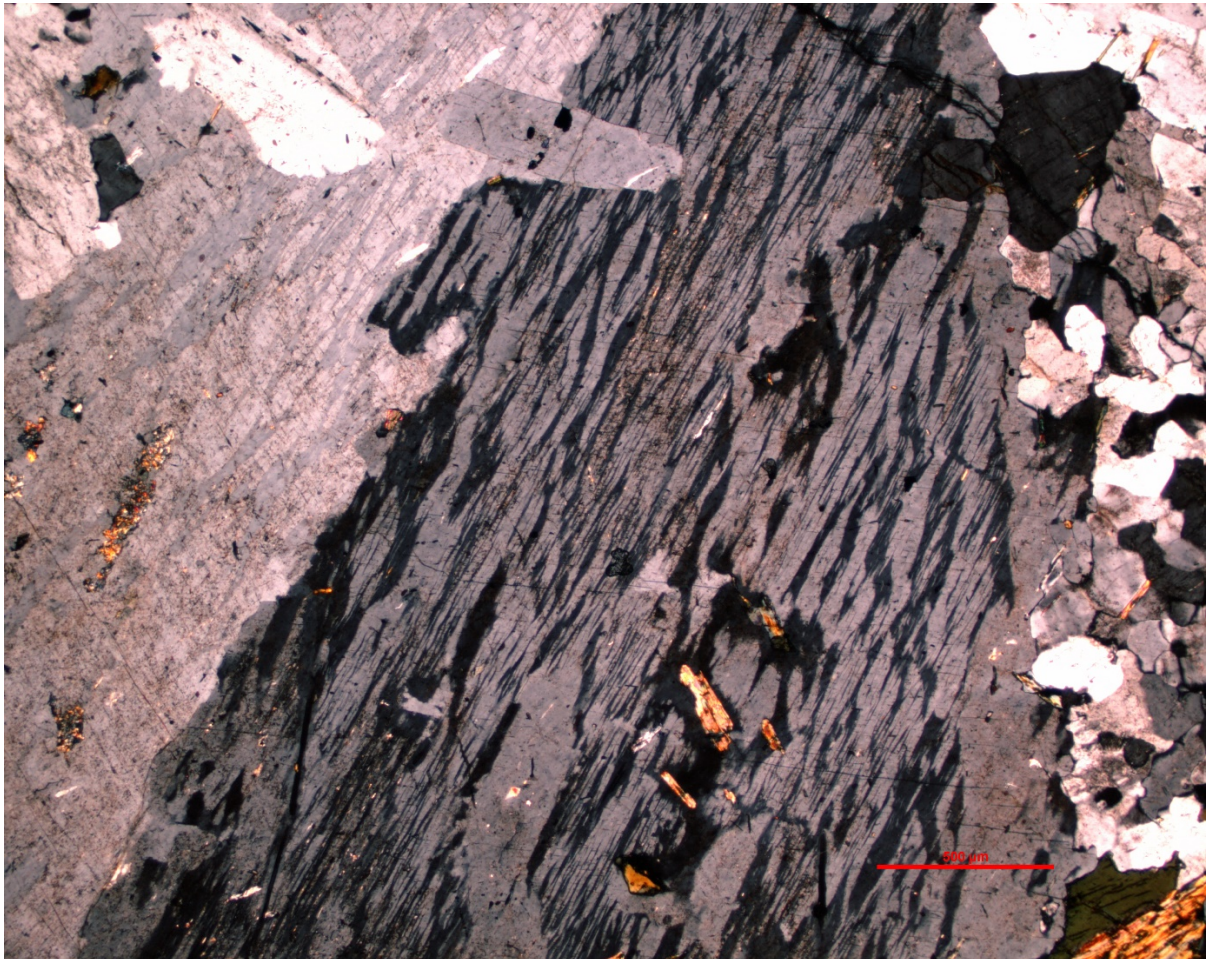


# U–Pb zircon age of a quartz monzonite from Sjävnjaluokta, northern Sweden – type area for the Perthite monzonite suite

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*Cover:* Microphoto of the analysed rock with a perthite crystal. Scale bar is 500  $\mu\text{m}$ .

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## ABSTRACT

The name Perthite monzonite suite was introduced by Witschard (1984) for monzonites and quartz monzonites in the map areas 28J Fjällåsen. These rocks form the bedrock in large areas in Norrbotten and northern Västerbotten counties. As no radiometric age determination from the area, where the name was introduced was available, a finely medium-grained, relict coarse-grained quartz monzonite from the area north of Sjävnjaluokta in map area 28J Fjällåsen SV was analysed (U–Pb method on zircon) and yielded an age of  $1878 \pm 4$  Ma. This age is within the normal age range for rocks in other areas that have been assigned to the Perthite monzonite suite, and the area north of Sjävnjaluokta is proposed for the lectotype area for the Perthite monzonite suite.

