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what proceeds the formation of (U)HP rocks:
THE INITIATION OF INTRA-OCEANIC SUBDUCTION FROM THE PETROCHRONOLOGY OF TETHYAN METAMORPHIC SOLES

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Metamorphic soles - how can they help to better constrain the physics of subduction initiation?

Prior to the formation of (U)HP rocks in subduction zone settings comes the evolution of a subduction zone from the start as shallow thrust fault to a slab that cooled its mantle surroundings reaching depths beyond 100km. Where and how subduction initiates within oceanic domains remains debated. Metamorphic soles, few-hundred-meters thick sequences of strongly foliated metabasites and pelagic sediments found below the mantle section of typically supra-subduction-zone (SSZ) ophiolites, record high (up to ~850°C) metamorphic temperatures at pressures up to 10-15 kbar (Jamieson, 1986; Dilek and Whitney, 1997; Hacker and Gnos, 1997; Wakabayashi and Dilek, 2000; Guilmette et al., 2008; Myhill, 2011). These metamorphic conditions are uncommon in normal subduction zones and are thus interpreted to reflect (intra-oceanic) subduction initiation, whereby soles represent the volcano-sedimentary top of a nascent subducting slab that accreted to the hot overriding peridotites.

40Ar/39Ar hornblende ages of metamorphic soles invariably overlap with overlying SSZ ophiolites' crustal crystallization ages, suggesting that spreading and sole cooling are causally linked. However, the time between the inception of subduction and sole cooling is generally assumed to be short, but remains unquantified.

What is the time difference between formation and cooling of the metamorphic sole?

Case study: petrology and geochronology of Tethyan SSZ ophiolites

Pınarbaşı metamorphic sole - Turkey

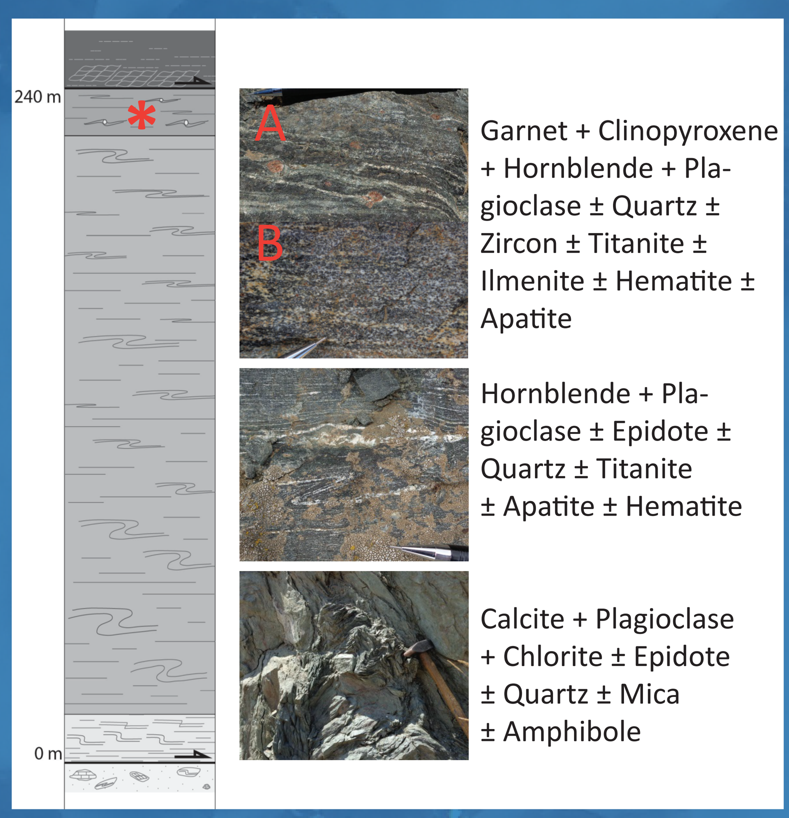

Figure 2. Tectonostratigraphic column and field photographs of the Pınarbaşı metamorphic sole, with serpentinised peridotite at the structural top and tectonic mélange underneath the metamorphic sole. Structural position of samples containing garnet and zircon indicated with a red star.

