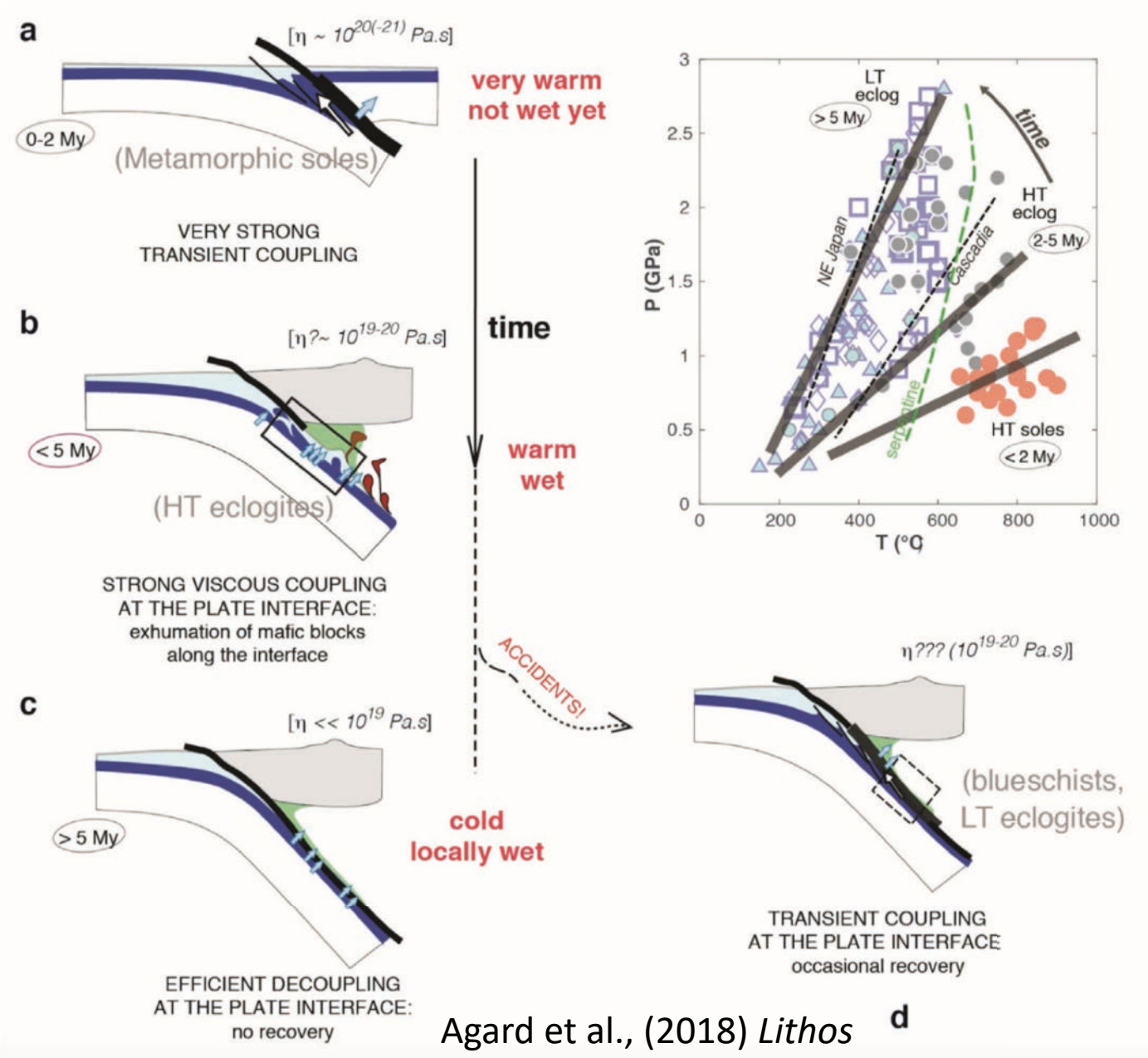
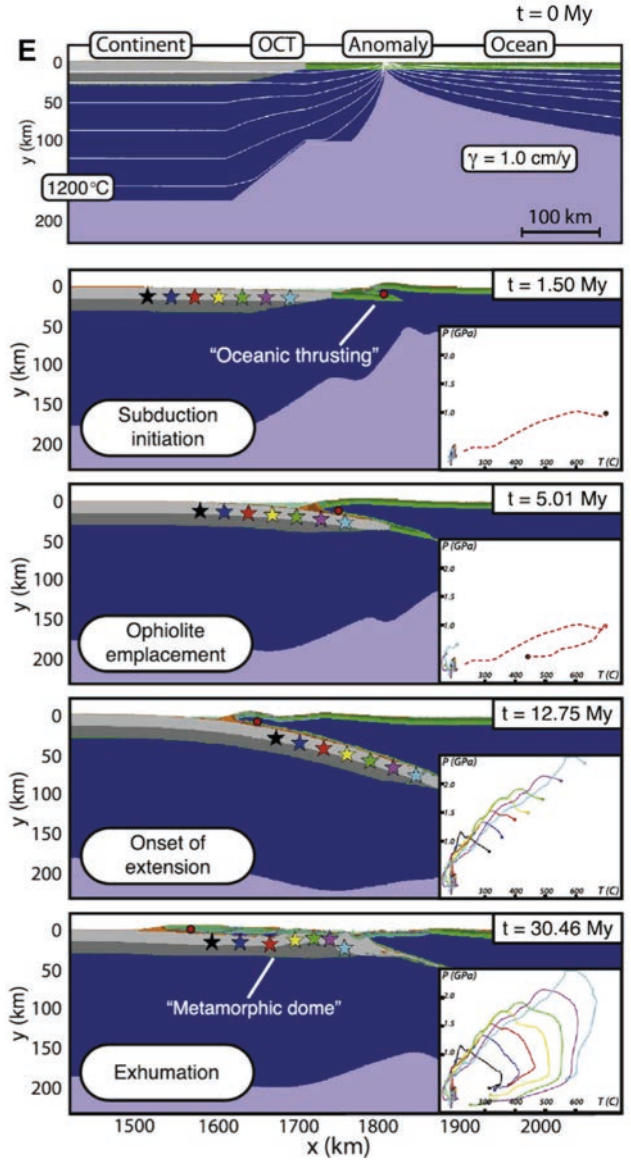
The Cycladic Subduction Zone from birth to death: Insights into the subduction cooling rate conundrum

Thomas Lamont[1], Mike Searle[2], Richard White[1], Nick Roberts[3], Phillip Gopon[2], Jon Wade[2] and Dave Waters[2]

1. University of St Andrews
2. University of Oxford
3. Geochronology and Tracers Facility, British Geological Survey

Motivation: Thermal evolution of the subduction interface





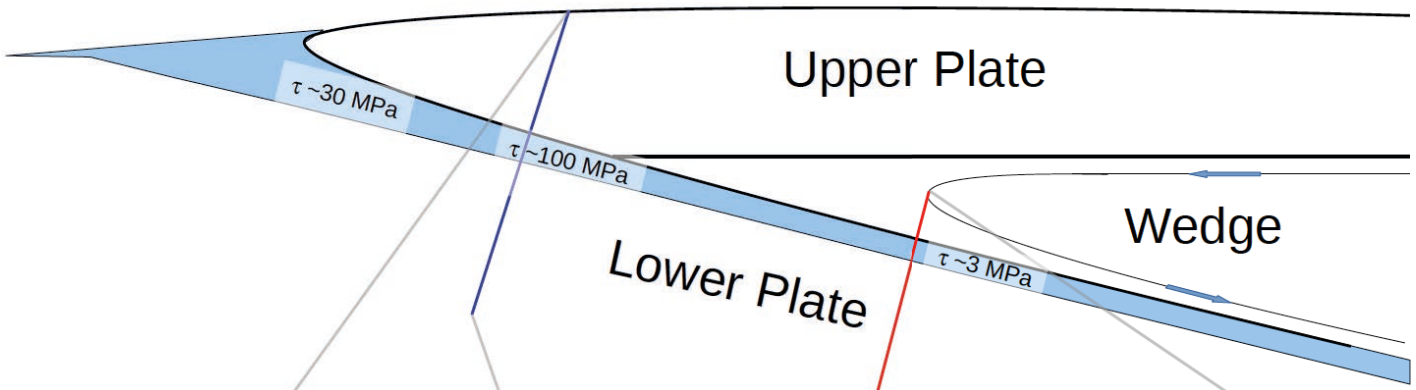
Agard et al., (2018) *Lithos*

Duretz et al., (2016) *Gondwana Research*

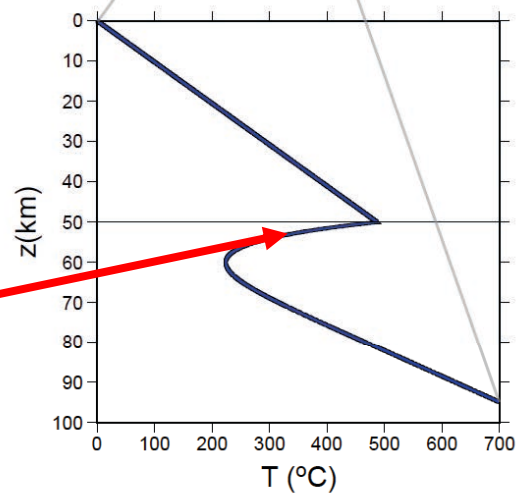
Steady state temperature distribution through an established subducting slab (i.e. forced subduction)

