U–Pb SIMS dating of some granitoids from eastern Blekinge, southern Sweden
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Abstract: Zircons from seven granitoids in eastern Blekinge have been dated using secondary ion mass spectrometry. The analyzed rocks include one Småland granitoid from north of the Småland-Blekinge Deformation Zone (SBDZ), two samples of megacrystic “Filipstad-type” granite from south of that zone and one sample each of the “Småland-type” Rödeby, Almö, Tjurkö and Jämjö granites. The results yield a crystallization age of 1778 ± 5 Ma for the Småland granitoid, and crystallization ages between 1770 ± 4 and 1758 ± 5 Ma for the other granitoids, in most cases substantially older than previous TIMS ages. These data show that the “Småland-type” granitoids in eastern Blekinge are similar in age to the surrounding Tving granitoids, and the more felsic of them may represent late-stage differentiates belonging to the same magmatic suite. As the Tving granitoids show differences both in degree of deformation, in geochemistry and in age, compared to the Småland granitoids north of the SBDZ, it is suggested that these represent two separate but closely related igneous suites, which could both be included within a TIB-1 supersuite. The investigated zircons showed very limited signs of metamorphic overprinting, and no metamorphic ages could be determined. However, the combined evidence from field observations and earlier U–Pb geochronology would suggest the presence of two separate metamorphic episodes in Blekinge, one in close connection with the formation of these rocks at 1.76–1.75 Ga and one connected to the intrusion of the Karlshamn granitoid suite at around 1.45 Ga.

Keywords: U–Pb zircon; SIMS dating; Tving granitoids; Småland granitoids; Blekinge

Introduction
The Proterozoic bedrock of eastern Blekinge in southern Sweden (Fig. 1) is dominated by gneissic tonalites, granodiorites and granites belonging to the Tving granitoid suite, characterized by the presence of 1–2 cm large microcline augen (Kornfält 1999a, 1999b; Kornfält 2002, 2007), which have been dated to 1.77–1.75 Ga both by conventional U–Pb TIMS geochronology on zircon (Johansson & Larsen 1989; Kornfält 1993) and by U–Pb spot dating of zircons using the Nordsim ion microprobe (Johansson et al. 2006). They thus overlap slightly in age with the 1.81–1.76 Ga Småland granitoids, which belong to the Transscandinavian Igneous Belt generation 1 (TIB-1; Högdahl et al. 2004), and outcrop north of the Småland-Blekinge Deformation Zone (SBDZ, Fig. 1; Wiklander 1974; Krauss et al. 1996; Lindh et al. 2001). The Tving granitoids can thus be considered a more deformed variety of the TIB-1 Småland granitoids, although they also differ in composition by being more mafic (granodioritic to adamellite) compared to the more alkali-rich and felsic Småland granitoids (adamellite to granitic; Kornfält 1999a, 1999b; Kornfält & Bruun 2002). The border zone between them, the SBDZ, although appearing as a sharp E–W trending fault zone on most geological maps, in fact is a wide and rather diffuse zone of increased E–W trending schistosity, along which the southern (Blekinge) deformed and metamorphosed block presumably has been uplifted relative to the northern (Småland) less deformed block (Krauss et al. 1996; Kornfält 1993, 1999a; Lindh et al. 2001; Kornfält & Bruun 2002). This uplift occurred after the formation of the Tving and Småland granitoids, i.e. after 1.75 Ga, but before the intrusion of the younger Karlshamn granitoids (1.45 Ga Eringsboda pluton; Kornfält 1999a; Lindh et al. 2001; Kornfält & Bruun 2002). As pointed out by Kornfält (1999a) and Kornfält & Bruun (2002), the SBDZ is not the southern boundary of the Transscandinavian Igneous Belt, since the Tving granitoids and other rocks in Blekinge can be included within it, but it is the northern limit of subsequent penetrative deformation.

Within the area of Tving granitoids in eastern Blekinge (Fig. 1), smaller massifs with granitoids of somewhat deviating character have been distinguished during geological mapping, especially within the well-exposed coastal area and archipelago, and considered to be more direct equivalents of the Småland granitoids north of the SBDZ (Kornfält 1999a, 1999b). Some of these massifs consist of relatively coarse-grained granite with plagioclase-mantled K-feldspar megacrysts, resembling the TIB-1 Filipstad granite in Värmland, and have been referred to as “Småland granite of the Filipstad-type” in the map descriptions (Kornfält 1999a, 1999b). In other places, the granite is strongly deformed and/or more fine-grained, and has been given local names such as Tjurkö granite, Jämjö granite and Almö...
Karlshamn granitoids, or whether they simply reflect analytical scatter caused by the discordancy of the zircons. As these granitoids have been given a special colour and code (88) on the latest geological overview bedrock map of Sweden from SGU (Bergman et al. 2012), and assigned a somewhat younger age (1.7 Ga) in the legend compared to the surrounding Tving granitoid suite (1.7–1.8 Ga), it became of interest to verify their real intrusion age. For that purpose, the original zircon separates used for conventional TIMS dating were recovered from the laboratories involved, zircons were selected by hand-picking, mounted in epoxy and studied under the microscope in transmitted and reflected light and in cathodoluminescence (CL) using a Hitachi scanning electron microscope to see their internal structure, followed by U–Th–Pb isotope analyses of selected spots using the Nordsim Cameca 1280 ion microprobe (SIMS) with procedures as outlined by Whitehouse et al. (1999) and Whitehouse & Kamber (2005), and using the 91500 zircon standard (Wiedenbeck et al. 1995, 2004). Most of the selected spots were in magmatic-looking internal parts of the zircons, in order to determine the crystallization age of these rocks, but in some cases overgrowths of possible metamorphic origin were also analyzed in order to check for metamorphic influence. The results of the individual spot analyses are listed in Table 2, and

![Simplified geological map of eastern Blekinge, based on Kornfält (2007a, 2007b), Kornfält & Bruun (2007), and SGU digital maps, with sample location and obtained weighted average 207Pb/206Pb age for each sample. SBDZ = Småland-Blekinge Deformation Zone.](image-url)

**Fig. 1.** Simplified geological map of eastern Blekinge, based on Kornfält (2007a, 2007b), Kornfält & Bruun (2007), and SGU digital maps, with sample location and obtained weighted average 207Pb/206Pb age for each sample. SBDZ = Småland-Blekinge Deformation Zone.

granite (Kornfält 1999b). On the map (Kornfält 2007b; Fig. 1), these have been grouped together as “leucogranites” belonging to the Småland granitoid suite. A medium-grained variety occurring around Rödeby, and called Rödeby granite, also deviates from the surrounding Tving granitoids in texture and composition (Kornfält 1999a, 2007a).

