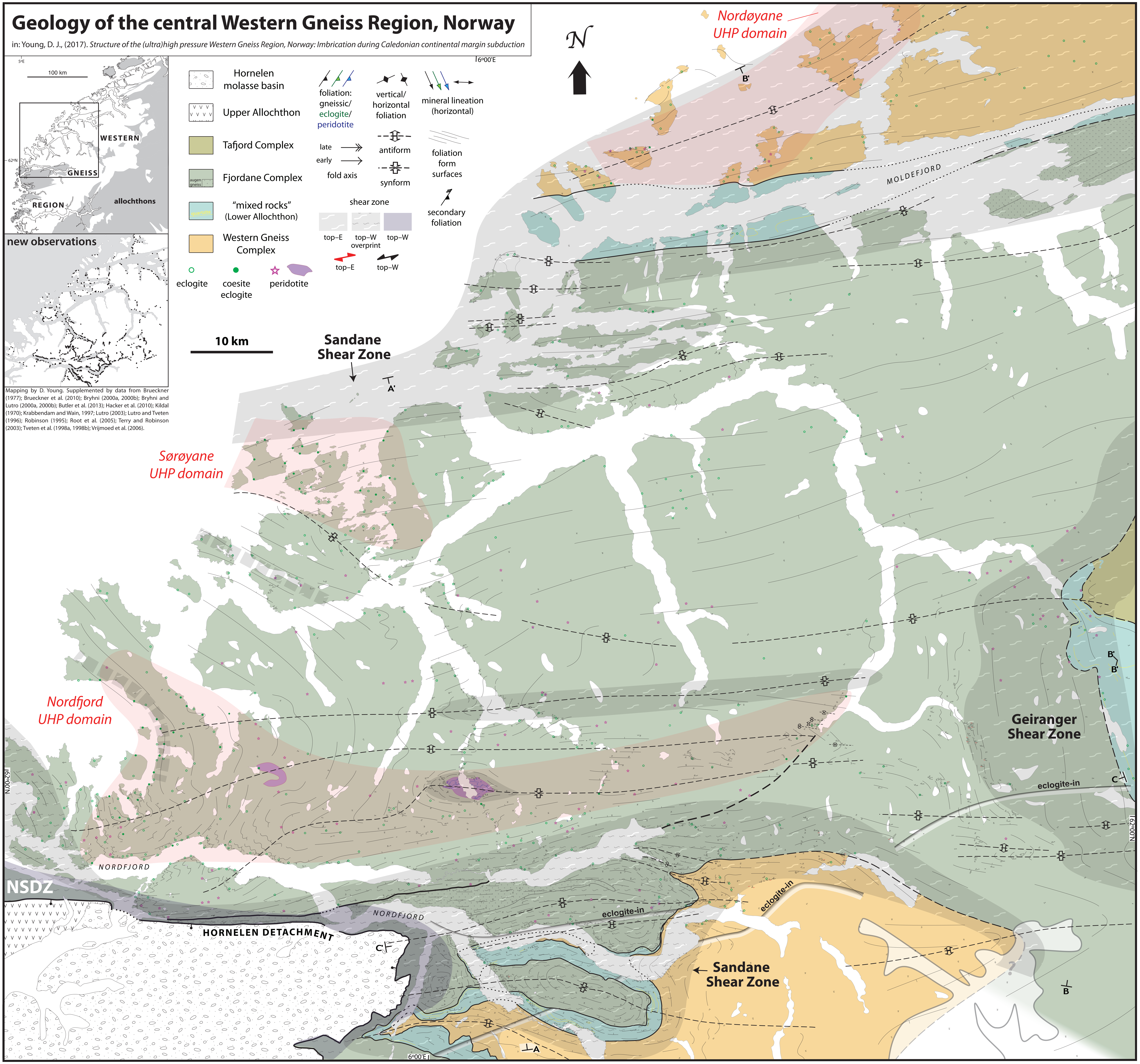
Geology of the central Western Gneiss Region, Norway
in: Young, D. J., (2017). Structure of the (ultra)high pressure Western Gneiss Region, Norway: Imbrication during Caledonian continental margin subduction
100 km
WESTERN
GNEISS
REGION
allochthons
new observations
Mapping by D. Young. Supplemented by data from Brueckner (1977); Brueckner et al. (2010); Bryhni (2000a, 2000b); Bryhni and Lutro (2000a, 2000b); Butler et al. (2013); Hacker et al. (2010); Kildal (1970); Krabbendam and Wain, 1997; Lutro (2003); Lutro and Tveten (1996); Robinson (1995); Root et al. (2005); Terry and Robinson (2003); Tveten et al. (1998a, 1998b); Vrijmoed et al. (2006).
Hornelen molasse basin
Upper Allochthon
Tafjord Complex
Fjordane Complex
augen gneiss
"mixed rocks" (Lower Allochthon)
Western Gneiss Complex
eclogite
coesite eclogite
peridotite
foliation: gneissic/ eclogite/ peridotite
vertical/ horizontal foliation
mineral lineation (horizontal)
late
early
fold axis
antiform
synform
foliation form surfaces
secondary foliation
shear zone
top–E
top–W overprint
top–W
top–E
top–W
10 km
N
6°00'E
Nordøyane UHP domain
MOLDEFJORD
B'
Sandane Shear Zone
A'
Sørøyane UHP domain
Nordfjord UHP domain
Geiranger Shear Zone
B'
B'
C
eclogite-in
62°N
NORDFJORD
NSDZ
HORNELEN DETACHMENT
NORDFJORD
eclogite-in
eclogite-in
C'
Sandane Shear Zone
B
A
6°00'E

