SVECONORWEGIAN MAGMATISM

Granitic Magmatism

The magmatic rocks investigated in this study have comparatively simple zircon U–Pb systematics, and are not described on a sampe-by-sample basis. The relevant data are presented in Electronic Supplement C, and as Tera–Wasserburg plots in Figs. ES–B.1 and ES–B.2. The dated zircons are typically prismatic and oscillatory zoned, supporting an igneous origin. In some cases, analytical outliers have been excluded by us or by Isoplot; these analyses have been indicated both in Electronic Supplement C and in the Tera–Wasserburg plots.

Sample VAG084396 is a deformed and metamorphosed SMB granite, cut by and undeformed and non-metamorphosed SMB granite (sample VAG084399). These samples have been described in detail in the section 'Metamorphism In Geographical Proximity To The SMB'.

Seventeen samples from SMB granites dated in this study yield ages between 1057 ± 14 Ma (two samples) and1014 ± 8 Ma. This range of ages matches that defined by Slagstad et al. (2013) and Coint et al. (2015), but extends it to somewhat younger ages.

Fifteen samples from ferroan hornblende-biotite granites dated in this study yield ages between 1000 ±8 Ma and 922 ± 7 Ma, again matching the age range from previous studes, but extending it to somewhat older ages.

Mafic Magmatism

Sample FLAAT089953, Ni-Mineralized Diorite, Flåt In Setesdalen

The sample displays a medium-grained equigranular texture (Fig. 4D, main text). Subhedral and elongate laths of plagioclase are surrounded by aggregates of secondary pale-green to green amphibole and biotite. Pale-green amphibole is restricted to the centre of the aggregates, whereas darker green amphibole forms the rims. Euhedral apatite is abundant. Anhedral to interstitial opaque minerals display jagged edges and comprise ilmenite, pyrite, chalcopyrite and pentlandite.

The zircons from sample FLAAT089953 are typically ca. 100 µm in size, irregular and display oscillatory zoning (Fig. ES–B.3A). Twelve LA–ICP–MS analyses yield concordant to slightly reversely discordant data, suggesting some U–Pb elemental fractionation unaccounted for in the normalization, U loss, or Pb gain (Fig. ES–B.4A). The analyses yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1025 ±13 Ma (MSWD=0.58; Fig. ES–B.4B), interpreted as the crystallization age of the dioritic magma.

Sample IH128058, Diorite, Kvås–Konsmo Area

This sample was taken from a medium-grained, homogeneous diorite (Fig. 4E main text) in a road cut between Kvås and Konsmo, that is surrounded by porphyritic granites of the SMB. Biotite, hornblende, plagioclase and orthopyroxene are the main rock-forming minerals. Hornblende, orthopyroxene and biotite together constitute approximately 50% of the rock, along with ca. 40% plagioclase. Zircon, apatite and opaque minerals are present as accessory phases.

The zircons from this sample are prismatic, ca. 100–200 µm long, and display grain-parallel, patchy CL zonation that may result from alteration along cracks (Fig. ES–B.3B). Twelve zircon crystals were dated from this sample and yield ca. 6% discordant to 7% reversely discordant data (Fig. ES–B.4C), with a weighted mean $^{207}Pb/^{206}Pb$ age of 990 ± 12 Ma (MSWD = 0.47; Fig. ES–B.4D). This age is interpreted to represent the crystallization age of the diorite.

Sample VAG084397 is from a quartz-dioritic migmatitic gneiss, with a protolith age similar to the SMB granites. This sample is described in the section 'Metamorphism In Geographical Proximity To The SMB'.

Anorthosite And Fayalite Granite

Sample OPX033146, High-Al Orthopyroxene Megacryst, Egersund–Ogna Anorthosite

Polycrystalline, high-Al orthopyroxene megacrysts are ubiquitous in Proterozoic anorthosite massifs and this sample represents a typical example of such an occurrence (Fig. 4C, main text). Individual orthopyroxene megacrysts range from 10 to 20 cm in length, are variably oriented and hosted by coarse-grained to pegmatitic anorthosite (*sensu lato*). Plagioclase lamellae are observed in most of the orthopyroxene megacrysts at this locality, and several of the orthopyroxene megacrysts are embayed by large, lath-like plagioclase crystals. Protrusions and veins of plagioclase into and between megacrysts are notable and could potentially provide sites for late-magmatic zircon crystallization. Alternatively, the zircon may have formed as a decompression exsolution product along with plagioclase and Fe–Ti oxide phases, or simply as inclusions within the orthopyroxene megacrysts (see below for further discussion).

