AGU PUBLICATIONS

Tectonics

Supporting Information for

Long-lived (180 Myr) ductile flow within the Great Slave Lake shear zone

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Additional Supporting Information (Files uploaded separately)

Captions for Tables S1 to S4

Introduction

This supplement includes detailed petrographic descriptions for the eleven samples selected for *in situ* U-Th-Pb accessory mineral petrochronology as well as supplementary figures containing apatite and titanite trace element analyses and images of representative apatite and titanite grains. Tables containing instrumentation settings for LA-ICP-MS analyses, apatite and titanite U-Pb and trace element data, and Zr-in-titanite temperature data are uploaded separately.

Text S1.

Sample petrography:

For the following petrographic descriptions, samples are ordered geographically from northwest to southeast. Four of the eleven samples (GSL-18-BD07, GSL-21-DS07, GSL-18-BD27, GSL-18-C50) were collected north of the Laloche River fault while the remaining seven are from south of the fault.

Sample GSL-18-BD07 is a greenschist facies ultramylonitic granodiorite that was collected from the northernmost greenschist belt (Fig. 1c). The metamorphic mineral assemblage is epidote–titanite–chlorite–biotite–muscovite–plagioclase–quartz–K-feldspar with relict amphibole and accessory (<0.5 modal%) apatite. Apatite grains occur primarily in the matrix and typically range from 50–100 μm in diameter (Fig. 2a). Most apatite grains are sub- to anhedral, although several preserve evidence of a hexagonal habit, and grains exhibit patchy core-rim zoning in CL (Fig. S1a). Titanite grains only occur in the matrix and are well-aligned with the foliation (Fig. 2a). They range from 60–700 μm in diameter and typically have an elongate sub- to euhedral shape. Most titanite grains appear either homogeneous in BSE or exhibit irregular, patchy zoning (Fig. S2a).

Sample GSL-21-DS07 is a heavily altered epidote-amphibolite facies mylonitic schist that was collected from the northernmost epidote-amphibolite belt (Fig. 1c). The metamorphic mineral assemblage is epidote–chlorite–feldspar–quartz with accessory titanite. The sample exhibits a weak foliation that is defined by the orientation of chlorite grains as well as by a pervasive network of thin anastomosing opaque-lined fractures. Late, coarse-grained quartz-epidote veins are present in the sample and crosscut the main matrix foliation; the majority of titanite grains occur along the boundaries of these veins (Fig. 2b). Several titanite grains also occur in the matrix, but these contain a higher density of inclusions and, therefore, were not selected as targets. Titanite grains range from 200–1000 μm in diameter. The quartz-epidote vein-hosted titanite grains are euhedral and exhibit oscillatory zoning in BSE (Fig. S2b). In contrast, matrix-hosted titanite grains display resorption textures and exhibit irregular, patchy zoning (Fig. S2b).

Sample GSL-18-BD27 is an upper-amphibolite facies garnet mylonitic schist that was collected from the upper-amphibolite belt (Fig. 1c). The metamorphic mineral assemblage is garnet–sillimanite–biotite–plagioclase–quartz with accessory apatite. The alignment of individual biotite grains defines an irregular, wavy foliation that wraps porphyroclasts of garnet. Apatite grains are found primarily in the matrix, although some occur as inclusions in garnet porphyroclasts. Apatite range from 50–200 μm in diameter and are typically rounded, subhedral and exhibit no zoning in CL (Fig. S1b).

