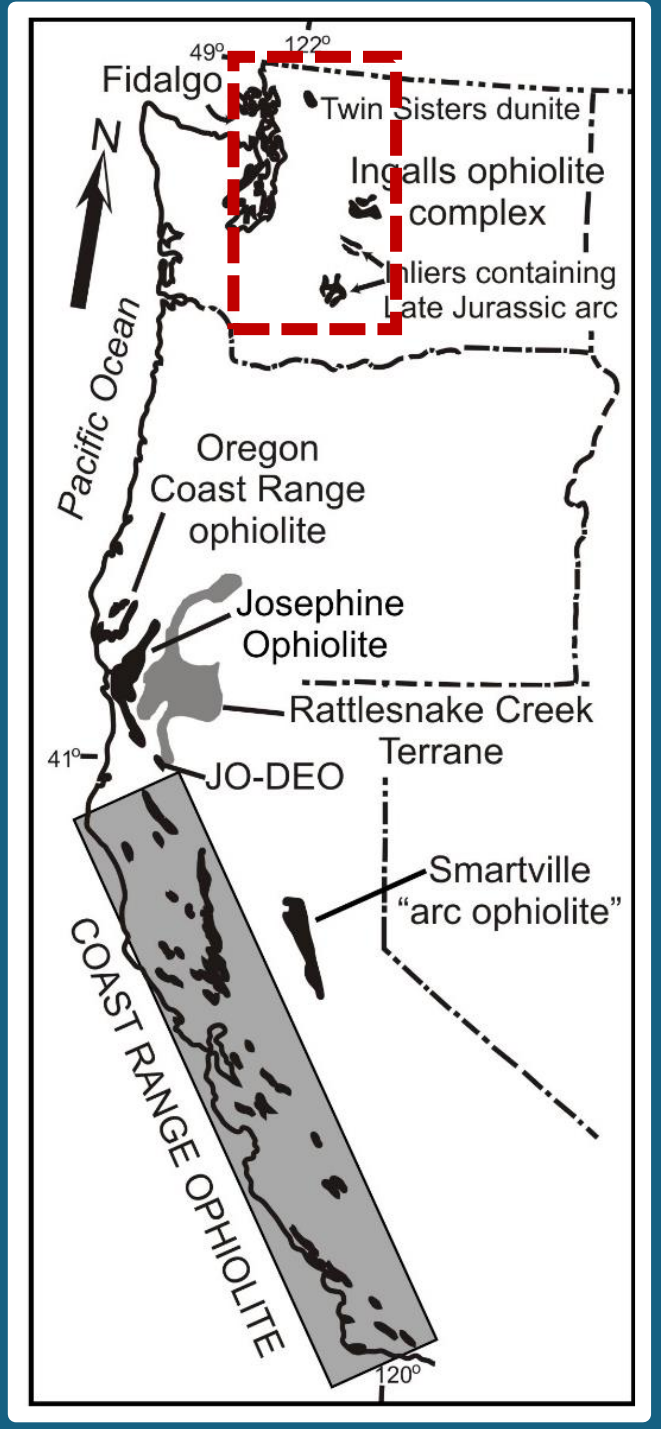
GEOCHEMISTRY AND TECTONIC EVOLUTION OF THE POLYGENETIC INGALLS OPHIOLITE COMPLEX, CENTRAL CASCADES, WASHINGTON

Plumes, ophiolites, and oceanic crust? We got'em all!

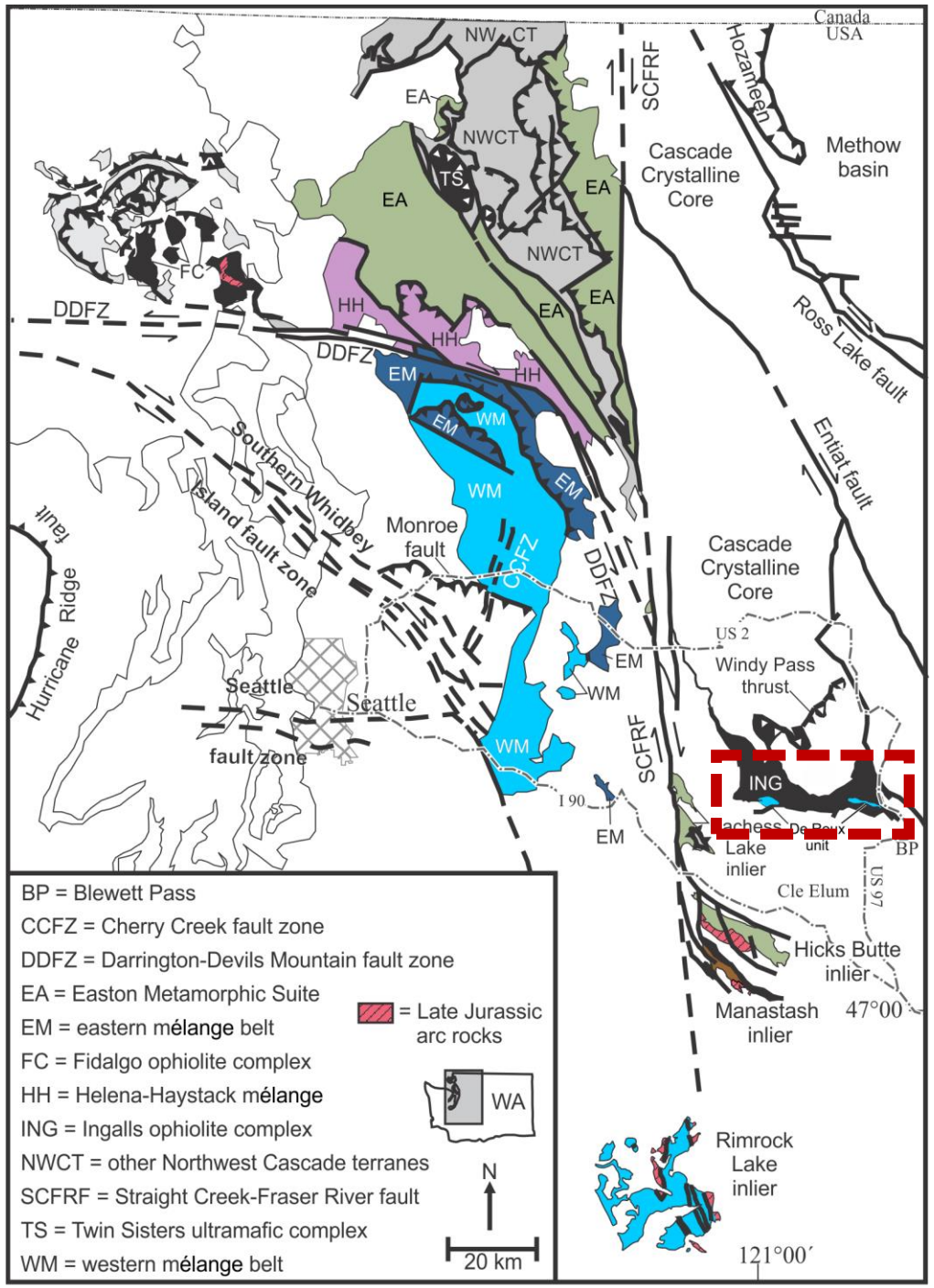
By Jamie MacDonald & Bob Miller



Location of the Middle to Late Jurassic North American Cordilleran ophiolites. The older ophiolitic Rattlesnake Creek terrane is also displayed.

Figure is from MacDonald et al. (2008).

JO-DEO = Devils Elbow ophiolite.



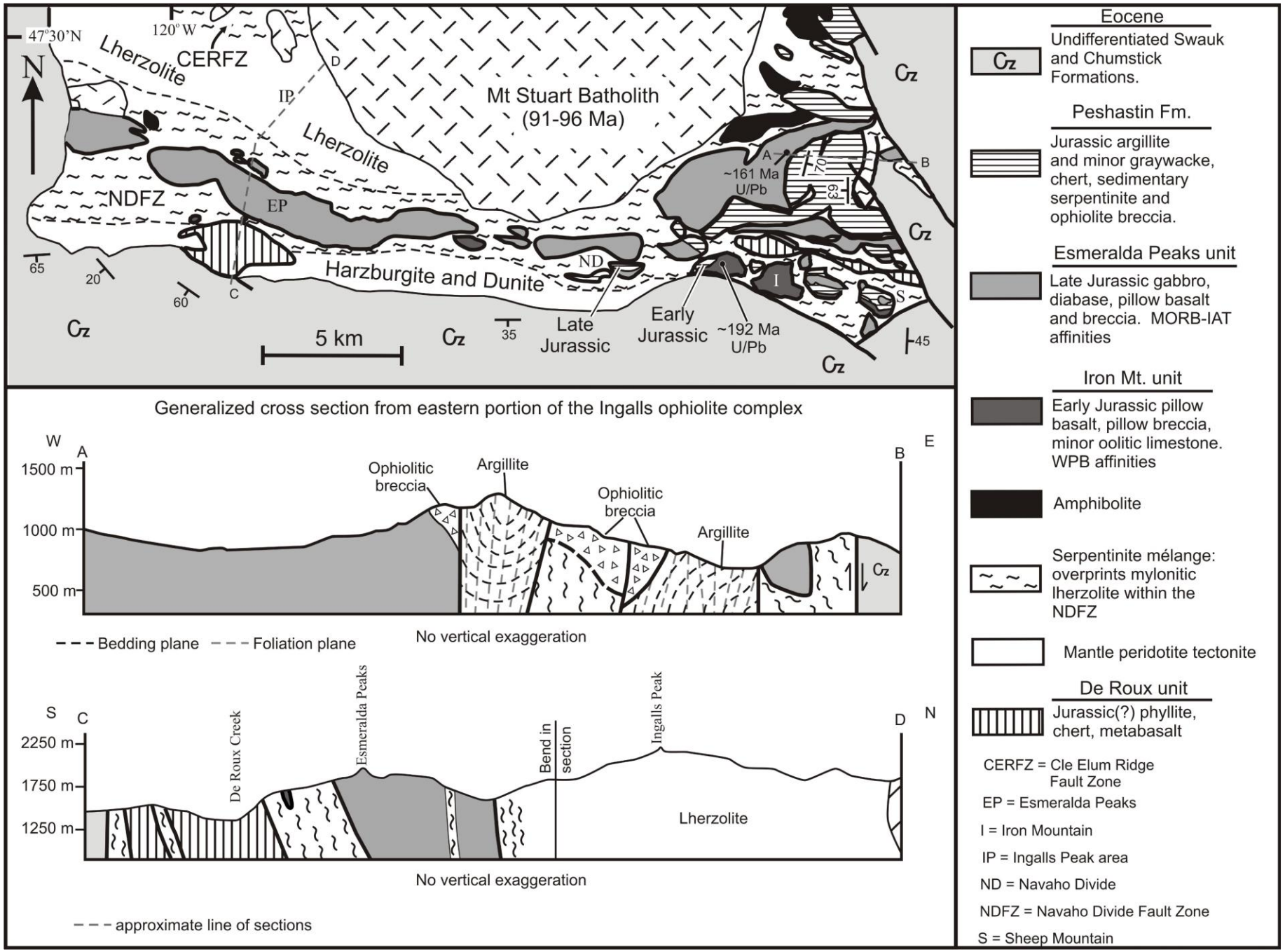
Simplified geologic map displaying pre-Cenozoic tectonic elements of the central and northwest Cascades