In connection with the mapping program by the Geological Survey of Sweden (SGU) in Blekinge, several of these smaller granitoid massifs were sampled and subjected to multigrain U–Pb TIMS (thermal ionization mass spectrometry) dating of zircon, either at the Laboratory for Isotope Geology (LIG) of the Swedish Museum of Natural History in Stockholm, or at the laboratory of the Geological Survey of Finland (GTK) in Espoo. The results, published by Kornfält (1993, 1996), in part showed rather large uncertainties due to the high degree of discordancy of many zircon fractions, and scattered between 1.65 and 1.75 Ga (with one sample of Småland granite north of the SBDZ at 1.78 Ga; Table 1). The question thus arose whether the lower ages really reflect a prolonged period of magmatism up to 100 million years younger than the surrounding Tving granitoids and the Småland granitoids north of the SBDZ, whether they reflect partial metamorphic resetting, possibly caused by heating and deformation related to the intrusion of the ca. 1.45 Ga Karlshamn granitoids, or whether they simply reflect analytical scatter caused by the discordancy of the zircons.

As these granitoids have been given a special colour and code (88) on the latest geological overview bedrock map of Sweden from SGU (Bergman et al. 2012), and assigned a somewhat younger age (1.7 Ga) in the legend compared to the surrounding Tving granitoid suite (1.7–1.8 Ga), it became of interest to verify their real intrusion age. For that purpose, the original zircon separates used for conventional TIMS dating were recovered from the laboratories involved, zircons were selected by hand-picking, mounted in epoxy and studied under the microscope in transmitted and reflected light and in cathodoluminescence (CL) using a Hitachi scanning electron microscope to see their internal structure, followed by U–Th–Pb isotope analyses of selected spots using the Nordsim Cameca 1280 ion microprobe (SIMS) with procedures as outlined by Whitehouse et al. (1999) and Whitehouse & Kamber (2005), and using the 91500 zircon standard (Wiedenbeck et al. 1995, 2004). Most of the selected spots were in magmatic-looking internal parts of the zircons, in order to determine the crystallization age of these rocks, but in some cases overgrowths of possible metamorphic origin were also analyzed in order to check for metamorphic influence. The results of the individual spot analyses are listed in Table 2, and
the obtained concordia and weighted average $^{207}\text{Pb}/^{206}\text{Pb}$ ages are listed in Table 1 together with relevant sample information. Images of all analyzed zircons in transmitted light, reflected light and CL, with analytical spots and obtained $^{207}\text{Pb}/^{206}\text{Pb}$ ages, is available as Supplementary material 1–7 (pdf-files). Sample locations are shown in Fig. 1.

Sample descriptions and results

**Sample KK90:100: Småland granite, Falan**

Sample KK90:100 is derived from the large area of Småland granitoids north of the SBDZ, and was taken in a road cut ca 3 km north of the boundary between Tving and Småland granitoids as marked on the map sheet 3F Karlskrona NO (Kornfält 2007a). According to the description by Kornfält (1993), the sampled rock was medium-grained and reddish grey. The purpose of the original dating was to compare the age of the Småland granitoids immediately north of the SBDZ with the 1.77 Ga age of the Småland granite at Falan.

**Sample KK90:102: “Filipstad-type granite”, Torstäva, SW Ramdala**

Sample KK90:102 is a reddish grey, porphyritic gneissic granite, similar to Filipstad granite, according to Kornfält (1993). It was sampled in a road cut at Torstäva 2 km SW of Ramdala church east of Karlskrona, in a ca 5-km wide body distinguished as “Småland granite” on the geological map (3F Karlskrona NO; Kornfält 2007a), and whose central part consists of the porphyritic “Filipstad-like” variety. In the original TIMS dating, three out of four discordant zircon fractions gave a seemingly precise

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**Table 1.** List of investigated samples, their coordinates, earlier obtained U–Pb TIMS ages and newly obtained U–Pb SIMS ages. Preferred ages in bold.

| Sample No. | Rock name | Locality | Map sheet | Latitude longitude | Old TIMS U–Pb age | Lab. | Reference | New SIMS concordia age | New SIMS wt avg $^{207}\text{Pb}/^{206}\text{Pb}$ age |
|------------|-----------|----------|-----------|--------------------|-------------------|------|-----------|------------------------|-----------------------------------------------|
| KK90:100   | “Småland granite” | Falan, 11.5 km NW Rödeby | 3F NO | 56°21′51″N 15°38′45″E | 1778 ± 11 Ma | GTK | Kornfält 1993 | 1776 ± 6 Ma | 1778 ± 5 Ma |
| KK90:102   | “Filipstad-type granite” | Torstäva, 2 km SW Ramdala | 3F NO | 56°10′16″N 15°44′10″E | 1723 ± 4 Ma | GTK | Kornfält 1993 | 1766 ± 6 Ma | 1765 ± 5 Ma |
| KK93:36    | “Filipstad-type granite” | Torp, Senoren | 3F SO | 56°07′04″N 15°45′09″E | 1724 ± 39 Ma | GTK | Kornfält 1996 | 1774 ± 5 Ma | 1766 ± 4 Ma |
| KK93:35    | Rödeby granite | 2 km NW Rödeby | 3F SO | 56°16′39″N 15°35′14″E | 1751 +41/−33 Ma | LIG | Kornfält 1996 | 1768 ± 5 Ma | 1765 ± 3 Ma |
| 89071      | Almö granite | Almö | 3F NO | 56°09′11″N 15°26′30″E | 1716 +108/−90 Ma | LIG | Kornfält 1996 | 1758 ± 6 Ma | 1758 ± 5 Ma |
| KK93:37    | Tjurkö granite | Tjurkö | 3F SO | 56°07′26″N 15°37′01″E | 1658 ± 104 Ma | GTK | Kornfält 1996 | 1763 ± 6 Ma | 1762 ± 5 Ma |
| KK93:38    | Jämjö granite | Gisslevik, 2 km NW Tohmann | 3F SO | 56°06′45″N 15°48′42″E | 1735 ± 56 Ma | GTK | Kornfält 1996 | 1779 ± 5 Ma | 1770 ± 4 Ma |