The zircon grains from sample OPX033146, a single, ca. 15 cm-large orthopyroxene megacrysts, are between 50 μm and 200 μm long, stubby and generally oscillatory zoned (Fig. ES–B.5A). Ten SIMS (SHRIMP II) analyses from 10 zircons correlate with common Pb (R^2 = 0.78), and a discordia line, anchored in a $^{207}Pb/^{206}Pb$ composition of 0.93, yields a lower intercept of 941 ± 14 Ma (MSWD = 1.8; Fig. ES–B.6A). Nineteen LA–ICP–MS analyses from 11 zircons yield <5% reversely discordant data with a weighted mean $^{207}Pb/^{206}Pb$ age of 932 ± 6 Ma (MSWD = 0.36; Fig. ES–B.6A), which overlaps within uncertainty of the SIMS age. These ages are also similar, within uncertainty, to those obtained from HAOM-related zircons by Schärer et al. (1996).

Moreover, a similar suite of high-Al (>8 wt.% Al_2O_3) orthopyroxene megacrysts from the Egersund–Ogna massif (RAP) yielded a Sm–Nd isochron age of 1041 ± 17 Ma (MSWD = 0.25) (Bybee et al., 2014). Finally, when three point Sm–Nd isochrons are constructed between the plagioclase decompression exsolution lamellae, surrounding orthopyroxene and the whole-rock megacryst compositions, an age of 968 ± 43 Ma is recorded. This age documents the time (albeit imprecisely) at which plagioclase exsolved from these Al-rich megacrysts as anorthositic diapirs were emplaced in the mid- to upper crust (Bybee et al., 2014).

Sjelset Fayalite Granite

The Sjelset fayalite granite is coarse-grained with anhedral feldspar crystals up to 3 mm and anhedral pyroxene crystals around 1 mm in size (Fig. 4F, main text). The most abundant pyroxene is inverted pigeonite, but clinopyroxene and orthopyroxene can occur as well. Strongly fractured subhedral to anhedral olivine (fayalite) can be found, with crystals up to 1 mm. Brown-green anhedral hornblende locally forms a discontinuous rim around the mafic silicates. Plagioclase and perthitic K-feldspars are subhedral, whereas quartz is subhedral to anhedral. Only the accessory minerals zircon and apatite are subhedral to euhedral. They are found associated with clusters of mafic silicates. Apatite is found as inclusions in all mafic silicates and oxides (magnetite and ilmenite). Small rounded pyrite crystals with rare inclusions of chalcopyrite are commonly associated with the oxides. The cores of subhedral plagioclase are strongly sericitized and locally pyroxene is retrogressed into chlorite.

Sample ROG 147, Sjelset fayalite granite. The zircons of sample ROG 147 range in size between 100 and 250 μm, are mostly prismatic and subhedral, with well-developed oscillatory zoning (Fig. ES–B.5B). Eighteen SIMS (SHRIMP II) analyses from 16 zircons show a strong relationship between $^{207}Pb/^{206}Pb$ age and common Pb ($R^2 = 0.95$). To arrive at an age for these data, we therefore calculate a discordia anchored at a $^{207}Pb/^{206}Pb$ composition of 0.93, which yields a lower intercept of 935 ± 8 Ma (MSWD = 1.3; Fig. ES–B.6B). Sixteen LA–ICP–MS analyses from 14 zircons yield nearly concordant data with a weighted mean $^{207}Pb/^{206}Pb$ age of 926 ± 6 Ma (MSWD = 0.29; Fig. ES–B.6B), overlapping within uncertainty of the SIMS age.

Sample ROG 151, Sjelset fayalite granite. The zircons from sample ROG151 are similar to those from ROG147 (Fig. ES–B.5C). Unlike the analyses from ROG147, the sixteen SIMS (SHRIMP II) analyses from 14 zircons in this sample do not correlate with common Pb; anchoring a discordia in a common Pb composition is, therefore, unwarranted. The analyses yield a Concordia age of 931 ± 9 Ma (MSWD = 3.1; Fig. ES–B.6C), which is similar to the dates obtained from sample ROG147 from the same unit.