Note the:

Ingalls ophiolite complex (ING) (MacDonald et al., 2008; Miller, 1985)

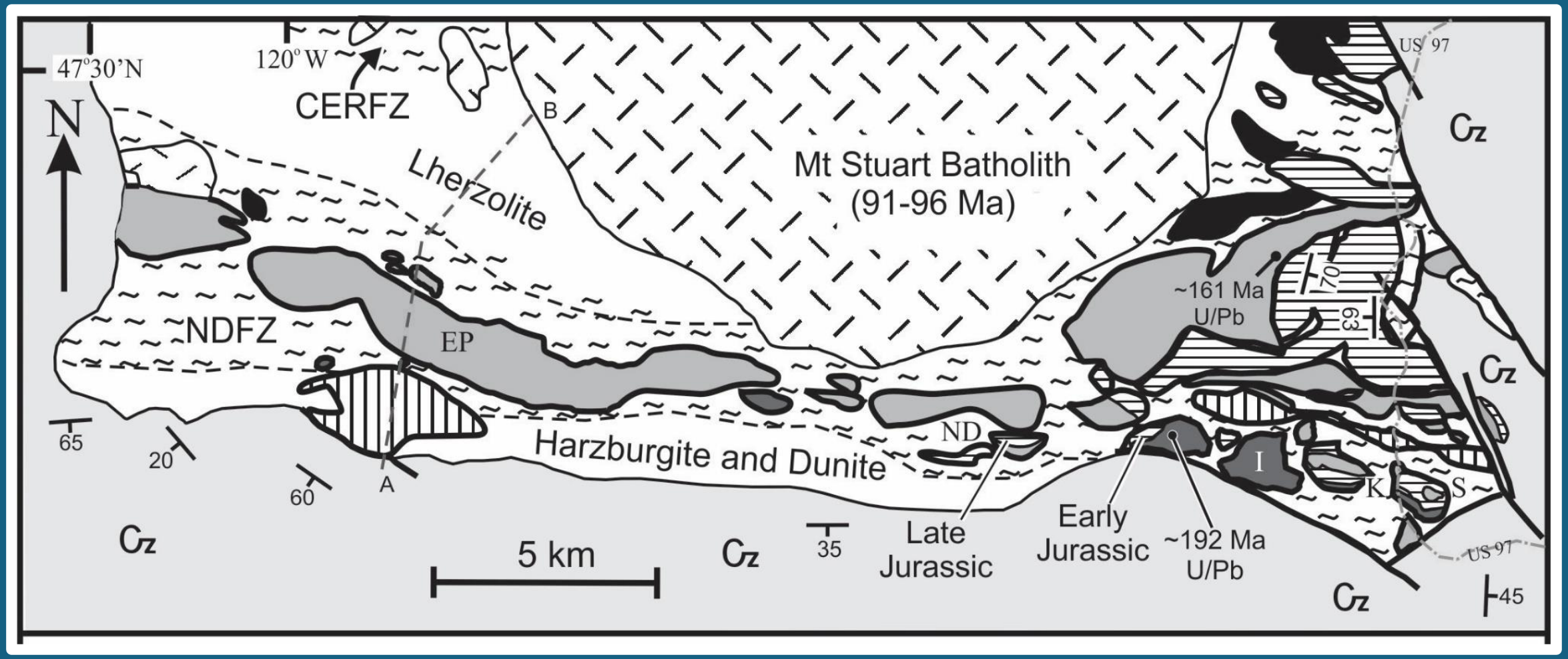
Fidalgo ophiolite complex (FC) of the Decatur terrane (Brown, 2012)

& Twin Sisters ultramafic complex (TS) in the Bell Pass mélange (Tikoff et al., 2010);



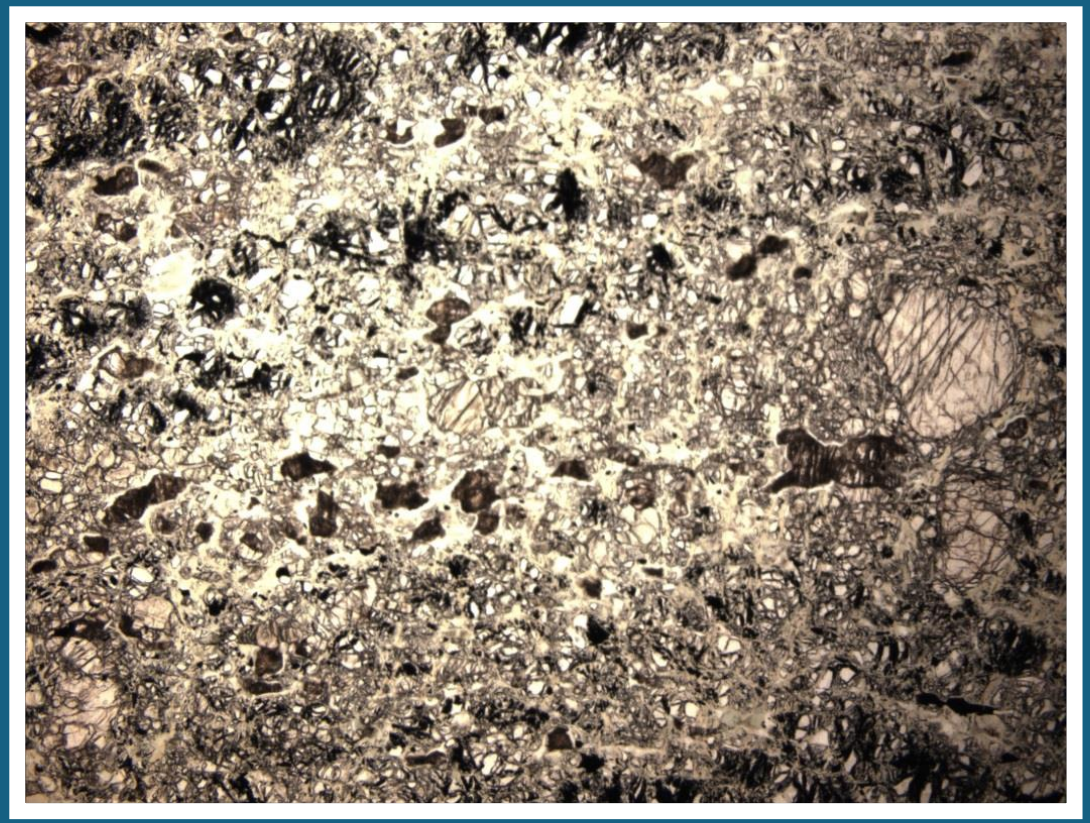
Ingalls ophiolite complex is a nearly complete, yet highly dismembered polygenic ophiolite.

(Miller, 1985; MacDonald et al., 2008)



Three distinct peridotite units, which have been variably serpentinized.