*Laboratory: GTK = Geological Survey of Finland, Espoo, Finland; LIG = Laboratory for Isotope Geology, Swedish Museum of Natural History, Stockholm, Sweden.
Table 2. U–Pb NORDSIM data from granitoids from eastern Blekinge.

| Sample/spot # | Measured ratios | Concentrations | Calculated ages in million years |
|---------------|-----------------|----------------|----------------------------------|
|               | $^{207}$Pb ±1σ  | $^{206}$Pb ±1σ | $^{235}$U ±1σ | $^{238}$U ±1σ | $^{207}$Pb $^{206}$Pb | $^{207}$Pb $^{206}$U | $^{207}$Pb $^{206}$U |
| n5232-04      | 0.1080 0.48     | 4.6500 1.26  | 0.3124 1.16 | 0.92 | -0.8 {0.01} | 229 110 89 | 0.48 | 1765 9 | 1758 11 1752 18  |
| n5232-05      | 0.1057 0.45     | 4.1969 1.26  | 0.2881 1.18 | 0.94 | -6.1 {0.01} | 347 190 125 | 0.55 | 1726 8 | 1673 10 1632 17  |
| n5232-08      | 0.1070 0.53     | 4.6907 1.27  | 0.3178 1.15 | 0.91 | 1.9 {0.01} | 136 60 53 | 0.44 | 1750 10 | 1766 11 1779 18  |
| n5232-10      | 0.1090 0.54     | 4.7319 1.50  | 0.3147 1.40 | 0.93 | -1.2 {0.01} | 142 49 54 | 0.35 | 1783 10 | 1773 13 1764 22  |
| n5232-12      | 0.1081 0.64     | 4.6047 1.62  | 0.3089 1.48 | 0.92 | -2.1 {0.01} | 149 87 59 | 0.59 | 1768 12 | 1750 14 1735 23  |
| n5232-14      | 0.1082 0.75     | 4.7455 1.42  | 0.3165 1.21 | 0.85 | -0.4 {0.01} | 70 28 27 | 0.40 | 1779 14 | 1752 12 1772 19  |
| n5232-15      | 0.1085 1.01     | 4.6516 1.78  | 0.3108 1.46 | 0.82 | -1.9 {0.09} | 38 21 15 | 0.55 | 1775 18 | 1759 15 1745 22  |
| n5232-17      | 0.1081 0.32     | 4.7740 1.14  | 0.3023 1.09 | 0.96 | 1.5 {0.01} | 366 194 148 | 0.53 | 1768 6 | 1780 10 1791 17  |
| n5232-18      | 0.1096 0.58     | 4.7143 1.40  | 0.3119 1.27 | 0.91 | -2.8 {0.00} | 131 65 51 | 0.50 | 1793 11 | 1770 12 1750 20  |
| n5232-23      | 0.1076 0.47     | 4.7172 1.12  | 0.3179 1.05 | 0.94 | 1.3 {0.00} | 250 130 100 | 0.52 | 1760 7 | 1770 9 1779 16  |
| n5232-25      | 0.1081 0.40     | 4.7706 1.41  | 0.3201 1.35 | 0.96 | 1.5 {0.00} | 252 145 102 | 0.58 | 1767 7 | 1780 12 1790 21  |
| n5232-30      | 0.1075 0.32     | 4.6767 1.19  | 0.3157 1.15 | 0.96 | 0.8 {0.04} | 413 189 161 | 0.46 | 1757 6 | 1763 10 1769 18  |
| n5232-34      | 0.1079 0.55     | 4.7138 1.27  | 0.3169 1.15 | 0.90 | 0.7 {0.00} | 130 62 51 | 0.48 | 1764 10 | 1770 11 1775 18  |
| n5232-40      | 0.1077 0.38     | 4.7091 1.17  | 0.3171 1.11 | 0.95 | 0.9 {0.01} | 279 142 111 | 0.51 | 1761 7 | 1767 9 1775 17  |
| n5232-41      | 0.1079 0.53     | 4.6917 1.37  | 0.3153 1.26 | 0.92 | 0.1 {0.00} | 148 71 58 | 0.48 | 1765 10 | 1766 12 1767 20  |
| n5232-42      | 0.1078 0.80     | 4.6859 1.34  | 0.3151 1.08 | 0.80 | 0.2 {0.00} | 105 45 41 | 0.43 | 1763 15 | 1765 11 1766 17  |
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| Sample | U-Pb Age (Ma) | Pb Isotopic Composition | Pb/Cd Ratio | Pb/U Ratio | U Content (ppm) | U/Pb Ratio | Pb Isotope Composition | Mean Error of Measurement | Pb/Cd Ratio | Pb/U Ratio | U Content (ppm) | U/Pb Ratio |
|--------|---------------|-------------------------|-------------|------------|-----------------|------------|------------------------|---------------------------|-------------|------------|-----------------|------------|
| KK93:36 | 434           | 0.1078                  | 0.0376      | 0.3217     | 0.1078          | 0.0376     | 0.0376                 | 0.001          | 0.0376      | 0.0376    | 0.0376          | 0.0376     |
| KK93:37 | 434           | 0.1081                  | 0.0376      | 0.3217     | 0.1081          | 0.0376     | 0.0376                 | 0.001          | 0.0376      | 0.0376    | 0.0376          | 0.0376     |
| KK93:38 | 434           | 0.1083                  | 0.0376      | 0.3217     | 0.1083          | 0.0376     | 0.0376                 | 0.001          | 0.0376      | 0.0376    | 0.0376          | 0.0376     |
| KK93:39 | 434           | 0.1084                  | 0.0376      | 0.3217     | 0.1084          | 0.0376     | 0.0376                 | 0.001          | 0.0376      | 0.0376    | 0.0376          | 0.0376     |
| KK93:40 | 434           | 0.1086                  | 0.0376      | 0.3217     | 0.1086          | 0.0376     | 0.0376                 | 0.001          | 0.0376      | 0.0376    | 0.0376          | 0.0376     |