SVECONORWEGIAN METAMORPHISM

Metamorphism In Geographic Proximity To The SMB

Sample VAG084396, Granitic Gneiss, Gyadalen

This sample is from a medium-grained granitic gneiss in the eastern part of Gyadalen. Quartz and K-feldspar are the main rock forming minerals. Biotite is sparse and where found it is chloritized. The foliation is defined by large, stretched quartz crystals. The quartz also displays undulatory extinction. Apatite, zircons and opaque minerals are present as accessory phases. Myrmekite, perthite and alteration of feldspar are also present.

The zircons are rounded, ca. 300 μm long, stubby to prismatic and relatively dark in the CL-images (Fig. ES–B.3C). Most of the zircons have rims which form irregular embayments in the dark, faintly oscillatory-zoned cores. Twenty-eight LA–ICP–MS analyses from zircon cores and rims are presented in Fig. ES–B.4E, and cluster around 1030 Ma. Although there is complete overlap between core and rim ages, the rims mainly cluster towards younger ages. The cores display some spread in U/Pb ratios, possibly indicating variable fractionation during analysis, and yield a weighted average $^{207}Pb/^{206}Pb$ age of 1030 ± 15 Ma (MSWD = 1.6; Fig. ES–B.4F), whereas all but three rim analyses are concordant and yield a Concordia age of 1027 ± 6 Ma (MSWD = 4.2; Fig. ES–B.4E inset). The age data from this sample, coupled with the zircon textures, are interpreted to reflect crystallization of the granite protolith at ca. 1030 Ma, followed shortly thereafter by high-grade metamorphism and deformation.

Sample VAG084397, Quartz Dioritic Migmatitic Gneiss, Gyadalen

This sample of granulite-facies quartz dioritic migmatitic gneiss was taken only a few hundred metres from the granitic gneiss (VAG084396). The texture is medium-grained to granoblastic. The main rock forming minerals are quartz, hornblende, plagioclase, clinopyroxene, biotite and apatite. Zircon and opaque minerals are accessory phases. Hornblende displays yellow to brown pleochroism, indicating high temperature and Ti-rich compositions. Clinopyroxene is pale green and has two main directions of exsolution. Quartz has lobate grain boundaries and shows undulatory extinction.

The zircons are rounded, ca. 200 μm with similar core-rim relationships as the granitic gneiss (VAG084396) (Fig. ES–B.3D). Most of the cores are oscillatory-zoned, the rims are CL bright and faintly oscillatory zoned. Twenty-eight LA–ICP–MS analyses targeted cores and rims in this sample. Most of the data are concordant but with some scatter (Fig. ES–B.4G), and again there is complete overlap between core and rim ages. Excluding 9 scattered analyses allows us to calculate a Concordia age of 1031 ± 5 Ma (MSWD = 0.1; Fig. ES–

B.4H), interpreted to reflect crystallization of the quartz dioritic protolith at ca. 1030 Ma, followed shortly thereafter by granulite-facies metamorphism and migmatization. The data are indistinguishable to those from the nearby sample VAG084396.

Sample VAG084399, Cross-Cutting, Foliated Porphyritic Hbl–Bt Granite, Gyadalen

This sample was taken from a foliated porphyritic hornblende–biotite granite, close to samples VAG084396 and 397. The granite cross-cuts the high-grade rocks in the area, and appears to represent apophyses of SMB granite at the western boundary of the central SMB batholith. The granite has a porphyritic to local granoblastic texture, and consists of quartz, K-feldspar, plagioclase, hornblende and biotite. Apatite, zircon and opaque minerals are accessory phases. The foliation is defined by biotite, hornblende and large, stretched quartz grains. The quartz also displays undulatory extinction and lobate grain boundaries. Myrmekite is also present.

The zircons are ca. 200 µm, rounded to euhedral and relative dark in CL. Most of the grains have a patchy zonation, some have an oscillatory zonation and some do not show any internal structures. Some of the grains have rims which seem to cut the older zonation.

Twelve zircons were analysed from this sample. The geochronological data yield a Concordia age of 1037 ± 7 Ma (MSWD = 0.01; Fig. ES–B.1P). The date is interpreted to represent the crystallization age of the granite, and overlaps within uncertainty the crystallization age and age of high-grade metamorphism of the host rock gneisses and migmatites. We interpret these data to reflect tectonically highly dynamic processes during construction of the SMB arc, with rapid burial and/or exhumation, and note that these ages are similar to those reported from Mo-bearing SMB granites at Knaben (Bingen et al., 2015).

