Stratigraphic structural and geochemical data on the Durkan Complex (Makran Accretionary Prism, SE Iran): constraints for its interpretation as a Late Cretaceous tectonically disrupted seamount chain

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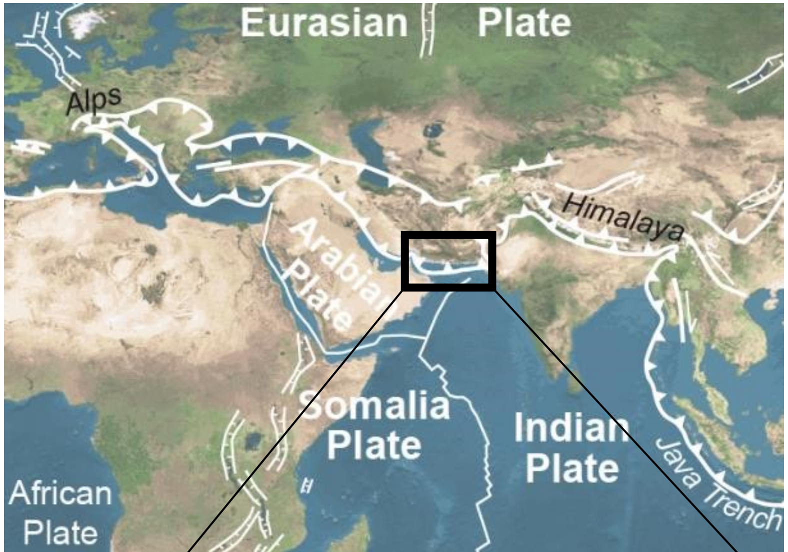
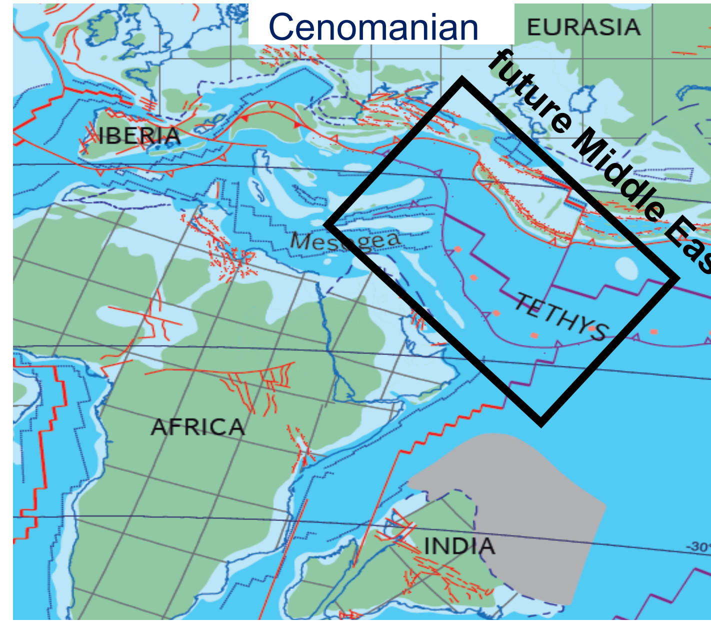
Geodynamic setting of the Makran Accretionary Prism



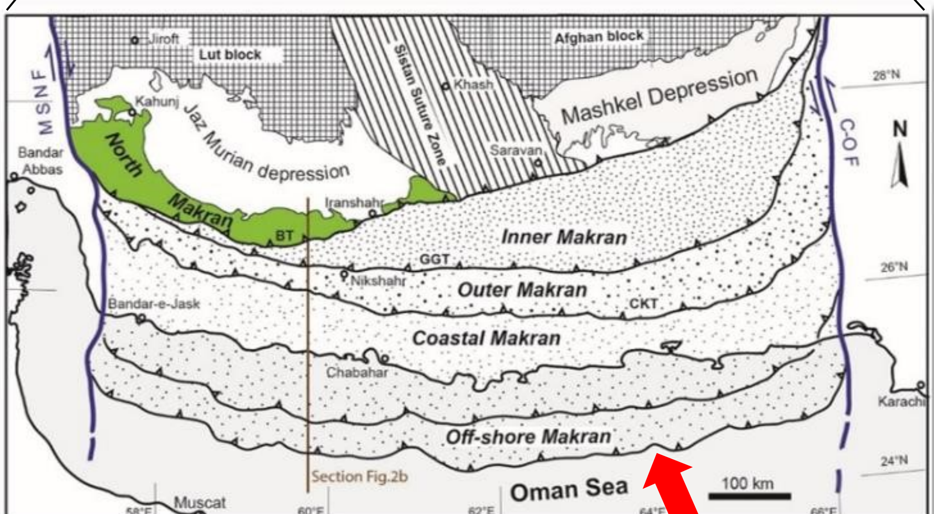
Festa et al., 2018, Gond. Res.

Makran Accretionary Prism (SE Iran, SW Pakistan):
part of the Alpine - Himalayan orogenic system

Barrier et al., 2018, CCGM/CGMW



Alpine - Himalayan orogenic systems in the **Middle East**: convergence between Arabia-India and Eurasian plates and **closure of the Neo-Tethys Ocean(s)** since Late Jurassic-Cretaceous



Burg et al., 2013, Front. Earth Sc.

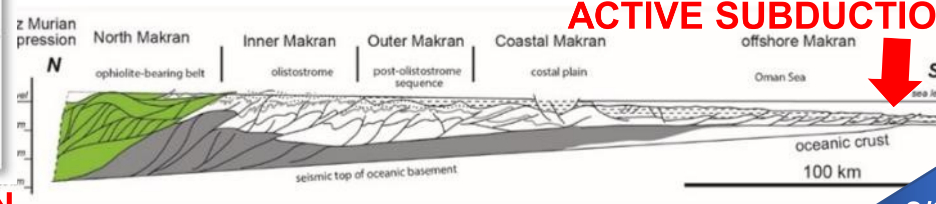
ACTIVE SUBDUCTION

Makran : E-W striking accretionary wedge

Four tectonic domains: North Makran includes **Mesozoic Ophiolites**

Inner, Outer, Coastal Makran include **Eocene-Quaternary sedimentary successions**

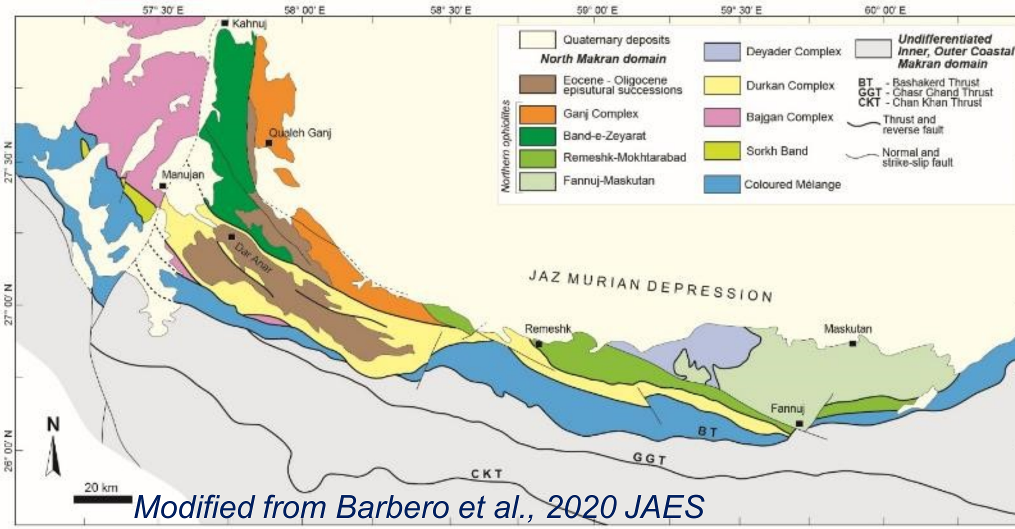
ACTIVE SUBDUCTION



Geological setting of the North Makran

From bottom to top:

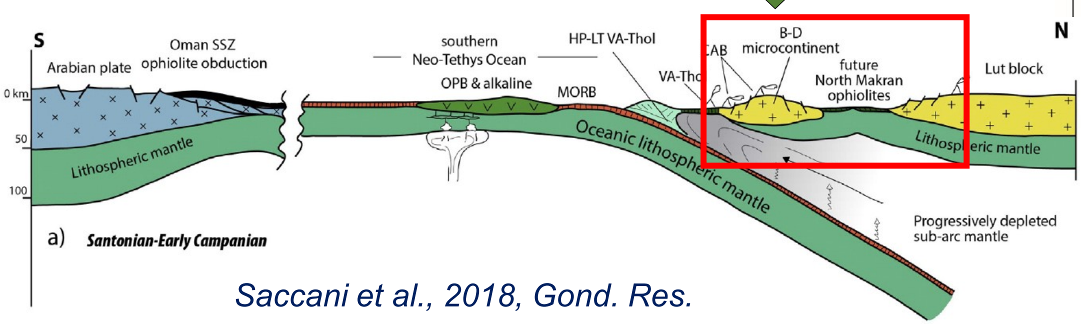
1) **Southern ophiolitic belt:** Coloured Mélange (fragments of ophiolite and sedimentary succession) and Sorkhband ophiolite (lower crust and mantle section)
2) **Bajgan-Durkan** metamorphic complexes (Paleozoic – Paleocene): interpreted as a microcontinent
3) **Norther ophiolitic belt:** North Makran ophiolites (Early Cretaceous-Paleocene)



Modified from Barbero et al., 2020 JAES

North Makran ophiolites: remnants of a Mesozoic oceanic basin known as **North Makran Ocean**

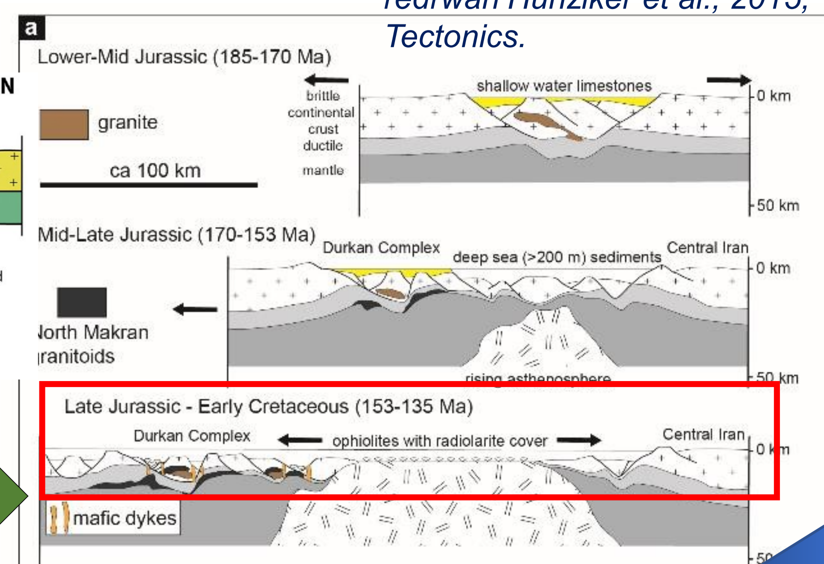
North Makran ophiolites: Early Cretaceous **back-arc basin** between the Lut continental margin and the Bajgan-Durkan microcontinent.