GSA Data Repository Item 2017308
Young, D.J., 2017, Structure of the (ultra)high-pressure Western Gneiss Region, Norway: Imbrication during Caledonian continental margin subduction: GSA Bulletin, https://doi.org/10.1130/B31764.1.

DATA REPOSITORY FILE S2

OVERVIEW OF THE CURRENT WESTERN GNEISS REGION GEOCHRONOLOGICAL DATASET

The timing of metamorphism and detachment in the subduction channel is bracketed by geochronometers with high closure temperatures, such as the garnet Lu-Hf and Sm-Nd systems, and U/Th-Pb in zircon. These separate isotopic systems can be cross referenced by the relative abundances of medium and heavy rare earth elements that partition into both zircon and garnet. The geological history of the *Fjordane complex* is well characterized by garnet and zircon geochronology. In the central Western Gneiss Region, garnet growth is constrained by a range of prograde Lu-Hf (420–410 Ma) and Sm-Nd dates (423–408 Ma) from various eclogites (Griffin and Brueckner, 1985; Carswell et al., 2003b; Kylander-Clark et al., 2007; Kylander-Clark et al., 2009) and pelites (Peterman et al., 2009). These data comport with garnet-bearing pelites in the southern strand of the Sandane shear zone, in which zircons younger than ca. 425 Ma (Young and Kylander-Clark, 2015) contain lower HREE concentrations, suggesting growth in the presence of other HREE-compatible phases like garnet. Eclogite in the Fjordane complex also yields a range of comparable U/Th-Pb zircon dates between 420 and 400 Ma (Root et al., 2004; Tucker et al., 2004; Walsh et al., 2007; Krogh et al., 2011; DesOrmeau et al., 2015). Pelitic rocks within the southern Sandane shear zone contain no zircon dates younger than ca. 412 Ma (Young and Kylander-Clark, 2015), indicating little new zircon growth in the base of the Fjordane sheet after this time. Eclogite in the western Fjordane complex continued to grow zircon until ca. 400 Ma; Eu* anomalies in zircon remain suppressed until the cessation of growth (DesOrmeau et al., 2015), reflecting weak retrogression of HP phases in the selected samples.

Few Scandian garnet or zircon data are published yet for the *Tafjord complex* in the hanging wall of the Geiranger shear zone. Ginsburg (2012) report a range of LA-ICPMS spot dates from various eclogites that mostly lie between 430 and 410 Ma, with a few younger analyses. Imprecise SIMS U/Th-Pb zircon dates in Walsh et al., (2007) are consistent with these data. In the Trollheimen district farther to the east, zircon TIMS analyses from eclogite in the upper gneiss unit (Vinddøldalen: Beckman et al., 2014) range from 440 to 410 Ma in age (mean ca. 425 Ma).

A single garnet Lu-Hf age from an eclogite in the southern *Western Gneiss complex* is 410 Ma (Kylander-Clark et al., 2009), whereas TIMS multigrain zircon dates from two other eclogites nearby in this domain (<40 km apart) are 421–417 Ma (Root, D.; pers. comm. 2015). If, as proposed herein, the Western Gneiss complex is exposed at the northern edge of the study area, two eclogites in that region have been dated by combined U/Th-Pb and REE analysis. Just below the northern Sandane shear zone along Moldefjord, zircon grew between 425 and 400 Ma (Midsund: Krogh et al., 2011; Kylander-Clark et al., 2013). Farther northeast, multigrain TIMS dates from the Averøya body range between 416 and 408 Ma (Krogh et al., 2011). Unpublished LA-ICPMS data from the same sample dated by Krogh yield zircon dates between 420 and 400

Ma (Kylander-Clark, A. R. C; pers. comm. 2015). Analyses in both eclogite localities show suppressed HREE concentrations associated with the oldest zircon dates, indicating garnet was already present. Eu* anomalies in zircon are consistently suppressed, indicating growth during and after breakdown of Eu-bearing phases such as feldspar. Lastly, for comparison, recrystallized Scandian phases in garnet peridotite near the structural top of the northern Western Gneiss complex define Sm-Nd isochrons of ca. 430 Ma (Otrøy: Spengler et al., 2009).