Sample ROG646L, Migmatitic Orthogneiss North Of UHT Core Area, Near Sandnes

This sample is from the folded leucosome of a migmatitic orthogneiss near Sandnes (Fig. 3A, main text). The zircons from this sample are between 100 and 200 µm, and display well-preserved core-mantle relationships with CL-bright, oscillatory-zoned cores surrounded by rather thick, CL-dark, oscillatory-zoned mantles (Fig. ES–B.7A). The cores yield ages around 1500 Ma, interpreted as the crystallization age of the protolith of the migmatitic orthogneiss; three mantles yield an age of ca. 1280 Ma (Fig. ES–B.8A), and the remaining mantles (16 analyses) yield a weighted average $^{207}Pb/^{206}Pb$ age of 1014 ± 14 Ma (MSWD = 1.2; Fig. ES–B.8B). The ca. 1280 Ma mantles are tentatively interpreted to reflect a hitherto poorly constrained pre-Sveconorwegian metamorphic event, whereas the 1014 ± 14 Ma age is interpreted as the age of leucosome crystallization.

Sample ROG092326, Gyadalen Paragneiss, Metapelite, Forsand

This sample was taken from a metapelite located near the outlet of Lysefjorden (Fig. 3D, main text). The metapelite has up to 3 cm garnet located in granitic leucosome. The metapelite is folded by tight- to isoclinal folds indicating high-strain deformation, and has a patchy migmatitic texture, with irregularly shaped leucosomes. Cordierite, plagioclase, biotite, quartz, garnet and sillimanite are the main rock-forming minerals. Zircon, monazite, apatite, green spinel and opaque minerals are present as accessory phases. Fibrous to needle-shaped sillimanite is present as inclusions in garnet (Fig. ES–B.9A). This texture has been recorded in several other metapelitic units in the host rocks to the Sveconorwegian magmatic rocks (Tobi et al., 1985; N. Coint, unpub. data, 2015). Garnet growing along earlier, folded fabrics defined by aligned, fibrous sillimanite can be seen in some thin sections. The garnet also contains inclusions of cordierite, green spinel, opaque minerals and biotite. Much of the cordierite has been altered to pinnite (muscovite). Zircon is found in corderite, garnet and quartz. Zircons found in the cordierite display yellow haloes. Symplectite textures with reaction between green spinel, opaque minerals, cordierite, biotite and sillimanite are observed (Fig. ES–B.9A).

The zircons are ca. 100–150 μm in size, with rather simple internal zoning characterized by oscillatory zoned grains or cores overgrown by CL-dark rims and mantles (Fig. ES–B.7B). Forty-two LA–ICP–MS analyses were madefrom this sample, and the analyses were grouped into dark grains and rims, interpreted to be metamorphic, and oscillatory zoned, interpreted as detrital (Fig. ES–B.8C). The detrital grains are generally older than ca. 1450 Ma, similar to the metapelite from Skurve (MM01349, see below), whereas the concordant to near-concordant analyses of interpreted metamorphic zircon plot in two groups; one group between 1.4 and 1.5 Ga and the other at ca. 1.05 Ga. The older group is interpreted to reflect either metamorphism of the source to the metapelite or metamorphism of the metapelite shortly after deposition, both of which are viable interpretations. The younger group includes 7 analyses that yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1039 ± 24 Ma (MSWD = 1.4; Fig. ES–B.8D), interpreted as the age of Sveconorwegian high-grade metamorphism.

Calculated Ti-in-zircon temperatures for this sample are typically between 760 and 780°C (Fig. ES–B.12F).

High-Grade Metamorphic Rocks (Xenoliths/Screens) Inside The SMB

Migmatitic Orthogneiss At Konsmo

This migmatitic orthogneiss xenolith is several hundred meters wide across strike and most likely several kilometres long. The rocks are migmatitic, light-colored, medium-grained with dm-thick layers of fine-grained amphibolite. Earlier geochronological data from a migmatitic orthogneiss from this outcrop were interpreted to reflect a ca. 1.5 Ga age for the orthogneiss protolith, and 1026 ± 14 Ma for the age of migmatization (Coint et al., 2015). Data from two new samples from the same outcrop are presented below. From one of these samples, we physically separated leucosome from melanosome prior to crushing and mineral separation.

Samples IH128065A (mesosome) and IH128065B (leucosome), Konsmo. Subsample A is from the mesosome and subsample B from the leucosome of this stromatic migmatite. The foliation in the mesosome is defined by alignment of ca. 2 mm-thick biotite foliae, and the granitic leucosomes form ca. 2–5 cm-thick layers that are concordant to slightly discordant to the mesosome foliation.

