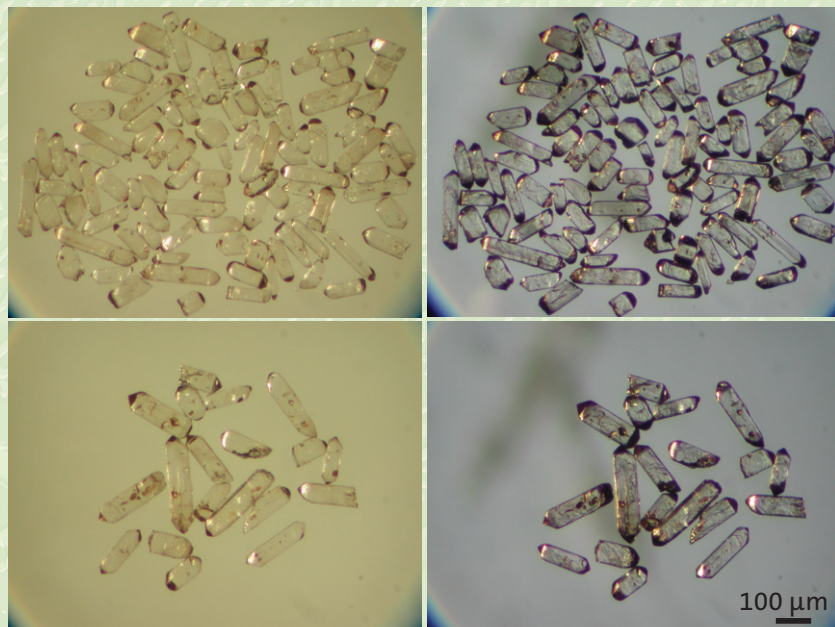




Results from radiometric datings and other isotope analyses 2



Fredrik Hellström (Ed.)

SGU-rapport
2008:27

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Sveriges geologiska undersökning
2008

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http://www.sgu.se/sgu/sv/produkter-tjanster/produkter/sgu_publ/publ_beskr/radiometriska-dateringar.html

Cover: Image of zircon from a granite at Spikberg, c. 14 km to the west of Harads, southern Norrbotten. See paper by Kathol & Persson (p. 27–28).

Contents

Editor's preface	4
Analytical methods	6
<i>Eliasson, T., Persson, P.-O. & Bergström, U., 2008a:</i> U-Pb zircon age of a TIB-1 quartz monzonite from Hultseryd north-east of Jönköping, south central Sweden	8
<i>Eliasson, T., Persson, P.-O. & Bergström, U., 2008b:</i> U-Pb zircon age of a TIB-1 granite from Bäckadal east of Jönköping, south central Sweden	11
<i>Eliasson, T., Rimša, A., Bergström, U. & Hellström, F., 2008c:</i> U-Pb zircon ion-probe geochronology of a porphyritic rhyolite from the Malmbäck volcanic area south-east of Jönköping, south central Sweden	14
<i>Eliasson, T., Bergström, U. & Persson, P.-O., 2008d:</i> Age of light grey metagranite in the Jönköping area	17
<i>Hallberg, A., Rimša, A. & Hellström, F., 2008:</i> Age of the host-rock to the Grängesberg apatite-iron ore	19
<i>Hellström, F., Rimša, A., Lundqvist, I. & Lundqvist, L., 2008a:</i> U-Pb zircon age of a gabbro from the Onsala peninsula, south-west Sweden	23
<i>Hellström, F., Rimša, A., Lundqvist, I. & Lundqvist, L., 2008b:</i> U-Pb zircon age of an augen-bearing gneissic granite from the Onsala peninsula, south-west Sweden	25
<i>Kathol, B. & Persson, P.-O., 2008a:</i> U-Pb zircon age of a massive granite from Spikberg, c. 14 km to the west of Harads, southern Norrbotten County, Sweden	27
<i>Kathol, B. & Persson, P.-O., 2008b:</i> Sm-Nd analysis of a quartz monzodiorite from Gunnarberget at Harads, southern Norrbotten County, Sweden	29
<i>Kathol, B. & Persson, P.-O., 2008c:</i> Sm-Nd analysis of a quartz diorite from Sandträskberget, southern Norrbotten County, Sweden	31
<i>Kathol, B., Lundmark, C., Hellström, F. & Rimša, A., 2008a:</i> U-Pb zircon age of a feldspar-porphyritic rhyolite from the Trollforsen area, c. 20 km north-west of Moskosel, southern Norrbotten County, Sweden	33
<i>Kathol, B., Rimša, A. & Hellström, F., 2008b:</i> U-Pb zircon age of a strongly deformed rhyolite from Danielstugan, c. 3.5 km north-north-east of Svartlå, southern Norrbotten County, Sweden	36
<i>Ripa, M., Rimša, A. & Hellström, F., 2008:</i> SIMS-dating of a Dala-type granite north of Evertsberg, Dalarna, Sweden	39

Editor's preface

Radiometric age determinations are carried out as an integral part of the bedrock mapping programme at the Geological Survey of Sweden (SGU). Results from these age determinations have previously been published in five volumes of SGU publication series C. From 2007 the results are published as short notes in the report series "SGU-rapporter". This publication presents U-Pb and Sm-Nd isotopic data from different geological provinces of the Swedish Precambrian bedrock (see Fig. 1).

The fruitful co-operation with the Laboratory for Isotope Geology of the Swedish Museum of Natural History in Stockholm (director, Dr. Per Andersson, head of NORDSIM, Dr. Martin Whitehouse) is gratefully acknowledged.

Uppsala, 2008-05-26

Fredrik Hellström

Phanerozoic cover rocks

Sandstone, siltstone, shale, limestone, dolerite, 545–55 Ma

Swedish Caledonides

700–430 Ma old rocks

- Granite, gabbro
- Sandstone, shale, limestone, volcanic rocks, predominantly metamorphosed
- Mica schist, mica gneiss, amphibolite
- Sandstone, diabase dykes
- Sandstone, fossiliferous shale and limestone

>1500 Ma old rocks

Granite, syenite, gabbro, volcanic rocks, mica gneiss

Fennoscandian Shield

1570–700 Ma old rocks

- Granite, pegmatite
- Sandstone, shale, mafic volcanic rocks, in part metamorphosed
- Granite, monzonite, syenite, gabbro, diabase, in part metamorphosed

1850–1590 Ma old rocks

- Mica gneiss, amphibolite
- Felsic volcanic rocks, metamorphosed
- Volcanic rocks, in part metamorphosed
- Granitoid gneiss
- Granite, pegmatite, monzonite, syenite, gabbro, in part metamorphosed

1960–1850 Ma old rocks

- Granite, monzonite, syenite, gabbro, in part metamorphosed
- Granite, granodiorite, tonalite, gabbro, metamorphosed
- Sandstone, shale, metamorphosed
- Volcanic rocks, metamorphosed

2500–1960 Ma old rocks

Mafic volcanic rocks, sandstone, shale, carbonate rock, metamorphosed

>2500 Ma old rocks

Granitoid gneiss, granite

Structures

- ★ Inferred impact structure
- Normal fault, symbols in downthrown block
- Caledonian thrust, symbols in elevated block
- Sveconorwegian reverse deformation zone, symbols in elevated block
- Svecokarelian deformation zone, symbols in downthrown block
- Deformation zone with strike-slip component of movement
- Deformation zone, kinematics unspecified
- Form line of tectonic foliation in the Fennoscandian Shield

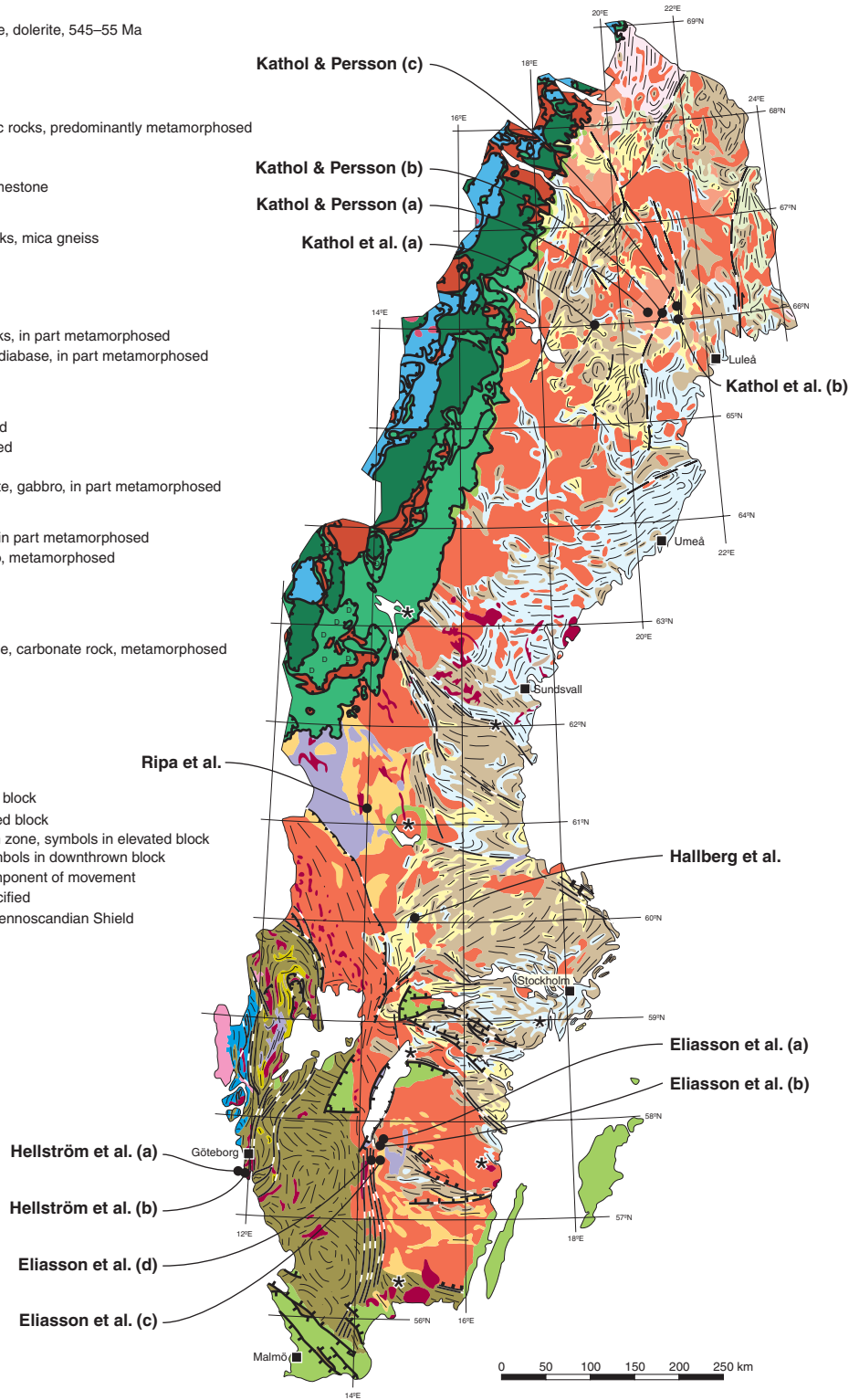


Fig. 1. Bedrock map of Sweden. The map was compiled on a commission basis from the Swedish Nuclear Fuel and Waste Management Company (SKB), and is based on the bedrock map of Sweden (Stephens et al. 1994). Location of areas within which results are presented in this publication are indicated.

Analytical methods

U-Pb TIMS zircon analysis

Analytical methods for the U-Pb datings performed at the Laboratory for Isotope Geology in Stockholm can be summarised as follows. Zircon mineral separates were obtained from density separation of about one kg of crushed rock sample using a Wilfley water table. The magnetic minerals were removed by a hand magnet. Most fractions were abraded according to the Krogh (1982) method. They were spiked with a ^{205}Pb - 233 - ^{236}U tracer and dissolved in HF:HNO₃ in Teflon® capsules in autoclaves according to the method of Krogh (1973). After decomposition and evaporation the samples were dissolved in 3.1 N HCl and loaded onto anion exchange columns with 50 µl resin volume for extraction of Pb and U which were collected together. H₃PO₄ was added and the solution was evaporated and subsequently loaded on Re single filaments with silica gel. The isotopic ratios were measured on a Finnigan MAT 261 mass spectrometer equipped with five faraday cups. For most samples, Pb was measured in the static mode on the faraday cups. U and some small Pb samples, yielding low signals, were measured in peak jumping mode on a secondary electron multiplier. The calculation of the corrected isotope ratios and the error propagation were made using the PBDAT program of Ludwig (1991), and the decay constants recommended by Steiger & Jäger (1977) were used. The calculation of the intercept ages and the drawing of the concordia plot were made with the ISOPLOT-program by Ludwig (version rev 2.49, 2001). The total Pb blank was 1–5 pg (standard value 2 pg) and the U blank less than 1 pg. The assigned composition of common Pb is calculated according to the Pb evolution model of Stacey & Kramers (1975). The mass fractionation for Pb is 0.10±0.04‰ per a.m.u. U mass fractionation was monitored and corrected for by means of the 233 - ^{236}U ratio of the spike. All analytical errors are given as 2σ.

U-Pb SIMS zircon analysis

Zircon mineral separates were obtained from density separation of about one kg of crushed rock sample using a Wilfley water table. The magnetic minerals were removed by a hand magnet. About 100–200 hand picked crystals from each sample were cast in epoxy. The zircon mounts were polished and after gold coating examined by cathodoluminescence (CL) imaging, using standard electron microscopy at the Museum of Natural History in Stockholm, Sweden (Hitachi S-4300 electron microscope, Gatan CL 3 detector).

High-spatial resolution secondary ion mass spectrometer (SIMS) analysis was made using a Cameca IMS

1270 at the Nordsim facility at the Swedish Museum of Natural History in Stockholm. Detailed descriptions of the analytical procedures for these analyses are given in Whitehouse et al. (1999) and Whitehouse & Kamber (2005). Analytical data are given in tables attached to the individual reports. Diagrams and age calculations of isotopic data were made using software Isoplot 3.00 (Ludwig 2003). The amount of common ^{206}Pb in measured ^{206}Pb is estimated from ^{204}Pb assuming a present day terrestrial Pb following the model of Stacey & Kramers (1975). Statistical precisions of age estimates are given at the 2σ level (unless otherwise explicitly stated).

Sm-Nd TIMS whole-rock analysis

About 100 mg of sample powder was weighed out in teflon capsules and spiked with a mixed ^{149}Sm - ^{150}Nd or ^{147}Sm - ^{150}Nd tracer. The samples were decomposed in 2 ml suprapur concentrated HF and 20 drops of concentrated HNO₃ in autoclaves at 205 °C for 5 days. Additional treatment with nitric and hydrochloric acids and subsequent centrifugation was carried out in order to eliminate solid residues. Initial ion exchange was performed in columns filled with 3.5 ml AG50W x 8 hydrogen form resin. Samples were loaded in 1 ml 2.5N HCl and REE eluted with 6N HNO₃. During a second ion exchange procedure Sm and Nd were separated from the other REE in Ln-spec columns (Pin & Zalduegui 1997). Samples were loaded in 2 ml 0.05N HNO₃, and Nd collected in 0.25N HCl and Sm in 0.75N HCl. Finally, the purified element fractions were treated with 6N HCl, a few drops of concentrated HNO₃ and H₂O₂ on hot plates in order to remove any organic residues.

Sm and Nd were loaded on Re double filaments and analysed on a Triton thermal ionisation mass spectrometer (TIMS) from Thermo Scientific, equipped with a multi-collector. The analyses were made in the static mode. $^{143}\text{Nd}/^{144}\text{Nd}$ ratios were corrected for ^{144}Sm interference and normalised to $^{146}\text{Nd}/^{144}\text{Nd}=0.7219$. Errors in the measurements are given as two standard deviations of the mean from the mass spectrometer runs in the last digits.

The La Jolla Nd standard gave an average $^{143}\text{Nd}/^{144}\text{Nd}$ ratio of 0.511846±5 (2σ). The recommended value is 0.512854 and the measured data were corrected accordingly.

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U-Pb zircon age of a TIB-1 quartz monzonite from Hultseryd north-east of Jönköping, south central Sweden

Thomas Eliasson^a, Per-Olof Persson^b & Ulf Bergström^a

^aGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden

Eliasson, T., Persson, P.-O. & Bergström, U., 2008: U-Pb zircon age of a TIB-1 quartz monzonite from Hultseryd north-east of Jönköping, south central Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 8–10.

