GEOCHEMISTRY AND AGE OF THE WESTERN MÉLANGE BELT IN THE CASCADE FOOTHILLS AND EASTERN PUGET LOWLANDS OF WASHINGTON STATE: A RECORD OF MULTIPLE MESOZOIC ARC TERRANE ACCRETIONS

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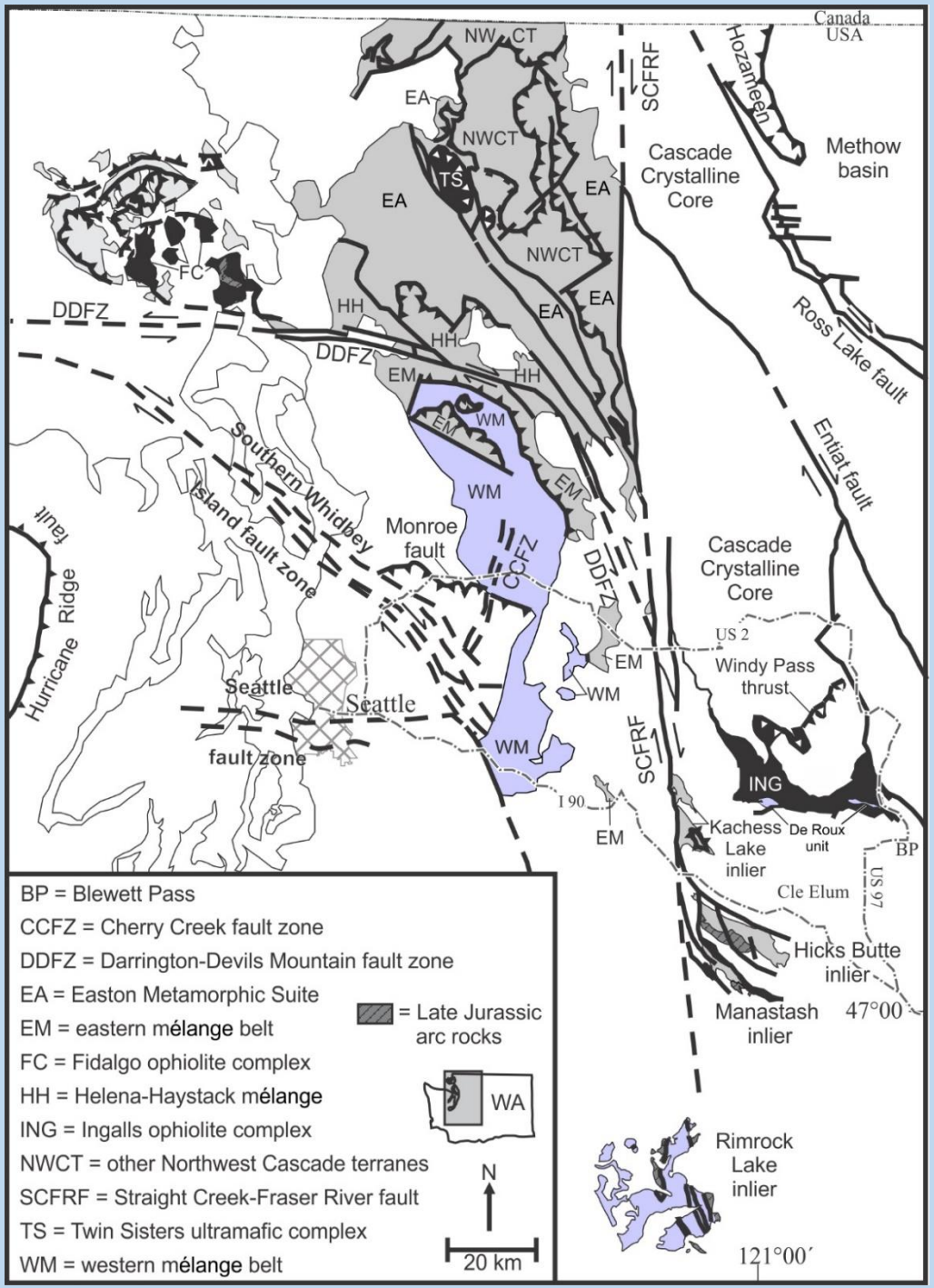
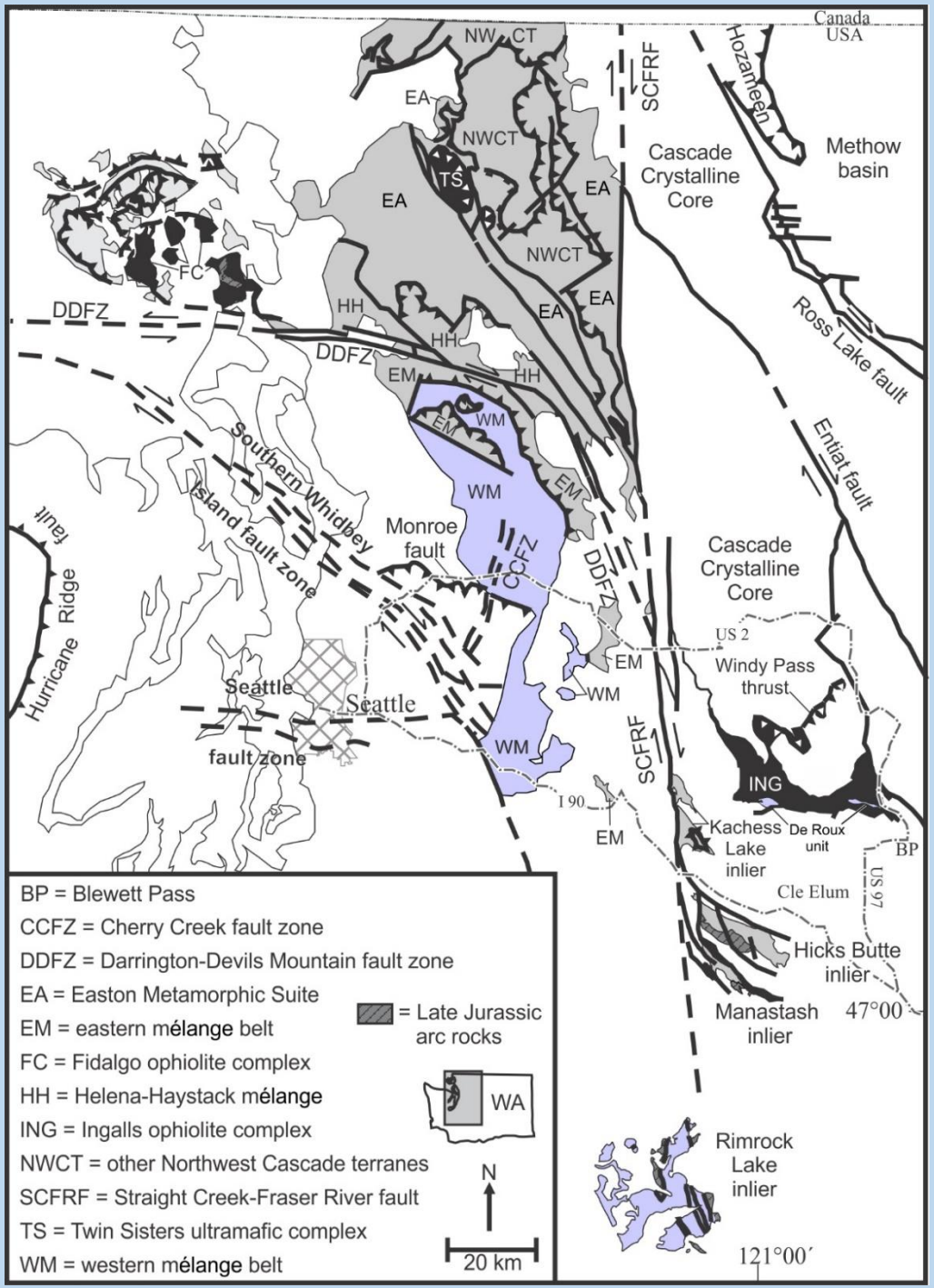


Regional geologic map of northwestern Washington.

Note the western mélange belt (WM) on the map in blue.

Also highlighted are the De Roux unit, in the central Cascades, and the Russell Ranch complex, in the Rimrock Lake inlier.

Diagram modified from Brown and Dragovich (2003) and MacDonald et al. (2017)

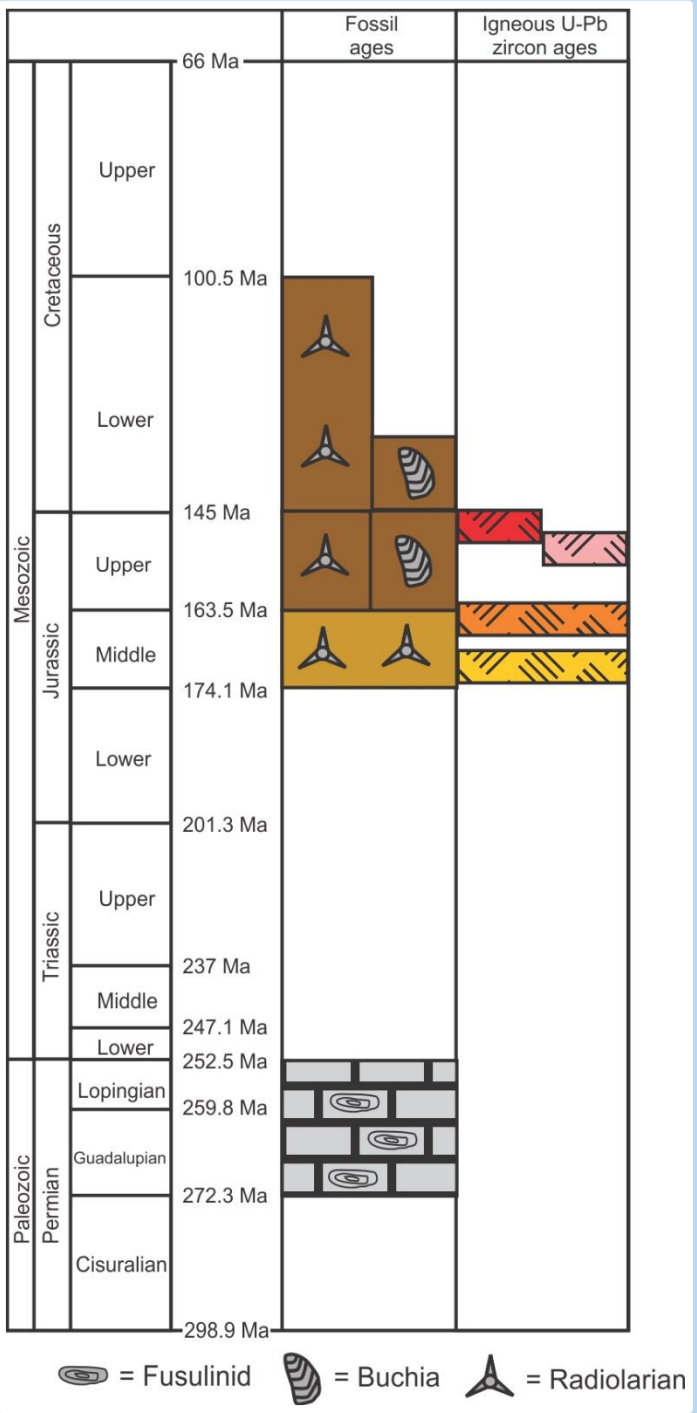


The western mélange belt was created by lumping numerous units with similar lithology and metamorphic grade (Frizzell et al., 1987).