**Keywords:** Perthite monzonite suite, granite, quartz monzonite, monzonite, radiometric age determination, zircon, U–Pb, lectotype area, Sjävnjaluokta

## SAMMANFATTNING

Namnet pertitmonzonitsviten introducerades av Witschard (1984) för monzoniter och kvartsmonzoniter i kartområdena 28J Fjällåsen. Dessa bergarter bygger upp berggrunden i stora områden i Norrbottens och norra Västerbottens län. Eftersom det inte fanns någon radiometrisk åldersbestämning från det område där namnet blev introducerat, analyserades (U–Pb-metoden på zirkon) en fint medelkornig, relict grovkornig kvartsmonzonit från området norr om Sjävnjaluokta inom kartområdet 28J Fjällåsen SV. Den erhållna åldern av  $1878 \pm 4$  miljoner år ligger inom det åldersintervall som är normalt för bergarter som i andra områden brukar tillskrivas pertitmonzonitsviten. Området norr om Sjävnjaluokta föreslås därför som lektotyp-område för pertitmonzonitsviten.

**Nyckelord:** Pertitmonzonitsviten, granit, kvartsmonzonit, monzonite, radiometrisk åldersbestämning, zirkon, U–Pb, lektotyp-område, Sjävnjaluokta.

## INTRODUCTION

Palaeoproterozoic rocks (granites, syenitoids and subordinated diorites and gabbros) of the Perthite monzonite suite occur in the entire Norrbotten County and the northern part of the Västerbotten County (Fig. 1). To the southwest, the suite is confined by a northwest– southeast striking line between Skellefteå and Sorsele, which is more or less parallel with the main structures in the Skellefte district. This line is even (sub-) parallel with the Archaean boundary between Luleå and Jokkmokk further to the northeast.

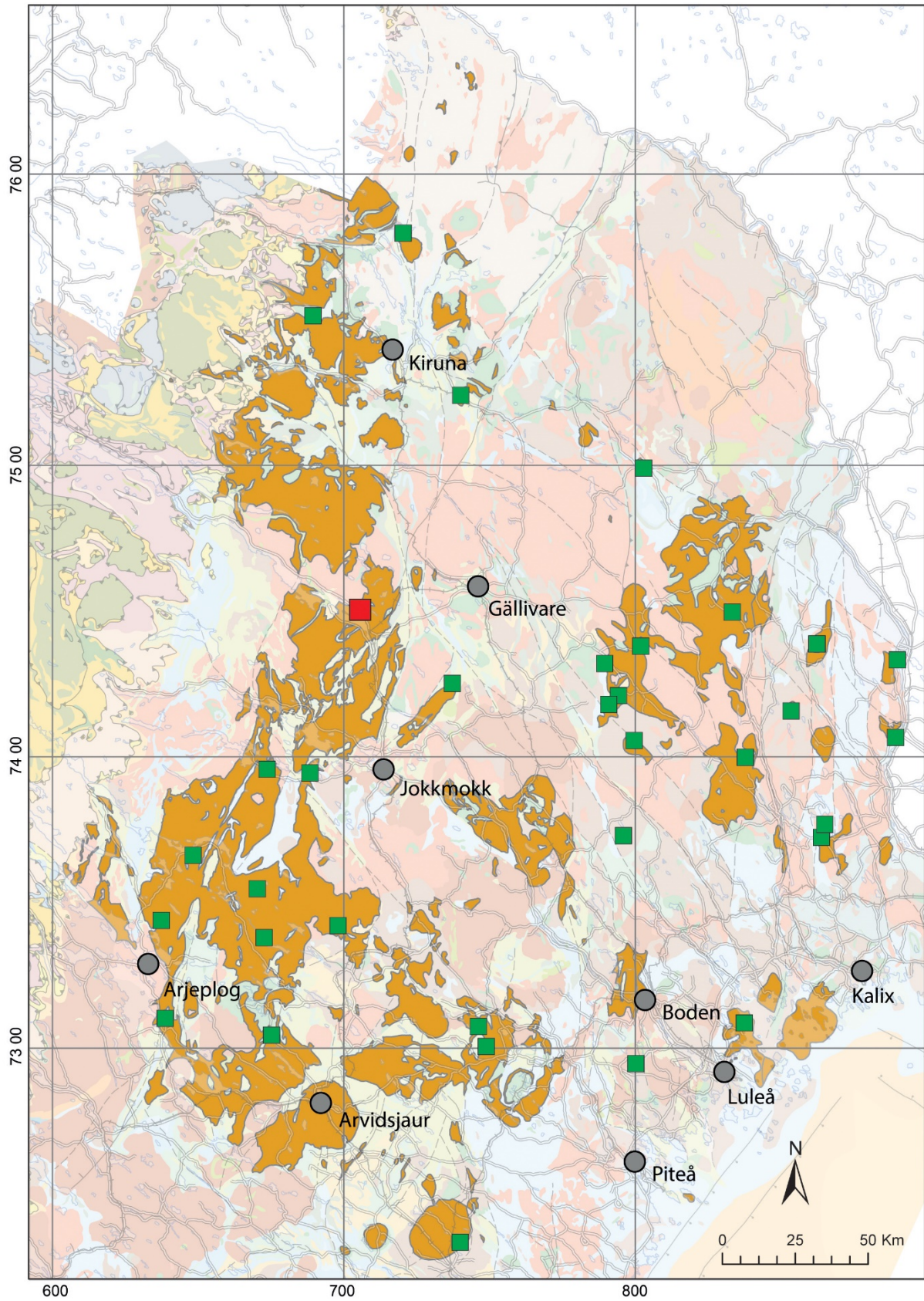
Rocks of what is now called the Perthite monzonite suite were described from the Kiruna area and Masugnsbyn as quartz syenites to granites and were called Perthite-granites by Geijer (1931). Witschard (1970) assigns similar rocks from the map area 29L Lainio as Perthite monzonites.