Lu-Hf in garnet: prograde metamorphism

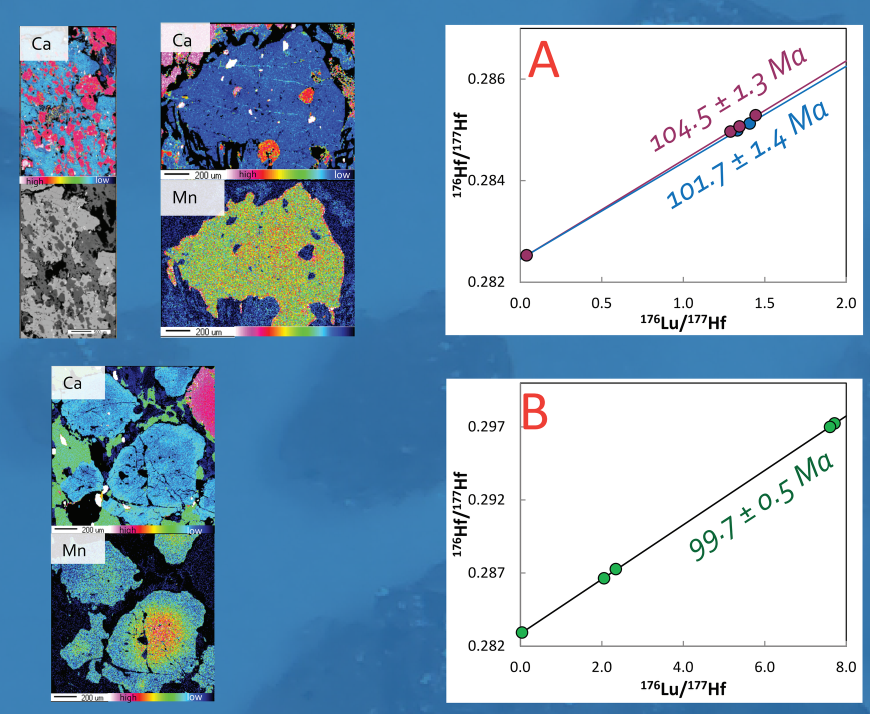

Figure 4. Ca and Mg element maps of garnet grains, and Lu-Hf garnet age of granulite facies garnet-amphibolite (A and B), of the Pınarbaşı metamorphic sole.

U-Pb in zircon: peak metamorphism

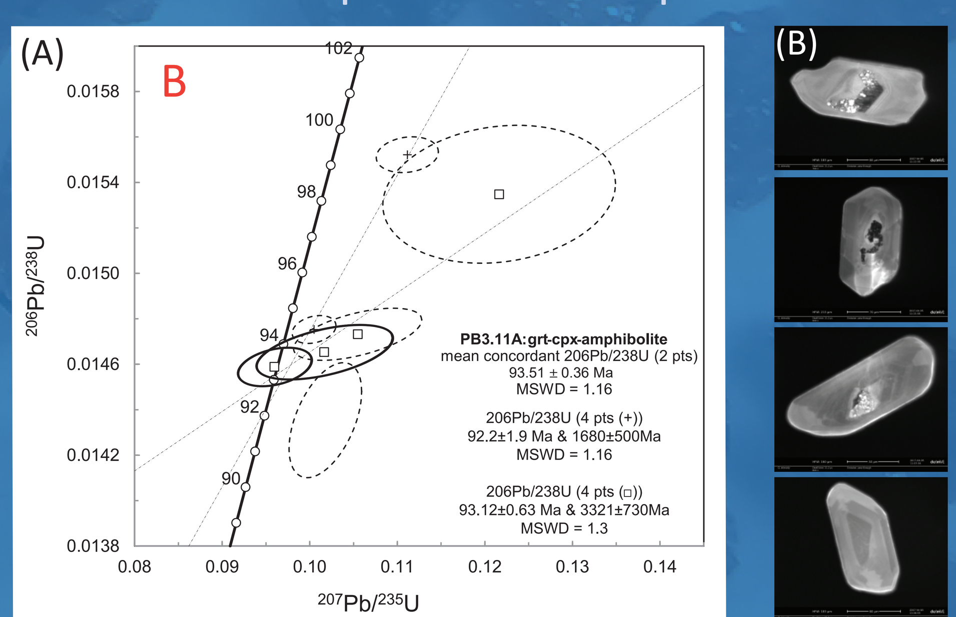

Figure 3. (A) Concordia diagram displaying U/Pb ages for zircon grains from the Pınarbaşı metamorphic sole. Ellipses indicate the 2 σ uncertainty. MSWD = mean square of weighted deviates. (B) CL images of zircon grains used for dating; grainsize 90-120 µm.