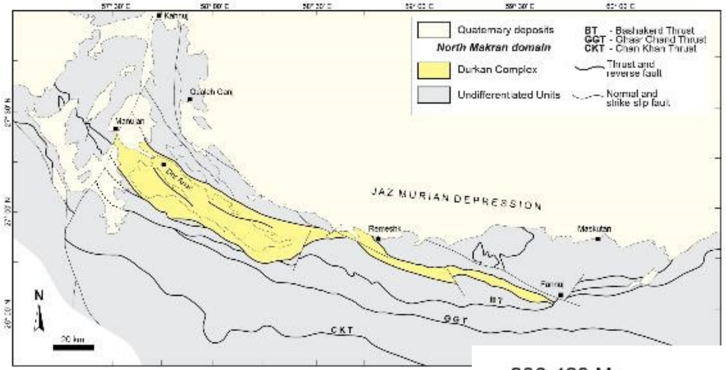


Saccani et al., 2018, Gond. Res.

North Makran ophiolites: Late Jurassic - Early Cretaceous **subduction unrelated ocean** between the Lut continental margin and the Bajgan-Durkan microcontinent.

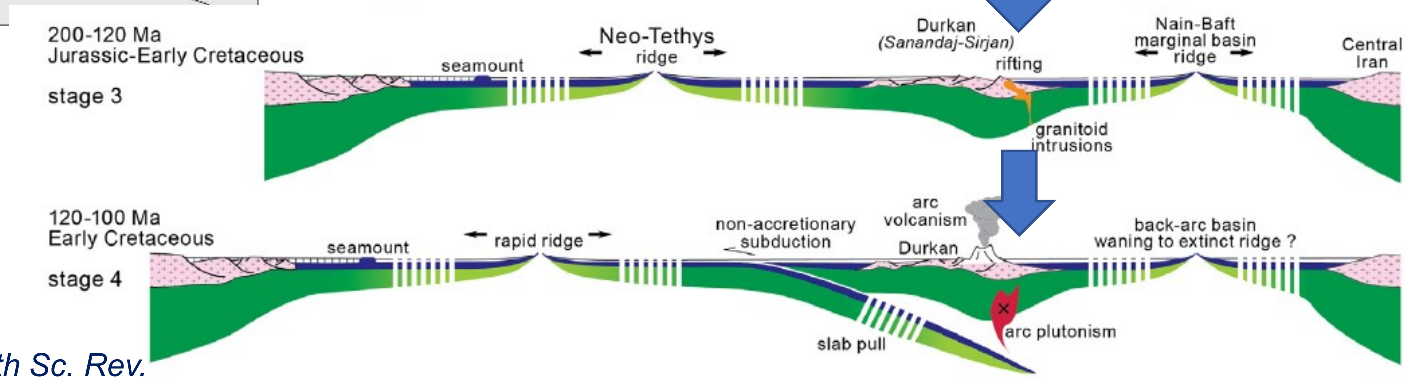
redrwan Hunziker et al., 2015, Tectonics.



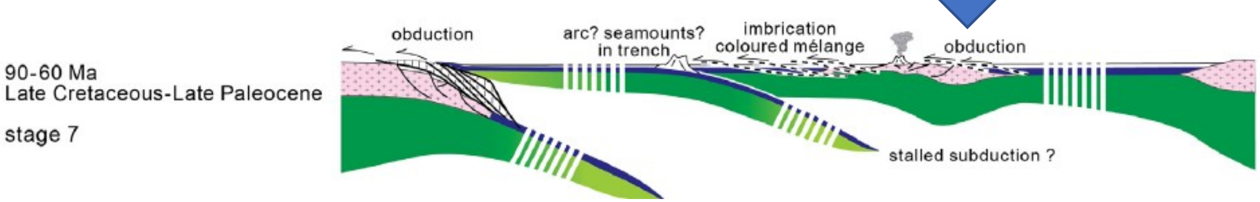


The Durkan Complex: interpreted as derived from the deformation of the sedimentary succession of the **southern continental margin of the North Makran Ocean**

Bajgan-Durkan microcontinent is thought to **separate two oceanic seaway**



Burg, 2018 Earth Sc. Rev.

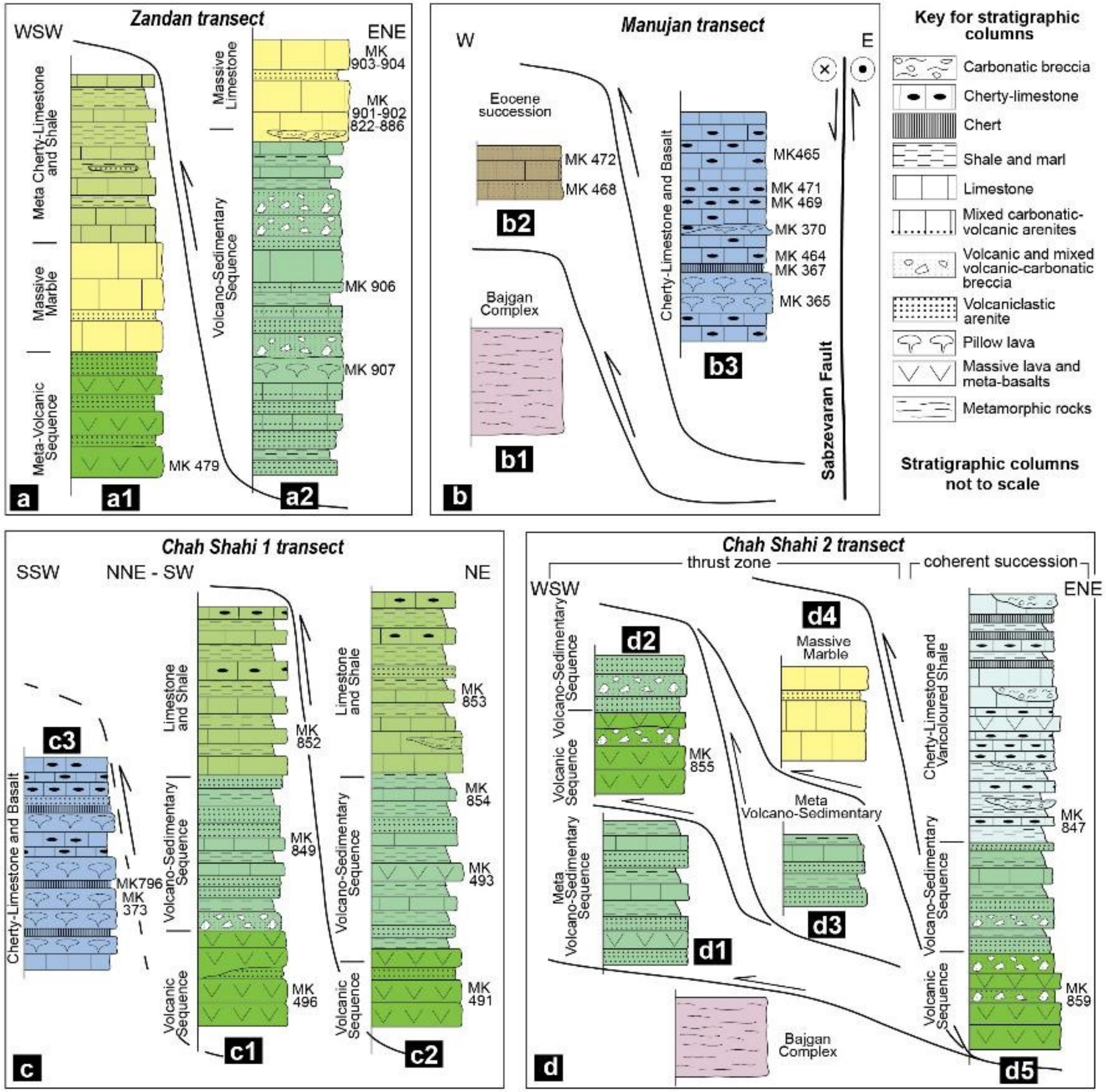


Burg, 2018 Earth Sc. Rev.

In the so far proposed geodynamic reconstruction **this interpretation of the Durkan Complex is fundamental** for the geodynamic reconstructions

Aim of our study: provide new geological, geochemical-petrological, and structural data to test these interpretations of the Durkan Complex

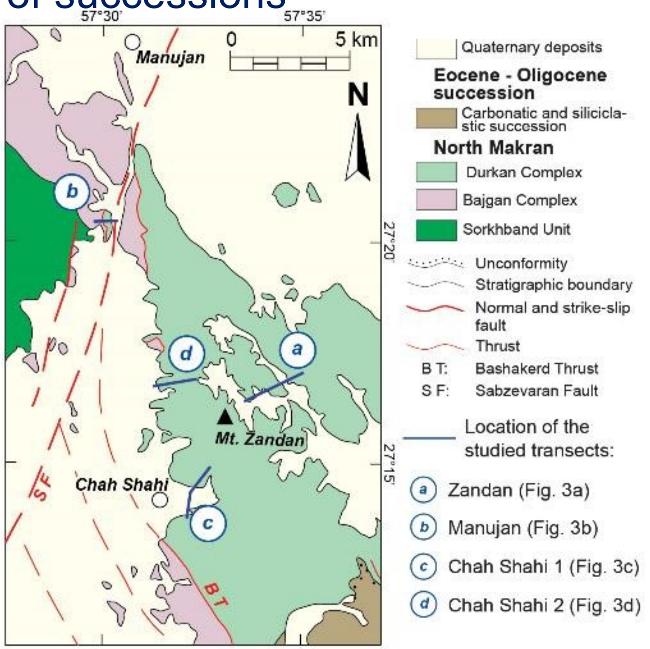
Tectono-stratigraphic architecture



Barbero et al., 2021 Geosc. Front.