Rock	Quartz monzonite
Sample number	TEN060076
Coordinates (RT90)	6409793 / 1416708
Map sheet	7E SW Jönköping, 1d
Locality	Hultseryd, 14 km ENE Jönköping
Project	Jönköping, SGU code: 80015

Aim of study

The aim of this study was to date igneous crystallisation of a quartz monzonitic facies of the Transscandinavian Igneous Belt (TIB) in the Jönköping area. At the sampling locality the rock exhibits a gradual change in texture and mode toward a red, coarse-grained, felsic granite. The latter facies is often named red Väjö granite (e.g. Geijer et al. 1951, Wikman 2000).

Sample description

The dated sample is a reddish grey, medium- to coarse-grained, isotropic, hornblende ± biotite quartz monzonite (Fig. 1A). Commonly it is unequigranular to sparsely porphyritic.

The quartz monzonite has a relatively high content of mafic minerals, amphibole predominates (c. 18 vol.-%) over biotite (3.6 vol.-%). The dated rock contains almost 1 vol.-% opaques, principally rounded ilmenite and some angular magnetite grains. Apatite and zircon are primary accessory phases.

The water-undersaturated character of the magma is shown by the presence of small remnants of primary orthopyroxen. Zircon occurs as sub- to euhedral inclusions in amphibole or biotite as well as idiomorphic crystals in late crystallising quartz and feldspar (Fig. 1B).

Analytical results and interpretation of geochronological data

U-Pb TIMS zircon analysis was performed at the Laboratory of Isotope geology at the Museum of Natural History, Stockholm. Analytical data are presented in Table 1.

The zircons are colourless, pink or brown. Most of them are euhedral, generally with weakly rounded terminations but also crystals with sharp terminations

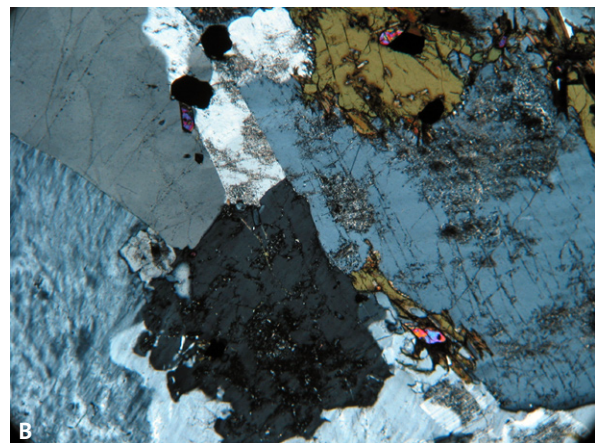


Fig. 1. A. The dated quartz monzonite. Length of scale bar is 20 mm. B. Photomicrograph showing zircon in hornblende. A euhedral zircon is also found between quartz and plagioclase (centre left). Crossed nicols. Field of view is 2.5 mm.

occur (Fig. 2). The prisms have mostly low-index crystal faces whereas the pyramids in many cases also have faces with high crystallographic indices. Cores and overgrowths are rare. Many grains are clear and free from cracks. Inclusions and weak magmatic zonation are common features. All analysed crystals were abraded. The hand-picked zircons were divided into two size populations prior to abrasion and were abraded separately, Abr 1 and Abr 2 (Fig. 2). The abraded zircon grains were divided into five fractions based on morphology.

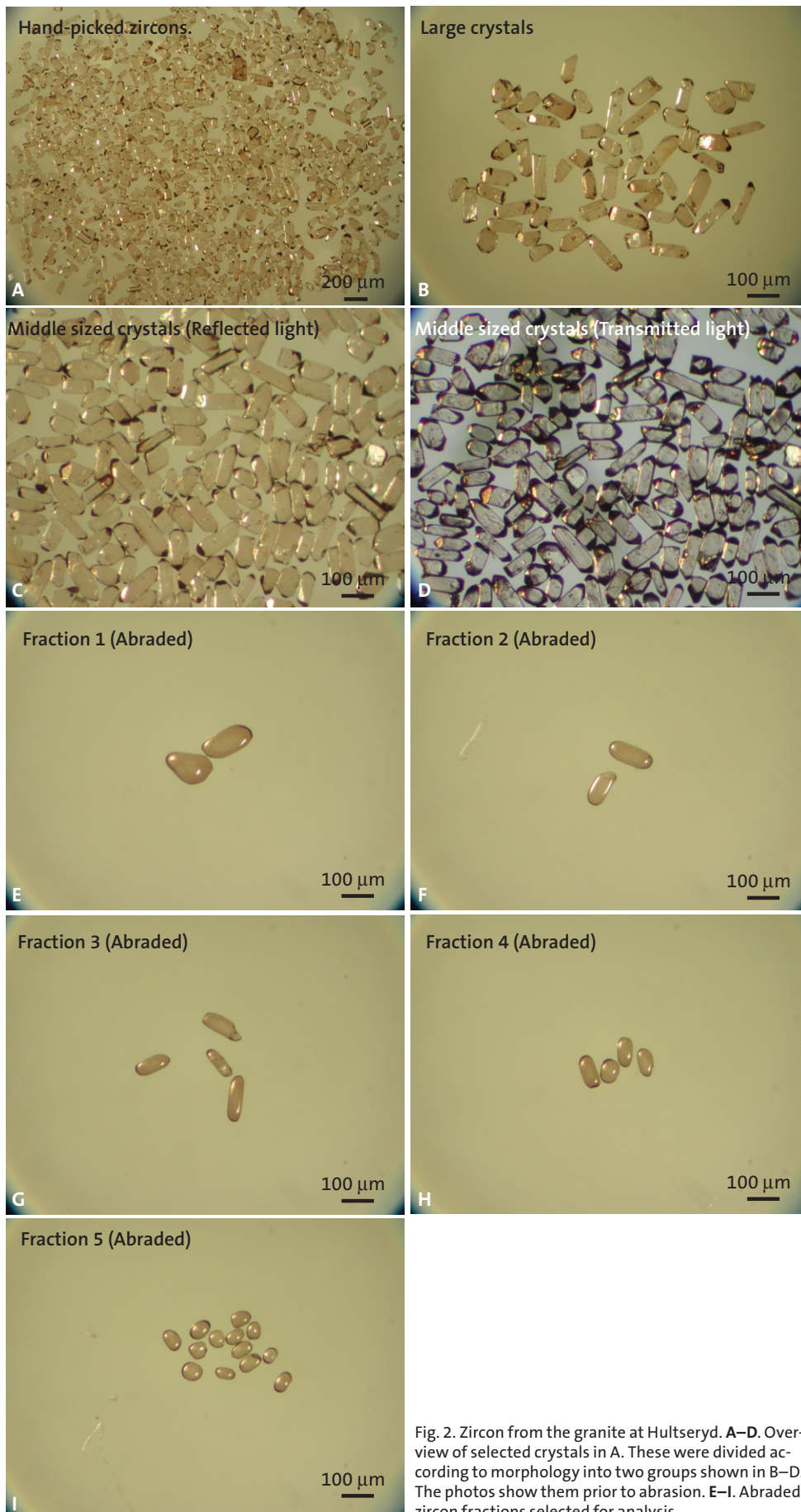


Fig. 2. Zircon from the granite at Hultseryd. A–D. Overview of selected crystals in A. These were divided according to morphology into two groups shown in B–D. The photos show them prior to abrasion. E–I. Abraded zircon fractions selected for analysis.

The five data points form a discordia with intercept ages of 1797 ± 7 Ma and 11 ± 100 Ma and a MSWD of 2.3 (Fig. 3).

Discussion and conclusion

The upper intercept of 1797 ± 7 Ma is interpreted to date the igneous crystallisation of the quartz monzonite at Hultseryd. This indicate that the quartz monzonite in the Jönköping area approximately has the same age as the grey, generally more basic TIB granites.

References

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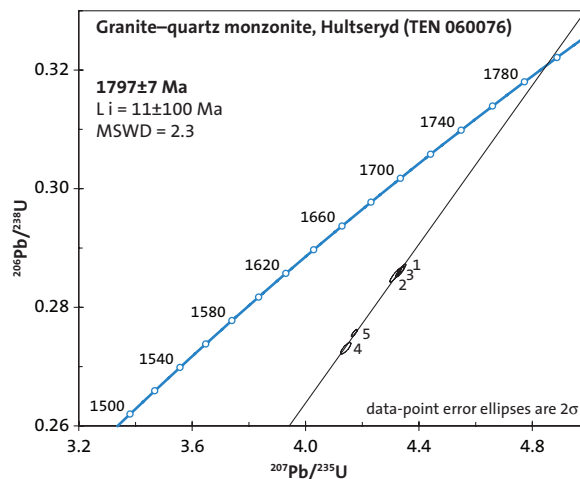


Fig. 3. U-Pb diagram of zircon data from the quartz monzonite at Hultseryd in the Jönköping area. Numbers refer to fraction-number in Table 1.

Table 1. U-Pb TIMS isotopic data for zircon from a granite at Hultseryd (TEN060076A).

Fraction	Weight (μg)	U (ppm)	Th ¹ (ppm)	Pb tot (ppm)	Pb com (ppm)	$^{206}\text{Pb}/^{204}\text{Pb}^2$	$^{206}\text{Pb}-^{207}\text{Pb}-^{208}\text{Pb}$ (At %) ³	$^{206}\text{Pb}/^{238}\text{U}^4$	2σ (%)	$^{207}\text{Pb}/^{235}\text{U}^4$	2σ (%)	$^{207}\text{Pb}/^{206}\text{Pb}^4$	2σ (%)	corr. coeff. ⁵	$^{207}\text{Pb}/^{206}\text{Pb}$ Age (Ma)
1	5	288.6	105.6	87.1	0.38	6446	82.0–9.0–9.0	0.2864	0.24	4.339	0.27	0.10987	0.12	0.892	1797.3±2.2
2	3	162.2	59.7	49.2	0.56	2315	82.0–9.0–9.0	0.2860	0.25	4.333	0.28	0.10989	0.14	0.868	1797.6±2.6
3	5	168.1	65.9	51.3	0.65	2758	81.5–9.0–9.5	0.2854	0.34	4.317	0.37	0.10970	0.15	0.910	1794.4±2.8
4	3	225.3	86.3	66.2	1.48	1727	81.7–9.0–9.3	0.2731	0.29	4.142	0.35	0.11000	0.21	0.810	1799.3±3.8
5	5	183.9	67.9	53.6	0.40	3843	82.0–9.0–9.0	0.2757	0.17	4.172	0.20	0.10976	0.10	0.857	1795.4±1.9

Analysed fractions (see photos in Fig 2.):

- Two crystals from Abr 1. Good quality with no cracks or visible inner structures.
- Two crystals from Abr 1. The same quality as fraction 1 but smaller grain size.
- Four elongated crystals from Abr 2. Good quality.
- Four short prismatic crystals from Abr 2. Good quality.
- 13 small and short, thoroughly rounded crystals from Abr 2. Good quality.

1. Calculated from ^{208}Pb content. Corrected for Pb loss.
2. Corrected for mass fractionation and spike.
3. Radiogenic Pb, i.e. corrected for common Pb och blank.
4. Corrected for mass fractionation, spike, common Pb and blank.
5. Correlation coefficient for errors in $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$.

The samples were not weighed. The weights are estimated from the number and size of the crystals.

U-Pb zircon age of a TIB-1 monzogranite from Bäckadal east of Jönköping, south central Sweden

Thomas Eliasson^a, Per-Olof Persson^b & Ulf Bergström^a

^aGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50007, SE-104 05 Stockholm, Sweden

Eliasson, T., Persson, P.-O. & Bergström, U., 2008: U-Pb zircon age of a TIB-1 monzogranite from Bäckadal east of Jönköping, south central Sweden. In F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 11–13.

Rock	Granite, TMB1
Sample number	TEN060105
Coordinates (RT90)	6407077 / 1415410
Map sheet	7E SW Jönköping, 1d
Locality	Bäckadal, 6 km E Huskvarna
Project	Jönköping, SGU code: 80015

Aim of study

The aim of this study was to date the igneous crystallisation of a felsic granite belonging to the Transscandinavian Igneous Belt (TIB) in the Jönköping area. Furthermore, it aims to bracket the time interval for the TIB-1 plutonism in the Jönköping area.

Sample description

The analysed monzogranite is light reddish grey with a medium-grained, unequigranular to sparsely porphyritic texture (Fig. 1A). The granite has a faint macroscopic igneous flow foliation defined by a preferred orientation of elongated aggregates of biotite and, subordinately, microcline phenocrysts.

Microcline is commonly fresh and unaltered, whereas plagioclase is severely optically clouded by fine-grained sericite and very fine-grained albite + epidote + calcite saussurite assemblage (Fig. 1B). In addition to the felsic phases, biotite, partly altered to chlorite ± pumpellyite, titanite, magnetite, accessory allanite, zircon, pyrite and apatite have been found. Zircon occurs as small tabular grains often partly surrounded by a secondary fine-grained epidote.

Analytical results and interpretation of geochronological data

U-Pb TIMS zircon analysis was performed at the Laboratory of Isotope geology at the Museum of Natural History, Stockholm. Analytical data are presented in Table 1.

The zircons are generally of poor analytical quality. Most are yellowish brown, but a minority is colourless (Fig. 2). The few transparent grains are mostly light brown or in some cases colourless. Most crystals are short prismatic and euhedral or slightly rounded but

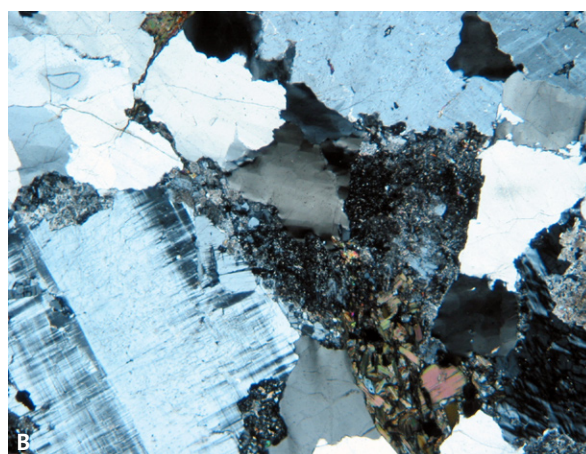


Fig. 1. A. The dated monzogranite. Length of scale bar is 20 mm. B. Photomicrograph showing fresh microcline, severely altered plagioclase and an aggregate of biotite. Crossed nicols. 2.5 mm field of view.

also more substantially rounded grains occur. Crystals with only low-order crystallographic faces predominate. Crystal-rim relations are seen in many of the zircons, usually as thin overgrowths on rounded cores, but the crystals selected for abrasion were devoid of such visible heterogeneities. Many grains show magmatic zonation. All analysed crystals were abraded. The selected zircons were divided according to morphology into three groups that were abraded separately (Abr 1 to Abr 3, Fig. 2). The

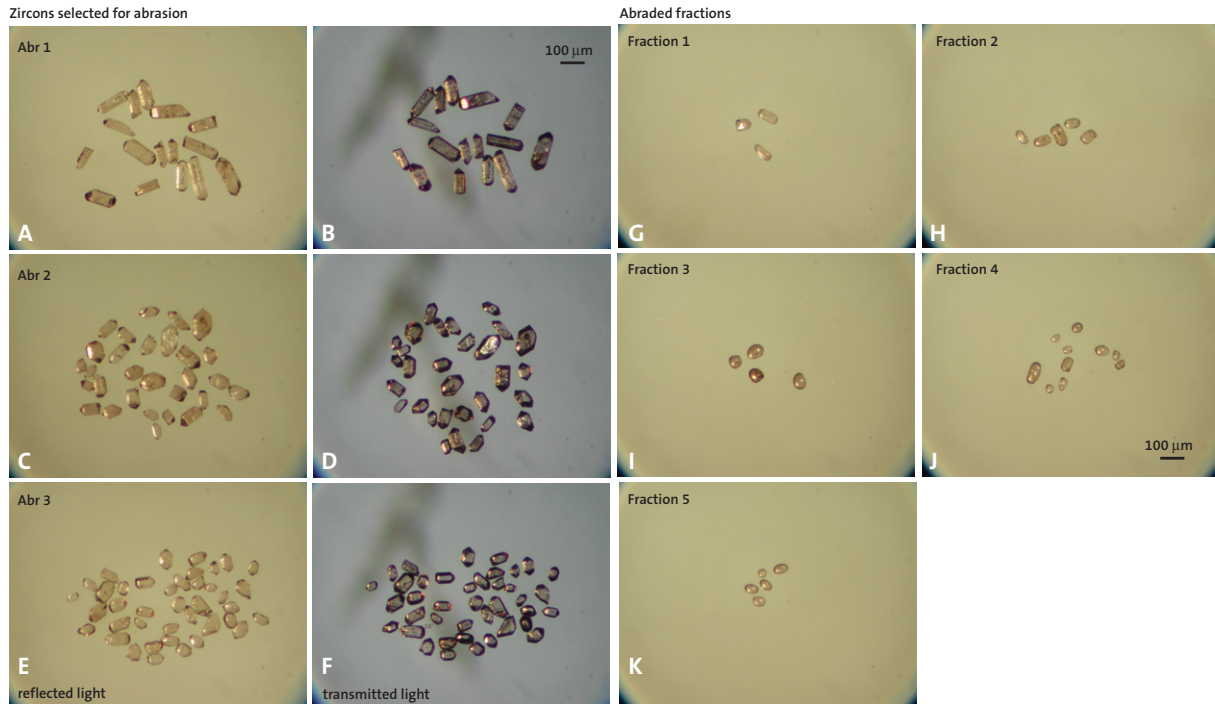


Fig. 2. Zircon from the monzogranite at Bäckadal. A–F. Selected crystals were divided according to morphology into three groups. The photographs show them prior to abrasion. G–K. Abraded zircon fractions selected for analysis. Some grains were lost during the washing and transferring procedures so the photos show larger numbers of grains than was actually analysed.

abraded zircon grains were divided into six fractions based on morphology and quality (Fig. 2).