(Continued)
| Sample/spot # | 206Pb % | 235U % | 238U % | corr. ppm | ppm 206Pb | ppm 235U | ppm 238U |
|--------------|----------|--------|--------|-----------|-----------|-----------|-----------|
| n5234-27a    | 0.1073   | 0.30   | 4.56   | 1.09      | 0.31      | 0.31      |
| n5234-28     | 0.1068   | 0.46   | 4.52   | 1.25      | 0.31      | 0.31      |
| n5234-31     | 0.1067   | 0.34   | 4.75   | 1.12      | 0.37      | 0.37      |
| n5234-37b    | 0.1080   | 0.47   | 4.53   | 1.31      | 0.37      | 0.37      |
| n5234-42     | 0.1088   | 0.45   | 4.76   | 1.24      | 0.31      | 0.31      |
| n5234-43     | 0.1062   | 0.59   | 4.32   | 1.34      | 0.31      | 0.31      |
| n5234-47b    | 0.1068   | 0.61   | 4.72   | 1.50      | 0.32      | 0.32      |
| n5234-52     | 0.1089   | 0.61   | 4.70   | 1.45      | 0.31      | 0.31      |

Continued
| Sample Code  | U/Th (ppm) | Rb/Sr (ppm) | Sr (ppm) | Sm (ppm) | Nd (ppm) | Sm/Nd | Sm/Rb | Eu/Eu* | Sm/La* |
|-------------|------------|-------------|----------|----------|----------|-------|-------|--------|--------|
| n5236-02    | 0.1077     | 0.45        | 4.7133   | 0.3173   | 1.19     | 0.94  | 0.9   | [0.00] | 150    |
| n5236-04    | 0.1074     | 0.98        | 4.7357   | 0.3199   | 1.42     | 0.82  | 2.2   | [0.00] | 41     |
| n5236-05    | 0.1081     | 0.21        | 4.6036   | 0.3090   | 1.08     | 0.98  | -2.0  | 0.01   | 669    |
| n5236-06a   | 0.1068     | 0.51        | 4.4191   | 0.3001   | 1.13     | 0.91  | -3.5  | 0.05   | 127    |
| n5236-06b   | 0.0983     | 0.33        | 2.6269   | 0.1938   | 1.73     | 0.98  | -30.9 | 0.23   | 1018   |
| n5236-07    | 0.1078     | 0.59        | 4.7141   | 0.3173   | 1.10     | 0.88  | 0.9   | 0.11   | 147    |
| n5236-12    | 0.1087     | 0.60        | 4.8121   | 0.1074   | 0.98     | 4.7357 | 0.3199 | 1.42   | 0.82   |
| n5236-13    | 0.1078     | 0.50        | 4.7794   | 0.3214   | 1.17     | 0.92  | 2.2   | [0.01] | 125    |
| n5236-18    | 0.1072     | 0.53        | 4.6123   | 0.3121   | 1.22     | 0.92  | 0.0   | 0.09   | 151    |
| n5236-23    | 0.1023     | 0.72        | 3.9294   | 0.2786   | 5.86     | 0.99  | -5.6  | 0.56   | 614    |
| n5236-28    | 0.1049     | 2.75        | 3.6495   | 0.2524   | 1.29     | 0.43  | -17.0 | 0.25   | 1427   |
| n5236-31    | 0.1049     | 0.34        | 2.3934   | 0.1656   | 1.17     | 0.96  | -45.6 | 0.15   | 583    |
| n5236-36a   | 0.1077     | 0.41        | 4.6087   | 0.3103   | 1.32     | 0.96  | -1.2  | 0.03   | 206    |
| n5236-36b   | 0.1071     | 0.28        | 4.5526   | 0.3083   | 1.29     | 0.98  | -1.2  | 0.04   | 775    |
| n5236-38    | 0.1073     | 0.52        | 4.6624   | 0.3150   | 1.31     | 0.93  | 0.7   | [0.01] | 171    |
| n5236-39    | 0.0886     | 2.73        | 1.6478   | 0.1349   | 8.47     | 0.95  | -44.2 | 0.25   | 1427   |
| n5236-44a   | 0.1083     | 0.52        | 4.7686   | 0.3194   | 1.09     | 0.90  | 1.0   | [0.01] | 119    |
| n5236-44b   | 0.0765     | 1.05        | 0.8415   | 0.0797   | 1.22     | 0.76  | -57.5 | 3.46   | 268    |
| n5236-44b   | 0.0765     | 1.05        | 0.8415   | 0.0797   | 1.22     | 0.76  | -57.5 | 3.46   | 268    |

