Possible counterclockwise P-T-t path from the Fort Jones Terrane near Yreka, California

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Abstract

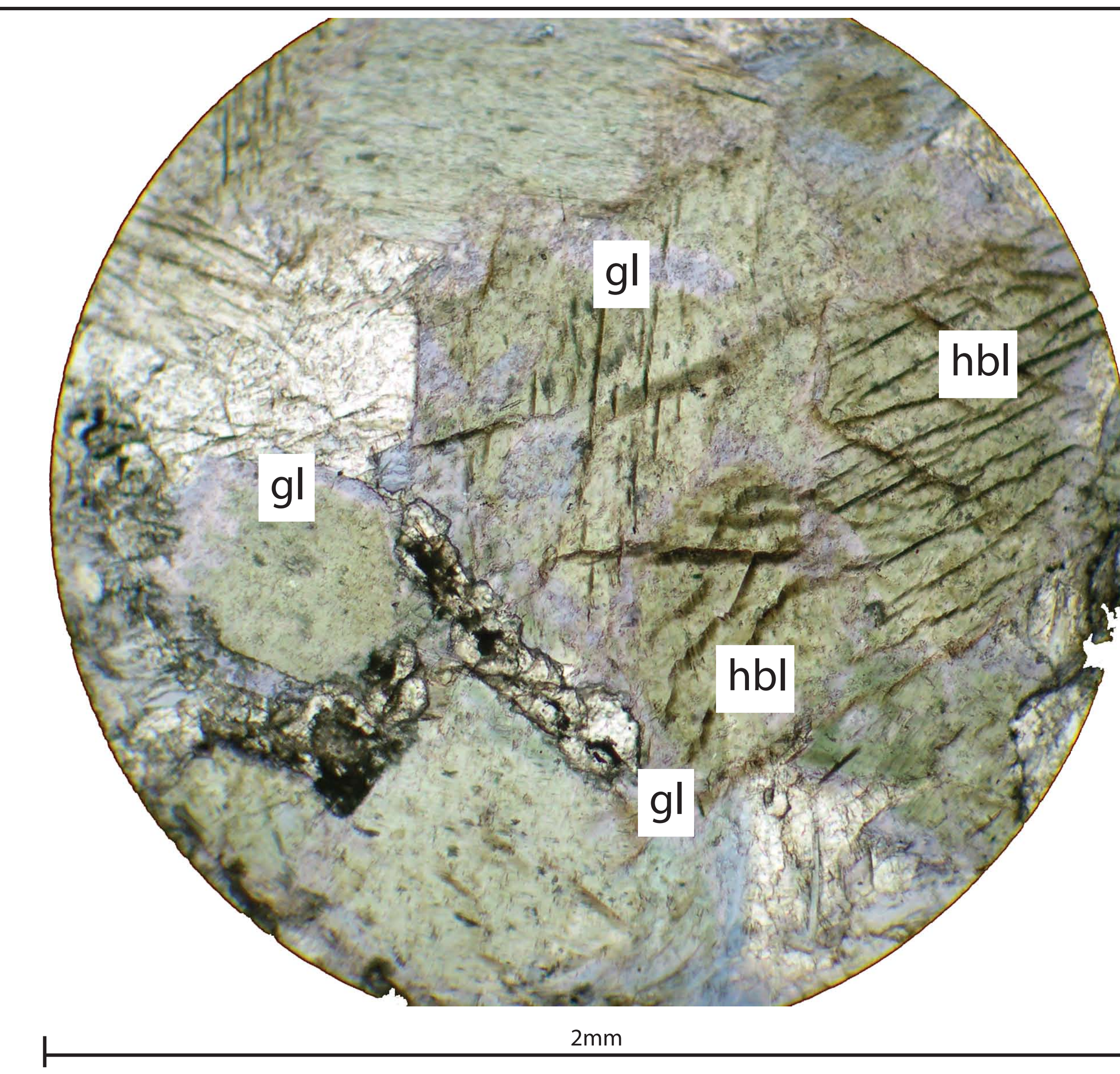
The Klamath Mountains preserve a Devonian to late Jurassic accretionary complex emplaced beneath the Eastern Klamath Terrane. At the latitude of Yreka, California, the structurally highest lower-plate unit is the Central Metamorphic Belt, which is underlain by the Fort Jones Terrane (FJT). Although the amphibolite-facies Central Metamorphic Belt has been considered to be a Devonian metamorphic sole based on old K/Ar dates, recently published Ar/Ar hornblende to the south yield a Triassic age, leaving open the possibility that these rocks are not related to the early history of the subduction zone.

