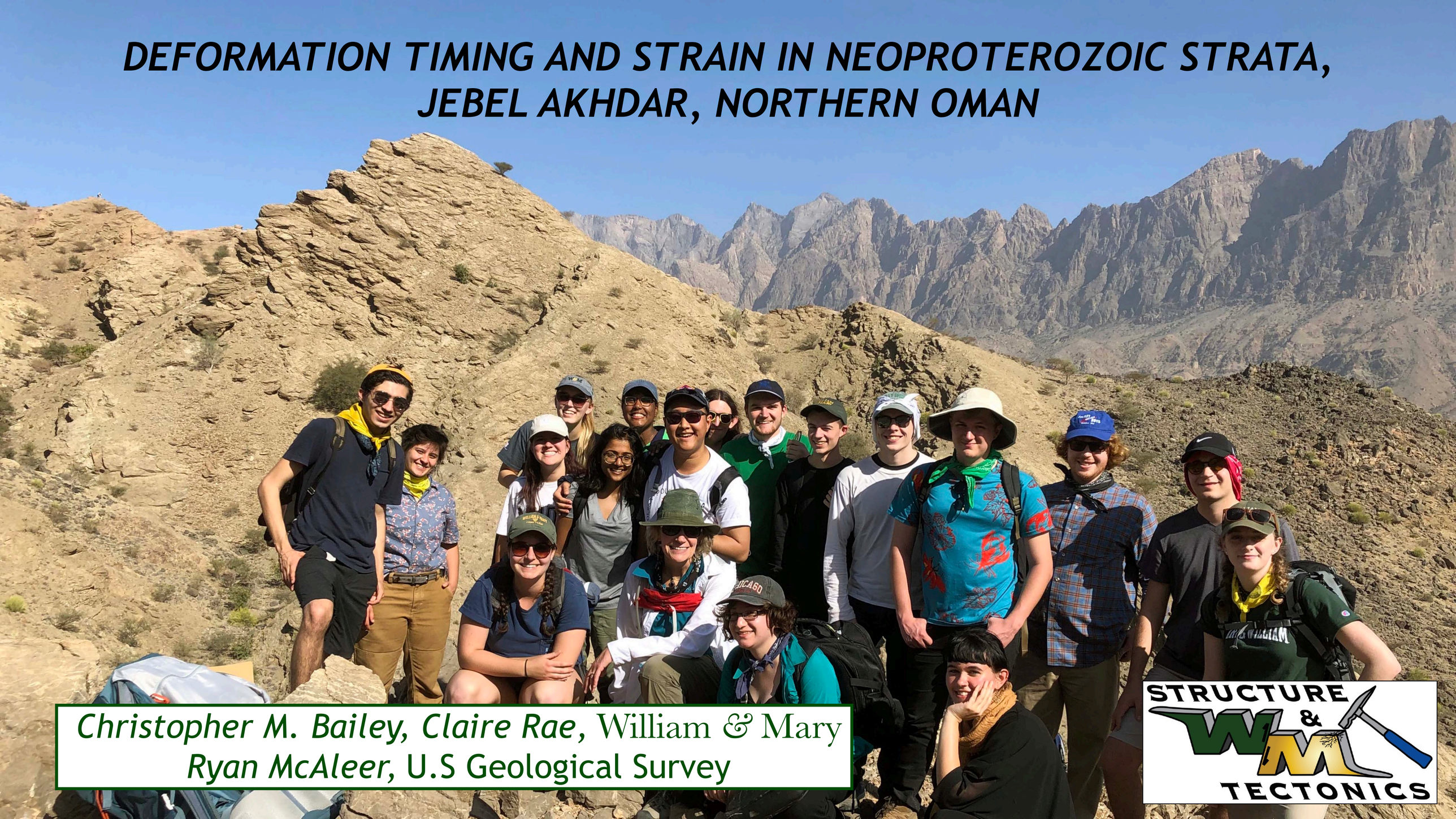
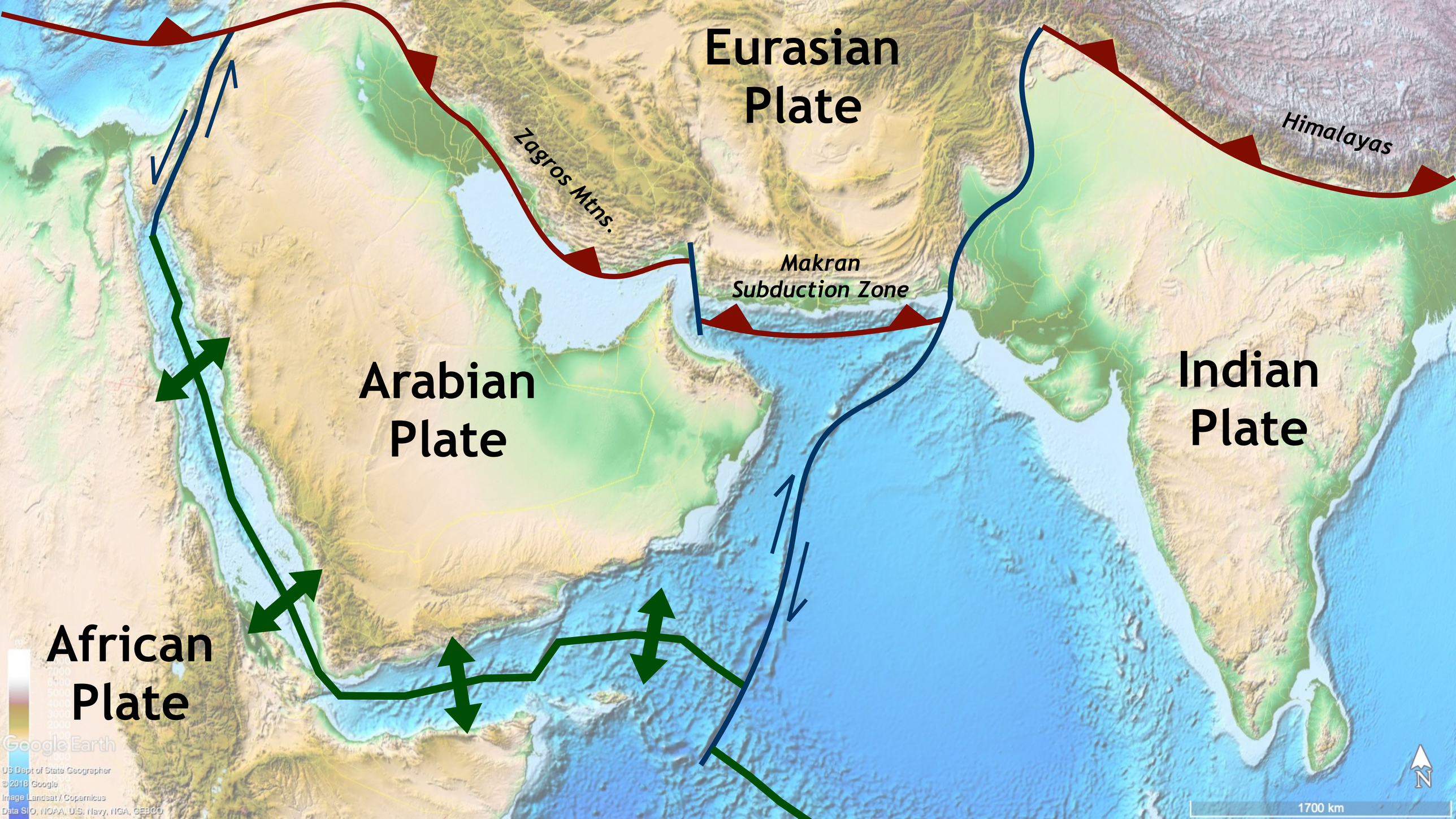
DEFORMATION TIMING AND STRAIN IN NEOPROTEROZOIC STRATA, JEBEL AKHDAR, NORTHERN OMAN