**Continued**
Table 2. (Continued)

| Sample/spot # | Measured ratios a | Concentrations | Calculated ages in million years |
|---------------|-------------------|----------------|----------------------------------|
|               | $^{207}\text{Pb}$ | $^{206}\text{Pb}$ | $^{235}\text{U}$ | $^{238}\text{U}$ | corr. ppm | meas $^{206}\text{Pb}$ | $^{207}\text{Pb}$ | $^{208}\text{Pb}$ | $^{235}\text{U}$ | $^{238}\text{U}$ | meas $^{208}\text{U}$ | $^{207}\text{Pb}$ | $^{208}\text{Pb}$ | $^{235}\text{U}$ | $^{238}\text{U}$ |
| n5237-40      | 0.1066            | 0.52            | 4.5412          | 1.23          | 0.3088     | 1.12          | 0.91            | -0.5          | 0.43          | 167         | 98         | 66         | 0.59          | 1743          | 9           | 1739          | 10           | 1735          | 17          |
| n5237-42      | 0.1077            | 0.50            | 4.7706          | 1.33          | 0.3212     | 1.23          | 0.93            | 2.3          | (0.01)        | 123         | 87         | 52         | 0.71          | 1761          | 9           | 1780          | 11           | 1796          | 19          |
| n5237-43      | 0.1090            | 0.54            | 4.7972          | 1.29          | 0.3191     | 1.17          | 0.91            | 0.1          | (0.00)        | 167         | 90         | 67         | 0.54          | 1783          | 10          | 1784          | 11           | 1785          | 18          |
| n5237-45      | 0.1075            | 0.62            | 4.7167          | 1.40          | 0.3183     | 1.26          | 0.90            | 1.6          | (0.00)        | 82          | 63         | 35         | 0.77          | 1757          | 11          | 1770          | 12           | 1781          | 20          |
| n5237-46      | 0.1085            | 0.58            | 4.7554          | 1.20          | 0.3179     | 1.05          | 0.88            | 0.3          | (0.00)        | 117         | 101        | 50         | 0.87          | 1774          | 10          | 1777          | 10           | 1779          | 16          |
| n5237-50      | 0.1083            | 0.68            | 4.8238          | 1.44          | 0.3232     | 1.27          | 0.88            | 2.3          | (0.02)        | 67          | 45         | 28         | 0.67          | 1770          | 12          | 1789          | 12           | 1805          | 20          |
| n5237-52      | 0.1081            | 0.42            | 4.8367          | 1.42          | 0.3244     | 1.35          | 0.95            | 2.8          | (0.01)        | 169         | 202        | 80         | 1.19          | 1768          | 8           | 1791          | 12           | 1811          | 21          |
| n5237-54      | 0.1084            | 0.39            | 4.9255          | 1.36          | 0.3297     | 1.30          | 0.96            | 4.2          | (0.00)        | 197         | 152        | 86         | 0.77          | 1772          | 7           | 1807          | 12           | 1837          | 21          |
| n5237-55      | 0.1077            | 0.38            | 4.7705          | 1.15          | 0.3211     | 1.09          | 0.95            | 2.2          | (0.01)        | 215         | 124        | 88         | 0.58          | 1762          | 7           | 1780          | 10           | 1795          | 17          |

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a Measured ratios corrected for present-day common lead according to Stacey & Kramers (1975) model: $^{206}\text{Pb}/^{204}\text{Pb} = 18.703$, $^{207}\text{Pb}/^{204}\text{Pb} = 15.629$, $^{208}\text{Pb}/^{204}\text{Pb} = 38.631$.

b Error correlation $^{207}\text{Pb}/^{235}\text{U} - ^{206}\text{Pb}/^{238}\text{U}$.

c Percent discordance; negative value = normal discordant; positive value = reverse discordant.

d Fraction of $^{206}\text{Pb}$ derived from common lead. Figures in brackets: no correction applied.

e Th/U ratio directly from measured Th and U concentrations.
Fig. 2. Concordia diagrams of the analyzed samples, with insets showing enlargements of the concordant points yielding the magmatic crystallization age. Error ellipses are 1σ, dashed ellipses with numbers (from Table 2) have been excluded from calculation, the thick grey ellipse in each diagram shows the concordia age with 2σ uncertainty.
Fig. 3. Left column: Th/U-ratio versus $^{207}$Pb/$^{206}$Pb age for the analyses from each sample. Insets in lower left part of diagrams show highly discordant points. Right column: Logarithmic Th versus U diagrams for the analyses from each sample, with correlation coefficient (r). For the Rödeby granite, two different correlation coefficients are given, depending on exclusion of data points, as outlined in the main text. Filled circles are concordant or semi-concordant points included in the age calculations, unfilled circles are discordant points excluded from age calculations.
upper intercept age of 1723 ± 4 Ma (Kornfält 1993), somewhat younger than the typical age range for both Tving and Småland granitoids, but the geological significance of this age remained obscure. Kornfält (1993) suggested that the result may be due to deformation and migmatization of this rock.

The handpicked zircons from this sample were prismatic and relatively clear with a magmatic appearance, having CL-bright and/or CL-zoned interiors and no obvious signs of any metamorphic overgrowths (Supplementary material 2). Sixteen spots in 16 zircons were analyzed, out of which one (zr05) was −6% discordant while the remaining 15 form a concordant cluster with a concordia age of 1766 ± 6 Ma (2σ, MSWD 0.28) and a weighted average 207Pb/206Pb age of 1765 ± 5 Ma (2σ, MSWD 1.3; Table 1, Fig. 2B), taken to indicate magmatic crystallization. The data points show a relatively narrow range of Th/U-ratios between 0.35 and 0.59 (Table 2), with the Th and U concentrations falling on a well-defined linear trend with a correlation coefficient of 0.98, presumed to have originated by magmatic differentiation (Fig. 3B). In spite of the metamorphic character of this rock, no metamorphic overprinting in the zircons that could explain the lowering of the conventional TIMS age could be discerned.

The obtained 1765 Ma age is similar to U–Pb TIMS and SIMS ages of the surrounding Tving granitoids (Johansson & Larsen 1989; Kornfält 1993; Johansson et al. 2006), and within the lower end of the 1.81–1.76 Ga age range typical for TIB-Larsen 1989; Kornfält 1993; Johansson et al. 2006), and within SIMS ages of the surrounding Tving granitoids (Johansson & Larsson 2007a, 2007b), would suggest that they belong to the same intrusive complex.