E.G., Old Metamorphic Series, in part (Carithers and Guard, 1945), Olo Mountain Unit, in part, Sultan Unit, Stillaguamish Group, and Woods Creek intrusive bodies (Danner, 1957).

The units not placed in the western mélange belt became the eastern ménage belt (slightly older & more ultramafic rocks).

Silberling et al. (1987) placed the western mélange belt in the Olney Pass terrane; and, correctly noted the mélange consists of outcrop- to mountain-size phacoids of sedimentary rocks with less common meta-igneous rocks.



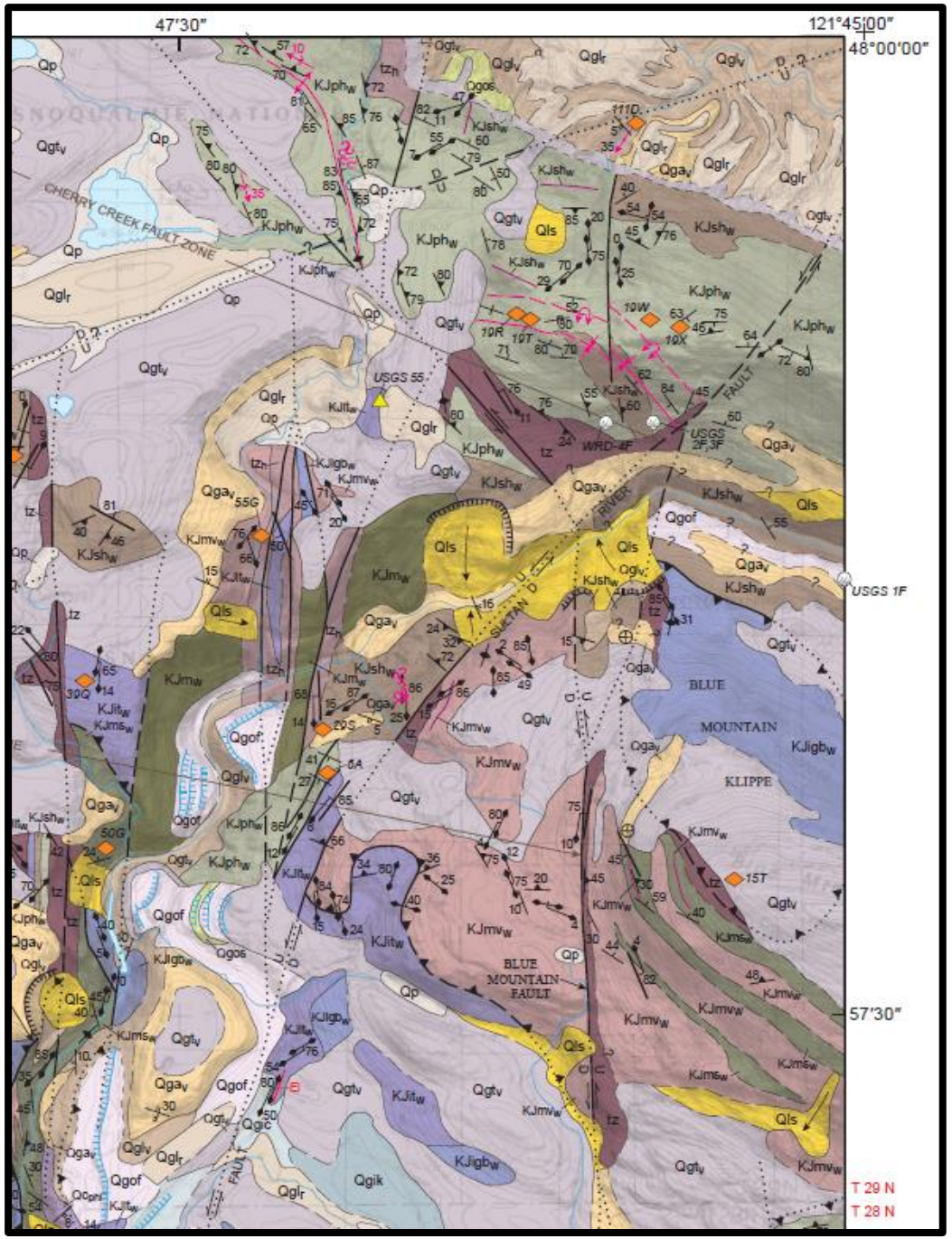
Summary of ages from the western mélange belt. Time scale from Ogg et al. (2016)

Fossil ages range from Middle Jurassic to Lower Cretaceous.

Permian limestone is interpreted to be exotic.

Igneous ages are Middle to Late Jurassic.

Fossil ages from Danner (1957; 1963; 1966), and Tabor et al. (2002)
Igneous ages from Whetten et al. (1980), Frizzell et al. (1987), Tabor et al. (1993; 2002).



Mesozoic Low- to Medium-Grade Metamorphic Rocks (Prehnite–Pumpellyite to Greenschist Facies)

