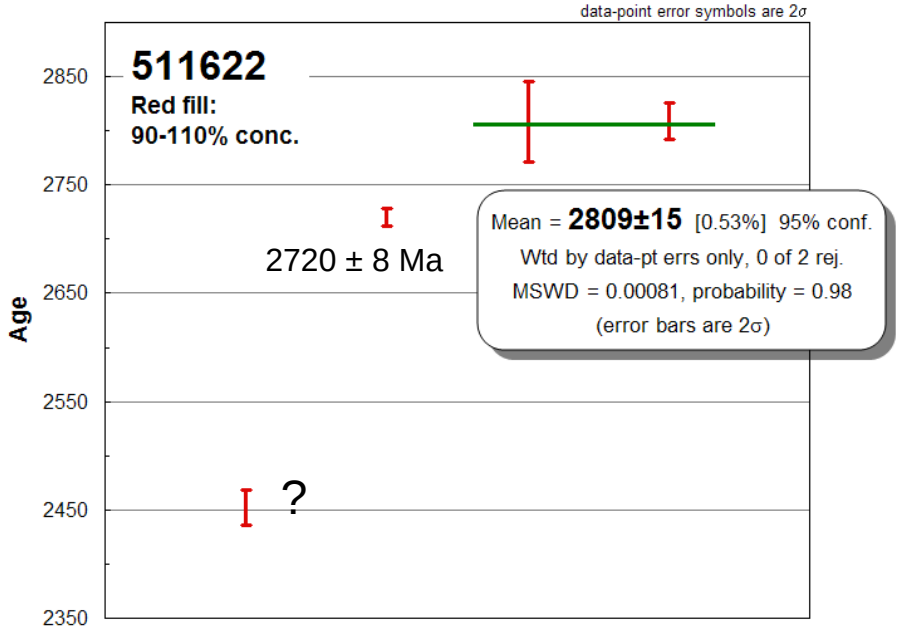


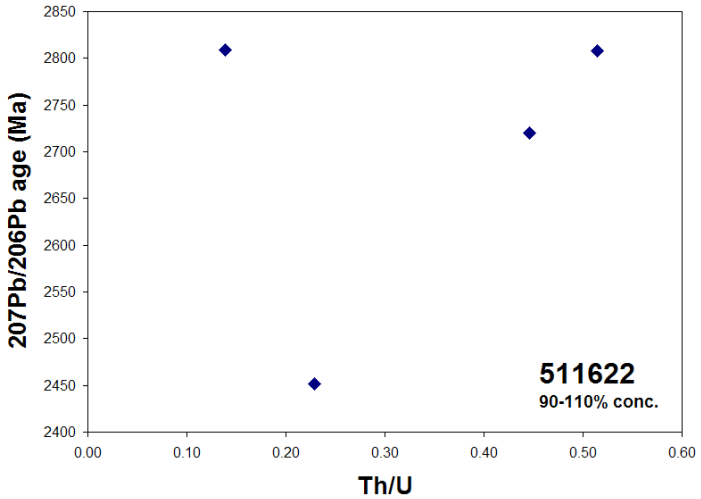


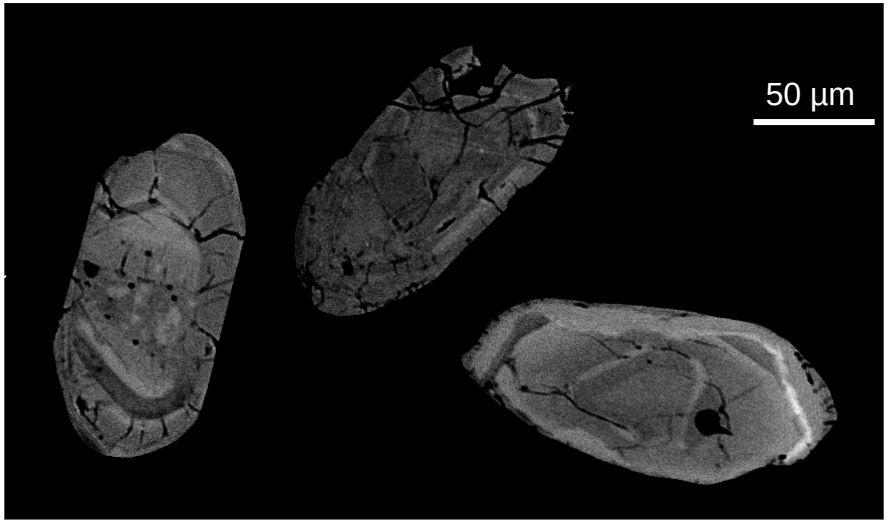


GEUS sample: 511622; **Coordinates:** N 61.884162 W 48.223243; **Collector:** NTK; **Station:** 10NTFK354; **Rock type:** aplite, cross-cuts foliation at low angle; **Aim:** intrusion, deformation; **Interpretation:** The number of concordant zircons are too low to make a meaningful interpretation. **Reference:** Kokfelt, T.F. (unpublished data).

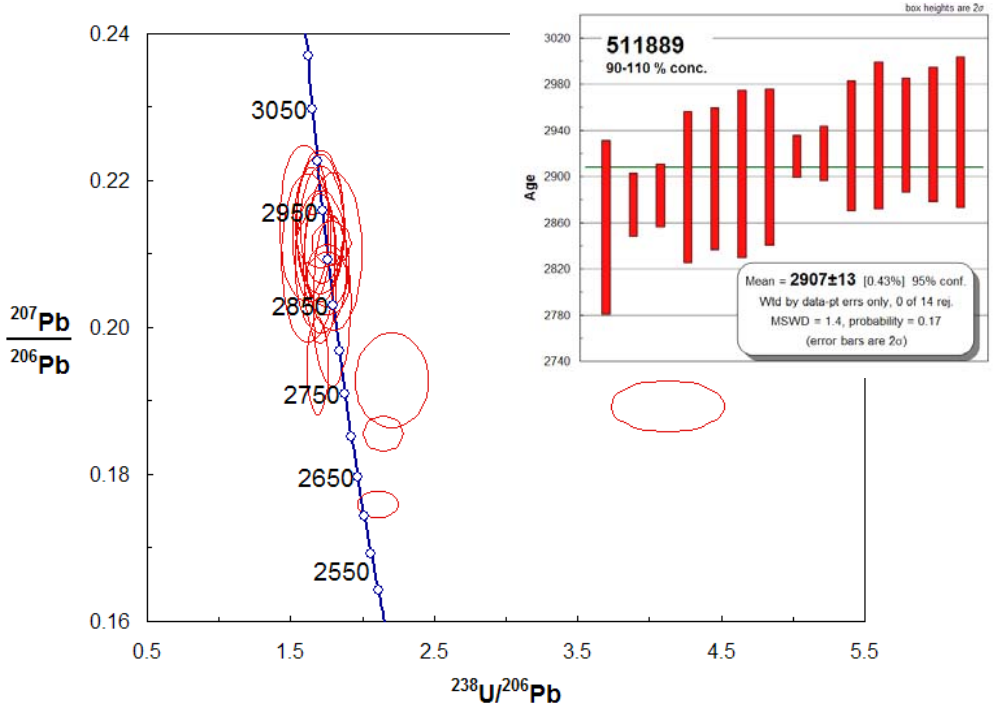


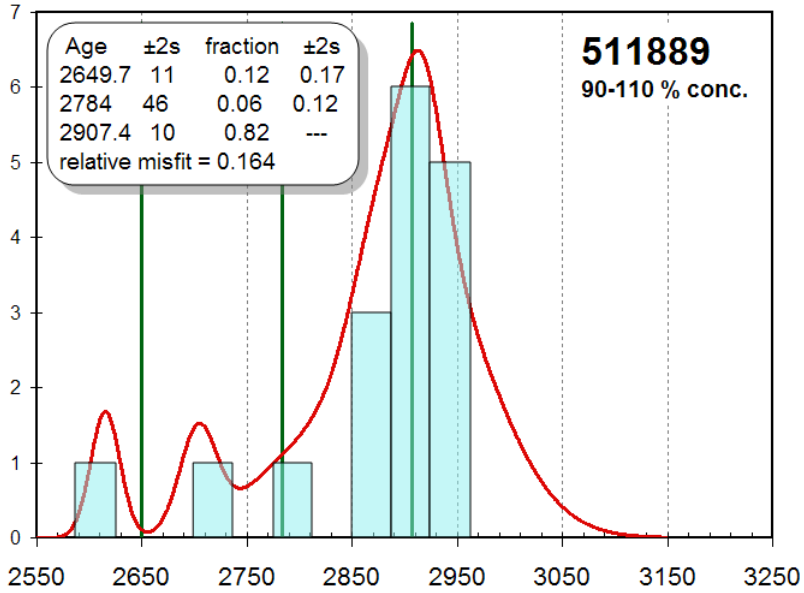


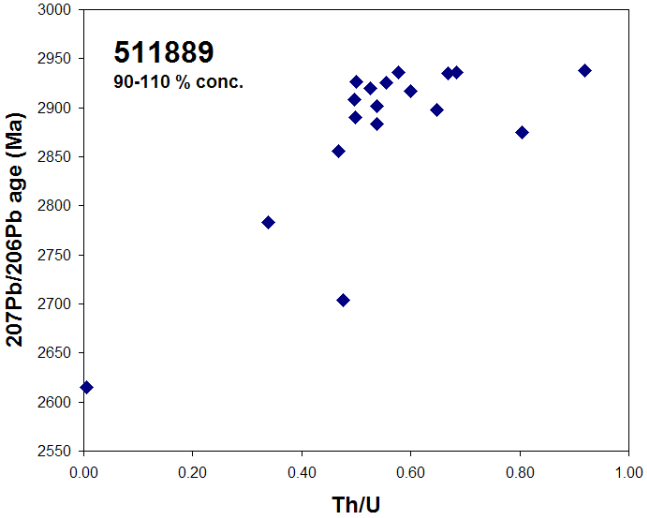


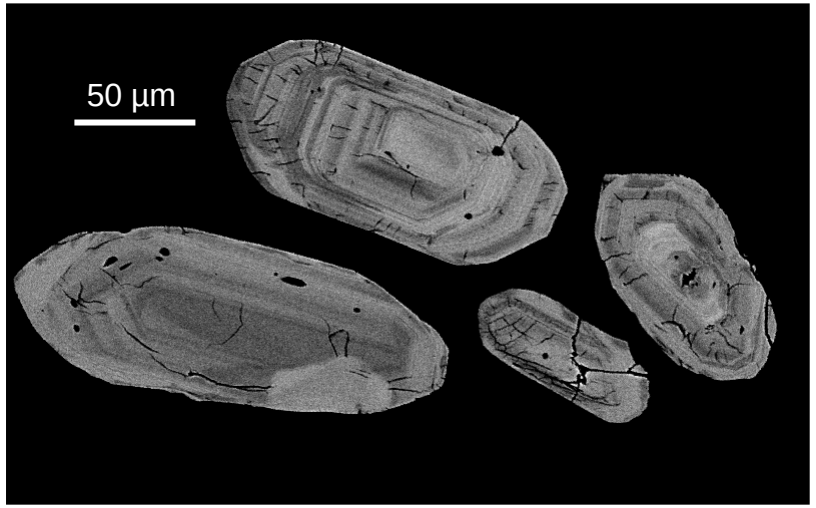


GEUS sample: 511889; **Coordinates:** N 61.813192 W 48.778295; **Collector:** JCS; **Station:** 10JCS069; **Rock type**: Orthogneiss; **Aim:** protolith intrusion; **Interpretation:** A main zircon population at 2907 ± 13 Ma is interpreted as the gneiss protolith intrusion age. A few younger (discordant) grains scatter between ~2.75 and ~2.6 Ga. **Reference:** Kokfelt, T.F. (unpublished data).