Sample KK93:36: “Filipstad-type granite”, Torp, Senoren

Sample KK93:36 is a reddish grey, medium-grained, porphyritic, weakly migmatized granite similar to the TIB-1 Filipstad granite in Värmland, sampled in a road cut at Torp on the island of Senoren east of Karlskrona (Table 1, Fig. 1; Kornfält 1996). Both the K-feldspar megacrysts and the matrix minerals have been affected by deformation, and the former are sometimes elongated into cm-wide red bands, alternating with black bands of biotite and amphibole (Kornfält 1996). Four discordant zircon fractions yielded an upper intercept age of 1724 ± 39 Ma by conventional TIMS dating (Table 1; Kornfält 1996), almost identical to the TIMS result from the “Filipstad-type granite” at Torstāva (1723 ± 4 Ma; Kornfält 1993).

The zircons from sample KK93:36 are similar to those from the Torstāva sample (KK90:102): relatively clear and prismatic with a magmatic appearance, ranging from bright to grey and zoned in CL, without any obvious metamorphic rims (Supplementary material 3). Twenty-three spots from 23 zircons were analyzed, all of which are concordant within error (Table 2, Fig. 2C). Excluding the somewhat deviating point 6, a concordia age of 1774 ± 5 Ma (2σ, MSWD 11.7) and a weighted average 207Pb/206Pb age of 1766 ± 4 Ma (2σ, MSWD 1.3; Table 1, Fig. 2C) are obtained. The high MSWD value of the concordia age calculation is caused by a tendency for most points to plot with a slight reverse discordance, which will increase the 235U/207Pb and 238U/206Pb ages as well as the overall concordia age and cause the latter not to overlap with the concordia curve. In view of this, the weighted average 207Pb/206Pb age of 1766 ± 4 Ma is considered the best estimate of the crystallization age of this rock. This age is identical to the new SIMS age of the “Filipstad-type granite” at Torstāva, ca 6 km north of Torp at Senoren, but substantially older than the previous ca 1724 Ma TIMS ages of these samples.

The zircons from the Torp sample also show a similar, rather narrow range in Th/U-ratios of 0.36–0.62 as the Torstāva zircons (0.35–0.59), following a well-defined linear trend with r = 0.97 (Table 2, Fig. 3C). The slightly deviating zircon 06 (with a 207Pb/206Pb age of 1735 Ma) stands out with its markedly lower Th and U concentrations (10 and 25 ppm, respectively), but has a similar Th/U-ratio (0.41) as the others. The similarity, not only in age but also in appearance and Th/U-ratio of the zircons of these two samples, together with the map pattern (Kornfält 2007a, 2007b), would suggest that they belong to the same intrusive complex.

Sample KK93:35: Rödeby granite, NW Rödeby

The Rödeby granite is an elongated 5 × 2 km large body of medium-grained, largely isotropic, reddish grey granite with red but not very clearly defined K-feldspar megacrysts, surrounded by Tving granitoids (Kornfält 1996, 1999a). Its composition is granitic, and more silicic than most Tving or Småland granitoids (71.6–73.8 wt% SiO2, n = 8, Table 12 in Kornfält 1999a). The contacts to the surrounding Tving granitoid are mostly diffuse, but a xenolith of Tving granitoid has been observed in the Rödeby granite (Kornfält 1999a, Fig. 17), suggesting that the Rödeby granite is younger than and intrusive into the Tving granitoid suite.

Sample KK93:35 is from a road cut 2 km NW of the village of Rödeby. The conventional TIMS dating of four fractions of zircon from this sample yielded a discordia with an imprecise upper intercept age of 1751 +41/−33 Ma (Kornfält 1996), similar or slightly younger than the surrounding Tving granitoid suite.

The handpicked zircons are mostly relatively clear and of good quality, with magmatic appearance and interiors ranging from CL-bright through CL-zoned to CL-grey. In a few cases (e.g. zr10, 17, 18, 22, 37, 38; Supplementary material 4), CL-dark or CL-zoned rims that could be of metamorphic origin were encountered. Those that were analyzed appeared, however, to have similar age as the underlying magmatic zircon, with the possible exception of point 18b. The latter point is highly U-rich (5590 ppm), with low Th/U (0.11) and is highly discordant plotting close to an age of 400 Ma on the concordia.

Thirty-two spots in 26 zircons were analyzed (Table 2). Out of these, 22 spots form a tight cluster yielding a concordia age of 1768 ± 5 Ma (2σ, MSWD 1.5) and a weighted average 207Pb/206Pb age of 1765 ± 3 Ma (2σ, MSWD 0.90; Table 1, Fig. 2D), taken as the magmatic crystallization age. In addition to point 18b, nine points are −6% to −32% discordant, apparently due to recent Pb loss. Most of the points, whether concordant or discordant, have Th/U-ratios between 0.40 and 1.0 (Table 2, Fig. 3D). However, there are some outliers, and the overall correlation coefficient between Th and U is only 0.75 (spot 18b excluded). Zircon spot 45 has a Th/U-ratio of 1.17, while, apart from 18b, also 03b and 06 have low Th/U-ratios of 0.20 and 0.06, respectively. The latter two spots, however, give discordant ages in the same range as the other spots (207Pb/206Pb ages of 1768 and 1765 Ma, respectively). CL observations, however, show that these two spots are located in CL-dark and homogeneous parts of each crystal (Table 2; Supplementary material 4), suggesting that these areas may have undergone some recrystallization, apparently lowering their Th contents, but this recrystallization presumably occurred
shortly after these two zircons had formed and a separate age cannot be determined. Zircon 11 is a very clear CL-bright crystal which is the lowest in Th (21 ppm) and U (41 ppm), but with a “normal” Th/U-ratio of 0.50. Excluding the deviating points 03b, 06 and 45 (as well as 18b) improves the Th–U correlation to 0.93 (Fig. 3D).

The obtained weighted average 207Pb/206Pb age of 1765 ± 3 Ma is slightly older than the previously obtained upper intercept TIMS age of 1751 + 41/-33 Ma (Kornfält 1996), although within error the same, and indistinguishable from that of the surrounding Tving granitoids. This would suggest that the Rödeby granite formed in close connection with the Tving granitoids, although locally showing an intrusive relationship as exemplified by the Tving granitoid xenolith. A possible metamorphic overprinting is hinted on by point 18b, but no age could be determined from this overgrowth due to its extremely U-rich, metamict and highly discordant nature.