A discordia calculated from all six data points give intercept ages of 1781 ± 20 Ma and -211 ± 360 Ma with a poor linear fit (MSWD=6.7, Fig. 3). Since the lower intercept is strongly negative, a calculation with an intercept forced through 0 ± 400 Ma was also made, yielding an upper intercept of 1792 ± 28 Ma and an MSWD of 8.2. If the most discordant point (#5) is omitted, the ages are 1781 ± 30 and -55 ± 360 Ma and the MSWD is 6.7.

As there is a poor linear fit (high MSWD), a model 2-fit was used in age calculation where data points are weighted equally, ignoring the data point errors. Age errors from a low-probability U-Pb discordia may, however, be unreliable. The upper intercept age from all six data points is interpreted as the crystallisation age of the granite poorly constrained at c. 1.78 Ga (1781 ± 20 Ma).

Discussion and conclusion

The igneous crystallisation age of the monzogranite is poorly constrained at about 1.78 Ga. The obtained age overlaps with the 1797 ± 7 Ma crystallisation age for a TIB-1 quartz monzonite at Hultseryd c. 2.5 km to the north of Bäckadal (Eliasson et al. 2008).

References

Eliasson, T., Persson, P.-O. & Bergström, U., 2008: U-Pb zircon age of a TIB-1 quartz monzonite from Hultseryd north-east of Jönköping, south central Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 8–10.

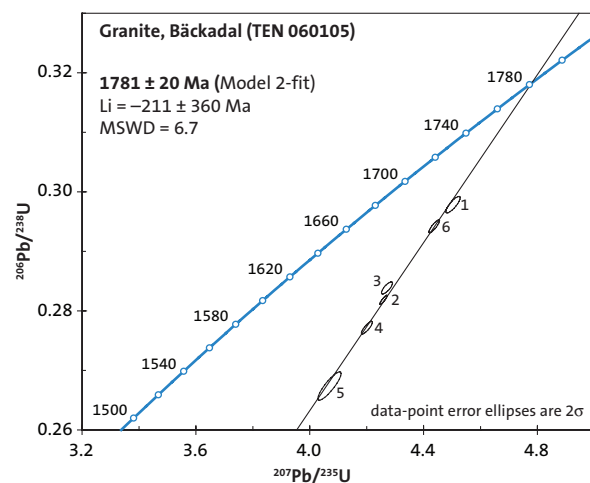


Fig. 3. U-Pb diagram showing zircon data from a monzogranite in the Jönköping area. Data-point error ellipses are 2σ . Numbers refer to fraction number in Table 1.

Table 1. U-Pb TIMS isotopic data for zircon from a granite at Bäckadal (TEN060105).

Fraction	Weight (µg)	U (ppm)	Th ¹ (ppm)	Pb tot (ppm)	Pb com (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb ²	²⁰⁶ Pb– ²⁰⁷ Pb– ²⁰⁸ Pb (At %) ³	²⁰⁶ Pb/ ²³⁸ U ⁴	2σ (%)	²⁰⁷ Pb/ ²³⁵ U ⁴	2σ (%)	²⁰⁷ Pb/ ²⁰⁶ Pb ⁴	2σ (%)	corr. coeff. ⁵	²⁰⁷ Pb/ ²⁰⁶ Pb Age (Ma)
1	1	430.0	200.4	139.3	1.72	2114	80.1–8.8–11.1	0.2978	0.38	4.503	0.45	0.10965	0.25	0.828	1793.7±4.6
2	2	529.6	266.8	163.7	1.89	3106	79.4–8.7–11.9	0.2819	0.22	4.259	0.24	0.10959	0.11	0.902	1792.6±1.9
3	2	308.8	130.6	94.3	1.18	2441	81.0–8.8–10.2	0.2839	0.29	4.271	0.37	0.10913	0.23	0.788	1785.0±4.1
4	2	232.3	114.7	73.5	3.92	789	79.6–8.8–11.6	0.2772	0.31	4.201	0.37	0.10991	0.20	0.848	1798.0±3.6
5	1	206.7	100.1	63.1	3.48	620	79.8–8.8–11.4	0.2674	0.73	4.069	0.82	0.11038	0.39	0.877	1805.7±7.2
6	3	159.0	76.6	52.0	1.60	1244	79.9–8.7–11.4	0.2942	0.30	4.437	0.34	0.10938	0.17	0.871	1789.2±3.1

Analysed fractions (see photos in Fig 2):

1. Three elongated crystals of good quality from Abr 1 with longitudinal zonation.
2. Four crystals with magmatic zonation from Abr. 1 have shorter aspect ratio than fraction 1 after abrasion and are of poorer quality with sparse cracks.
3. Three crystals from Abr 2, thoroughly rounded after abrasion. The quality is rather good but some cracks and turbid domains are seen.
4. Five crystals from Abr 2 with lighter colour than fraction 3 and similar quality.
5. Two crystals from Abr 3, thoroughly rounded after abrasion with good quality.
6. Six crystals from Abr 3, thoroughly rounded after abrasion with poorer quality than fraction 5.

1. Calculated from ²⁰⁸Pb content. Corrected for Pb loss.
2. Corrected for mass fractionation and spike.
3. Radiogenic Pb, i.e. corrected for common Pb och blank.
4. Corrected for mass fractionation, spike, common Pb and blank.
5. Correlation coefficient for errors in ²⁰⁶Pb/²³⁸U and ²⁰⁷Pb/²³⁵U.

The samples were not weighed. The weights are estimated from the number and size of the crystals.

U-Pb zircon ion-probe geochronology of a porphyritic rhyolite from the Malmbäck volcanic area south-east of Jönköping, south central Sweden

Thomas Eliasson^a, Andrius Rimša^b, Ulf Bergström^a & Fredrik Hellström^b

^aGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

^bGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

Eliasson, T., Rimša, A., Bergström, U. & Hellström, F., 2008: U-Pb zircon ion-probe geochronology of a porphyritic rhyolite from the Malmbäck volcanic area south-east of Jönköping, south central Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 14–16.

Rock	Rhyolite
Sample number	TEN072022A, n2848 (Nordsim)
Coordinates (RT90)	6387118 / 1415354
Map sheet	6E NW Nässjö
Locality	Gränsen, 4.5 km north-west of Malmbäck
Project	Jönköping, SGU code: 80015

Aim of study

In the Jönköping area, interbedded felsic to mafic sequences of volcanic rocks occur spatially associated with intrusive rocks of the Transscandinavian Igneous Belt (TIB). Stratigraphically the extrusive rocks are older and occur as xenoliths in, and are intruded by, the TIB

intrusive rocks. Some 20 km south-east of Jönköping an area of fairly well preserved volcanic rocks occurs (the Malmbäck volcanic rocks).

In general, the volcanic rocks are weakly foliated and in places gently folded as opposed to the surrounding TIB intrusions that are essentially undeformed. However, field observations and geochemical data indicate a close temporal and petrogenetic connection between the intrusive and extrusive rocks in the Malmbäck area. The aim of this study was to determine the age of an ignimbritic rhyolite in the volcanic succession. Furthermore, it aims to investigate the age relations between intrusive and extrusive rocks in this part of TIB.

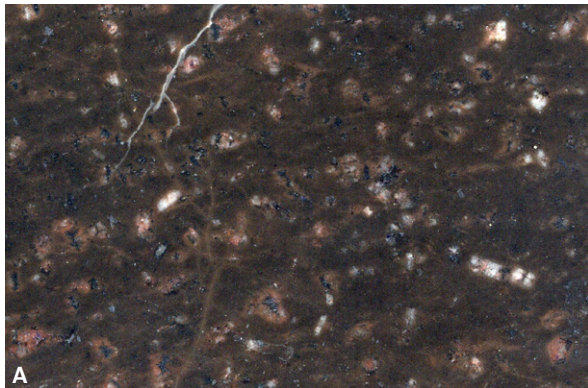


Fig. 1. The dated rhyolite. **A.** Sawn surface with dispersed feldspar phenocrysts and mineral aggregates. Scanned wetted surface. 75 mm field of view. **B.** Photomicrograph showing a microcline phenocryst and aggregates composed of muscovite and feldspar. Cross-polarised light. 5 mm field of view.

Sample description

The dated rock is a reddish grey, fine-grained, weakly foliated and lineated rhyolite with 0.5 to 1.5 mm large microcline phenocrysts (Fig. 1A). The rhyolite also carries up to 1.5 mm large aggregates of biotite±muscovite (Fig. 1B). The matrix is composed of a fine-grained assemblage of quartz and feldspar with some biotite and muscovite. The recrystallised texture is interpreted to be due to contact metamorphic transformation caused by heat from the surrounding intrusive TIB rocks.

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 1.

Zircon in the sample is generally euhedral to subhedral, prismatic crystals or fragment of crystals. In CL-images most grains show an internal oscillatory zonation (Fig. 2). In a few grains there are CL-dark or CL-bright outer zircon domains that could be of secondary origin. The oscillatory zoned domains are interpreted to represent igneous zircon.

The U content of analysed zircons grains is 122–369 ppm and Th/U ratios are 0.66–0.96 (n=10; Table 1). Two analyses (5 and 9) with exceptionally high com-

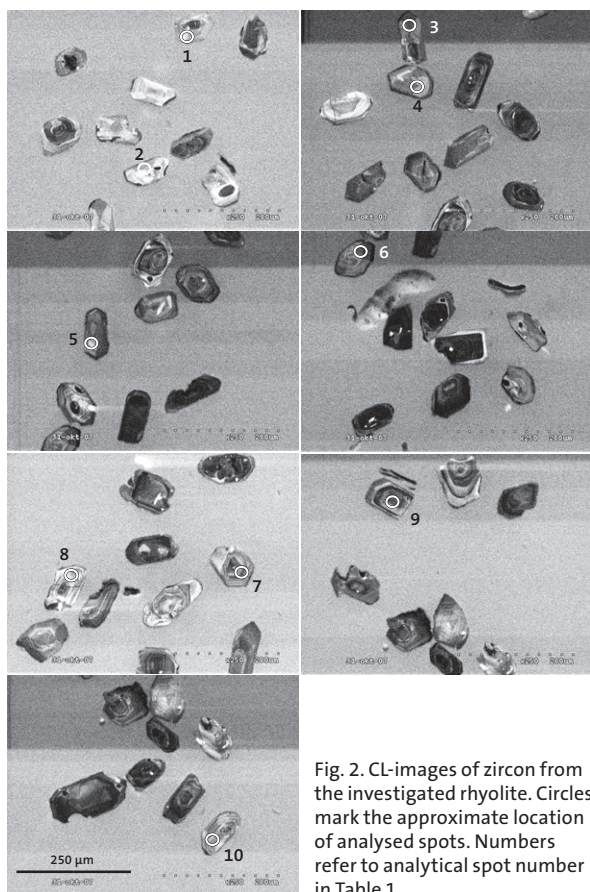


Fig. 2. CL-images of zircon from the investigated rhyolite. Circles mark the approximate location of analysed spots. Numbers refer to analytical spot number in Table 1.

mon Pb ($f_{206}\%$ = 1.23 and 4.19, respectively) and one strongly discordant analysis (1) were excluded from the age calculation and not included in the further discussion below (Fig. 3).

Six analyses are concordant and yield a concordia age at 1796 ± 7 Ma (MSWD=1.3; Fig. 3). The $^{207}\text{Pb}/^{206}\text{Pb}$ weighted average age is 1792 ± 10 Ma ($n=6$, MSWD=0.33) or 1790 ± 9 Ma (2σ , MSWD=0.43) if also a weakly discordant analysis (2) is included. The concordia age of 1796 ± 7 Ma is chosen as the best estimate of the age for igneous crystallisation of the rhyolite.

Discussion and conclusion

Igneous crystallisation of a rhyolite that also dates the deposition of the volcanic rocks in the Malmbäck area is set at 1796 ± 7 Ma. This age is principally the same as the crystallisation ages for three undeformed TIB plutonic rocks intrusive into the Malmbäck volcanic rocks (Eliasson et al. 2008a, b, c). The geochronological data suggest that the ductile deformation and metamorphism affecting the volcanic rocks in the Malmbäck area is coeval with voluminous intrusion of TIB plutonic rocks. This is supported by observations of contact metamorphism causing grain-size coarsening and gran-

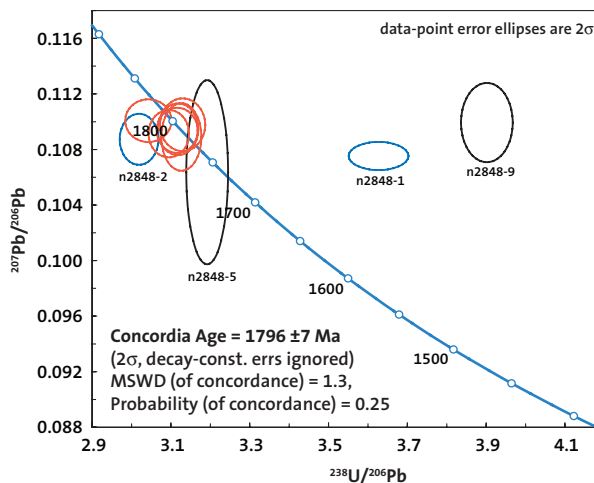


Fig. 3. Terra-Wasserberg concordia diagram showing U-Pb zircon data from a rhyolite in the Jönköping area. Analyses used for age calculation are shown in red. Analyses with high common lead are shown in black and discordant analyses in blue.

ite veining in xenoliths and larger areas (megaxenoliths) of volcanic rocks.

A belt of anastomosing shear zones occurs between Jönköping and Oskarshamn, the so-called Oskarshamn-Jönköping belt (Wik et al. 2006). Lithologically it is composed of 1.83 and 1.86 Ga old intrusive and extrusive rocks. Mansfeld et al. (2005) defined the Oskarshamn-Jönköping belt (OJB) as a remnant of a late Svecofennian area surrounded by younger, 1.81–1.77 Ga TIB rocks. The area was described as composed of calc-alkaline volcanic and intrusive rock as well as sedimentary units formed during a short interval between 1.83 and 1.82 Ga. Based on the geochronological data presented here, the Malmbäck volcanic rocks and the surrounding intrusive rocks (Eliasson et al. 2008a, b, c) in the Jönköping–Malmbäck area belong to the 1.81–1.77 Ga TIB unit and should not be included in the lithologically defined OJB of Mansfeld et al. (2005).

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- Eliasson, T., Persson, P.-O. & Bergström, U., 2008b: U-Pb zircon age of a TIB-1 monzogranite from Bäckadal east of Jönköping, south central Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 11–13.

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Mansfeld, J., Beunk, F.F., & Barling, J., 2005: 1.83–1.82 Ga formation of a juvenile volcanic arc – im-

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Wik, N.-G., Andersson, J., Bergström, U., Claesson, D., Juhojuntti, N., Kero, L., Lundqvist, L., Möller, C., Sukotjo, S. & Wikman, H., 2006: Beskrivning till regional berggrundskarta över Jönköpings län. *Sveriges geologiska undersökning K 16*, 60 pp.

Table 1. SIMS U-Pb-Th zircon data of a rhyolite from the Jönköping area (TEN072022A).