KJm_w **Western mélange belt undivided**

$KJmv_w$ **Metavolcanics**

$KJsh_w$ **Greenschist**

$KJms_w$ **Metasedimentary**

$KJph_w$ **Phyllite**

$KJigb_w$ **Metagabbro**

$KJit_w$ **Metatrondhjemite**

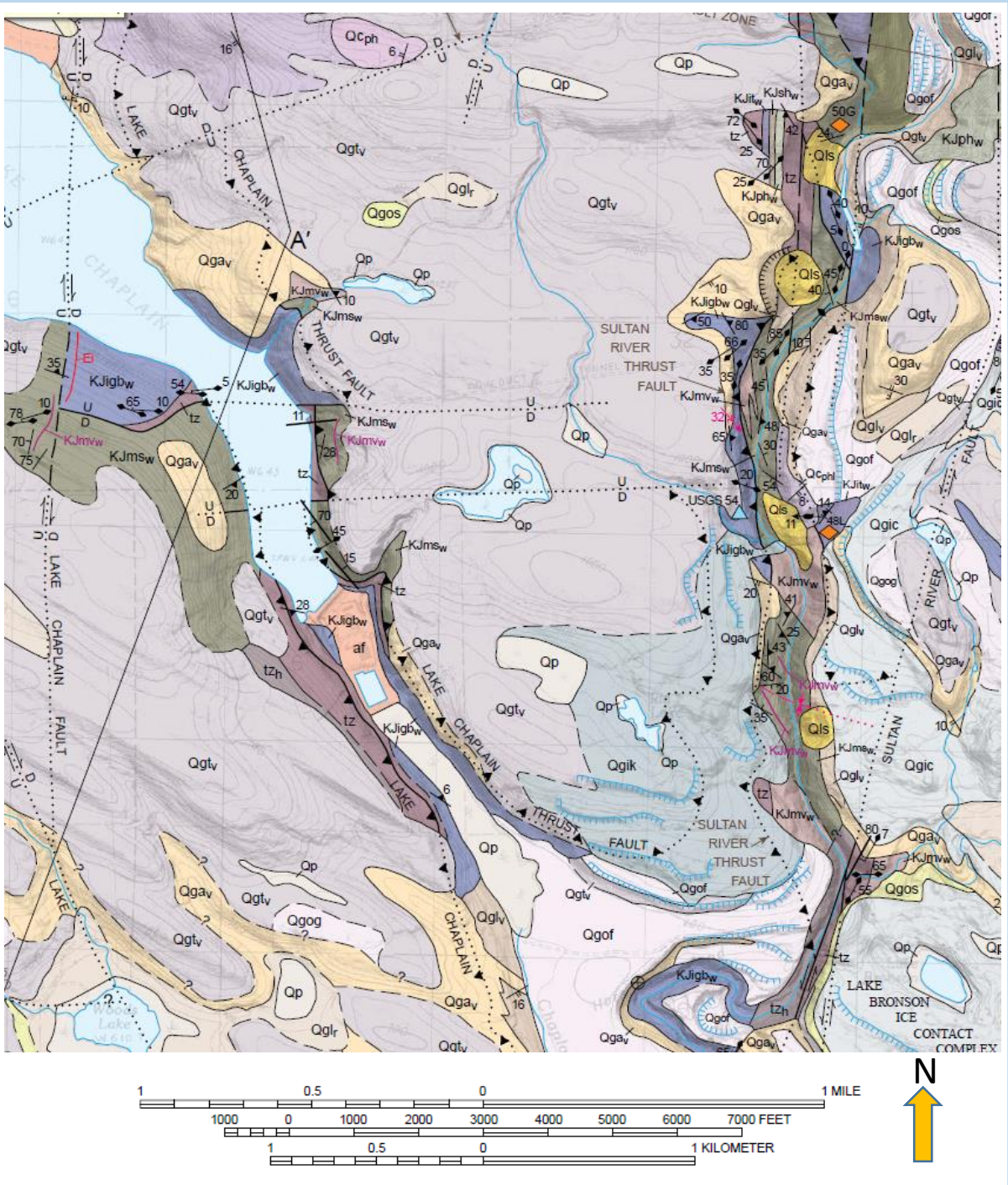
1 kilometer

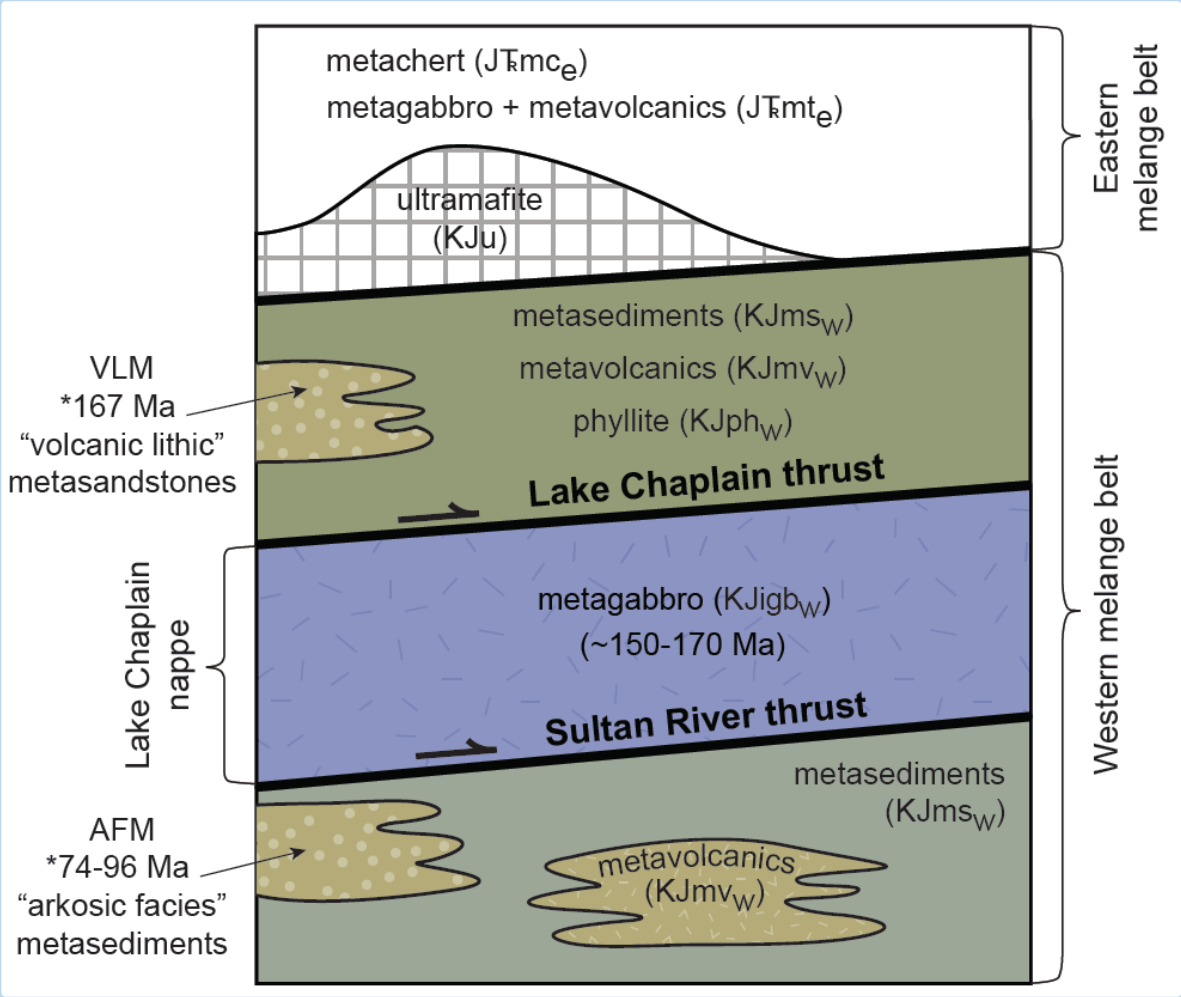
True North

Holocene to Tertiary Tectonic Zones

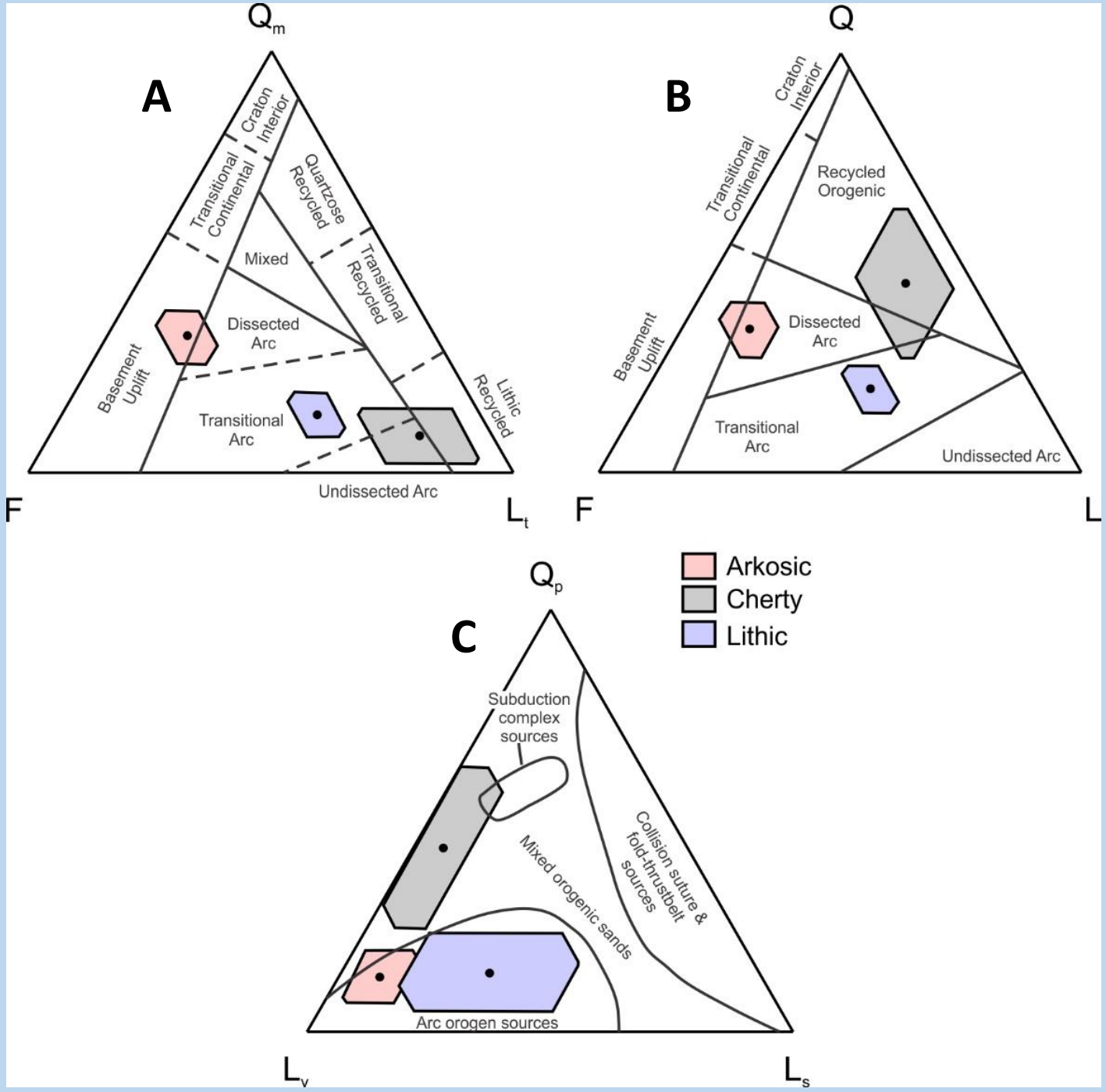
tz **Fault zones**

tz_h





Structural block diagram showing the Sultan River and Lake Chaplain thrusts bounding the Lake Chaplain nappe of Dragovich et al. (2014, 2015).



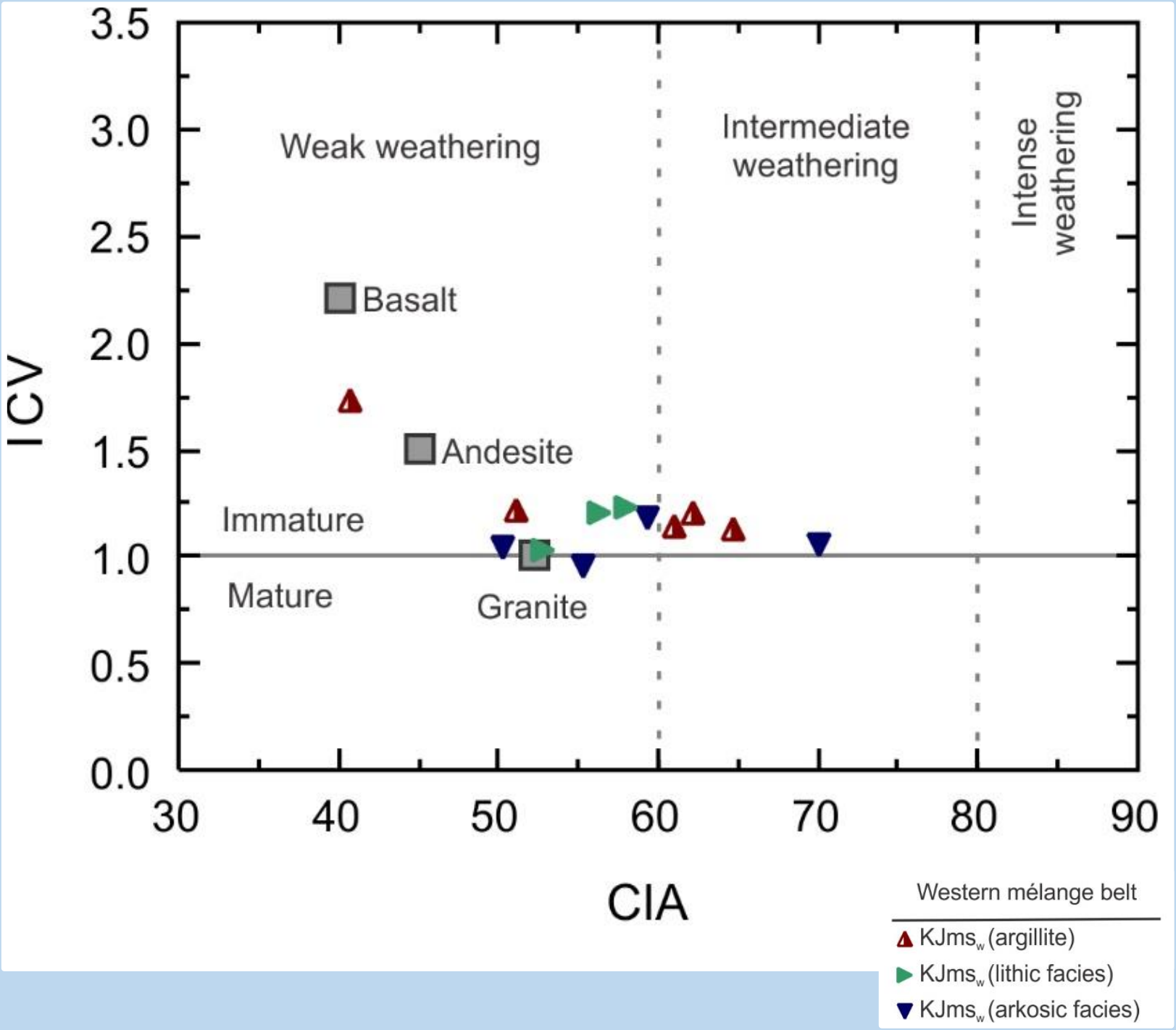
Western mélange belt sandstone point-count data from Jett and Heller (1988).

A) Q_m–F–Lt diagram after Dickinson et al. (1983).

B) Q–F–L diagram after Dickinson et al. (1983).

C) Q_p–L_v–L_s diagram after Dickinson (1985).