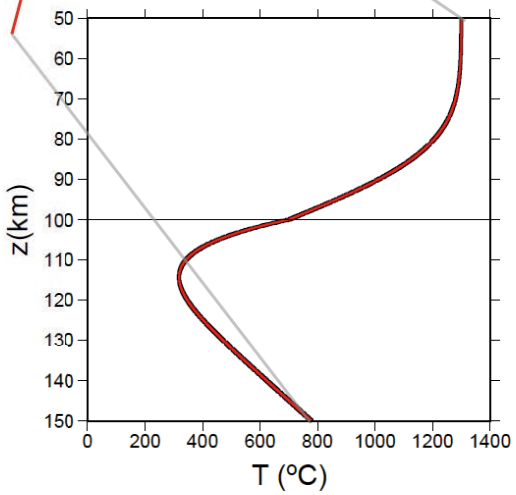
Shallow: Slab-Plate Interface

Deep: Slab-Wedge Interface



Shear heating



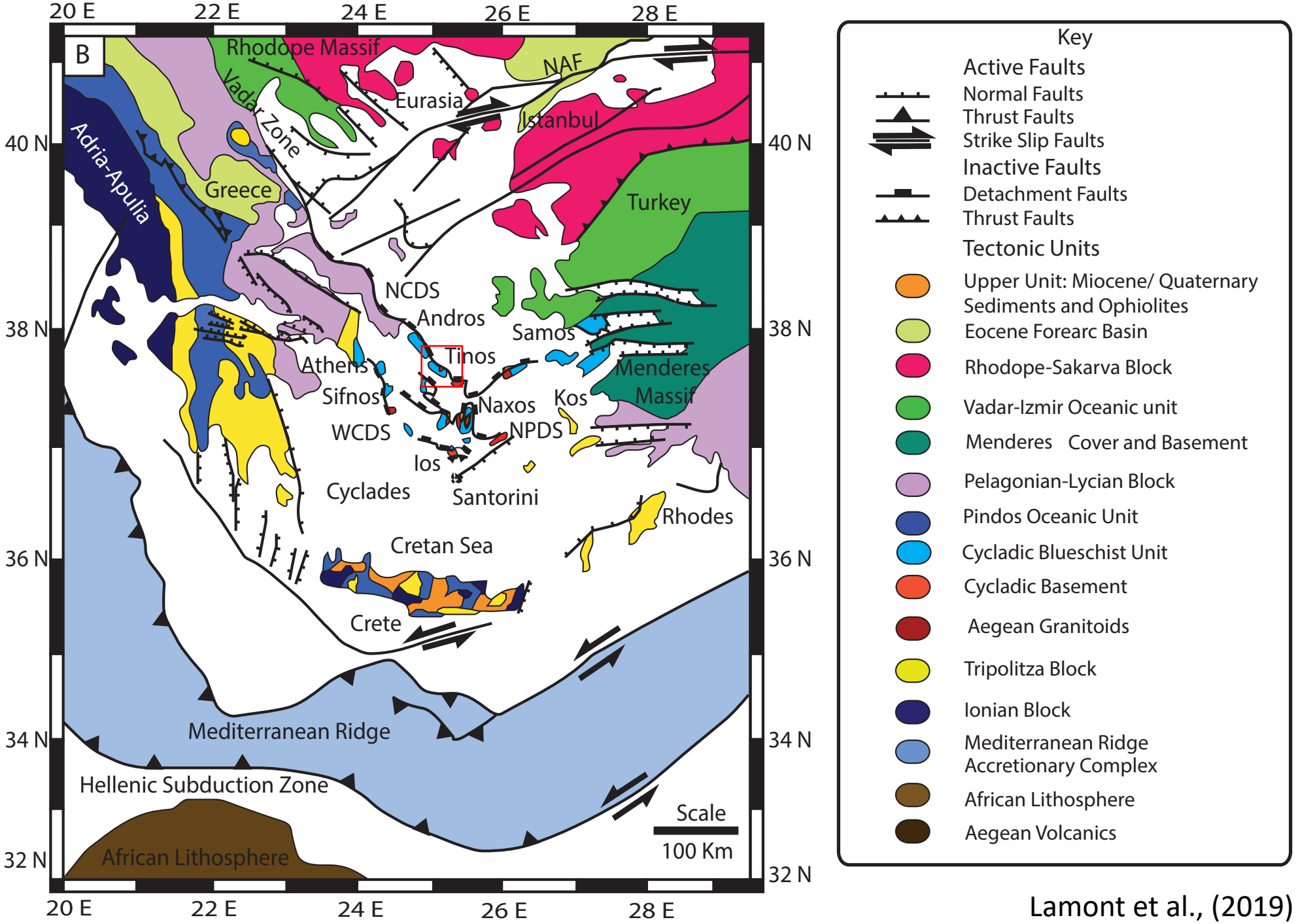


After England and Molnar, (1993) *Tectonics*

Tsiknias Metamorphic Sole ca. 0.8 GPa 700-800 ˚C, at 74 Ma

Cycladic Blueschist Unit ca. 2.4-1.8 Gpa, 560-500 ˚C at 53-46 Ma

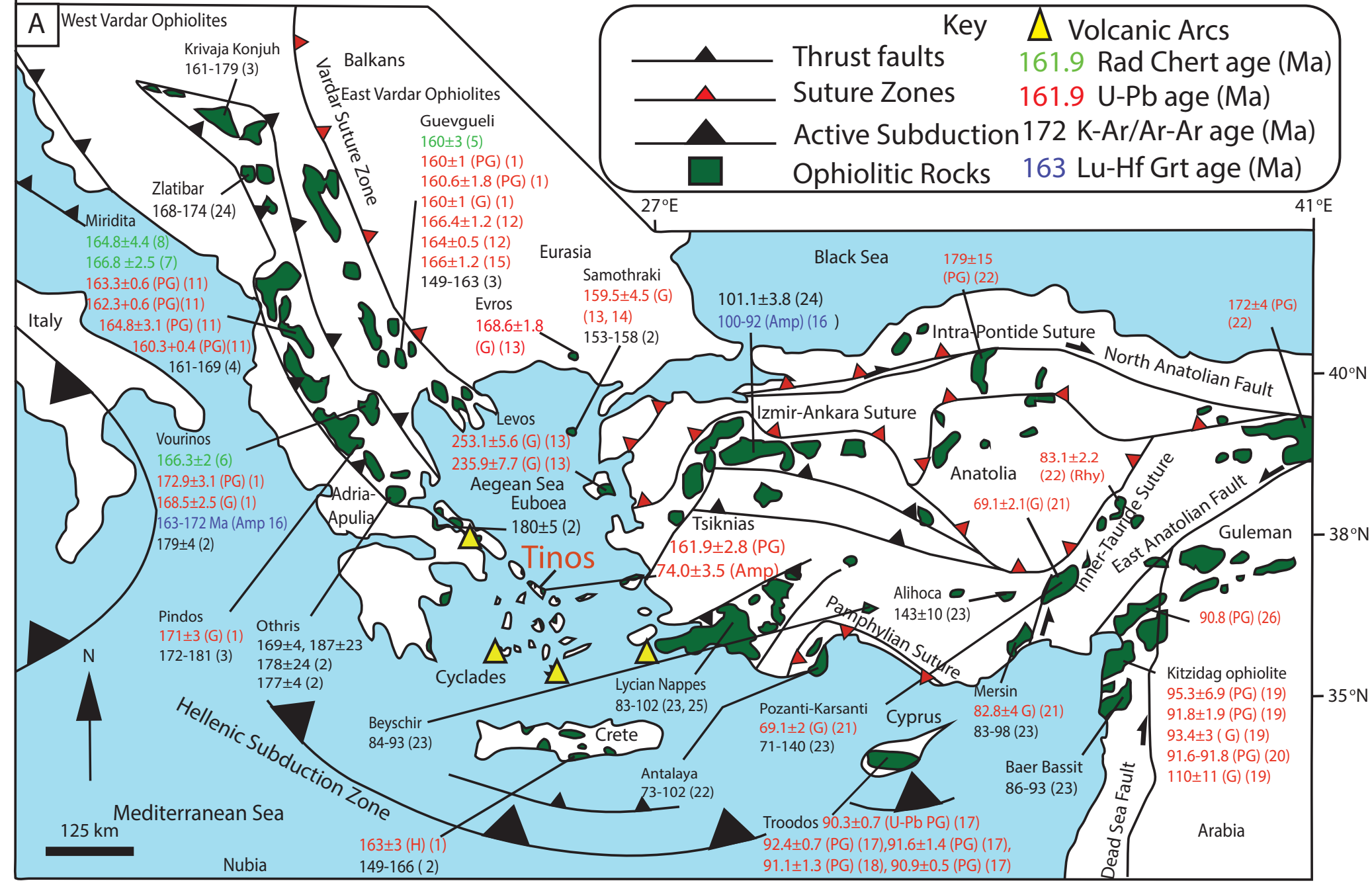


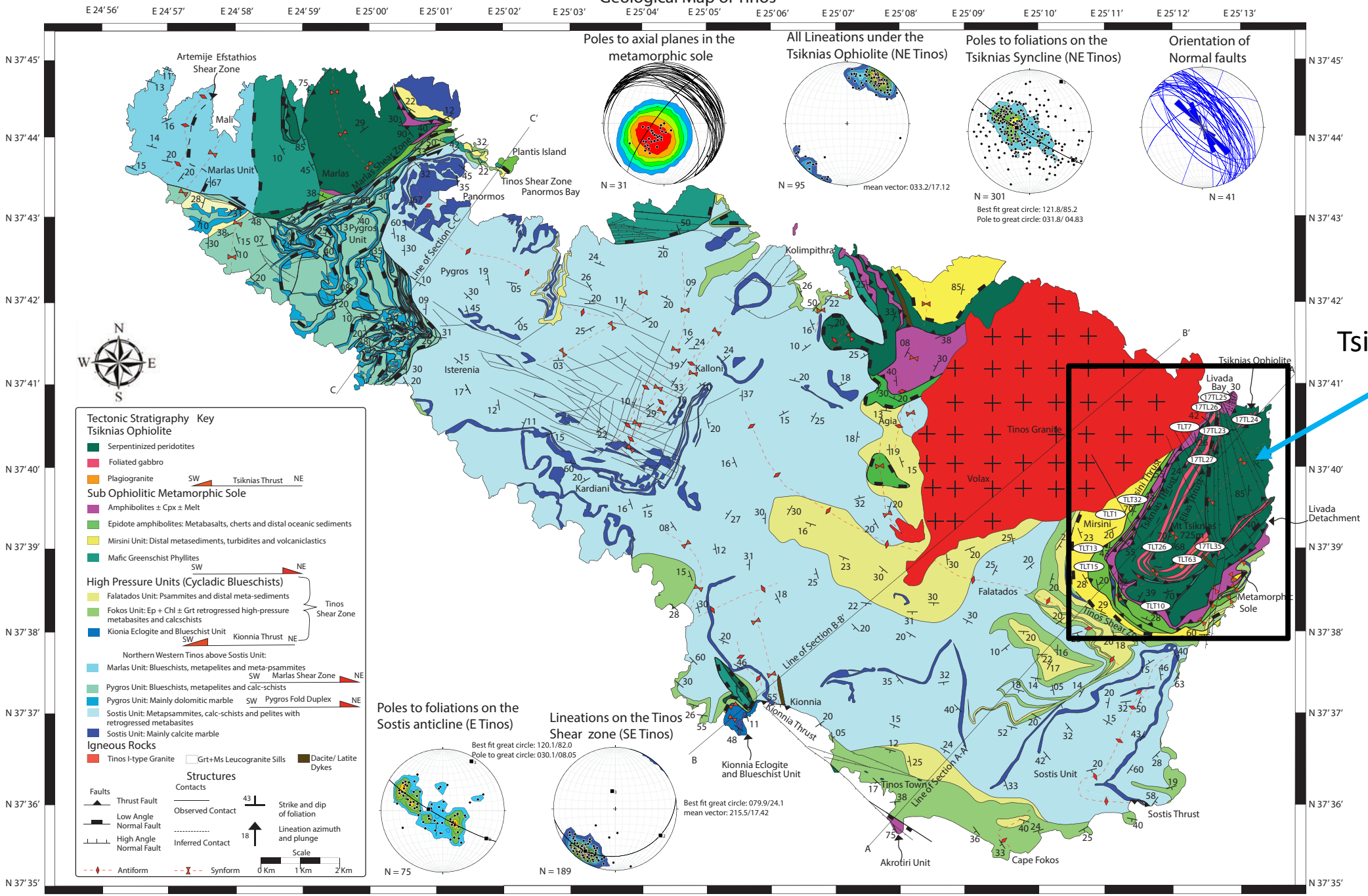


Lamont et al., (2019) Tectonics

Map of Eastern Mediterranean Ophiolites with Ages

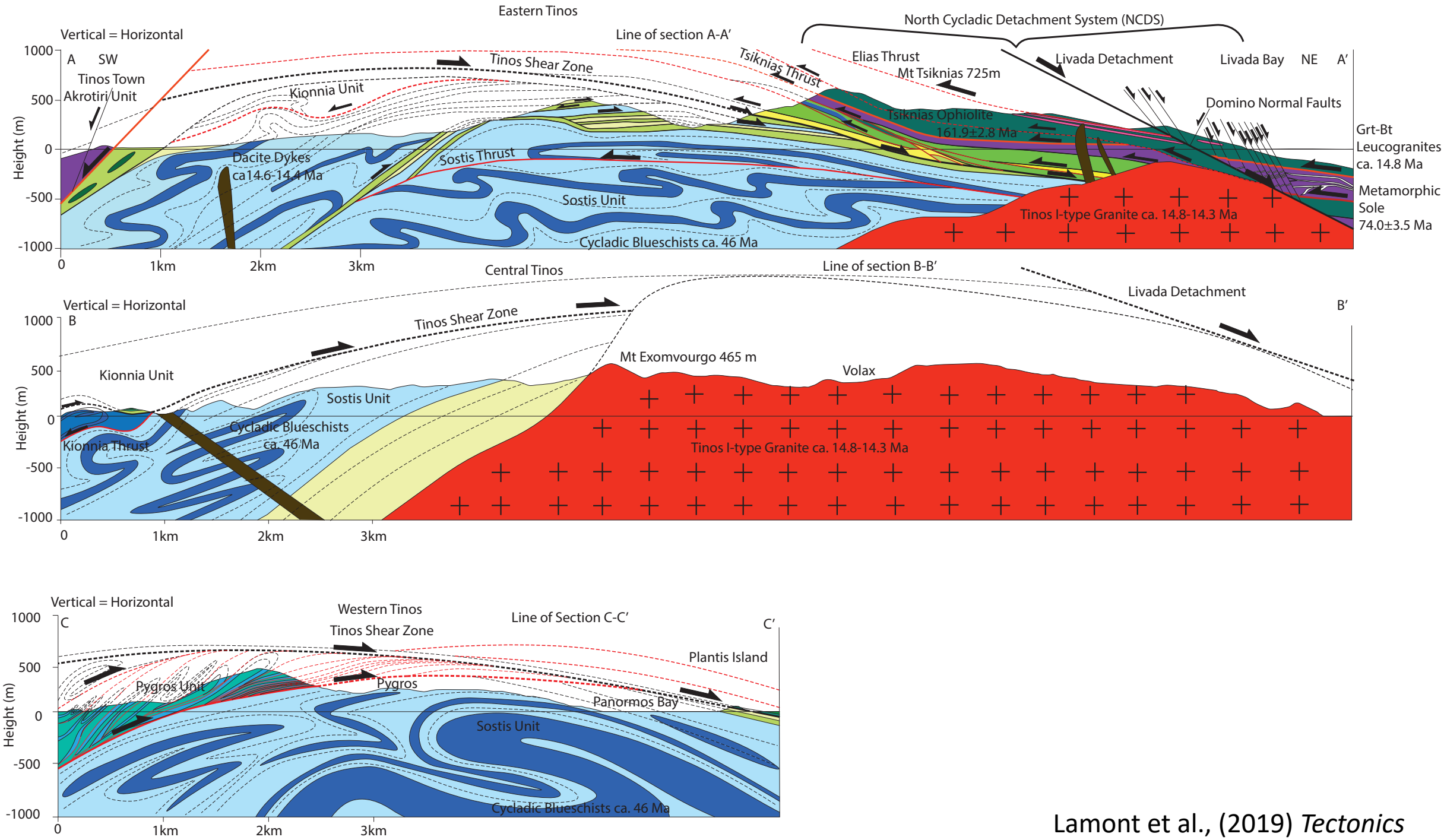
Lamont et al., (2019) *Tectonics*





Tsiknias Ophiolite

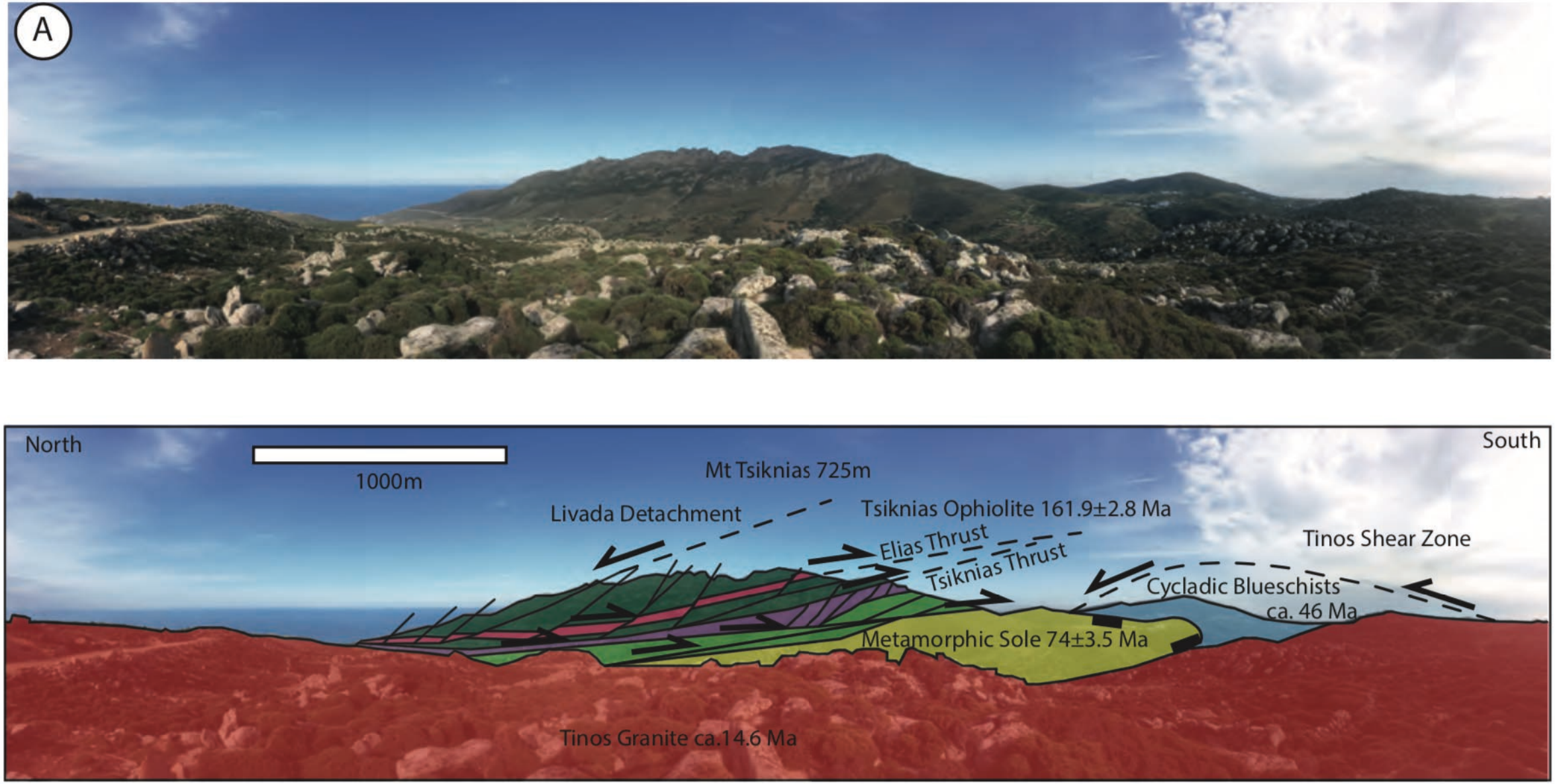
Lamont et al., (2019) *Tectonics*



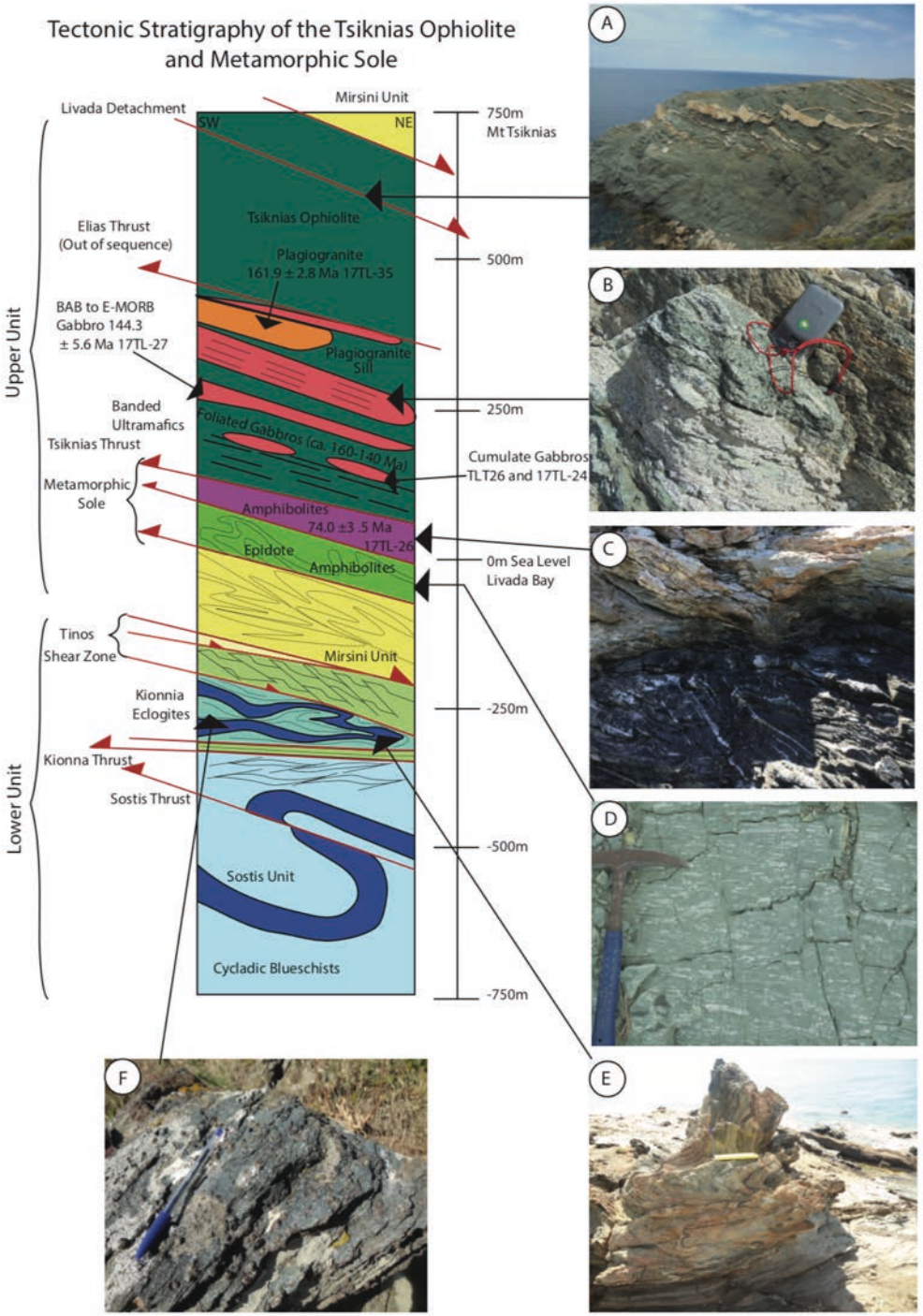
Lamont et al., (2019) *Tectonics*

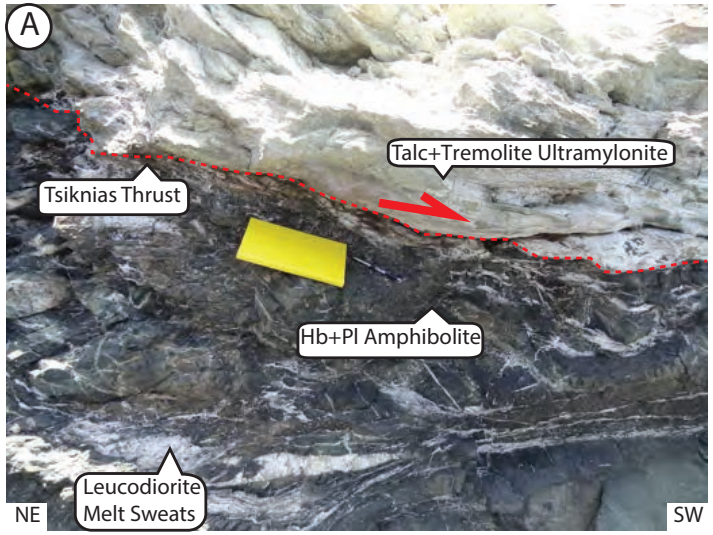
The Upper Unit: Tsinkias Ophiolite, Metamorphic Sole, Pelagic Metasediments

