Interplay between tectonics, magmatism, and hydrothermal activity in slow-spreading systems: insights from the sheeted dyke complexes of the Limassol Forest and Troodos ophiolites, Cyprus

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Take-home messages:

- Comparing the Limassol Forest Ophiolite (LFO) to the Troodos Ophiolite using new high-quality petrological and geochemical data on the sheeted dyke complexes (SDC).
- Magmatic evolution of the LFO differs distinctly from the Troodos Ophiolite.
- Arakapas Transform Fault not the cause for the deviation, apparent from comparison of the SDC of the LFO with the SDC of the Troodos Ophiolite at equidistance from fault.
- LFO formed under different conditions then Troodos, recorded in its magmatic evolution and unique late-stage dyke set (MgO >20 wt.%).

Background

The tectonically complex Limassol Forest Ophiolite (LFO) has received little attention in studies into the ophiolites of Cyprus. The well-studied Troodos Ophiolite, with standard *Penrose conference (1972)* stratigraphy (Fig. 1C), is thought to have formed at a spreading centre close to a subduction zone (e.g. *Lehmann et al., 2025*). The Arakapas Fault Zone (Fig. 1A/E), interpreted to be a fossil transform fault, separates the Troodos from the LFO, which has an anomalous stratigraphy (Fig. 1D). If the deviating stratigraphy is the result of a difference in formation (mechanism), the LFO lava data should not be considered part of Troodos, as is usually done (e.g. *Lehmann et al., 2025*). In this study, sheeted dyke complex samples taken at equidistance of the fault are studied with fieldwork, petrological, and geochemical analyses. The unravelled magmatic evolution is used to assess **if the formation of the LFO and Troodos occurred under the same conditions**. When different, this would support studying the LFO separately and potentially inferring movement (direction) of the well-exposed Arakapas.