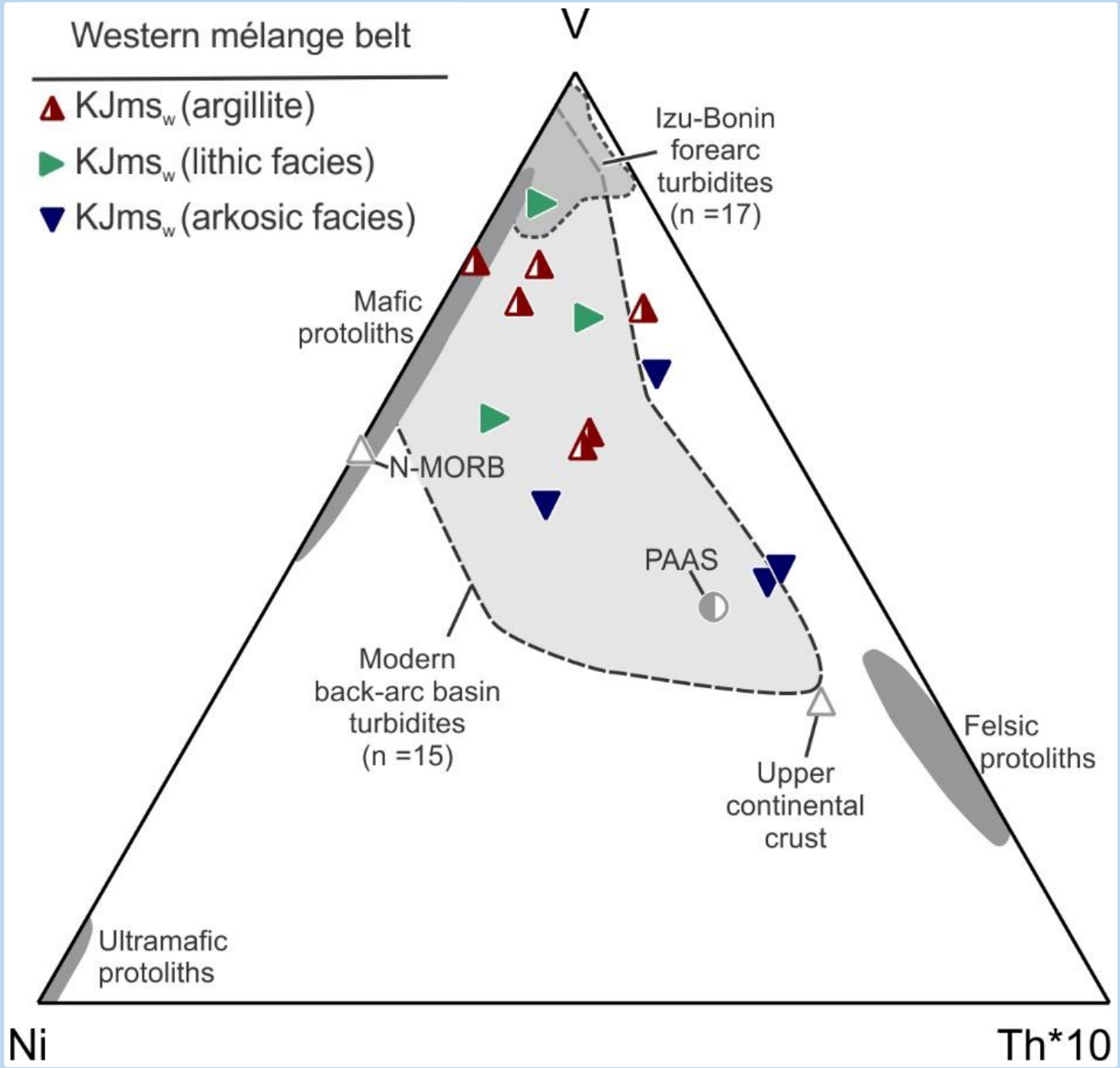
Q—monocrystalline quartz + polycrystalline quartz + chert; F—feldspar (all plagioclase in these samples); L—unstable lithics; Qm—monocrystalline quartz; Lt—total polycrystalline lithic fragments, including stable quartzose; Qp—chert + polycrystalline quartz; Lv—lithic volcanics; Ls—sedimentary + metasedimentary lithics.



CIA = chemical index of alteration (Nesbit & Young, 1982; Nesbit et al., 1995). ICV = index of compositional variability (Cox et al., 1995)

CIA suggested the western mélange belt sedimentary samples are weakly to intermediately weathered.

ICV suggests the western mélange belt sedimentary samples are mostly immature and transitional between felsic and intermediate

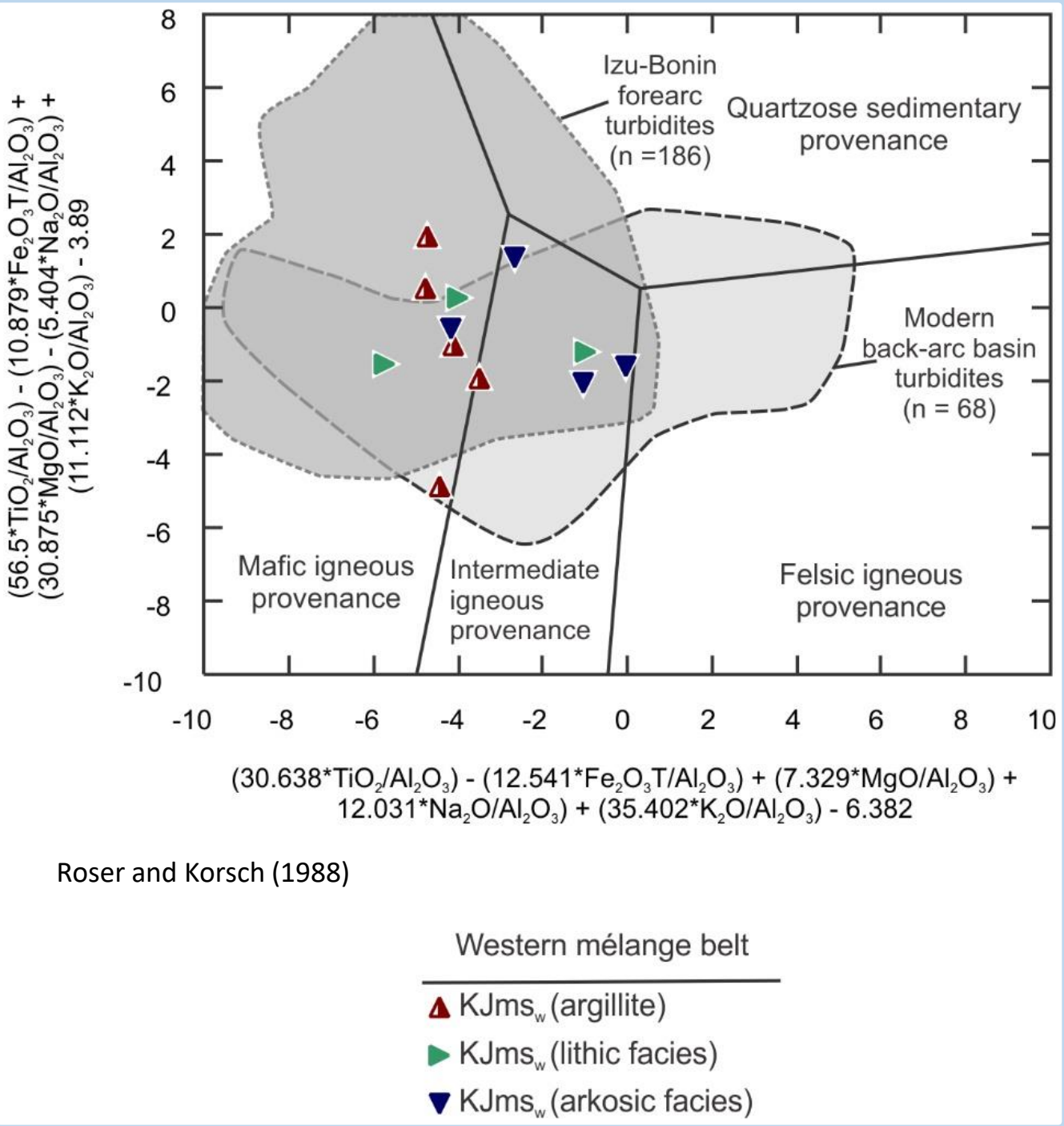


Provenance sedimentary geochemistry for the western mélange belt plotted on the V-Ni-Th diagram of Bracciali et al. (2007).

Arkosic facies are intermediate to felsic

Lithic facies is intermediate to mafic.

Modified from MacDonald and Dragovich (2015). Field for modern back-arc basin turbidites from McLennan et al. (1990). Field for forearc turbidites from Hiscott and Gill (1992) & Gill et al. (1994).



Roser and Korsch (1988)

Western mélange belt

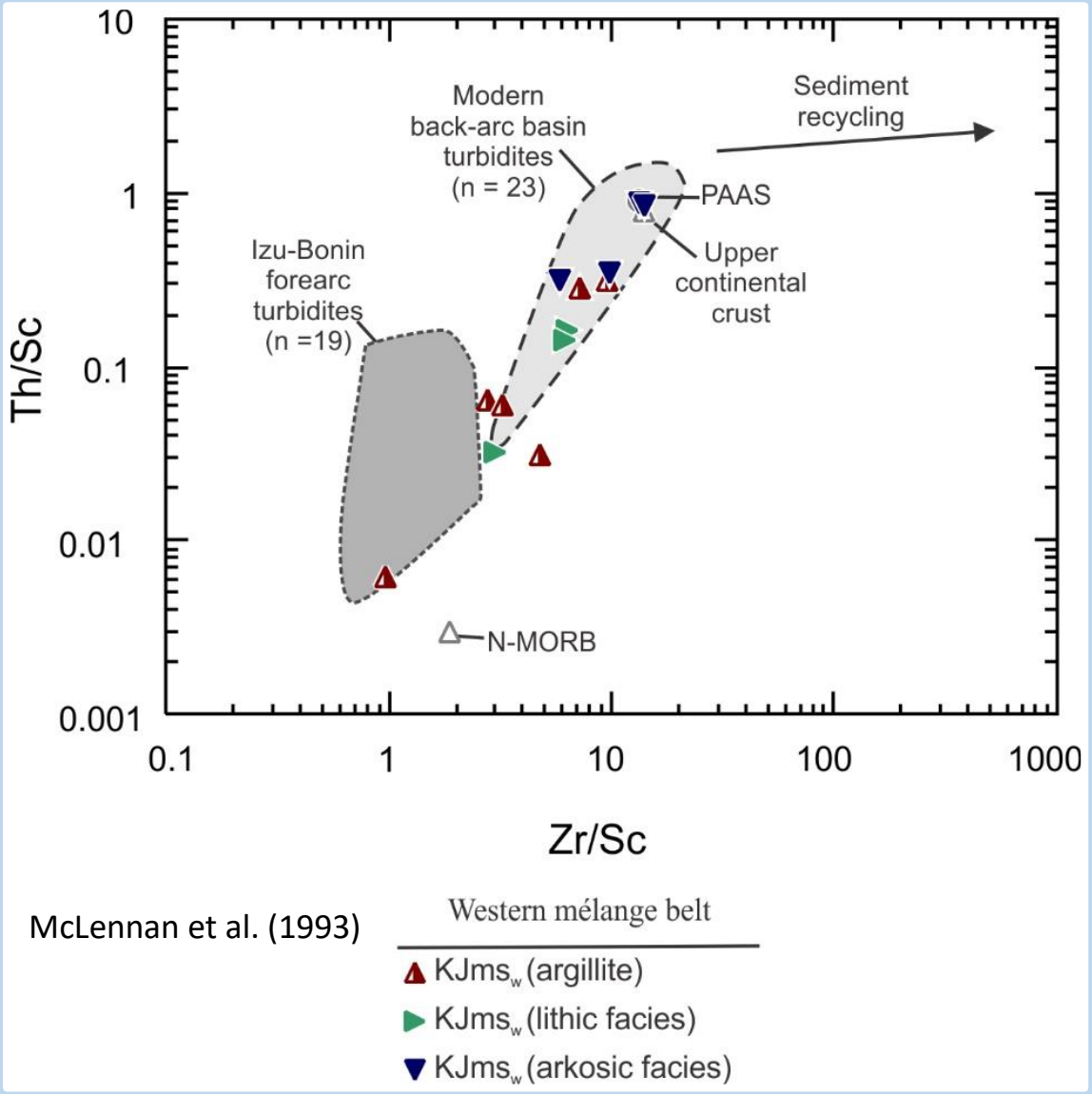
- KJms$_w$ (argillite)
- KJms$_w$ (lithic facies)
- KJms$_w$ (arkosic facies)

Provenance sedimentary geochemistry for the western mélange belt modified from Roser and Korsch (1988).