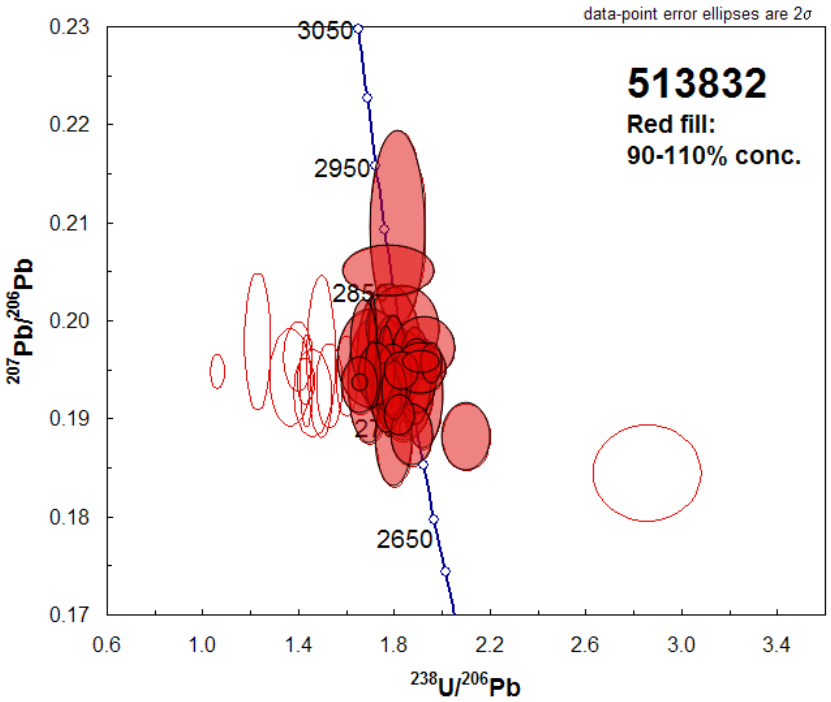


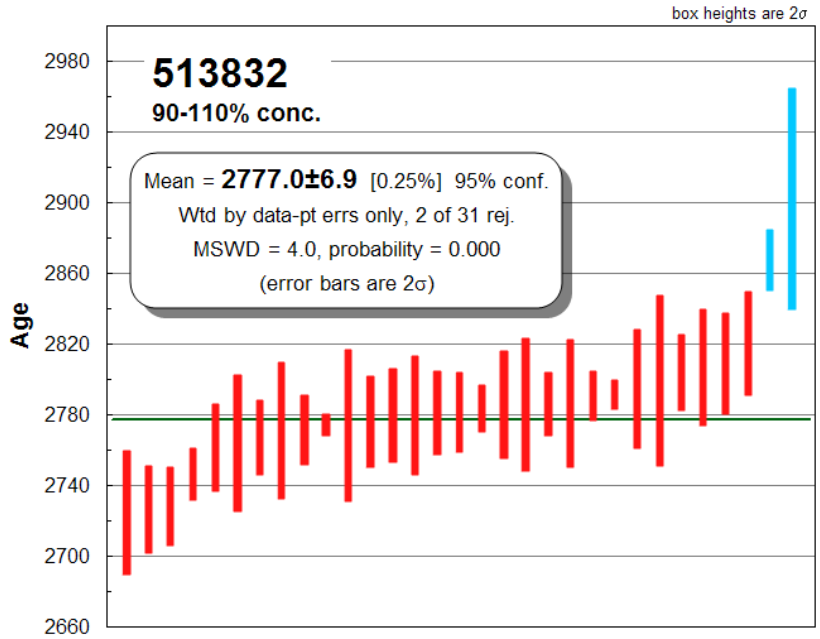


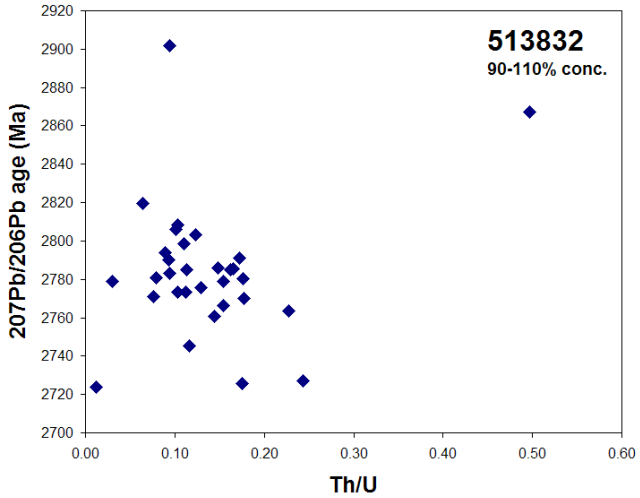


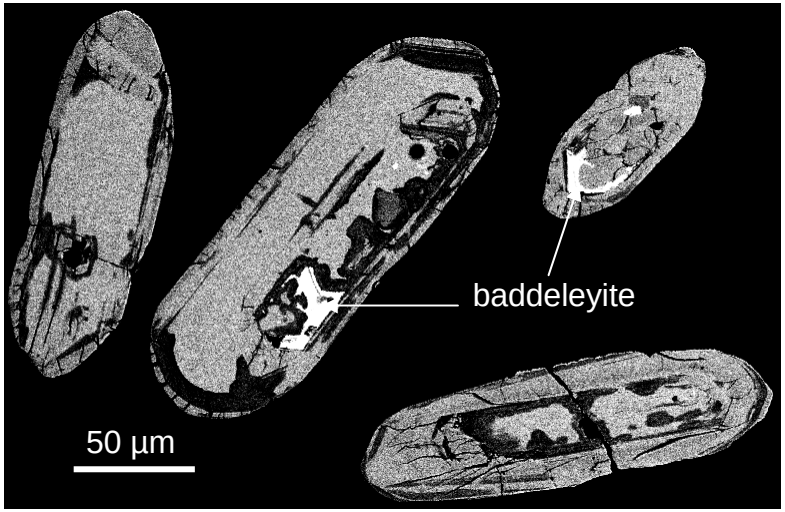


GEUS sample: 513832; **Coordinates:** N 63.346317 W 49.282887; **Collector:** PKA; **Station:** 08PKA011; **Rock type:** meta-leucogabbro; **Aim:** intrusion, metamorphism; **Zircon morphology:** Zircons are prismatic and show metamorphic equilibration textures; several grains contain (exsolved?) domains or zones of baddeleyite. **Interpretation:** A main zircon population yields an age of 2777 ± 7 Ma, interpreted as peak metamorphism in the area. **Reference:** Kokfelt, T.F. (unpublished data).