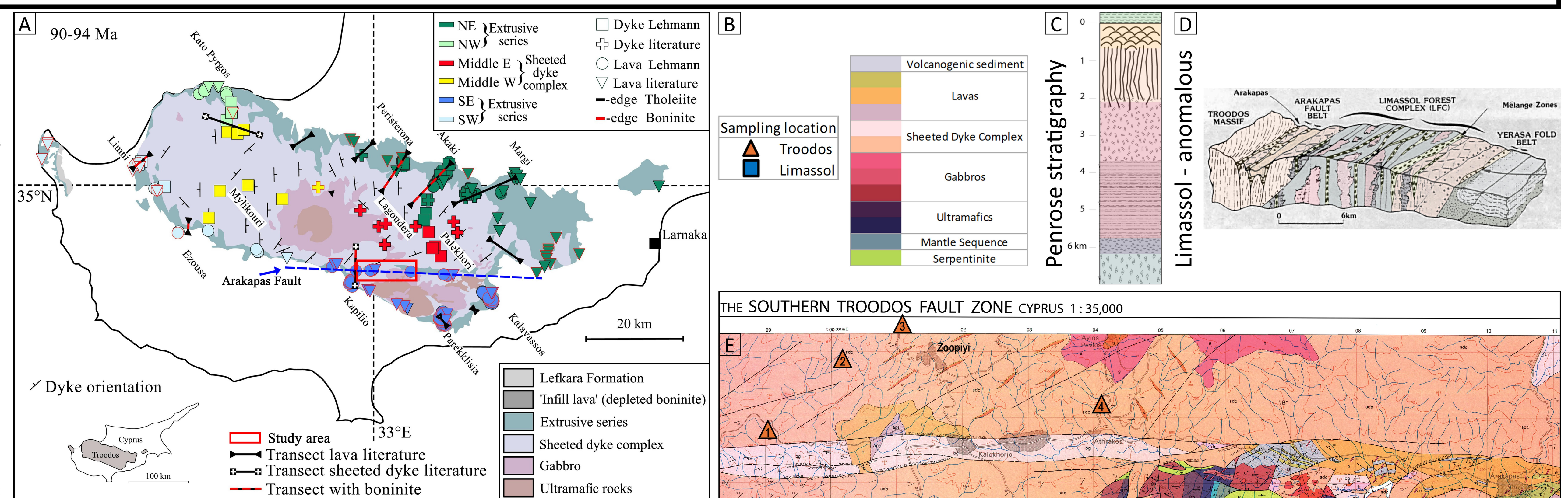
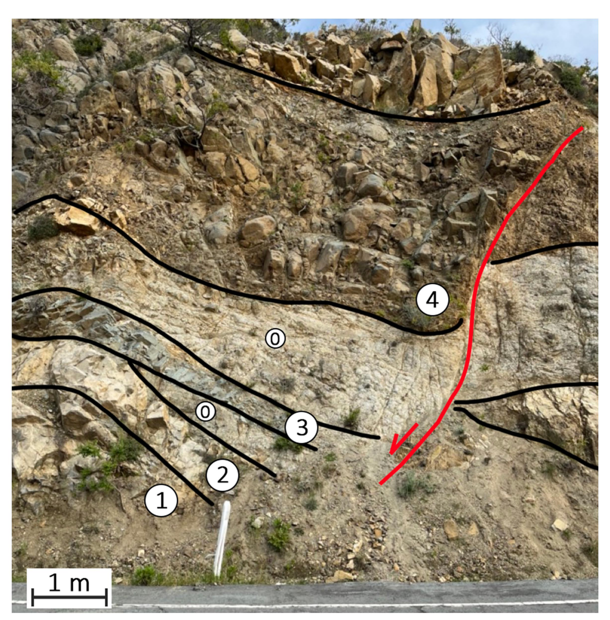
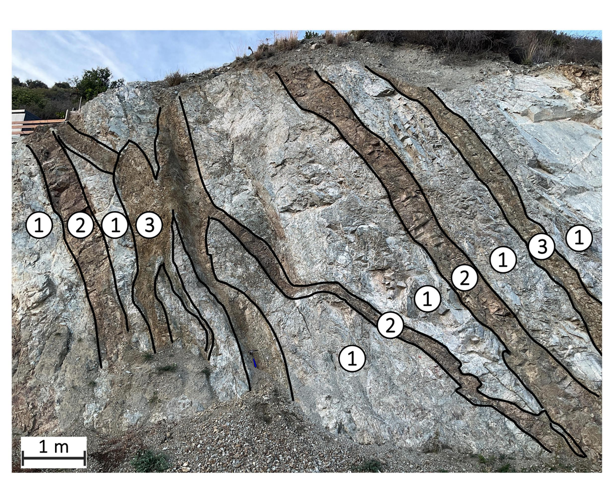


Figure 1: A) Simplified geological map of Cyprus modified from and including the dataset used in *Lehmann et al. (2025)*. The red rectangle indicates the sampling area of this study. B) Legend for C, D, and E. C) Idealized ophiolite section following the *Penrose stratigraphy (1972)*. D) Anomalous stratigraphy of the Limassol Forest Ophiolite *(Murton, 1987)*. E) Geological map of Murton (1987) with indicated the sampling locations of this study in the Troodos Ophiolite (orange triangles) and in the Limassol Forest Ophiolite (blue squares).