The zircons from the mesosome (A) are stubby to prismatic, up to 200 μm long, brown with some inclusions. The internal structures are varied; some are oscillatory zoned, whereas others are CL-dark or show a patchy zonation (Fig. ES–B.7C). Twelve LA–ICP–MS analyses define a discordia with upper and lower intercepts at 1464 ± 21 and 664± 86 Ma, respectively (MSWD = 0.28; Fig. ES–B.8E inset). The upper intercept age is interpreted as the age of the orthogneiss protolith, whereas the significance of the lower intercept age, if any, is unclear.

The zircons from the leucosome (B) are large, typically 300–500 μm in size, prismatic with somewhat irregular oscillatory zoning (Fig. ES–B.7D). Twelve zircons were analysed from this sample. One analysis is strongly discordant, another is an older (but concordant) outlier at 1160 Ma, whereas the remaining analyses cluster around 1040 Ma (Fig. ES–B.8E). Apart from two analyses, these data are concordant within their 2σ uncertainties and yield a Concordia age of 1043 ± 8 Ma (MSWD = 1.6; Fig. ES–B.8F), which is just within uncertainty of the age obtained by Coint et al. (2015) and interpreted to reflect the age of high-grade metamorphism and migmatization.

Sample IH128072 (migmatite), Konsmo. This is the second sample from the Konsmo migmatite screen investigated in this study. Unlike the previous sample, the leucosome and mesosome was not physically separated prior to crushing.

The zircons are colorless to brown, ca. 150 µm and irregular, with irregularly zoned cores surrounded by CL-dark rims or thick mantles (Fig. ES–B.7E).Twelve LA–ICP–MS analyses from cores and rims/mantles, yield a bimodal age distribution (Fig. ES–B.8G) with one population between 1.4 and 1.5 Ga, corresponding to cores, and a younger population (4 analyses) yielding a Concordia age of 1065 ± 23 Ma (MSWD = 0.38 Ma; Fig. ES–B.8H), corresponding to rims and mantles. These ages overlap with the interpreted protolith and migmatization ages inferred from the above sample (IH128065) and by Coint et al. (2015).

Sample IH128061, Gyadalen Paragneiss, Metapelite, Kvås

This sample was taken from a metapelite xenolith from a xenolith-rich zone in SMB granite near Kvås. Several tight- to isoclinal folds were observed in the metapelite, indicating high-strain deformation. The metapelite is migmatitic with leucosomes of irregular shape and size. The melanosomes mainly consist of aligned biotite with smaller grains of quartz and plagioclase. The biotite shows micro-folding in thin-section. The leucosomes mainly consist of anhedral to subhedral quartz and plagioclase. Garnet is mainly found in the leucosomes, is up to 2–3 cm with inclusions of quartz, biotite and apatite. Zircon, monazite, apatite and opaque minerals are present as accessory phases.

The zircons from this sample are ca. 100 µm in size, slightly elongate and irregular, commonly with irregularly zoned cores transected by slightly darker, irregularly zoned rims and mantles (Fig. ES–B.7F). Thirty-five zircons were analysed from this sample. The analyses are grouped in the figure using different colors (Fig. ES–B.8I): red ellipses for metamorphic rims, green ellipses for dark grains, blue ellipses for zircons with low Th/U and black ellipses for other zircons (mainly cores). The cores cluster around 1.5 Ga and are interpreted to represent detrital grains. The other groups, which can generally be interpreted as metamorphic based on textures and/or composition (low Th/U), cluster around 1020 Ma, with smaller clusters at ca. 1200 and 940 Ma. The Sveconorwegian 'cluster' at 1020 Ma comprises 15 analyses of which four are clear outliers. Excluding one 10% discordant and two 6% reversely discordant analyses allows us to calculate a Concordia age of 1025 ± 10 Ma (MSWD = 0.27; Fig ES–B.8J). This age is interpreted to approximate the age of the youngest high-grade metamorphism and migmatization of the metapelite. The significance of the older cluster at ca. 1200 Ma is unclear, but could point to an hitherto unidentified metamorphic event, for which cryptic evidence also appears in other places in SW Norway (e.g., sample ROG646L). The younger cluster at ca. 940 Ma suggests that post-peak metamorphic reactions may have taken place in this highly reactive lithology well after the main phase of high-grade metamorphism, the significance of which is discussed in detail below. We note that the sample locality is only ca. 500 m from a ferroan granite body dated at 951 ±7 Ma.