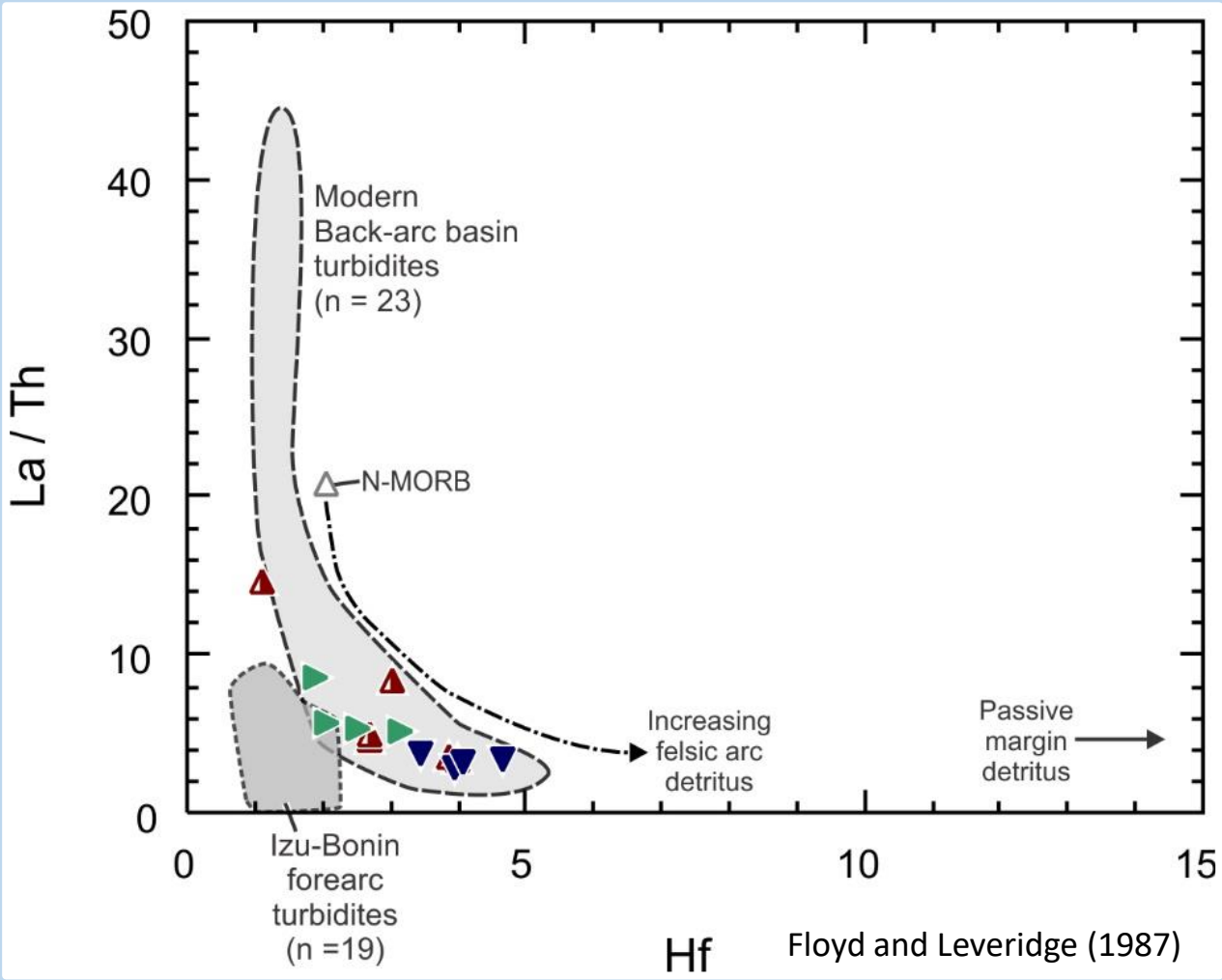
Arkosic facies are mostly intermediate

Lithic facies are mostly mafic.

Field for modern back-arc basin turbidites from McLennan et al. (1990) and Bednarz and Schmincke (1994). Field for forearc turbidites from Hiscott and Gill (1992) & Gill et al. (1994).



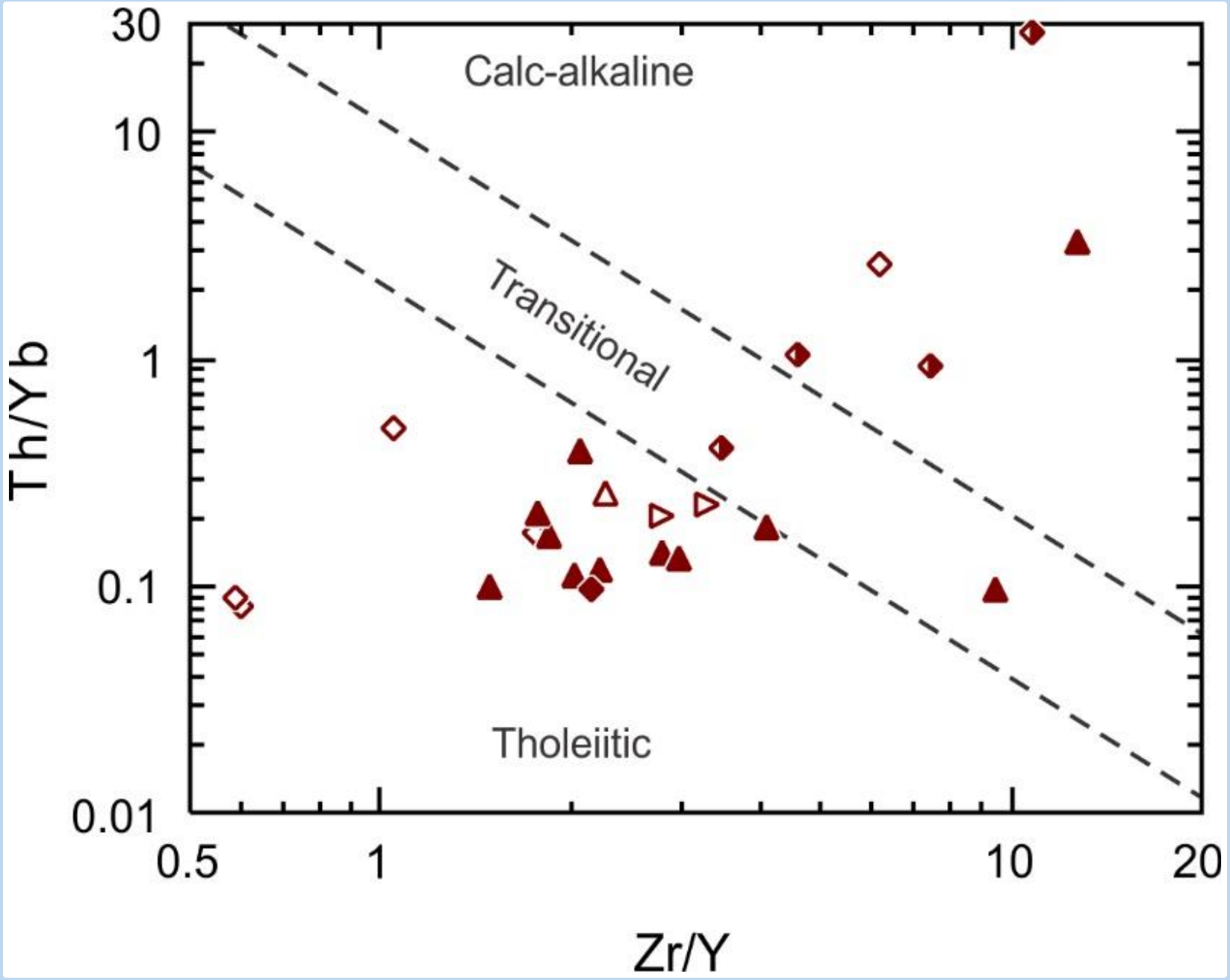
McLennan et al. (1993)



Floyd and Leveridge (1987)

Sedimentary geochemistry discrimination diagrams for the western mélange belt. Samples plot in the field defined by back-arc basins.

Field for modern back-arc basin turbidites from McLennan et al. (1990). Field for forearc turbidites from Hiscott and Gill (1992) & Gill et al. (1994).