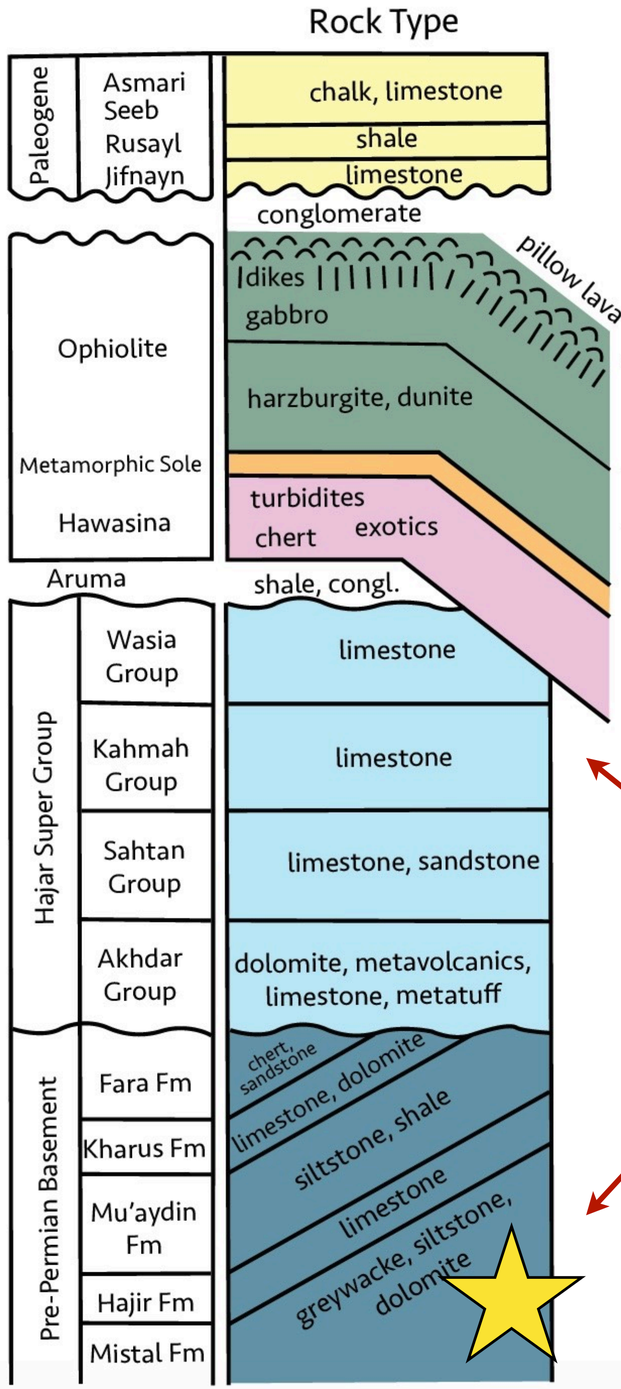


Christopher M. Bailey, Claire Rae, William & Mary
Ryan McAleer, U.S Geological Survey

STRUCTURE & TECTONICS


Eurasian Plate
Zagros Mtns.
Himalayas
Makran Subduction Zone
Arabian Plate
Indian Plate
African Plate
Google Earth
US Dept of State Geographer
© 2018 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
1700 km


Arabian Gulf
IRAN
Sea of Oman
UAE
• Muscat
north Oman Mountains
SAUDI ARABIA
Google Earth
US Dept of State Geographer
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
100 km