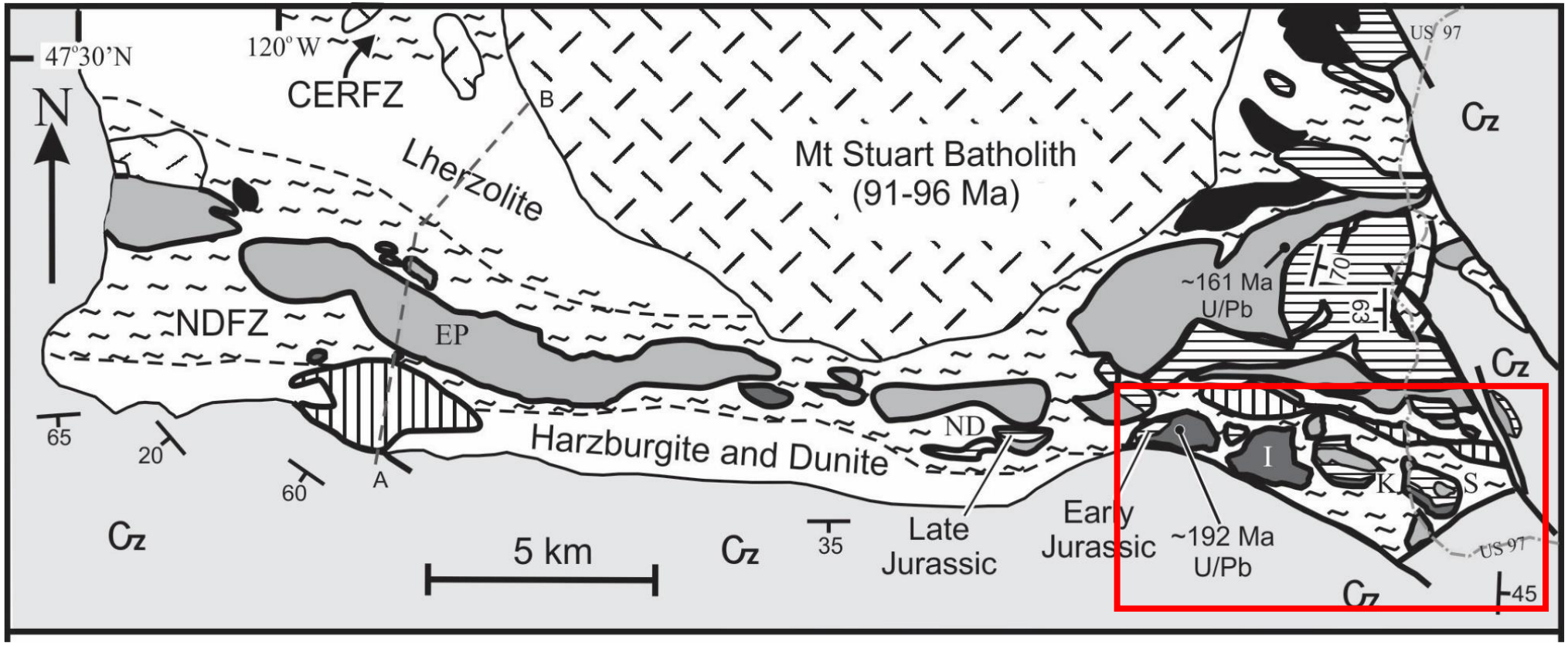
1. **Southern dunite and harzburgite unit;**
2. **Central lherzolite, hornblende peridotite, and plagioclase peridotite overprinted by a high-to low-temperature Navaho Divide fault zone (NDFZ);**
3. **And a northern lherzolite unit (Miller and Mogk, 1987).**



Mylonitic Plagioclase (An_{74}) Peridotite. Base of photo = 8 mm

Opx Porphyroclast – Mylonitic Hbl Peridotite

Mineral assemblages in the mylonitic peridotites overprinted by the NDFZ record high temperatures (≥ 900 °C) and were interpreted by Miller and Mogk (1987) to have formed in a fracture zone.



Eocene

Cz — Undifferentiated Swauk and Chumstick Formations.

Peshastin Fm.

Jurassic argillite and minor graywacke, chert, sedimentary serpentinite and ophiolite breccia.

Esmeralda Peaks unit

Late Jurassic gabbro, diabase, pillow basalt and breccia. MORB-IAT affinities

Iron Mt. unit

Early Jurassic pillow basalt, pillow breccia, minor oolitic limestone. WPB affinities

Amphibolite

Serpentinite mélange: overprints mylonitic lherzolite within the NDFZ

Mantle peridotite tectonite

De Roux unit

Jurassic(?) phyllite, chert, metabasalt

CERFZ = Cle Elum Ridge Fault Zone

EP = Esmeralda Peaks

I = Iron Mountain

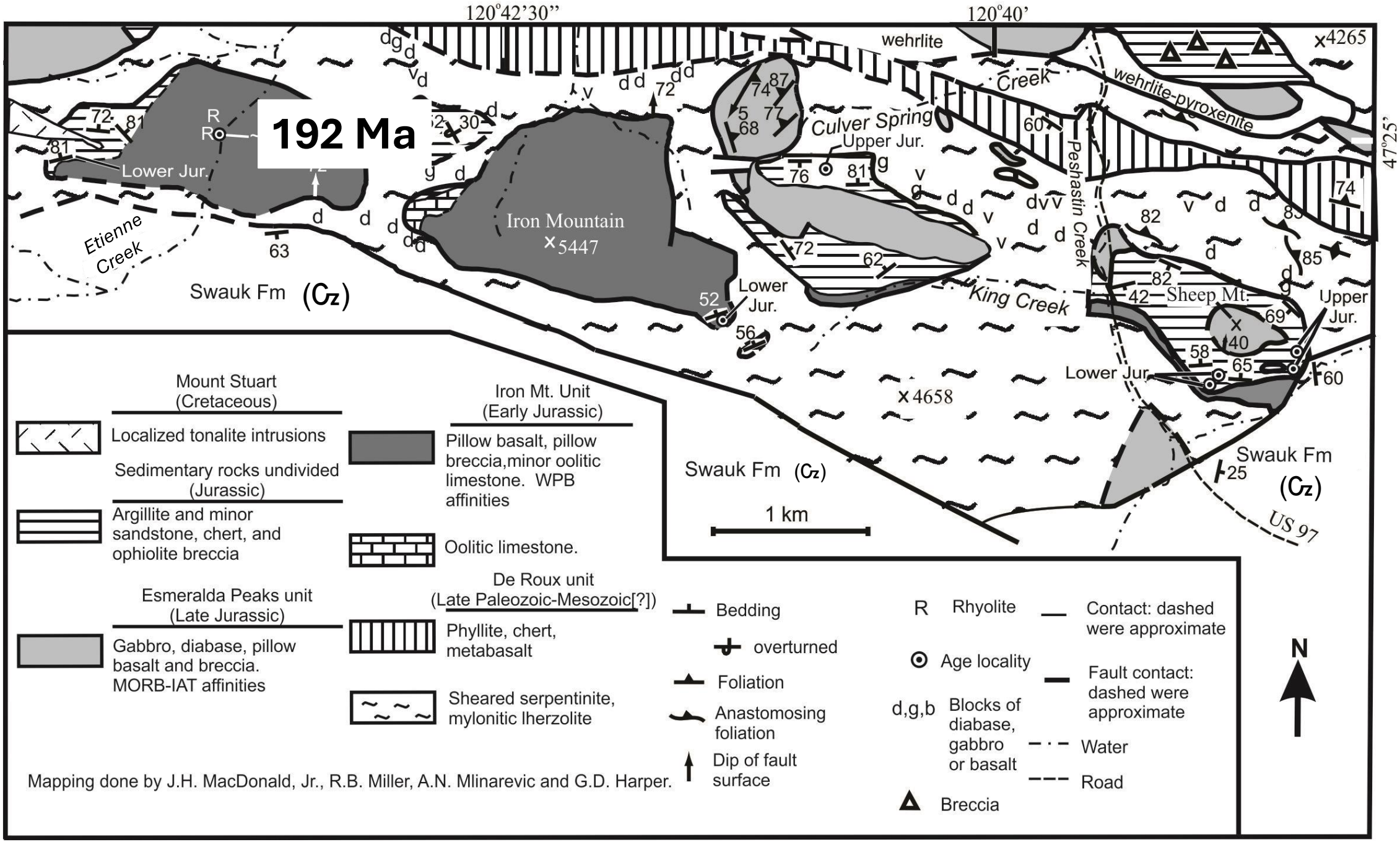
IP = Ingalls Peak area

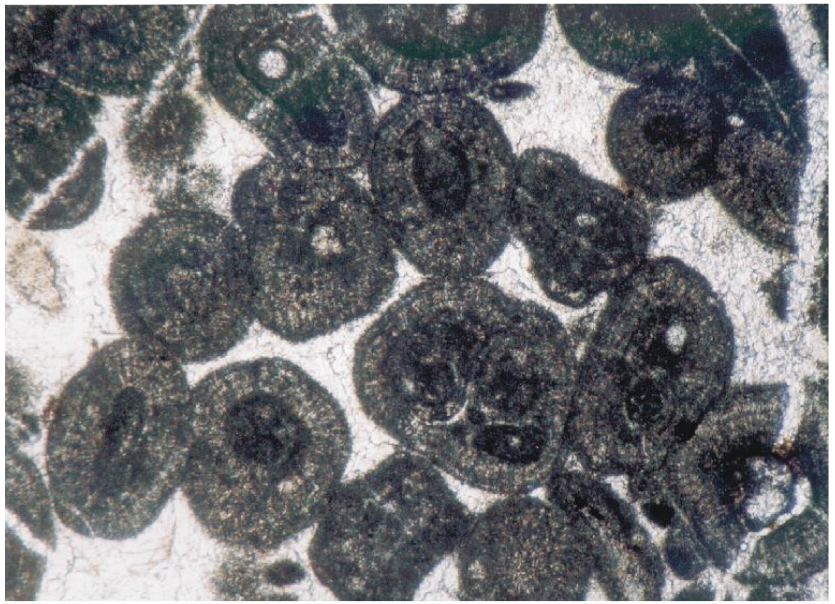
ND = Navaho Divide

NDFZ = Navaho Divide Fault Zone

S = Sheep Mountain

Iron Mountin unit


120°42'30"
120°40'
47°25'
192 Ma
Lower Jur.
Etienne Creek
Swauk Fm (Cz)
Iron Mountain
×5447
wehrlite
Creek
wehrlite-pyroxenite
×4265
Culver Spring
Upper Jur.
Peshastin Creek
King Creek
Sheep Mt.
×4658
Swauk Fm (Cz)
1 km
US 97
Mount Stuart
(Cretaceous)
Localized tonalite intrusions
Sedimentary rocks undivided
(Jurassic)
Argillite and minor sandstone, chert, and ophiolite breccia
Esmeralda Peaks unit
(Late Jurassic)
Gabbro, diabase, pillow basalt and breccia. MORB-IAT affinities
Iron Mt. Unit
(Early Jurassic)
Pillow basalt, pillow breccia,minor oolitic limestone. WPB affinities
Oolitic limestone.
De Roux unit
(Late Paleozoic-Mesozoic[?])
Phyllite, chert, metabasalt
Sheared serpentinite, mylonitic lherzolite
Bedding
overturned
Foliation
Anastomosing foliation
Dip of fault surface
R Rhyolite
Age locality
d,g,b Blocks of diabase, gabbro or basalt
Breccia
Contact: dashed were approximate
Fault contact: dashed were approximate
Water
Road
N
Mapping done by J.H. MacDonald, Jr., R.B. Miller, A.N. Mlinarevic and G.D. Harper.