Crosscutting relationships and geochronology of igneous dykes bracket the deformation history in the Sandane and Geiranger shear zones. Across the Western Gneiss Region, U/Th-Pb zircon and titanite dates from Scandian felsic intrusions that are discordant or weakly deformed, range from ca. 405 to ca. 385 Ma (Krogh et al., 2011; Gordon et al., 2013; Spencer et al., 2013; Kylander-Clark and Hacker, 2014). Those dykes that are specifically discordant to shear zone fabrics in coastal regions of the central Western Gneiss Region (A0722G4 and K7717K: Kylander-Clark and Hacker, 2014), yield zircon dates of 391–389 Ma. Zircon ages from undeformed leucosomes filling strain shadows bookending eclogite pods indicate ductile deformation must be older than 404–393 Ma (Krogh et al., 2011; Gordon et al., 2013). Concordant deformed dykes yield mainly Precambrian zircon ages; most notably, mylonitization in the Geiranger shear zone overprints and transposes 942–923 Ma granitic dykes (Ornfjell: Tucker et al., 1990; Djupvatnet: Kylander-Clark and Hacker, 2014), supporting a Paleozoic age for this structure. A nearly concordant TIMS $^{206}Pb/^{238}U$ titanite age of 401 Ma from an undeformed leucosome within the Geiranger shear zone (sample 15: Kylander-Clark et al., 2008) is possibly a maximum age for deformation within this shear zone. Overall, the data from igneous rocks place a similar minimum bound as garnet upon the age of deformation in the Sandane shear zone and the Geiranger shear zone: translation was Scandian, and largely complete before at least 405–390 Ma. The presence of plagioclase in the dykes mandates crystallization during or after decompression—by association, the age of the oldest discordant dykes (ca. 405 Ma: Kylander-Clark and Hacker, 2014) indicates the (U)HP tectonism had ended by this time. If the discordant leucosomes largely crystallized after peak burial, then top-to-the-foreland translation on the shear zones described here is mostly earlier; it also must pre-date top-to-the-W extension (except where local reactivation took place).

The $^{40}Ar/^{39}Ar$ thermochronology of muscovite and biotite places constraints on when the gneiss sheets cooled through temperatures of <500–600ºC. Throughout hotter areas of the central and coastal Western Gneiss Region, biotite and muscovite cooling ages are 395–370 Ma (Hacker and Gans, 2005; Root et al., 2005; Walsh et al., 2007; Walsh et al., 2013) and young northwestward, suggesting slow, W-directed exhumation beneath regional extensional detachment systems. Regional muscovite chrontours (Walsh et al., 2013) are not disturbed by the Geiranger or Sandane shear zones, suggesting translation on these structures had ceased before this isotopic system closed. In the footwall of the Nordfjord-Sogn detachment zone, muscovite dates range more narrowly from 398 to 395 Ma in the Nordfjord area (Young et al., 2011; Warren et al., 2012) to 412–394 Ma in the southern Western Gneiss Region (Fossen and Dallmeyer, 1998; Fossen and Dunlap, 1998). Some disturbance of the chrontours around Nordfjord is due to extensional reactivation of Sandane shear zone where it converges with the Nordfjord-Sogn detachment zone. These dates specify top-to-the-west extension and regional cooling was ongoing by at least ca. 400 Ma, after top-to-the-east shearing had ceased. In the Lower Allochthon beneath the Jotun nappe complex (Middle Allochthon), phyllonites with top-to-the-east kinematic indicators yield muscovite $^{40}Ar/^{39}Ar$ ages between 415 and 408 Ma, interpreted as the latest age of thrusting toward the foreland (Fossen, 2000). Conversely, rocks overprinted by top-to-the-west fabrics yield muscovite $^{40}Ar/^{39}Ar$ ages between 405 and 398 Ma (Fossen and Dallmeyer, 1998; Fossen and Dunlap, 1998).

U/Th-Pb age systematics in monazite and titanite are more complex, and regional patterns in the central Western Gneiss Region are unclear. Titanites from mylonitic rocks in coastal exposures yield very young ages (389–377 Ma: Kylander-Clark et al., 2008; Spencer et al., 2013)—the disparity with the minimum age of shearing interpreted from other data sources (see above) may arise from late titanite growth, continuing recrystallization, or late closure of deformed, porphyroclastic titanite to Pb loss. Monazite data throughout the central Western Gneiss Region yield inherited Proterozoic ages and a few Scandian dates between 427 and 405 Ma (Hacker et al., 2015; Holder et al., 2015), but are mostly younger than ca. 400 Ma, reflecting the influence on age exerted by continued growth, deformation, recrystallization, melt formation, and fluid activity during exhumation. Overall, the Proterozoic to Scandian age variability of titanite and monazite in the central Western Gneiss Region complicates any macroscopic patterns that might relate to tectonostratigraphic position, proximity to deformation zones, or timing of exhumation.

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