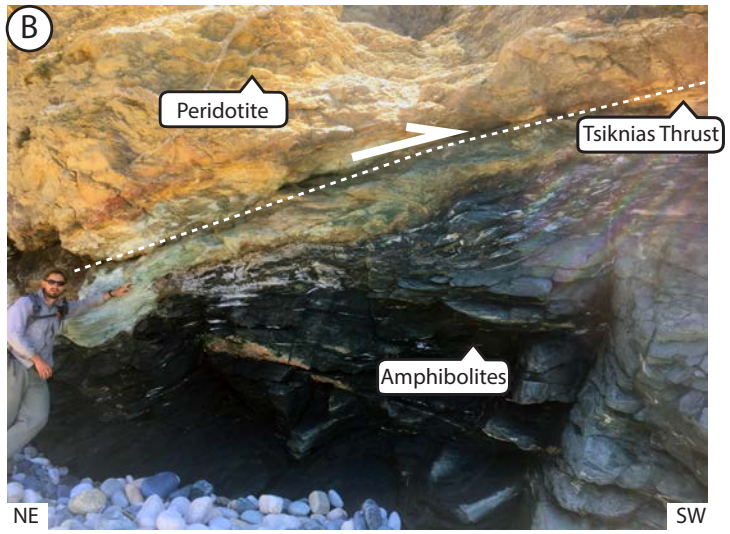
Lamont et al., (2019) *Tectonics*

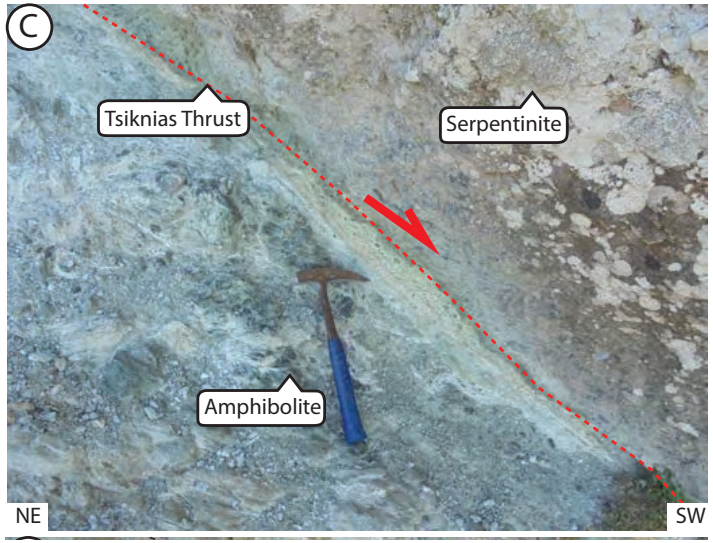


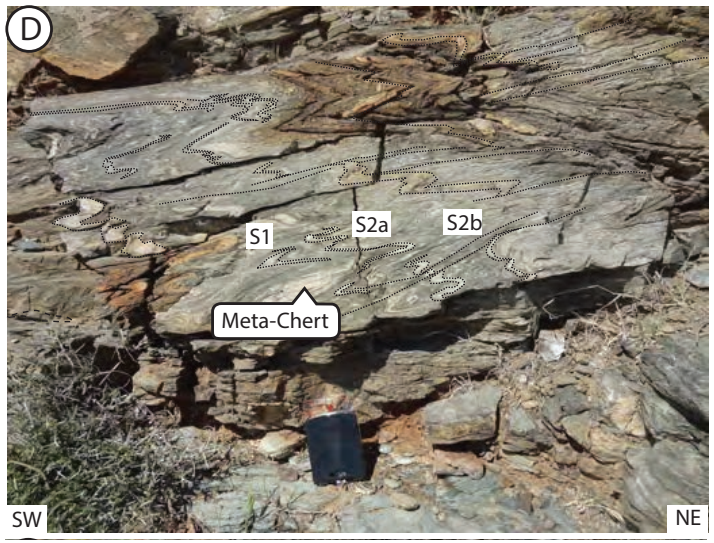
The Tsiknias Ophiolite and metamorphic sole on Tinos





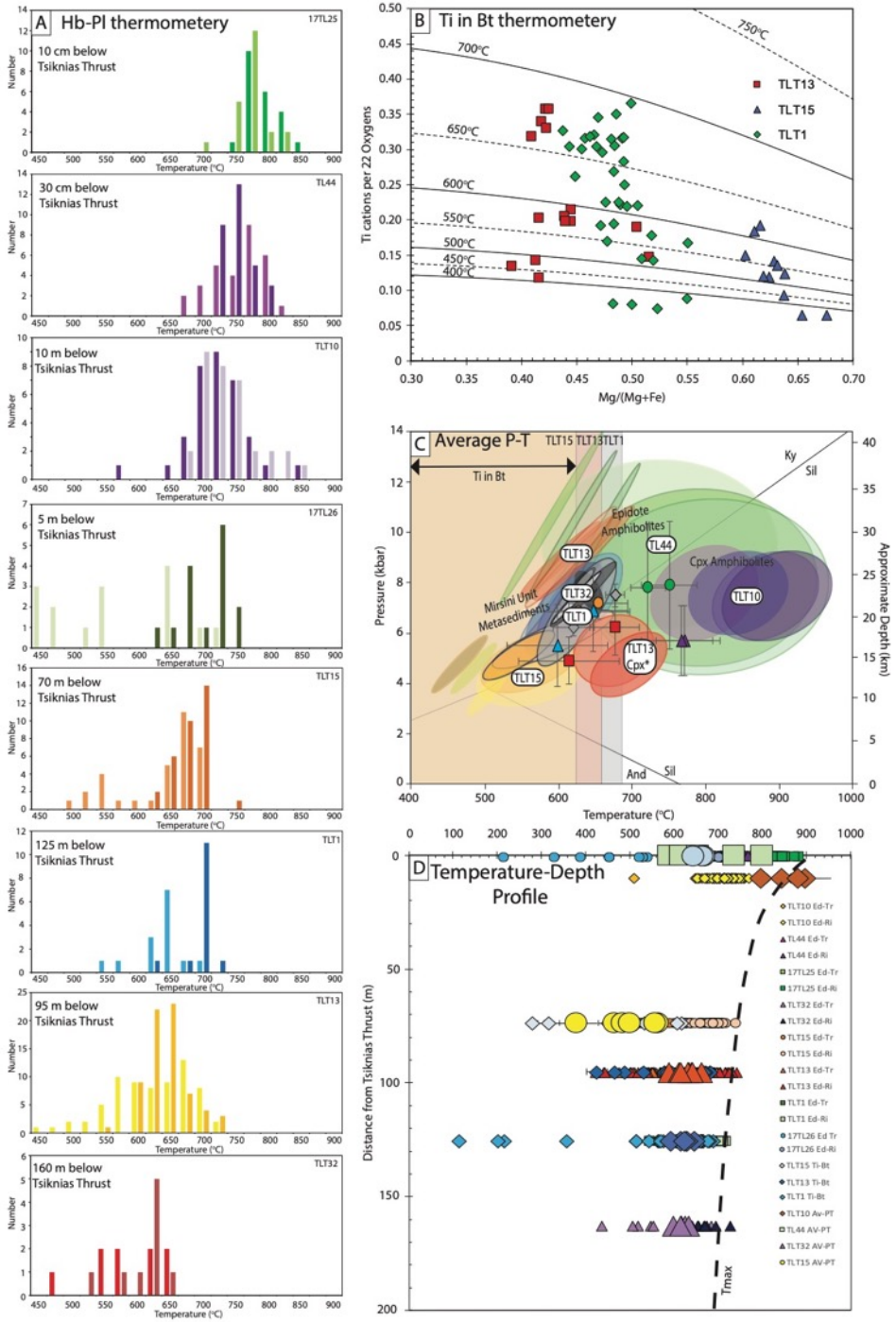


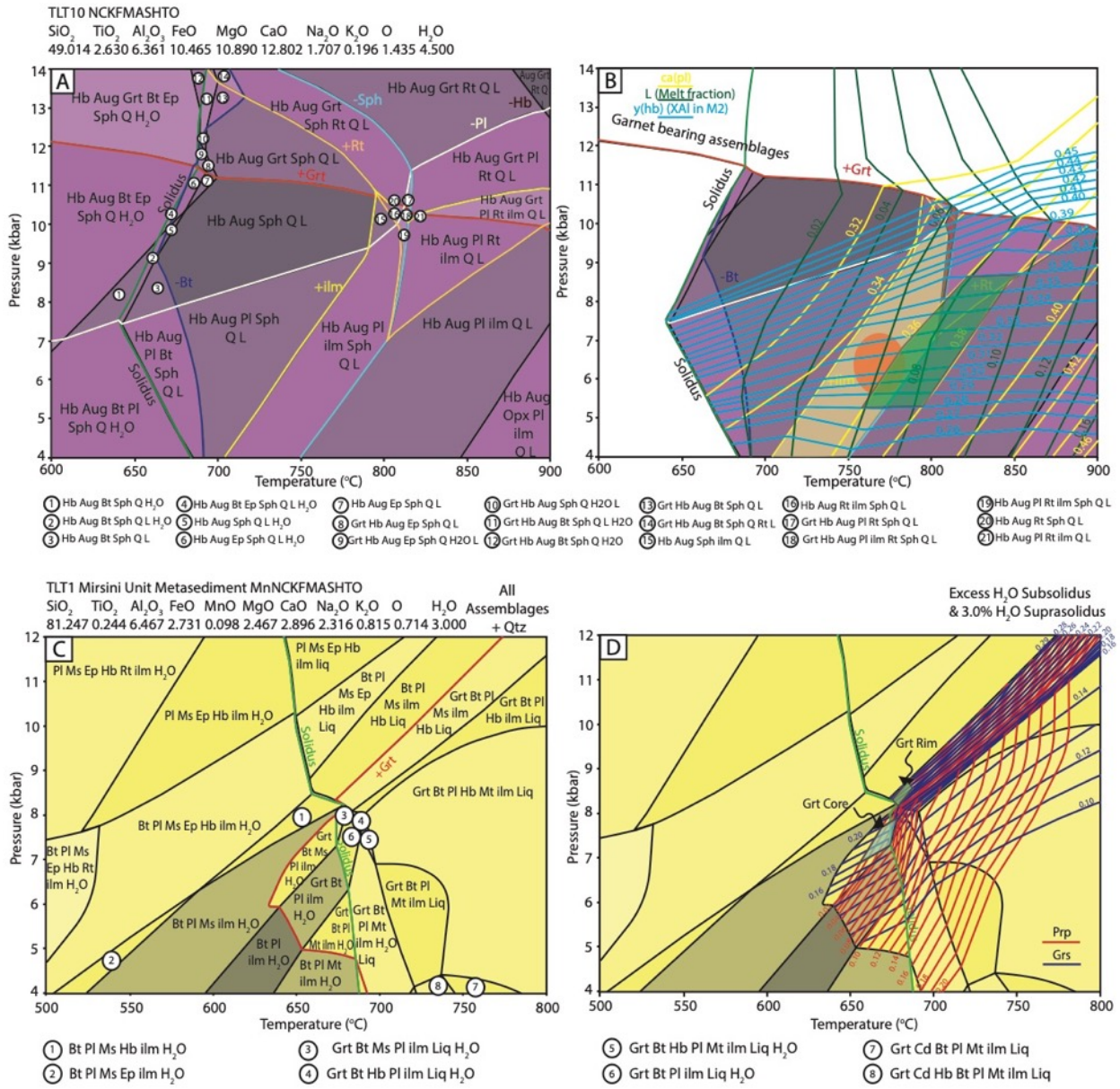




Lamont et al., (2019) *Tectonics*

Thermobarometry of the Tsiknias Metamorphic Sole

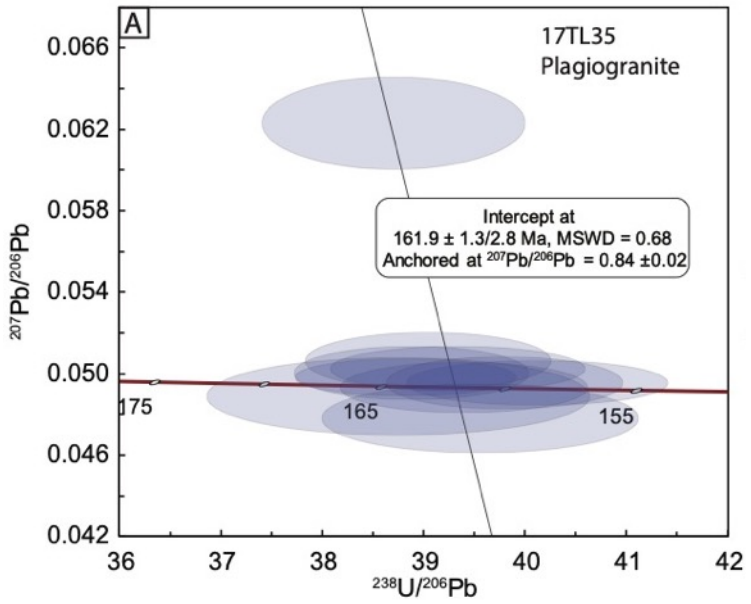




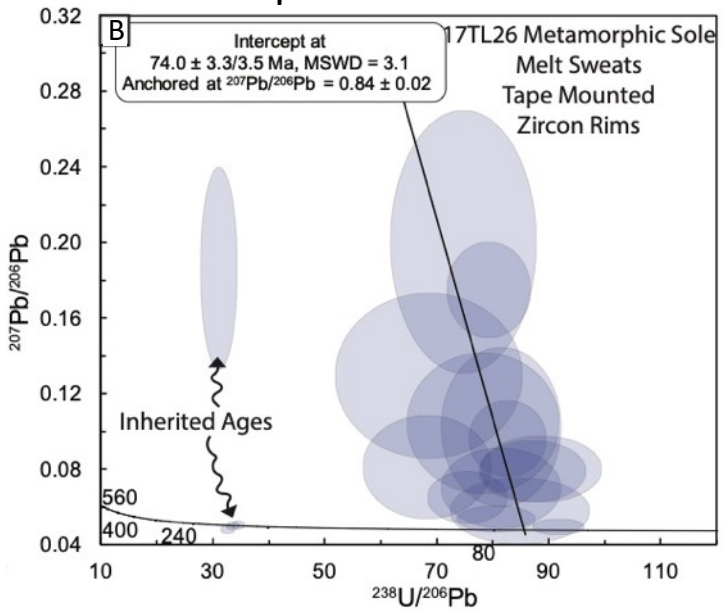
Lamont et al., (2019) *Tectonics*

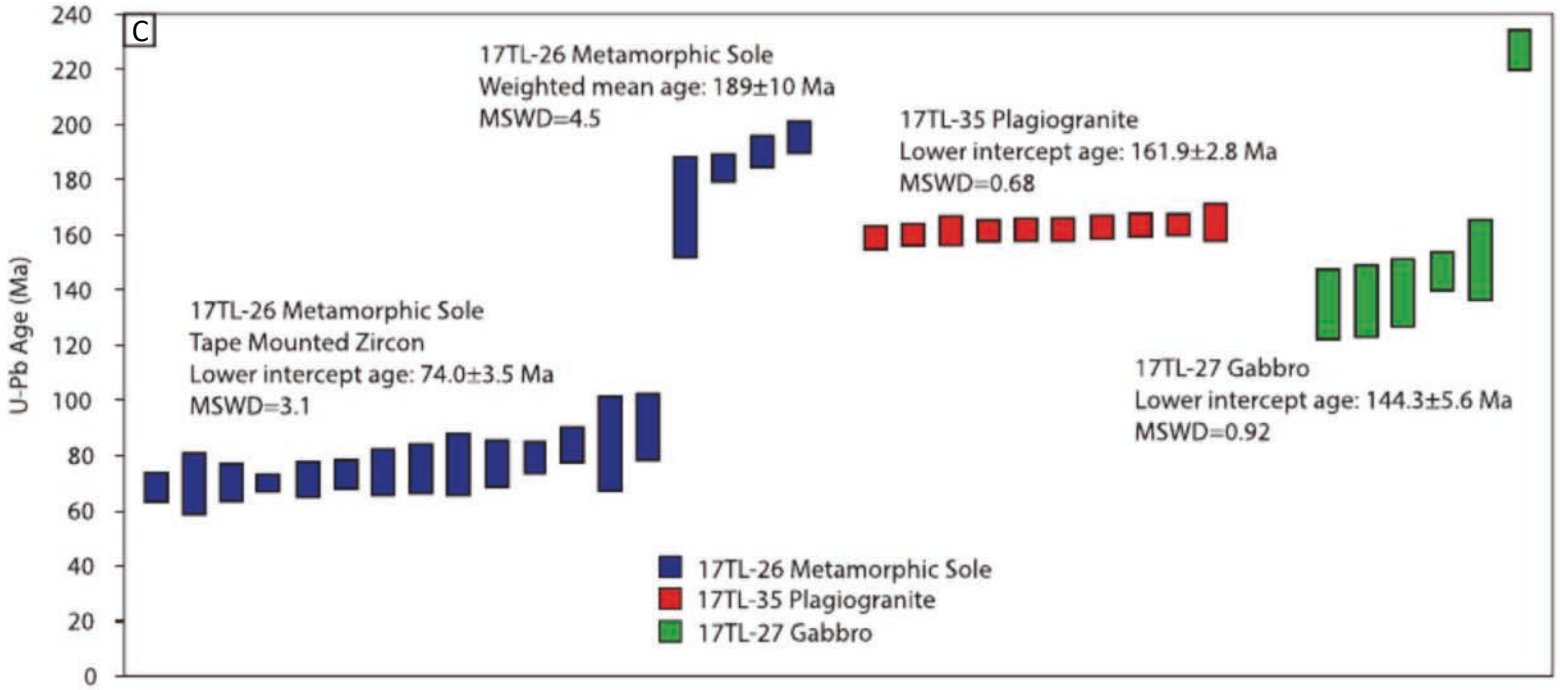
U-Pb Zircon Geochronology

Tsiknias Ophiolite



Metamorphic Sole





Lamont et al., (2019) *Tectonics*

A ca. 90 Myr age discrepancy between Ophiolite and Sole: A thermal conundrum?