The bedrock in large areas of the map area 28J Fjällåsen consists of monzonites and quartz monzonites and are comprised by Witschard (1975) under the name Perthite Granite series. Later, Witschard (1984) introduced the name Perthite monzonite suite for these rocks occurring in a broad belt parallel to the Caledonides, but no holotype locality or area has been pointed out by the author. Witschard (1975) gave names to three of the massifs in the southern part of the Fjällåsen map area; the Stuur-Maksjojaure massif in the west, the more centrally located Sjaunjaätno massif and the Pikku-Svierkku massif in the east.

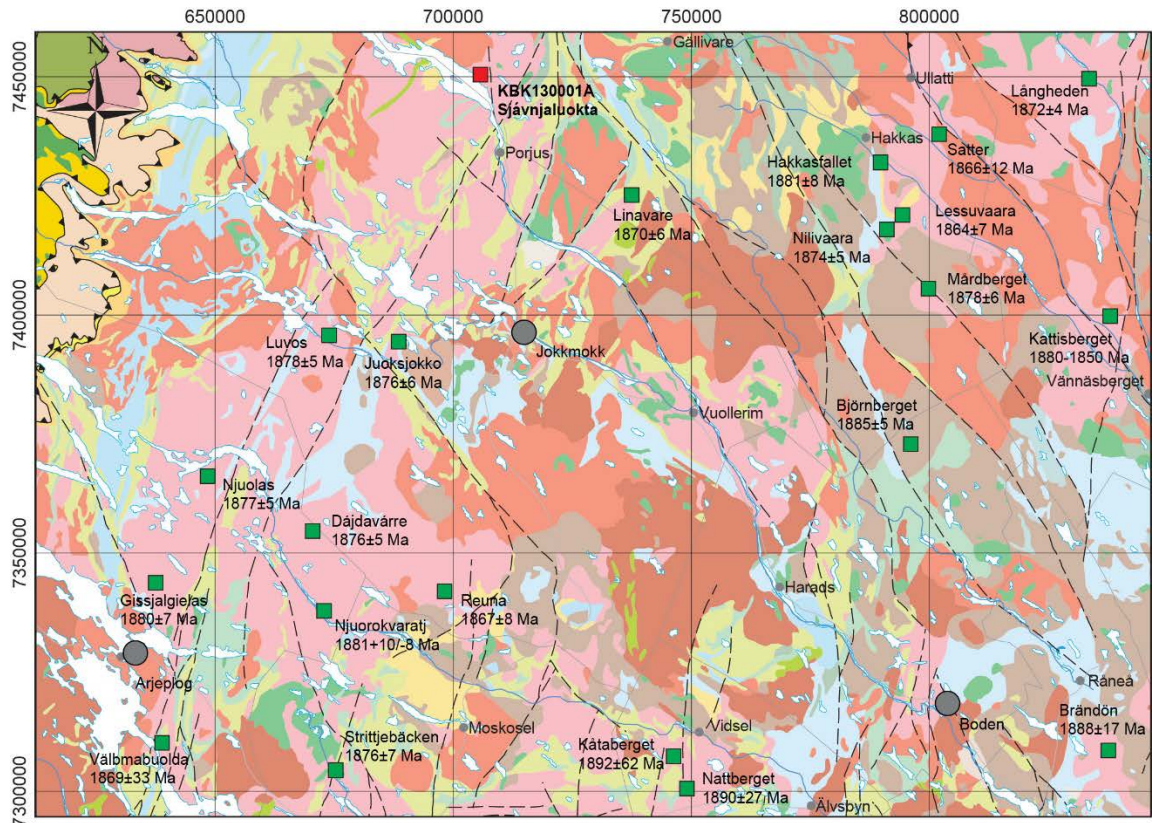
According to the rules of the ‘Guide for geological nomenclature in Sweden’ (Kumpulainen 2017) which has been compiled by the order of the Royal Academy of Science (KVA), every formal stratigraphic or lithodemic unit must have a type locality or type area. In this case, the area directly to the north of Sjävnjaluokta in the Sjaunjaätno massif lies inside the Fjällåsen map areas, where the term Perthite monzonite suite was introduced, and it is also situated in the central part of the above named broad belt. Furthermore, the area is easily accessible by the road (länsväg BD 827) between Porjus and Stora Sjöfallet. This area should therefore be suitable as the lectotype area for the Perthite monzonite suite.