Calculated Ti-in-zircon temperatures for this sample are typically below 740°C (Fig. ES–B.12F).

Sample NC080843, Hornblende–Biotite-Gneiss Xenolith In SMB, Near Knaben

The sample is of a foliated, hornblende–biotite gneiss xenolith of intermediate to felsic composition within the SMB. The gneiss xenolith contains large, undeformed subhedral crystals of K-feldspar with subhedral inclusions of plagioclase and biotite, similar to the ones present in the surrounding SMB porphyritic granite. Sparse 1–2 mm, undeformed subhedral quartz and plagioclase crystals weakly oriented parallel to the foliation are also present. The matrix hosting these larger crystals is fine to medium grained and composed mainly of anhedral equant plagioclase, K-feldspar and quartz. Biotite and green hornblende, which represent about 15–20% of the rock, are oriented and define the foliation. Opaque minerals surrounded by brown pinkish titanite constitute accessory phases along with zircon, metamict allanite and apatite.

The zircons from sample NC080843 are mainly between 100 and 200 µm, stubby and rounded with rather complex internal textures, characterized by irregularly zoned, CL-light and CL-dark parts (Fig. ES–B.7G). In some grains, the CL-light zircon forms a core surrounded by CL-dark zircon, whereas in other grains the reverse relationship is observed.

Twelve analyses yield relatively scattered data with no clear relationship between texture and age (Fig. ES–B.8K). Four analyses appear to be affected by common Pb and one is strongly (12%) reversely discordant. Excluding one younger, 10% discordant analysis, the remaining analyses are within 2σ uncertainty of concordia. These six analyses yield a weighted average $^{207}Pb/^{206}Pb$ age of 1049 ± 19 Ma (MSWD = 0.35; Fig. ES–B.8L). One ca. 950 Ma analysis was excluded by Isoplot as a statistical outlier, and the significance of this age is unknown. We therefore regard 1049 ± 19 Ma as the age of metamorphism of this amphibolite xenolith.

High-Grade Metamorphic Core Area In Rogaland, West And South Of The SMB

Samples ROG640 And ROG642, Nedrebø Oxide-Rich Rock, Faurefjell Metasediments

ROG640 is from an orthopyroxene-spinel-oxide gneiss displaying a granoblastic texture (Fig. ES–B.9B). Pleochroic pink orthopyroxene and plagioclase are the most abundant minerals. Crystals are weakly elongated parallel to the foliation, which is defined by modal layering and variable proportions of orthopyroxene and plagioclase. Opaque minerals, commonly associated with orthopyroxene, are dispersed throughout the sample. Accessory minerals are apatite, zircon, green spinel and orange-brown biotite. Apatite occurs as euhedral grains in the matrix of the gneiss, whereas small and rounded zircon is found as inclusions in both feldspar and more rarely in orthopyroxene.

ROG642 is an oxide-rich cordierite-spinel-orthopyroxene gneiss. The texture is highly variable, from medium grained equigranular to granoblastic to locally symplectitic (Fig. ES–

B.9C). The main silicates are plagioclase, orthopyroxene and cordierite. Plagioclase is anhedral in the granoblastic part of the thin section, and becomes subhedral in the equigranular part. In the latter area, plagioclase is antiperthitic, displays undulated contacts with K-feldspar and evidence of late resorption. K-feldspar, where present, is interstitial between subhedral plagioclase. Opaque minerals are abundant, comprising up to 20% of the thin section, and form large anhedral clusters associated with green spinel (Fig. ES–B.9C). Corundum exsolution is present in some oxide crystals. In the vicinity of the large anhedral oxides and spinel clusters, orthopyroxene occurs as anhedral equant crystals associated with granular oxides separated by thin films of cordierite. Apatite, zircon and monazite are the main accessory phases. Apatite is subhedral, dispersed in the gneiss matrix. Zircon is rounded and present as inclusions in orthopyroxene, cordierite and plagioclase. Monazite grains are quite large, up to 500 µm in diameter. The highly reactive symplectitic texture, as indicated by abundant exsolution textures and products of replacement reactions, is characteristic of the UHT granulites of the region.

The zircons from samples ROG640 and ROG642 are large, typically >150 µm, irregular, with highly complex zoning including cores with multiple rims and several generations of diffusely zoned zircon (Fig. ES–B.10A).