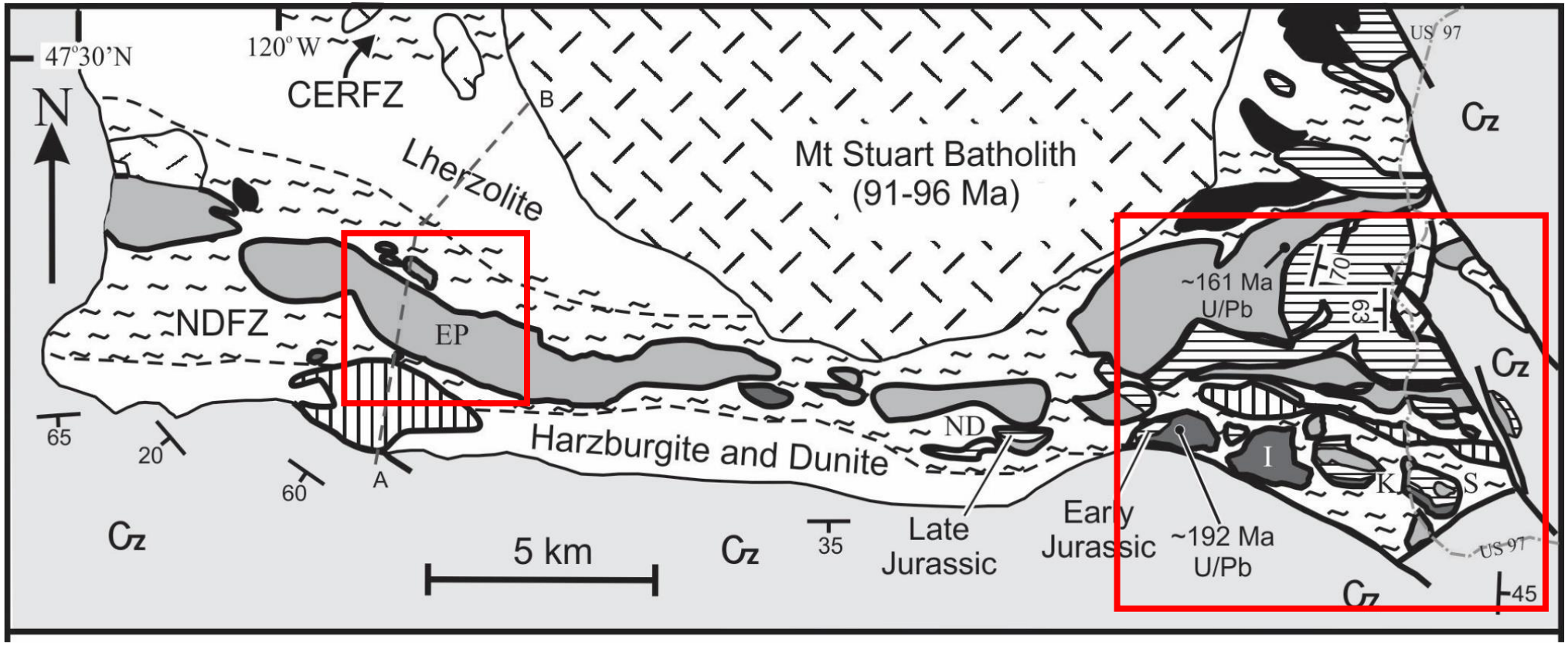
Common lithologies of the Iron Mountain unit of the Ingalls ophiolite complex

Pillow and massive flows

Hyaloclastites

Limestones

Chert



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EP = Esmeralda Peaks

I = Iron Mountain

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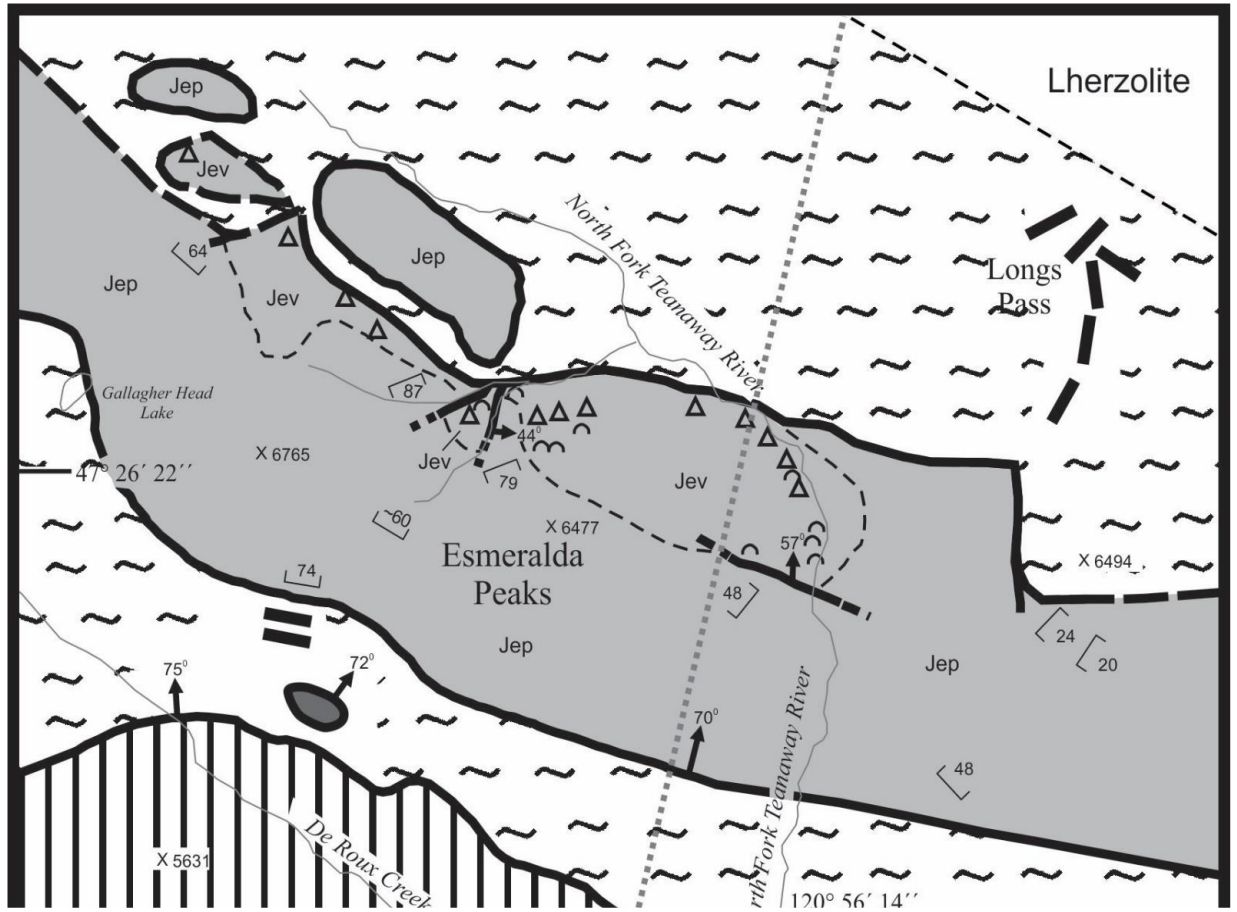
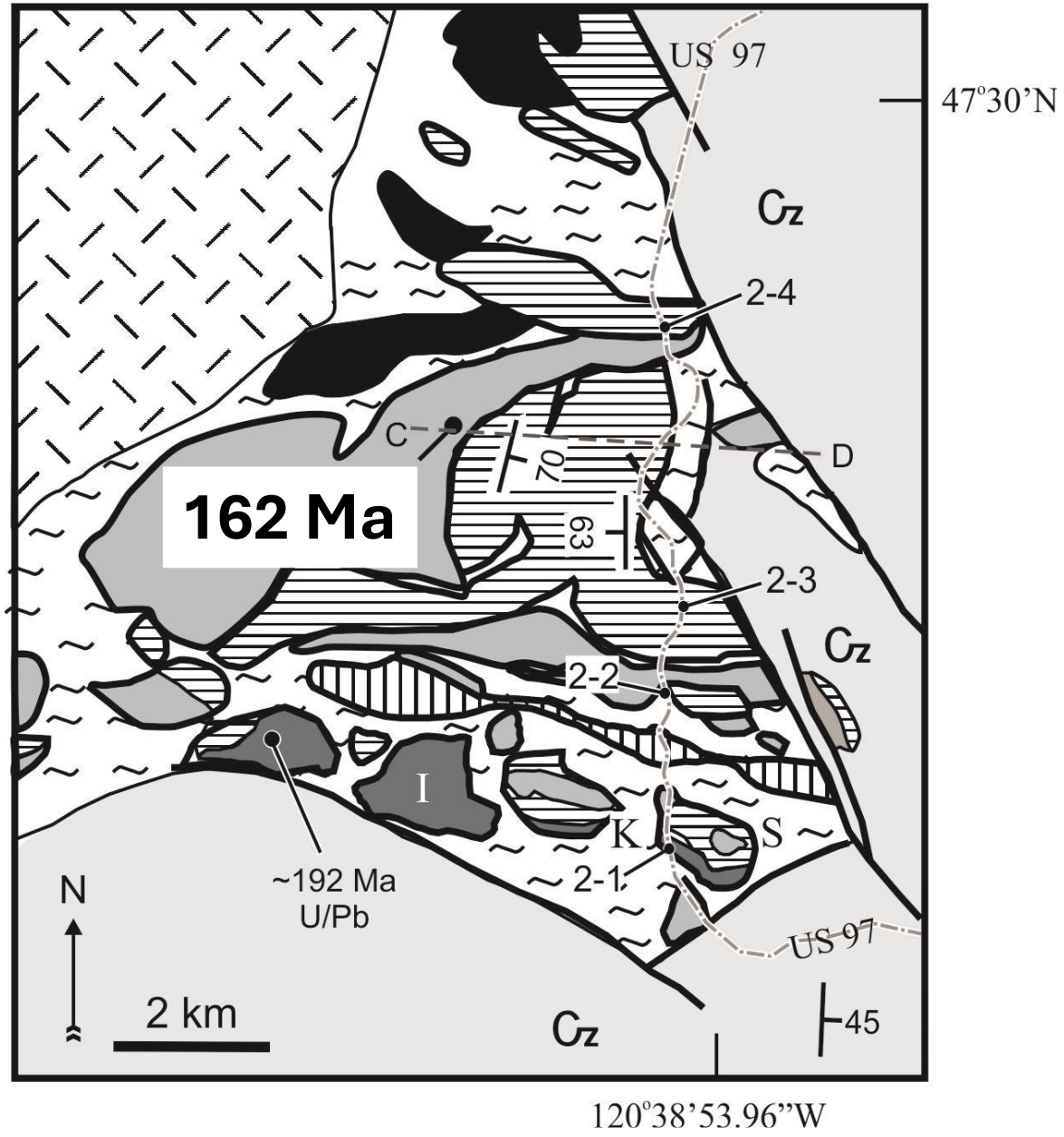
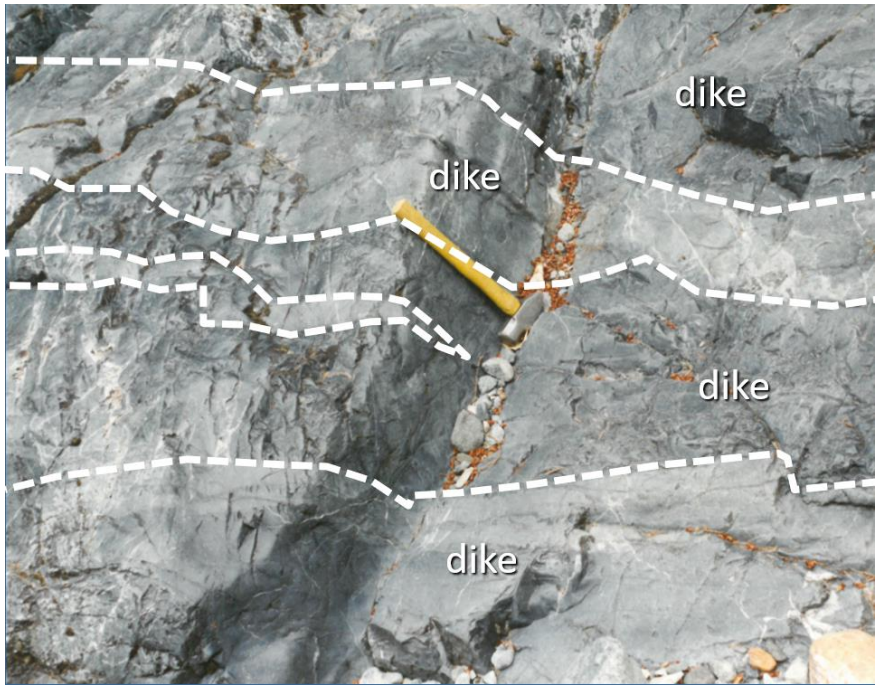
NDFZ = Navaho Divide Fault Zone