The underlying FJT, usually considered to be an extension of the Stuart Fork Terrane to the south, consists of a diverse assemblage of phyllite, quartzite, chert, and metabasalt, in both coherent and mélange tectonic textures. These rocks were affected by a widespread blueschist-facies metamorphic event, presumably of Triassic age. Good exposures of the block-in-matrix fabric of the FJT exist in the Soap Creek Valley, just west of Yreka. Here, we individually describe blocks mapped by previous workers, finding lawsonite-blueschist and omphacite-lawsonite metabasalt, actinolite schist, and amphibolite. In addition, eclogite has been reported in the literature.

One metabasalt block has late glaucophane overprinting early hornblende, suggesting a blueschist-facies overprint on an amphibolite protolith. Furthermore, widespread late lawsonite overprints omphacite-rich rocks that likely co-existed with garnet. These observations, indicative of a higher-temperature event followed by a lower-temperature event, may indicate a counterclockwise pressure-temperature-time path, one which may record the early stages of subduction in the Klamath Mountains. If so, geochronology on these rocks may provide the best opportunity to date of initiation of this subduction zone. Alternately, the blueschist-over-amphibolite metamorphic relationship could be explained by the blocks having undergone two cycles of subduction.

y010

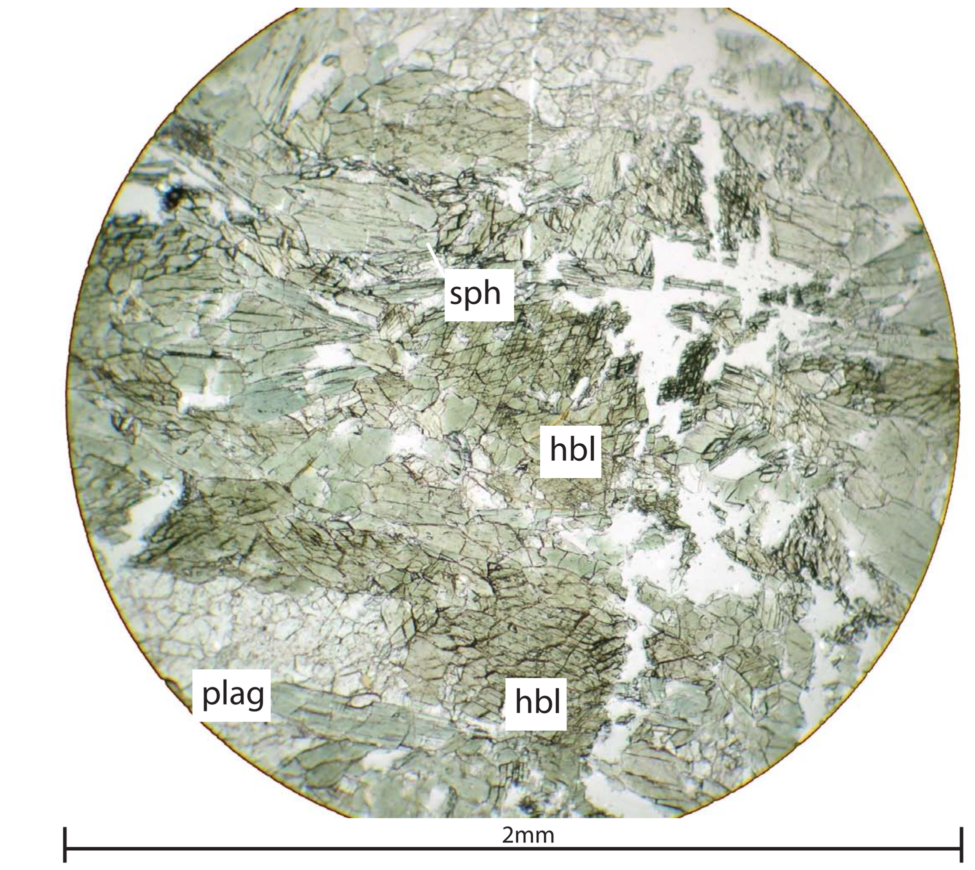
	gl1	gl2	hbl1	hbl2
SiO2	57.58	57.74	49.38	50.27
Al2O3	9.10	9.95	5.69	5.08
TiO2	0.07	0.14	1.24	0.30
FeO	12.92	12.05	13.42	13.68
MnO	0.14	0.10	0.35	0.18
MgO	9.68	9.99	15.10	15.75
CaO	0.82	0.42	11.17	10.02
Na2O	6.70	7.96	0.80	1.12
K2O	0.02	0	0.18	0.04
Total	97.03	98.35	97.33	96.44
Si	7.99	7.93	7.05	7.14
Ti	0.01	0.01	0.13	0.03
Al	1.49	1.61	0.96	0.85
Fe3+	0.47	0.25	1.00	1.45
Fe2+	1.03	1.13	0.60	0.18
Mn	0.02	0.01	0.04	0.02
Mg	2.00	2.05	3.21	3.33
Ca	0.12	0.06	1.71	1.52
Na	1.80	2.12	0.22	0.31
K	0	0	0.03	0.01
	gl	gl	mghbl	mghbl