Sample ROG642 has been dated by SIMS at NORDSIM and in Perth (SHRIMP II), and LA-ICP–MS at NGU, and consistently yields a range of concordant ages between ca. 1080 and 920 Ma (Fig. ES–B.11A, B), interpreted as reflecting protracted high-grade conditions which may have been quasi-continuously maintained for ca. 150 million years. Although we cannot rule out that the array of ages reflects differential resetting, the CL images show that the different ages come from different domains within the zircon grains (Fig. ES–B.10A), suggesting extensive resorption and regrowth of zircon rather than resetting. In addition, calculated alpha doses do not correlate with age (Fig. ES–B.12A), also arguing against partial resetting. Calculated Ti-in-zircon temperatures are between 740 and 780°C for most of the recorded time interval, but increase to ca. 840°C from ca. 970 Ma onwards (Fig. ES–B.12B).

Sample ROG640 was taken only a few hundred metres from ROG642, from a similar lithology, and yields a similar range of ages (Fig. ES–B.11C).

Sample ROG639, Nedrebø Quartzite, Faurefjell Metasediments

ROG639 is from a ca. 1 m-thick quartzite layer directly above the oxide-rich rock represented by sample ROG640.

The zircons from this sample range in size between 100 and 200 μm and are characterized by partially resorbed, oscillatory-zoned cores mantled by CL-darker, diffusely zoned or unzoned mantles of variable thickness (Fig. ES–B.10E). Some grains lack cores altogether, and are interpreted as metamorphic.

The cores yield $Pb/^{206}Pb$ ages between 1930 and 1340 Ma, interpreted as detrital ages, whereas the rims and metamorphic grains yield a Concordia age of 938 ± 6 Ma (MSWD = 0.66), interpreted as the age of high-grade metamorphism (Fig. ES–B.11E, F).

Sample ROG033048, Gyadalen Paragneiss, Vikesdal Osumilite-Bearing Metapelite

The migmatitic metapelitic gneiss in Vikesdal is composed of dark blue to purple melanosomes and leucocratic quartz-bearing leucosomes (Fig. 3B, main text). Melanosomes are composed of orthopyroxene, osumilite, spinel, local interstitial quartz and intergrown cordierite and K-feldspar. Magnetite and ilmenite are the main opaque phases. Garnet is present both as anhedral resorbed crystals surrounded by osumilite or fine symplectitic cordierite and K feldspar and as rims around orthopyroxene and magnetite (Fig. ES–B.9D). Leucosomes are composed of quartz, perthitic alkali feldspar, rare plagioclase, ilmenite and magnetite. Zircon is present as an accessory mineral in both leucosome and melanosome.

Sample ROG033048 is from the well-known 'osumilite locality' at Vikesdal, ca. 2 km from the contact with the Bjerkreim–Sokndal layered intrusion. The zircons from this sample range in size between 100 and 200 µm, and are characterized by complex internal zoning and truncations, suggesting multiple events of growth and resorption, similar to ROG640 and 642 (Fig. ES–B.10B). LA–ICP–MS and SHRIMP analyses from this sample yield a similar range of concordant ages between 1130 and 950 Ma (Fig. ES–B.11G, H). As for sample ROG642, the lack of correlation between alpha dose and age (Fig. ES–B.12C) argues against differential resetting. Interestingly, none of the analyses appears to date detrital grains in this assumed paragneiss, suggesting that any detrital zircons were thoroughly recrystallized.

Calculated Ti-in-zircon temperatures mainly range between 760 and 780°C for zones dated at between 1130 and 1000 Ma, with relatively elevated temperatures between 760 and 820°C for zones dated at between ca. 970 and 950 Ma (Fig. ES–B.12D).

From the same locality, Laurent et al. (2016) identified monazite populations based on sulfate concentration with ages of ca. 1034–1028, 1005–998, 952 and 935 Ma. This range of ages is similar to that observed in this study.

Sample MM01349, Gyadalen Paragneiss, Skurve Metapelite

Migmatitic metapelitic gneisses at Skurve consist of foliated melanosomes with dark-blue cordierite, spinel, garnet and locally sillimanite, cut by leucocratic granitic leucosomes with cordierite and garnet (Fig. 3C, main text).