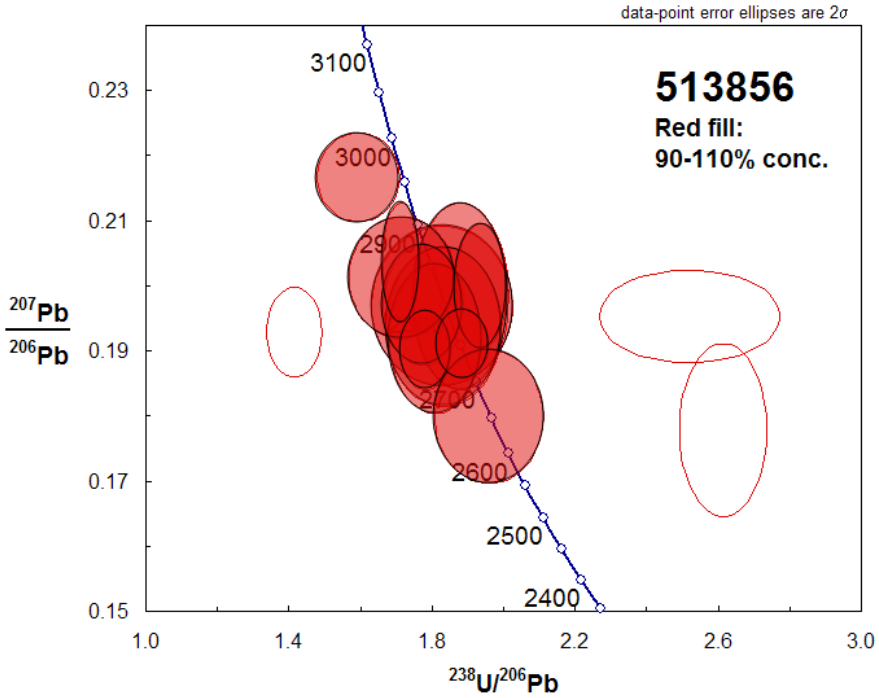


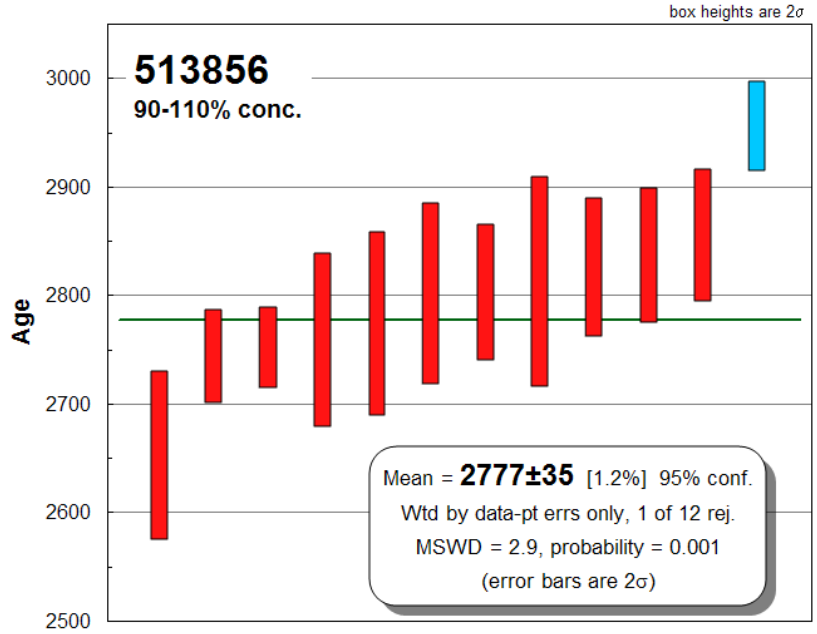


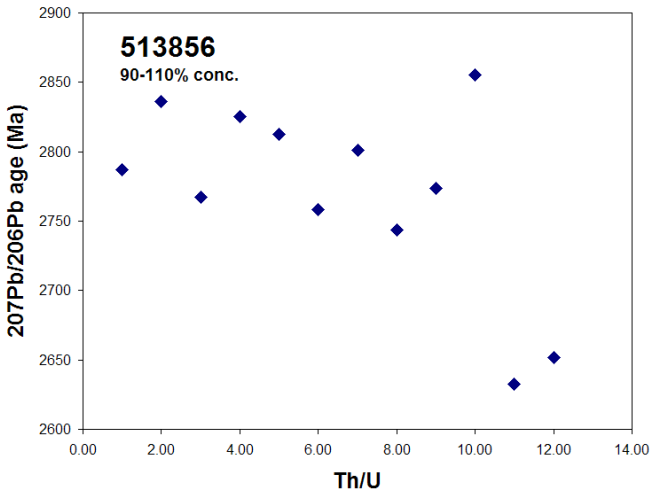


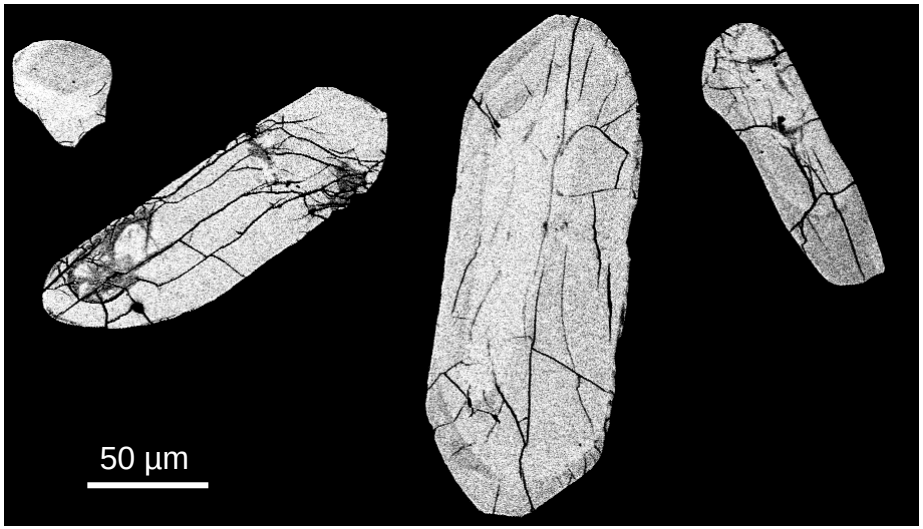


GEUS sample: 513856; **Coordinates:** N 63.346223 W 49.275968; **Collector:** PKA; **Station:** 08PKA015; **Rock type:** Granite (intruded into anorthosite); **Aim:** intrusion, metamorphism; **Interpretation:** A main population of zircons gives a poorly defined age of 2777 ± 35 Ma, interpreted as the timing of the peak metamorphism in the area. **Reference:** Kokfelt, T.F. (unpublished data).

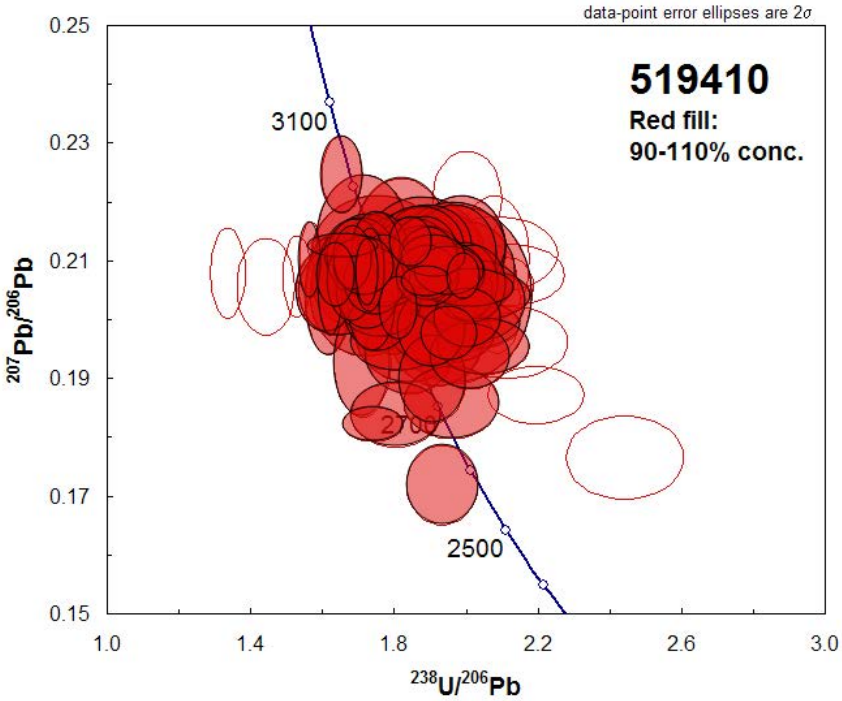


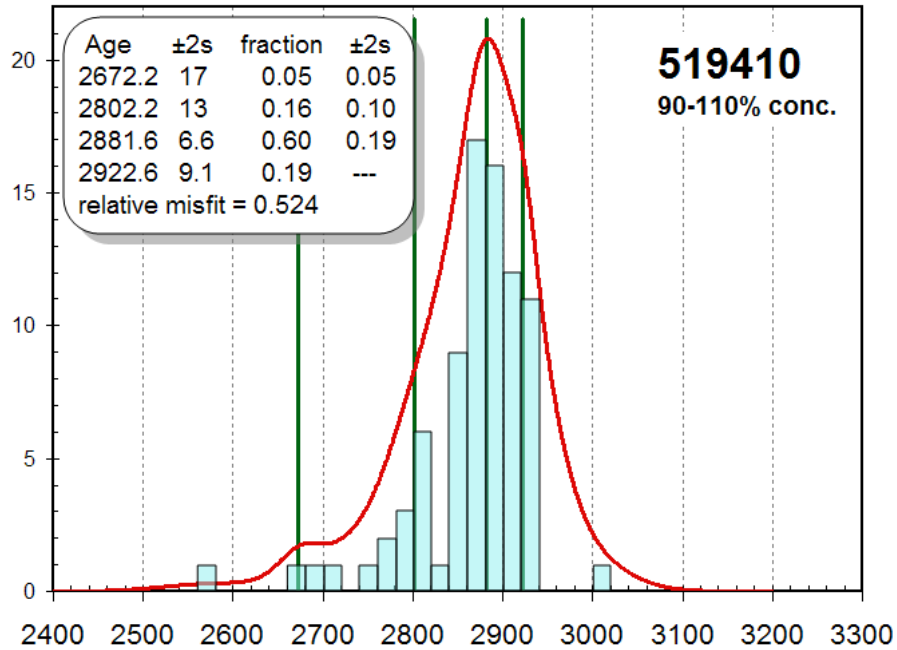


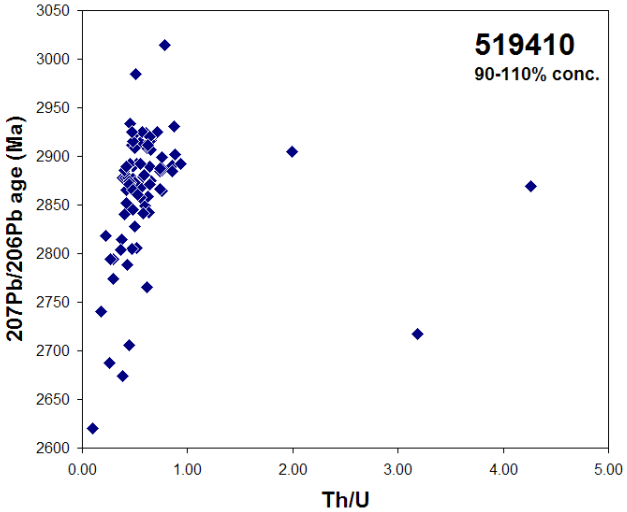


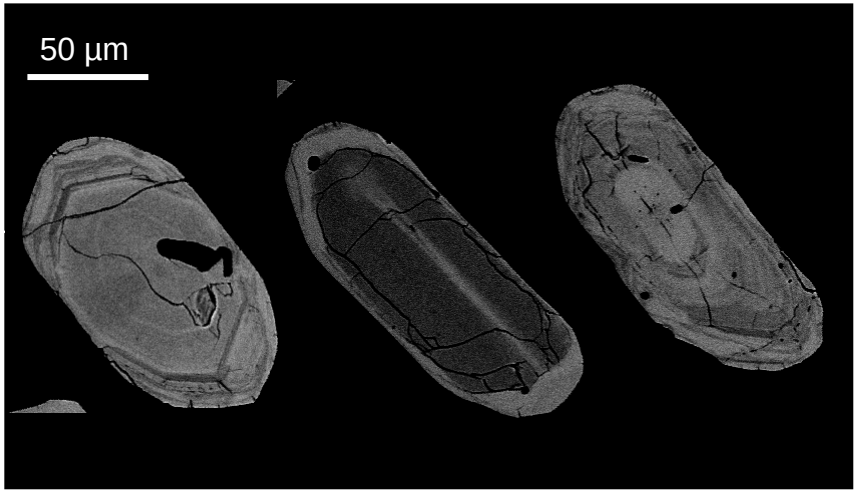


GEUS sample: 519410; **Coordinates:** N 61.82869 W 48.33367; **Collector:** NTK; **Station:** 10NTK011; **Rock type:** Bt-Grt gneiss (paragneiss?); **Aim:** metamorphism; **Interpretation:** Rather broad main peak at ~2.9 Ga that is interpreted as two separate peaks at 2923 ± 9 Ma (inherited) and 2881 ± 7 Ma (main source component for metasediment). Two minor peaks occur at 2802 ± 13 Ma and 2717 ± 17 Ma, interpreted as two events of metamorphism in the area. **Reference:** Kokfelt, T.F. (unpublished data).