Sample GSL-18-C50 is an epidote-amphibolite facies amphibole mylonitic schist that was collected immediately north of the Laloche River fault (Fig. 1c). The metamorphic mineral assemblage is clinozoisite–amphibole–biotite–titanite–chlorite–quartz–albite–K-feldspar with accessory apatite. The sample consists of a very fine-grained mylonitic matrix with large (cm-scale) winged porphyroclasts that record a dextral shear sense. The sample exhibits a penetrative foliation that is defined by the alignment of matrix minerals. The matrix is primarily composed of chlorite, plagioclase, quartz and K-feldspar, and wraps large clinozoisite–amphibole–titanite pseudomorphs after garnet (Dyck et al., 2021). Apatite grains in this sample occur both in the matrix, where they are aligned with the foliation, and within the pseudomorphed garnet domains, where they tend to be oriented oblique to the main matrix foliation. Apatite grains range from 50–400 μm in diameter and are anhedral and fractured. Grains exhibit either patchy or core-rim zoning in CL (Fig. S1c). Titanite grains are typically oriented oblique to the main matrix foliation and range from 100–800 μm in diameter. The grains are rhombic and exhibit either patchy or oscillatory zoning in BSE (Fig. S2c).

Sample GSL-21-DS14 is a greenschist facies amphibole mylonitic granodiorite that was collected from a mafic boudin in the greenschist facies belt immediately to the south of the Laloche River fault (Fig. 1c). The metamorphic mineral assemblage is biotite–amphibole–plagioclase–K-feldspar–calcite–quartz with secondary chlorite and accessory apatite, titanite and allanite. Fine-grained micaceous domains wrap around winged amphibole and feldspar porphyroclasts, defining a penetrative foliation (Fig. 2c). Coarser-grained regions of quartz, biotite and chlorite are observed adjacent to large porphyroclasts. Quartz ribbons display a crystallographic preferred orientation under the tint plate, consistent with dextral shear. Apatite grains only occur in the matrix, are well-aligned with the foliation and range from 60–500 μm in diameter. Grains are elongate and commonly exhibit patchy CL zoning (Fig. S1d). Titanite grains in this sample occur only in the matrix, are aligned with the foliation, and are relatively small (50–200 μm in diameter; Fig. 2c). Titanite grains exhibit core-rim zoning in BSE (Fig. S2d).

Sample GSL-18-BD11 is an epidote-amphibolite facies mylonitic granodiorite collected south of Laloche River fault (Fig. 1c). The metamorphic mineral assemblage is biotite–quartz–albite–K-feldspar with accessory apatite and titanite. The thin section exhibits a strong, anastomosing foliation defined by the alignment of biotite and by the orientation of planar quartz ribbons. Quartz ribbons display a crystallographic preferred orientation under the tint plate consistent with dextral shear. Apatite grains occur primarily in the matrix and are well-aligned with the foliation. Grains range from 60–250 μm in diameter and are typically sub- to anhedral and elongate. The grains commonly exhibit either oscillatory or core-rim zoning in CL (Fig. S1e). Titanite grains are uncommon, occurring primarily along micaceous layers, and are very small, ranging from 20–120 μm in diameter. Titanite grains are blocky in shape and exhibit little to no zoning in BSE (Fig. S2e).

Sample GSL-21-DS16 is an epidote-amphibolite facies amphibole mylonitic granodiorite that was collected from a mafic boudin south of Laloche River fault (Fig. 1c). The metamorphic mineral assemblage is amphibole–plagioclase–biotite–epidote–quartz with secondary chlorite and accessory apatite and titanite. This sample exhibits a strong foliation that is defined by the alignment of amphibole and biotite. Apatite grains commonly occur in amphibole-rich domains and are well-aligned with the foliation (Fig. 2e). Apatite grains range in diameter from 80–250 µm, are typically rounded and elongate in shape and exhibit irregular core-rim zoning in CL (Fig. S1f). Two populations of titanite were identified based on textural observations (Fig. 2e). The first population consists of sub- to anhedral titanite grains that are well-aligned with the foliation (referred to as "fabric-aligned titanite"), while the second consists of round titanite grains clustered together around long masses of ilmenite (referred to as "clustered titanite"). Grain size varies similarly across both populations, ranging from 25–120 µm. Clusters of titanite are typically elongate and can reach up to 500 µm in length. Both populations of titanite exhibit some evidence of core-rim zoning in BSE (Figs. S2f & g).