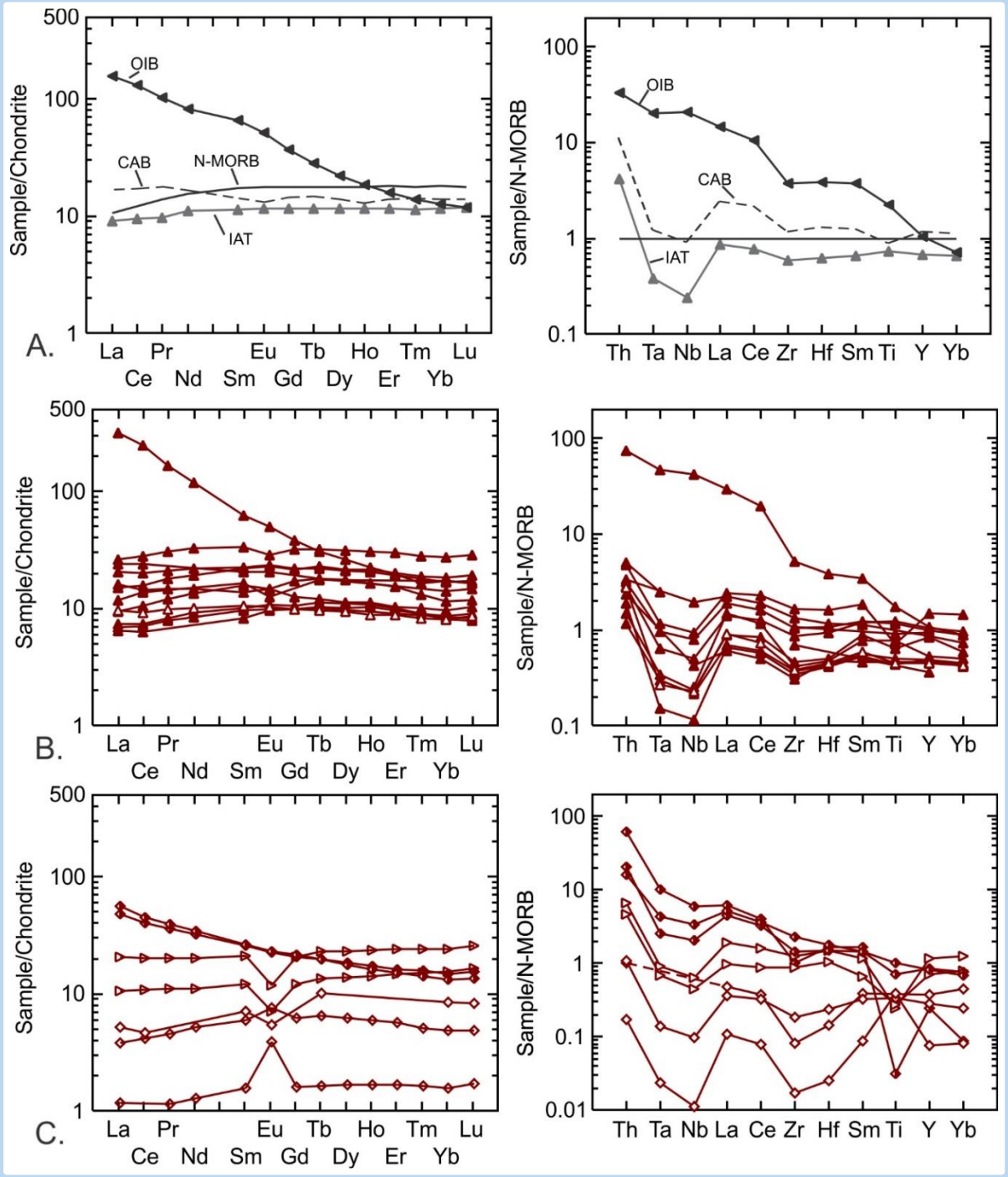


Igneous samples from the western mélange belt plotted on the Th/Yb vs. Zr/Y magmatic affinity discrimination diagram of Ross & Bédard (2009). Samples are mostly tholeiitic

Data from Vance et al. (1980), Tabor (1994), & Dragovich et al. (2009a,b, 2013, 2014).

Western mélange belt

- $Kjmv_w$ & $KJsh_w$
- $KJit_w$
- $KJigb_w$
- $KJmv_w$-tuff & $KJsh_w$-tuff
- $KJigb_w$(diabase)
- $KJigb_w$(amphibolite)



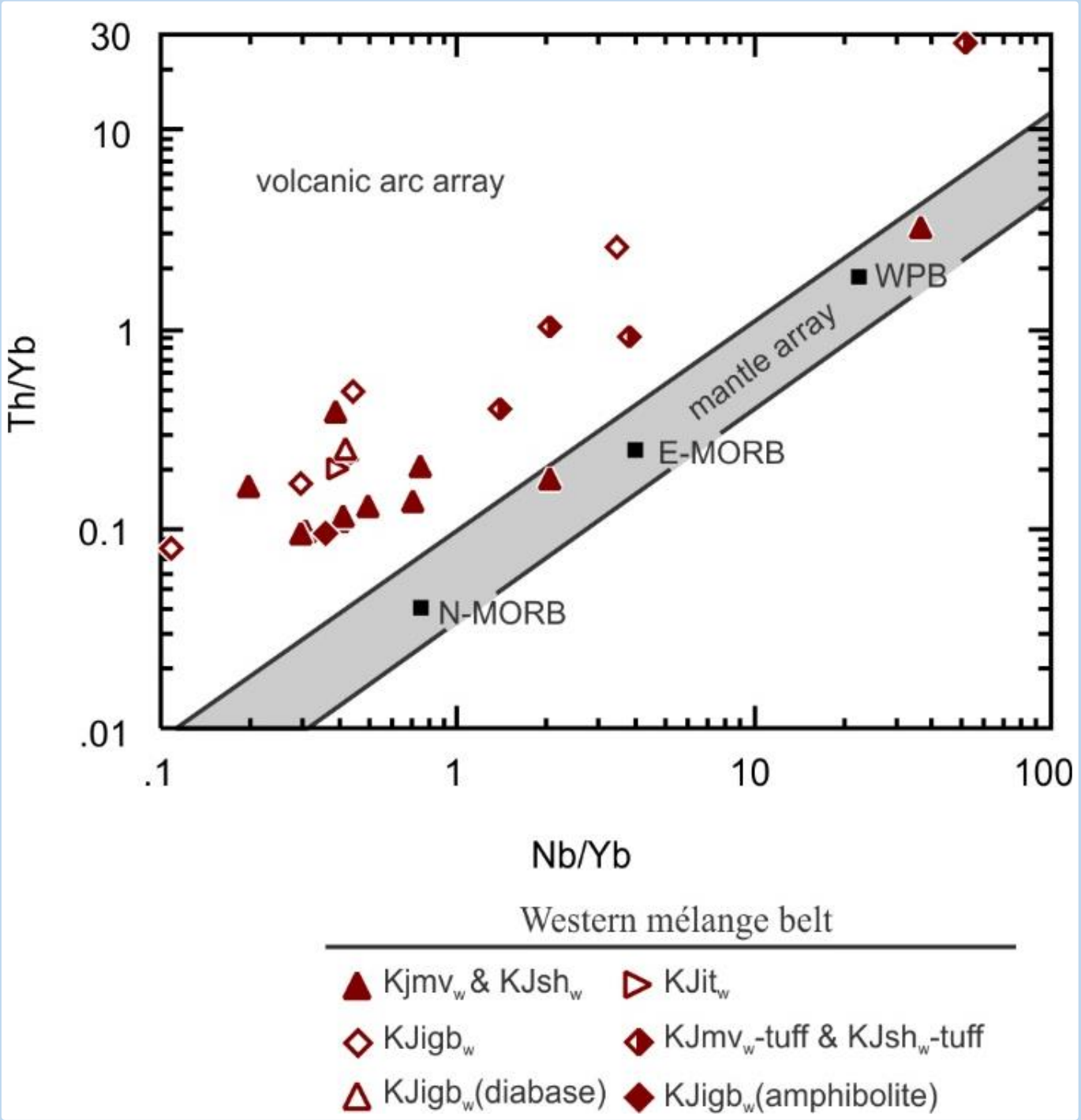
Chondrite– & N-MORB-normalized diagrams for western mélange belt igneous samples. Data from Vance et al. (1980), Tabor (1994), & Dragovich et al. (2009a,b, 2013, 2014).

Note the strong arc geochemical signature for most sampels.

Normalized values are from Sun and McDonough (1989) and McDonough & Sun (1995).

Western mélange belt

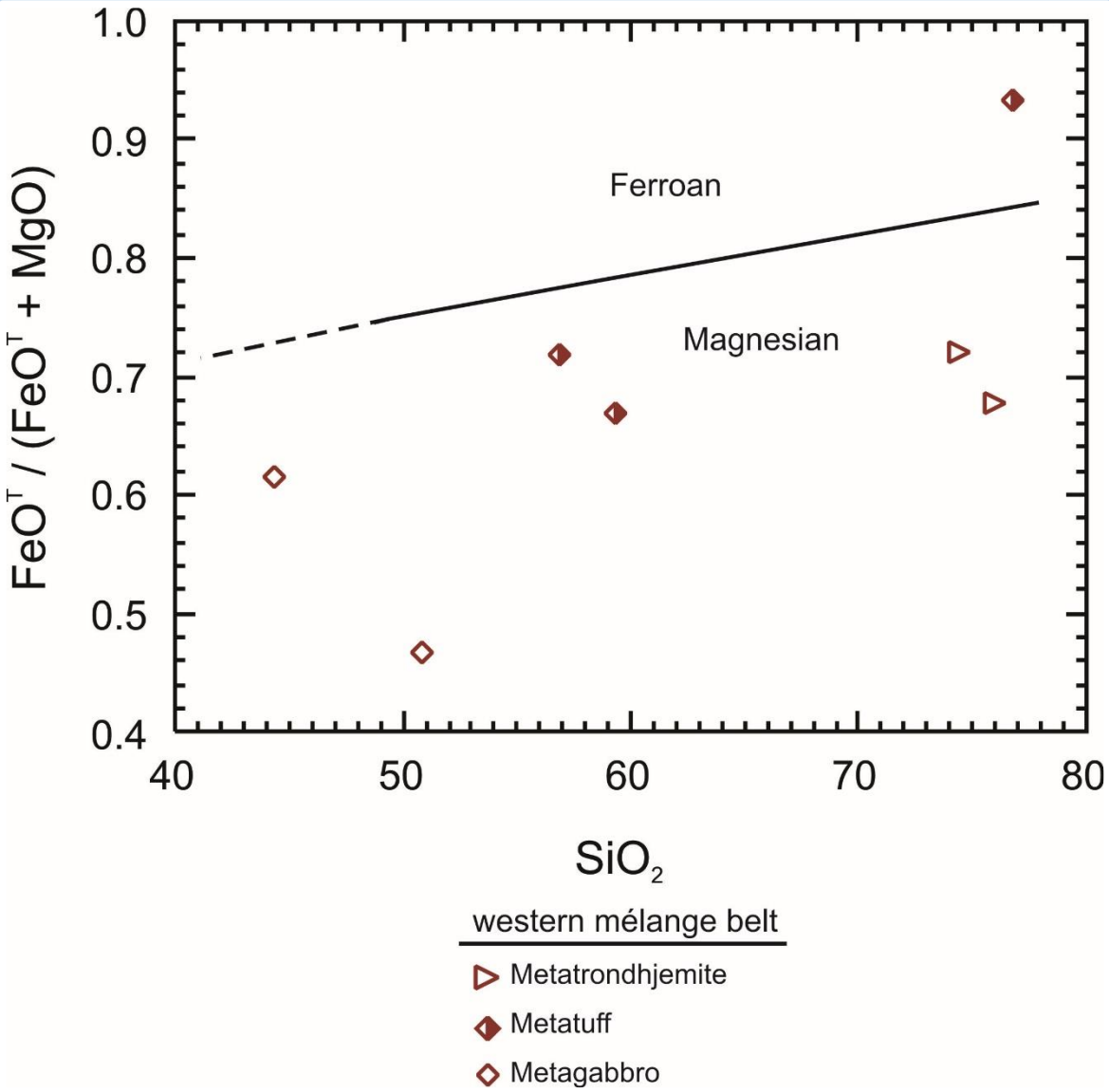
- $Kjmv_w$ & $KJsh_w$
- $KJit_w$
- $KJigb_w$
- $KJmv_w$-tuff & $KJsh_w$-tuff
- $KJigb_w$(diabase)
- $KJigb_w$(amphibolite)