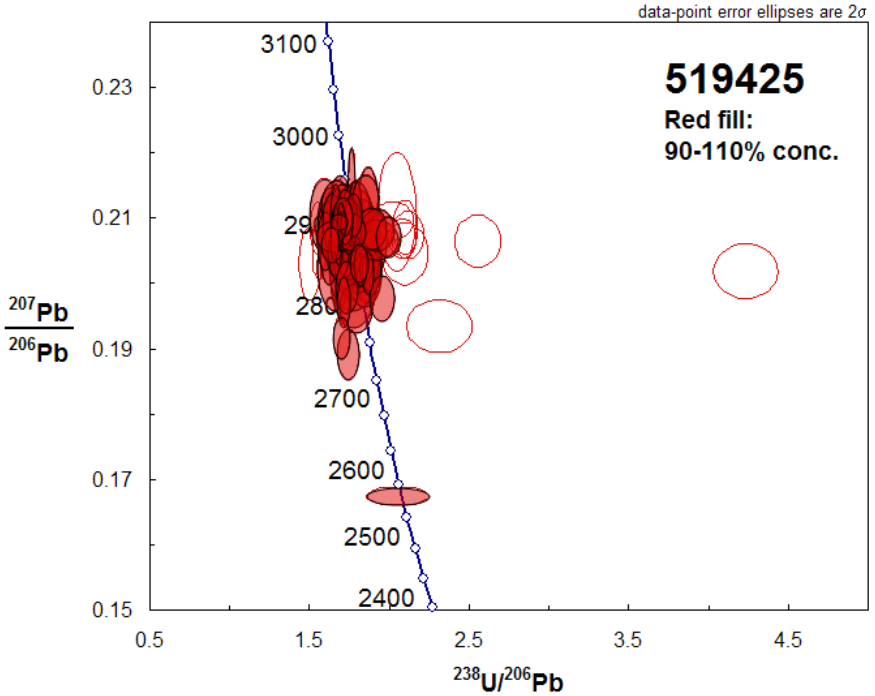


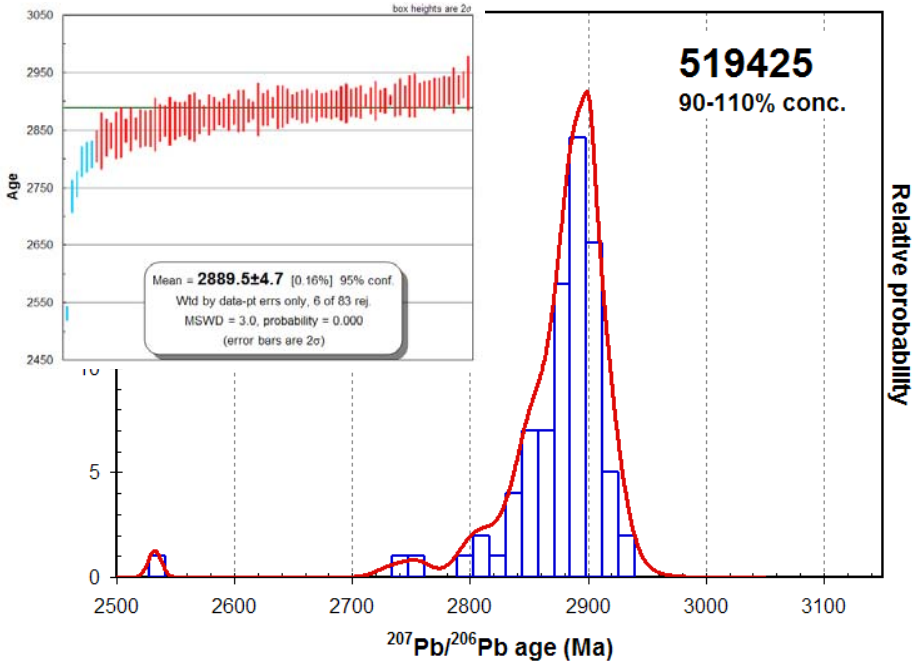


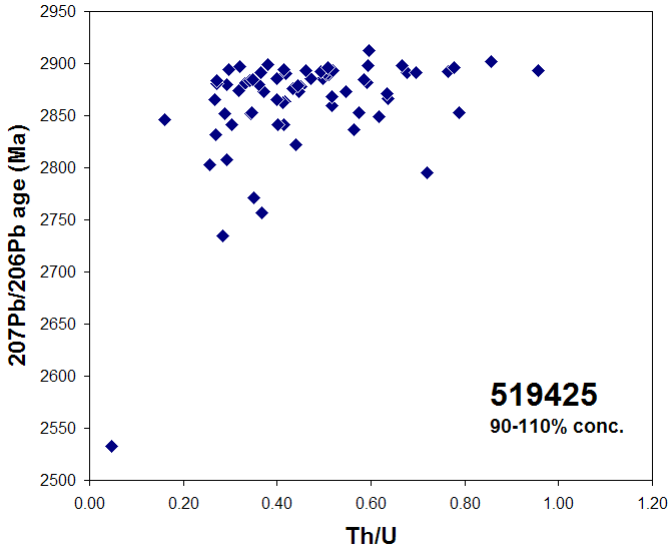


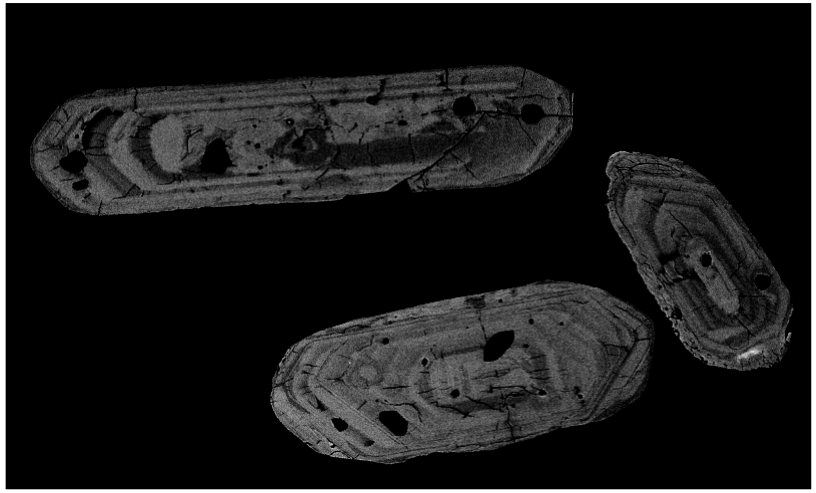


GEUS sample: 519425; **Coordinates:** N 61.822522 W 48.347143; **Collector:** TFK; **Station:** 10TFK014; **Rock type:** Orthogneiss, tonalitic, melanosome part; **Aim:** intrusion, metamorphism; **Interpretation:** Main peak at 2890 ± 5 Ma interpreted as the intrusion age of the gneiss protolith. Scattered ages down to ~2.8 Ga and a minor peak at ~2.74 Ga may reflect ancient Pb-loss and/or metamorphism in the area. A single zircon grain yields a concordant age of ~2.54 Ga. **Reference:** Kokfelt, T.F. (unpublished data).