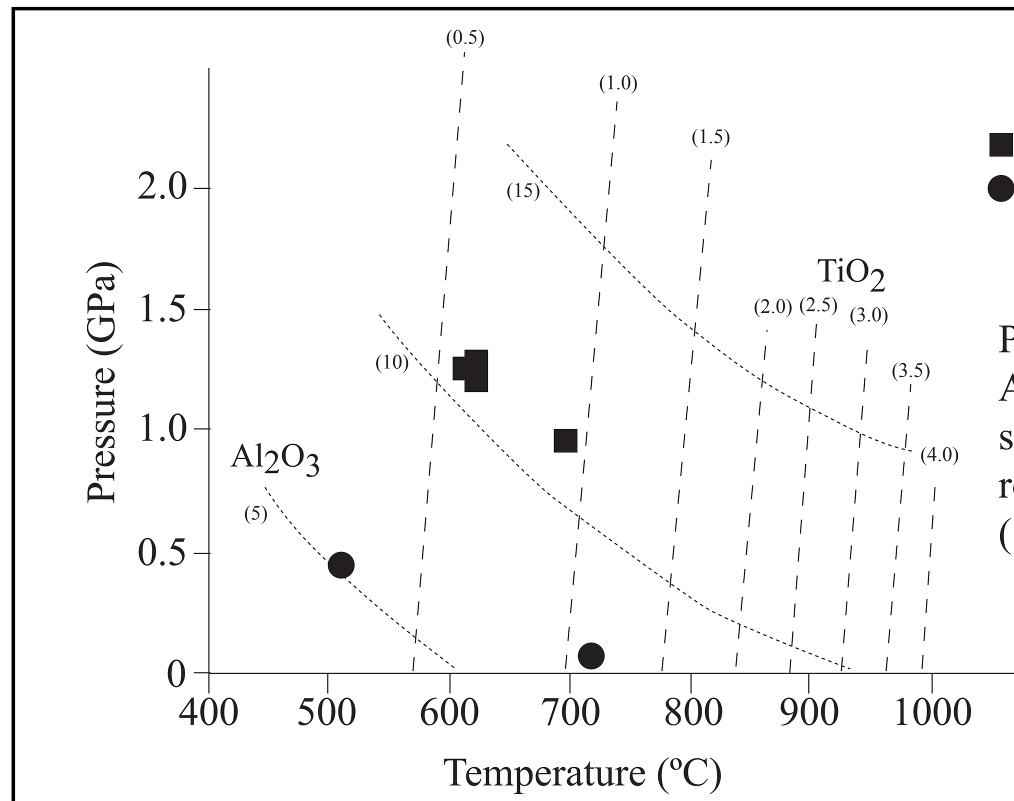
Glaucophane rim on a hornblende core; this texture could be an indication of a counterclockwise P-T-t path (see in the Counterclockwise P-T-t figure below). Another possible explanation is a two-cycle subduction where an amphibolite block is exhumed, resubducted and metamorphosed under blueschist facies conditions. Dating of the hornblende minerals would likely distinguish between the two possibilities.