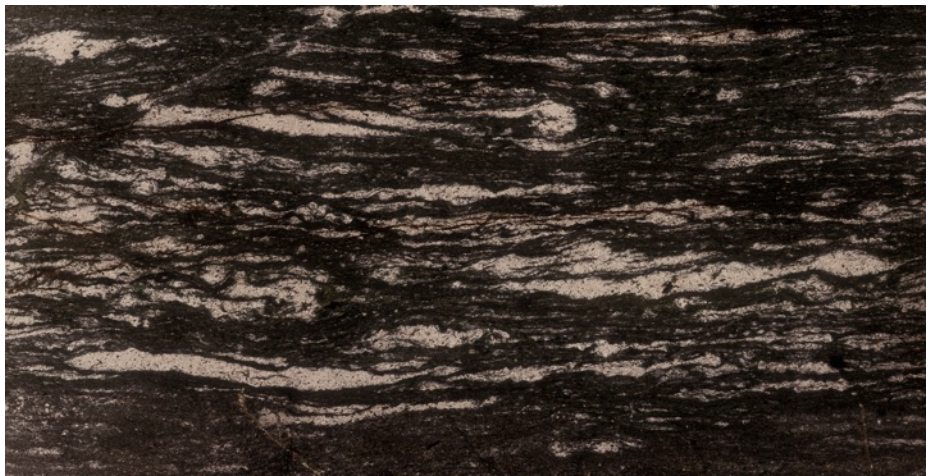
- Subduction initiation in old cold oceanic lithosphere.
- Possible Heating Mechanisms to cause heating in sole:

1. Incursion of the mantle wedge following subduction initiation
2. Shear heating on subduction interface
3. Transient heating?









Episodic melting and recrystallization?

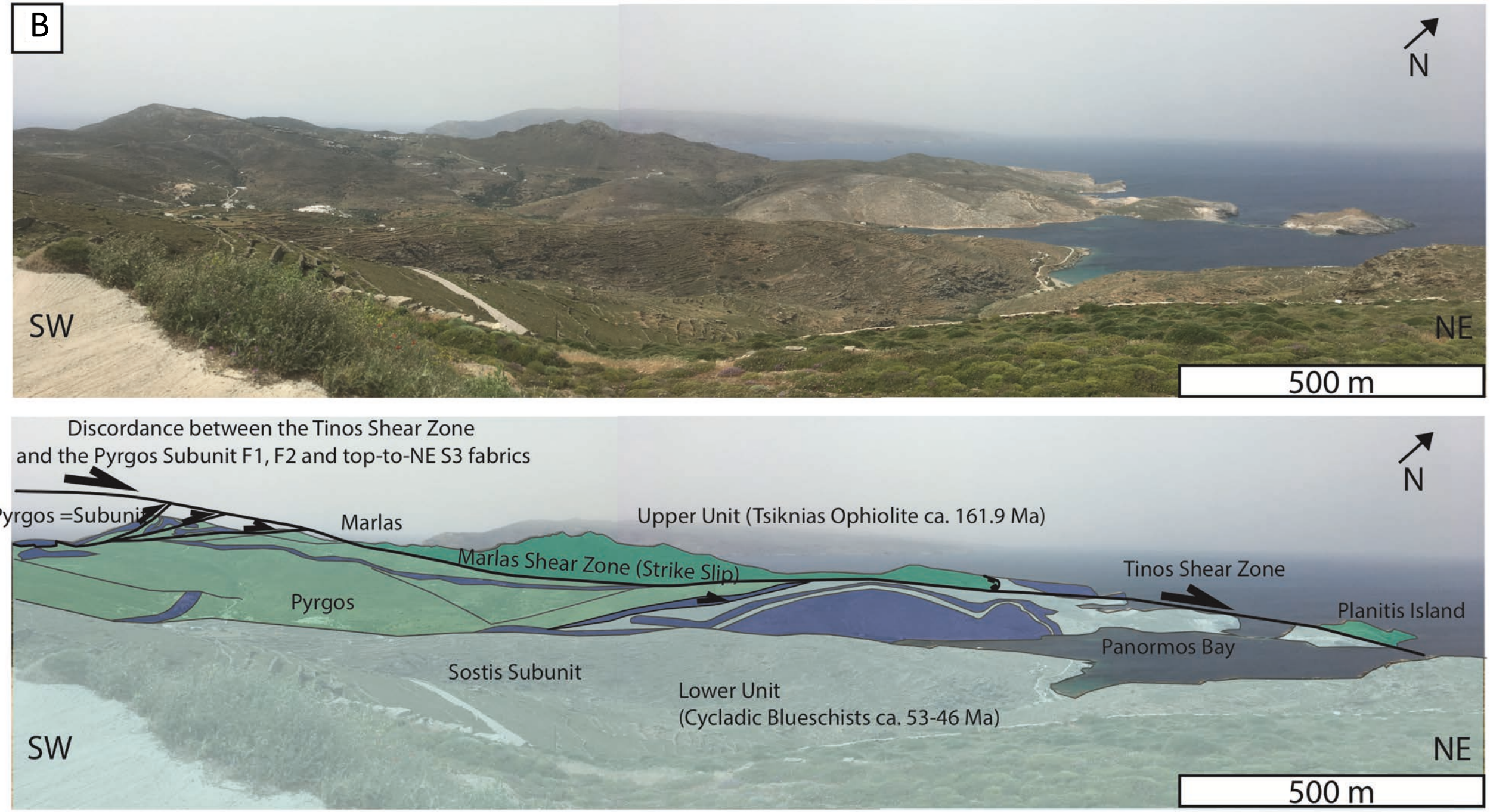
Increasing degree of recrystallization

The Cycladic Blueschist Unit on Tinos

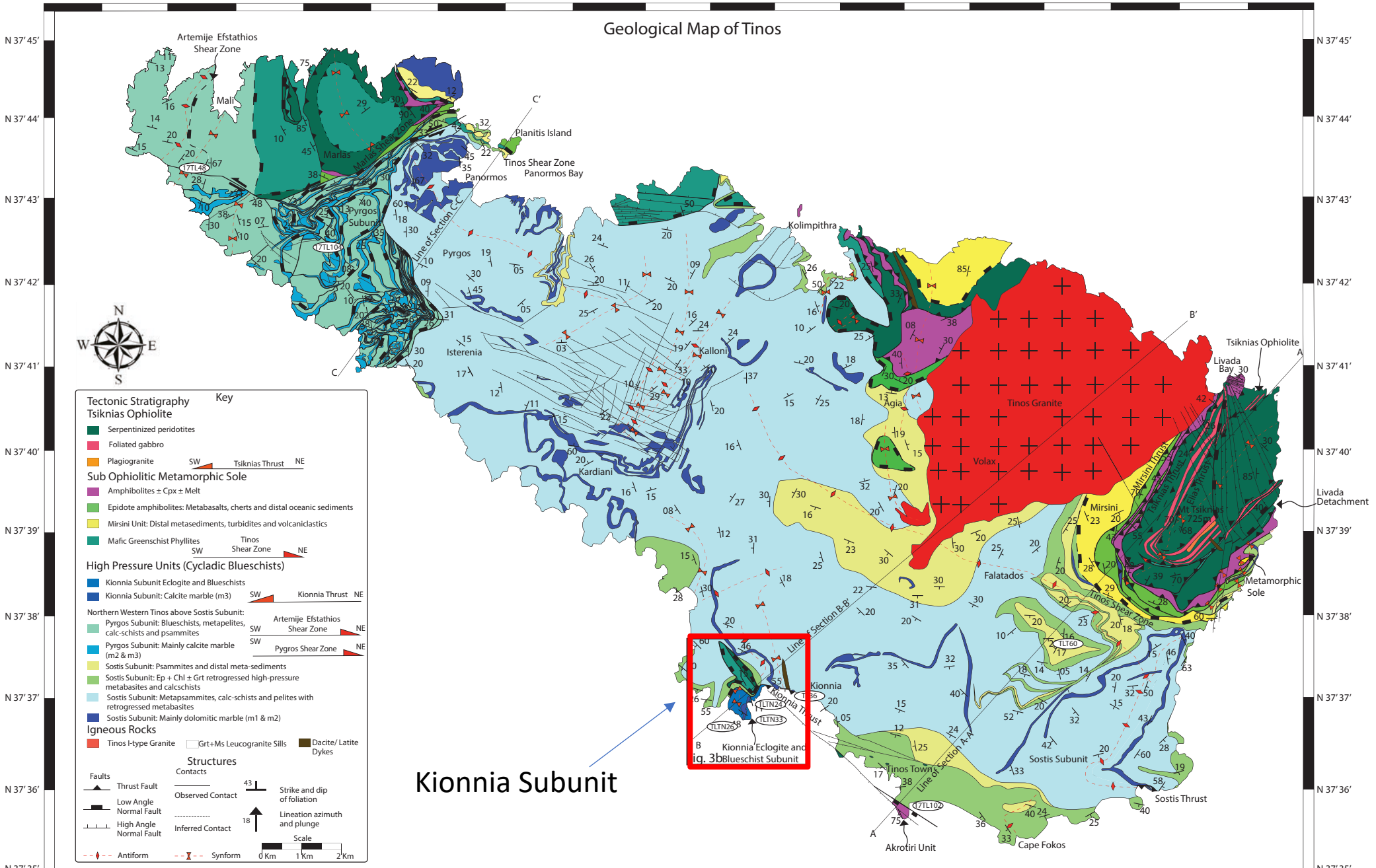
Lamont et al., (under review) *Tectonics*

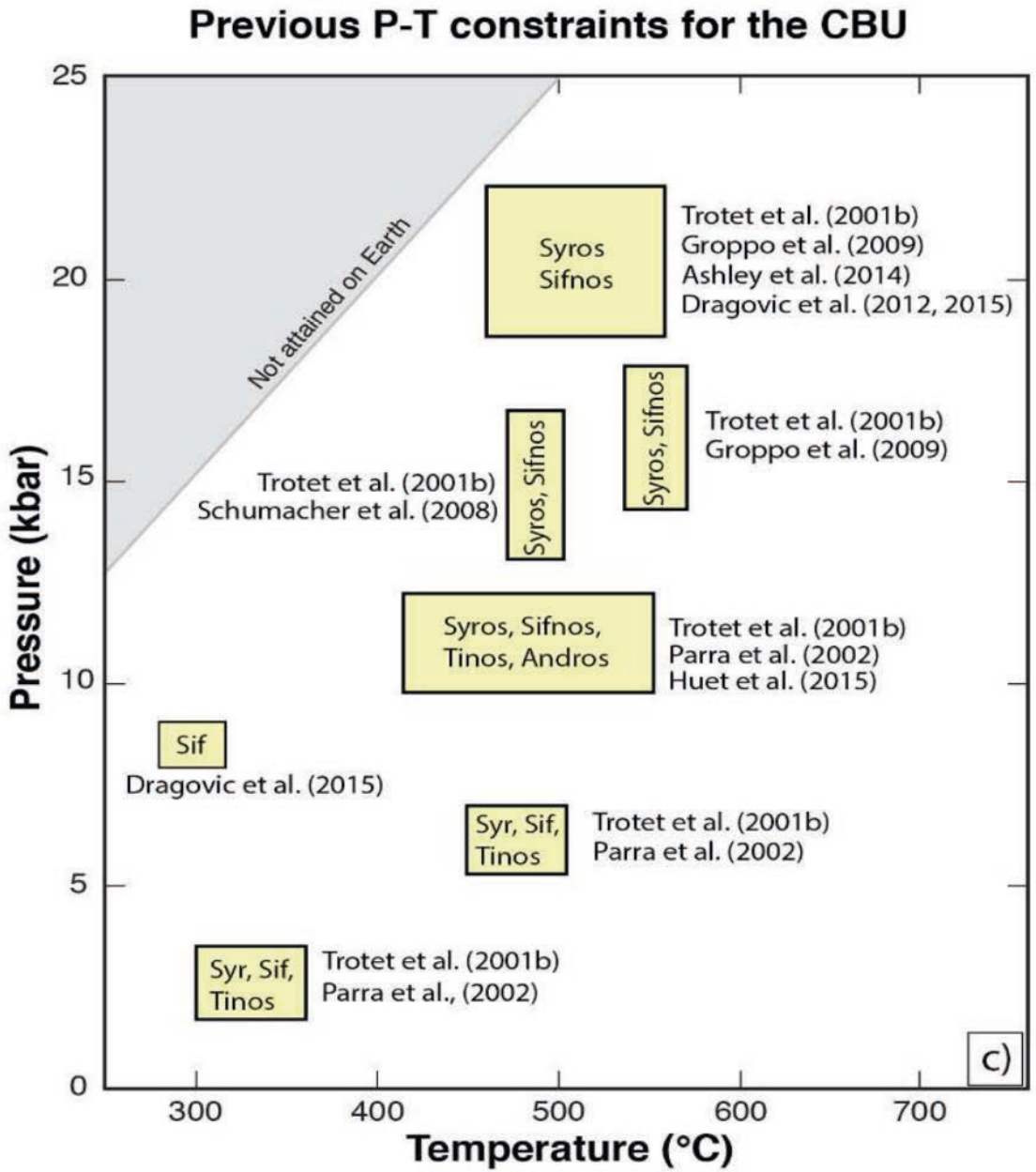


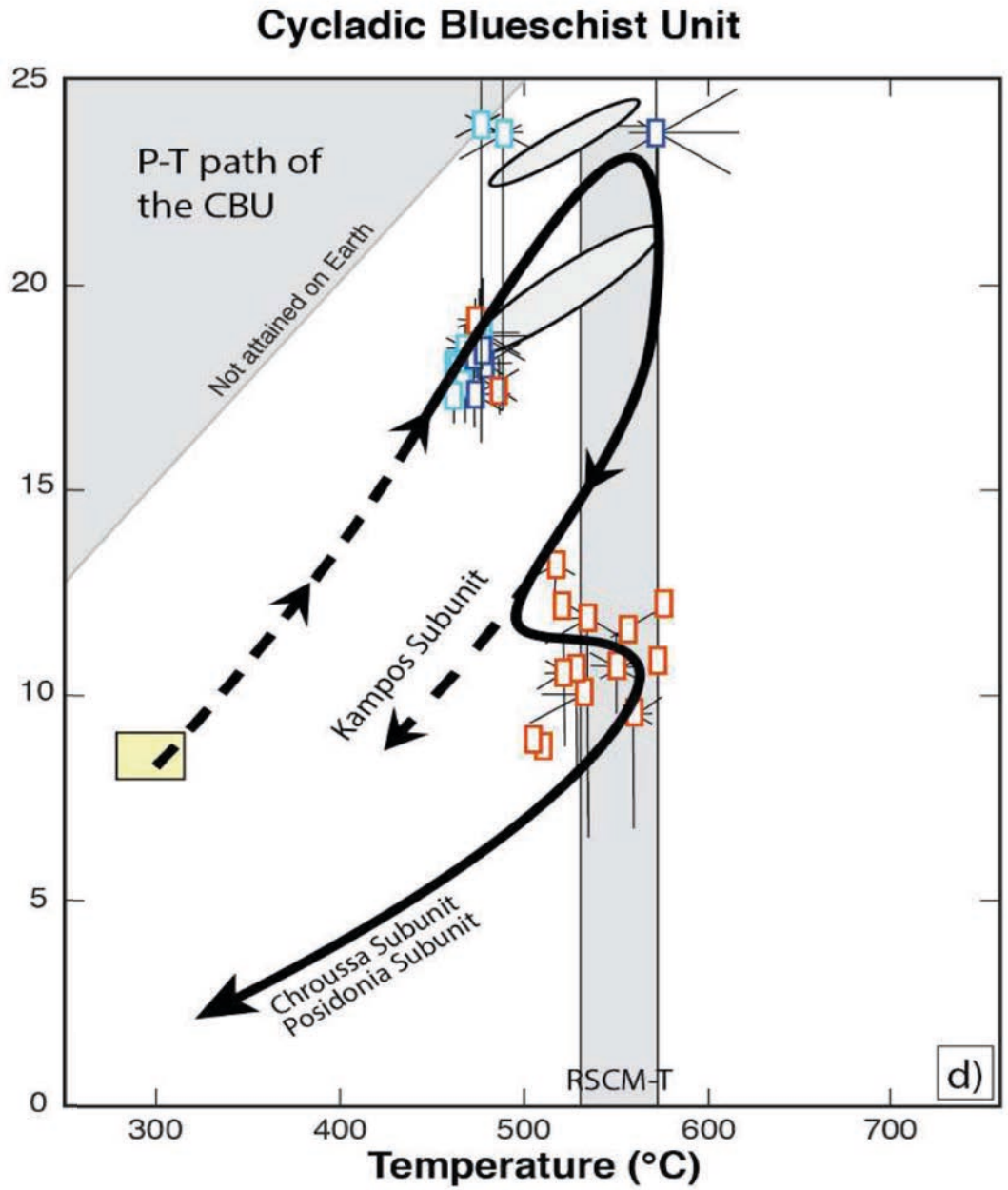
Tsiknias Ophiolite and metamorphic sole juxtaposed against Cycladic Blueschists by Tinos Shear Zone