Figure 1 shows the known extent of the Perthite monzonite suite. There are 33 radiometric datings, situated mainly in the eastern and southern part of the suite. Evidently, dating was not carried out in the proposed lectotype area or in the central part of the broad belt, where the suite was defined (Witschard 1984). Figure 2 gives an overview of the obtained U–Pb zircon ages in southern Norrbotten County taken from the database of radiometric age determinations at SGU.

Figure 3 shows the extension and the magnetic pattern of the Perthite monzonite suite between Kiruna and Jokkmokk on the magnetic anomaly map. If the area north to Sjävnjaluokta should be pointed out as the lectotype area for the Perthite monzonite suite, a modern U–Pb zircon crystallisation age should be available.



**Figure 1.** Rocks of the Perthite monzonite suite, accentuated with brownish colour, in Norrbotten and Västerbotten counties. Sample sites of previous radiometric age determinations (U–Pb) are marked with green squares; the site Sjävnjaluokta is marked by a red square. Geological background is from the 1:1 000 000 database of the SGU.



## CALEDONIAN OROGEN

### Seve Nappe Complex

- Gneiss, mica schist, quartzite, calcareous schist
- Amphibolite
- Gabbro-diorite, anorthosite

### Stalon Nappe Complex

- Meta-arkose, schist, phyllite, sandstone
- Syenitoid-granite

### Blaik Nappe Complex

- Sandstone, greywacke, quartzite, conglomerate

## EDIACARAN - CAMBRIAN SEDIMENTARY COVER

- Alum shale, mudstone, siltstone
- Sandstone, quartz arenite, quartzite, siltstone, shale, conglomerate

## SVECOKARELIAN OROGEN

### Late Svecokarelian intrusive rocks, c. 1.81–1.75 Ga

- Syenitoid-granite; Revsund and Edefors suites
- Gabbro-diorite; Revsund and Edefors suites
- Granite, pegmatite; Lina suite

### Early Svecokarelian intrusive rocks, c. 1.91–1.85 Ga

- Syenitoid-granite; Perthite monzonite suite
- Tonalite-granodiorite-granite; Jörn G1 and Haparanda suites
- Gabbro-diorite; Jörn G1 and Haparanda suites

### Svecofennian supracrustal rocks

- Sandstone, arkose, paragneiss; Snavva-Sjöfallet and Svartå groups
- Dacite-rhyolite; Arvidsjaur group
- Basalt-andesite; Arvidsjaur group
- Dacite-rhyolite; Porphyrite group
- Basalt-andesite; Porphyrite group
- Marble; Bothnian supergroup
- Paragneiss, greywacke, sandstone; Bothnian supergroup