S = Sheep Mountain

Esmeralda Peaks unit


Lherzolite
Jep
Jev
Jep
Jep
Jev
64
North Fork Teanaway River
Longs Pass
Gallagher Head Lake
87
44°
X 6765
47° 26′ 22″
Jev
79
Jev
60
X 6477
Esmeralda Peaks
57°
X 6494
74
48
24
20
75°
72°
Jep
Jep
70°
48
X 5631
De Roux Creek
North Fork Teanaway River
120° 56′ 14″
N
1 Km
Map symbols are the same as Figure 3 except the following:
Pillow breccia.
Dike orientation.
Jev
Broken pillow breccia, pillow basalt, isolated pillow breccia.
Pillow basalt.
Dike cutting mylonite.
Jep
Diabase (minor sheeted dikes) and gabbro.
Line of cross-section


US 97
47°30'N
Cz
2-4
C
D
70
63
162 Ma
2-3
Cz
2-2
I
K
S
2-1
~192 Ma
U/Pb
US 97
N
2 km
Cz
45
120°38'53.96"W



Common lithologies of the Esmarelda Peaks unit of the Ingalls ophiolite complex

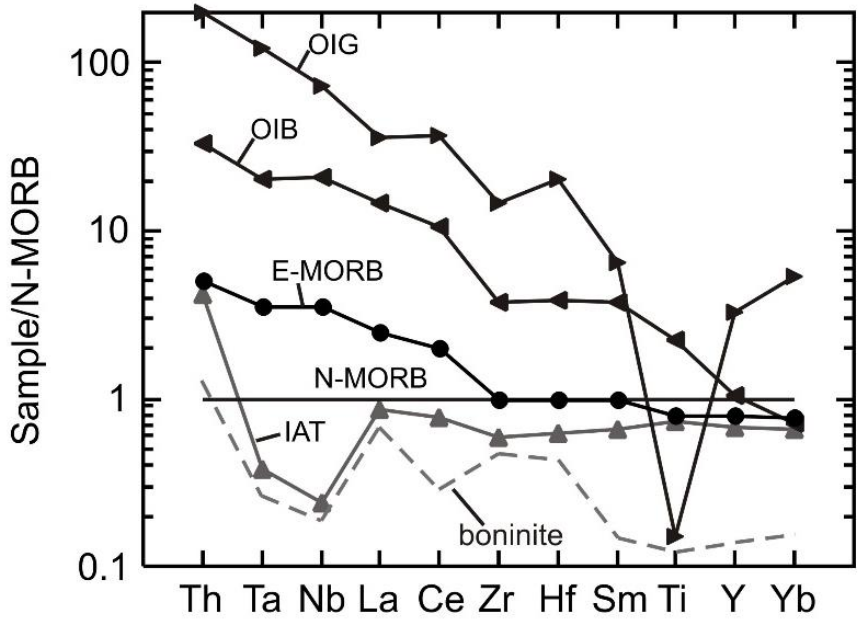
Pillow and massive flows

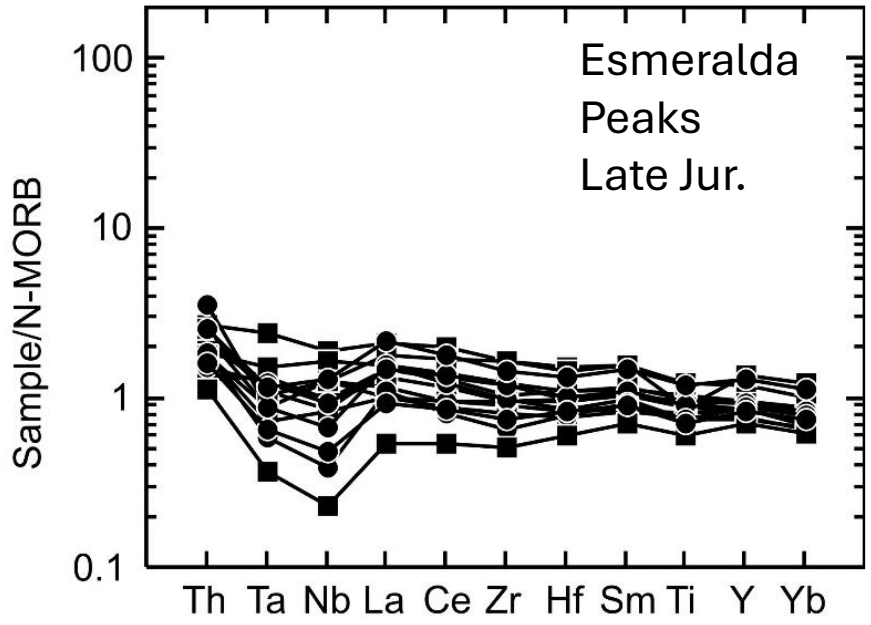
Massive diabase with rare dikes

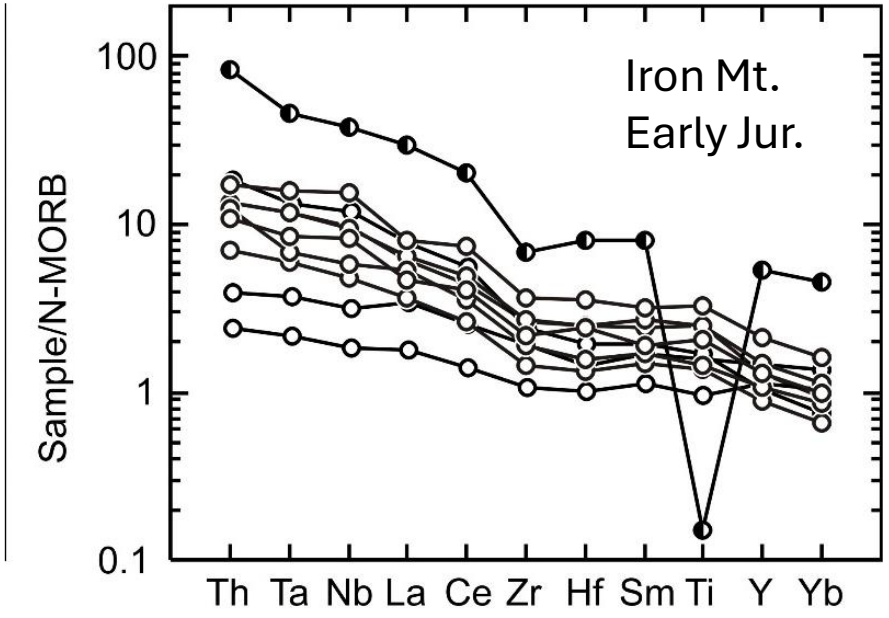
Gabbro

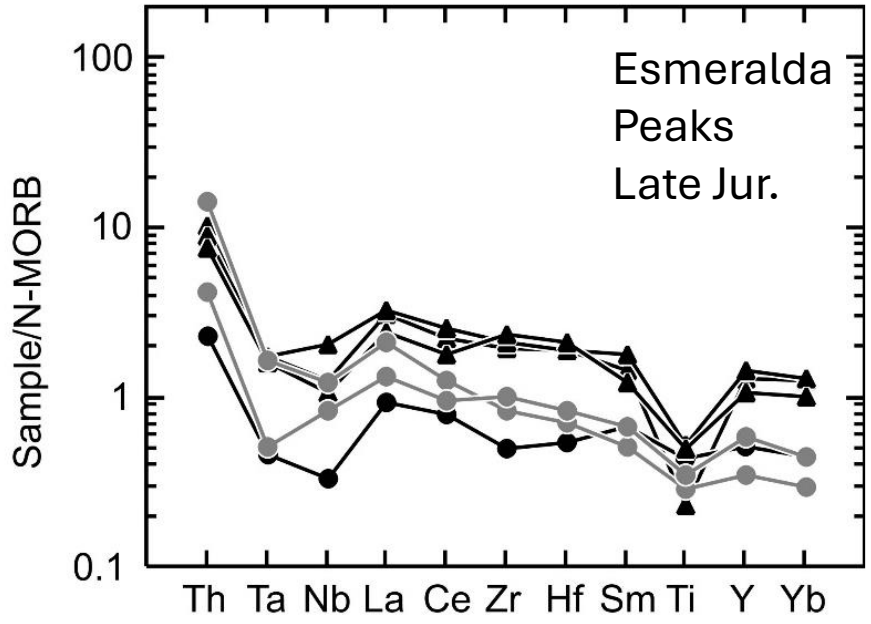
Rare plagiogranites

Rare chert









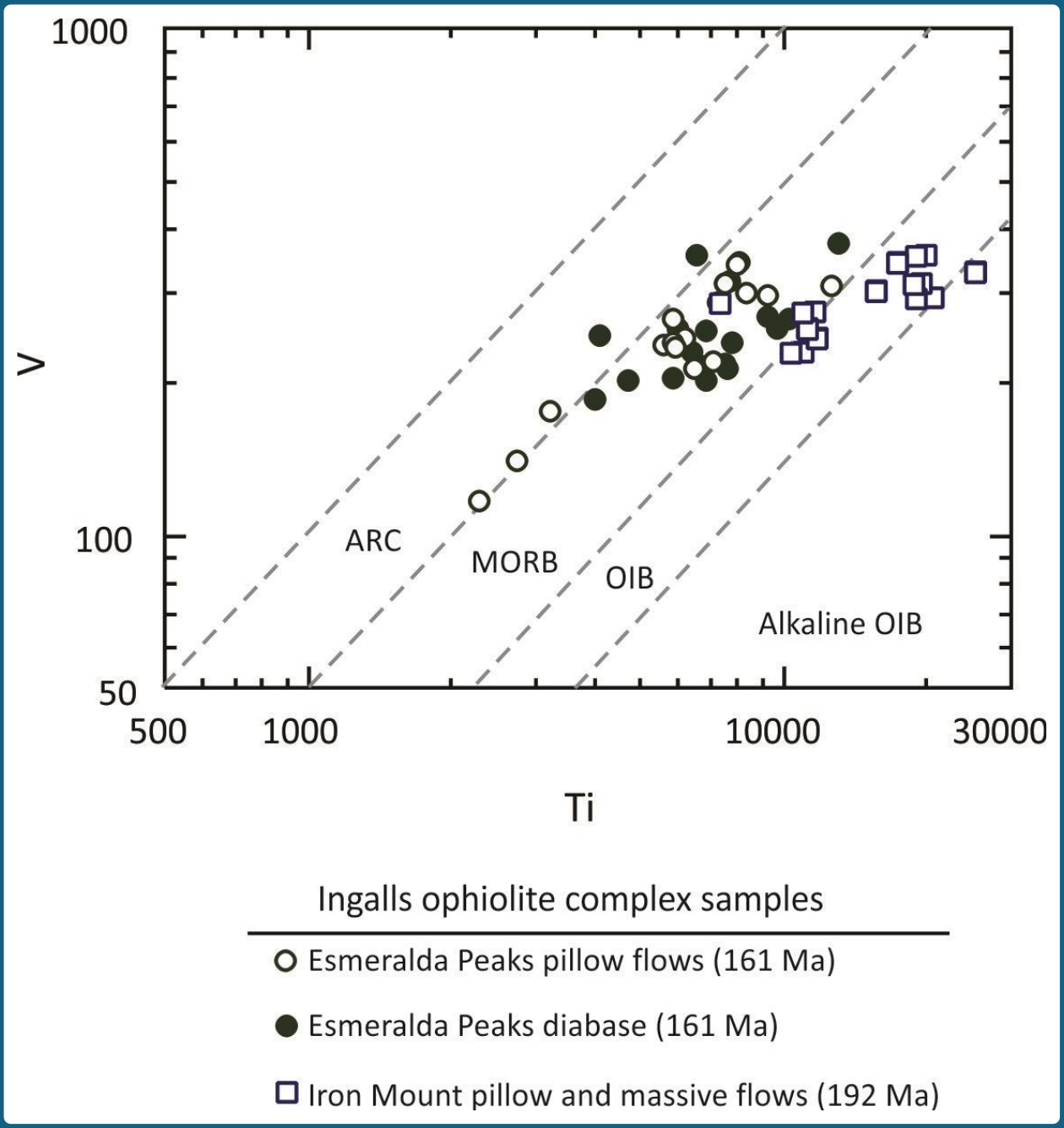
MORB-normalized diagrams for all Ingalls ophiolite samples. From MacDonald et al. (2008)

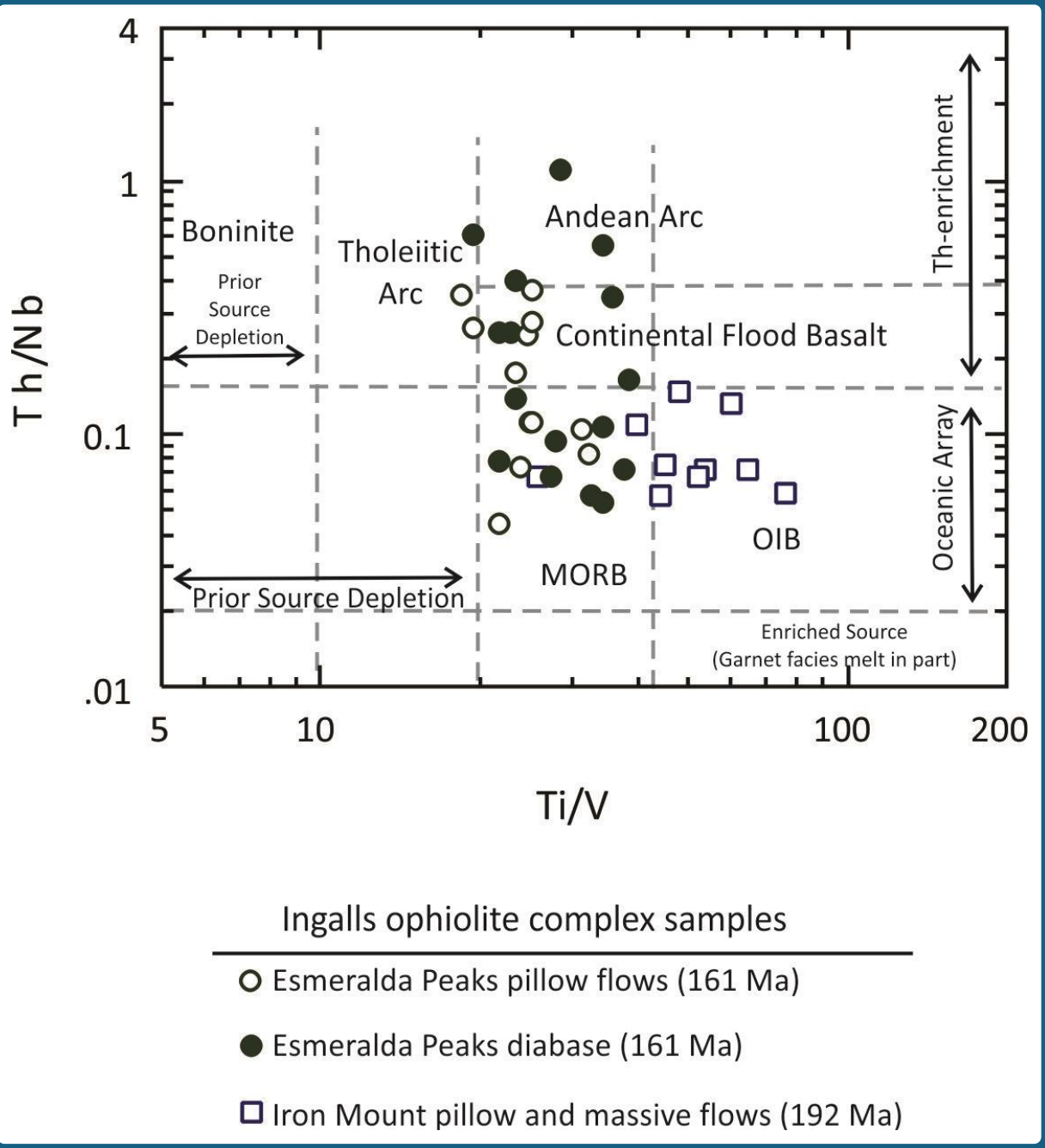
Esmeralda Peaks unit
(Late Jurassic)