Lamont et al., (under review) *Tectonics*


Geological Map of Tinos
Key
Tectonic Stratigraphy
Tsiknias Ophiolite
Serpentinized peridotites
Foliated gabbro
Plagiogranite
SW Tsiknias Thrust NE
Sub Ophiolitic Metamorphic Sole
Amphibolites ± Cpx ± Melt
Epidote amphibolites: Metabasalts, cherts and distal oceanic sediments
Mirsini Unit: Distal metasediments, turbidites and volcaniclastics
Mafic Greenschist Phyllites
SW Tinos Shear Zone NE
High Pressure Units (Cycladic Blueschists)
Kionnia Subunit Eclogite and Blueschists
Kionnia Subunit: Calcite marble (m3)
SW Kionnia Thrust NE
Northern Western Tinos above Sostis Subunit:
Pyrgos Subunit: Blueschists, metapelites, calc-schists and psammites
SW Artemije Efstathios Shear Zone NE
Pyrgos Subunit: Mainly calcite marble (m2 & m3)
SW Pygros Shear Zone NE
Sostis Subunit: Psammites and distal meta-sediments
Sostis Subunit: Ep + Chl ± Grt retrogressed high-pressure metabasites and calcschists
Sostis Subunit: Metapsammites, calc-schists and pelites with retrogressed metabasites
Sostis Subunit: Mainly dolomitic marble (m1 & m2)
Igneous Rocks
Tinos I-type Granite
Grt+Ms Leucogranite Sills
Dacite/ Latite Dykes
Structures
Faults
Thrust Fault
Low Angle Normal Fault
High Angle Normal Fault
Contacts
Observed Contact
Inferred Contact
Strike and dip of foliation
Lineation azimuth and plunge
Antiform
Synform
Scale
0 Km 1 Km 2 Km
Kionnia Subunit
Fig. 3b
Artemije Efstathios Shear Zone
Mali
Marlas
Marlas Shear Zone
Pyrgos Subunit
Planitis Island
Tinos Shear Zone
Panormos Bay
Panormos
Line of Section C-C'
Pyrgos
Isterenia
Kalloni
Kardiani
Kolimpithra
Agia
Tinos Granite
Volax
Falatados
Mirsini
Mirsini Thrust
Elias Thrust
Tsiknias Thrust
Mt Tsiknias 725m
Tsiknias Ophiolite
Livada Bay
Livada Detachment
Metamorphic Sole
Tinos Shear Zone
Line of Section B-B'
Kionnia
Kionnia Thrust
Kionnia Eclogite and Blueschist Subunit
Line of Section A-A'
Tinos Town
Sostis Subunit
Sostis Thrust
Akrotiri Unit
Cape Fokos
17TL48
17TL104
TLTN24
TLTN33
TLTN26
TLT60
17TL102
N 37° 45′
N 37° 44′
N 37° 43′
N 37° 42′
N 37° 41′
N 37° 40′
N 37° 39′
N 37° 38′
N 37° 37′
N 37° 36′
N 37° 35′
E 24° 56′
E 24° 57′
E 24° 58′
E 24° 59′
E 25° 00′
E 25° 01′
E 25° 02′
E 25° 03′
E 25° 04′
E 25° 05′
E 25° 06′
E 25° 07′
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E 25° 10′
E 25° 11′
E 25° 12′
E 25° 13′