Sample GSL-21-DS18 is an epidote-amphibolite facies amphibole mylonitic granodiorite that was collected from a strongly foliated mafic boudin at an outcrop otherwise dominated by pink, heteroclastic mylonitic granodiorite host rock. The metamorphic mineral assemblage is amphibole–biotite–plagioclase–quartz with secondary chlorite and accessory titanite, apatite and monazite. The sample exhibits a strong foliation that is defined by the alignment of planar quartz ribbons, biotite and chlorite, all of which wrap amphibole and plagioclase porphyroclasts (Fig. 2d). Apatite occurs primarily in the matrix and grains range from 50–200 µm in diameter. They are elongate, aligned with the foliation and exhibit patchy zoning with uncommon bright core domains in CL (Fig. S1g). Titanite only occurs in the matrix and is commonly associated with biotite. Titanite grains range from 50–350 µm in diameter and are elongate in shape, aligned with the foliation (Fig. 2d). Most grains exhibit irregular, patchy zoning in BSE (Figs. S2h & i).

Sample GSL-18-BD24 is an epidote-amphibolite facies amphibole mylonitic granodiorite collected south of Laloche River fault (Fig. 1c). The metamorphic mineral assemblage is amphibole–biotite–titanite–albite–epidote–quartz with secondary chlorite and accessory apatite. This sample is medium-grained with a strong foliation defined by the crystallographic and shape preferred orientation of amphibole grains. Apatite occurs primarily in the matrix and grains range from 50–200 µm in diameter. Apatite grains are elongate, aligned with the foliation and exhibit patchy zoning with uncommon bright core domains in CL (Fig. S1h). Titanite grains occur in the matrix, are well-aligned with the foliation, ranging in diameter from 100–1500 µm. The grains are sub- to anhedral and exhibit distinct core and rim structures in transmitted light and BSE (Figs. 2f, S2j & k).

Sample GSL-21-DS20 is an epidote-amphibolite facies amphibole mylonitic granodiorite that is the southernmost sample analyzed from the shear zone (Fig. 1c). The thin section from this sample features both the mafic boudin and the pink, homoclastic mylonitic host rock. The metamorphic mineral assemblage amphibole–epidote–biotite–plagioclase–quartz with secondary chlorite and accessory titanite and apatite. The sample exhibits a strong foliation that is defined by the alignment of amphibole, biotite and chlorite. Apatite grains only occur in the matrix and range from 70–300 µm in diameter.

Apatite grains are elongate in shape, aligned with the foliation, and exhibit irregular oscillatory zoning in CL (Fig. S1i). Titanite grains are aligned with the foliation and commonly associated with amphibole and biotite. Titanite grains range from 50–500 μm in diameter, are rhombic in shape and do not typically exhibit internal zoning in BSE (Fig. S2l).

Sample GSL-21-BD12 is an upper-amphibolite facies amphibole schist that was collected from a supracrustal unit in the Rutledge Group, ~10 km to the south of the previously defined southern boundary of the shear zone (Fig. 1c). The metamorphic mineral assemblage is amphibole–plagioclase–quartz–biotite–chlorite with accessory titanite, apatite and monazite. The sample is strongly foliated, as defined by the shape and crystallographic preferred orientation of amphibole and biotite grains. The thin section exhibits a flattened equigranular texture, with interlocking plagioclase, quartz, and amphibole grains separated by thin lenticular domains of fine-grained micaceous and quartz-rich material. Apatite occurs either in the matrix or as inclusions in amphibole grains. Apatite grains range from 50–200 μm in diameter, are anhedral and exhibit patchy core-rim zoning in CL (Fig. S1j). Titanite grains occur in the matrix, are well-aligned with the foliation, and range from 50–200 μm in diameter. The grains exhibit a range of shapes, from blocky to anhedral, and often have patchy, core-rim zoning in BSE (Fig. S2m).