### Early Svecokarelian intrusive rocks, c. 1.96–1.92 Ga

- Tonalite-granodiorite-granite

### Karelian supracrustal rocks

- Quartz arenite, arenite, arkose; Sockberget group

### Archaean rocks, > 2.5 Ga

- Syenitoid-granite, porphyritic
- Tonalite-trondhjemite-granodiorite gneiss

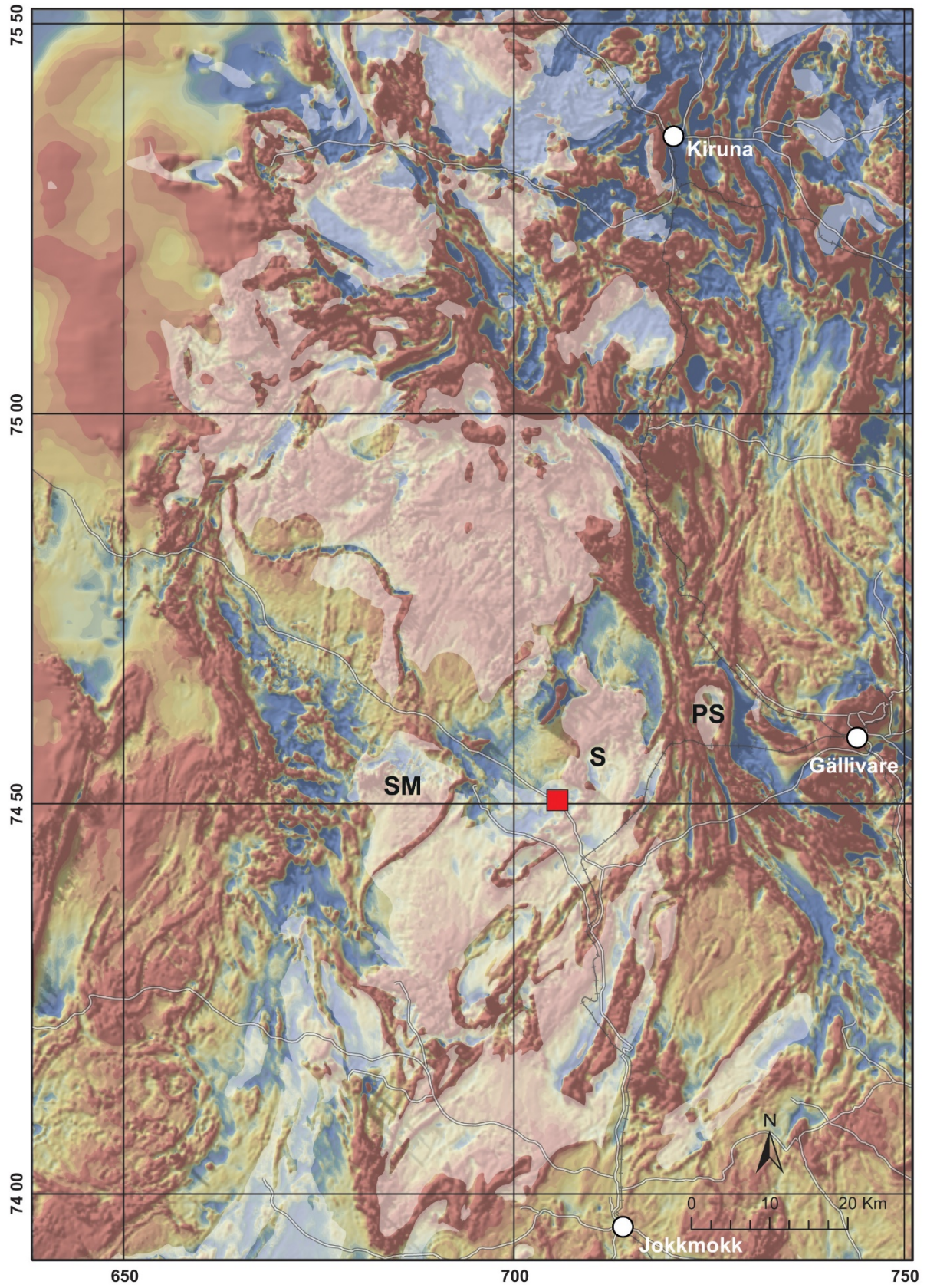
Ductile to brittle deformation zone

Reverse ductile deformation zone

Sample site, Sjövnjaluokta

Sample sites for radiometric age determinations of the Perthite monzonite suite

**Figure 2.** Radiometric age determinations (U-Pb) of rocks of the Perthite monzonite suite in southern Norrbotten County. The sites are indicated by green squares and taken from the database of radiometric age determinations at SGU. The site for the Sjövnjaluokta sample is marked by a red square. Geological background is from the 1:1 000 000 database of SGU, and the reference grid is in Sweref 99 TM and shows 50 km cells. References to age determinations: Åkerman & Kero (2012), Bergman et al. (2016), Claeson & Antal Lundin (2012), Hellström et al. (2012a, b, c, 2015), Kathol & Aaro (2006a, b), Kathol et al. (2006), Mellqvist & Aaro (2006a, b), Öhlander & Billström (1989), Skiöld et al. (1993), Thelander & Bastani (2006), Wikström et al. (1996).



**Figure 3.** Magnetic anomaly map of the area between Kiruna and Jokkmokk. The Perthite monzonite suite is shaded. Sample site is marked with a red square. SM: Stuor Maksjoaure, S: Sjaunjaätno, PS: Pikku-Sverkku.

## SAMPLE DESCRIPTION

The sample site lies south of the road and east of the bridge over Sjävnjaädno. The sampled rock is a light red, weakly foliated quartz monzonite (Table 1, Fig. 4). The rock is recrystallized, finely medium-grained and relict coarse-grained. Feldspar and quartz are the main constituents with subordinate amounts of biotite and hornblende.

**Table 1.** Summary of sample data.

<b>Rock type</b>	Quartz monzonite
<b>Tectonic domain</b>	Svecokarelian
<b>Tectonic subdomain</b>	Norrbottnen lithotectonic unit
<b>Lithodemic unit</b>	Perthite monzonite suite
<b>Sample number</b>	KBK130001A
<b>Lab-id</b>	n5169
<b>Coordinates</b>	7450465/705577 (SWEREF 99 TM), 7450380/1670770 (RT90)
<b>Map sheet</b>	745-70-01 (SWEREF), 28J Fjällåsen 0e (RT90)
<b>Locality</b>	Sjävnjaluokta
<b>Project</b>	Barents regional



**Figure 4.** Finely medium-grained, relict coarse-grained quartz monzonite from the sampling site, north of Sjävnjaluokta.