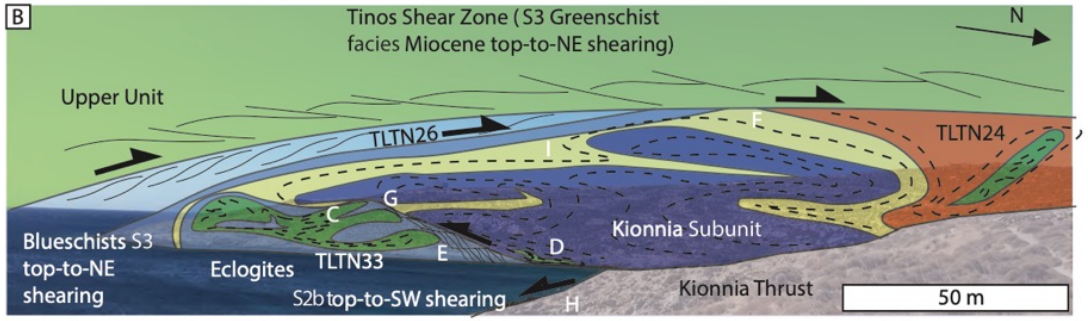


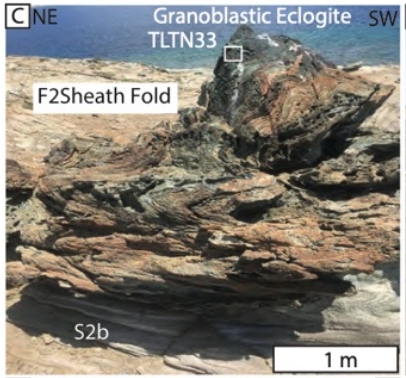


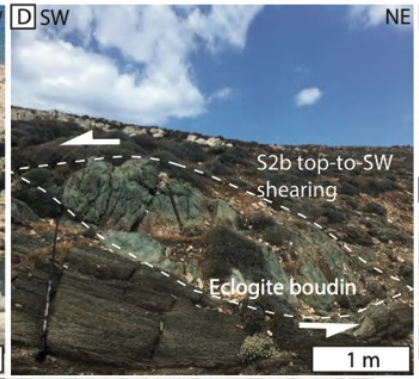
Laurent et al., (2018) *JMG*

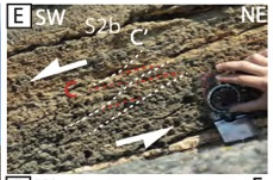
The Cycladic Blueschist Unit on Tinos

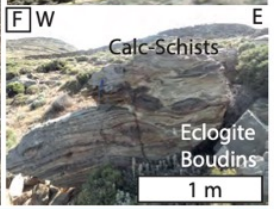


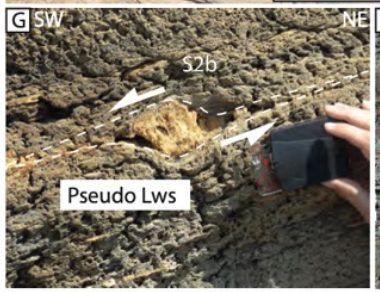


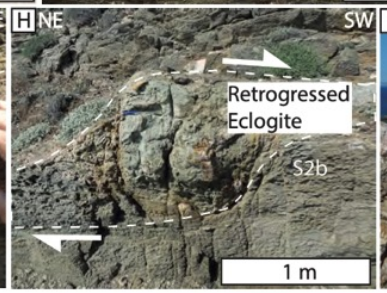






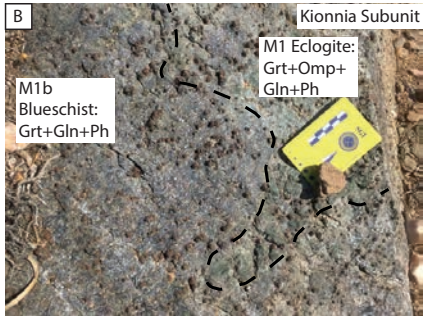




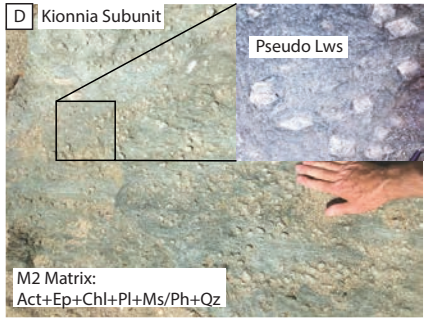


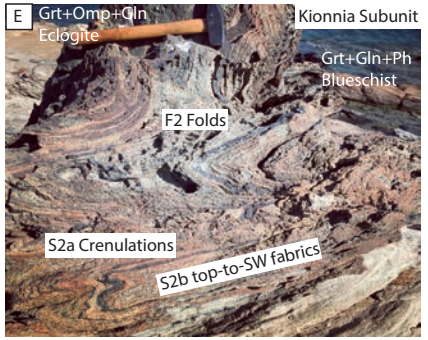


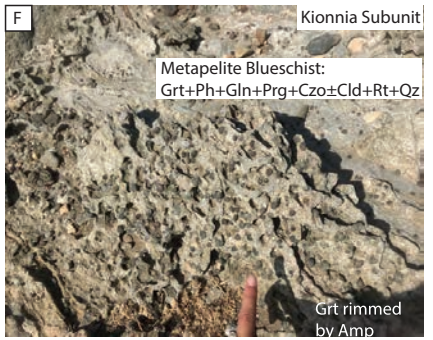


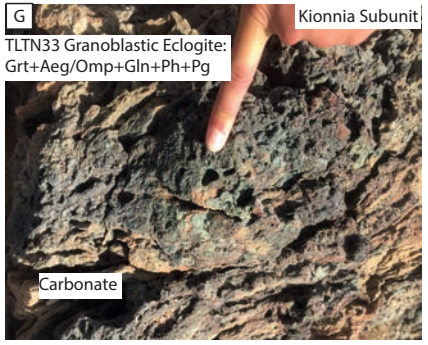


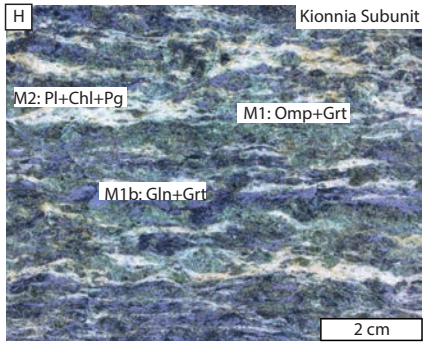






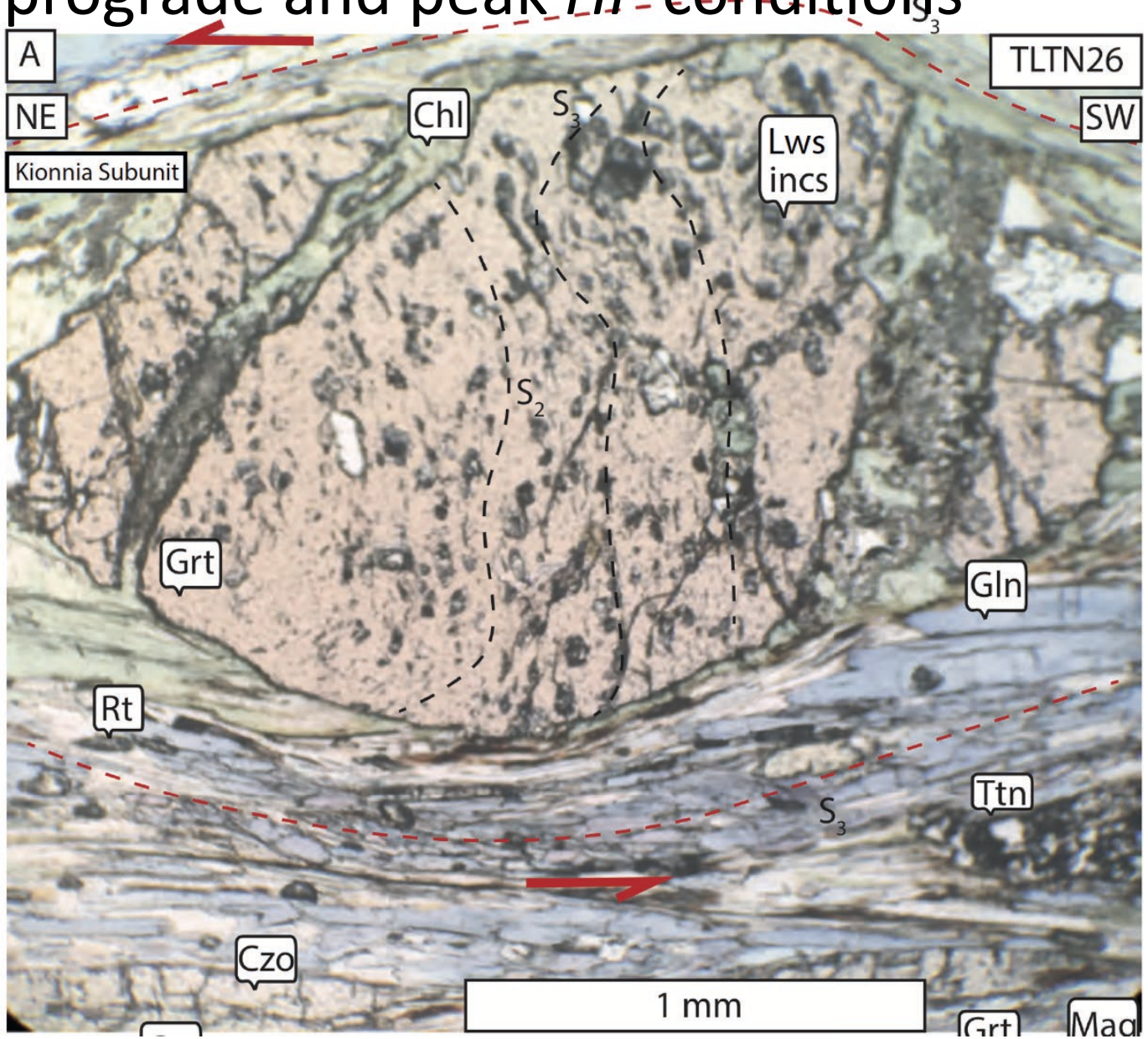


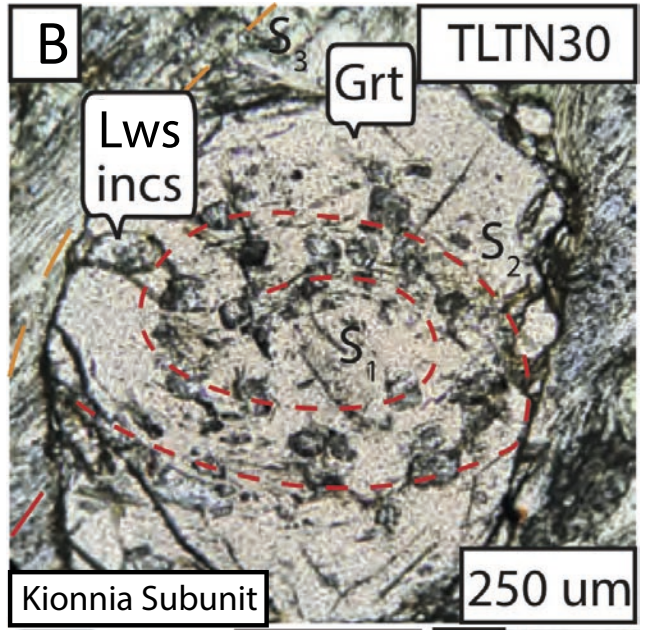


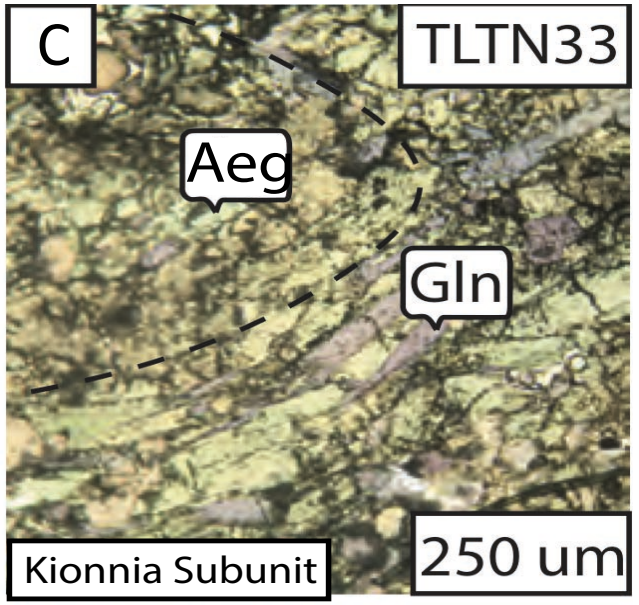


Lamont et al., (under review) *Tectonics*

Pseudomorphed Lawsonite during prograde and peak *HP* conditions

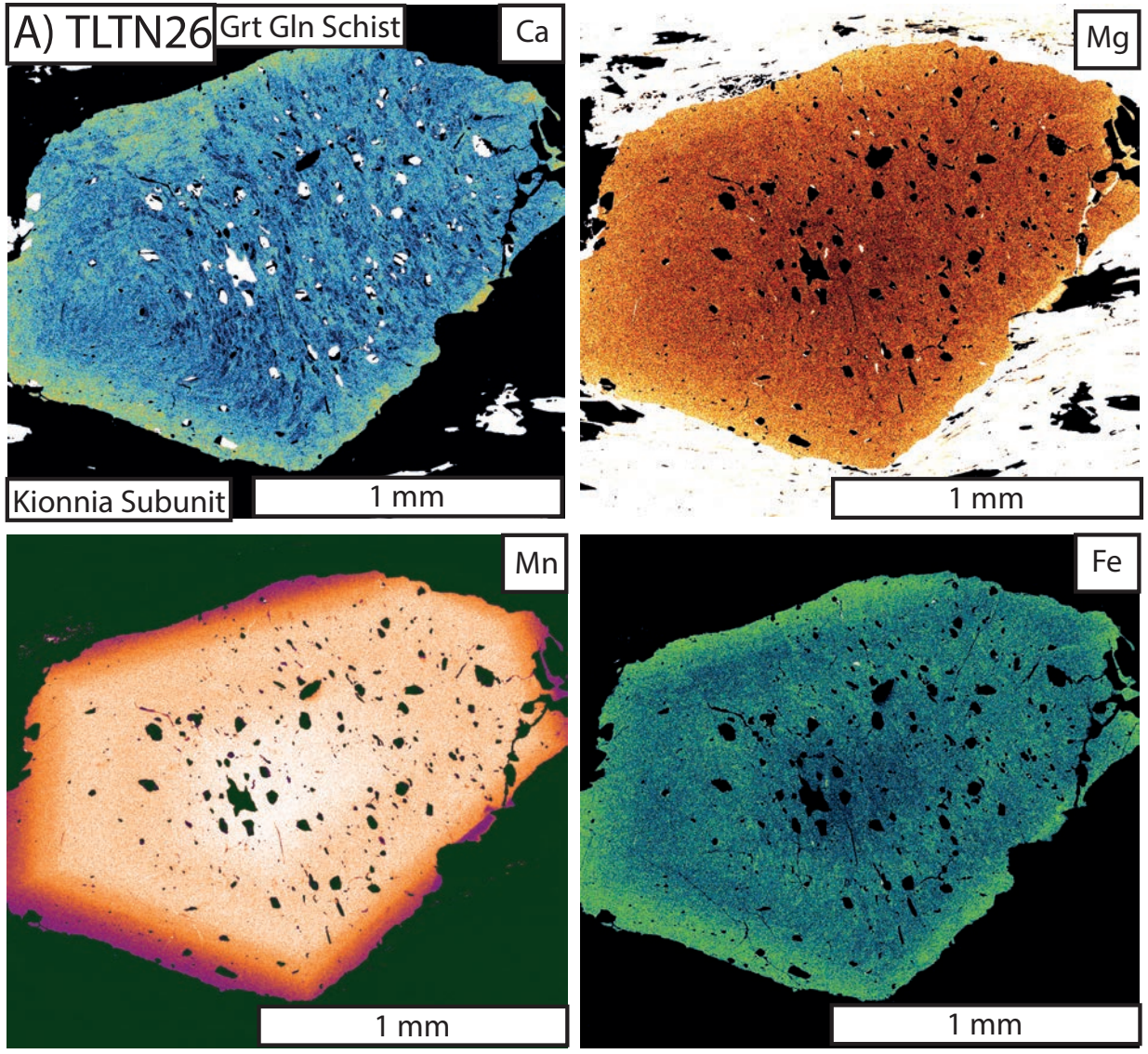


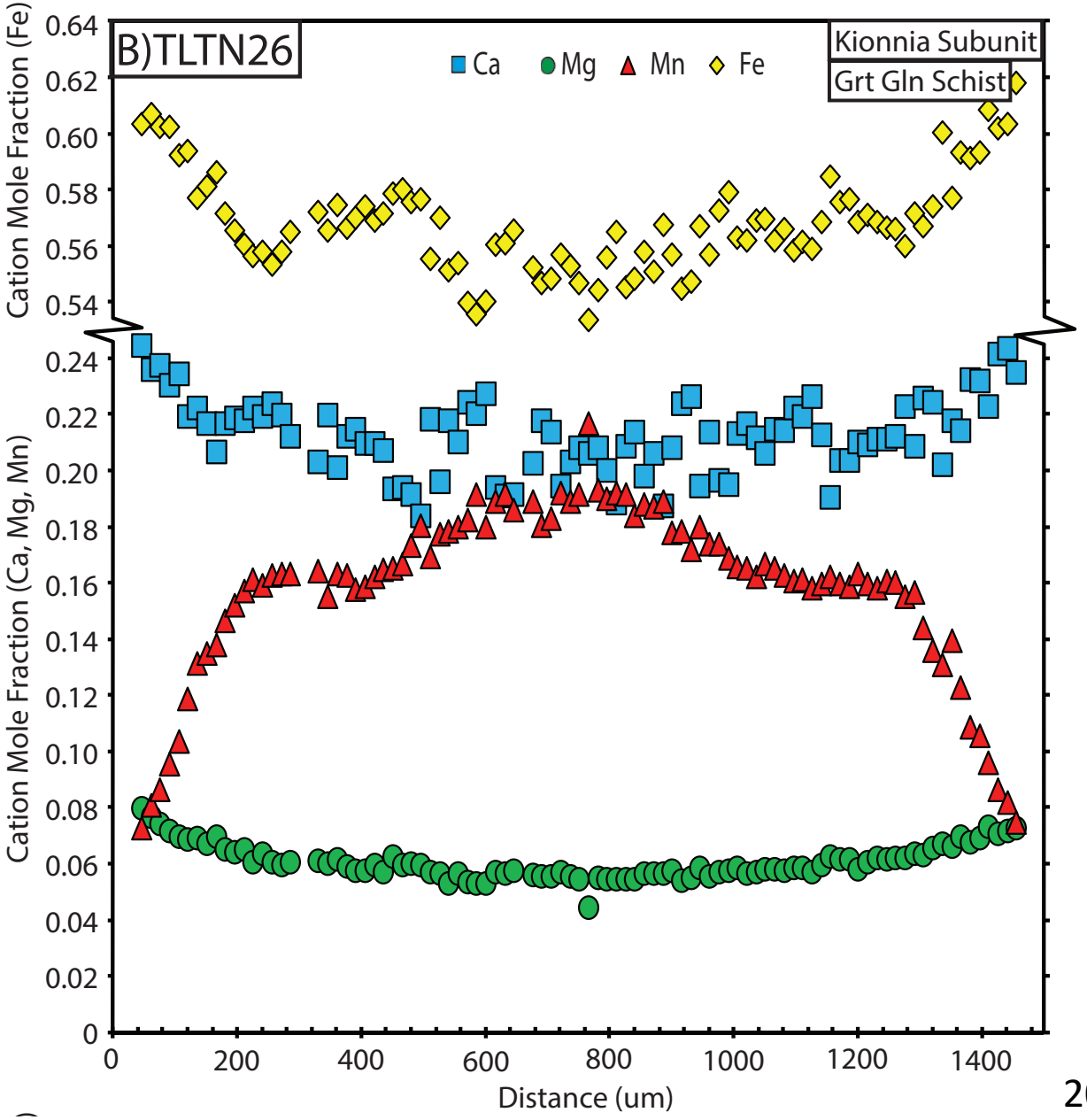




Lamont et al., (under review) *Tectonics*

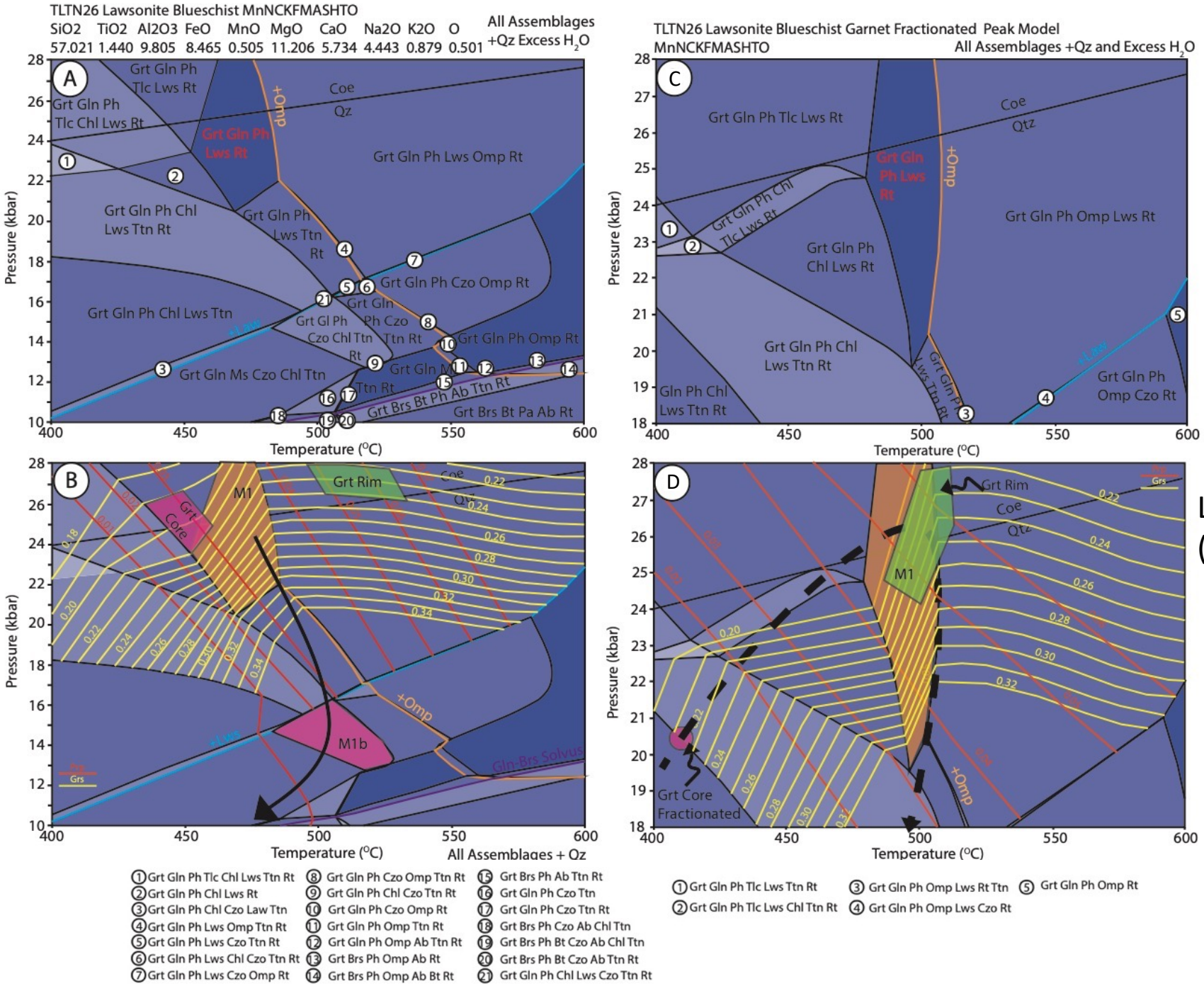
Garnet chemistry





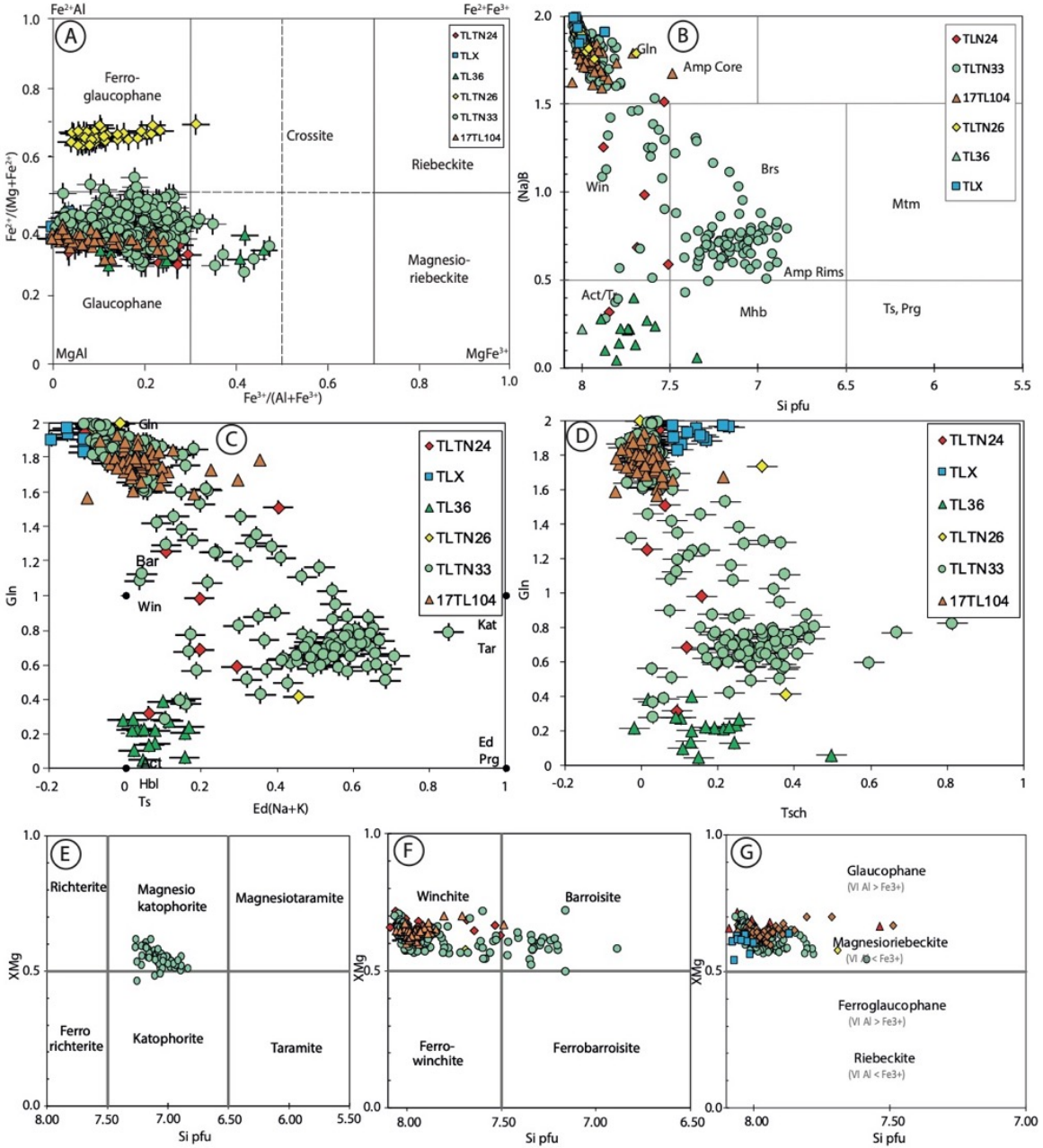
Lamont et al., (under review) *Tectonics*