Field Data & Petrology

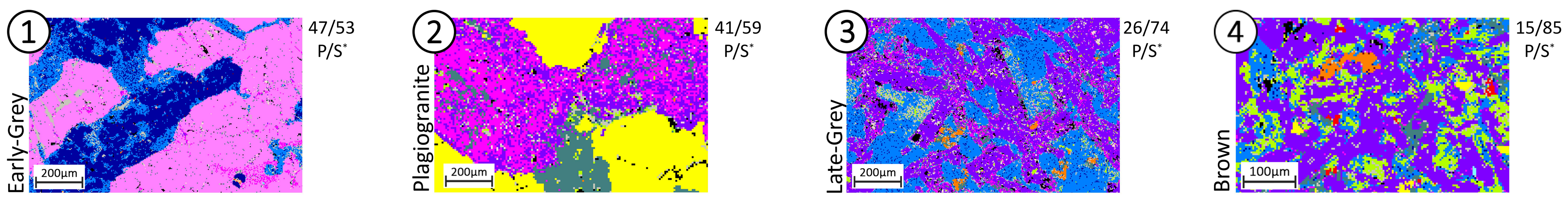




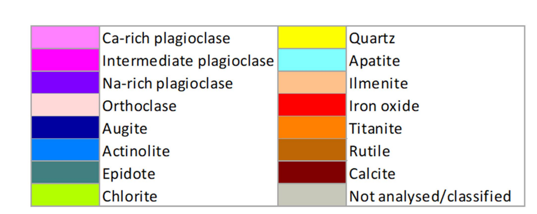
Field appearance and SEM images of the dyke types of:
Troodos - Zoopiyi area (in left: 0 is gabbro, SEM from *Van Grieken (2024)*)
&
LFO - Louvaras and Dhierona area.

**P = primary minerals S = secondary minerals*

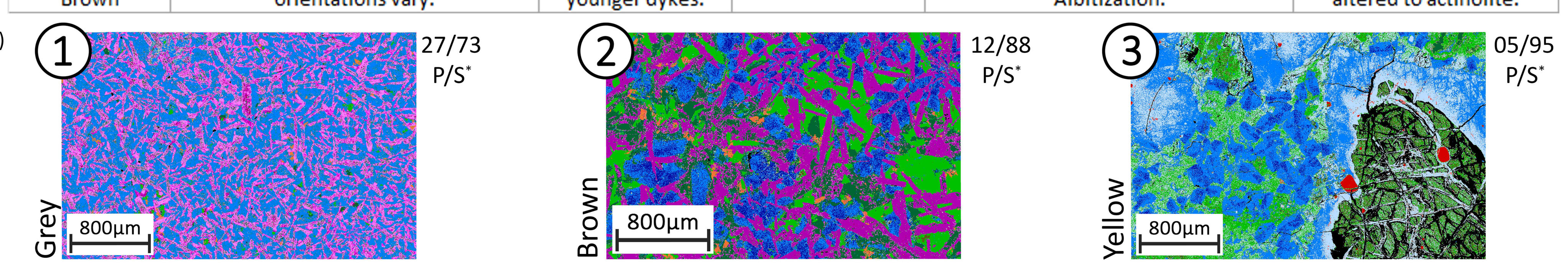
Troodos

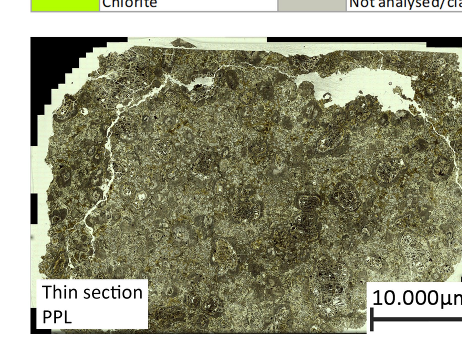


Dyke types:	*Field appearance*	*Petrography*	*Petrology*	*Alteration + degree*	
Early-Grey Plagiogranite Late-Grey Brown	Grey dykes being cross-cut and cross-cutting plagiogranite dykes, two generations of grey dykes. Dyke orientations vary.	Larger grain size than LFO. Grain size decreases in younger dykes.	Main constituents: amphibole and feldspar.	Pyroxene to actinolite, plagioclase to epidote, quartz, chlorite. Much more epidote and quartz than in LFO. Albitization.	Early-Grey contains cores of pyroxene, in Late-Grey and Brown all pyroxene has altered to actinolite.