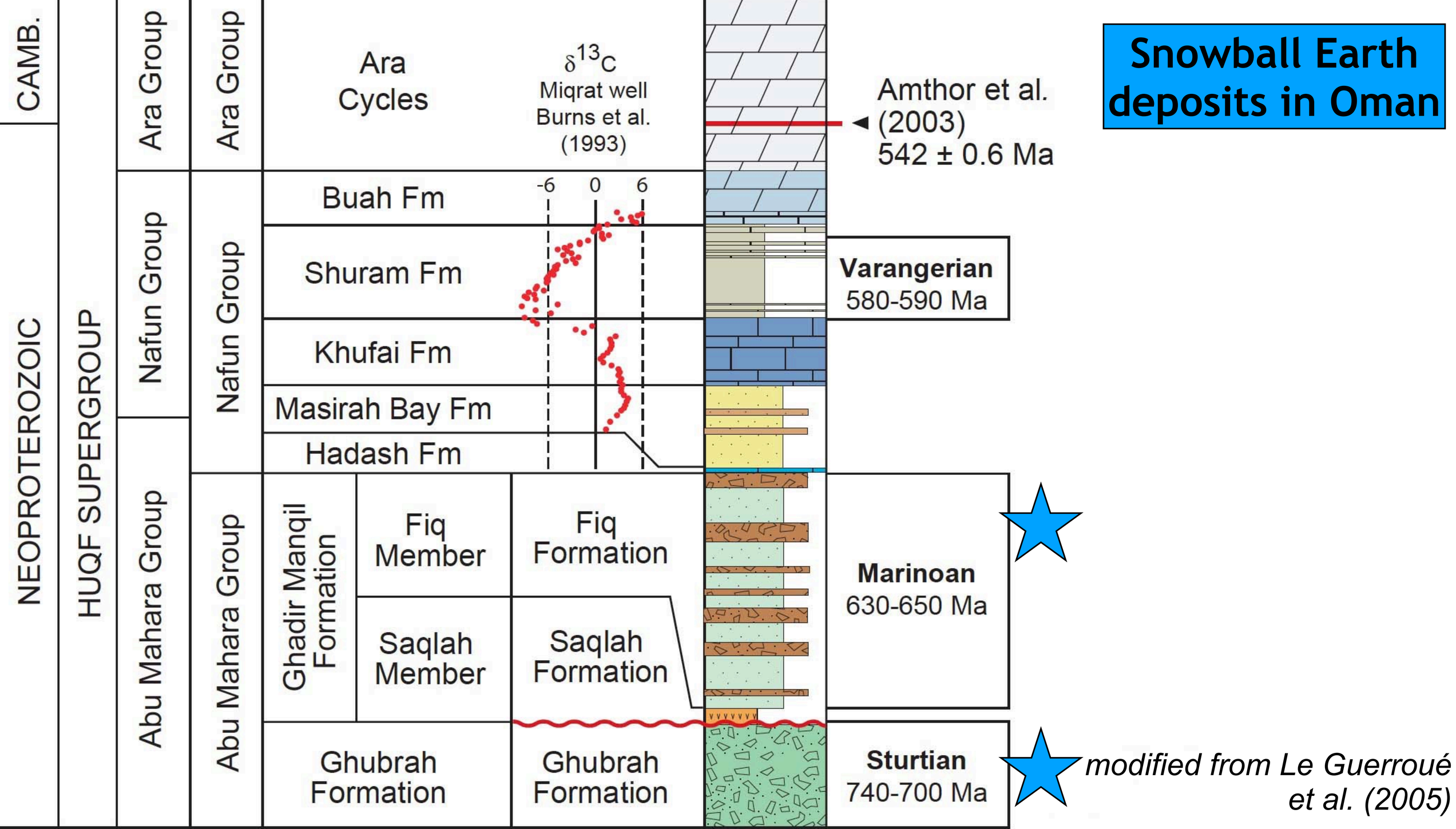
Oceanic crust: oceanic sediment, pillow basalts, sheeted dike complex, and both layered and isotropic gabbro.

Moho: seismic discontinuity and petrologic transition zone between crust and mantle rocks.