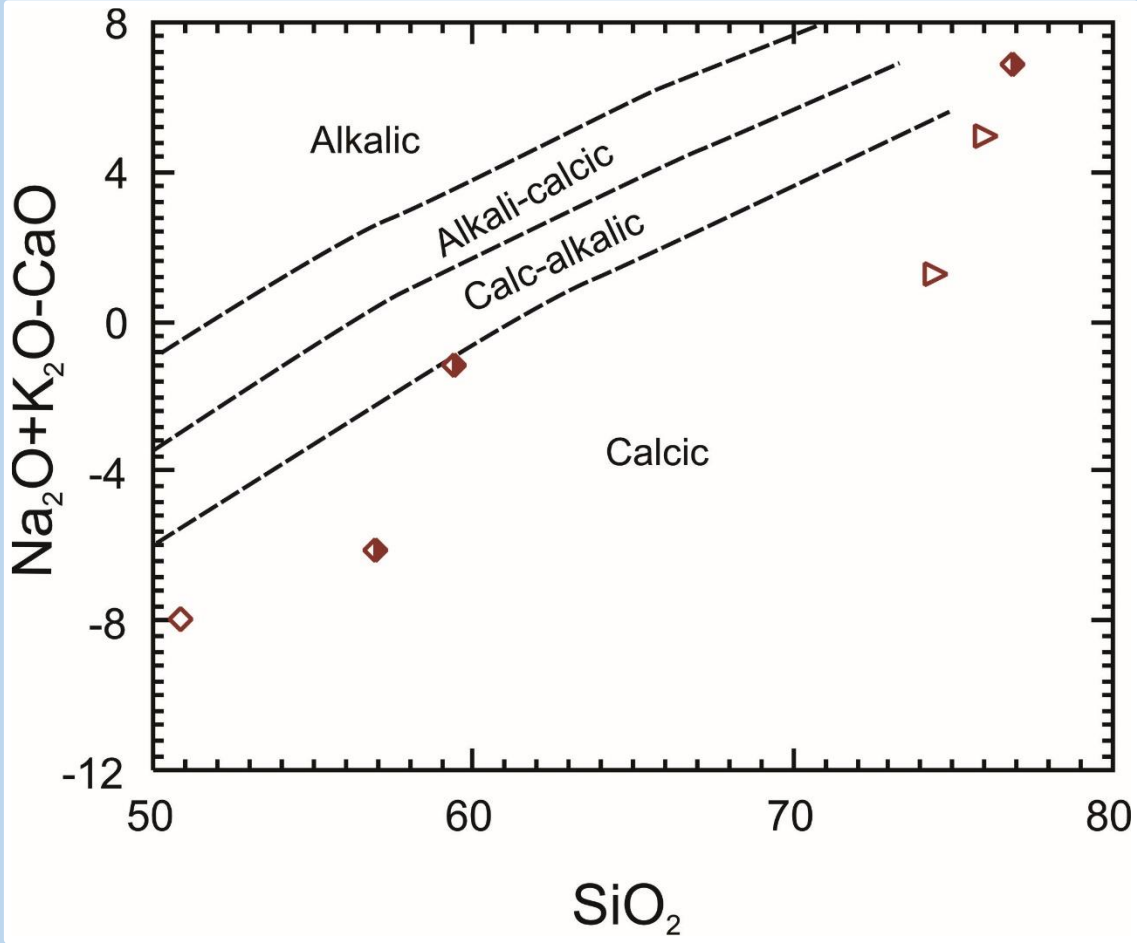


Igneous samples form the western mélange belt plotted on the Th/Yb vs. Nb/Yb diagram of Pearce (1982, 2008).

Note the primarily arc composition for most sampels.

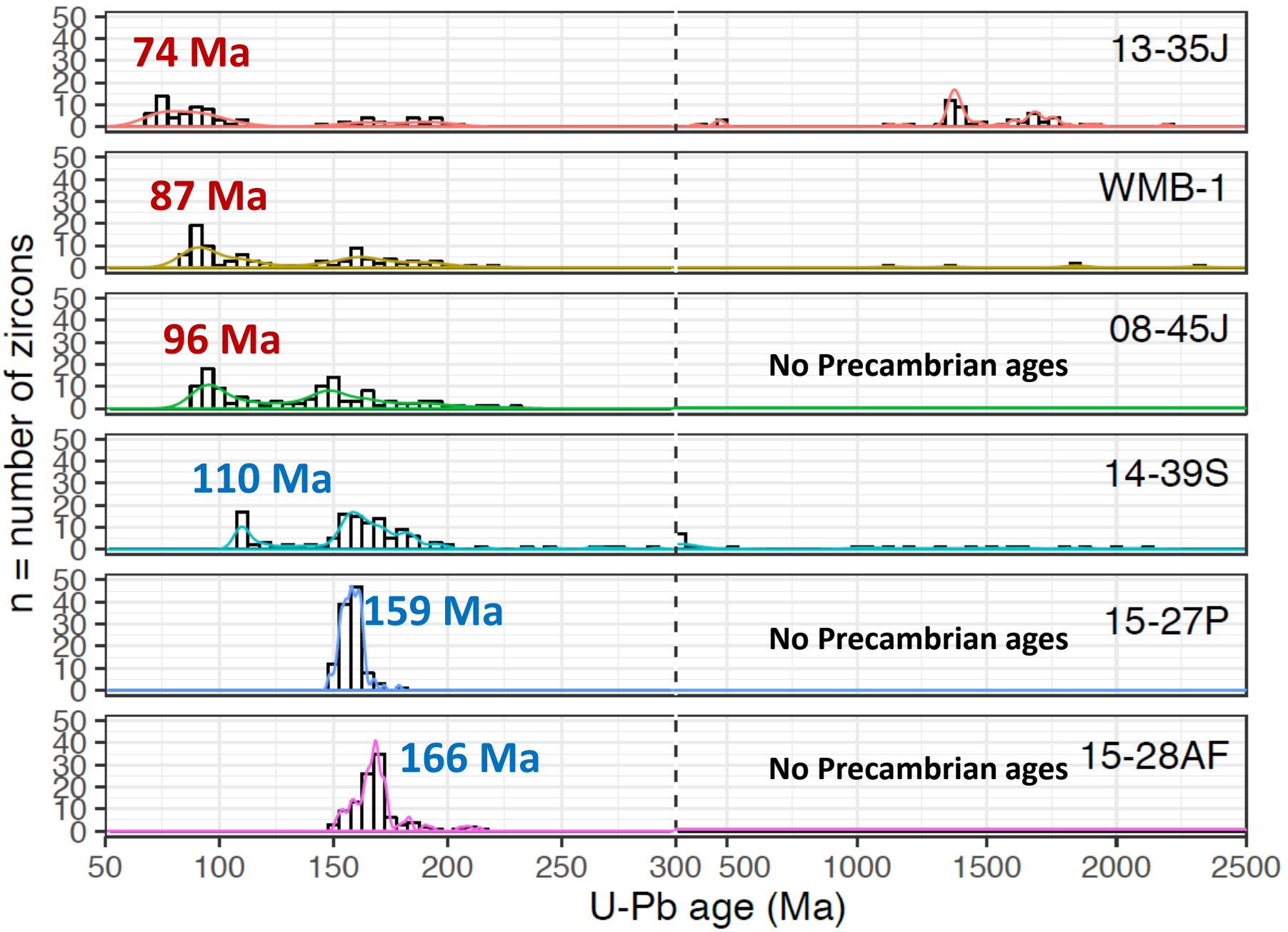
Data from Vance et al. (1980), Tabor (1994), & Dragovich et al. (2009a,b, 2013, 2014).





Intrusives and tuffs from the western mélange belt plotted on the Fe-number vs. SiO_2 and modified alkaline-calcic index (MALI) vs. SiO_2 diagrams of Frost et al. (2001).

Detrital zircon U-Pb ages from western mélange belt sandstones



Arkosic facies (Dragovich et al., 2014; Sauer et al., 2017)

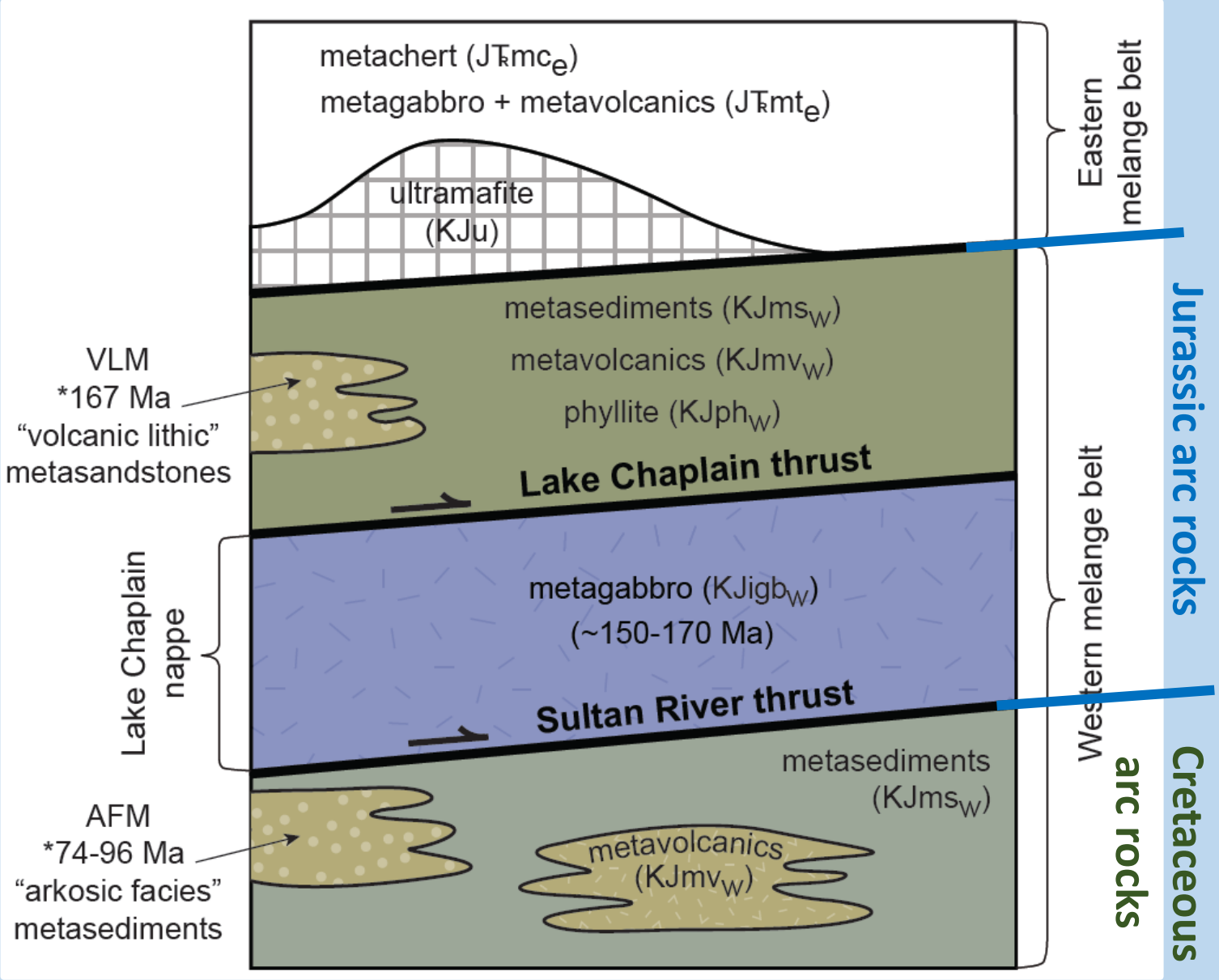
Arkosic facies (Brown, 2012)