Sample/spot #	U ppm	Pb ppm	Th/U calc	²⁰⁶ Pb/ ²⁰⁴ Pb measured	f ₂₀₆ %	²³⁸ U/ ²⁰⁶ Pb	±σ %	²⁰⁷ Pb/ ²⁰⁶ Pb	±σ %	²⁰⁷ Pb/ ²⁰⁶ Pb age (Ma)	±σ	²⁰⁶ Pb/ ²³⁸ U age (Ma)	±σ	Disc. % 2σ lim.
n2848-1	369	135	0.67	18606	0.10	3.627	0.85	0.10753	0.38	1758	7	1570	12	-9.70
n2848-2	160	72	0.93	20941	0.09	3.019	0.66	0.10873	0.69	1778	13	1844	11	0.68
n2848-3	179	75	0.67	1854	1.01	3.118	0.67	0.10945	0.70	1790	13	1793	11	
n2848-4	124	54	0.86	15432	0.12	3.095	0.68	0.10914	0.64	1785	12	1805	11	
n2848-5	122	50	0.74	1520	1.23	3.192	0.68	0.10636	2.55	1738	46	1757	10	
n2848-6	125	53	0.71	37116	0.05	3.116	0.68	0.10937	0.61	1789	11	1794	11	
n2848-7	223	99	0.96	2471	0.76	3.130	0.75	0.10978	0.71	1796	13	1787	12	
n2848-8	124	52	0.69	3802	0.49	3.127	0.66	0.10890	0.91	1781	17	1789	10	
n2848-9	324	112	0.66	446	4.19	3.902	0.69	0.10994	1.06	1798	19	1471	9	-15.31
n2848-10	157	71	0.96	17560	0.11	3.043	0.79	0.11007	0.57	1801	10	1832	13	

U-Pb zircon age of a TIB monzogranite from Haborarp south of Jönköping, south central Sweden

Thomas Eliasson^a, Per-Olof Persson^b & Ulf Bergström^a

^aGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden

Eliasson, T., Persson, P.-O. & Bergström, U., 2008. U-Pb zircon age of a TIB monzogranite from Haborarp south of Jönköping, south central Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 17–18.

Rock	Monzogranite
Sample number	TEN070200A
Coordinates (RT90)	6385873 / 1409492
Map sheet	6E NW Nässjö, 7b
Locality	Haborarp, 23 km SSE Jönköping
Project	Jönköping berg, SGU code: 80015

Aim of study

The aim of this study was to date the igneous crystallisation of a monzogranite of the Transscandinavian Igneous Belt (TIB). The dated sample is from Haborarp c. 23 km south of Jönköping close to the contact between the 1.81–1.78 Ga TIB-1 rocks in the east and the medium- to coarse-grained porphyritic, 1.69 Ga TIB-2 Barnarp granite in the west (Gorbatshev & Bogdanova 2006).

Sample description

The dated rock is a light grey, non-equigranular to sparsely finely porphyritic, weakly foliated biotite monzogranite (Fig. 1A). Phenocrysts consist of 3 to 7 mm large plagioclase and microcline crystals in a fine-grained to finely medium-grained matrix (Fig. 1B). Plagioclase is severely altered to saussurite and sericite (Fig. 1B). A diffuse SW trending, steep foliation is defined by a preferred orientation of biotite and, subordinately, feldspar phenocrysts. The rock is cut by slightly winding, epidote- and biotite-filled microfractures (Fig. 1A)

Analytical results and interpretation of geochronological data

U-Pb TIMS analysis of zircon was performed at the Laboratory of Isotope Geology at the Museum of Natural History. The analytical results are shown in Table 1.

Most zircons are euhedral with only low-index crystal faces (Fig. 2). The edges and pyramid tips are generally sharp but also more rounded grains occur. Almost all crystals are brown and metamict but a few are colourless and clear or partly clear. The selected best-quality crystals were split into three groups according to morphology and each group was abraded separately (Fig. 2). The analysis fractions consist of 2–5 crystals. Fractions 1, 2

and 4 comprise crystals with low-order crystallographic faces only, whereas fraction 3 comprises 2 crystals displaying also high-order faces.

Group 1 consists of euhedral, colourless or pale brown crystals with aspect ratios of 2–4. Some have magmatic zonation but no visible cores or overgrowths. Group 2 consists of pale brown to dark brown, non-metamict crystals. They are euhedral with sharp edges and terminations and have aspect ratios of 1–3. Magmatic zonation is common. Group 3 consists of larger crystals of good analytical quality even if some cracks are present in most of the grains. They are pale brown to dark brown.

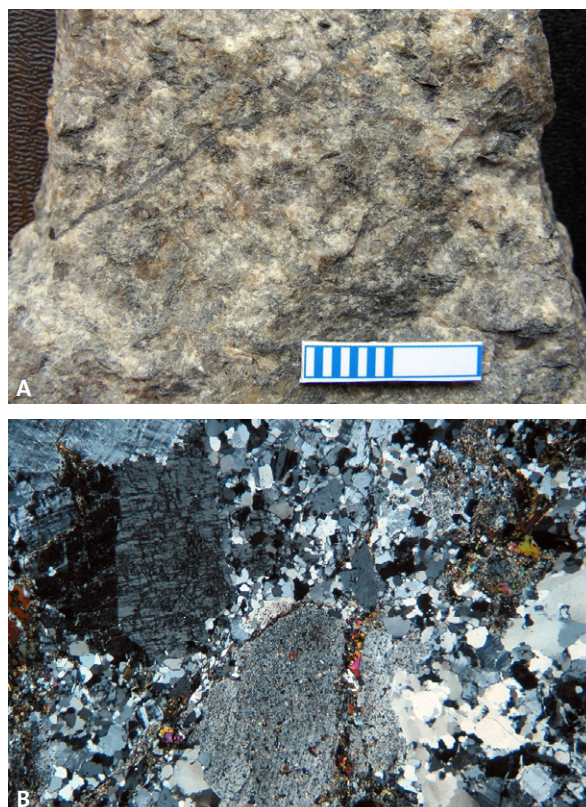


Fig. 1. A. The dated monzogranite. Length of scale bar is 20 mm. B. Photomicrograph showing fresh microcline and severely altered plagioclase. Crossed nicols. View about 6 mm wide.

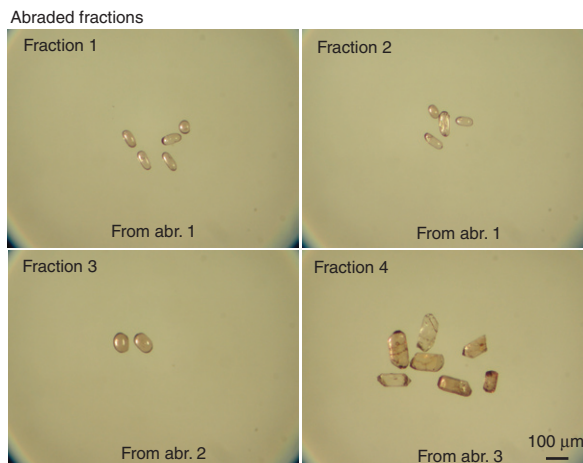
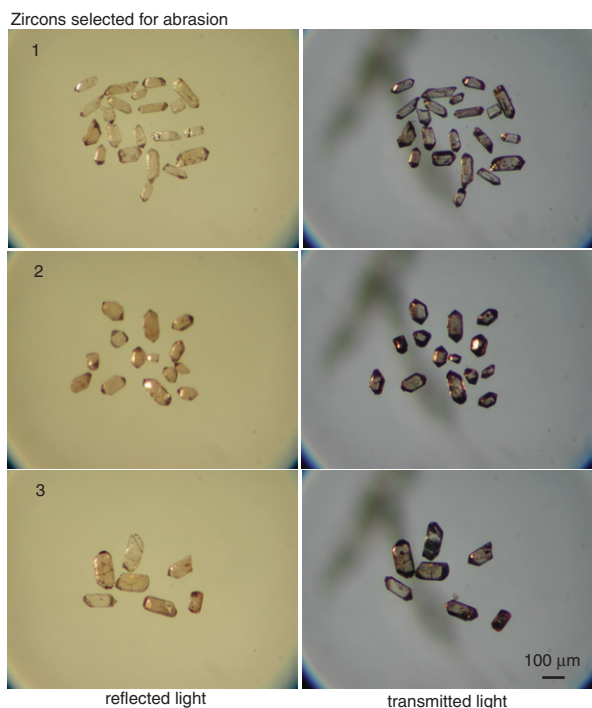


Fig. 2. The left part shows the selected zircon crystals prior abrasion and the right part the abraded grains. The selected best-quality crystals were split into three groups according to morphology and each group was abraded separately and then divided into four analysis fractions. Fraction 1 consists of five clear crystals with faint magmatic zonation seen in some of them. Fraction 2 consists of four crystals, which have more cracks and are more turbid than fraction 1. Fraction 3 consists of two crystals with faint magmatic zonation and of good analytical quality. Fraction 4 consists of four crystals of good analytical quality.

Table 1. TIMS U-Pb-Th zircon data (TEN070200A).

Fraction	Weight (µg)	No of crystals	U (ppm)	Th ¹ (ppm)	Pb tot (ppm)	Pb com (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb ²	²⁰⁶ Pb– ²⁰⁷ Pb– ²⁰⁸ Pb (At %) ³	²⁰⁶ Pb/ ²³⁸ U ⁴	2σ (%)	²⁰⁷ Pb/ ²³⁵ U ⁴	2σ (%)	²⁰⁷ Pb/ ²⁰⁶ Pb ⁴	2σ (%)	corr. coeff. ⁵	²⁰⁷ Pb/ ²⁰⁶ Pb Age (Ma)
1	3	5	156.1	61.7	49.1	1.48	1270	81.5–8.9–9.6	0.28907	0.40	4.37122	0.51	0.10967	0.30	0.797	1794.0±5.6
2	3	4	170.2	68.5	52.2	1.79	1168	81.4–8.9–9.7	0.28033	0.26	4.23208	0.34	0.10949	0.22	0.759	1791.0±4.0
3	2	2	157.9	65.5	46.6	2.5	825	81.2–8.9–9.9	0.26363	0.23	3.98705	0.32	0.10969	0.21	0.749	1794.2±3.9
4	3	4	213.9	92.8	60.9	2.14	1180	80.8–8.8–10.4	0.25797	0.24	3.89640	0.65	0.10954	0.55	0.587	1791.8±10.0

1. Calculated from ²⁰⁸Pb content. Corrected for Pb loss.
2. Corrected for mass fractionation and spike.
3. Radiogenic Pb, i.e. corrected for common Pb och blank.
4. Corrected for mass fractionation, spike, common Pb and blank.
5. Correlation coefficient between errors in ²⁰⁶Pb/²³⁸U and ²⁰⁷Pb/²³⁵U.

The data points are 10–20% discordant and define a straight line with concordia intercepts at 1791±9 Ma and –24±110 Ma and an MSWD of 0.7 (Fig. 3). The upper intercept age is interpreted as the crystallisation age of the granite.

Discussion and conclusion

An age of 1791±9 Ma for igneous crystallization shows that the monzogranite at Haborarp belongs to the TIB-1 rocks.

References

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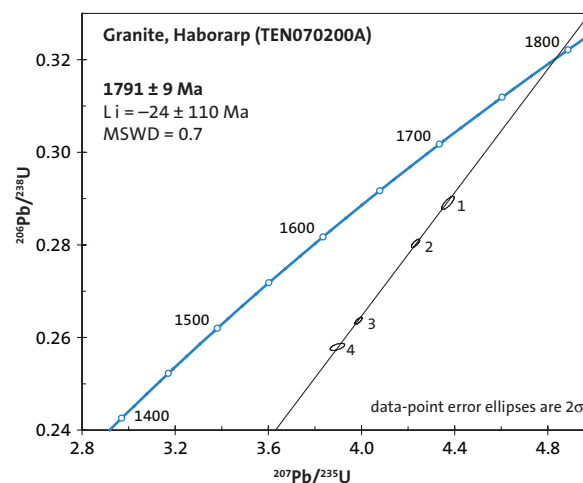


Fig. 3. Diagram showing U-Pb zircon data of a grey monzogranite from the Jönköping area. Numbers refer to fraction-number in Table 1.

Age of the host-rock to the Grängesberg apatite-iron ore

Anders Hallberg, Andrius Rimša & Fredrik Hellström

Geological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

Hallberg, A., Rimša, A. & Hellström, F., 2008: Age of the host-rock to the Grängesberg apatite-iron ore. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 19–22.

Rock	Dacitic metavolcanic rock
Sample number	LAL042020, n2855 (Nordsim)
Coordinates (RT90)	6661735 / 1454562
Map sheet	12F SW Ludvika, 2a
Locality	Grängesberg
Project	MalmDok, SGU project number: 14002

Sample description

The sample for isotopic dating was taken from a road outcrop some 250 meter south of the Export Field open pit (Fig. 2). The rock is fine-grained, dark grey to black

Aim of study

Apatite-iron ores in Sweden are exclusively found in two regions, the north-western part of the Norrbotten County and in north-western Bergslagen. In north-western Bergslagen the apatite-iron ores occur in an about 40 km long, north-north-east trending zone with the Idkersberget deposits in the north and the Grängesberg Mining District (GMD) in the south (Figs. 1 & 2). The deposits in the GMD is by far the largest in Bergslagen and they are the third largest iron ores in Sweden, only outnumbered by the giant Kirunavaara and Malmberget iron ores in north-western Norrbotten.

The host-rocks to the apatite iron ores in the GMD mainly consist of Na-altered metadacites. Some K-altered and less altered metadacites also occur in the district. The metadacitic host rocks and the apatite iron ores have been intruded by a few felsic dykes and large numbers of mafic dykes. These rocks have been penetratively deformed in amphibolite facies grade metamorphism. Isotopic age determinations in the area have mainly been made on younger granites. An U-Pb zircon age of an older metagranite close to the Idkerberget deposit gave an age of 1857^{+11}_{-7} Ma (Ripa & Kübler 2006). None of the metavolcanic rocks have been dated.

The composition of the metavolcanic rocks in the Grängesberg area is different compared to other parts of western Bergslagen where rhyolitic compositions dominate. The difference in composition of the volcanics and the different style of iron ores could indicate that the rocks in the area represent a separate event in Bergslagen, perhaps also formed at somewhat different age. Dating of the zircon obtained from the host rocks to the Export Field apatite-iron ore in the Grängesberg mining district will solve this question.

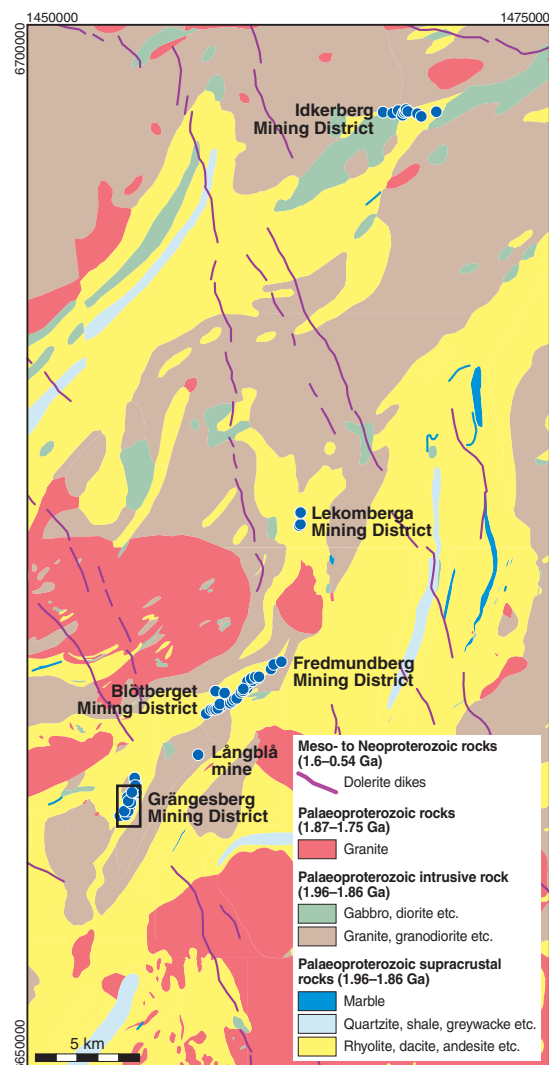


Fig.1. Geological map of part of Western Bergslagen with the apatite iron ore districts marked with blue dots. The frame shows location of the geological map of the Grängesberg Mining District. From Stephens et al (2007).

and has a pronounced foliation and lineation. The geochemistry of the sample shows that it is of dacitic composition and that it has been affected by Na-alteration (Table 1). The less mobile trace element composition of the sample is identical to most of the felsic metavolcanic rocks in the area and the sample is therefore regarded as representative for the dominantly dacitic rocks in the area. From the map it appears that the sample is located at a position equivalent to the immediate structural foot-wall to the largest iron ores in the GMD, those in the Grängesberg Field, and in the structural hangingwall to the ores in the Risberget Field and Ormberget Field. Some 70 meters west of the sample location, a hematite-mineralised and K-altered metadacite can be seen in a road cut. Most likely these rocks represent the northernmost part of the Lomberget Field.