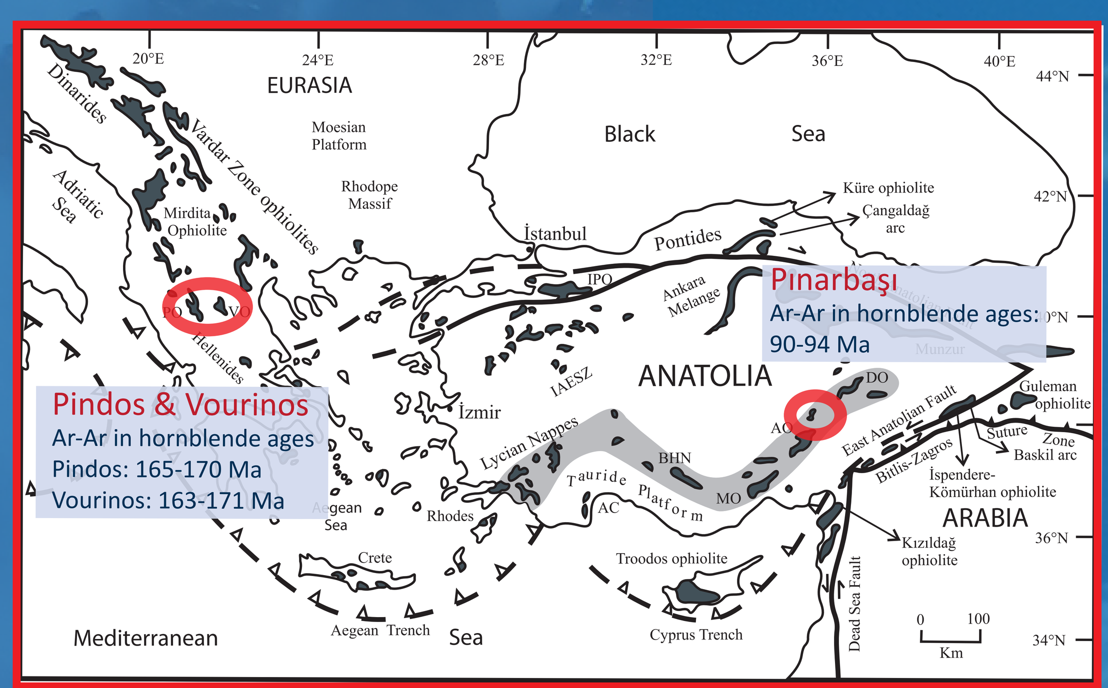

Figure 1. Distribution of Neotethyan ophiolites in the Eastern Mediterranean region, after Parlak (2006). 40Ar/39Ar ages for the metamorphic soles from Parlak (2016) and refrences therein.