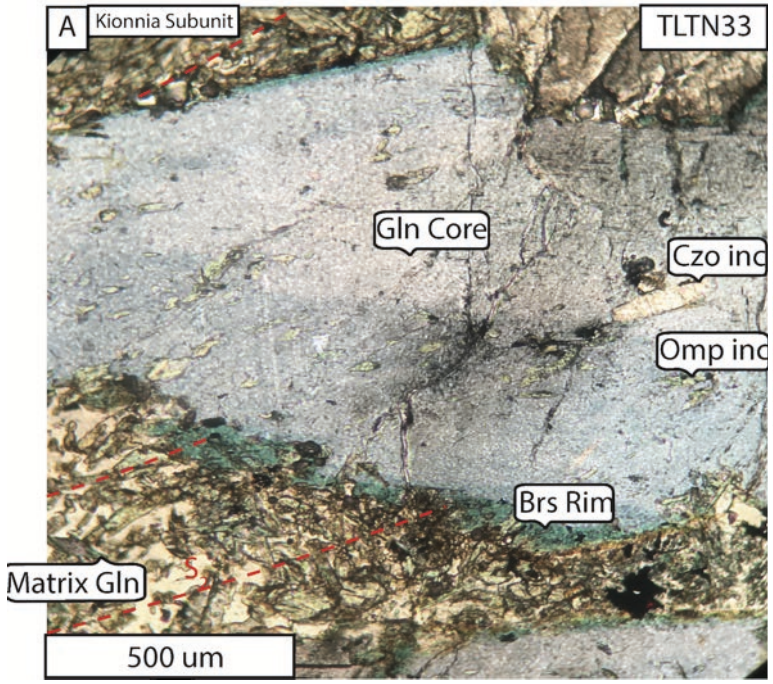
Kionnia Blueschist *P-T*: 0.24-0.26 GPa, 490-520˚C

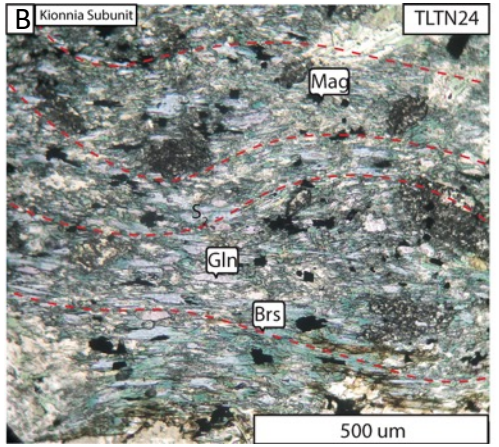


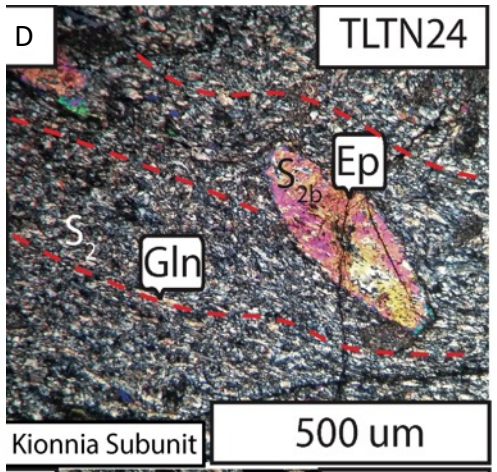
Lamont et al., (under review) *Tectonics*

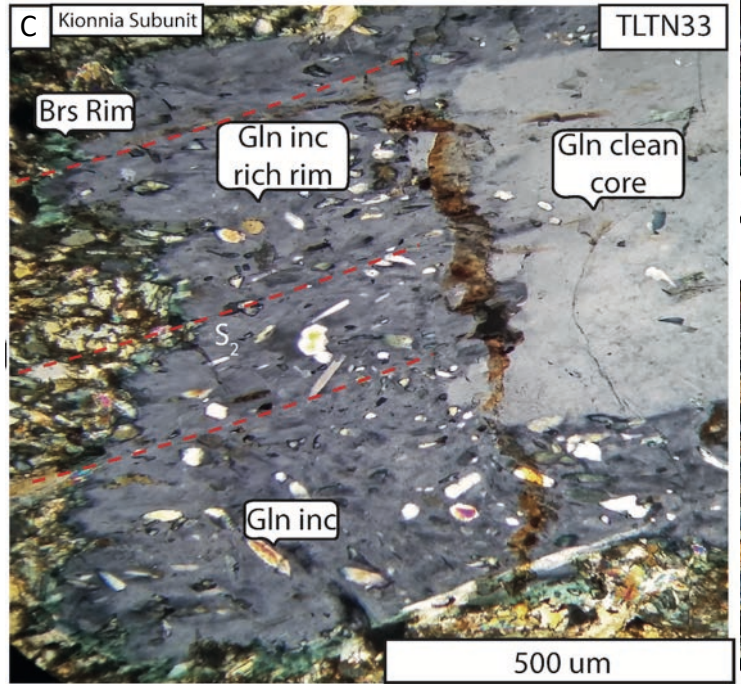
Lawsonite breakdown and fluid loss during exhumation

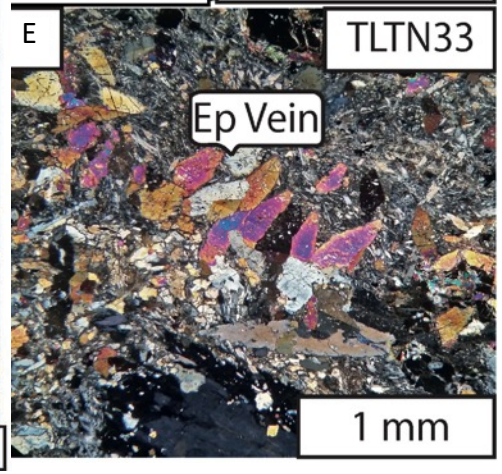






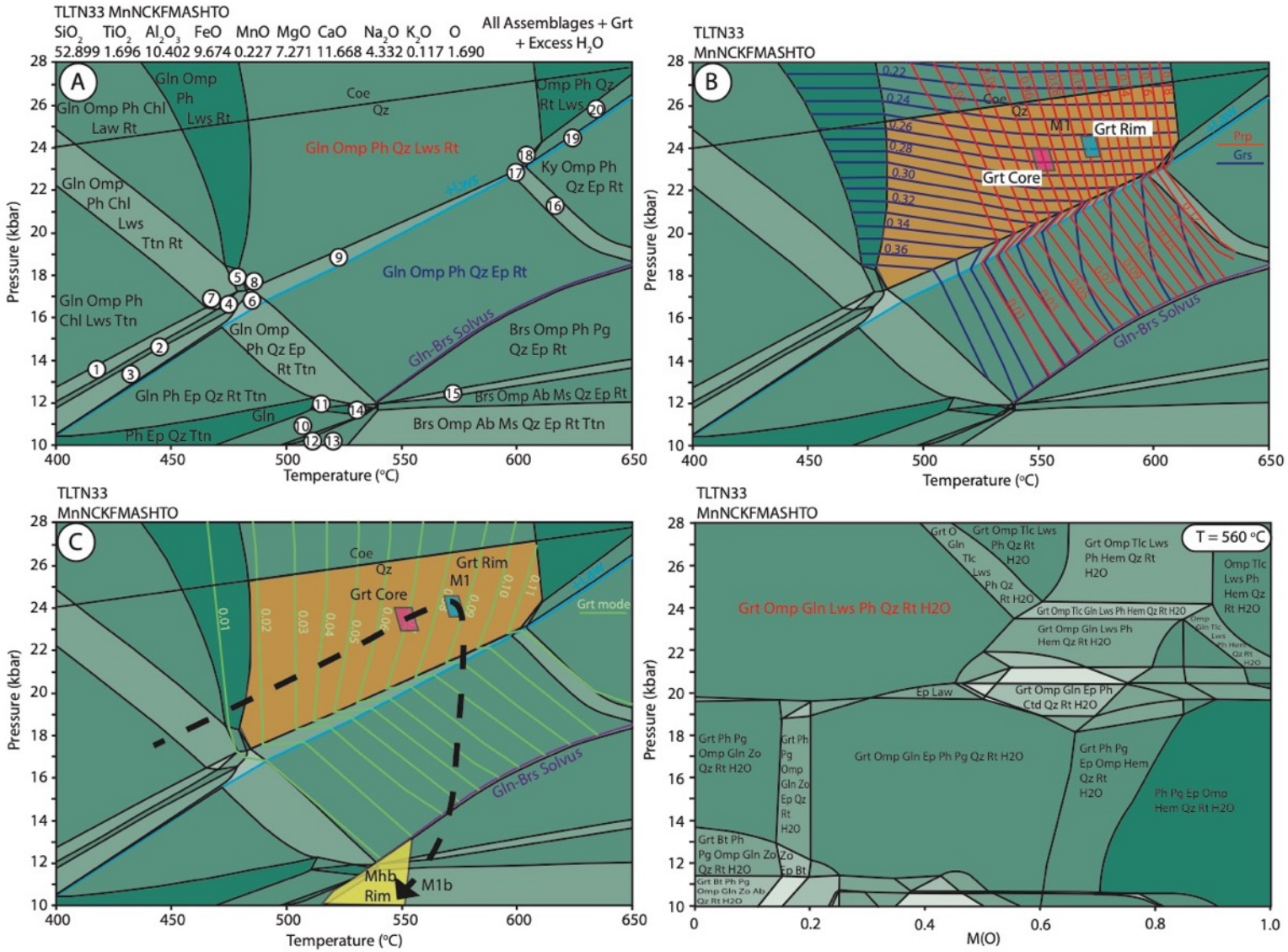






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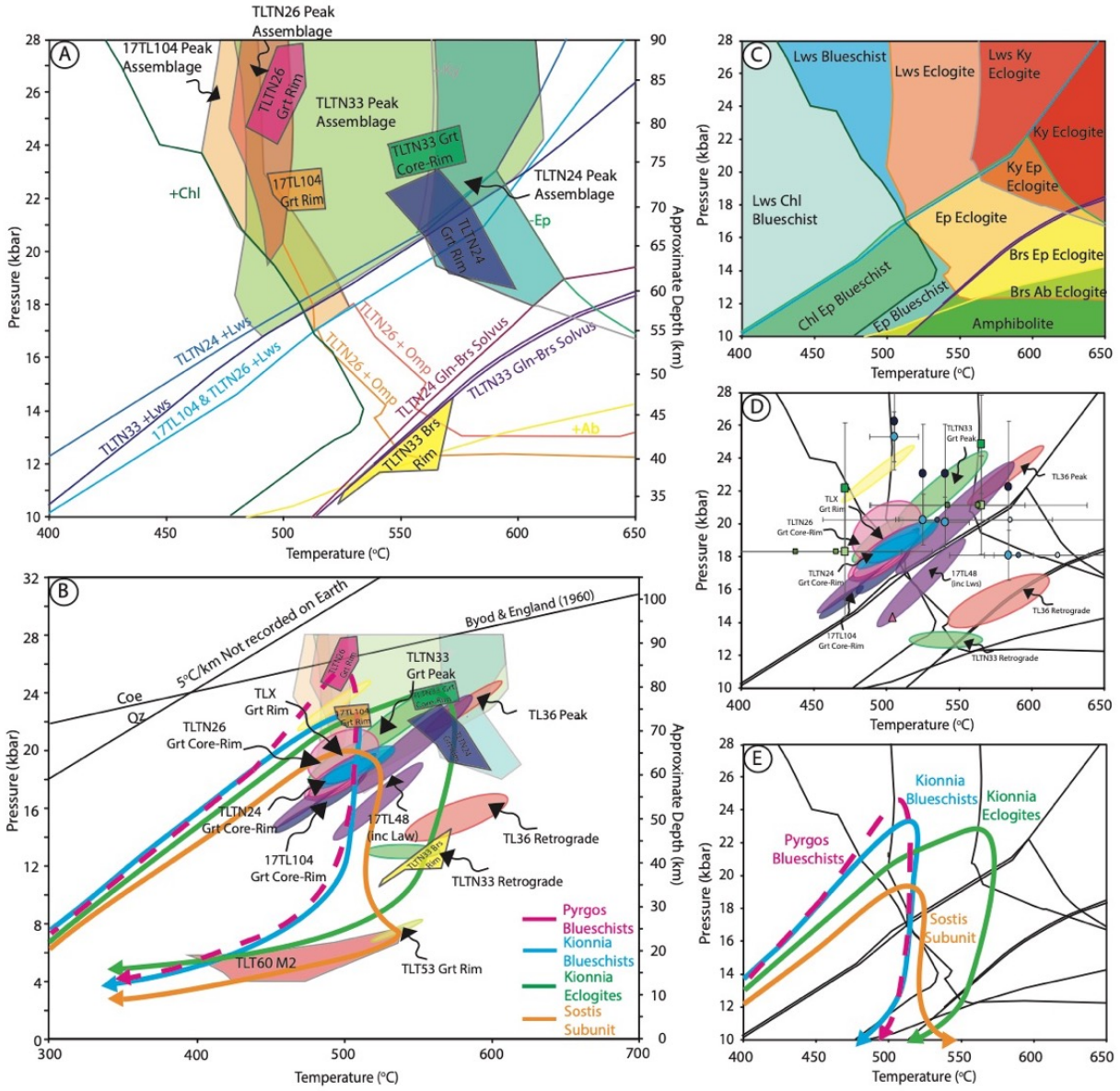
Kionnia Eclogite *P-T*: 0.22-0.24 GPa, 540-570˚C



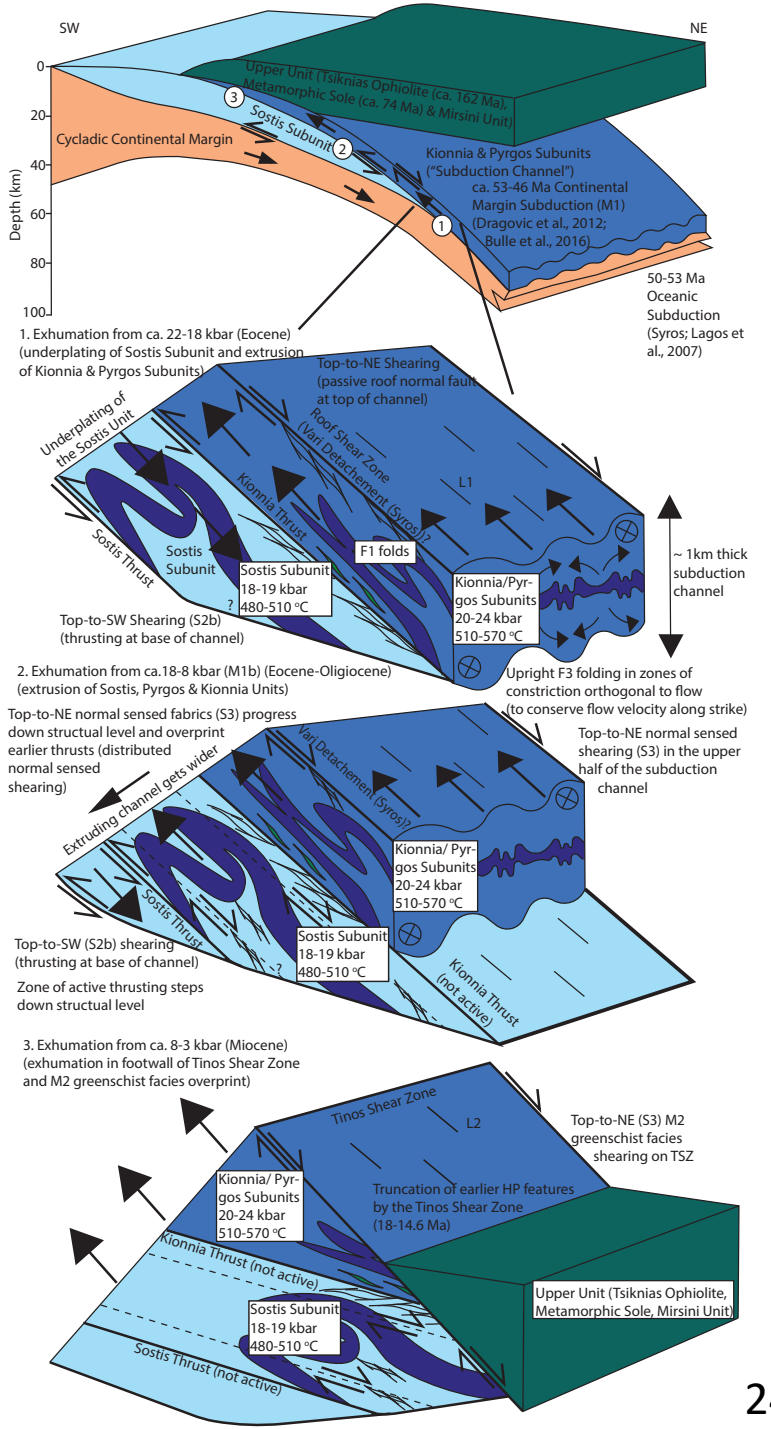
① Gln Ph Omp Chl Lws Ep Ttn
② Gln Ph Omp Lws Ep Ttn
③ Gln Ph Omp Lws Ep Qz Ttn
④ Gln Ph Omp Lws Ep Rt Ttn
⑤ Gln Ph Omp Lws Rt Ttn
⑥ Gln Omp Ph Qz Lws Ep Rt Ttn
⑦ Gln Omp Ph Chl Lws Ep Rt Ttn
⑧ Gln Omp Ph Qz Lws Rt Ttn
⑨ Gln Omp Ph Qz Ep Rt
⑩ Gln Ph Ep Ab Qz Ttn
⑪ Gln Ph Ep Qz Ttn Rt
⑫ Brs Ph Ep Ab Qz Ttn
⑬ Brs Ph Ep Ab Qz Rt Ttn
⑭ Brs Ph Ep Ab Qz Rt Ttn
⑮ Brs Omp Ab Ms Pg Qz Ep Rt
⑯ Brs Ky Omp Ph Qz Ep Rt
⑰ Brs Ky Omp Ph Qz Lws Ep Rt
⑱ Brs Ky Omp Ph Qz Lws Rt
⑲ Ky Omp Ph Qz Lws Ep Rt
⑳ Ky Omp Ph Qz Lws Rt