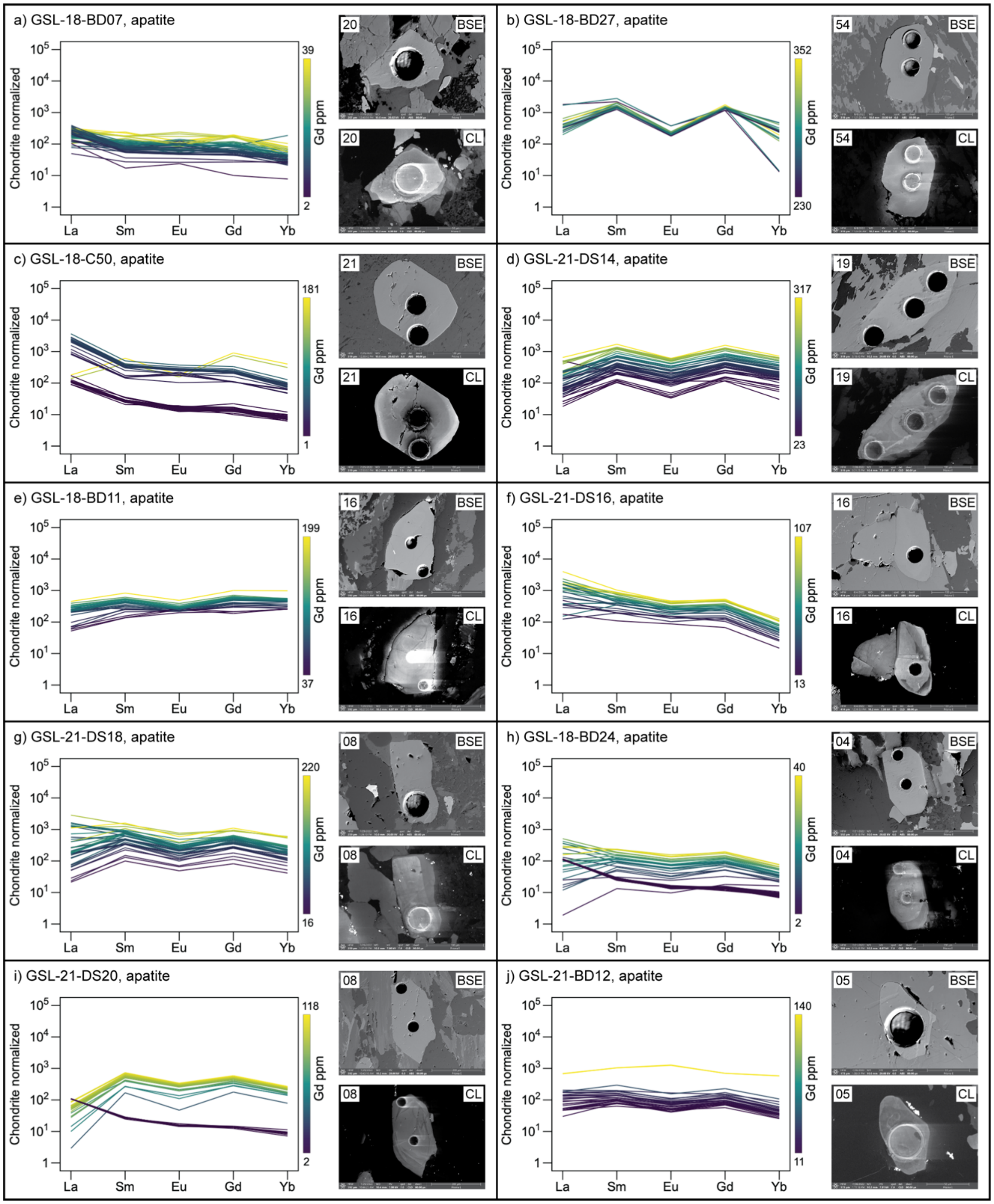