YRK12-3

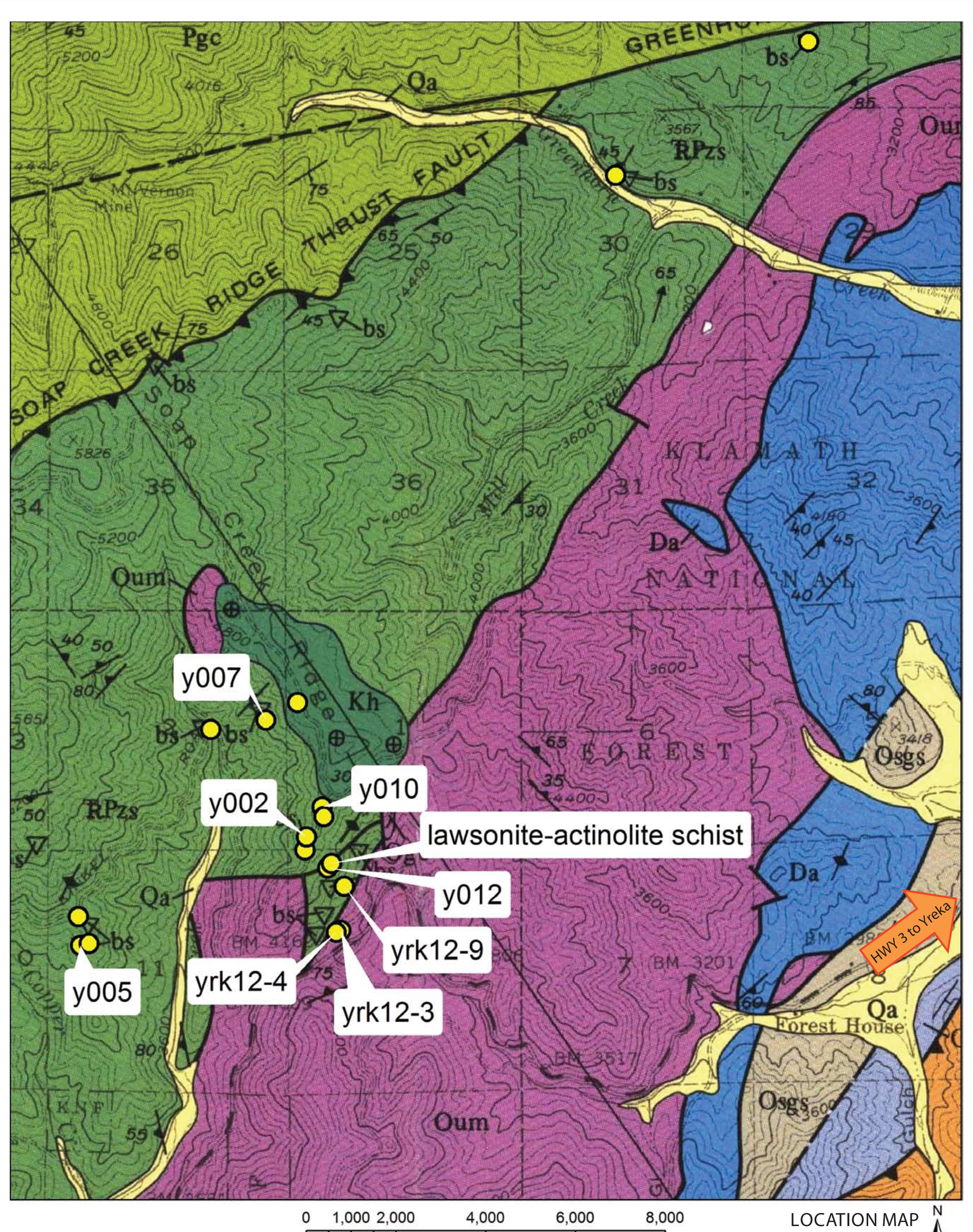
	hbl1	hbl2
SiO2	42.06	42.85
Al2O3	11.27	11.32
TiO2	0.58	0.57
FeO	19.21	18.61
MnO	0.52	0.43
MgO	8.88	8.61
CaO	10.44	10.50
Na2O	3.28	3.06
K2O	0.62	0.62
Total		96.57
Si	6.39	6.52
Ti	0.07	0.06
Al	2.02	2.03
Fe3+	0.57	0.34
Fe2+	1.87	2.03
Mn	0.07	0.06
Mg	2.01	1.95
Ca	1.70	1.71
Na	0.97	0.90
K	0.12	0.12
	edenite	edenite