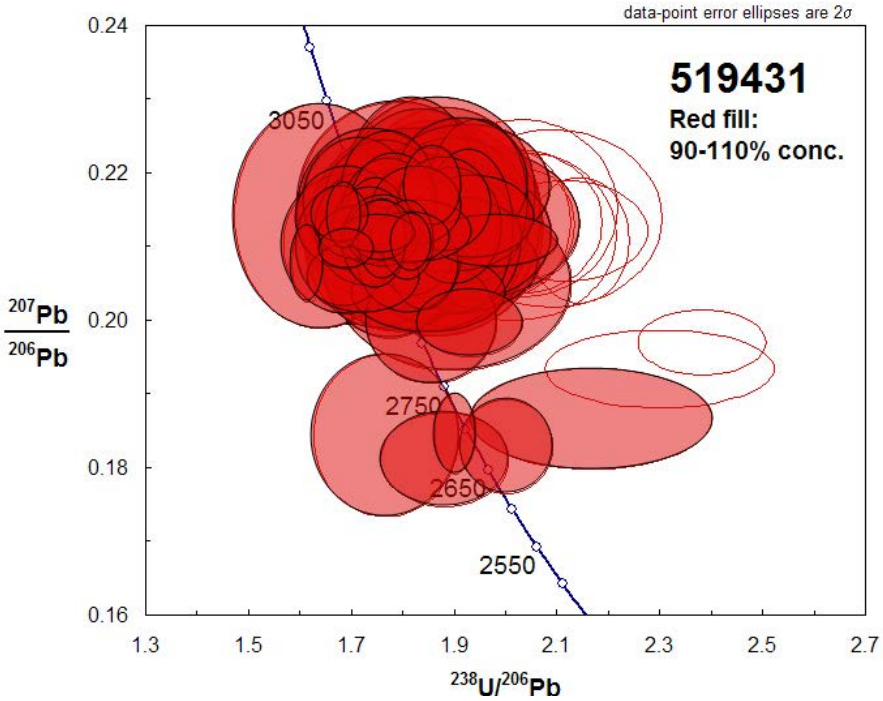


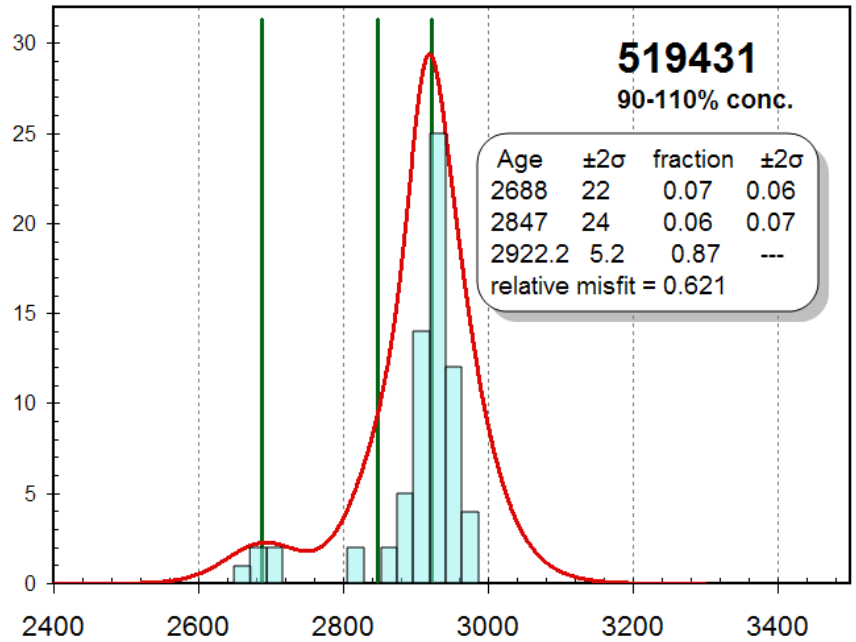


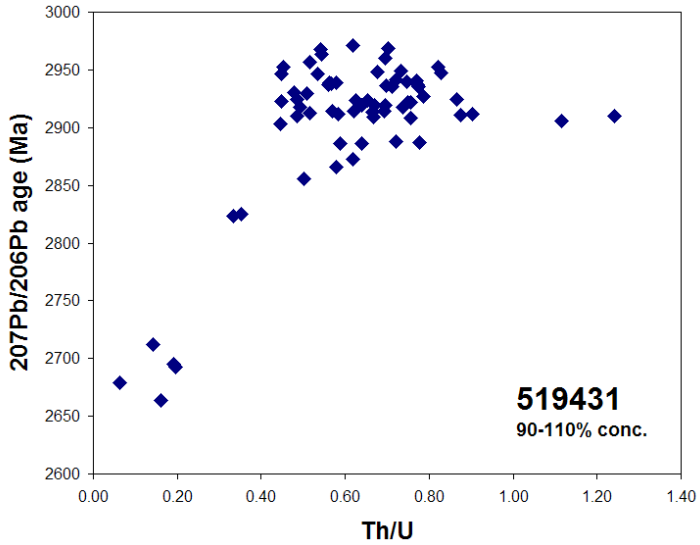




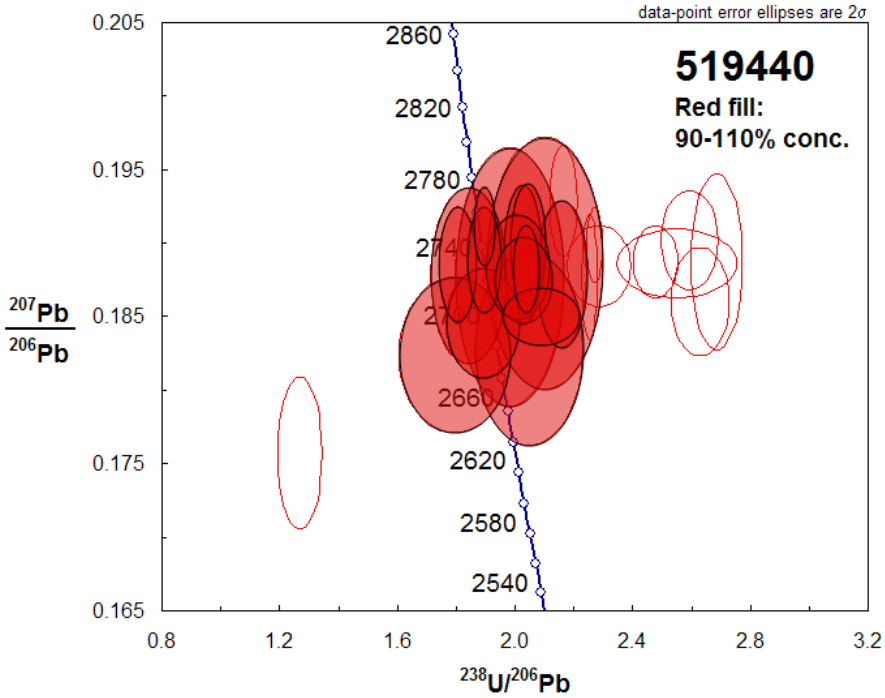
GEUS sample: 519431; **Coordinates:** N 61.862987 W 48.622212; **Collector:** TFK; **Station:** 10TFK038; **Rock type:** Orthogneiss, tonalite; **Aim:** intrusion, metamorphism; **Interpretation:** Well defined main peak at 2922 ± 5 Ma interpreted as the intrusion age of the gneiss protolith. A smaller peak at ~2690 may reflect late metamorphic growth. Few grains have intermediate ages possibly reflecting ancient Pb-loss. **Reference:** Kokfelt, T.F. (unpublished data).

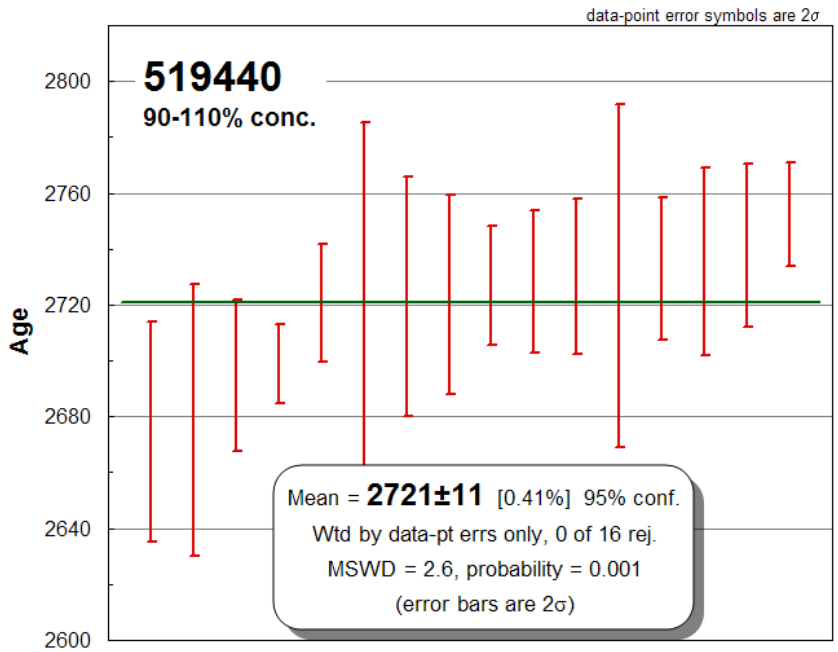


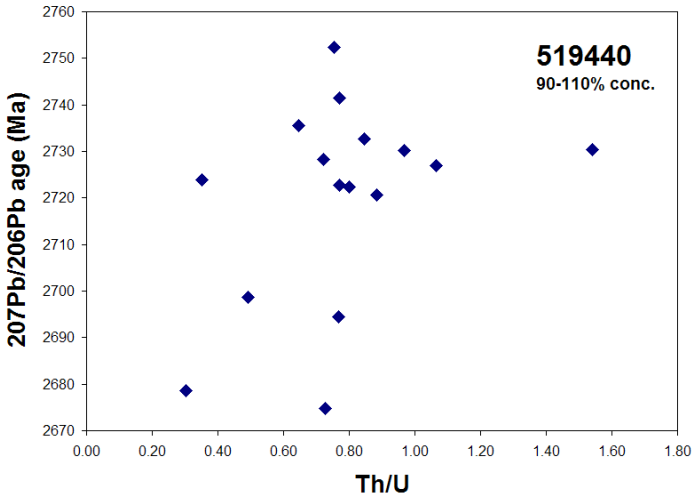


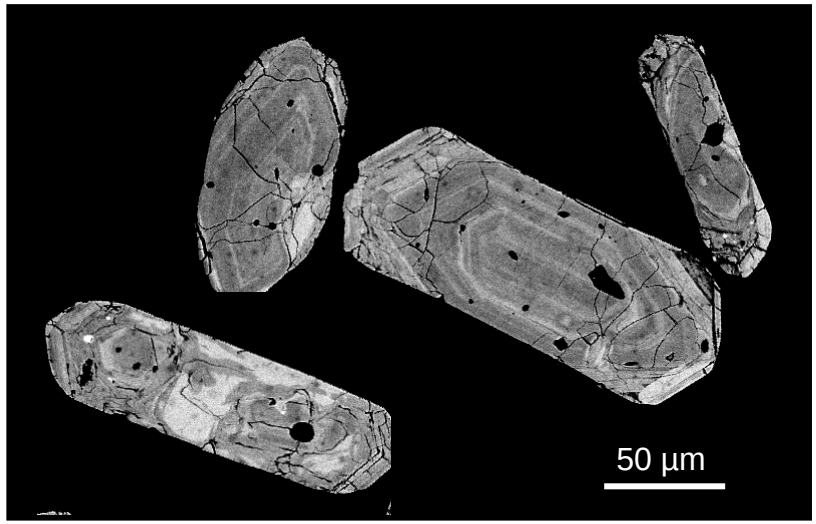


GEUS sample: 519440; **Coordinates:** N 62.091700 W 49.195090; **Collector:** TFK; **Station:** 10TFK182; **Rock type:** Granite, locally pegmatic; **Aim:** intrusion; **Interpretation:** A main peak at 2721 ± 11 Ma interpreted as the intrusion age of the granite. The granite pegmatite is part of the abundant and openly folded pegmatites that were intruded syntectonically into the supracrustal belts of the Kvanefjord area. **Reference:** Kokfelt, T.F. (unpublished data).