## ANALYTICAL RESULTS AND INTERPRETATION OF GEOCHRONOLOGICAL DATA

Zircons were obtained from a density separate of a crushed rock sample using a Wilfley water table. The magnetic minerals were removed by a hand magnet. Handpicked crystals were mounted in transparent epoxy resin together with chips of reference zircon 91500. The zircon mounts were polished and after gold coating examined by Back scattered electron (BSE) and Cathodoluminescence (CL) imaging using electron microscopy at EBC, Uppsala University and at the Swedish Museum of Natural History in Stockholm. High-spatial resolution secondary ion mass spectrometer (SIMS) analysis was done in November and December 2014 using a Cameca IMS 1280 at the Nordsim facility at the Swedish Museum of Natural History in Stockholm. The analytical results are shown in Table 2.

Detailed descriptions of the analytical procedures are given in Whitehouse et al. (1997, 1999), and Whitehouse & Kamber (2005). A c. 6 nA O<sup>2-</sup> primary ion beam was used, yielding spot sizes of c. 15 µm. Pb/U ratios, elemental concentrations and Th/U ratios were calibrated relative to the Geostandards zircon 91500 reference, which has an age of c. 1065 Ma (Wiedenbeck et al. 1995, 2004). Common Pb corrected isotope values were calculated using modern common Pb composition (Stacey & Kramers 1975) and measured <sup>204</sup>Pb, in cases of a <sup>204</sup>Pb count rate above the detection limit. Decay constants follow the recommendations of Steiger & Jäger (1977). Diagrams and age calculations of isotopic data were made using software Isoplot 4.15 (Ludwig 2012). All age uncertainties are presented at the 2σ/95% confidence level. BSE-imaging of the dated zircons was performed using electron microscopy at the Department of Geology, Uppsala University.

The heavy mineral concentrate contains crystal fragments of zircons, but also titanite as revealed when the mounted grains were examined in SEM. Back-scattered electron (BSE-) images of analysed zircon grains show usually homogeneous BSE-level or larger domains of different brightness. An oscillatory zonation is seen in grains no 1 and 5 (Fig. 5).

The zircons contain 179–1472 ppm U and have Th/U ratios of 0.12–1.33 (Table 2). Four uranium-rich analyses (1a, 5a, 7a, 11a) record high values of common lead and are also strongly discordant. Six analyses are concordant, but one analysis (no 3a) is slightly younger preventing calculation of a concordia age as the points not are equal (Fig. 6). One possibility is that the young analysis is affected by ancient Pb-loss from metamict parts, i.e. sufficiently close in time not to drag it off the concordia. Excluding analysis (3a), a Concordia age is calculated at  $1878 \pm 4$  Ma ( $2\sigma$ ,  $n = 5$ , MSWD of concord. & equiv. = 0.42, probability (of concord. & equiv.) = 0.93), similar to the weighted average <sup>207</sup>Pb/<sup>206</sup>Pb age of  $1877 \pm 4$  Ma ( $2\sigma$ ,  $n = 6$ , MSWD = 0.13, probability = 0.99), including also the weakly reversely discordant analysis no 2a. The concordia age at  $1878 \pm 4$  Ma is chosen as the best age estimate interpreted to date igneous crystallization of the quartz monzonite at 1.88 Ga.

**Table 2.** SIMS U–Pb–Th zircon data (KBK130001A, laboratory id n5169).

Anal. spot	Isotope ratios													Calculated ages (Ma)							
	U ppm	Th ppm	Pb ppm	Th/U calc <sup>1</sup>	<sup>207</sup> Pb / <sup>235</sup> U	±σ %	<sup>208</sup> Pb / <sup>232</sup> Th	±σ %	<sup>238</sup> U / <sup>206</sup> Pb	±σ %	<sup>207</sup> Pb / <sup>208</sup> Pb	±σ %	r <sup>2</sup>	Disc. % conv. <sup>3</sup>	Disc. % 2σ lim. <sup>4</sup>	<sup>207</sup> Pb / <sup>206</sup> Pb	±σ	<sup>206</sup> Pb / <sup>238</sup> U	±σ	<sup>206</sup> Pb / <sup>204</sup> Pb <sup>5</sup>	f <sub>206</sub> % <sup>6</sup>
1a	1272	394	196	0.17	1.576	1.04	0.0373	2.25	7.623	0.96	0.0871	0.42	0.92	-44.3	-41.7	1363	8	795	7	2598	0.72
2a	834	434	376	0.54	5.647	1.07	0.1007	2.05	2.804	1.06	0.1148	0.19	0.98	5.5	3.1	1877	3	1966	18	42379	0.04
3a	799	348	331	0.44	5.235	0.99	0.0969	2.02	2.990	0.97	0.1135	0.21	0.98	0.2		1857	4	1860	16	25237	0.07
4a	699	262	293	0.39	5.401	1.04	0.1012	2.03	2.929	1.00	0.1148	0.27	0.97	1.1		1876	5	1893	16	219711	{0.01}
5a	1174	532	187	0.24	1.588	1.06	0.0377	2.07	7.663	0.95	0.0883	0.48	0.89	-45.7	-42.8	1388	9	791	7	3083	0.61
6a	548	190	227	0.35	5.399	0.99	0.0997	2.02	2.936	0.96	0.1150	0.24	0.97	0.6		1879	4	1890	16	>1e6	{0.00}
7a	1473	427	168	0.15	1.038	1.10	0.0289	2.24	10.165	0.99	0.0765	0.47	0.90	-47.6	-44.4	1109	9	605	6	2663	0.70
8a	609	193	248	0.32	5.348	1.01	0.0988	2.04	2.961	0.99	0.1148	0.22	0.98	-0.1		1877	4	1876	16	276015	{0.01}
9a	179	232	91	1.33	5.404	1.12	0.0996	2.34	2.931	1.04	0.1149	0.41	0.93	0.9		1878	7	1892	17	46900	{0.04}
10a	616	250	259	0.42	5.391	0.99	0.0998	2.02	2.933	0.96	0.1147	0.22	0.97	1.0		1875	4	1891	16	>1e6	{0.00}
11a	1053	190	252	0.12	2.938	1.10	0.0585	2.27	4.828	1.07	0.1029	0.28	0.97	-30.3	-28.2	1677	5	1214	12	5274	0.35