Melanosomes display corona textures typical of UHT metapelites (Drüppel et al., 2013; Kelsey and Hand, 2015) with remnant elongated garnet crystals containing oriented inclusions of sillimanite needles defining a previous foliation (Fig. ES–B.9E). Biotite, ilmenite, pyrite, zircon and sparse, rounded brown spinel are also found as inclusions. Garnet is replaced by cordierite, brown to dark green spinel and quartz. Quartz has not been observed in direct contact with spinel. Sillimanite is not present in the matrix of this particular sample, however, it has been observed at the same locality as euhedral crystals associatd with cordierite and spinel. Leucosomes are composed of large (up to 8 mm) anhedral but blocky quartz, displaying undulose extinction, associated with smaller anhedral plagioclase, sparse perthitic K-feldspar, anhedral garnet and altered cordierite. Larger poikilitic porphyroblast of garnet (1–5 mm) are present and contain rounded quartz inclusions but no sillimanite. Biotite is present as small euhedral crystals in the leucosome. Zircon, opaque minerals and monazite are accessory minerals.

Zircons from sample MM01349 display complex internal zoning and truncations interpreted to repflect multiple growth/resportion events (Fig. ES–B.10C). The LA–ICP–MS and SIMS data from metamorphic grains and rims of this sample yields a range of concordant ages between ca. 1050 and 940 Ma (Fig. ES–B.11I, J). Detrital grains yield ages between 1620 and 1420 Ma, with very few older and younger analyses, suggesting a maximum age of deposition around 1420 Ma.

Sample MM01348, Faurefjell Metasediments, Kydland Calc-Silicate Gneiss

This sample is a granoblastic diopside gneiss, with light-green pyroxene, plagioclase, quartz and up to 5% disseminated opaque minerals (Fig. ES–B.9F). Apatite and zircon are accessory phases. Zircon is rounded and found as inclusions in other minerals.

As for the above samples, zircons from sample MM01348 display complex internal zoning and truncations indicative of multiple growth/resportion events (Fig. ES–B.10D). SIMS analyses of these zircons yield a range of ages between ca. 1060 and 960 Ma (Fig. ES–B.11D). A limited number of detrital zircon analyses yield ages between 1800 and 1180 Ma, suggesting a significantly younger depositional age for the Faurefjell metasediments than the Gyadalen paragneiss (sample MM01349).

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FIGURE CAPTIONS

Figure ES–B.1. Tera–Wasserburg plots presenting new U–Pb zircon age data from Sirdal Magmatic Belt granites.

Figure ES–B.2. Tera–Wasserburg plots presenting new U–Pb zircon age data from ferroan hornblende-biotite granites.

Figure ES–B.3. Selected CL images of zircons from Sveconorwegian magmatic rocks, variably overprinted by Sveconorwegian metamorphism.

Figure ES–B.4. U–Pb zircon age data from Sveconorwegian mafic magmatic rocks.

Figure ES–B.5. Selected CL images of zircons from (A) high-Al orthopyroxene megacrysts in the Egersund–Ogna anorthosite and (B, C) the Sjelset fayalite granite.

Figure ES–B.6. U–Pb zircon age data from (A) high-Al orthopyroxene megacrysts in the Egersund–Ogna anorthosite and (B, C) the Sjelset fayalite granite.

Figure ES–B.7. Selected CL images of zircons from high-grade metamorphic rocks outside the core area.

Figure ES–B.8. U–Pb zircon age data from high-grade metamorphic rocks outside the core area.

Figure ES–B.9. Photomicrographs of the investigated high-grade rocks. (A) Metapelite from the outlet of Lysefjorden; sample ROG092326. (B, C) Orthopyroxene-oxide-spinel-cordierite-bearing gneisses from Nedrebø; samples ROG640 and ROG642. (D) Osumilite-bearing metapelite from Vikesdal; sample ROG033048. (E) Metapelite from Skurve; sample MM01349. (F) Quartz-diopside gneiss from Kydland; sample MM01348. Mineral abbreviations are from Witney and Evans (2010).

Figure ES–B.10. Selected CL images of zircons from high-grade metamorphic rocks inside the core area.

Figure ES–B.11. U–Pb zircon age data from high-grade metamorphic rocks inside the core area.

Figure ES–B.12. Calculated alpha doses and Ti-in-zircon temperatures versus $^{207}Pb/^{206}Pb$ age for samples ROG642 (A and B) and ROG033048 (C and D), both within the core area. For comparison, (E) shows calculated Ti-in-zircon temperatures for samples ROG092326 and IH128061, both metapelites outside the core area. Alpha doses calculated following Murakami et al. (1991), and Ti-in-zircon temperatures following Watson et al. (2006). 1σ error bars for both age and calculated temperature.