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Tinos *P-T* Summary: Decreasing pressure with structural depth: Underplating coeval with extrusion in subduction channel

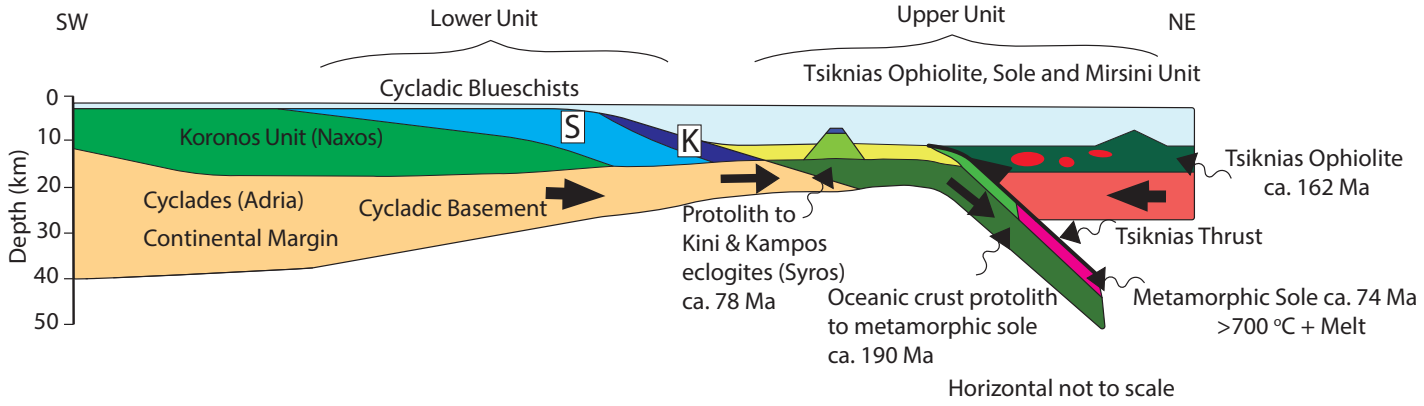


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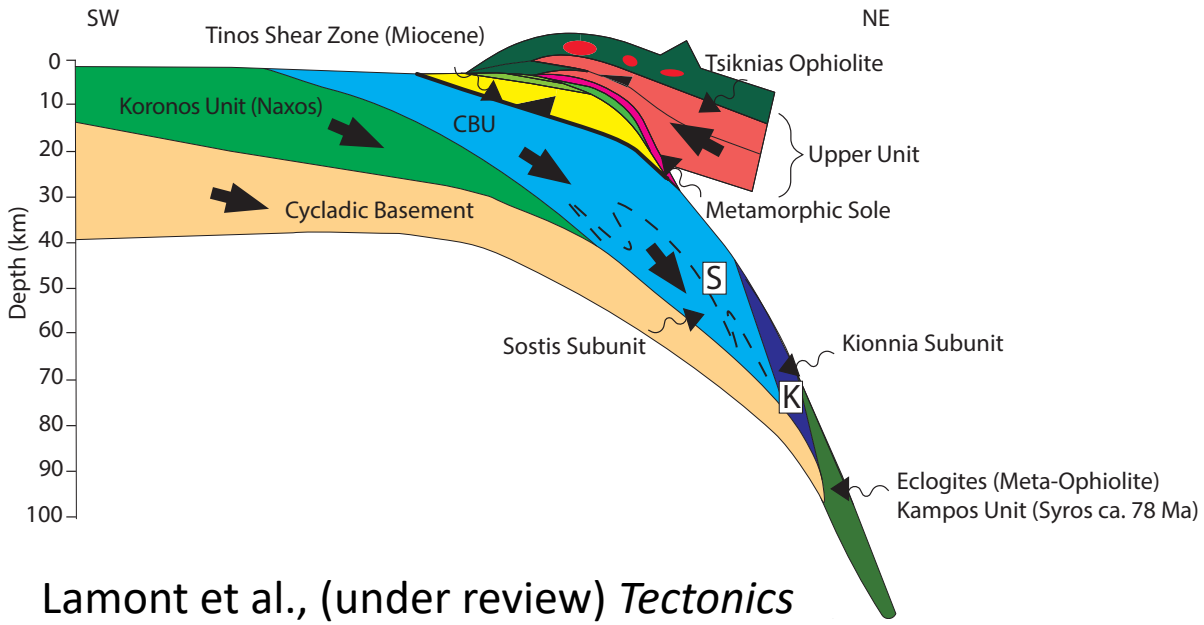


Tectonic Model for the Cycladic Subduction Zone

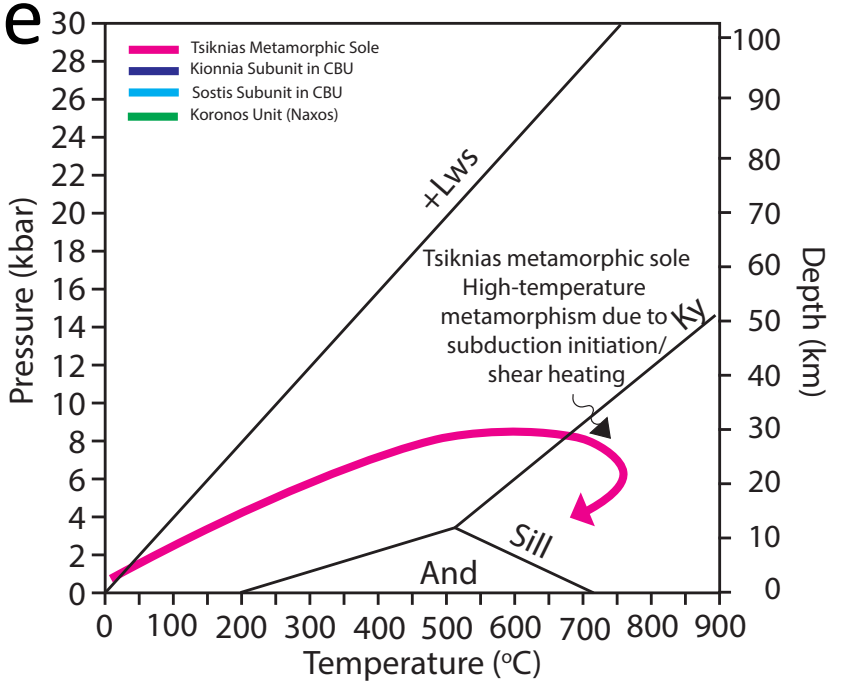
Stage 1 (74 Ma): Initiation of a NE dipping intra-oceanic subduction zone and metamorphic sole formation

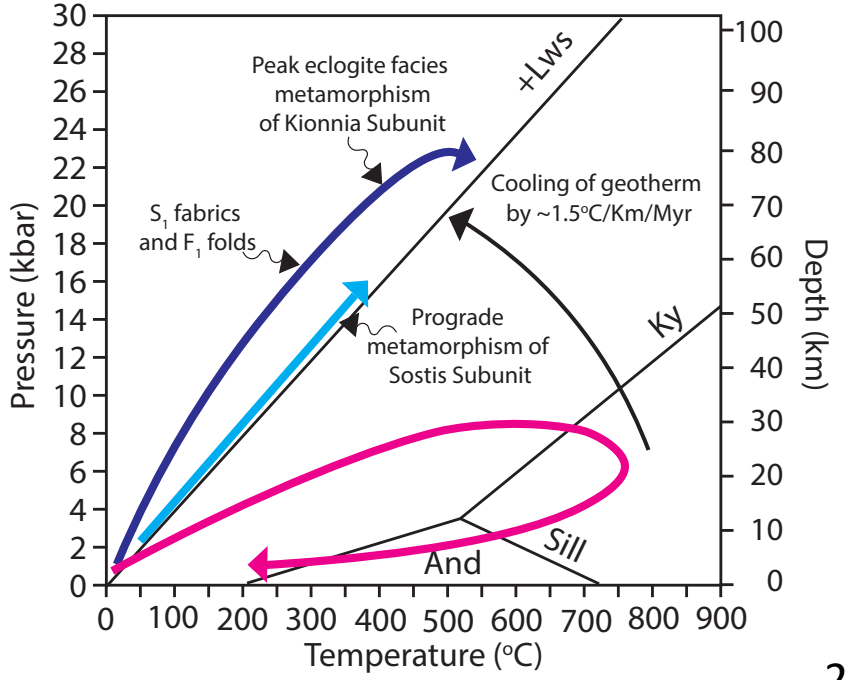


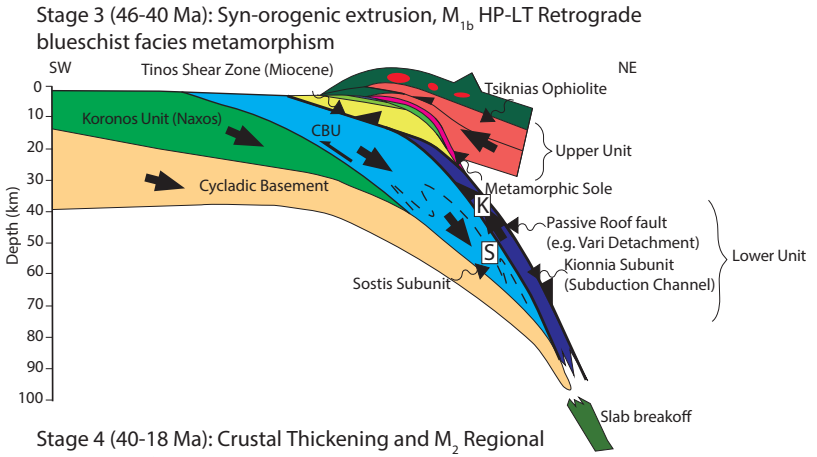
Stage 2 (53-46 Ma): Subduction of Cycladic Continental Margin and M_1 HP-LT eclogite and blueschist facies metamorphism

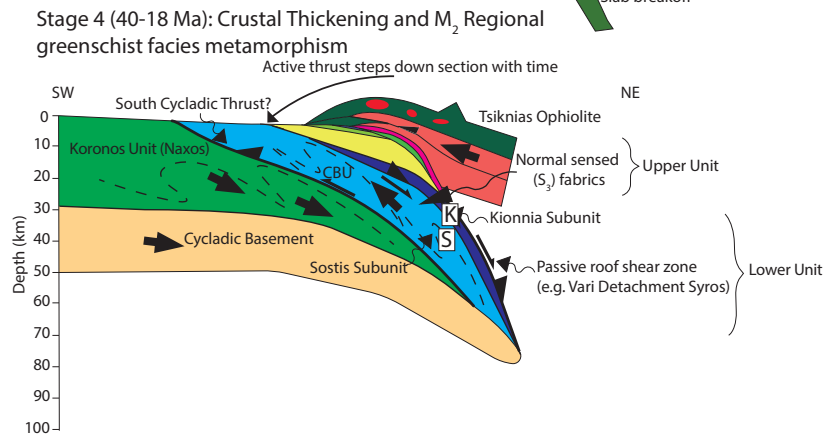


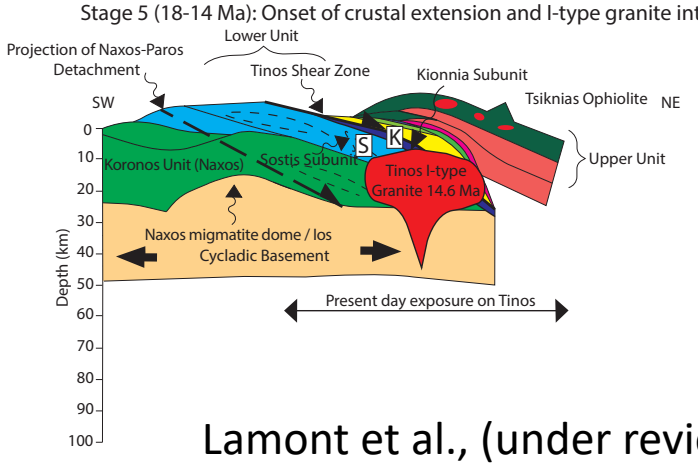
Lamont et al., (under review) *Tectonics*

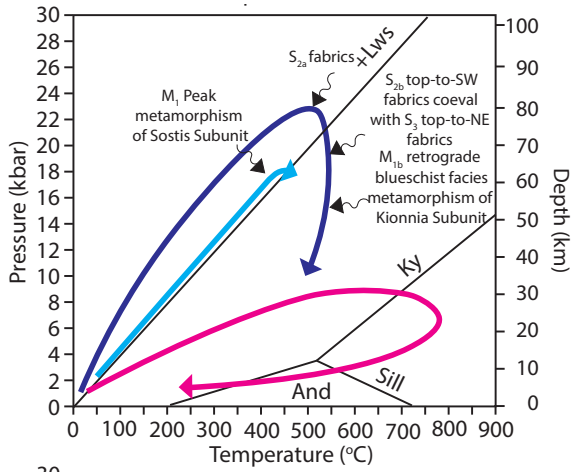


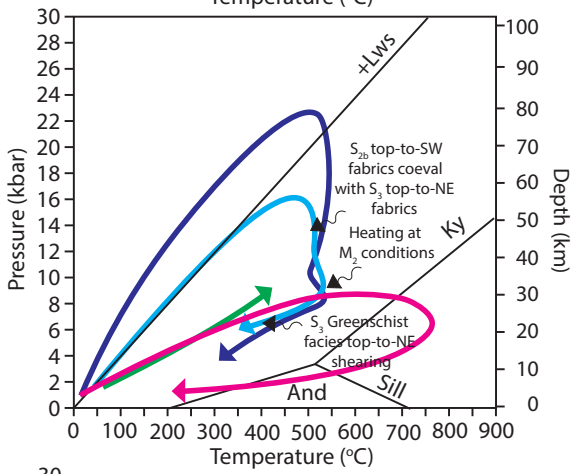


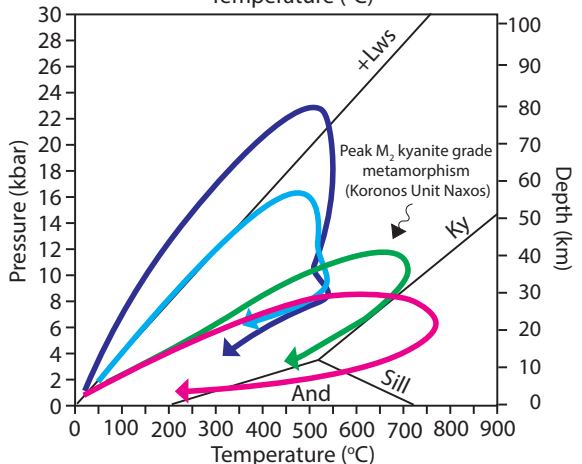












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Conclusions

- SSZ Tsiknias Ophiolite formed at ca. 162 Ma to NE of Cyclades in present day co-ordinates.
- NE-subduction initiation and metamorphic sole formation at ca. 74 Ma (in ca. 190 Ma oceanic crust protolith) ~90 Myrs after over-riding ophiolite formed.
- Heat causing metamorphism in sole derived from:
    1. Possible incursion of mantle wedge following subduction initiation.
    2. Shear heating on subduction interface
- Subduction interface stepped downwards as material continued to be underplated and sole accreted to upper plate between ca. 74 and 53-46 Ma
- Arrival and attempted subduction of Cycladic-Adriatic continental margin at ca. 53-46 Ma caused *HP-LT* metamorphism in the Cycladic Blueschist Unit jamming the subduction zone, followed by Barrovian metamorphism ~25 Myrs later (Naxos).
- Geotherm in subducting plate cooled at a minimum rate of ca. 1-1.5˚C /km/Myr between ca. 74-46 Ma.
- Lawsonite breakdown shortly following peak *HP* conditions hydrated adjacent shear zones, causing extensive retrogression and facilitated extrusion related exhumation.

Thanks for Listening







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