Detailed **stratigraphic-structural** study →
An **assemblages of tectonic slices** showing:

- different stratigraphic successions
- abundant **basalts** and **volcaniclastic rocks**
- Volcanic and volcano-sedimentary sequence covered by different types of successions

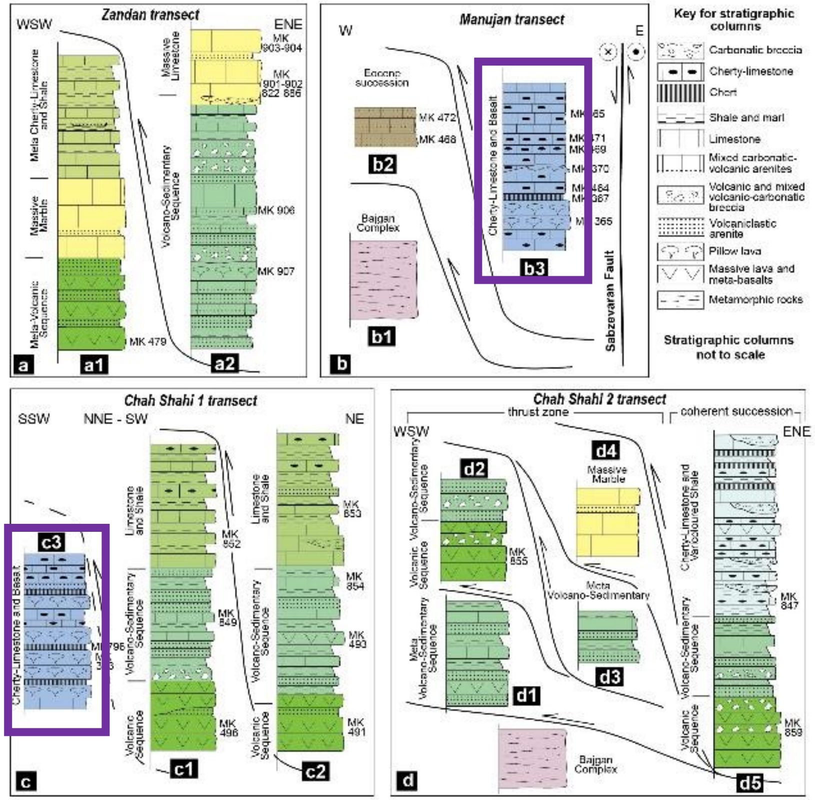


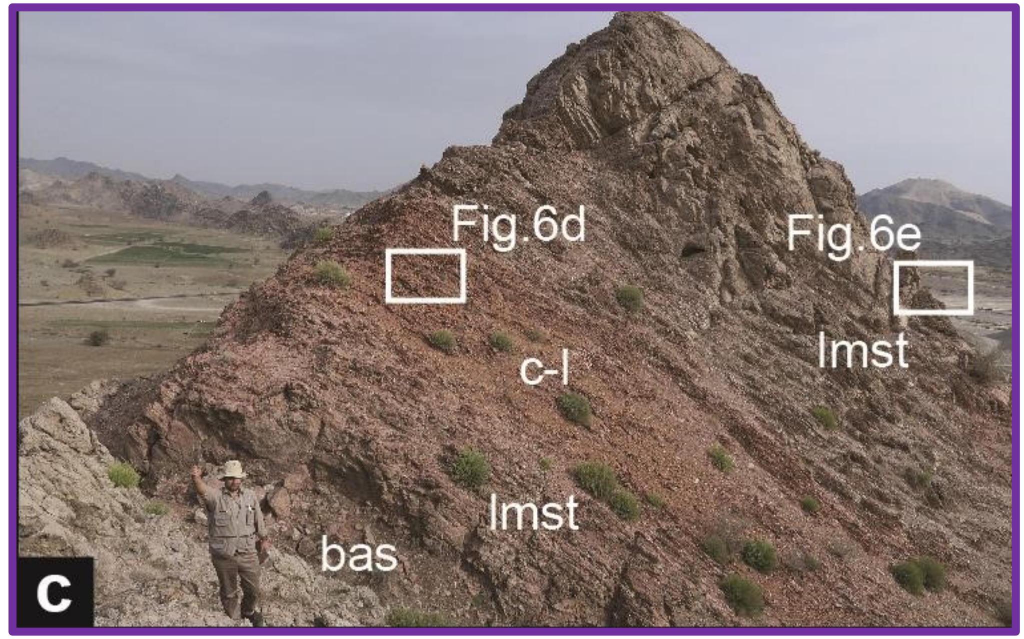
Barbero et al., 2021 Geosc. Front.

Biostratigraphic dating of the sedimentary rocks associated with the basalts

Basaltic rocks associated with three different types of stratigraphic sequences

Tectono-stratigraphic architecture: Type 1 succession



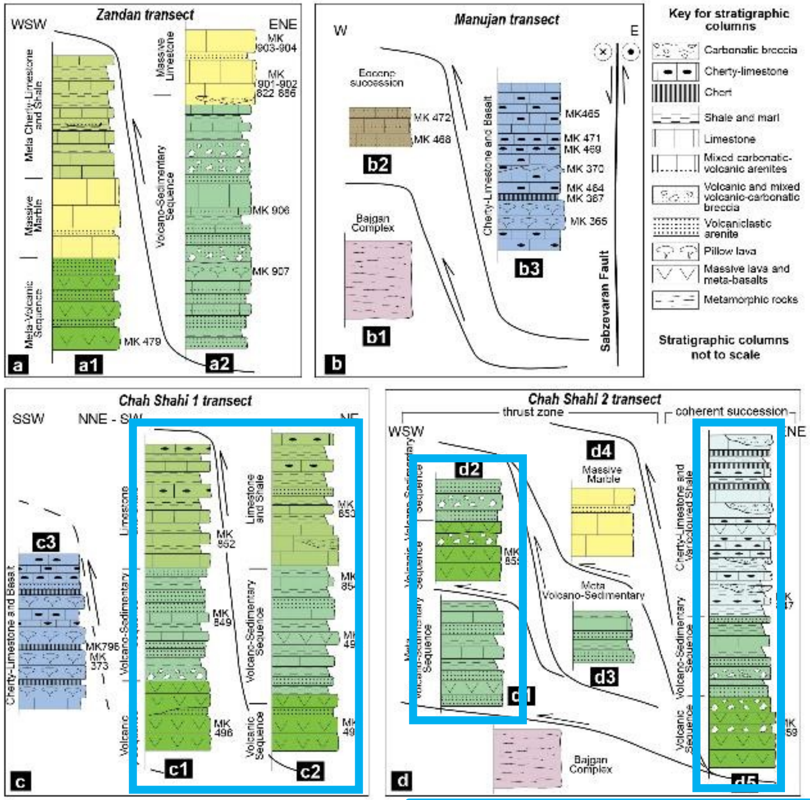


Barbero et al., 2021 Geosc. Front.

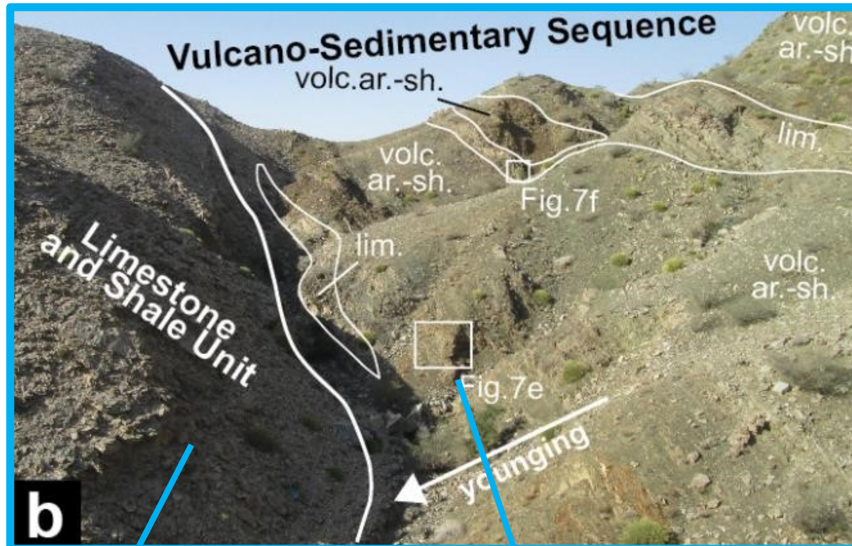
Coniacian – Campanian pelagic sequence:

- Alternation of **cherty limestones**, **marls**, **cherts**, and shales
- Basaltic rocks stratigraphically **associated with pelagic** sedimentary rocks

Tectono-stratigraphic architecture: Type 2 succession



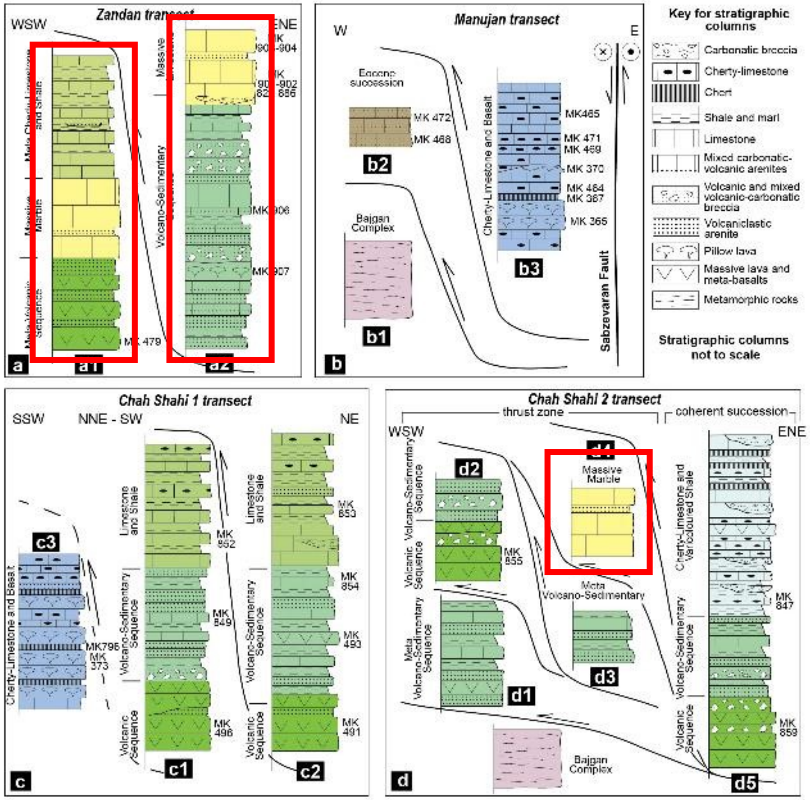
Barbero et al., 2021 Geosc. Front.