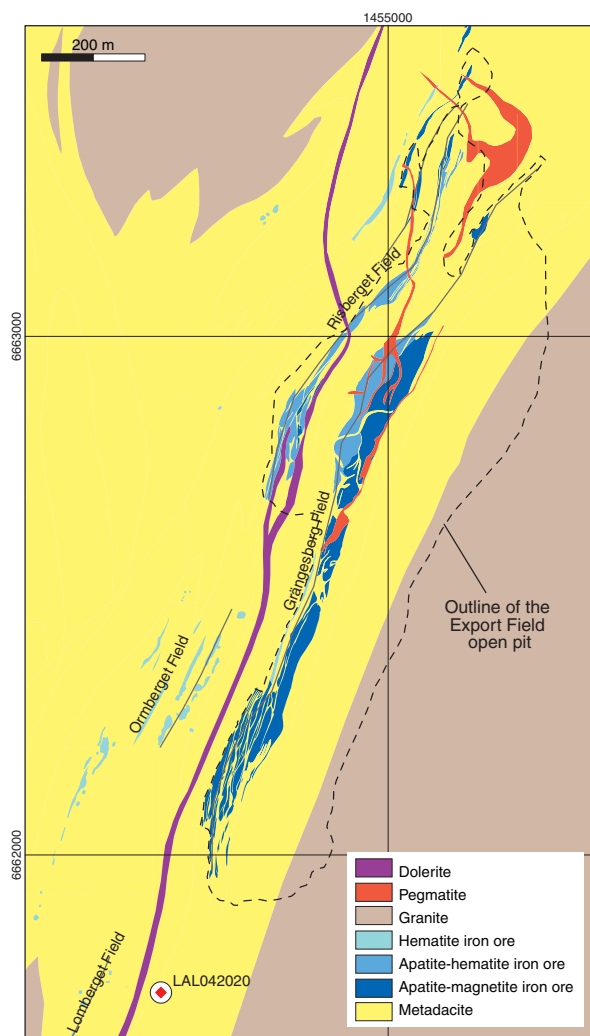


Fig. 2. Geological map of the Grängesberg Mining District with three different types of iron ores. Outline of the Export Field open pit shown with broken line. Location of dating sample LAL042020 are found south of the open pit. Map compiled from Magnusson (1938) and scanned and rectified mine maps.

Analytical results and interpretation of geochronological data

Ion-microprobe (SIMS) analyses on selected zircons have been performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 2.

The sample contains subhedral to anhedral zircon crystals or fragments of zircon crystals. CL-images show oscillatory zoned zircon (Fig. 3). CL intensity varies between the different crystals as well as within single grains. Some of the crystals are apparently non-zoned, homogeneous CL-dark. The analysed zircon has 99–243 ppm U and Th/U ratios between 0.26 and 0.49 (Table 2).

The data points define a discordia line with intercept ages of 1908 ± 14 Ma and 447 ± 420 Ma ($n=8$, $MSWD=0.78$). Five analyses are concordant and yield a concordia age at 1894 ± 7 Ma (2σ ; $MSWD=16$; Fig. 4) and a $^{207}\text{Pb}/^{206}\text{Pb}$ weighted average age of 1904 ± 8 Ma (2σ , $MSWD=0.65$). The high $MSWD$ of the concordia age results from spread in $^{228}\text{U}/^{206}\text{Pb}$ ages. The geological significance of this spread is unclear. The weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1904 ± 8 Ma for the five concordant analyses (2σ , $MSWD=0.65$) is chosen as the best estimate of igneous crystallisation of the metadacite.

Table 1. Whole-rock geochemical data of dated sample (LAL042020).

IDNR	LAL042020A	MO	1,5
NSKOORD	6661735	NB	13,9
OVKOORD	1454562	NI	5,8
	%	PB	3,8
SiO ₂	68,54	RB	19,9
TiO ₂	0,77	SB	<0,1
Al ₂ O ₃	13,75	SC	15
Fe ₂ O ₃	6,03	SE	<,5
MGO	1,4	SN	<1
CAO	1,71	SR	49,6
MNO	0,04	TA	1
Na ₂ O	5,49	TH	15,2
K ₂ O	0,36	TL	<0,1
P ₂ O ₅	0,18	U	3,5
L.O.I.	1,1	V	70
SUM	99,39	W	1,8
C	0,02	Y	42,1
S	0,01	ZN	19
	ppm	ZR	250,1
AG	<0,1	LA	27,3
AS	0,5	CE	58,8
AU	0,8	PR	7,37
BA	64,6	ND	30,4
BE	3	SM	6,5
BI	<0,1	EU	1,16
CD	<0,1	GD	6,64
CO	8,4	TB	1,09
CR	190	DY	6,61
CS	0,6	HO	1,42
CU	3,8	ER	4,04
GA	20	TM	0,67
HF	7,8	YB	4,57
HG	0,01	LU	0,6

Discussion and conclusion

Published U-Pb zircon ages of good quality and with small errors indicate a time span for deposition of meta-volcanic rocks in Bergslagen of around 15 million years (1890–1905 Ma). Additional unpublished data from the Bergslagen Project (Stephens et al., in prep.) also fall within this time frame. The age of the metadacite at Grängesberg, weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1904 ± 8 Ma, suggests that the rocks are among the oldest so far recorded in Bergslagen and comparable in age with metavolcanic rocks from Utö, eastern Bergslagen (Lundström et al. 1998). It is similar in age, or perhaps even slightly older than the 1891 ± 4 Ma age obtained for volcanic rocks at Ekebergshöjden (Lundström et al. 1998) some 40 km south-west of the GMD. The sample location at Ekebergshöjden is situated in the lowermost part of the volcanic succession in the Grythyttan-Hällefors area (Allen et al 1996) and was chosen to represent the early “intense volcanic stage”. The number of isotope ages of volcanic rocks in Bergslagen are still too few

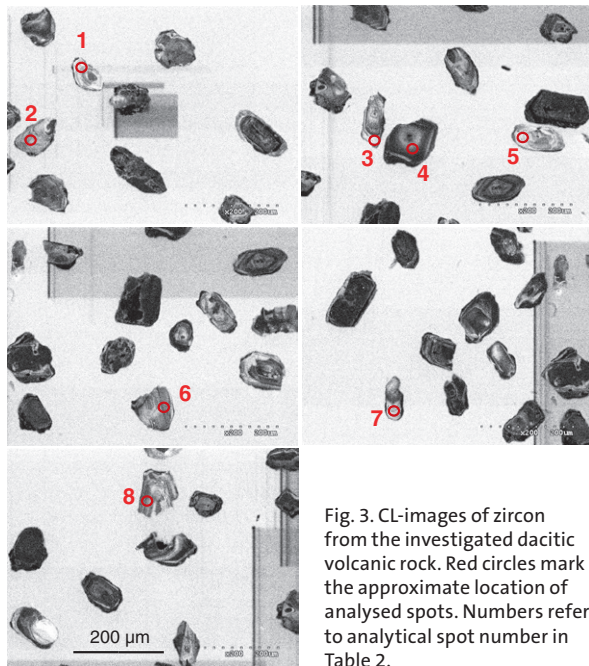


Fig. 3. CL-images of zircon from the investigated dacitic volcanic rock. Red circles mark the approximate location of analysed spots. Numbers refer to analytical spot number in Table 2.

Table 2. SIMS U-Pb-Th zircon data (LAL042020).

Sample/spot #	U ppm	Pb ppm	Th/U calc	$^{206}\text{Pb}/^{204}\text{Pb}$ measured	f_{206} %	$^{238}\text{U}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$ age (Ma)	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$ age (Ma)	$\pm\sigma$	Disc. % 2σ lim.
n2855-1	243	103	0.45	148736	{0.01}	2.943	0.66	0.117	0.53	1904	10	1885	11	
n2855-2	210	87	0.37	66571	0.03	2.963	0.66	0.117	0.46	1910	8	1874	11	
n2855-3	242	102	0.45	39465	0.05	2.966	0.67	0.116	0.45	1900	8	1873	11	
n2855-4	229	95	0.49	40020	0.05	3.048	0.66	0.115	0.44	1886	8	1829	11	-1.06
n2855-5	99	41	0.36	30362	0.06	2.958	1.02	0.117	0.66	1913	12	1877	17	
n2855-6	199	78	0.32	36842	0.05	3.121	0.72	0.116	0.63	1900	11	1792	11	-3.34
n2855-7	149	60	0.26	55702	0.03	2.971	0.83	0.116	0.55	1893	10	1870	14	
n2855-8	215	86	0.43	46455	0.04	3.134	0.72	0.116	0.46	1889	8	1785	11	-3.79

to draw any conclusion on different centres of volcanism and how these are separated in time. It can, however, be concluded that volcanism in Western Bergslagen started much earlier than previously believed and that the apatite iron ores in the Grängesberg Mining District is hosted by rocks older than 1900 Ma.

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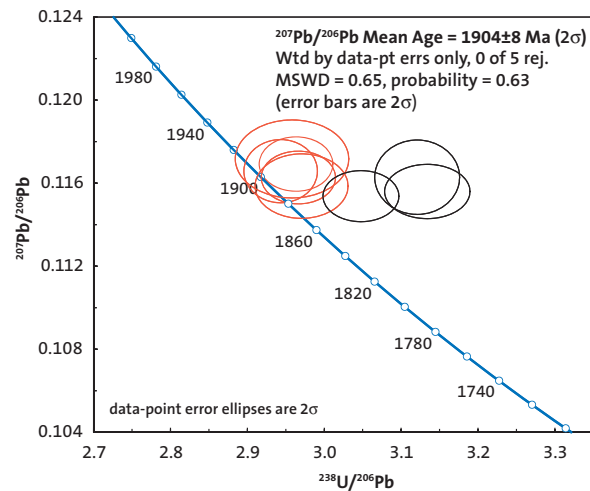


Fig. 4. Terra Wasserburg diagram showing U-Pb zircon data from a dacitic metavolcanic rock from Grängesberg. Analyses used in age calculation are shown in red.

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U-Pb zircon age of a gabbro from isle of Rön west of the Onsala peninsula, south-west Sweden

Fredrik Hellström^a, Andrius Rimša^a, Inger Lundqvist^b & Lena Lundqvist^b

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

Hellström, F., Rimša, A., Lundqvist, I. & Lundqvist, L., 2008: U-Pb zircon age of a gabbro from the Onsala peninsula, south-west Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 23–24.

Rock	Gabbro
Sample number	FHM071095A, n2852 (Nordsim)
Coordinates (RT90)	6373134 / 1261179
Map sheet	6B SW Kungsbacka, 4c
Locality	Isle of Rön, west of Onsala peninsula
Project	Västra Götaland, SGU code: 11092

Aim of study

On the Onsala peninsula south of Göteborg, metagabbroic rocks are associated with both 1.58–1.56 Ga metagranitoids (Lundqvist 2000, Hellström et al. 2007, 2008) and a younger generation of about 1.33 Ga me-

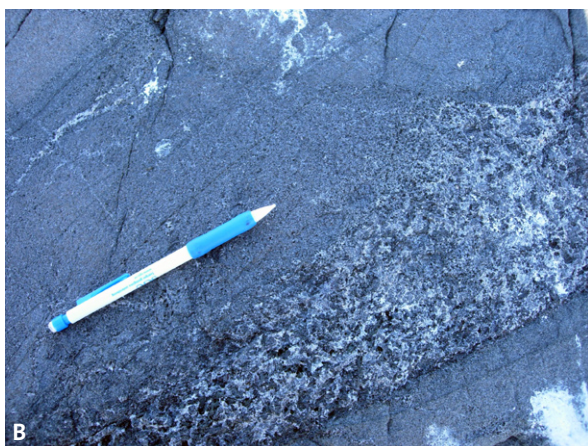
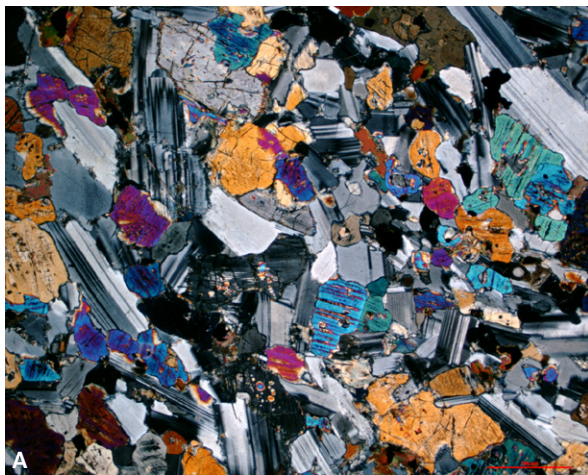


Fig. 1. A. Microphoto of gabbro from isle of Rön (crossed nicols, the long side is 3.6 mm). The main minerals are plagioclase, clinopyroxene and orthopyroxene. B. The sampled gabbro pegmatite.

tagranite (Askim granite, Austin Hegardt et al. 2007). An isotropic gabbro with igneous mineralogy and texture (Fig. 1A) crops out on the outermost islands west of the Onsala peninsula. The aim of this study was to determine the age of the gabbro intrusion.

Sample description

A coarse-grained, plagioclase rich gabbro pegmatite with well-preserved igneous texture was sampled for radiometric dating (Fig. 1B).

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 1.

The heavy mineral concentrate contains a homogenous population of euhedral zircon, whole crystals or fragments of crystals. A weak internal oscillatory zonation is evident from CL-images (Fig. 2).

The analysed zircon has 293–1000 ppm U and high Th/U ratios of 0.49–0.78 (n=5, Table 1). Four concordant analyses and one weakly discordant analysis (–0.1%, analysis 2) together yield a concordant age of 1574 ± 4 Ma (2σ , MSWD=9.9, Fig. 3). The high MSWD (of concordance) show that there is a large spread in the age data, but is partly a result of one analysis actually being discordant. The weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age is 1577 ± 5 Ma (2σ) i.e. within error the same age as the concordia age, but with a low MSWD of 0.83, showing that there is a low spread in the $^{207}\text{Pb}/^{206}\text{Pb}$ ages. The internal oscillatory zonation and the euhedral crystal shapes suggest that zircon in the gabbro pegmatite is igneous. The weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1577 ± 5 Ma is chosen as the best estimate of igneous crystallisation of the gabbro.

Discussion and conclusion

The igneous crystallisation age of the gabbro intrusion that crop out on the outermost islands west of the Onsala peninsula is 1577 ± 5 Ma. It is thus contemporary with

Table 1. SIMS U-Pb-Th zircon data (FHM071095A).

Sample/spot #	U ppm	Pb ppm	Th/U calc	$^{206}\text{Pb}/^{204}\text{Pb}$ measured	f_{206} %	$^{238}\text{U}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$ age (Ma)	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$ age (Ma)	$\pm\sigma$	Disc. % 2 σ lim.
n2852-1	293	100	0.49	35431	0.05	3.668	0.66	0.097	0.44	1574	8	1554	9	
n2852-2	692	249	0.73	197091	0.01	3.660	0.66	0.098	0.27	1585	5	1557	9	-0.08
n2852-3	861	313	0.74	114637	0.02	3.612	0.89	0.097	0.25	1574	5	1575	12	
n2852-4	716	256	0.70	99799	0.02	3.647	0.89	0.097	0.28	1575	5	1562	12	
n2852-5	1000	363	0.78	117963	0.02	3.657	0.87	0.097	0.25	1576	5	1558	12	

a group of c. 1.59–1.52 Ga old intrusions in the western part of the Idefjorden terrane of the Sveconorwegian province (the Hisingen suite of Åhäll & Connelly 2007, Hellström et al. 2007, 2008). It can be concluded that degree of deformation and metamorphic alteration can not be used as a criterion to discriminate between the different generations of gabbro intrusives in the area.

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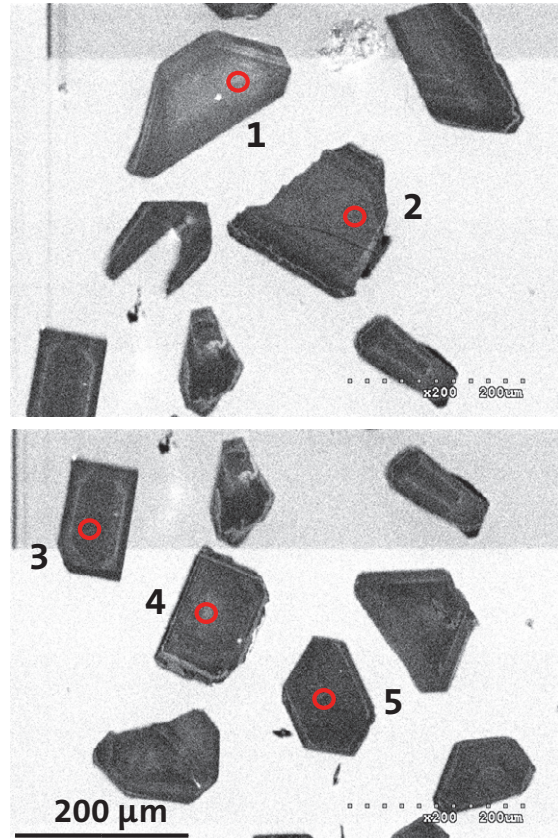


Fig. 2. CL-images of zircon from the investigated gabbro. Red circles mark approximate location of analysed spots. Numbers refer to analytical spot number in Table 1.