Mantle: predominantly harzburgites and dunites with varying levels

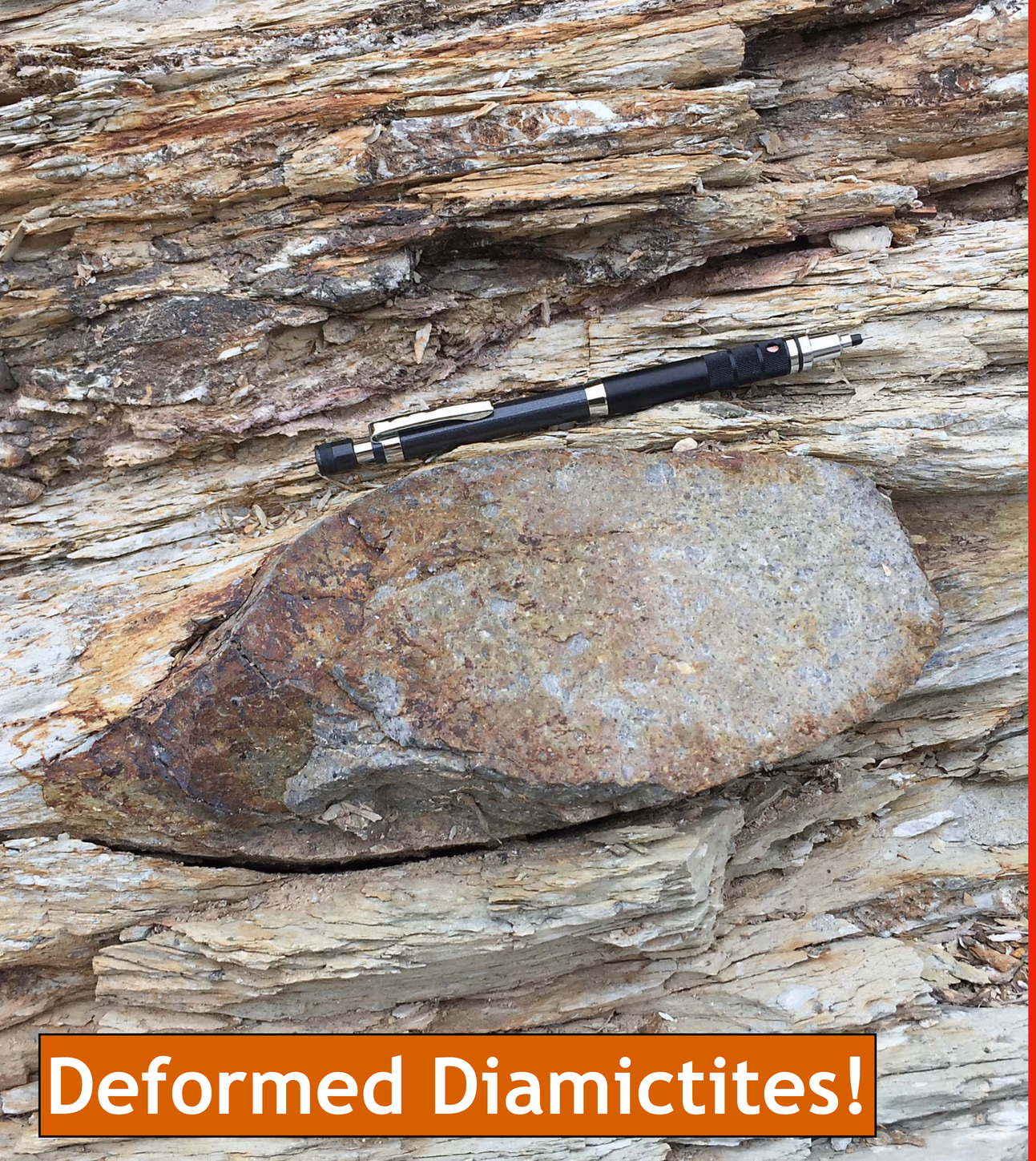
Autochthonous Sequence

Snowball Earth deposits in Oman



modified from Le Guerroué et al. (2005)

Diamictites Galore



Deformed Diamictites!