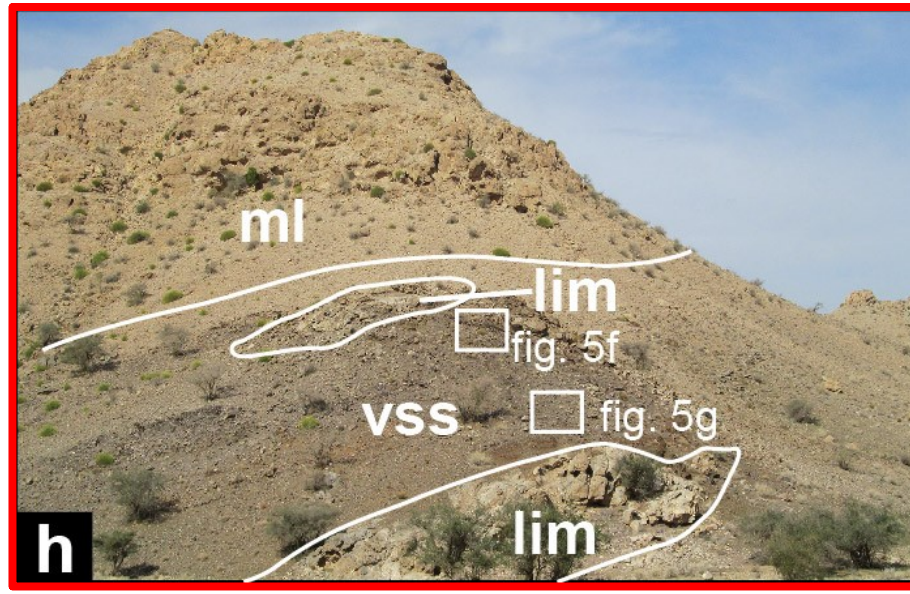
A basal **volcanic and volcano-sedimentary sequence** passing upward to a **pelagic sequence** (alternating of limestones, marls, and shale)

Basaltic rocks **alternated with volcaniclastic** arenites and breccias and **Cenomanian** pelagic limestones

Tectono-stratigraphic architecture: Type 3 succession



Barbero et al., 2021 Geosc. Front.

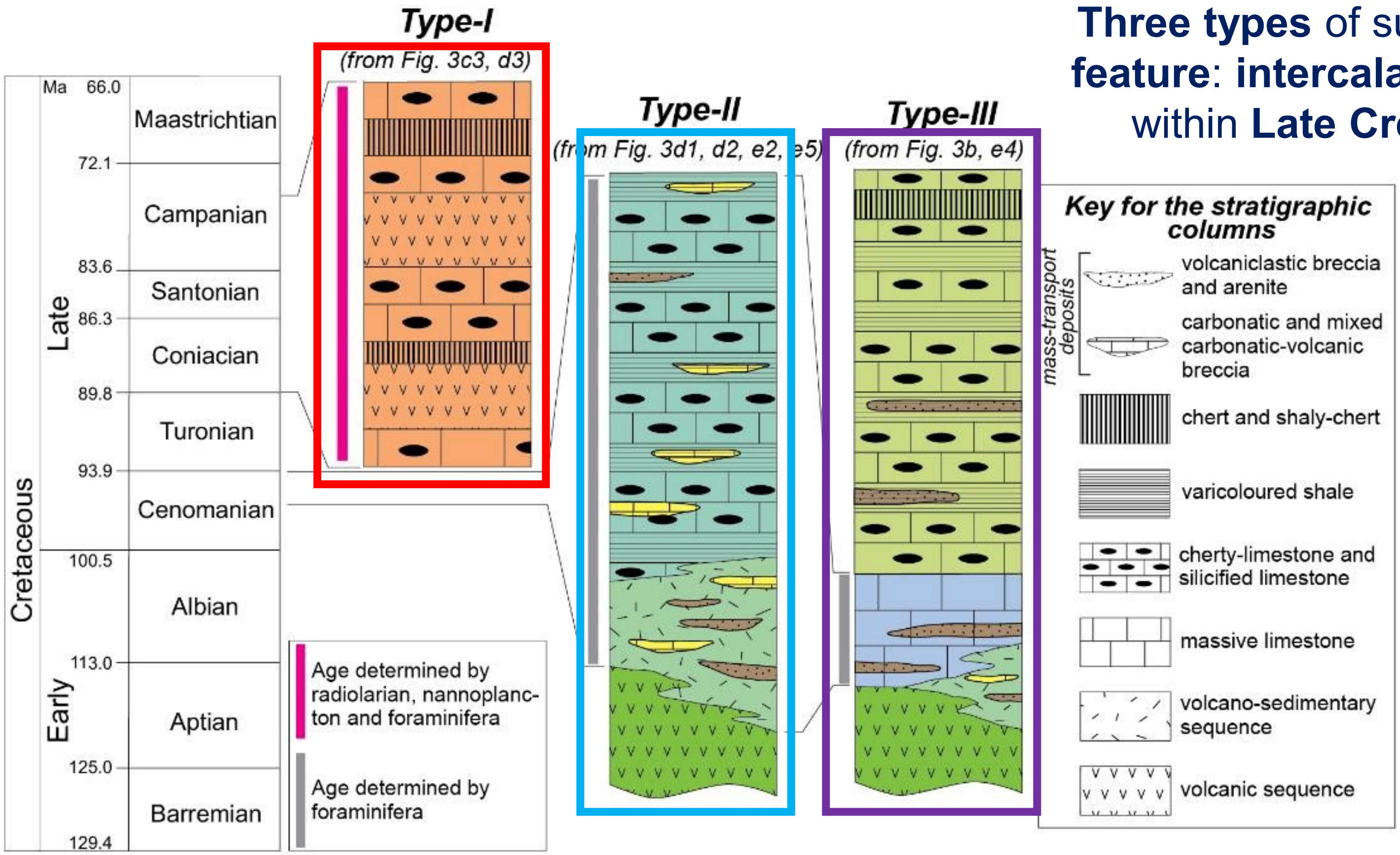


A **basal volcanic and volcano-sedimentary sequence** is **covered by Cenomanian** carbonatic **platform** succession

Primary stratigraphic relationships between **platform rocks** and highly **vesicular lavas** and **pillow breccias** → **volcanism in shallow-water environment**

Tectono-stratigraphic architecture

Three types of successions → **Common feature**: **intercalations of basaltic rocks** within **Late Cretaceous** sequences



Barbero et al., 2021 Geosc. Front.

Type I: pelagic sequence with pillow lava, and volcaniclastic rocks

Volcanism and pelagic sedimentation

Type II: volcanic/volcano-sedimentary sequence passing to pelagic sequence. Abundant volcaniclastic rocks

Volcanism and mass-transport deposits (slope)

Type III: volcanic sequence overlain by carbonatic platform succession.