Isotope values are common Pb corrected using modern common Pb composition (Stacey & Kramers 1975) and measured <sup>204</sup>Pb.

<sup>1</sup> Th/U ratios calculated from <sup>208</sup>Pb/<sup>206</sup>Pb and <sup>207</sup>Pb/<sup>206</sup>Pb ratios, assuming a single stage of closed U-Th-Pb evolution.

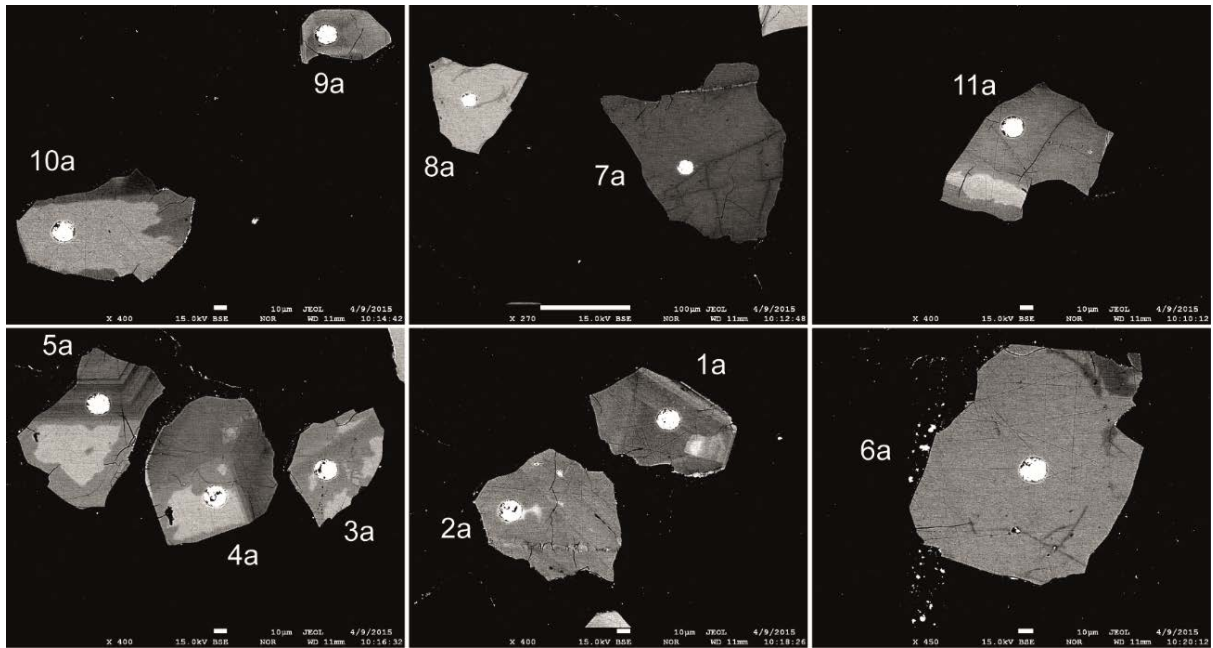
<sup>2</sup> Error correlation in conventional concordia space. Do not use for Tera-Wasserburg plots.

<sup>3</sup> Age discordance in conventional concordia space. Positive numbers are reverse discordant.