- Boninite pillow basalt
- Diabase
- Pillow basalt
- Tonalite or trondhjemite

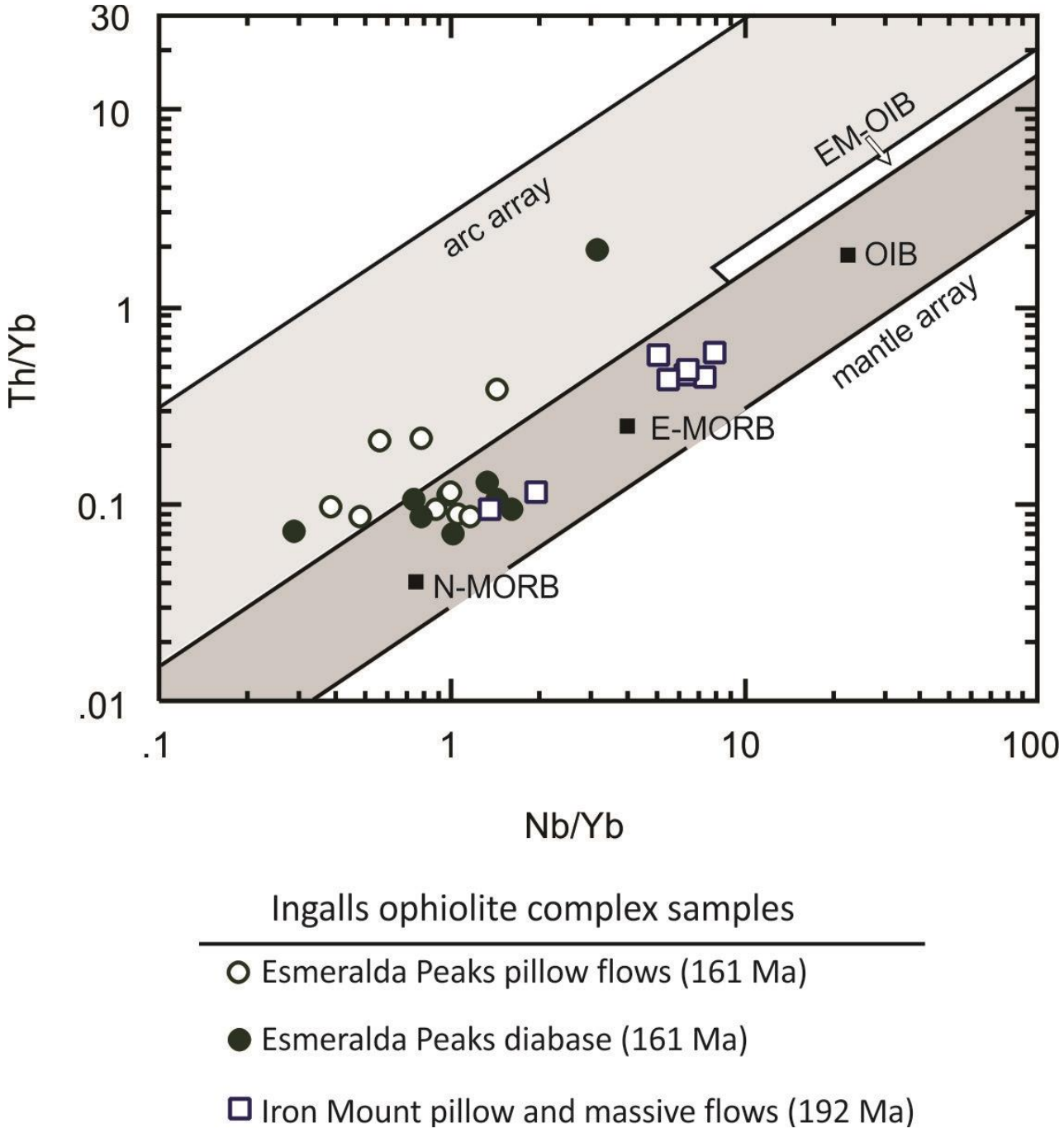
Iron Mountain unit
(Early Jurassic)

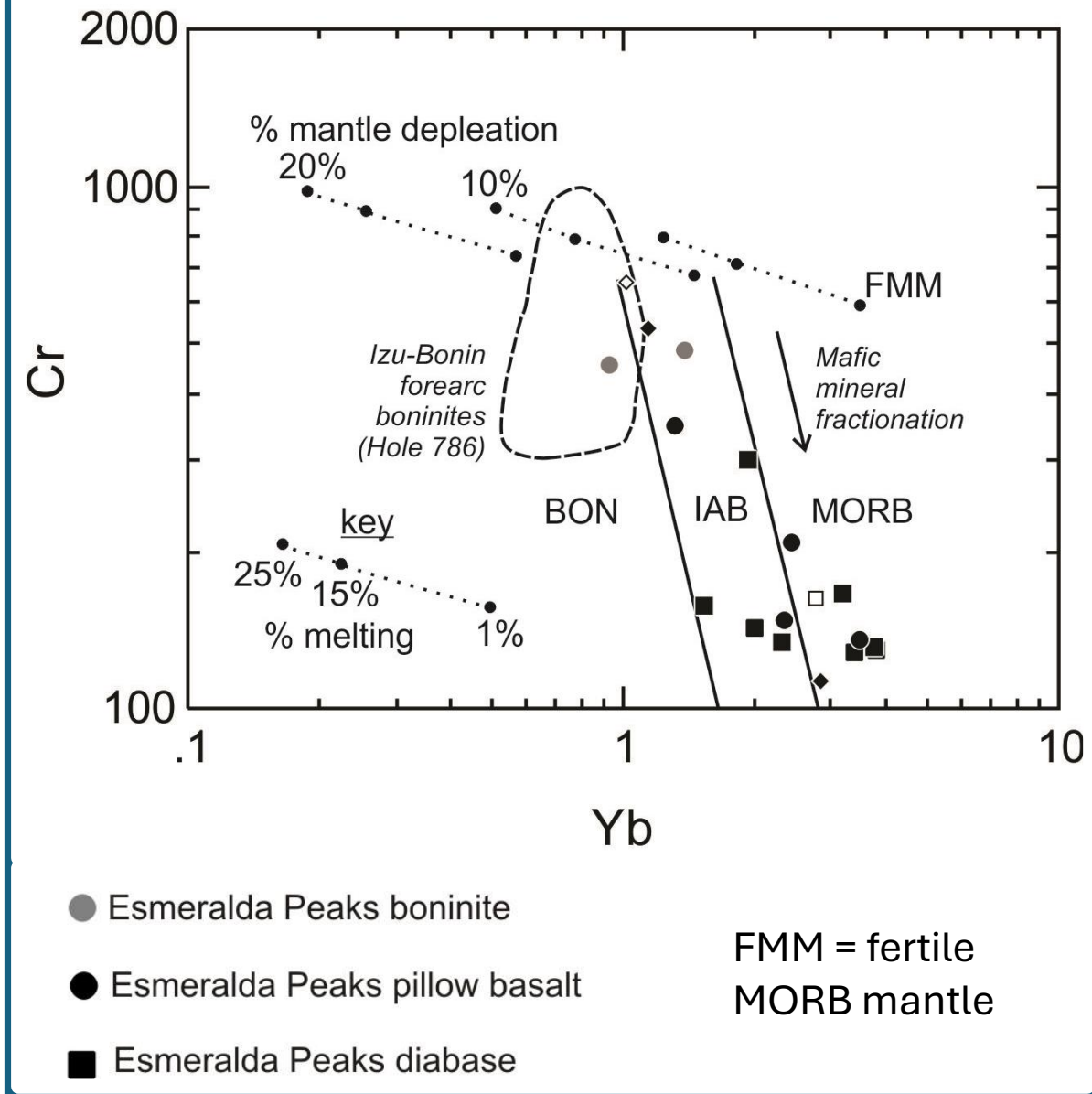
- Pillow basalt
- Alkali rhyolite





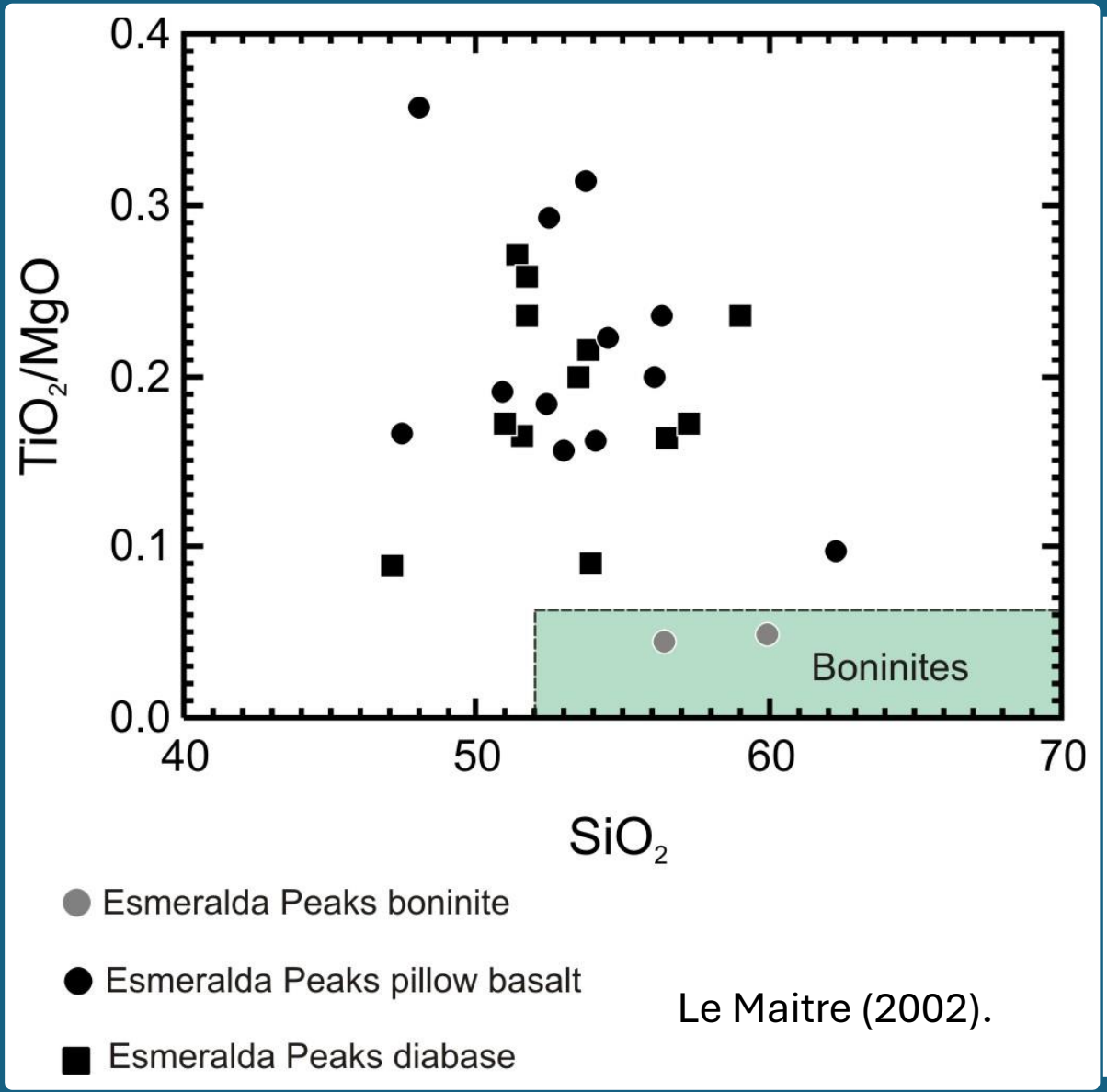
Mafic Ingalls ophiolite samples plotted on the Shervais (2022) discrimination diagram