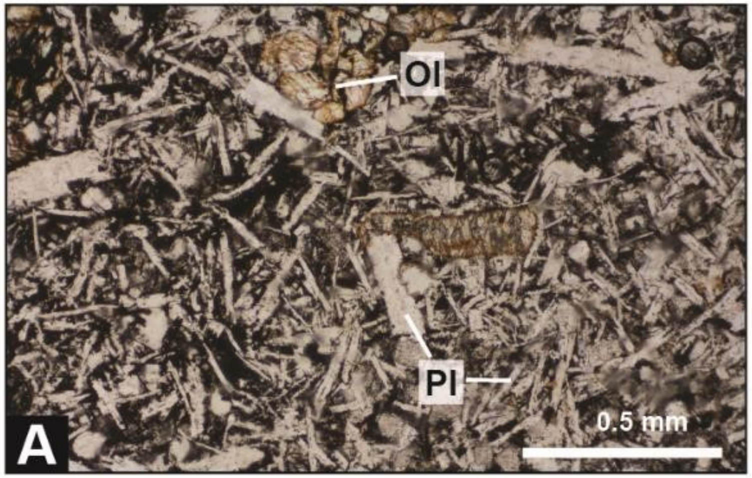
Volcanism and platform sedimentation

Geochemical affinity of the basalts is fundamental for tectonic interpretation

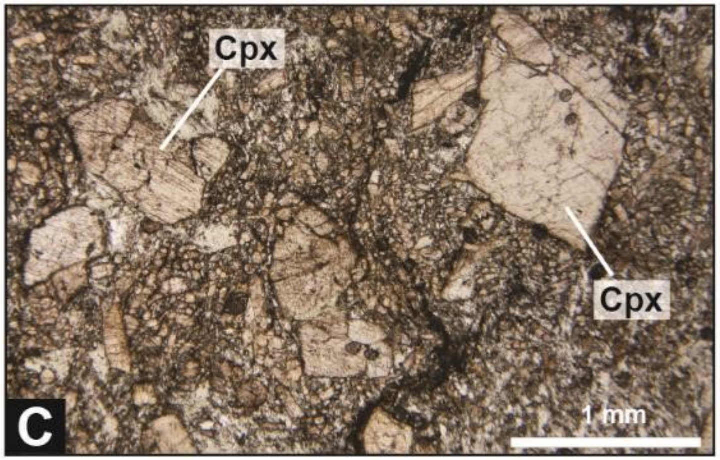
Petrography of the magmatic rocks

Great variety of texture of the volcanic rocks

- **Aphyric type**



- **Porphyritic type**: large phenocrysts of clinopyroxene



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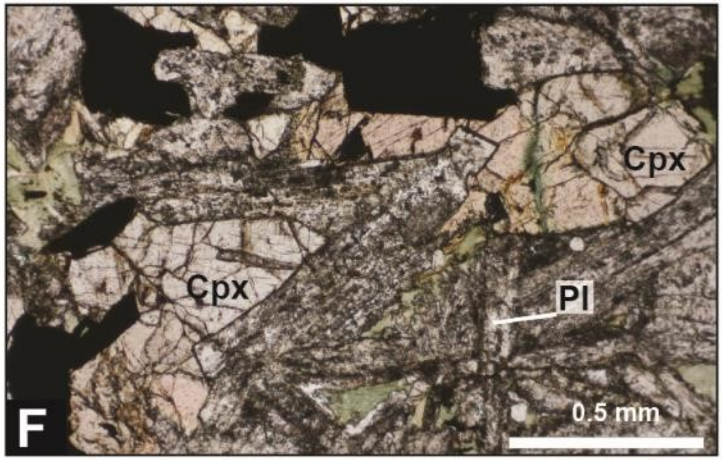
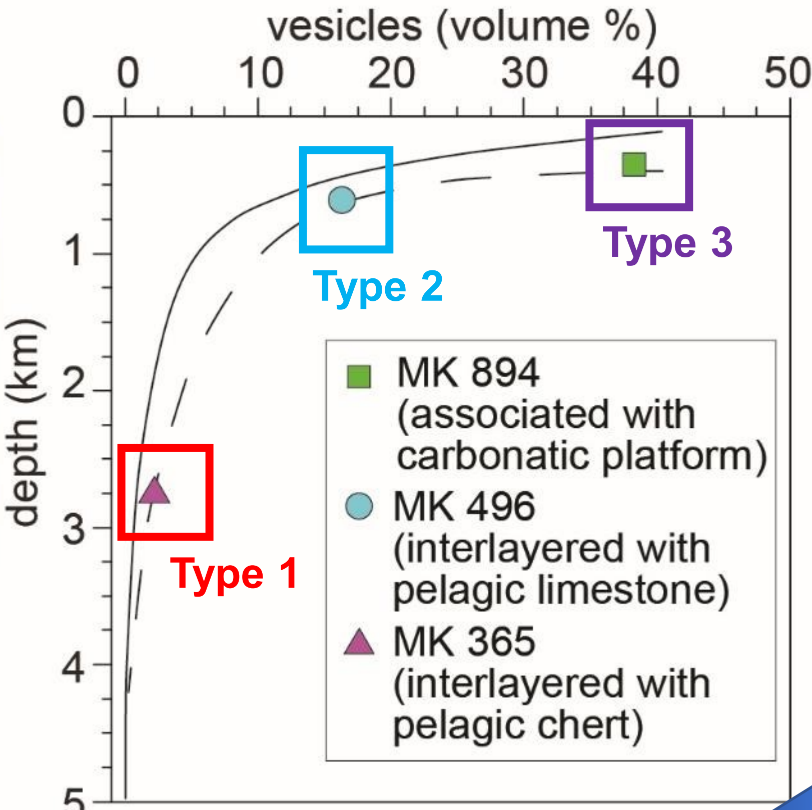
- **Sub-volcanic type**: plagioclase, clinopyroxene and interstitial Fe-Ti oxide



Different percentage of vesicles in basalts from Type 1, Type 2, and Type 3 successions → possible relationships with depth of eruption setting



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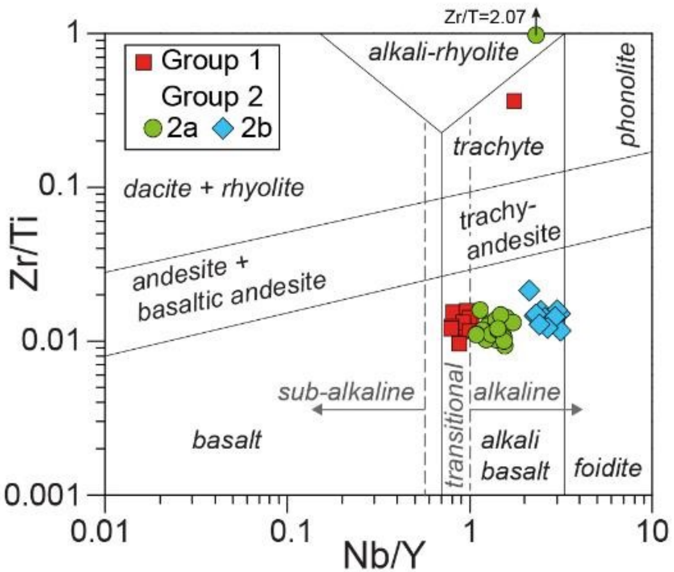
Geochemistry of the magmatic rocks



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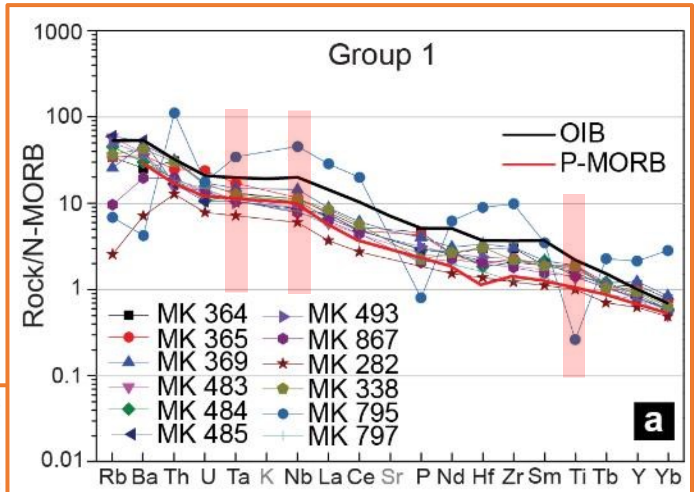
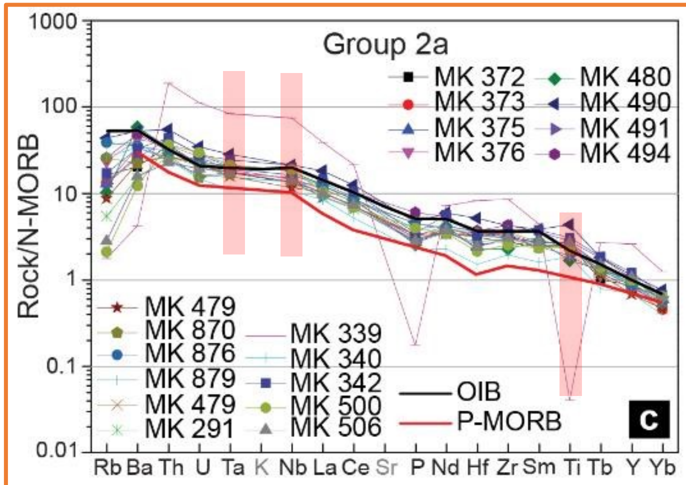
Group 1 alkaline/transitional affinity
Group 2a and 2b show a clear **alkaline nature**

Distinguishing features in the spider diagrams:

- Strongly **decreasing** pattern from **Th** to **Yb**



- no **Nb** and **Ta** negative anomalies
- **High Ti** contents



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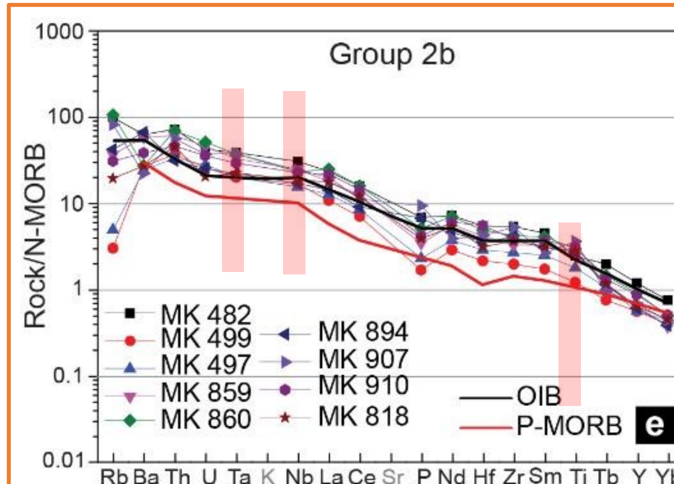
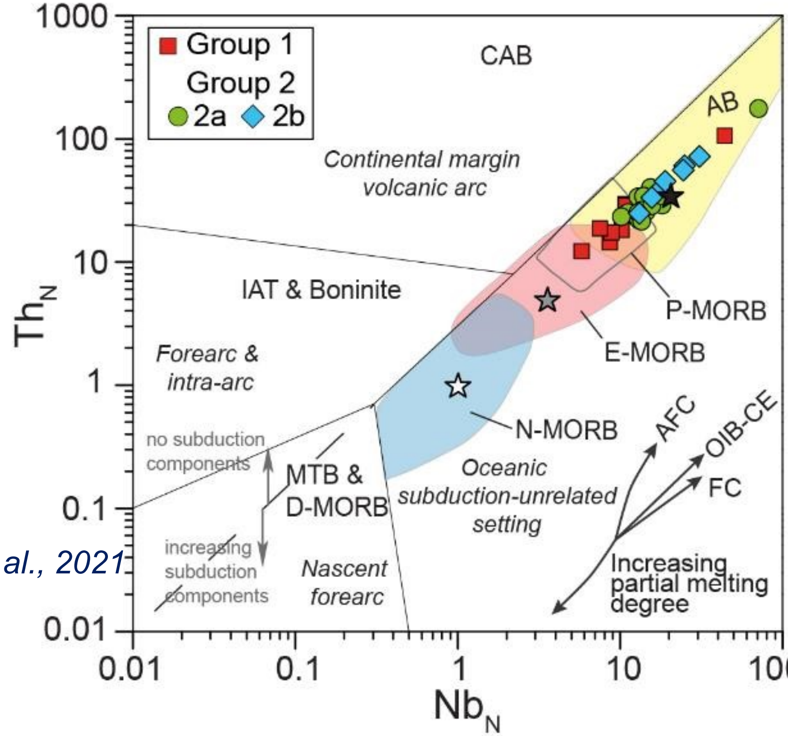


- **Large Ion Lithophile elements** and **Light REE** increase in abundance from Group 1 to Group 2a and 2b rocks

In **tectonic discrimination diagrams** plot along the **MORB-OIB compositional array**

- **Group 1: P-MORB** compositional field
- **Group 2a and 2b: alkaline basalts** compositional field



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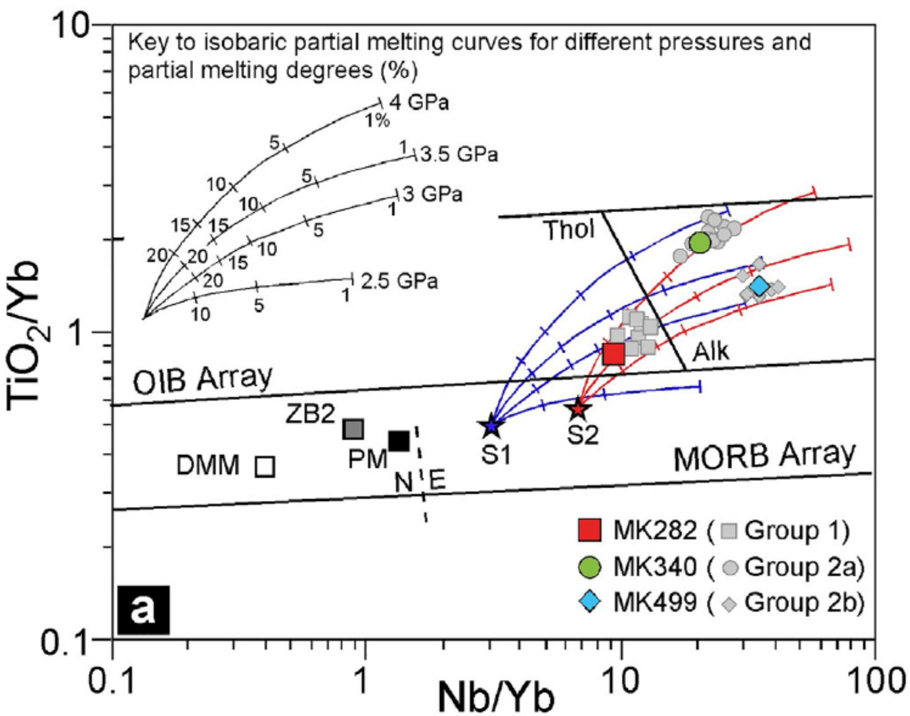
Chemical affinity with oceanic island basalts (OIB)