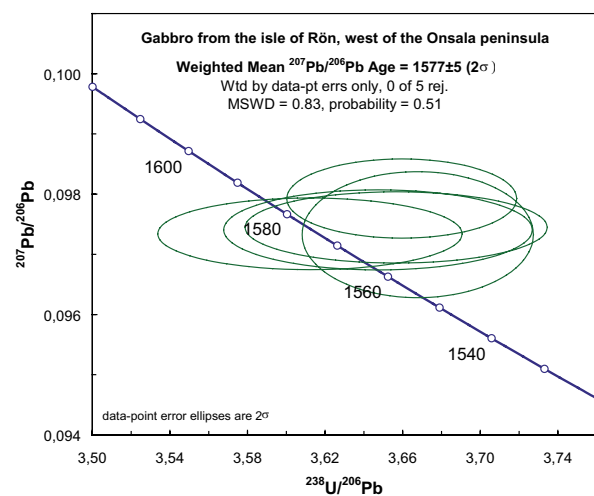


Fig. 3. Terra Wasserburg diagram showing U-Pb zircon data of the gabbro from the isle of Rön west of the Onsala peninsula.

U-Pb zircon age of an augen-bearing gneissic granite from the Onsala peninsula, south-west Sweden

Fredrik Hellström^a, Andrius Rimša^a, Inger Lundqvist^b & Lena Lundqvist^b

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bGeological Survey of Sweden, Guldhedsgatan 5A, SE-413 20 Göteborg, Sweden

Hellström, F., Rimša, A., Lundqvist, I., & Lundqvist, L., 2008: U-Pb zircon age of an augen-bearing gneissic granite from the Onsala peninsula, south-west Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 25–26.

Rock	Augen-bearing gneissic granite
Sample number	FHM061095A, n2866 (Nordsim)
Coordinates (RT90)	6371403 / 1267106
Map sheet	6B SW Kungsbacka, 3d
Locality	Svångehällar-Fjäreahals, Onsala peninsula
Project	Västra Götaland, SGU code: 1109302

Aim of study

On the Onsala peninsula south of Göteborg there are augen-bearing gneissic granites to granodiorites that resemble the field appearance of 1.33 Ga Askim granite (Austin Hegardt et al. 2007). The aim of this study was to date an augen-bearing gneissic granite on the western side of the peninsula to determine if it belongs to c. 1.58–1.56 Ga gneissic granitoids (Lundqvist 2000, Hellström et al. 2007) or to a younger generation of about 1.33 Ga porphyric metagranites (Askim granite, Austin Hegardt et al. 2007). On the petrological map of the Onsala peninsula by Sandegren & Lundegårdh (1950), the granite is marked as Askim granite.

Sample description

The dated sample consists of reddish grey, gneissic granite with 0.5–3 cm large K-feldspar augens (Fig. 1).



Fig. 1. The dated augengneiss from the western part of the Onsala peninsula.

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 1.

Zircon in the sample is prismatic subhedral with abraded crystal faces. CL-images show oscillatory zoned cores and locally <5 μm wide, CL-bright rims (Fig. 2).

The analysed zircon has generally 208–390 ppm U and Th/U ratios of 0.41–0.64 (n=5, Table 1). One analysis (1) has higher U (2271 ppm) and Th (1398 ppm) concentrations and a lower Th/U ratio (0.14). This highly discordant analysis has exceptionally high common Pb and is excluded from age calculation and not included in the further discussion below.

Five concordant analyses yield a concordia age of 1579±10 Ma (95 % confidence, MSWD=1.6, Fig. 3), which is within error the same age as the weighted average ²⁰⁷Pb/²⁰⁶Pb age of 1582±8 Ma (2σ, MSWD=1.8). The weighted average ²⁰⁷Pb/²⁰⁶Pb age of 1582±8 Ma is chosen as the best estimate of igneous crystallisation of the augen-bearing gneissic granite.

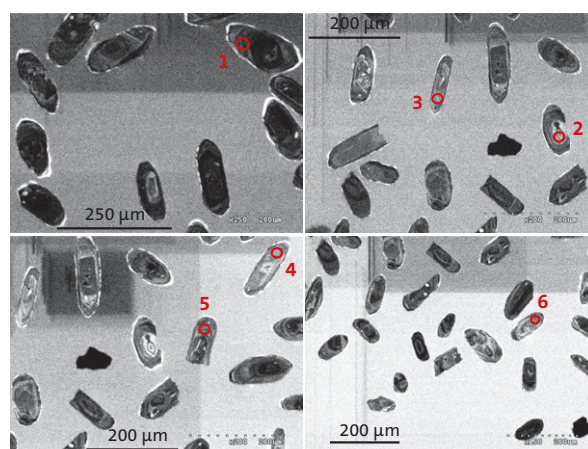


Fig. 2. CL-images of zircon from the investigated granitic augen gneiss. Red circles mark the approximate location of analysed spots. Numbers refer to analytical spot number in Table 1.

Table 1. SIMS U-Pb-Th zircon data (FHM061095A).

Sample/spot #	U ppm	Pb ppm	Th/U calc	²⁰⁶ Pb/ ²⁰⁴ Pb measured	f ₂₀₆ %	²³⁸ U/ ²⁰⁶ Pb	±σ %	²⁰⁷ Pb/ ²⁰⁶ Pb	±σ %	²⁰⁷ Pb/ ²⁰⁶ Pb age (Ma)	±σ	²⁰⁶ Pb/ ²³⁸ U age (Ma)	±σ	Disc. % 2σ lim.
n2866-1	2271	312	0.14	461	4.06	8.649	1.07	0.095	3.43	1535	63	705	7	-38.43
n2866-2	252	90	0.64	58306	0.03	3.606	0.73	0.098	0.47	1582	9	1578	10	
n2866-3	254	85	0.41	83918	0.02	3.651	0.73	0.099	0.48	1596	9	1561	10	
n2866-4	208	72	0.50	49323	0.04	3.587	0.73	0.098	0.51	1590	9	1585	10	
n2866-5	390	133	0.53	28752	0.07	3.666	0.73	0.097	0.39	1567	7	1555	10	
n2866-6	344	120	0.52	23140	0.08	3.566	0.73	0.098	0.42	1584	8	1594	10	

Discussion and conclusion

The igneous crystallisation age of the augen-bearing gneissic granite from the western part of the Onsala peninsula is 1577 ± 5 Ma. It is thus contemporary with the group of c. 1.59–1.52 Ga old intrusions in the western part of the Idefjorden terrane of the Sveconorwegian province (Åhäll & Connelly 2007, Hellström et al. 2007, 2008).

References

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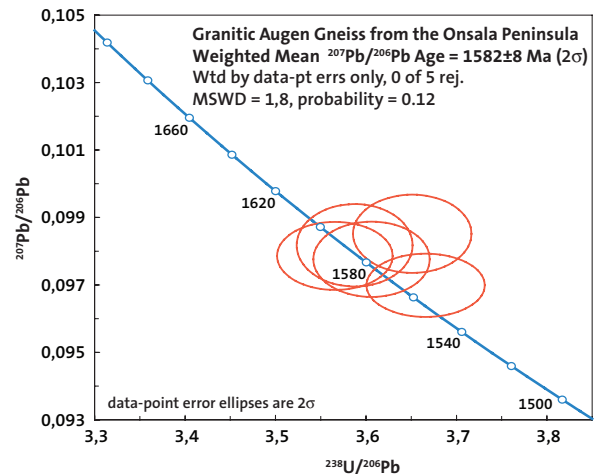


Fig. 3. Terra Wasserburg diagram showing U-Pb zircon data of an augengneiss from the western part of the Onsala peninsula. A highly discordant analysis (n2866-1) is not shown (Table 1).

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U-Pb zircon age of a massive granite from Spikberg, c. 14 km west of Harads, southern Norrbotten County, Sweden

Benno Kathol^a & Per-Olof Persson^b

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden

Kathol, B. & Persson, P.-O., 2008: U-Pb zircon age of a massive granite from Spikberg, c. 14 km west of Harads, southern Norrbotten County, Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 27-28.

Rock	Granite
Sample number	CHB070056X
Coordinates (RT90)	7342635 / 1719127
Map sheet	25K NW Harads, 8d
Locality	Spikberg, Outcrop at the road between Harads and Kåbdalis, c. 14 km to the west of Harads.
Project	Moskosel–Harads, SGU code: 80005

Aim of study

Red granites to monzonites dominate the bedrock in the north-western part of the map area 25K Harads. These rocks are part of a large intrusion, which is considered to belong to the 1.8 Ga old Edefors suite (Grip 1946, Ödman 1957, Öhlander & Skiöld 1994). Geochronological data are presently lacking from this large intrusion.

Sample description

The sampled rock is a massive, red to light red, coarsely medium-grained granite (Fig. 1). Rapakivi textures occur in places.

Analytical results and interpretation of geochronological data

U-Pb TIMS analysis of zircon was performed at the Laboratory of Isotope Geology at the Museum of Natural History. The analytical results are shown in Table 1.

The zircons are of good analytical quality. They are colourless or faintly brown (Fig. 2). The prism edges are generally sharp whereas the pyramid tips generally are more or less rounded. The grains selected for abrasion had sharp or only slightly rounded terminations. Magmatic zonation is common. All analysed crystals were strongly abraded (Fig. 2).

The data points are slightly discordant and yield a discordia with intercepts at 1803±10 Ma and 12±610 Ma



Fig. 1. Coarsely medium-grained granite from Spikberg.

Table 1. TIMS U-Pb-Th zircon data (CHB070056X).

Fraction	Weight (µg)	No of crystals	U (ppm)	Th ¹ (ppm)	Pb tot (ppm)	Pb com (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb ²	²⁰⁶ Pb– ²⁰⁷ Pb– ²⁰⁸ Pb (At %) ³	²⁰⁶ Pb/ ²³⁸ U ⁴	2σ (%)	²⁰⁷ Pb/ ²³⁵ U ⁴	2σ (%)	²⁰⁷ Pb/ ²⁰⁶ Pb ⁴	2σ (%)	corr. coeff. ⁵	²⁰⁷ Pb/ ²⁰⁶ Pb Age (Ma)
1	2	5	346	92	110	1.1	3082	84.1–9.2–6.7	0.307	0.48	4.664	0.49	0.110	0.09	0.981	1802.3±1.7
2	3	5	230	59	76	1.4	2092	84.3–9.3–6.4	0.317	0.19	4.822	0.22	0.110	0.12	0.846	1802.2±2.2
3	4	5	204	50	66	0.9	2816	84.5–9.3–6.2	0.314	0.15	4.778	0.18	0.110	0.09	0.850	1805.0±1.7
4	3	2	394	80	129	4.3	1480	85.5–9.4–5.1	0.315	0.18	4.779	0.21	0.110	0.11	0.865	1801.7±1.9

1. Calculated from ²⁰⁸Pb content. Corrected for Pb loss.

2. Corrected for mass fractionation and spike.

3. Radiogenic Pb, i.e. corrected for common Pb och blank.

4. Corrected for mass fractionation, spike, common Pb and blank.

5. Correlation coefficient between errors in ²⁰⁶Pb/²³⁸U and ²⁰⁷Pb/²³⁵U.

The samples were not weighed but the sample weights were estimated from the number and size of the crystals.

Therefore, the individual concentrations of U and Pb are only approximate.

This does not affect the isotope ratios or errors or the positions of the data points in the concordia diagram.

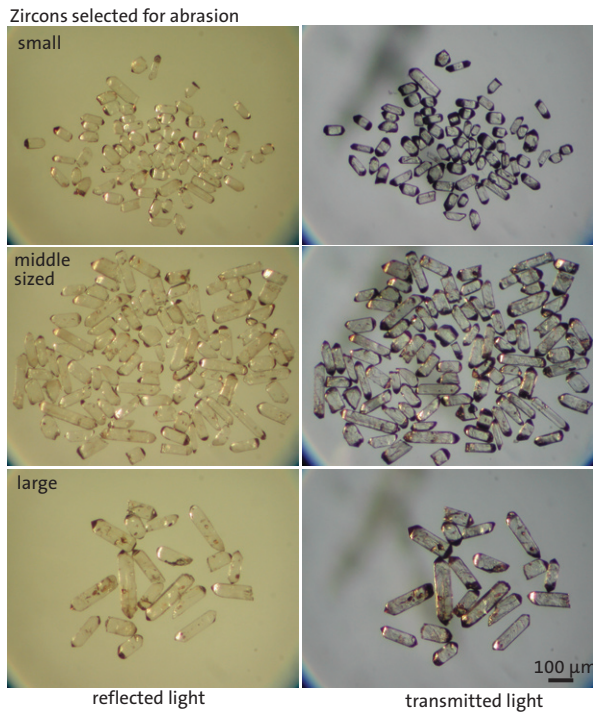


Fig. 2. The upper part shows the selected zircon crystals prior abrasion and the lower part the abraded grains. The selected zircon crystals were divided into four analysis fractions. **Fraction 1:** Five small crystals with magmatic zonation. Some of the crystals in the picture were lost during the washing and transferring procedures. **Fraction 2:** Five middle-sized elongated crystals of good analytical quality. The grains show a weakly discernible magmatic zonation. **Fraction 3:** Five middle sized, short prismatic crystals with a weakly discernible magmatic zonation. The grains were thoroughly rounded after the abrasion. **Fraction 4:** Two large crystals with weakly discernible magmatic zonation.

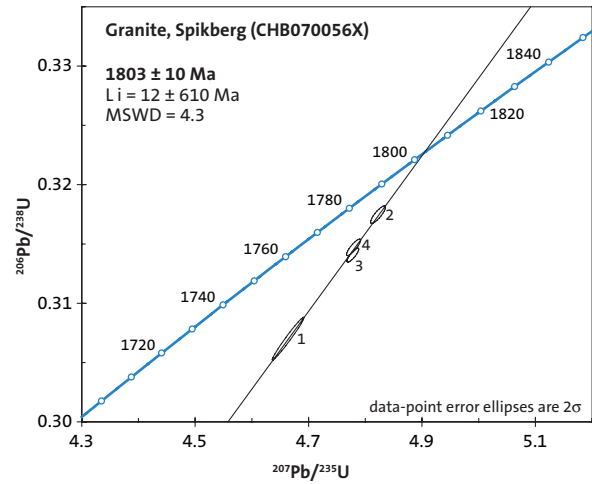


Fig. 3. Diagram showing U-Pb zircon data of a granite from Spikberg in the Harads area.

and an MSWD of 4.3 (Fig. 3). The upper intercept age is interpreted as the igneous crystallisation age of the rock.

Discussion and conclusion

The igneous crystallisation of the red granite from Spikberg is dated at 1803 ± 10 Ma, which confirms an affiliation to the 1.8 Ga old Edefors suite.

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Sm-Nd analysis of a quartz monzodiorite from Gunnarberget at Harads, southern Norrbotten County, Sweden

Benno Kathol^a & Per-Olof Persson^b

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden

Kathol, B. & Persson, P.-O., 2008: Sm-Nd analysis of a quartz monzodiorite from Gunnarberget at Harads, southern Norrbotten County, Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 29–30.

Rock	Quartz monzodiorite
Sample number	CHB070318K
Coordinates (RT90)	7341730 / 1733107
Map sheet	25K NE Harads, 8g
Locality	Gunnarberget, 500 m north-east of Harads
Project	Moskosel–Harads, SGU code: 80005

Aim of study

The boundary between calc-alkaline intrusive rocks of the Jörn GI suite (Kathol & Weihed 2005) and the Haparanda suite (Ödman et al. 1949, Ödman 1957) in the south-eastern part of Norrbotten County is, among other criterias, defined by isotope geochemical characteristics (Mellqvist 1999, Mellqvist et al. 1999, Mellqvist et al. 2003). The Jörn GI suite was formed in a juvenile, island arc terrane, that was accreted to the Archaean craton during a later collisional stage of the Svecokarelian orogeny. It generally shows positive $\epsilon_{\text{Nd}}(\text{T})$ values, whereas the Haparanda suite generally shows negative $\epsilon_{\text{Nd}}(\text{T})$ values as it was formed within or in marginal parts of the Archaean craton (Mellqvist et al. 2003). A quartz monzodiorite at Gunnarberget investigated in this study and a quartz diorite from Sandträskberget (Kathol & Persson 2008) have been sampled for Sm-Nd analysis in order to further characterize the Archaean–Proterozoic boundary, i.e. the



Fig. 1. Foliated quartz monzodiorite from Gunnarberget.

boundary between juvenile crust in the south-west and the Archaean craton in the north-east.