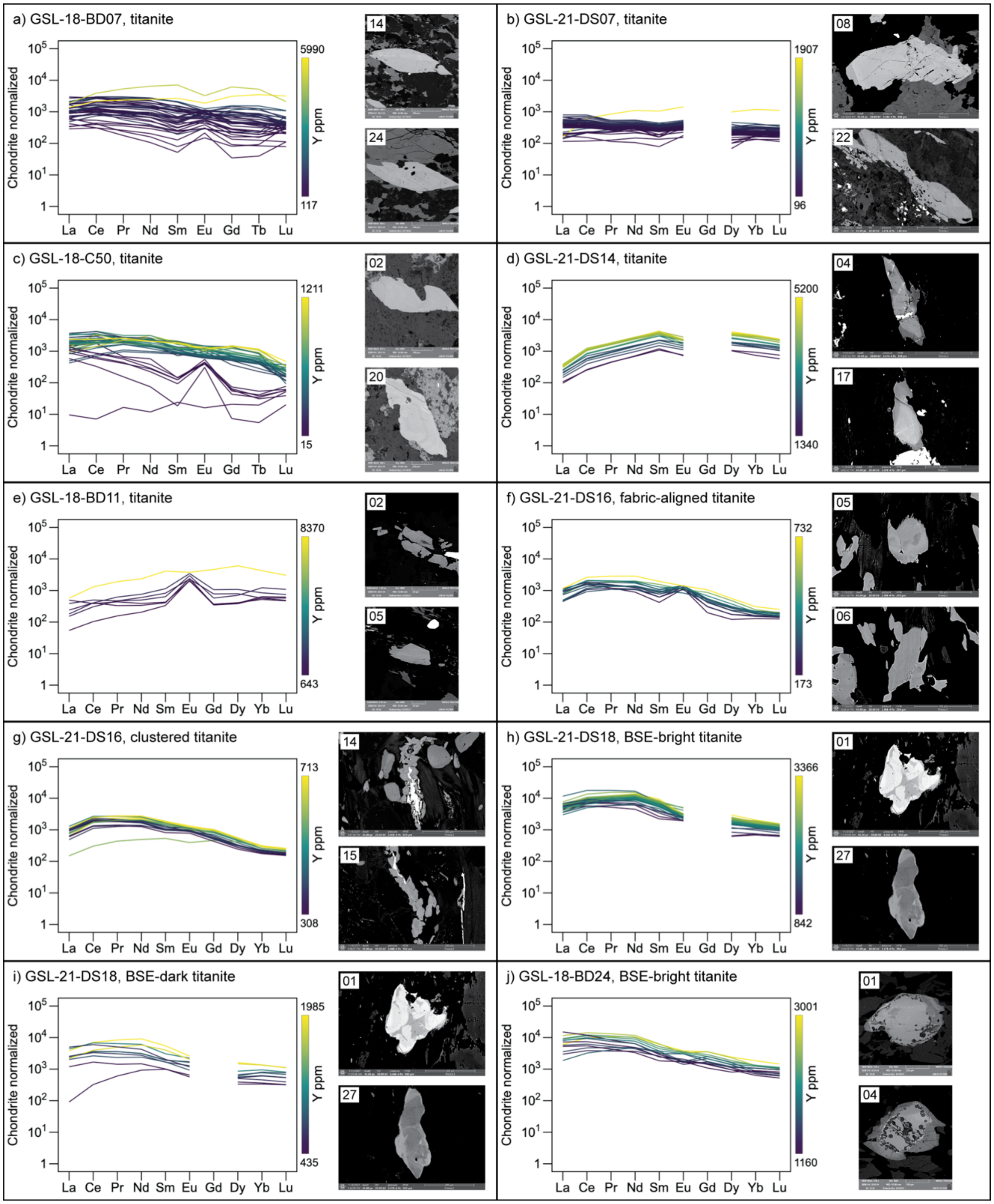