Arkosic facies (Dragovich et al., 2009)

Lithic facies (Dragovich et al., 2015; Sauer et al., 2017)

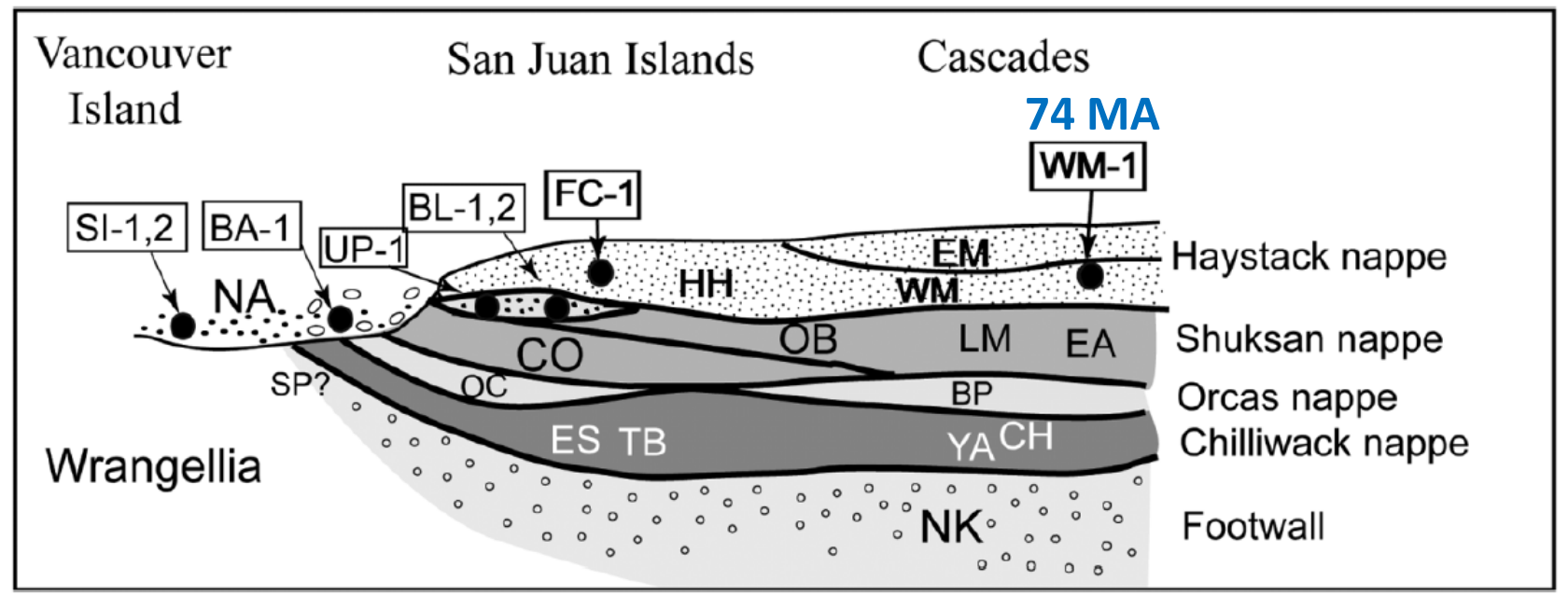
Lithic facies (Dragovich et al., 2016)

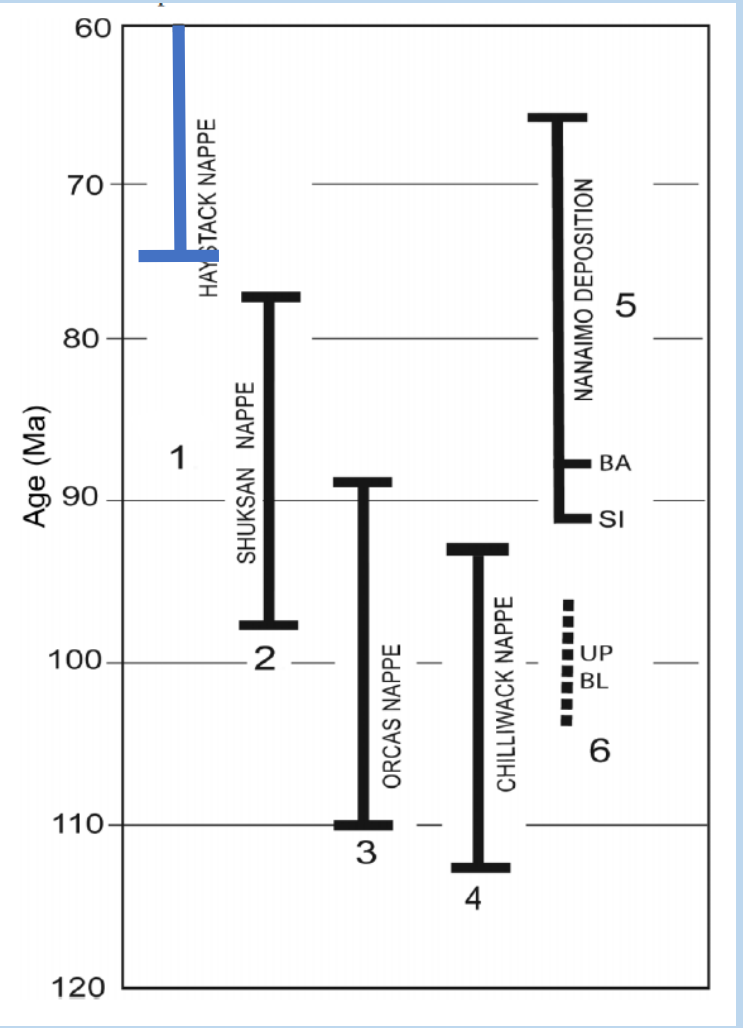
Lithic facies (Unpublished)



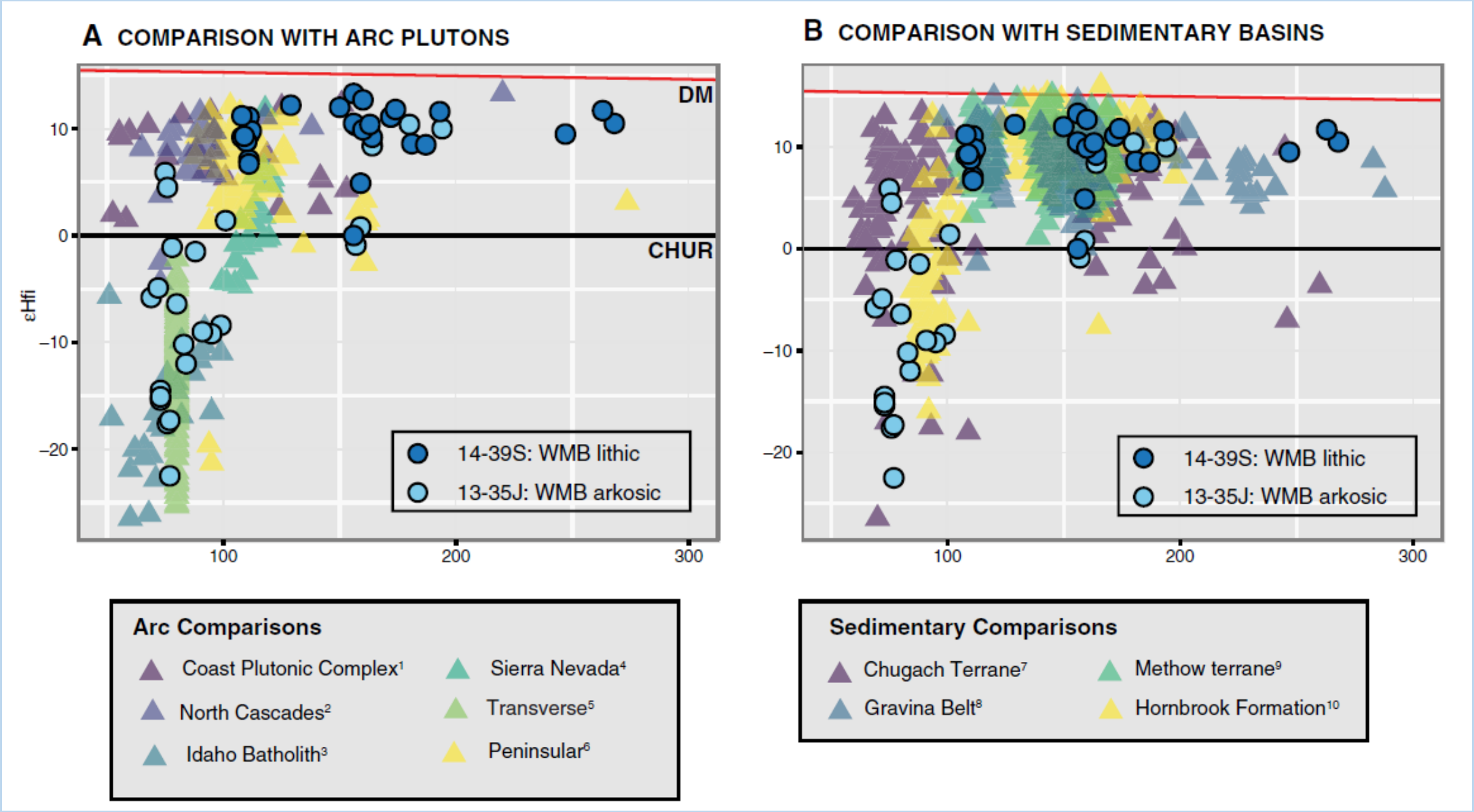
- **Western mélange belt consists of at least two distinct arc terranes:**
  - **one is Jurassic**
  - **one is Cretaceous**
- **In our map area, the Jurassic arc rocks are thrust faulted over the Cretaceous arc rocks.**
- **Relationship between Jurassic and Cretaceous arc rocks is structural.**

Dragovich et al. (2016)





Age of nappe emplacement modified from Brown (2012). The 74 ma detrital zircon age decreases the maximum mage of thrusting by 13 million years.



What, if any, implications do these finds have on terrane translations?

See Sauer et al. (2017)