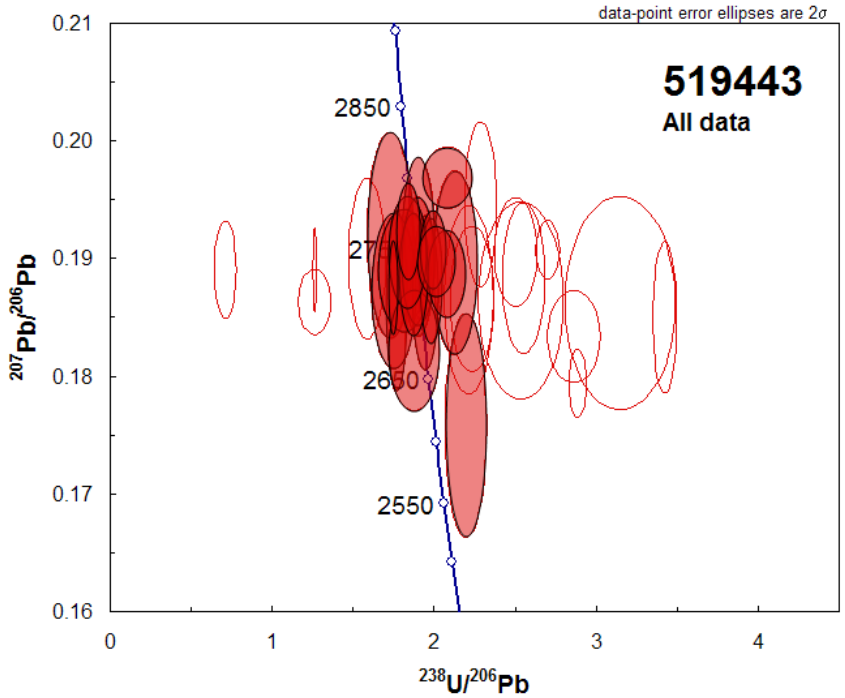


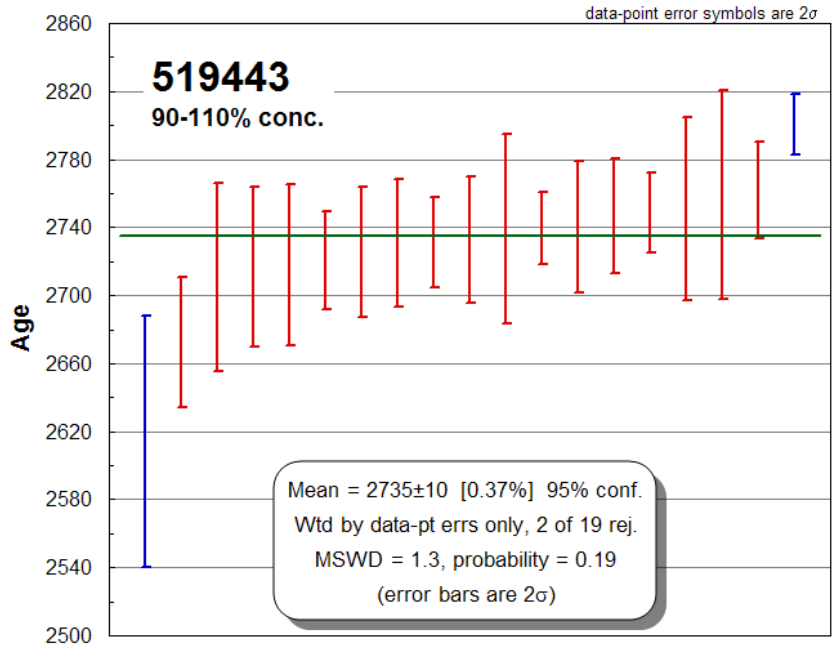


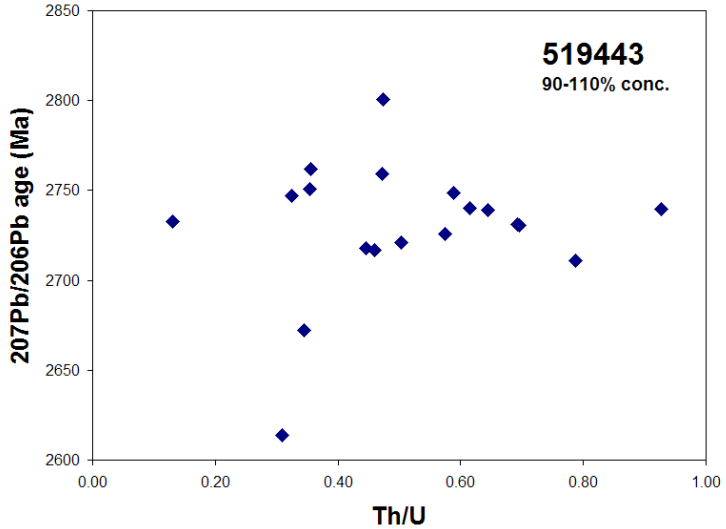


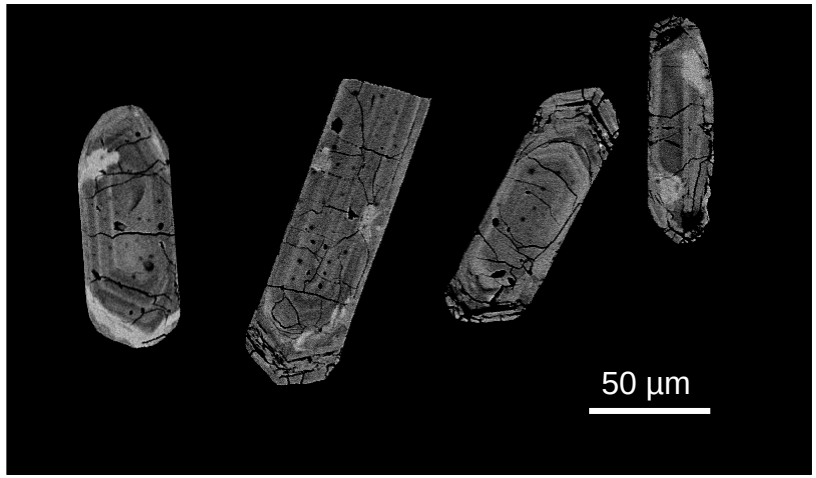


GEUS sample: 519443; **Coordinates:** N 62.091057 W 49.166758; **Collector:** TFK; **Station:** 10TFK186; **Rock type:** Granite, locally pegmatic; **Aim:** intrusion; **Interpretation:** A main peak at 2735 ± 10 Ma interpreted as the intrusion age of the granite. The granite pegmatite is part of the abundant and openly folded pegmatites that were intruded syntectonically into the supracrustal belts of the Kvanefjord area. **Reference:** Kokfelt, T.F. (unpublished data).

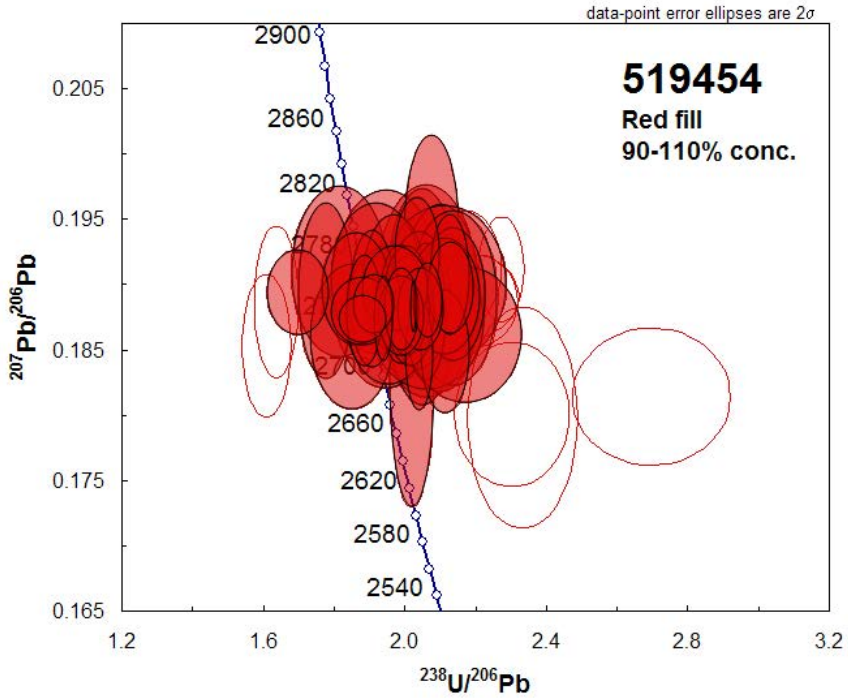


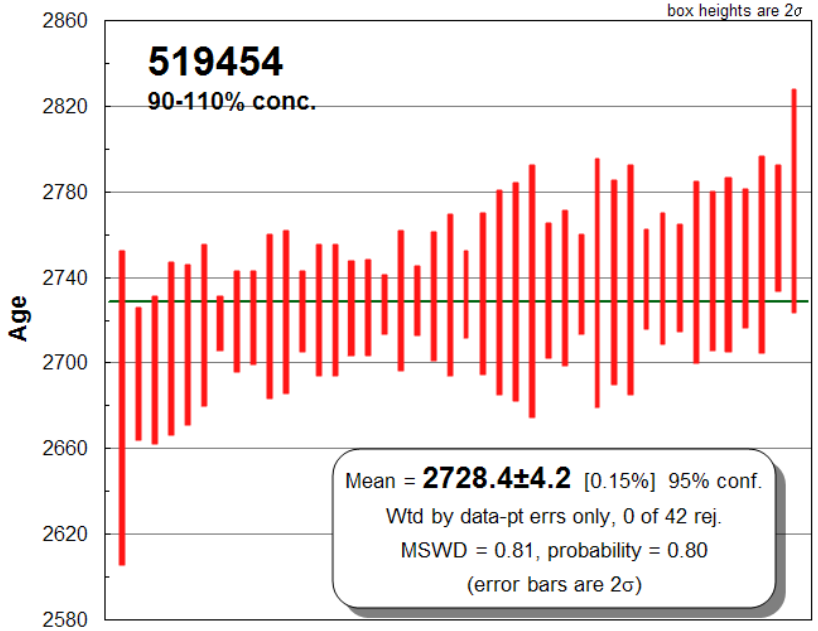


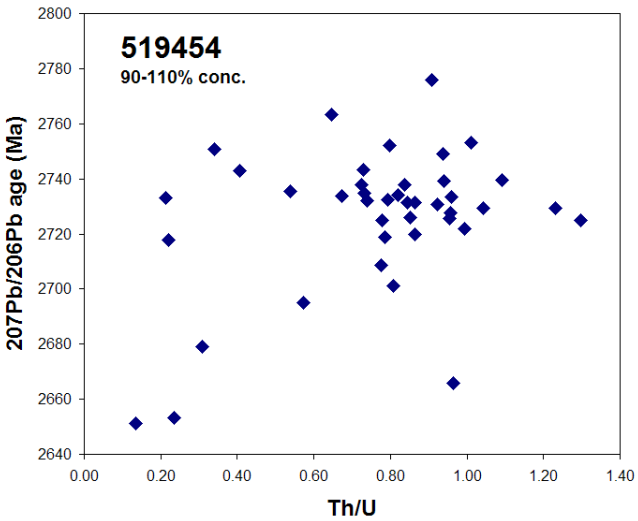


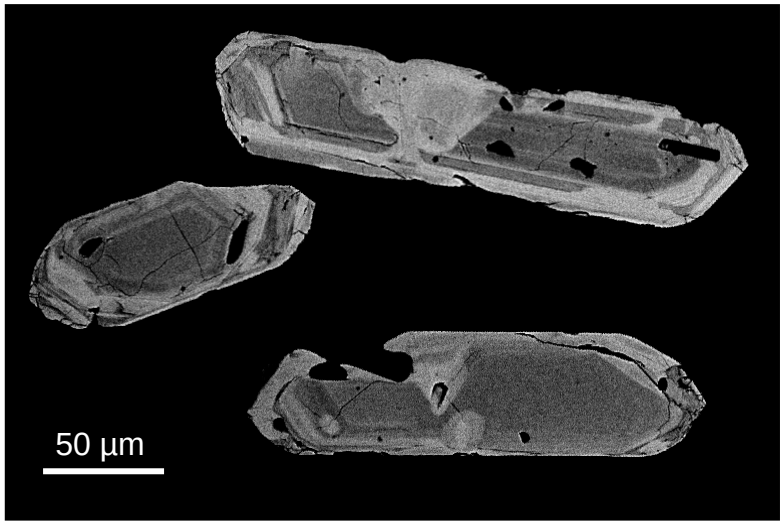


GEUS sample: 519454; **Coordinates:** N 62.108117 W 49.154833; **Collector:** TFK; **Station:** 10TFKxxx; **Rock type:** Granite, late tectonic; **Aim:** intrusion, metamorphism; **Interpretation:** Well defined peak at 2728 ± 4 Ma interpreted as the intrusion age of the granite, i.e. the intrusion is synchronous with the large, abundant granitic pegmatites in the Kvanefjord area. **Reference:** Kokfelt, T.F. (unpublished data).