Vourinos - Greece

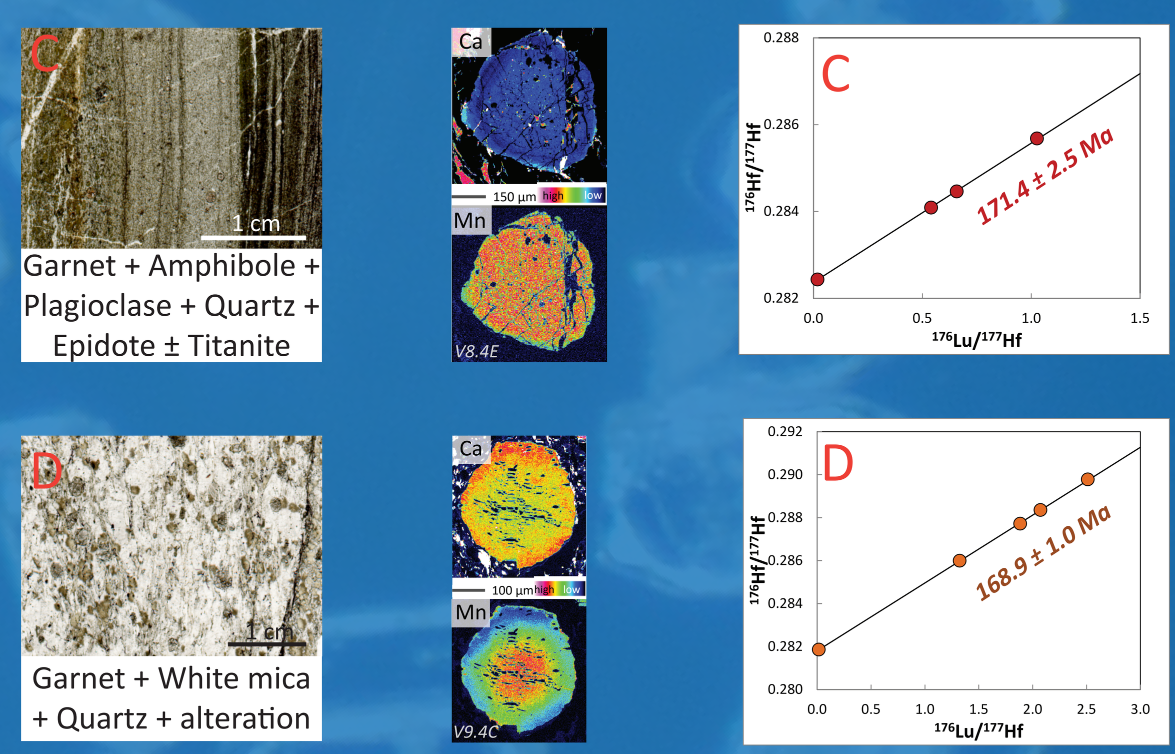

Figure 4. Photomicrographs, Ca and Mg element maps of garnet grains, and Lu-Hf garnet age of upper amphibolite facies garnet-amphibolite (C), and photomicrographs, Ca and Mg element maps of garnet grains, and Lu-Hf garnet age of lower amphibolite facies garnet-micaschists (D) from Vourinos, Greece.

Pindos - Greece

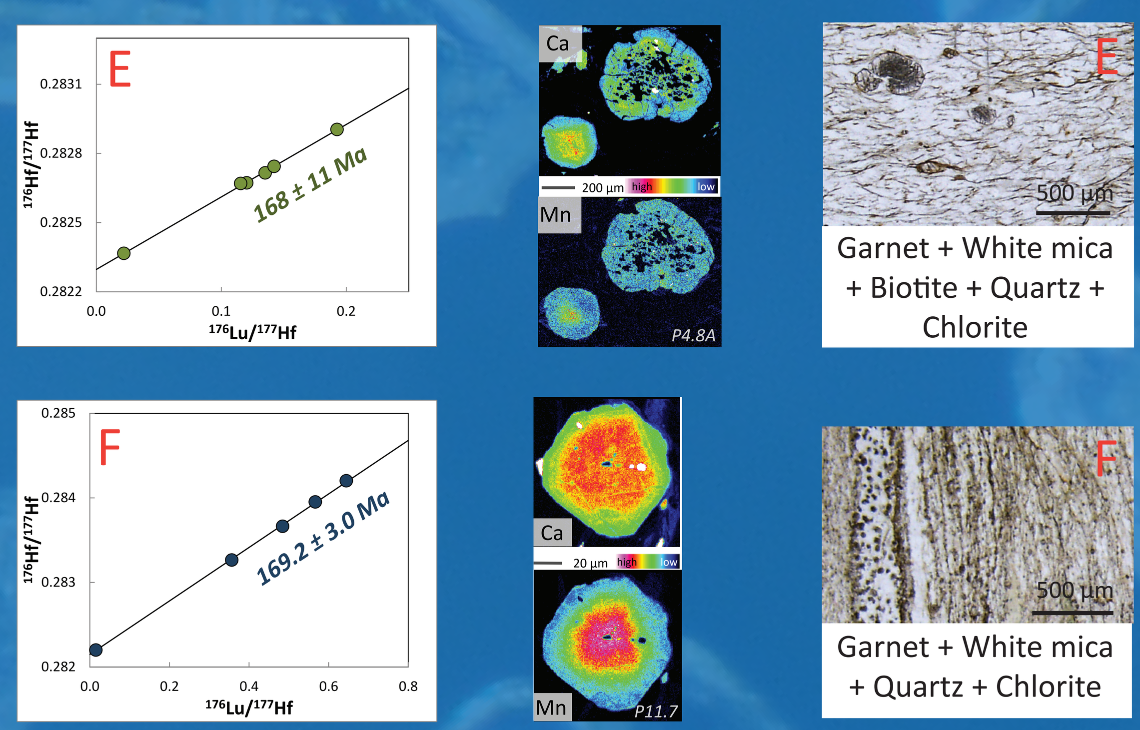

Figure 5. Photomicrographs, Ca and Mg element maps of garnet grains, and Lu-Hf garnet age of lower amphibolite facies garnet-micaschists (E and F) from Pindos, Greece.

Results demonstrate that the highest grade rocks from the Pınarbaşı metamorphic sole (Turkey) started to undergo metamorphism around 104 Ma (Lu-Hf garnet chronology), earlier than new c. 94 Ma U-Pb zircon ages and published 40Ar/39Ar cooling ages of about 90-94 Ma. Lu-Hf garnet chronology on Jurassic soles in northern Greece provides ages around 169 Ma for the lower grade garnet-micaschists of the sole at Pindos, and ages of c. 171 Ma from the highest grade garnet-amphibolites, and c. 169 Ma for the lower grade garnet-micaschists in Vourinos, both synchronous with published 40Ar/39Ar cooling ages on hornblendes.

The difference between the formation and cooling of the metamorphic sole and thereby the mechanism of sole formation and exhumation, may vary for diffrent tectonic settings where metamorphic soles occur.

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