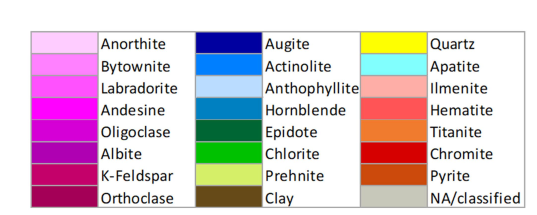


Limassol (LFO)



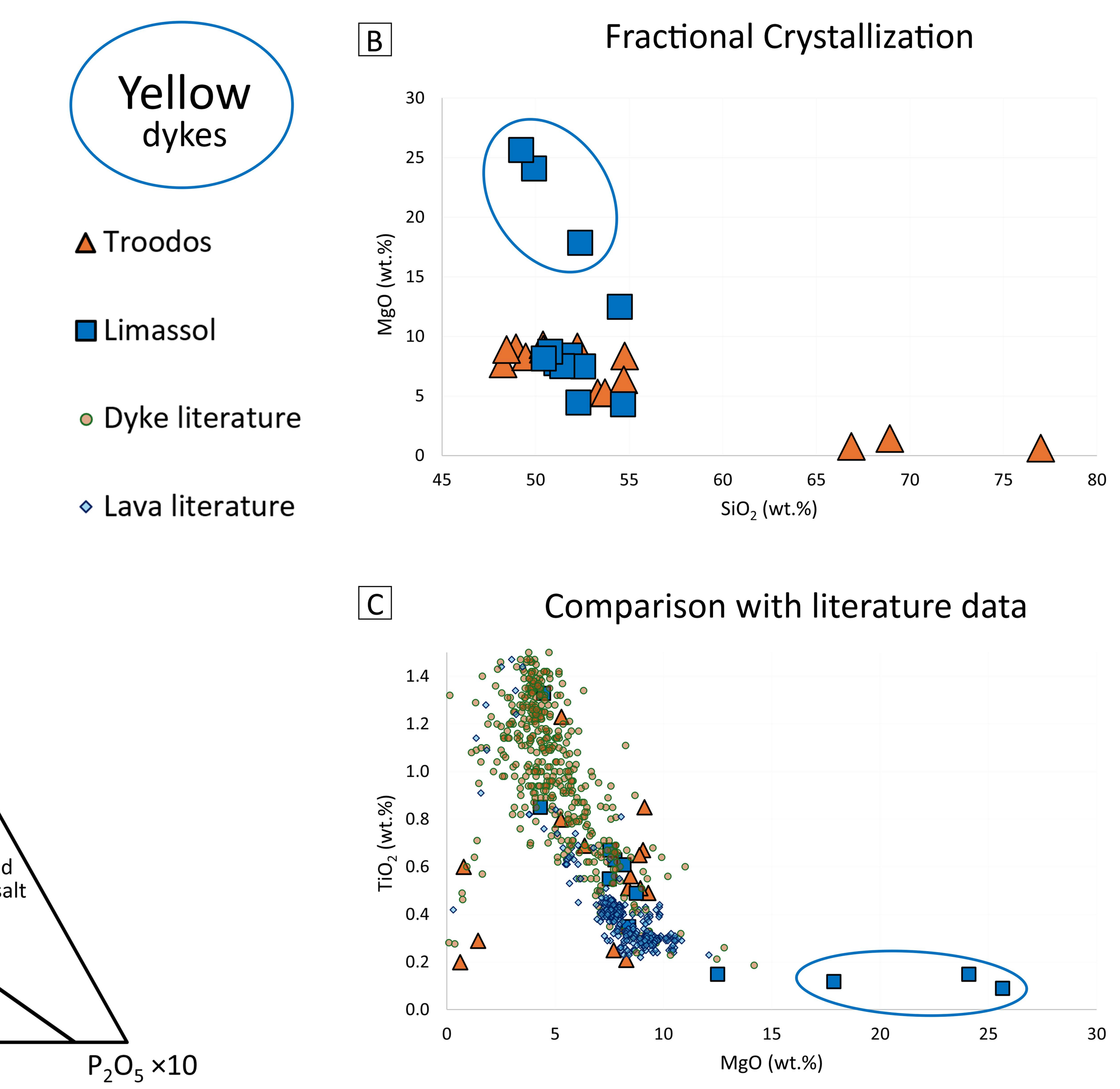


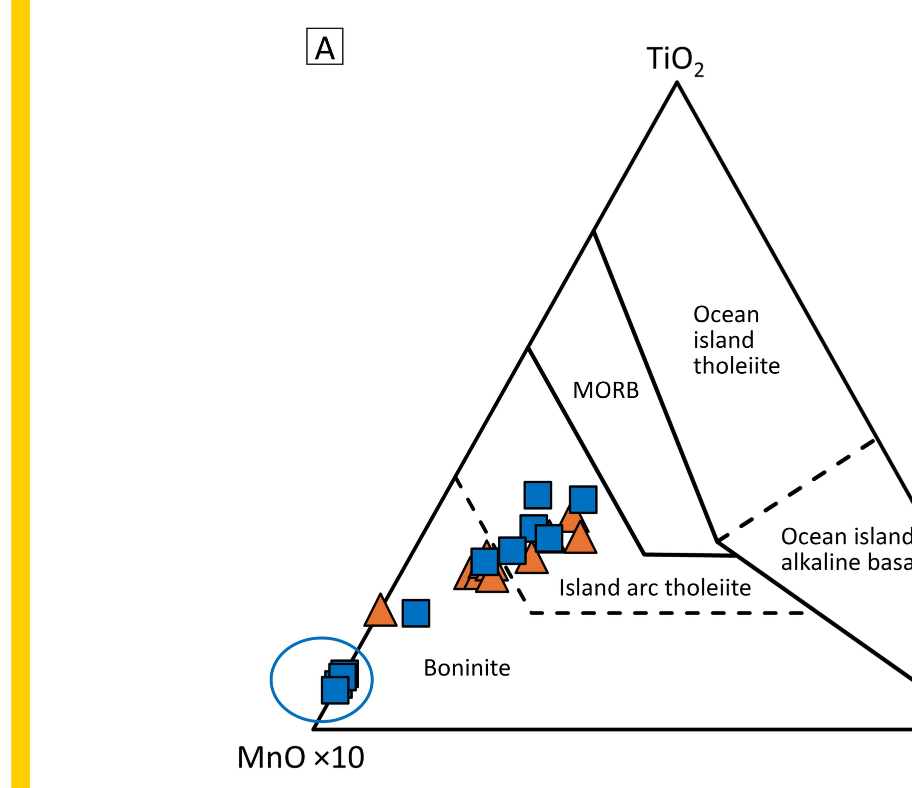
Dyke types:	*Field appearance*	*Petrography*	*Petrology*	*Alteration + degree*	
Grey Brown Yellow	Weathering pattern varied from little in Grey, blocky in Brown, to crumbly in Yellow dykes. Yellow dykes show sinuous intrusion. Dyke orientations vary.	Smaller grain size than Troodos. Grain size increases in younger dykes.	Main constituents: pyroxene, amphibole and feldspar. Cr-spinels in Yellow dykes.	Pyroxene to amphibole, plagioclase to epidote, minor quartz, chlorite. Alteration of actinolite and anthophyllite to clay. Much more chlorite than in Troodos. Albitization.	In Grey all pyroxene has altered to actinolite, Brown and Yellow contain cores of pyroxene.