Figure S1. Trace element results for all apatite populations plotted on chondrite-normalized REE plots. BSE and CL images of representative grains are shown for each population. Populations (samples) are ordered geographically from NW to SE.


a) GSL-18-BD07, titanite
b) GSL-21-DS07, titanite
c) GSL-18-C50, titanite
d) GSL-21-DS14, titanite
e) GSL-18-BD11, titanite
f) GSL-21-DS16, fabric-aligned titanite
g) GSL-21-DS16, clustered titanite
h) GSL-21-DS18, BSE-bright titanite
i) GSL-21-DS18, BSE-dark titanite
j) GSL-18-BD24, BSE-bright titanite
Chondrite normalized
Y ppm
La Ce Pr Nd Sm Eu Gd Tb Lu
La Ce Pr Nd Sm Eu Gd Dy Yb Lu
5990
117
1907
96
1211
15
5200
1340
8370
643
732
173
713
308
3366
842
1985
435
3001
1160
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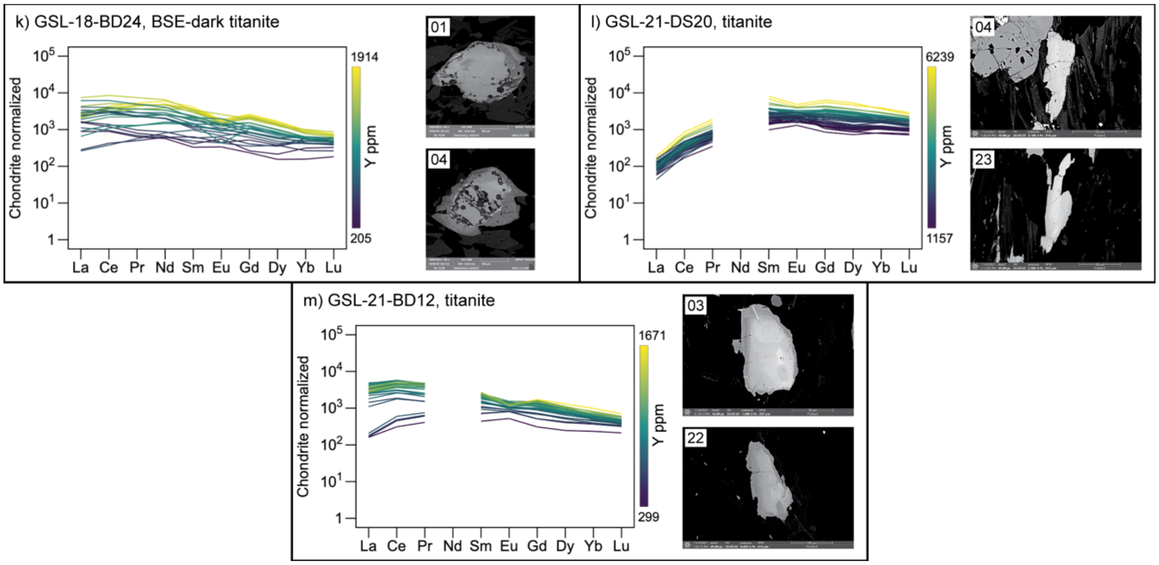

Figure S2. Trace element results for all titanite populations plotted on chondrite-normalized REE plots. BSE images of representative grains are shown for each population. Populations (samples) are ordered geographically from NW to SE.

Table S1. LA-ICP-MS metadata for all analytical sessions.

Table S2. Apatite U-Pb isotope and trace element data (unknowns and reference materials).

Table S3. Titanite U-Pb isotope and trace element data (unknowns and reference materials).

Table S4. Zr-in-titanite geothermometry results for all titanite analyses.