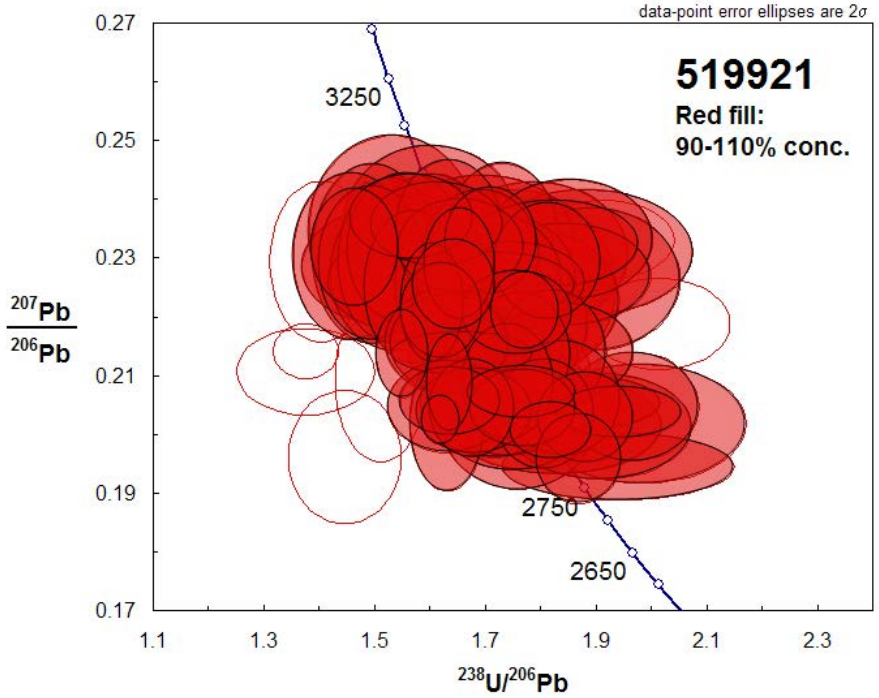


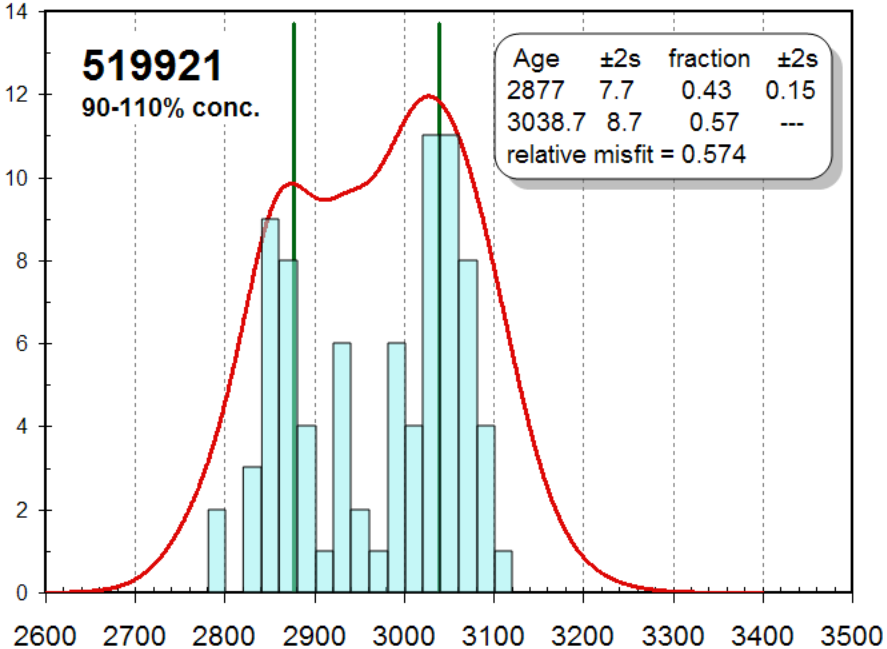


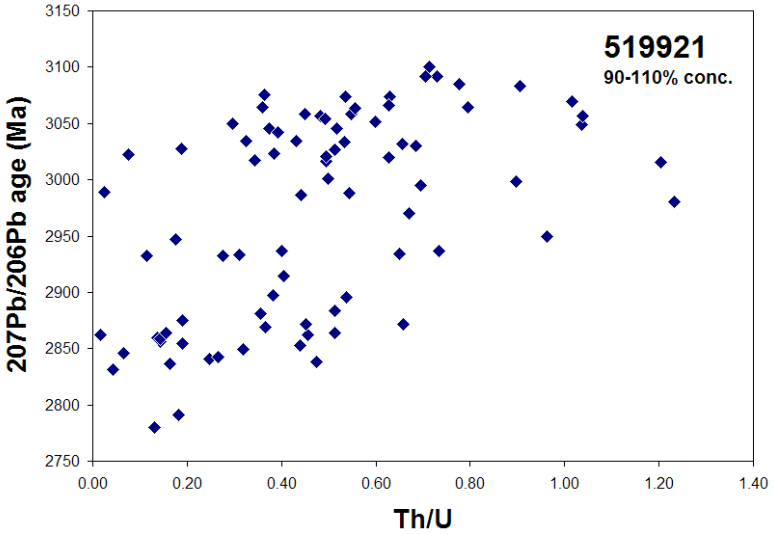


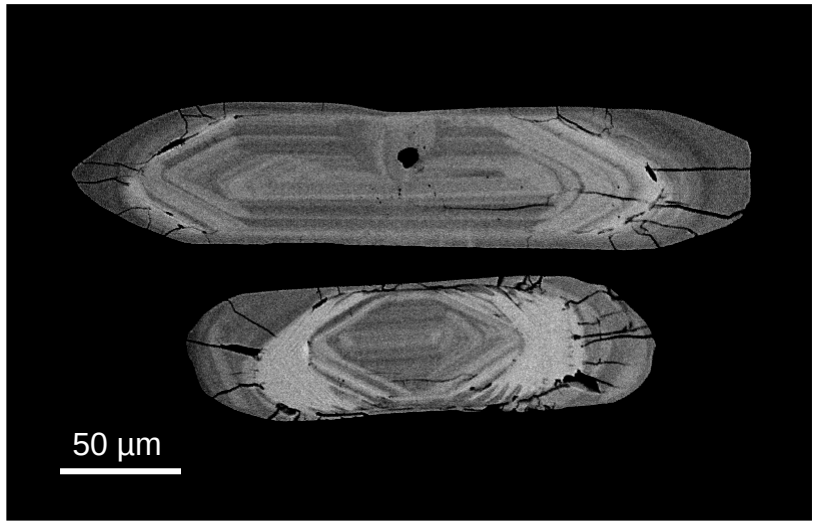


GEUS sample: 519921; **Coordinates:** N 62.651957 W 49.569628; **Collector:** TFK; **Station:** 10TFK106; **Rock type:** TTG, containing xenoliths and mafic enclaves; **Aim:** intrusion, metamorphism; **Interpretation:** The zircon ages form two broadly equally sized peaks at 3039 ± 9 Ma and 2877 ± 8 Ma and 2717 ± 8 Ma, interpreted as two separate intrusive TTG events. **Reference:** Kokfelt, T.F. (unpublished data).