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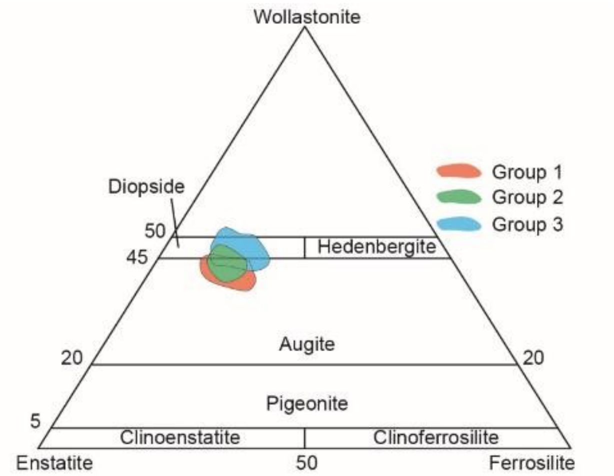
Petrogenetic modelling → aimed to constrain the tectono-magmatic setting of formation

- All Groups formed from variably **enriched mantle** sources (**OIB-type sources**)
- **S1 (Group 1) → enriched** lherzolite
- **S2 (Group 2) → strongly enriched** lherzolite
- Partial melting in both garnet- and spinel-facies→ primary magma results from **mixing of melts**

Mineral chemistry of clinopyroxene

from **Augitic to Diopsidic** compositions



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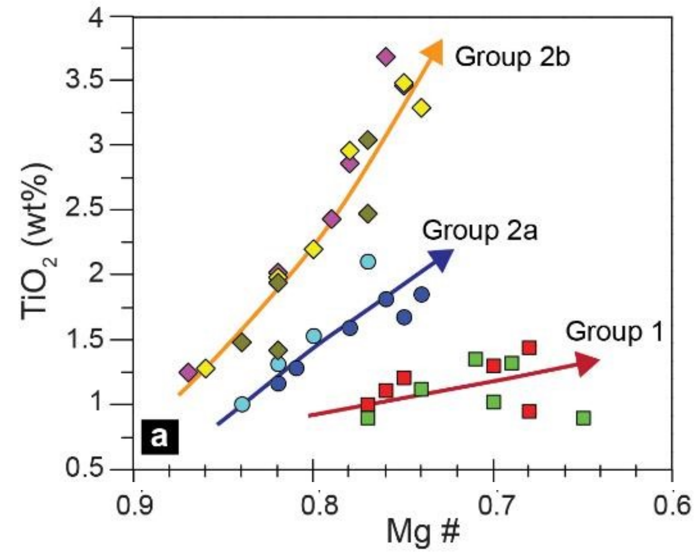
Clinopyroxene chemistry slightly **change in relation to** the whole rock geochemistry

Main differences: **Ti** and **Ca contents**



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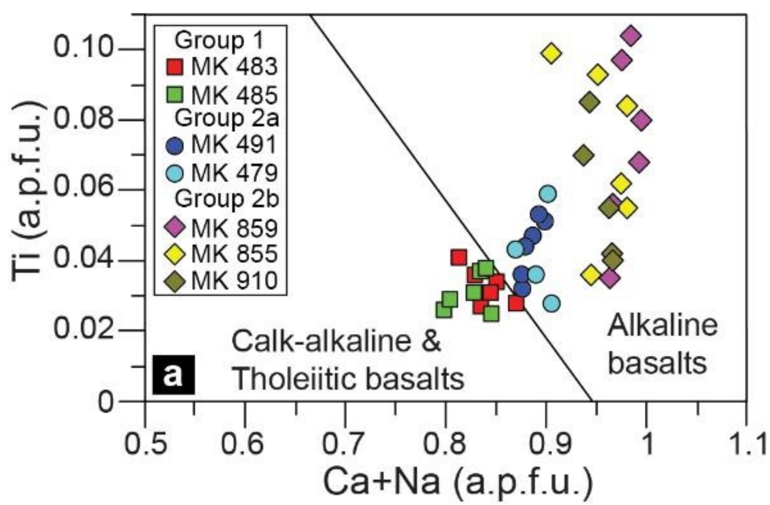

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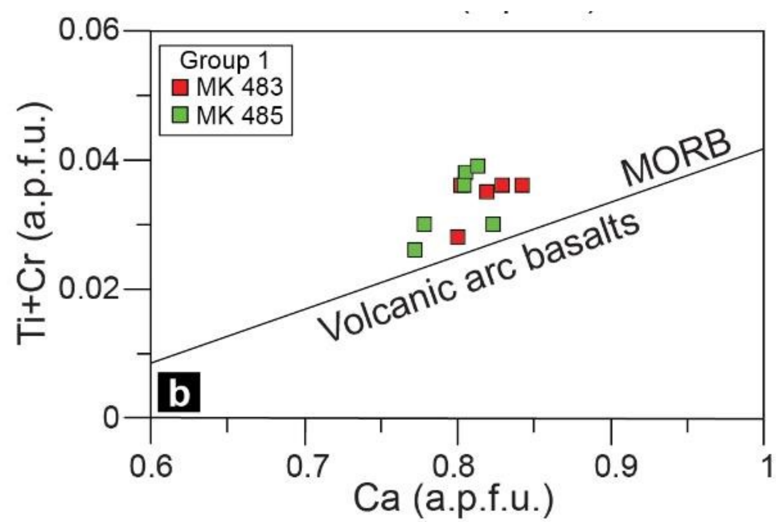
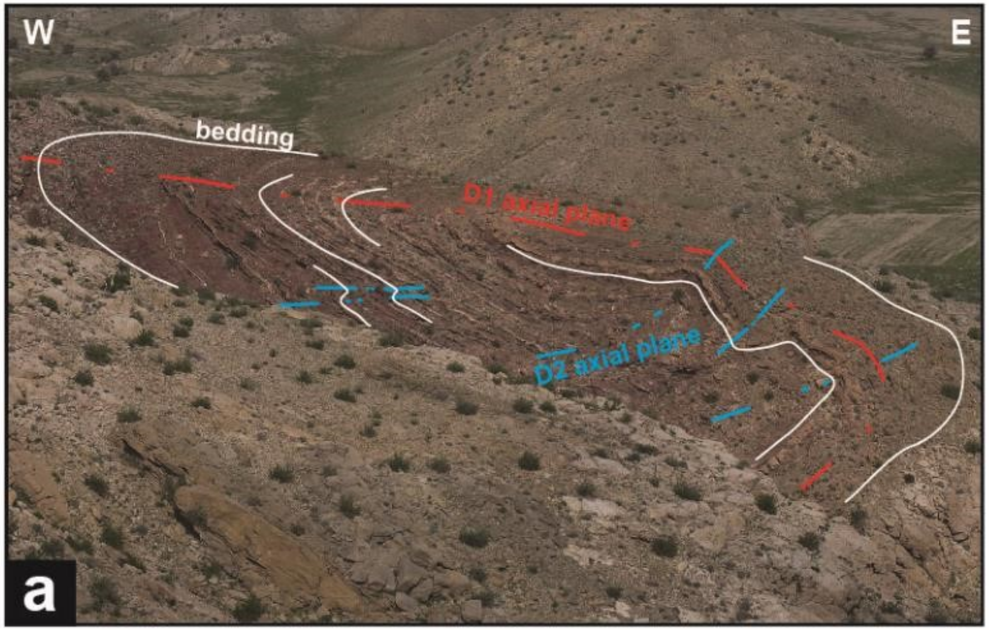


Discrimination diagram:
Group 2a and **2b** Cpx plot in the field for **alkaline pyroxene**
Group 1 Cpx in the field for **MOR clinopyroxene**

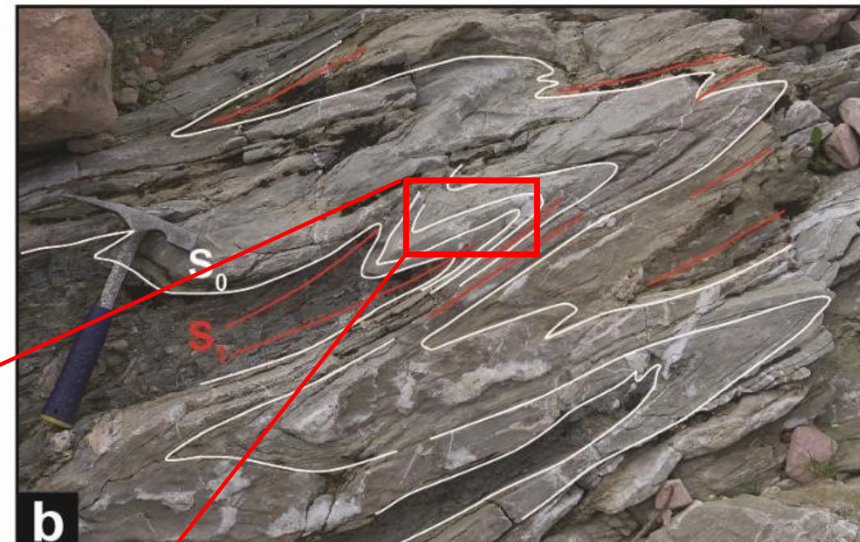
Deformation history



Barbero et al., 2021 Geosc. Front.