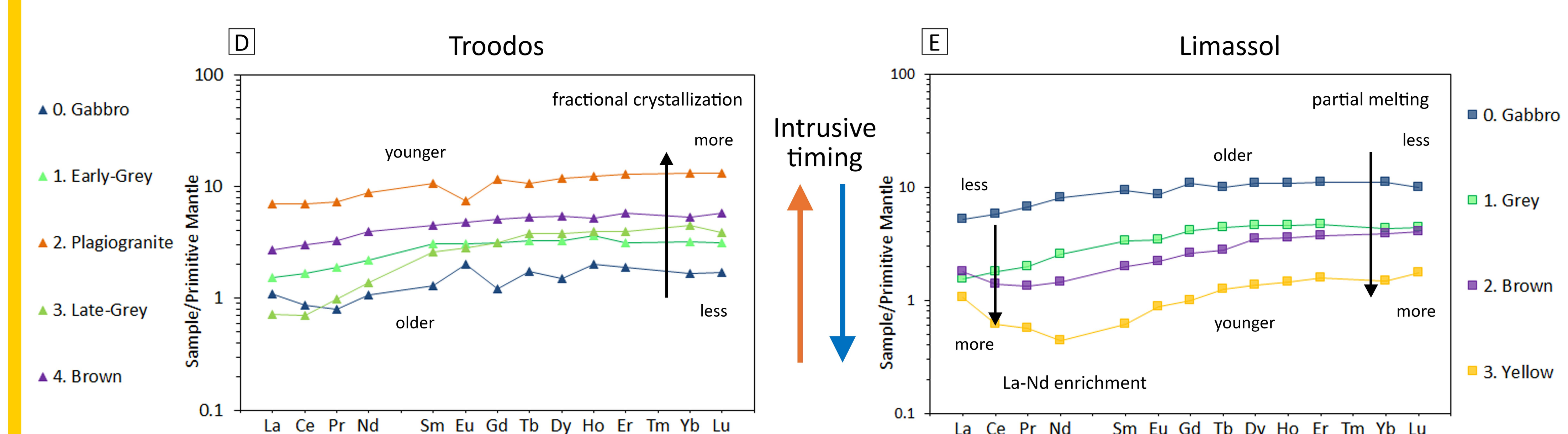


Geochemistry

Figure 2: XRF data: A) Tectonic discrimination diagram modified after *Mullen (1983)*. B) Fractional crystallization diagram, the high-SiO_2 dykes are plagiogranites. C) Comparison with available data on Cyprus sheeted dykes and lavas as compiled by *Lehmann et al. (2025)*.
LA-ICP-MS data: D) Spider diagram for Troodos showing its temporal evolution of an increase in total REE content; an increase in degree of fractional crystallization in line with the XRF data. E) Spider diagram for LFO showing its temporal evolution of an increase in degree of partial melting and of metasomatism (La-Nd enrichment).







Conclusions

<u>Magmatism Limassol Forest Ophiolite:</u> The new sheeted dyke complex data show boninitic signatures do not only occur in the lavas. The SDC boninites do deviate from all other boninites on Cyprus with its high MgO content (>20 wt.%).

<u>SDC LFO vs Troodos:</u> The LFO SDC does not contain Plagiogranite dykes. Though petrologically the LFO Grey dykes appear similar to the Troodos Late-Grey, geochemistry reveals it is more alike to the Early-Grey. Formation of the LFO SDC does not simply post-date the start of the formation of the Troodos SDC.

<u>Deviation LFO not due to Arakapas Fault Zone:</u> Plagiogranite dykes are suggested to be related to fault influence *(Cooke et al., 2014)*. The absence of Plagiogranite supports that the deviating evolution of LFO cannot (fully) be ascribed to influence of the Arakapas. The Troodos data is comparable to literature data, in line with little influence of the fault zone.

<u>LFO different formation conditions:</u> As the Troodos data of this study show values similar to the literature data, the studied area is considered representative. The SDC in the LFO at equidistance of the fault zone, is considered to represent the formation of the LFO. The petrological and geochemical data from the sheeted dyke complexes (SDC's) show that the SDC of the Troodos Ophiolite resulted from fractional crystallization, whereas the SDC of the Limassol Forest Ophiolite resulted from partial melting, indicating the ophiolites should be considered and studied separately.

References:
1. Penrose/Anonymous (1972) *Penrose field conference on ophiolites.*
2. Lehmann et al. (2025) *Geochemistry of the sheeted dyke complex, Troodos Ophiolite (Cyprus): Evidence for the magmatic evolution during subduction initiation.*
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4. van Grieken (2024) *The evolution of Troodos ophiolite dikes and their relationship with the spreading ridge-transform fault system on Cyprus.* MSc thesis Utrecht University.
5. Mullen (1983) *MnO/TiO2/P2O5: a minor element discriminant for basaltic rocks of oceanic environments and its implications for petrogenesis.*
6. Cooke et al. (2014) *Construction of a sheeted dyke complex: evidence from the northern margin of the Troodos ophiolite and its southern margin adjacent to the Arakapas fault zone.*

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