Sample description

The sampled rock at Gunnarberget is a foliated, grey to reddish grey, finely medium-grained quartz monzodiorite (Fig. 1).

Analytical results and interpretation of geochronological data

Sm-Nd analysis was carried out at the Laboratory of Isotope Geology, Museum of Natural History, Stockholm. The analytical results are presented in Table 1.

The $^{143}\text{Nd}/^{144}\text{Nd}$ ratio is 0.511876 (± 0.00005 , 2σ). The model ages are 2.24 (T_{DM}) and 1.73 (T_{CHUR}) Ga. An intrusion age of 1.9 Ga produces an $\epsilon_{\text{Nd}}(\text{T})$ of +1.45.

Discussion and conclusion

The result of this study together with the obtained $\epsilon_{\text{Nd}}(\text{T})$ value of -2.75 from Sandträskberget (Kathol & Persson 2008) indicate that the Archaean–Proterozoic boundary is situated somewhat to the north-east of Harads in the north-easternmost part of map sheet 25K Harads NO.

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- Mellqvist, C., 1999: Proterozoic Crustal Growth along the Archaean Continental Margin in the Luleå and Jokkmokk Areas, Northern Sweden. *Doctoral thesis 1999:24*, Luleå University of Technology, Sweden, 15 pp.

Table 1. Sm-Nd isotopic whole-rock data.

Sample	Sm (ppm)	Nd (ppm)	$^{143}\text{Nd}/^{144}\text{Nd}$	$\pm (2\sigma)$	$^{147}\text{Sm}/^{144}\text{Nd}$	T_{CHUR} (Ga)	T_{DM81} (Ga)	T_{DM91} (Ga)	Age (Ga)	$\epsilon_{\text{Nd}}(T)$
CHB070318K	8.95	41.71	0.512	0.000	0.130	1.73	2.12	2.24	1.9	1.45

Mellqvist, C., Öhlander, B., Skiöld, T. & Wikström, A., 1999: The Archaean–Proterozoic Palaeoboundary in the Luleå area, northern Sweden: field and isotope geochemical evidence for a sharp terrane boundary. *Precambrian Research* 96, 225–243.

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Sm-Nd analysis of a quartz diorite from Sandträskberget, southern Norrbotten County, Sweden

Benno Kathol^a & Per-Olof Persson^b

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bLaboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden

Kathol, B. & Persson, P.-O., 2008: Sm-Nd analysis of a quartz diorite from Sandträskberget, southern Norrbotten County, Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 31–32.

Rock	Quartz diorite
Sample number	SPN070190
Coordinates (RT90)	7348437 / 1749094
Map sheet	25K NE Harads, 9j
Locality	Sandträskberget, 1.6 km north of Sandträsk
Project	Moskosel–Harads, SGU code: 80005

Aim of study

The boundary between calc-alkaline intrusive rocks of the Jörn GI suite (Kathol & Weihed 2005) and the Haparanda suite (Ödman et al. 1949, Ödman 1957) in the south-eastern part of Norrbotten County is, among other criterias, defined by isotope geochemical characteristics (Mellqvist 1999, Mellqvist et al. 1999, Mellqvist et al. 2003). The Jörn GI suite was formed in a juvenile, island arc terrane, that was accreted to the Archaean craton during a later collisional stage of the Sveco Karelian orogeny. It generally shows positive $\epsilon_{Nd}(T)$ values, whereas the Haparanda suite generally shows negative $\epsilon_{Nd}(T)$ values as it was formed within or in marginal parts of the Archaean craton (Mellqvist et al. 2003). A quartz diorite at Sandträskberget investigated in this study and a quartz monzodiorite from



Fig. 1. Isotropic quartz diorite from Sandträskberget.

Gunnarberget (Kathol & Persson 2008) have been sampled for Sm-Nd analysis in order to further characterize the Archaean–Proterozoic boundary, i.e. the boundary between juvenile crust in the south-west and the Archaean craton in the north-east.

Sample description

The sampled rock at Sandträskberget is a massive, grey to dark grey, coarsely medium-grained quartz diorite (Fig. 1).

Analytical results and interpretation of geochronological data

Sm-Nd analysis were carried out at the Laboratory of Isotope Geology, Museum of Natural History, Stockholm. The analytical results are presented in Table 1.

The $^{143}\text{Nd}/^{144}\text{Nd}$ ratio is 0.511573 (± 0.00005 , 2σ). The model ages are 2.57 Ga (T_{DM}) and 2.19 Ga (T_{CHUR}). An intrusion age of 1.9 Ga produces an $\epsilon_{Nd}(T)$ of -2.75 .

Discussion and conclusion

The result of this study together with the obtained $\epsilon_{Nd}(T)$ value of 1.45 from Gunnarberget (Kathol & Persson 2008) indicate that the Archaean–Proterozoic boundary is situated somewhat to the north-east of Harads in the north-easternmost part of map sheet 25K Harads NO.

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Table 1. Sm-Nd isotopic whole-rock data.

Sample	Sm (ppm)	Nd (ppm)	$^{143}\text{Nd}/^{144}\text{Nd}$	$\pm (2\sigma)$	$^{147}\text{Sm}/^{144}\text{Nd}$	T_{CHUR} (Ga)	T_{DM81} (Ga)	T_{DM91} (Ga)	Age (Ga)	$\epsilon_{Nd}(T)$
SPN070190K	4.72	23.26	0.512	0.00005	0.1227	2.19	2.48	2.57	1.9	-2.75

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U-Pb zircon age of a feldspar-porphyrific rhyolite from the Trollforsen area, c. 20 km north-west of Moskosel, southern Norrbotten County, Sweden

Benno Kathol^a, Christina Lundmark^b, Fredrik Hellström^a & Andrius Rimša^a

^aGeological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

^bGeological Survey of Sweden, Mineral Resources Information Office, Skolgatan 4, SE-930 70 Malå, Sweden

Kathol, B., Lundmark, C., Hellström, F. & Rimša, A., 2008: U-Pb zircon age of a feldspar-porphyrific rhyolite from the Trollforsen area, c. 20 km north-west of Moskosel, southern Norrbotten County, Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 33–35.

Rock	Rhyolite
Sample number	CLU040008X, n2854 (Nordsim)
Coordinates (RT90)	7329281 / 1656292
Map sheet	25J NW Moskosel, 5b
Locality	Trollforsen, c. 20 km north-west of Moskosel
Project	Moskosel–Harads, SGU code: 80005

Aim of study

The bedrock in the Trollforsen–Abmoälven area consists of well preserved, finely laminated volcanic sand- and siltstones with intercalations of porphyritic volcanic rocks and small carbonate lenses. This volcano-sedimentary succession is considered as deposited in a back arc environment in relation to the 1.88 to 1.86 Ga Arvidsjaur terrestrial arc. The sediments have been derived from volcanic rocks of the Arvidsjaur Group.

The volcanic rocks between Malmesjaure and Trollforsen–Abmoälven are intruded by a granodiorite, which is considered to belong to the Jörn GI suite (Kathol & Weihed 2005). The granodiorite was dated at Övre Ljusset (25J 4c) to c. 1.88 Ga (Kathol & Persson 2007a). This age could imply that at least parts of the volcanic rocks are older than the 1.88–1.86 Ga Arvidsjaur Group (Kathol & Weihed 2005). However, the calculated age of the granodiorite is uncertain as

two younger data points were excluded based on the assumption of the presence of secondary zircon domains. Alternatively, the three analyses used in the age calculation contained inherited zircon domains.

Direct dating of the igneous crystallization age of a volcanic rock within the volcano-sedimentary succession of the Trollforsen–Abmoälven area will help to determine the stratigraphic position of the porphyritic volcanic rocks and intercalated volcanic sand- and siltstones. This age will also set the upper age of the granodiorite at Övre Ljusset.

Sample description

The sampled rock is a foliated feldspar-porphyrific rhyolite (Fig. 1).

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 1.

Zircon in the sample is generally euhedral to subhedral, prismatic crystals. In CL-images most grains show



Fig. 1. Foliated, feldspar-porphyrific rhyolite from Trollforsen.

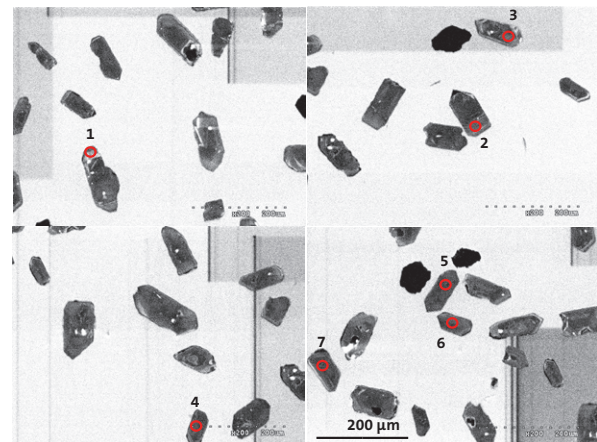


Fig. 2. CL-images of zircon from the investigated acid volcanic rock. Red circles mark the approximate location of analysed spots. Numbers refer to analytical spot number in Table 1.

Table 1. SIMS U-Pb-Th zircon data of a rhyolite at Trollforsen in the Moskosel area (CLU040008X).

Sample/spot #	U ppm	Pb ppm	Th/U calc	$^{206}\text{Pb}/^{204}\text{Pb}$ measured	$f_{206}\%$	$^{238}\text{U}/^{206}\text{Pb}$	$\pm\sigma\%$	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma\%$	$^{207}\text{Pb}/^{206}\text{Pb}$ age (Ma)	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$ age (Ma)	$\pm\sigma$	Disc. % 2 σ lim.
n2854-1	323	82	0.145	1753.40	1.07	4.638	0.68	0.114	0.71	1860	13	1259	8	-32.14
n2854-2	356	142	0.249	17554.87	0.11	2.982	0.69	0.115	0.40	1887	7	1864	11	
n2854-3	562	232	0.322	69043.56	0.03	2.920	0.76	0.115	0.27	1879	5	1899	13	
n2854-4	504	201	0.287	92676.32	0.02	3.013	0.73	0.115	0.40	1874	7	1848	12	
n2854-5	480	200	0.327	528.18	3.54	2.892	0.90	0.115	1.79	1873	32	1915	15	
n2854-6	361	144	0.271	4195.80	0.45	2.997	1.45	0.114	0.52	1868	9	1856	23	
n2854-7	567	226	0.302	4495.84	0.42	3.025	0.76	0.115	0.32	1883	6	1841	12	-0.49

a weak internal oscillatory zonation (Fig. 2).

The U content of the analysed zircon grains varies between 323 and 567 ppm (n=7, Table 1) and Th/U ratios are 0.15–0.33. One analysis (5) with exceptionally high common Pb ($f_{206}\%$ =3.54, Table 1) and one strongly discordant analysis (n2854-1) are excluded from the age calculation and not included in the further discussion below (Fig. 3).

Together, five concordant and one weakly discordant (no 7, 0.5% discordant) analysis yield a concordia age of 1876 ± 10 Ma (2 σ , MSWD=1.9; Fig. 3). The $^{207}\text{Pb}/^{206}\text{Pb}$ weighted average age is 1880 ± 6 Ma (2 σ , MSWD=0.90), i.e. within error the same age as the concordia age. The more precise $^{207}\text{Pb}/^{206}\text{Pb}$ weighted average age of 1880 ± 6 Ma is chosen as the best estimate of igneous crystallisation of zircon hosted in the rhyolite.

Discussion and conclusion

The calculated age of the feldspar-porphyritic rhyolite from Trollforsen at 1880 ± 6 Ma indicates that the volcano-sedimentary succession of the Trollforsen–Abmoälven area is coeval with or possibly slightly older than rocks of the Arvidsjaur Group further to the south and east. Ignimbritic rhyolites from Benbryteforsen (map area 25J Moskosel, 3 i) and Skyberget–Gråberget (map area 24J Arvidsjaur, 1 i and 3 h) yielded ages of 1874 ± 13 Ma and 1878 ± 2 Ma, respectively (Kathol & Persson 2007b, Skiöld et al. 1993). A feeder dyke for subaerial dacites at Fågelberget (map area 24J Arvidsjaur, 2 g) was dated at 1877 ± 9 Ma (Kathol & Triumf 2004). Furthermore, a granitic intrusion at Antakberget (map area 24J Arvidsjaur, 0i), considered as a shallow magma chamber for ignimbritic rhyolites, was dated at 1879^{+15}_{-12} Ma (Kathol & Persson 1997).

The age of the rhyolite from Trollforsen thus suggests the existence of a shallow basin with volcanic-derived infill at the same time as or possibly slightly prior to the development of the Arvidsjaur volcanic arc.

The geochemical signature of rocks from the Malmesjaure–Trollforsen–Abmoälven area is similar to the signature of ignimbritic rhyolites from the area north of Arvidsjaur which suggests a genetic correlation between

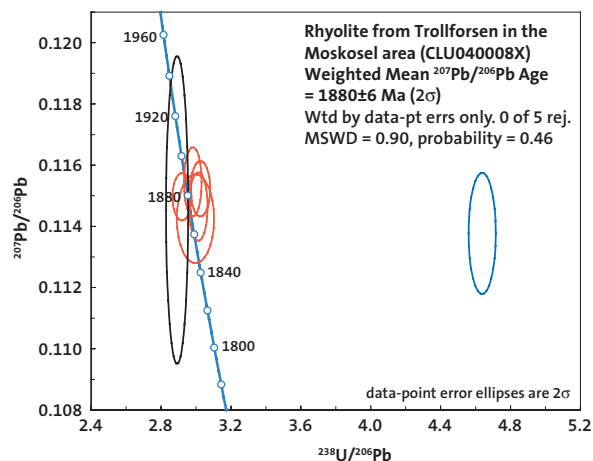


Fig. 3. Terra-Wasserburg concordia diagram showing U-Pb SIMS zircon data from a feldspar-porphyritic rhyolite in the Trollforsen area, Moskosel. Analyses used for age-calculation are shown in red. Geologically meaningless analysis with high common-Pb content shown in black and discordant analysis shown in blue.

the rock units. The volcano-sedimentary succession of the Trollforsen–Abmoälven area is considered to be deposited in a back arc environment. The sediments were derived from a terrestrial arc.

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U-Pb zircon age of a strongly deformed rhyolite from Danielstugan, c. 3.5 km north-north-east of Svartlå, southern Norrbotten County, Sweden

Benno Kathol, Andrius Rimša & Fredrik Hellström

Geological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

Kathol, B., Rimša, A. & Hellström, F., 2008: U-Pb zircon age of a strongly deformed rhyolite from Danielstugan, c. 3.5 km north-north-east of Svartlå, southern Norrbotten County, Sweden. In F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 36–38.

Rock	Rhyolite
Sample number	ABK070154X, n2862 (Nordsim)
Coordinates (RT90)	7336989 / 1745595
Map sheet	25K NE Harads, 7j
Locality	Danielstugan, Quarry c. 3.5 km north-north-east of Svartlå
Project	Moskosel–Harads, SGU code: 1106301

Aim of study

The aim of this study was to date the deposition of a strongly deformed volcanic sequence to the east of a major deformation zone in the eastern part of the map area 25K Harads. This north-north-west trending deformation zone is a lithological and structural

boundary that separates metasedimentary rocks of the Bothnian Supergroup and the Svartlå Group to the west from strongly deformed felsic volcanic rocks to the east. Whereas the general structural trend in the volcanic rocks to the west of the metasedimentary rocks is roughly east-west, the foliation in the volcanic rocks east of the zone strikes north–south. Parts of the latter volcanic succession are ignimbritic rhyolites, which have been deposited under subaerial conditions. This depositional environment could possibly relate these volcanic rocks with the subaerial Arvidsjaur Group further to the south-west.

Sample description

The sampled rock is a strongly deformed, weakly porphyritic and in places ignimbritic rhyolite (Fig. 1).

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in November 2007. The analytical results are shown in Table 1.

Zircon in the sample is generally euhedral to subhedral, prismatic crystals. In CL-images most grains show a weak internal oscillatory zonation (Fig. 2). The U content of the analysed zircon grains varies between 118 and 513 ppm and Th/U ratios are 0.33–0.64. Two analyses (no 2 and 3) with exceptionally high common Pb are excluded from age calculation and not included in the further discussion below (black circles in Fig. 3; Table 1).

The data points define a discordia line with intercept ages of 1876 ± 6 Ma and 210 ± 140 Ma ($n=6$, $MSWD=0.87$). Four analyses are concordant and yield a concordia age at 1877 ± 6 Ma ($MSWD=1.3$), identical to the $^{207}\text{Pb}/^{206}\text{Pb}$ weighted average age of 1876 ± 6 Ma (2σ , $MSWD=0.70$) also including a weakly discordant analysis (no 1, -0.6% discordant). The weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1876 ± 6 Ma is chosen as the best estimate of igneous crystallisation of the rhyolite.