**Sample 89071: Almö granite, Almö**
The Almö granite forms a massif of red to reddish grey, fine- to medium-grained, leucocratic and gneissic or foliated granite on the island of Almö, which straddles the boundary between map sheets 3F NO and 3F SO west of Karlskrona (Kornfält 2007a, 2007b). It contains xenoliths of the so-called “coastal gneiss” (see Fig. 24 in Kornfält 1999b), a grey fine-grained rock that may be of volcanic or subvolcanic origin. Sample 89071 is from a small abandoned quarry on the northern part of Almö island and is finely medium-grained, red to greyish red and foliated (Kornfält 1996).

Conventional TIMS dating of four zircon fractions yielded a discordia with an ill-defined upper intercept age at 1716 +105/–59 Ma (Kornfält 1996; Table 1). In addition, Kornfält (1996) reported the result from the U–Pb analysis of two titanite fractions, which yielded an upper intercept age of 1471 +153/–59 Ma, suggesting some metamorphic overprinting related to the intrusion of the large nearby ca 1.45 Ga Karlskarn granite massif.

Handpicked zircons from sample 89071 were relatively turbid and fractured and thus not of very good quality. Although dominated by CL-grey or CL-zoned interiors of magmatic appearance, many grains contained CL-dark outer rims that potentially could be of metamorphic origin (Supplementary material 5). Twenty-two spots in 19 zircon crystals were analyzed (Table 2). Out of these, 11 points form a concordant cluster with a concordia age of 1758 ± 5 Ma (2σ, MSWD 1.04; Table 1, Fig. 2E), one point (zr22) is 7% reversely discordant and the remaining ten points are −4% to −66% discordant. Most of the points, whether concordant or discordant, show rather moderate U concentrations in a narrow range between 100 and 300 ppm, with only a few points at higher concentrations, and with relatively high Th/U-ratios between 0.48 and 1.00 (Table 2, Fig. 3E left) and a Th–U correlation coefficient of 0.94 (Fig. 3E right, point 20b excluded). Both texturally and from their Th/U-characteristics most of the discordant points appear to be normal magmatic zircon that have lost radiogenic Pb. This also includes the potential overgrowth spots 19b and 38b. Only the most discordant point, 20b, which texturally appears to be from a CL-dark overgrowth cutting across the older zircon, shows a very high U content (4930 ppm) and low Th/U-ratio (0.04) suggestive of a metamorphic origin, but unfortunately no reliable age can be obtained from that spot.

The 1758 ± 5 Ma age is considered the magmatic crystallization age of the Almö granite. It is thus similar in age to the Tving and other older Blekinge granitoids, or only marginally younger. There are some signs of metamorphic overprinting, both in the rock itself and the zircons, but no metamorphic age could be obtained.

**Sample KK93:37: Tjurkö granite, Tjurkö**
Sample KK93:37 comes from a large abandoned quarry on the island of Tjurkö in the archipelago outside Karlskrona, and is a greyish red, medium-grained, foliated, leucocratic granite (Kornfält 1996). Similar reddish and felsic, leucocratic and strongly foliated granite occurs over much of the neighbouring islands of Tjurkö and Sturkö, and is considered a more deformed and foliated variety of the “Filipstad-type granite” on Senoren (Kornfält 1999b).

However, there is also a compositional difference, with the “Filipstad-type granite” containing 67.9–70.7 wt% SiO₂ (n = 4) and 2–8 vol% biotite (n = 6), compared to 76.3–78.7 wt% SiO₂ (n = 5) and maximum 2 vol% biotite (n = 6) for the Tjurkö granite (Tables 7–10 in Kornfält 1999b). The foliation in this area may be related to the Karlskrona Deformation Zone, a ca 20 km wide NW-trending ductile deformation zone inferred from aeromagnetic maps (cf. Johansson et al. 2006). In the conventional TIMS analysis, the four zircon fractions analyzed plotted very discordantly due to high U contents (1100–2200 ppm), and yielded a very uncertain upper intercept age of 1658 ± 104 Ma (Table 1; Kornfält 1996).

The handpicked zircons from sample KK93:37 are mostly relatively turbid and fractured, but with good magmatic zonation. A few clear grains also occur, e.g. zr02, 04, 12, 13 (Table 2, Supplementary material 6). In CL, they range from bright to dominantly grey and zoned, with little or no signs of metamorphic overgrowths. During the SIMS analysis, 18 spots in 15 zircons were analyzed. Eleven of these spots form a concordant cluster with a concordia age of 1763 ± 6 Ma (2σ, MSWD 0.88) and a weighted average 207Pb/206Pb age of 1762 ± 5 Ma (2σ, MSWD 1.2; Table 1, Fig. 2F), which is considered the crystallization age of the undeformed protolith of the Tjurkö granite. The remaining points are mostly from more turbid zircon, and are −3% to −58% discordant, evidently due to fairly recent Pb loss, in part through cracks.

Th/U-ratios range between 0.24 and 0.78, with a substantial range both in Th (26–954 ppm) and U (41–2586 ppm), but still following a rough common linear trend with r = 0.96, and with the most U- and Th-rich points being discordant (Fig. 3F). This pattern suggest that they are late-stage magmatic differentiates, rather than metamorphic overgrowths which would be high in U but low in Th.

**Sample KK93:38: Jämjö granite, Gisslevik, NW Torhamn**
The Jämjö granite is a fine- to medium-grained, mostly reddish, strongly foliated and leucocratic granite occurring on the Torhamn peninsula in southeasternmost Blekinge (map sheet 3F Karlskrona SO; Kornfält 1999b, 2007b). Sample KK93:38, collected from a large abandoned quarry at Gisslevik 2.2 km NW of Torhamn, is a fine medium-grained, red granite with a weak structure outlined by thin streaks of mafic minerals (Kornfält 1996). Kornfält (1999b) regards the Jämjö granite as an even more intensely deformed variety of the “Filipstad-type granite” than the Tjurkö granite, with highly attenuated K-feldspar megacrysts. As the Tjurkö granite, it is highly silicic (75.8–
Conventional TIMS dating of four zircon fractions from sample KK93:38 gave an uncertain upper intercept age of 1735 ± 56 Ma for the Jämjö granite (Kornfält 1996).