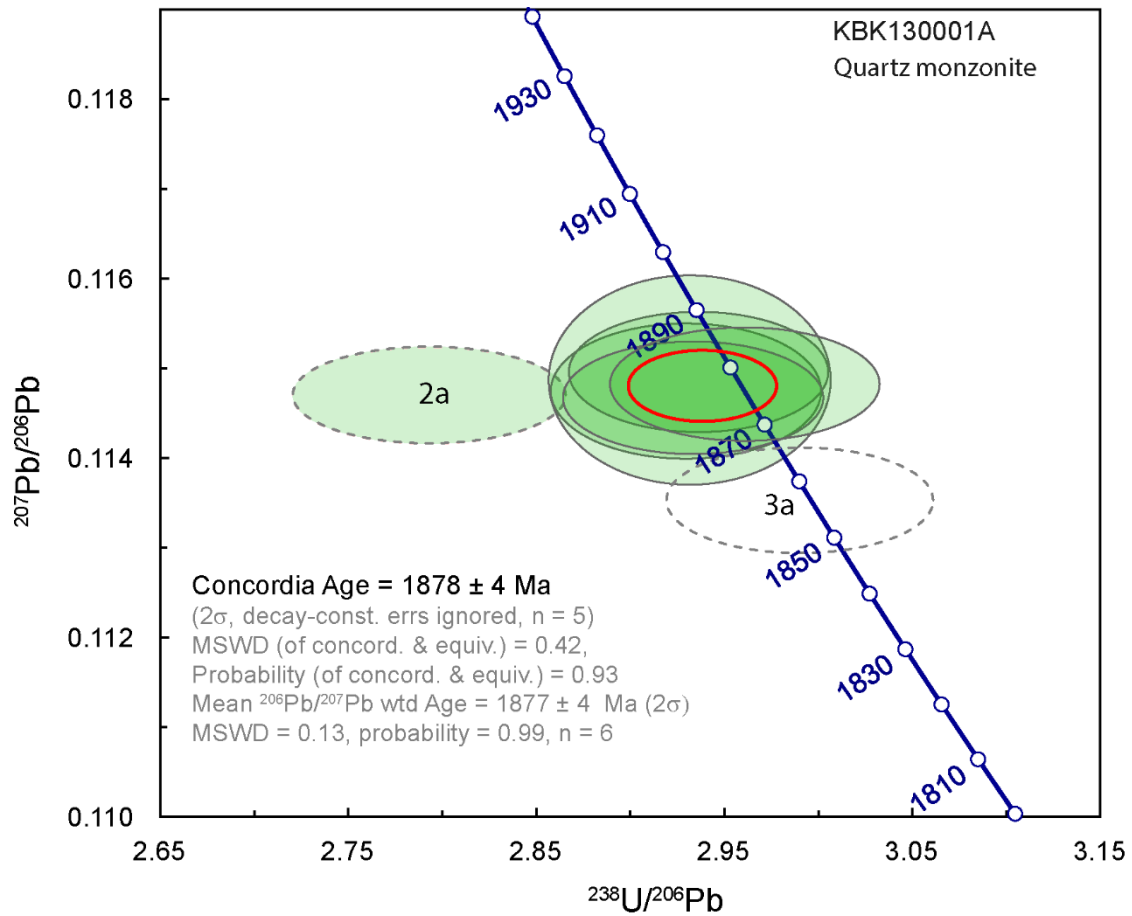
<sup>4</sup> Age discordance at closest approach of error ellipse to concordia (2σ level).

<sup>5</sup> Measured

<sup>6</sup> Figures in parentheses are given when no correction has been applied, and indicate a value calculated assuming present-day Stacey-Kramers common Pb.



**Figure 5.** Back-scattered electron (BSE-) images of analysed zircon grains. White spots mark the locations of analyses. Numbers refer to analytical spot number in Table 2.



**Figure 6.** Tera Wasserburg diagram showing U-Pb SIMS data of zircon analyses. Analyses shown with broken lines were excluded from calculation of the concordia age. Error ellipse of calculated weighted mean age is shown in red.

## DISCUSSION AND CONCLUSION

The received crystallization age of  $1878 \pm 4$  Ma shows that the sampled rock from the area north of Sjävnjaluokta was formed within the time interval of 1.89 – 1.85 Ga which is outlined for the Perthite monzonite suite by previous radiometric age determinations in the Norrbotten and northern Västerbotten counties (Fig. 2). Thus, this age supports the assignment of the bedrock in large areas in the central part of the broad belt, where no age determinations previously have been available, to the Perthite monzonite suite as introduced in the map areas 28J Fjällåsen by Witschard (1984). This also means that the area north of Sjävnjaluokta within the Sjaunjaätöno massif, which is situated within the map areas 28J Fjällåsen, is suitable as a lectotype area (see Kumpulainen 2017) for the Perthite monzonite suite.

We therefore propose to choose this area as the lectotype area for the Perthite monzonite suite in Norrbotten and northern Västerbotten counties. The chosen area is easily accessed by the road (länsväg BD 827) between Porjus and Stora Sjöfallet and it has also a good probability of continued preservation.

## ACKNOWLEDGEMENTS

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