Fig. 1. Strongly deformed rhyolite from Danielstugan (25K Harads).

Discussion and conclusion

The igneous crystallisation age of 1876 ± 6 Ma for the ignimbritic rhyolite from Danielstugan confirms the affiliation of the strongly deformed felsic volcanic succession east of the above mentioned major deformation zone to the Arvidsjaur Group.

More or less consistent ages have been obtained from U-Pb datings on zircons (TIMS) from volcanic rocks in areas further to the south-west as follows. Ignimbritic rhyolites from Benbryteförsen (map area 25J Moskosel, 3 i) and Skyberget–Gråberget (map area 24J Arvidsjaur, 1 i and 3 h) yielded ages of 1874 ± 13 Ma and 1878 ± 2 Ma, respectively (Kathol & Persson 2007, Skiöld et al. 1993). A feeder dyke for subaerial dacites at Fågelberget (map area 24J Arvidsjaur, 2 g) was dated at 1877 ± 9 Ma (Kathol & Triumf 2004). Furthermore, a granitic intrusion at Antakberget (map area 24J Arvidsjaur, 0i), considered as a shallow magma chamber for ignimbritic rhyolites, has an age of 1879^{+15}_{-12} Ma (Kathol & Persson 1997).

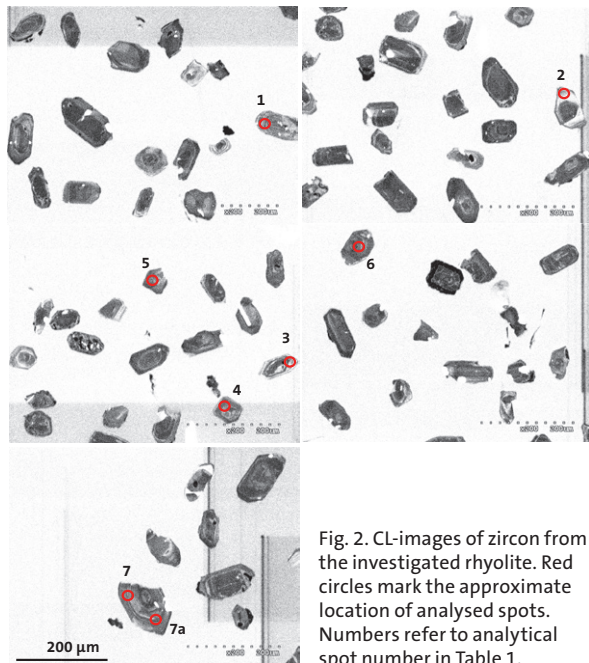


Fig. 2. CL-images of zircon from the investigated rhyolite. Red circles mark the approximate location of analysed spots. Numbers refer to analytical spot number in Table 1.

The volcanic rocks at Skyberget–Gråberget, Fågelberget and Antakberget belong to the Arvidsjaur Group and are situated in the type area of this group. Within this area, the rocks are almost undeformed and show low grade metamorphic conditions. The ages of volcanic rocks at Benbryteförsen and Danielstugan, and the subaerial nature of these rocks suggest that the Arvidsjaur Group can be extended towards the north-easternmost parts of map area 25K Harads NE.

The affiliation of the strongly deformed rocks from Danielstugan (and Benbryteförsen) to the Arvidsjaur Group demonstrates that degree of deformation and metamorphic conditions vary in different parts of the Arvidsjaur Group.

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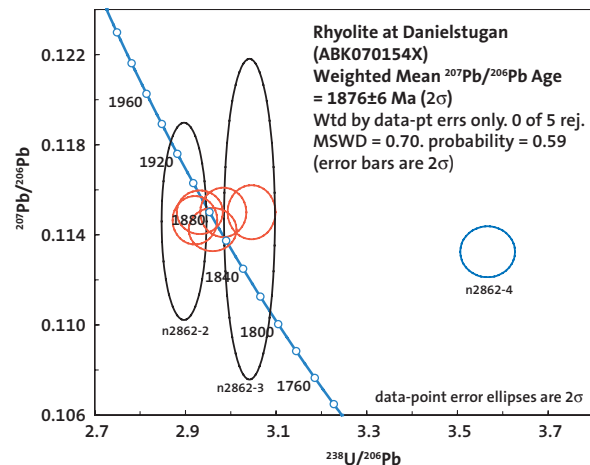


Fig. 3. Terra-Wasserburg concordia diagram showing U-Pb SIMS zircon data from a strongly deformed rhyolite from Danielstugan in the Harads area. Analyses used for age-calculation are shown in red. Geologically meaningless analyses with high common-Pb content are shown in black. Highly discordant data not used for age calculation shown in blue.

Table 1. SIMS U-Pb-Th zircon data of a metarhyolite from Danielstugan in the Harads area (ABK070154X).

Sample/spot #	U ppm	Pb ppm	Th/U calc	$^{206}\text{Pb}/^{204}\text{Pb}$ measured	f_{206} %	$^{238}\text{U}/^{206}\text{Pb}$ ±σ %	$^{207}\text{Pb}/^{206}\text{Pb}$ ±σ %	$^{207}\text{Pb}/^{206}\text{Pb}$ age (Ma) ±σ	$^{206}\text{Pb}/^{238}\text{U}$ age (Ma) ±σ	Disc. % 2σ lim.	
n2862-1	303	127	0.53	5725	0.33	3.046	0.71	0.115 0.43	1880 8	1830 11	-0.64
n2862-2	118	51	0.51	277	6.74	2.897	0.70	0.115 1.56	1874 28	1912 12	
n2862-3	177	70	0.33	548	3.41	3.041	0.75	0.115 2.54	1875 45	1833 12	
n2862-4	382	133	0.38	3482	0.54	3.567	0.69	0.113 0.41	1852 7	1593 10	-13.56
n2862-5	297	123	0.40	44417	0.04	2.960	0.73	0.114 0.34	1868 6	1876 12	
n2862-6	513	227	0.64	90174	0.02	2.932	0.71	0.115 0.34	1880 6	1892 12	
n2862-7	254	107	0.39	22648	0.08	2.921	0.69	0.115 0.38	1874 7	1898 11	
n2862-7a	277	115	0.43	53487	0.03	2.984	0.70	0.115 0.39	1880 7	1863 11	

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- Kathol, B. & Triumf, C.-A., 2004: Bedrock map 24J Arvidsjaur, scale 1:50 000. *Sveriges geologiska undersökning Ai 148–151*.
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SIMS-dating of a Dala-type granite north of Evertsberg, Dalarna, Sweden

Magnus Ripa, Andrius Rimša & Fredrik Hellström

Geological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

Ripa, M., Rimša, A. & Hellström, F., 2008: SIMS-dating of a Dala-type granite north of Evertsberg, Dalarna, Sweden. *In* F. Hellström (ed.): Results from radiometric datings and other isotope analyses 2. *SGU-rapport 2008:27*, 39–41.

Rock	Granite
Sample number	CMR060098A, n2865 (Nordsim)
Coordinates (RT90)	6784547 / 1401707
Map sheet	14E NW Mora, 6a
Locality	Sovaldbergs fäboddar, sample from old abandoned quarry
Project	Västra Dalarna, berg, regional, SGU code: 1109201

Aim of study

Dala-type granites (Hjelmqvist 1966, Ahl et al. 1999, 2004) are frequent in the north-central parts of Dalarna county, Sweden. They belong to the so-called Transscandinavian Igneous Belt (TIB; e.g. Gorbatshev 2004). Most isotope analyses of zircon in the TIB granites and associated magmatic rocks (syenitoids and volcanics) were emplaced either at 1.8 Ga (TIB-1) or at 1.7 Ga (TIB-2; Larson & Berglund 1992).

At Sovaldberg, c. 3 km north of the village of Evertsberg, a Dala-type granite occurs. The magnetic anomaly pattern of the granite appears to cross-cut east-north-east-trending regional magnetic anomalies (see Figs. 2 & 4 in Ripa et al. 2007) interpreted to represent dolerite dykes of so-called Tuna-type (Hjelmqvist 1966), which co-exist with felsic dykes that were dated at 1474 ± 4 Ma by Lundström et al. (2002).



Fig. 1. The dated granite sample.

Sample description

The sampled rock is an isotropic, red, fine- to medium-grained, equigranular granite (Fig. 1). Local, less than 0.5 cm wide quartz veins suggest limited deformation and the rock may be bleached close to the veins.

Analytical results and interpretation of geochronological data

In situ U-Pb-Th SIMS analysis of zircon was performed at the NORDSIM facility at the Museum of Natural History in Stockholm in November 2007. The analytical results are shown in Table 1.

Zircon in the sample is metamict, subhedral to anhedral grains of poor analytical quality. Some grains are CL-dark throughout whereas others show oscillatory-zoned, CL-bright inner core domains surrounded by CL-dark outer domains (Fig. 2).

Several of the analysed zircon grains have exceptionally high U and Th contents (Table 1). The U concentration varies between 107 and 7508 ppm, the Th concentration between 107 and 7020 ppm and Th/U ratios are 0.20–0.63 (n=18; Table 1; Fig. 3). Most analyses indicate exceptionally high common lead contents ($f_{206} > 1$; Table 1). These analyses are excluded from the age calculations and not included in the discussion below.

Three of the zircon analyses are concordant and yield a concordia age of 1681 ± 28 Ma (95 % confidence, MSWD=5.7, Fig. 4). The weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ age is 1695 ± 17 Ma (2σ , MSWD=0.12), i.e. within error the same age as the concordia age, but is more precise. A fourth analysis (4) gave a discordant data point (Fig. 4), which yields a significantly older $^{207}\text{Pb}/^{206}\text{Pb}$ age and presumably indicates the presence of inherited material. The analytical data indicate igneous crystallisation of the granite at c. 1.70 Ga.

Discussion and conclusion

The analytical data suggest a magmatic crystallisation age at 1.70 Ga for the Sovaldberg granite, which then would belong to the TIB-2 generation of granitoids. The granite is considerably older than the c. 1.47 Ga

Table 1. SIMS U-Pb-Th zircon data (CMR060098A).

Sample/spot #	U ppm	Pb ppm	Th/U calc	$^{206}\text{Pb}/^{204}\text{Pb}$ measured	f_{206} %	$^{238}\text{U}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$	$\pm\sigma$ %	$^{207}\text{Pb}/^{206}\text{Pb}$ age (Ma)	$\pm\sigma$	$^{206}\text{Pb}/^{238}\text{U}$ age (Ma)	$\pm\sigma$	Disc. % 2 σ lim.
n2865-1	521	148	0.45	40	46.67	4.372	2.47	0.094	22.34	1505	372	1328	30	
n2865-2	280	49	0.25	66	28.14	7.094	1.02	0.096	14.20	1551	245	850	8	
n2865-3	215	67	0.58	99	18.81	4.218	1.67	0.105	15.45	1715	260	1372	21	
n2865-4	774	286	0.37	31118	0.06	3.314	0.75	0.110	0.26	1802	5	1700	11	-4.57
n2865-5	5118	596	0.36	31	60.74	11.725	1.12	0.084	11.92	1289	216	528	6	
n2865-6	353	90	0.63	309	6.05	5.455	0.77	0.101	3.17	1637	58	1085	8	-20.97
n2865-7	7508	680	0.43	117	16.00	13.957	1.41	0.062	11.53	670	229	446	6	
n2865-8	197	71	0.45	16761	0.11	3.438	0.76	0.104	0.61	1692	11	1646	11	
n2865-9	149	40	0.26	142	13.18	4.412	1.14	0.095	5.50	1532	100	1317	14	
n2865-10	6768	3660	0.36	1035	1.81	2.180	0.84	0.107	0.14	1751	2	2434	17	44.43
n2865-11	2836	2115	0.57	874	2.14	1.601	1.56	0.110	0.19	1799	3	3128	39	87.86
n2865-12	127	48	0.46	1868	1.00	3.257	1.72	0.103	1.95	1686	35	1726	26	
n2865-13	1242	142	0.20	30	61.81	10.446	9.74	0.076	47.30	1090	737	589	55	
n2865-14	259	82	0.63	128	14.56	4.204	1.51	0.102	1.76	1654	32	1376	19	-9.81
n2865-8a	107	40	0.53	4532	0.41	3.340	1.51	0.104	0.72	1699	13	1688	23	
n2865-8b	313	73	0.32	55	33.85	5.294	2.41	0.095	18.41	1534	312	1115	25	
n2865-15	304	37	0.28	43	43.38	11.546	1.51	0.108	7.10	1766	124	535	8	-35.76
n2865-16	2242	471	0.20	190	9.85	5.600	1.51	0.092	1.76	1461	33	1059	15	-20.38

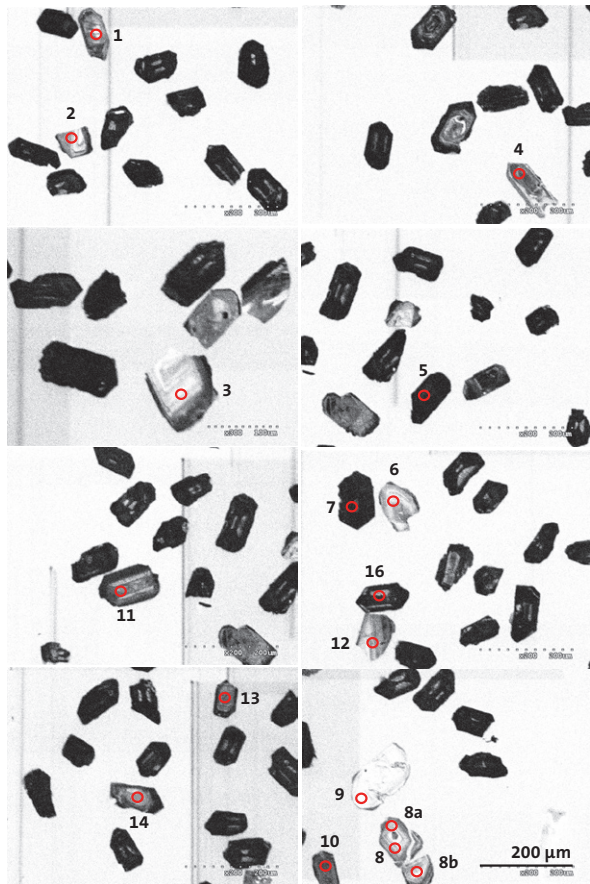


Fig. 2. CL-images of zircon grains from the investigated granite. Red circles mark the approximate locations of analysed spots. Numbers refer to analytical spot number in Table 1.

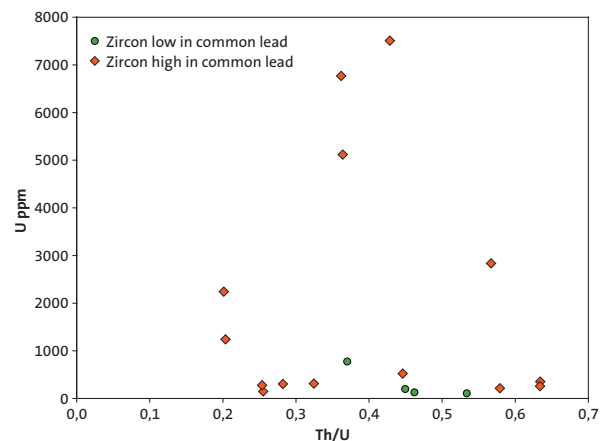


Fig. 3. U versus Th/U for analysed zircon.

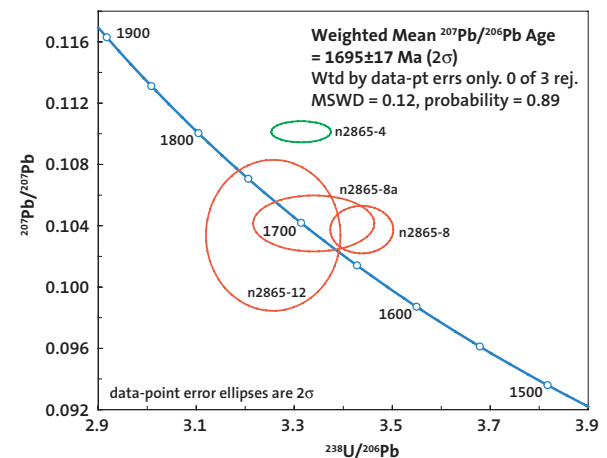


Fig. 4. Terra Wasserburg diagram showing U-Pb zircon data. Analyses used in age calculation are shown in red. Analyses with exceptionally high common lead contents are excluded, see Table 1.

dolerite dykes of Tuna-type (see above). This means that the dykes (or the phenomenon that forms the magnetic anomalies) that are cut by the granite do not belong to the Tuna-type generation of dykes.

References

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