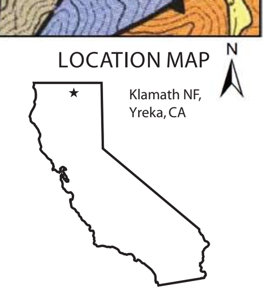


Hornblende+plagioclase+sphene amphibolite schist; collected east of the FJT (which has been called the Central Metamorphic Belt, or the Forest Mountain Subterran), the photomicrograph shows a hornblende schist. The Al- and Ti-in-hornblende seminquantative thermobarometer indicates that these hornblendes are much higher pressure than those in sample y010. This indicates that yrk12-3 probably did not serve as the protolith of y010. Previous dating yeilds ages of about 398:!: 12 and 407:t 12 Ma, K/Ar hornblende (Hotz 1974).



P-T estimates based on the Al- and Ti-in-hornblende semiquantitative thermobarometer of Ernst and Liu (1998).

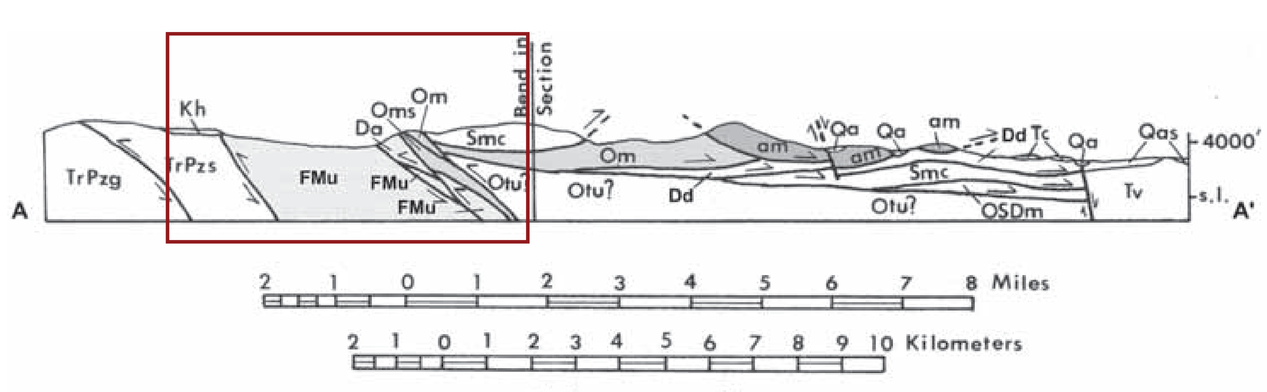




Geologic map (Hotz 1977) with corrected GPS plots of sampled blueschist blocks

yrk 12 -3	hornblende+plagioclase+sphene amphibolite schist
yrk 12 -4 "Magnolia"	glaucophane+sphene schist
yrk 12 -9	late lawsonite+glaucophane overgrowing omphacite
y002	glaucophane+lawsonite+sphene blueschist
y005A	glaucophane-bearing quartz schist
y005B	glaucophane+lawsonite blueschist
y007	white mica+glaucophane+chlorite+sphene schist
y010 YOLO!	glaucophane overgrowing hornblende schist
y012	glaucophane+lawsonite+sphene+white mica blueschist