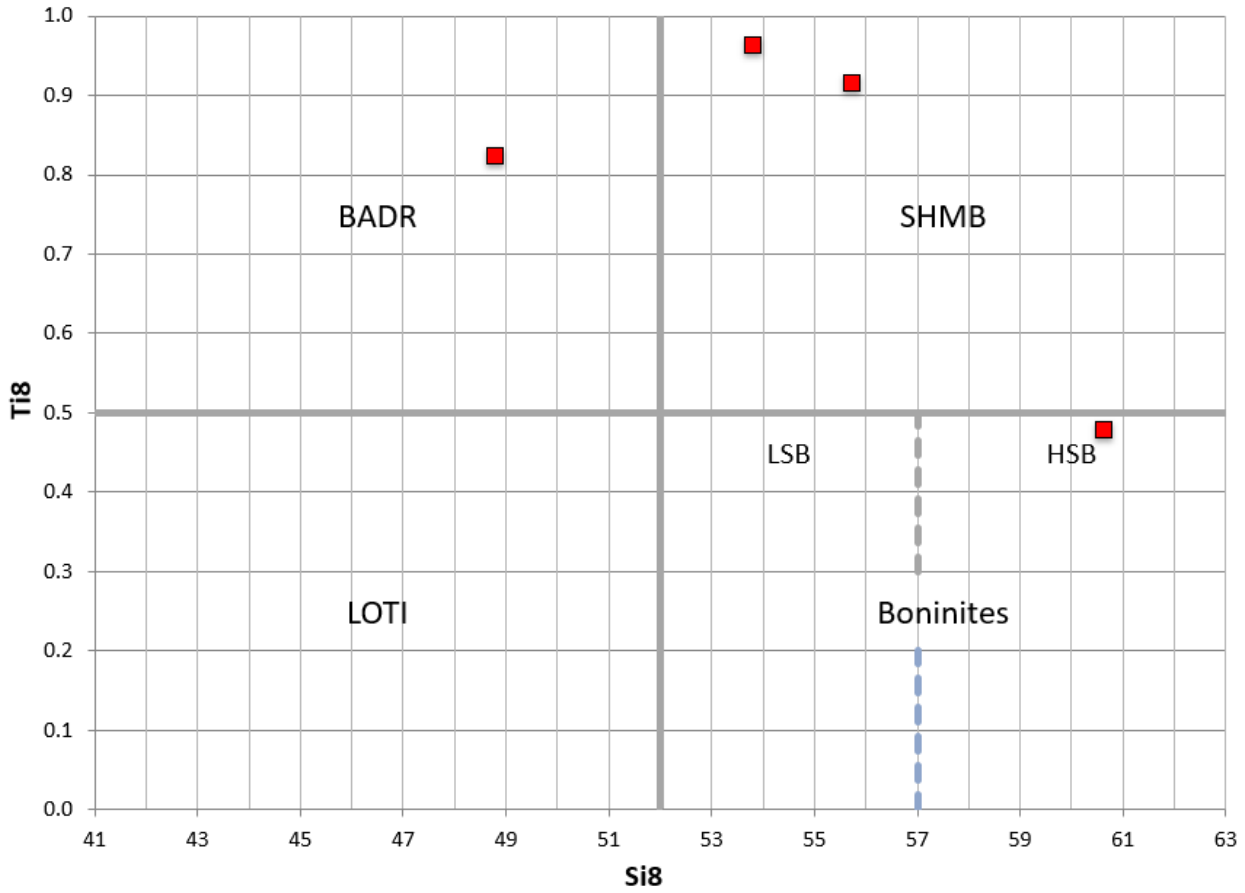


FMM = fertile MORB mantle

All extrusive Ingalls ophiolite samples plotted on “Pearce diagrams”.

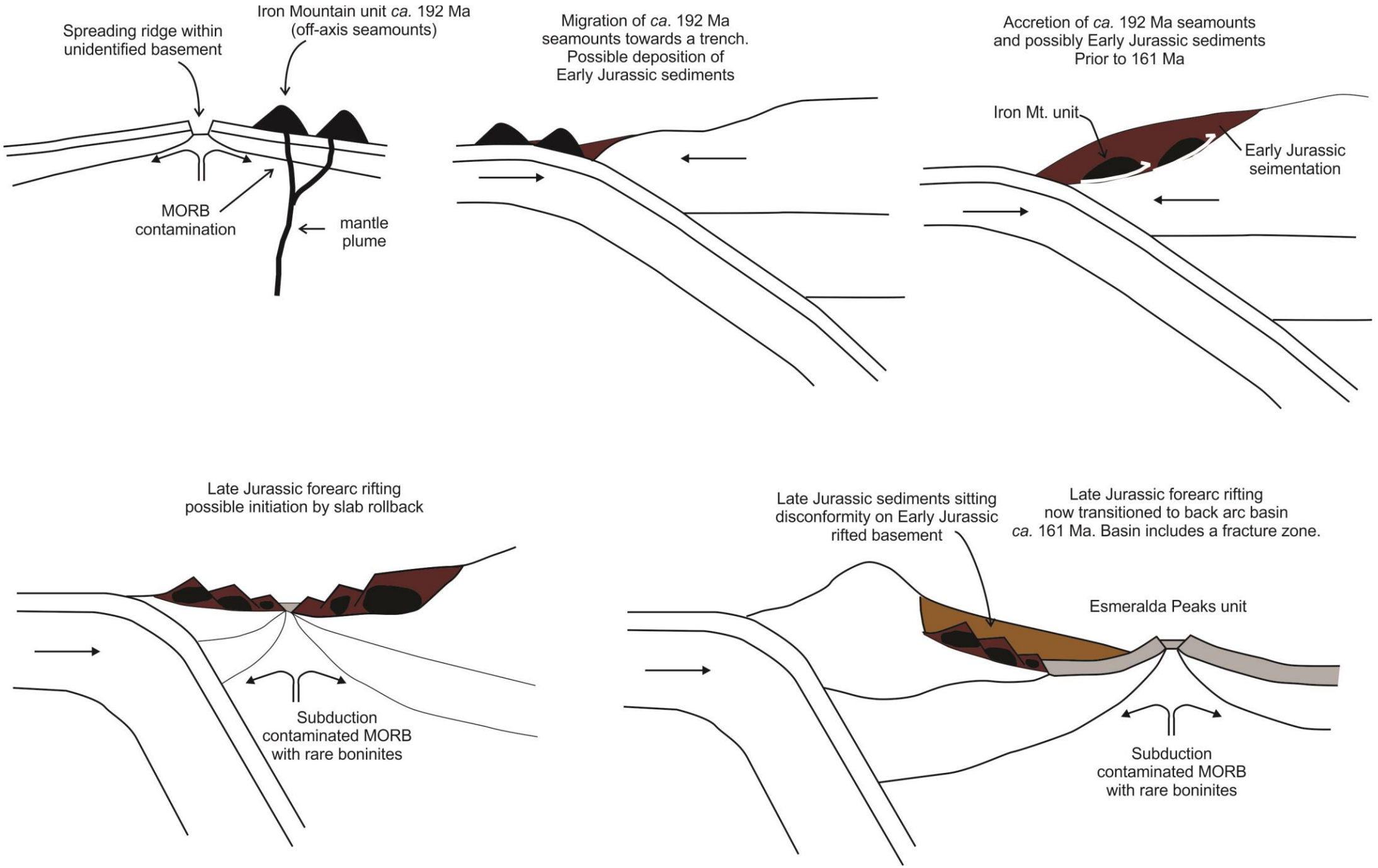


Le Maitre (2002).



high-Mg basalts (SHMB)
low-Ti basalts (LOTI)
high-Si boninites (HSB)
low-Si boninites (LSB).

Boninite classifications of LeMaitre (2002) (top left) and Pearce and Reagan (2019) (top right) for Ingalls ophiolite complex


Spreading ridge within unidentified basement
Iron Mountain unit *ca.* 192 Ma (off-axis seamounts)
MORB contamination
mantle plume
Migration of *ca.* 192 Ma seamounts towards a trench. Possible deposition of Early Jurassic sediments
Accretion of *ca.* 192 Ma seamounts and possibly Early Jurassic sediments Prior to 161 Ma
Iron Mt. unit
Early Jurassic seimentation
Late Jurassic forearc rifting possible initiation by slab rollback
Subduction contaminated MORB with rare boninites
Late Jurassic sediments sitting disconformity on Early Jurassic rifted basement
Late Jurassic forearc rifting now transitioned to back arc basin *ca.* 161 Ma. Basin includes a fracture zone.
Esmeralda Peaks unit
Subduction contaminated MORB with rare boninites