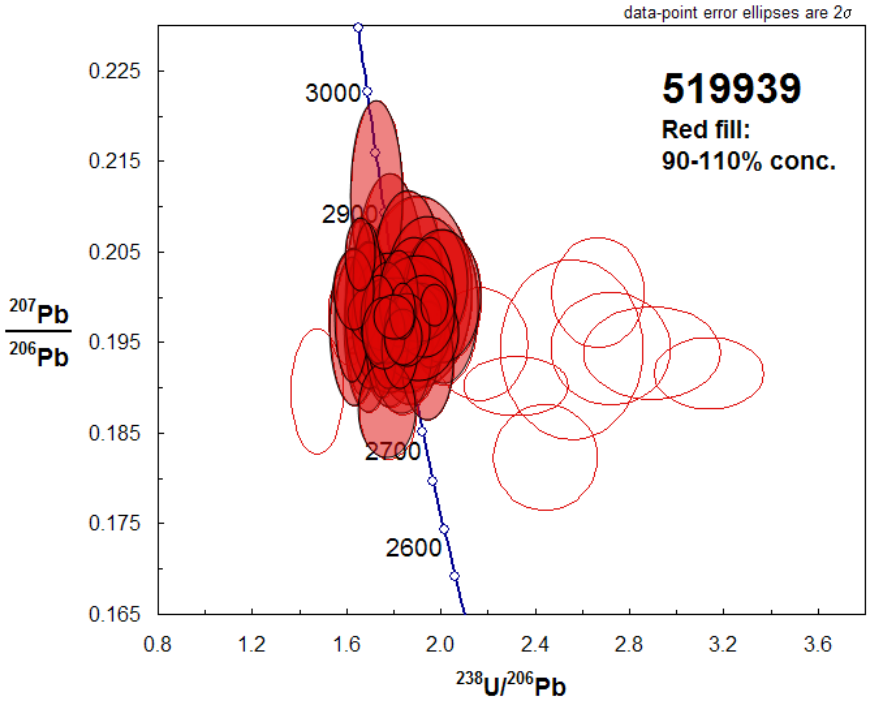


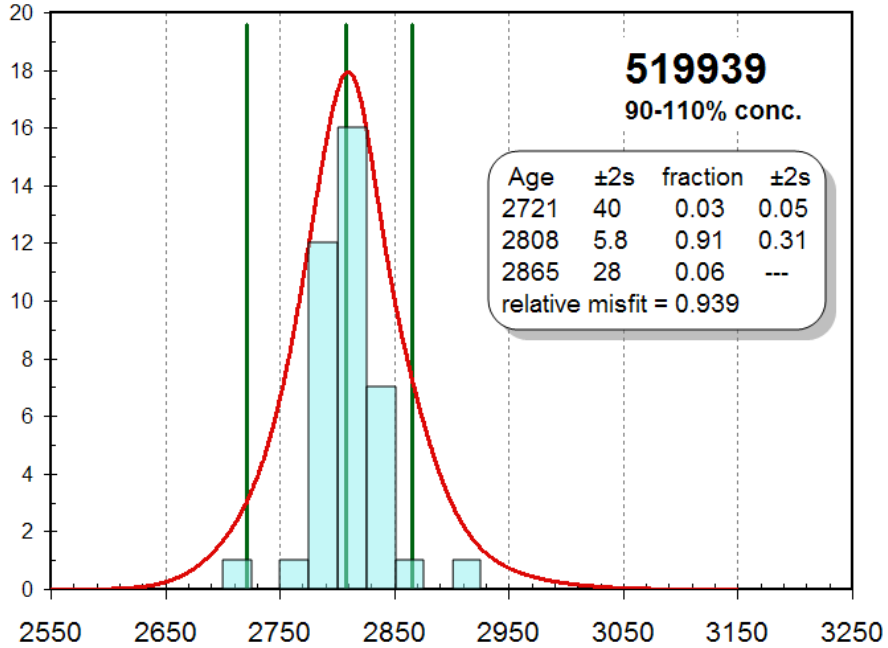


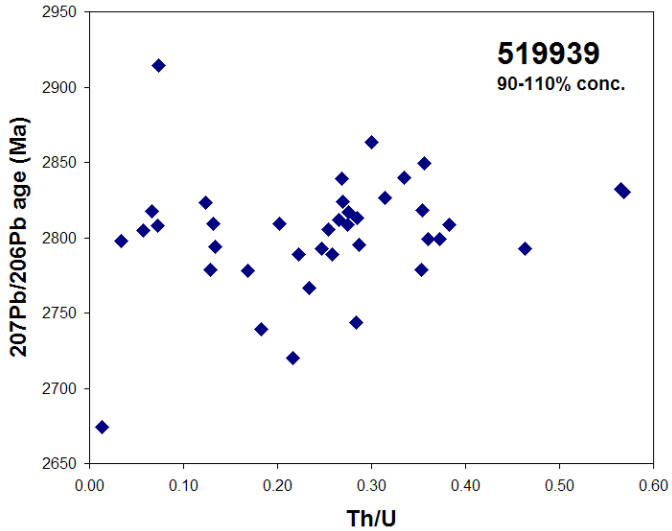


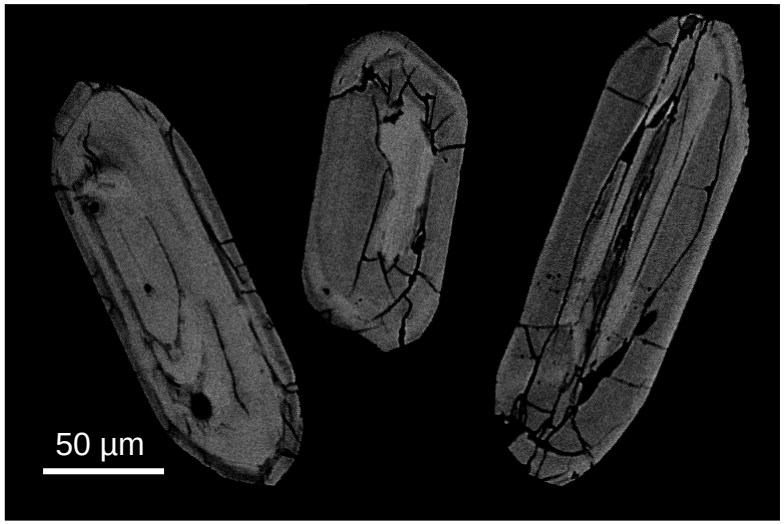
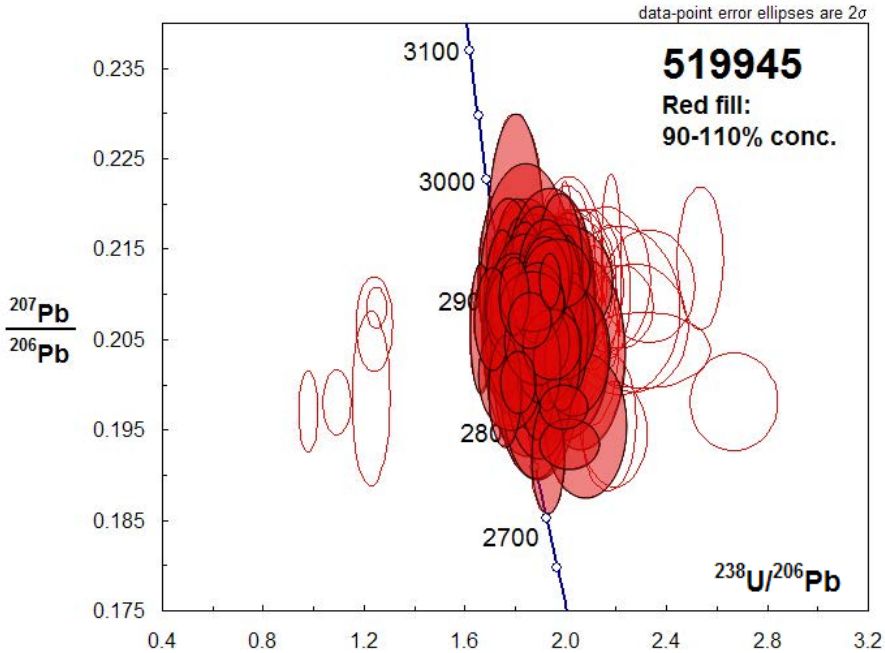
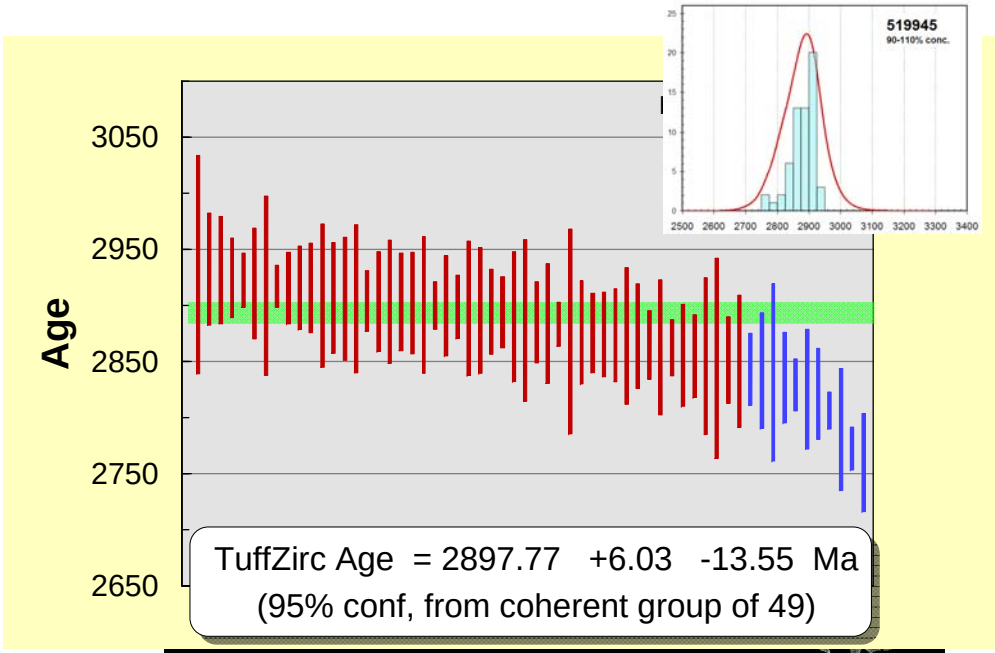
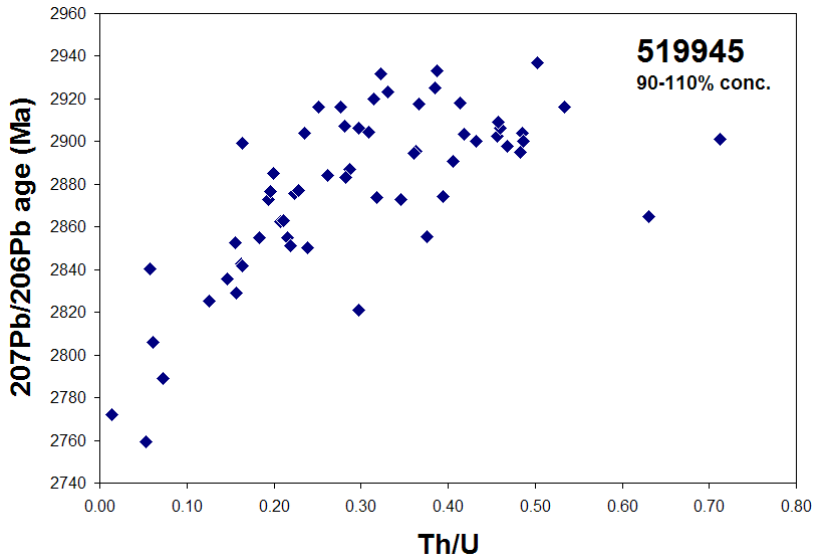


GEUS sample: 519939; **Coordinates:** N 62.625123 W 49.930262; **Collector:** TFK; **Station:** 10TFK125; **Rock type:** Orthogneiss, tonalitic, solid state deformed; **Aim:** intrusion, metamorphism; **Interpretation:** The zircons range between ~2720 and ~2910 Ma with a main peak at 2808 ± 6 Ma, the latter interpreted as the timing of the main deformation event in the area. A metamorphic origin is consistent with metamorphic appearance of the zircons. **Reference:** Kokfelt, T.F. (unpublished data).









GEUS sample: 519945; **Coordinates:** N 62.716860 W 49.848030; **Collector:** TFK; **Station:** 10TFK131; **Rock type:** Pegmatite; **Aim:** intrusion, metamorphism; **Interpretation:** Weakly defined main peak at 2898 (+6 / -13 Ma), interpreted as the intrusion age of the gneiss protolith. A tail of lower aged (lower Th/U) zircons down to ~2760 Ma may reflect mixing of distinct age domains during analysis and/or ancient Pb-loss. **Reference:** Kokfelt, T.F. (unpublished data).