As in the Almö and Tjurkö granites, the zircons in the Jämjö granite sample are relatively turbid, fractured and rounded in their morphology, although some relatively clear crystals could be selected during handpicking. In CL, they range from bright to grey, and from zoned to having more irregular and patchy interiors, still without any visible metamorphic overgrowths. In several cases, the pattern goes from CL-grey and even in the centre, to CL-bright and zoned in the outer part (e.g. zr07, 17, 50, 52), i.e. a reverse magmatic zonation with apparent lowering of the Th and U concentrations, perhaps due to magma replenishment (Table 2, Supplementary material 7).

Twenty-five spots from 25 zircons were analyzed (Table 2). The results are somewhat complex. Eighteen of these points form a cluster with a slight reverse discordancy, yielding a concordia age of 1779 ± 5 Ma (2σ, MSWD 16) and a weighted average 207Pb/206Pb age of 1770 ± 4 Ma (2σ, MSWD 0.73; Table 1, Fig. 2G). Two points (zr10 and 54) show a greater degree of reverse discordancy and were excluded from this calculation. Four points (zr06, 13, 14, 40) form an additional semi-concordant cluster with a slight normal discordancy, while a fifth point is −11.9% normal discordant. Considering the high MSWD value of the concordia age, caused by the slight reverse discordancy of the analyses within the main 18-point cluster, the weighted average 207Pb/206Pb age of 1770 ± 4 Ma is considered the best estimate for the crystallization age for the protolith of the Jämjö granite. The subsequent deformation, with development of foliation and subsequent folding, has not left any obvious imprint on the zircons.

The analyzed Jämjö granite zircons of sample KK93:38 show unusually high Th/U-ratios between 0.49 and 1.19, but still following a common magmatic differentiation trend with \( r = 0.91 \) (Fig. 3G). Given the limited amounts of discordancy, there are no systematic differences in Th and U contents between the “concordant” group of 18 points, and the points deviating in either direction in their discordancy. The differences in Th–U systematics between the zircons in the Jämjö and Tjurkö granite, compared to those in the “Filipstad-type granites” at Torstäva and Torp, however would suggest that the Jämjö and Tjurkö granites are not more foliated direct counterparts of the latter. The more silica-rich composition of the Tjurkö and Jämjö granites compared to the “Filipstad-type granites” would also argue against such an interpretation. Rather, the Jämjö and Tjurkö granites could be late-stage more felsic differentiates from the same magma as the “Filipstad-type granite”, belonging to the same plutonic complex and within error having the same age, but being more susceptible to subsequent deformation.

Discussion and conclusions

Relation between the Småland and Tving granitoids

The new SIMS weighted average 207Pb/206Pb age of 1778 ± 5 Ma for Småland granite sample KK90:100, taken only 3 km north of the Småland-Blekinge Deformation Zone, confirms the previously obtained TIMS age. This age is somewhat older than SIMS ages of Småland granitoids in the whole Småland lithotectonic unit north of the SBDZ, from the SGU website [http://apps.sgu.se/kartvisare/kartvisare-bergets-alder-sv.html](http://apps.sgu.se/kartvisare/kartvisare-bergets-alder-sv.html), most of which are significantly older than the Tving granitoids and the other Blekinge rock units.

76.3 wt% SiO₂, \( n = 4 \), Table 12 in Kornfält 1999b) and low in mafic minerals. The strong deformation may be attributed to its position within the ductile NW-trending Karlskrona Deformation Zone. The more coarse-grained and megacrystic “Filipstad-like” granitoids at Torstäva and Torp would then represent somewhat less felsic, more competent and well-preserved lenses within this deformation zone, which encompasses the whole coastal area in southeastern Blekinge. As pointed out by Kornfält (1999b), the foliation in the Jämjö granite has undergone subsequent ductile folding (see Fig. 20 in Kornfält 1999b).

Fig. 4. Summary and comparison of weighted average 207Pb/206Pb SIMS ages of zircons from Blekinge rocks, illustrating the similarity in age of the “Filipstad-type granites” and leucogranites in eastern Blekinge dated here with the surrounding Tving granitoids and other Blekinge rocks (except for the older Nättraby gneissic granite) dated by Johansson et al. (2006), as well as the slightly older age of the Småland granite at Falan north of the Småland-Blekinge Deformation Zone. Grey error bars show 2σ uncertainty of each age. Shown on top is a compilation of 24 published U–Pb zircon TIMS and SIMS ages of Småland granitoids in the whole Småland lithotectonic unit north of the SBDZ, from the SGU website [http://apps.sgu.se/kartvisare/kartvisare-bergets-alder-sv.html](http://apps.sgu.se/kartvisare/kartvisare-bergets-alder-sv.html), most of which are significantly older than the Tving granitoids and the other Blekinge rock units.
The age of the “Småland-type” granitoids in Blekinge and their relation to the Tving granitoids

The granitoids from eastern Blekinge dated here by SIMS have been considered by Kornfält (1993, 1996, 1999a, 1999b) to be Småland granitoids enclosed within the large Tving granitoid area in eastern Blekinge south of the SBDZ, whether being megacrystic “Filipstad-type” granitoids or medium- to fine-grained, more or less foliated leucogranites. The new age data show them to be coeval with the surrounding Tving granitoids (Fig. 4). Although they locally may show an intrusive relationship to the Tving granitoid (block of Tving granitoid within the Rödeby granite), the age difference is probably minor. These granitoids, and especially the more felsic and leucocratic ones, could possibly be late-stage differentiates from the Tving granitoid suite, which locally have undergone strong deformation within the Kullerön crustal block (Kornfält 1999b, 2002). These could possibly be late-stage differentiates from the Tving granitoid suite, which locally have undergone strong deformation within the Kullerön crustal block (Kornfält 1999b, 2002).

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No potential conflict of interest was reported by the author.

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