The Durkan Complex show a polyphase deformation

- D1 phase: sub-isoclinal to close folds with similar geometry and stretched limbs
- Axial plane foliation showing metamorphic recrystallization



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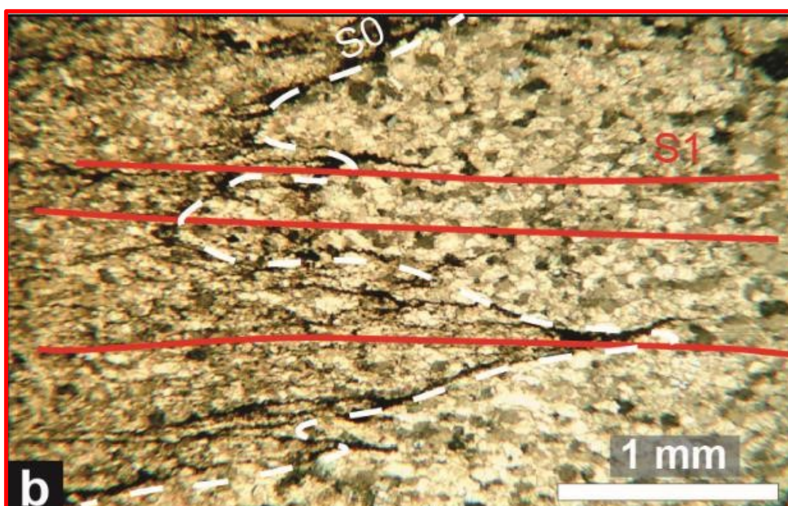

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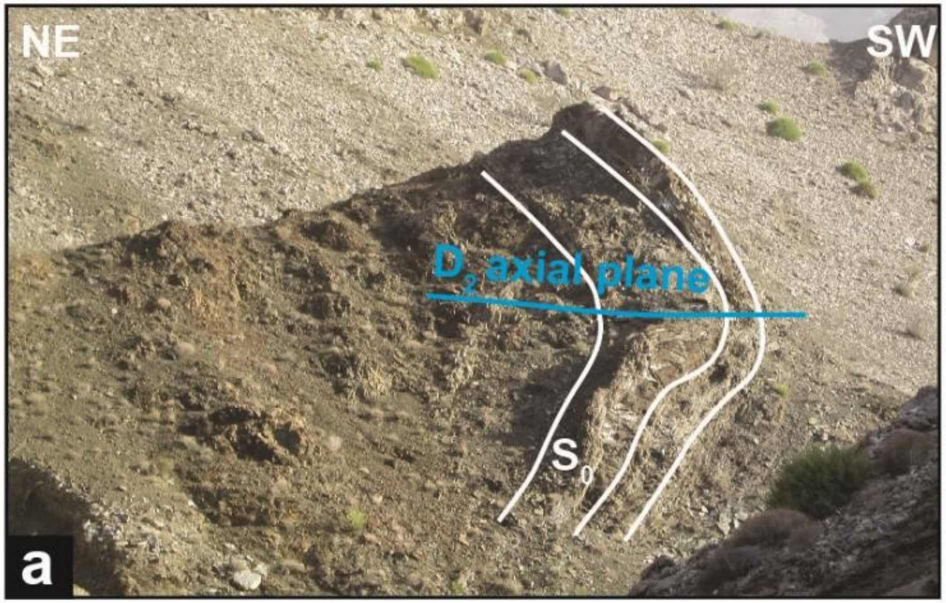
- Foliation development is heterogeneous in the different tectonic slices

Deformation history



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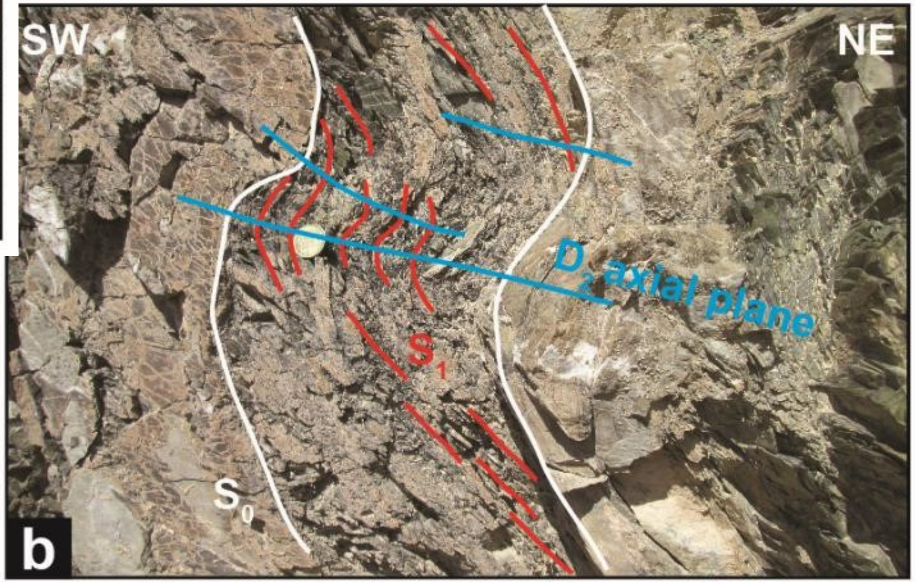
From macro- to micro-scale structures

- D2 phase: open to close folds, generally asymmetric
- Disjunctive cleavage as axial plane foliation



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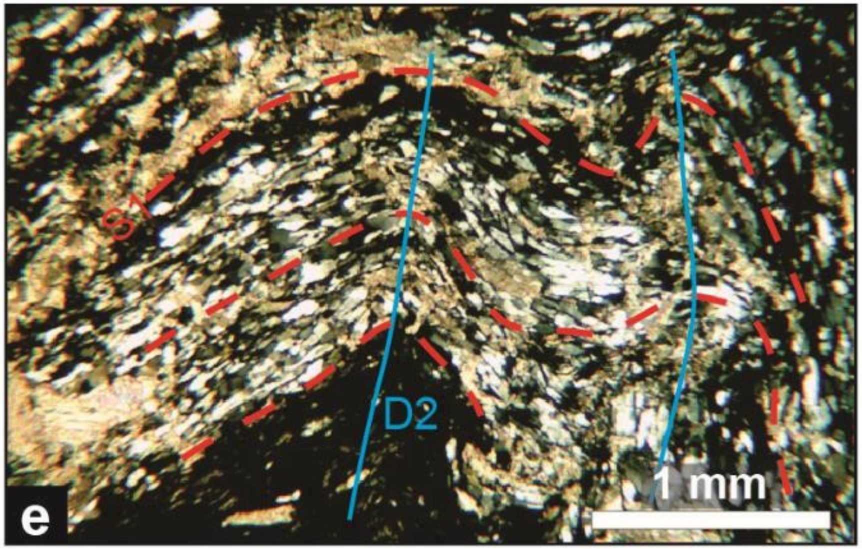


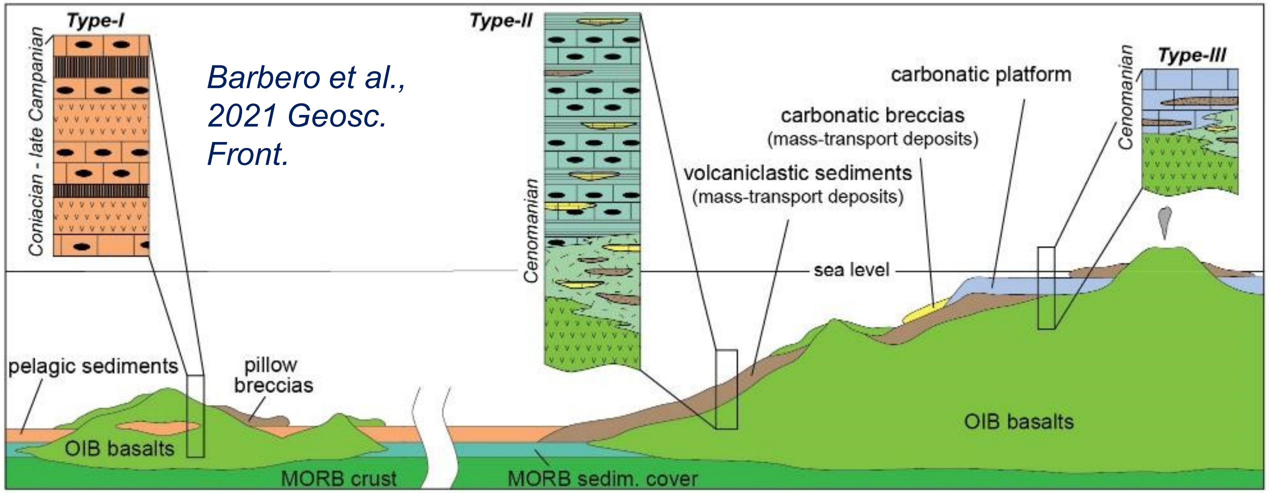
- D2 folds microfolds: folding of S1 foliation
- Axial plane: fractures or weak re-orientation of the S1 mineral assemblage

- What is the possible **tectono-sedimentary** and **tectono-magmatic setting of formation** of the Durkan Complex stratigraphic successions?

- What is the **possible tectonic setting for the deformation** of the Durkan Complex stratigraphic successions?

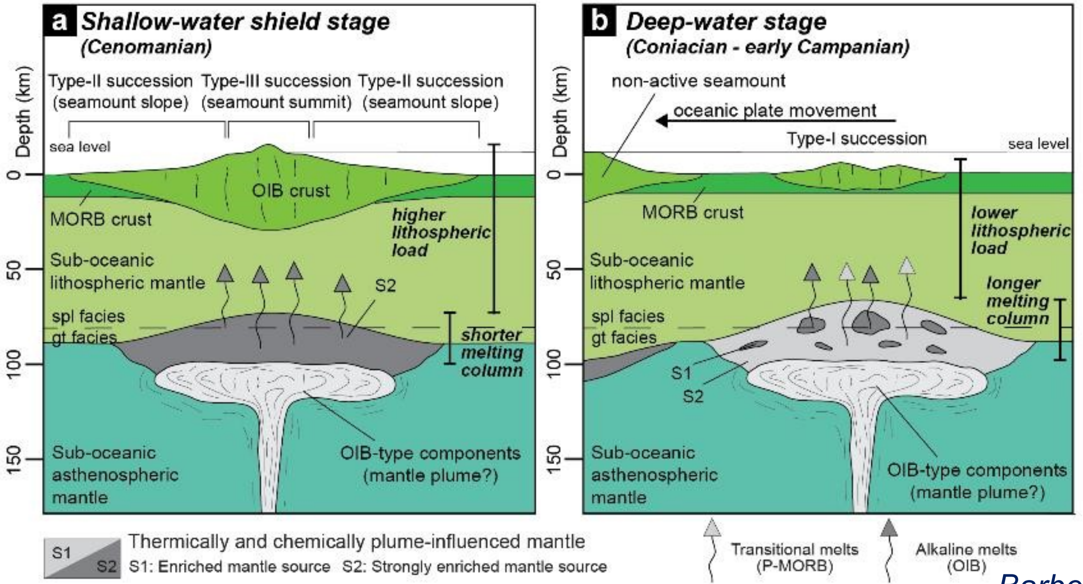
Discussion: a Late Cretaceous plume-related seamount chain

- Three types of stratigraphic successions associated with **alkaline and transitional** basaltic rocks of **Late Cretaceous** age.