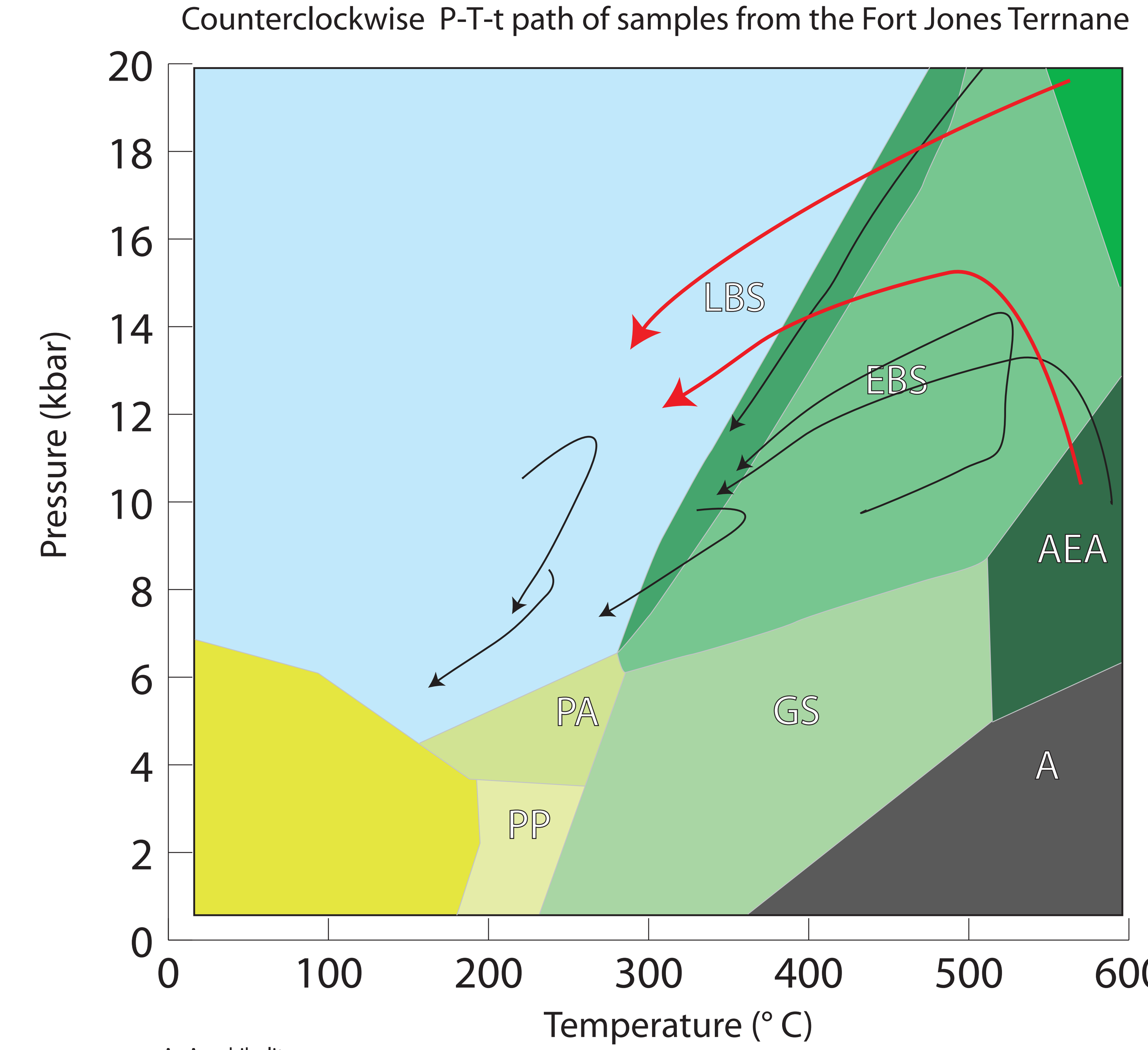
*Bold indicates microprobe data



Cross section (Griffin 2008), study area highlighted

- Qa — Alluvium
- Kh — **Hornbrook Formation** Cretaceous
- bs — Isolated blueschist block
- TR Pzs — **Stuart Fork Formation** (Paleozoic and Triassic?)
- Pgc — Permian greenstone-chert assemblage
- Da — Devonian amphibolite
- Smc — **Moffett Creek Formation** Silurian or older dismembered calcareous sandstone-shale unit
- Osgs — Ordovician semischist adjacent to amphibolite belt
- Osg — Ordovician phyllitic siltstone, discontinuous lenses of chert and quartzite
- Oum — Ordovician ultramafic