- **Magmatism** and **deposition** during the formation of **seamounts** :

Type 1 → deep water stage; **Type 2 and Type 3 → slope** and **summit** of an oceanic island (emerged seamount)



Tectono-magmatic setting:

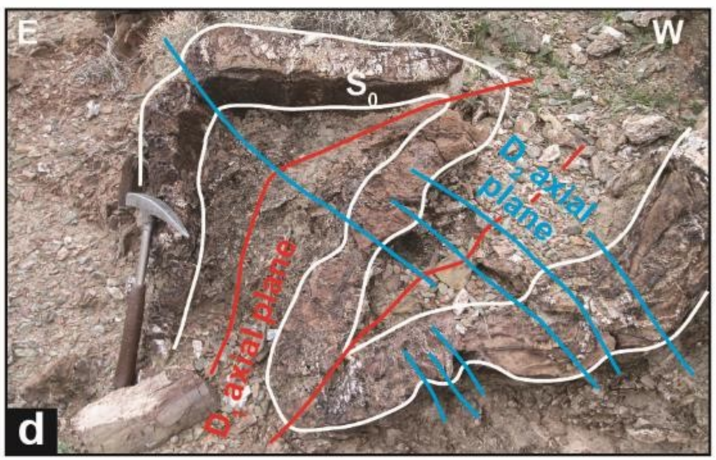
- Basalts derived from partial melting of variably **enriched OIB-mantle sources** that melted at spinel- and garnet-facies
- Durkan Complex → rock assemblages formed during seamounts formation influenced by Late Cretaceous **mantle plume activity**

Barbero et al., 2021 Lithos

Western Durkan Complex → Late Cretaceous **seamounts fragments**

Discussion: the significance of the deformation history

- Deformation of the seamount fragments during the latest **Late Cretaceous – Paleocene**
- **Superposition of D1 and D2** phase testify by Type 3 interference pattern (*Ramsey, 1967*)



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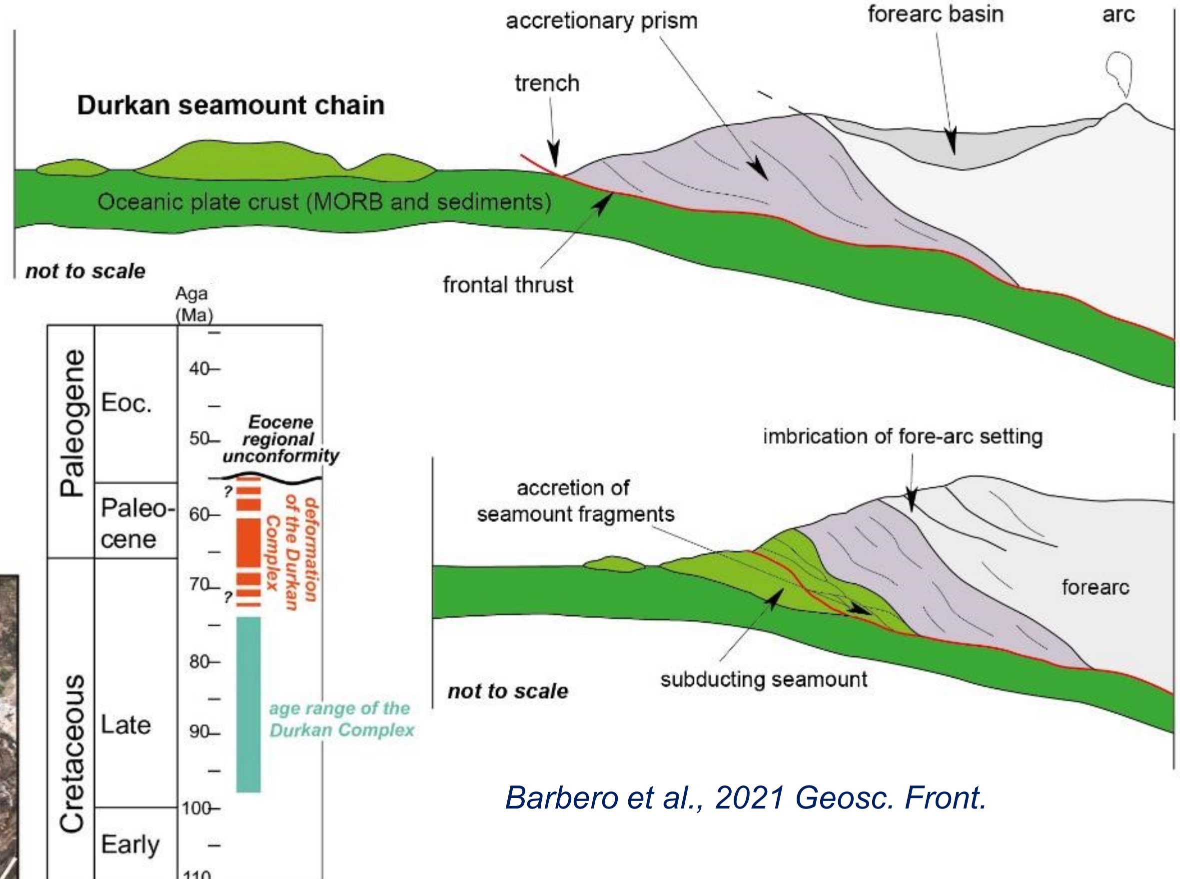

Barbero et al., 2021 Geosc. Front.

- **Underplating** of seamount material at rather shallow levels of the prism (**D1 phase**).
- Accretion is followed by a **progressive exhumation** at shallower level within the prism (**D2 phase**).

- The incorporation of Durkan seamounts in the Late Cretaceous – Paleocene Makran prism likely caused a **shortening of the whole convergent margin and its fore-arc**

Conclusion and open problems

- In the **western Durkan no evidence** of **continental crust rocks** and **continental margin successions** → different from previous interpretations
- Western Durkan Complex includes **Late Cretaceous successions formed in a seamount setting** characterized by P-MORB and Alkaline basalts recording **mantle plume activity (?)**
- Seamount fragments **underplated** in the Makran prism during Late Cretaceous – Paleocene
- The **interaction between Makran prism and Durkan seamount chain is a key tectonic event** for controlling the tectonic evolution of the Makran margin

Still a lot of open problems…

- Estimation of the **metamorphic P-T conditions** are key to understand the **depth of the underplating**
- In the western North Makran, the remnants of **the microcontinental block** must be searched in the Bajgan Complex → **key to test these data**
- The time is come for a **critical review of the geodynamic evolution** of the Makran Prism and the paleogeographic setting of the norther part of the Neo-Tethys during the Jurassic - Cretaceous

Research team

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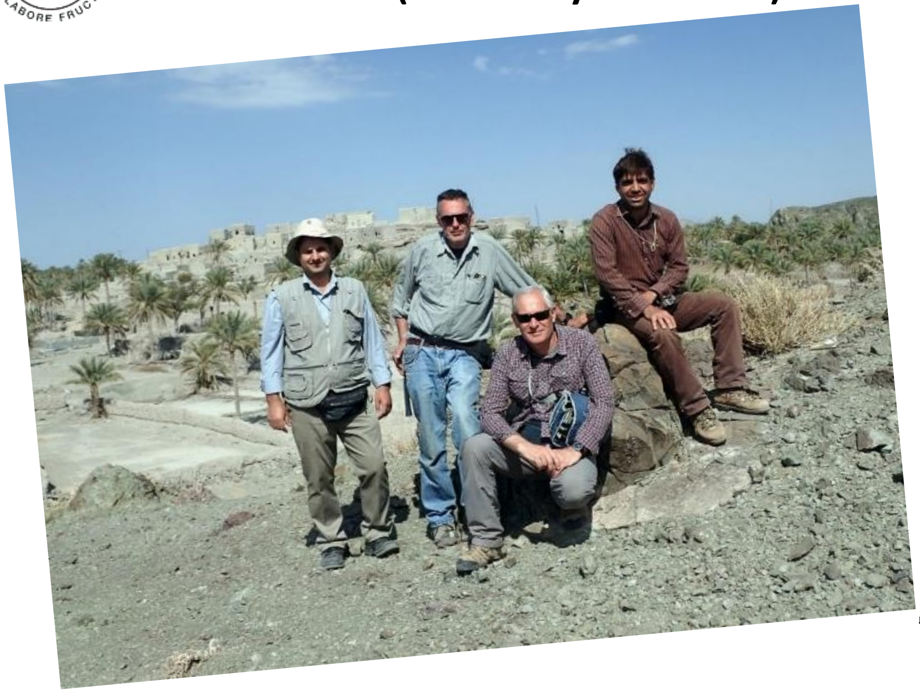

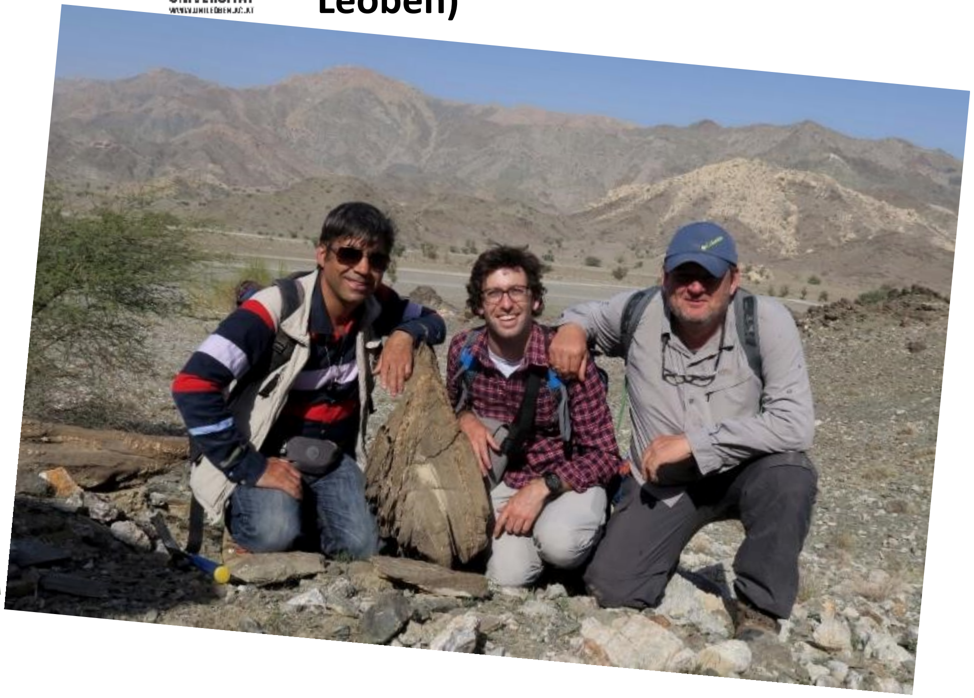

Thank you for your attention

ممنون از توجه شما