Counterclockwise P-T-t path of samples from the Fort Jones Terrnane

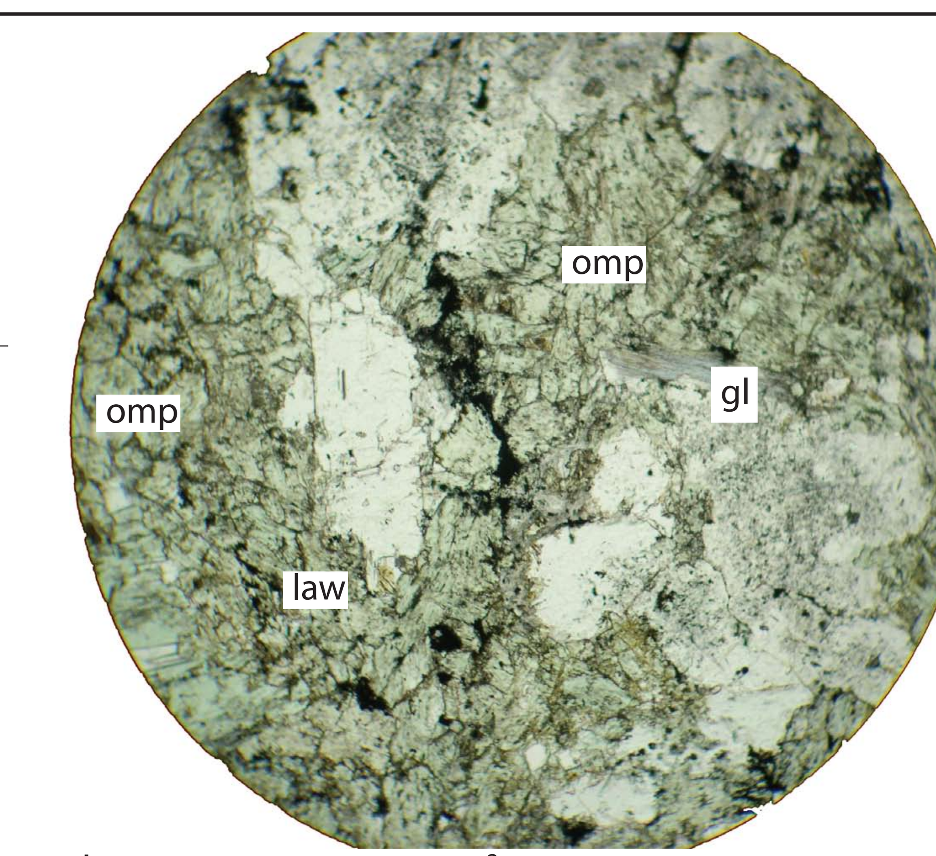


A: Amphibolite
AEA: Albite epidote amphibolite
E: Eclogite
EBS: Epidote blueschist
LBS: Lawsonite blueschist
PA: Pumpellyite actinolite
PP: Prehnite pumpellyite
Franciscan
Fort Jones Terrane

Comparison of FJT metamorphic path with those found in the Franciscan orogen (Agard, 2009).

YRK12-9

	omph1	omph2	omph3
SiO2	54.77	55.90	56.08
Al2O3	8.89	8.79	9.01
TiO2	0.12	0.16	0.06
FeO	9.65	8.39	10.01
MnO	0.30	0.40	0.26
MgO	6.26	7.07	6.85
CaO	10.45	11.03	10.81
Na2O	8.18	7.73	8.00
K2O	0.00	0.00	0.00
Total	98.62	99.45	101.08
Ae	21.12	13.64	19.46
Jd	37.51	42.27	37.77
Di	41.37	44.09	42.77



Late lawsonite+glaucophane overgrowing omphacite; garnets were previously identified in this unit (Borns 1984) combined with chemical data and this photomicrograph appear to indicate that an eclogite may have been overprinted with a blueschist facies.