Pencil Structure

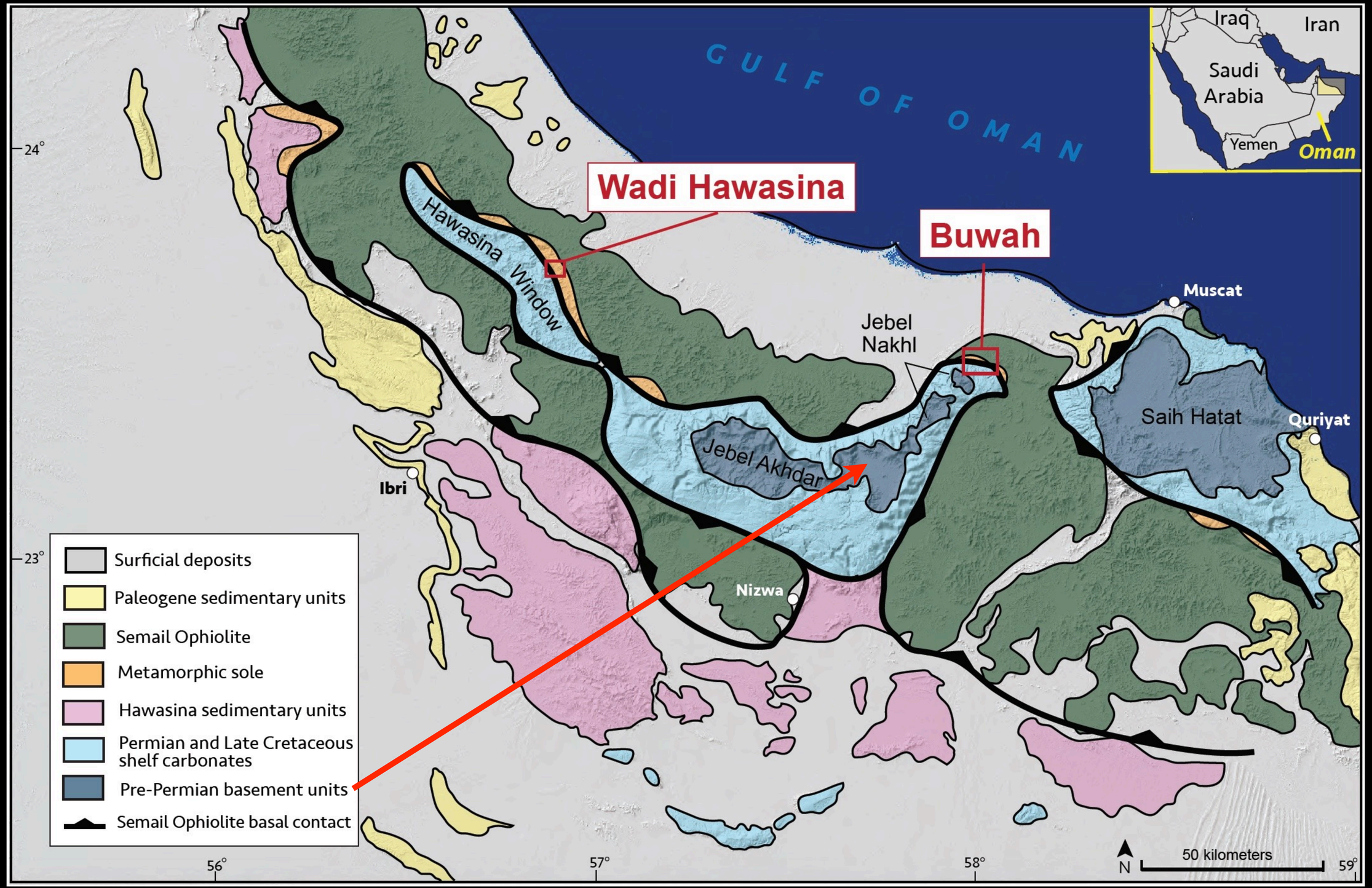
RESEARCH GOALS

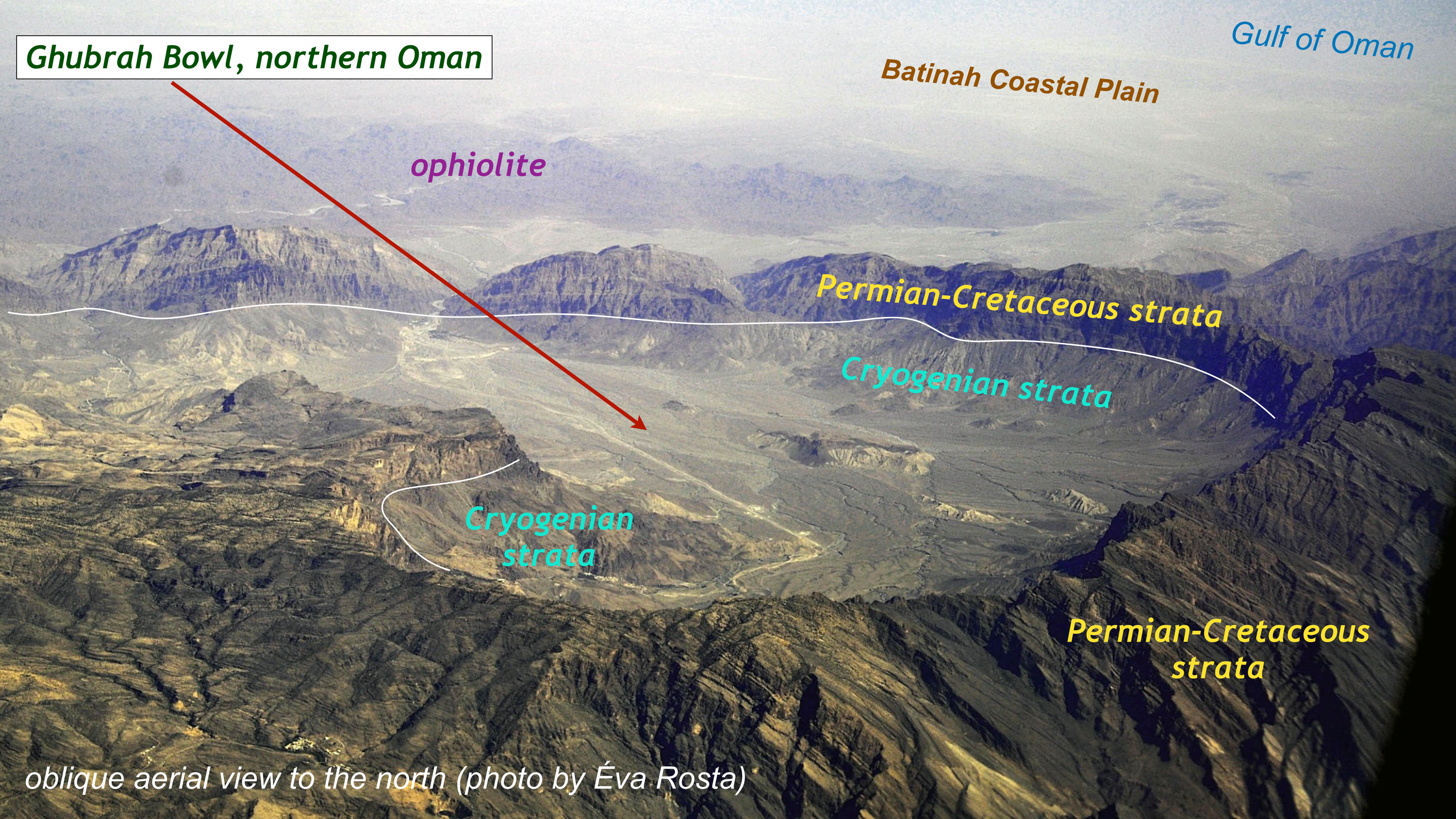
1. Quantify the ***three-dimensional finite strain and vorticity*** in deformed rocks of the Ghubrah and Fiq formations in order to understand the ***regional kinematic history***

2. Determine the ***physical conditions*** and ***timing of deformation,*** as well as its relationship to the orogenic history of northern Oman.

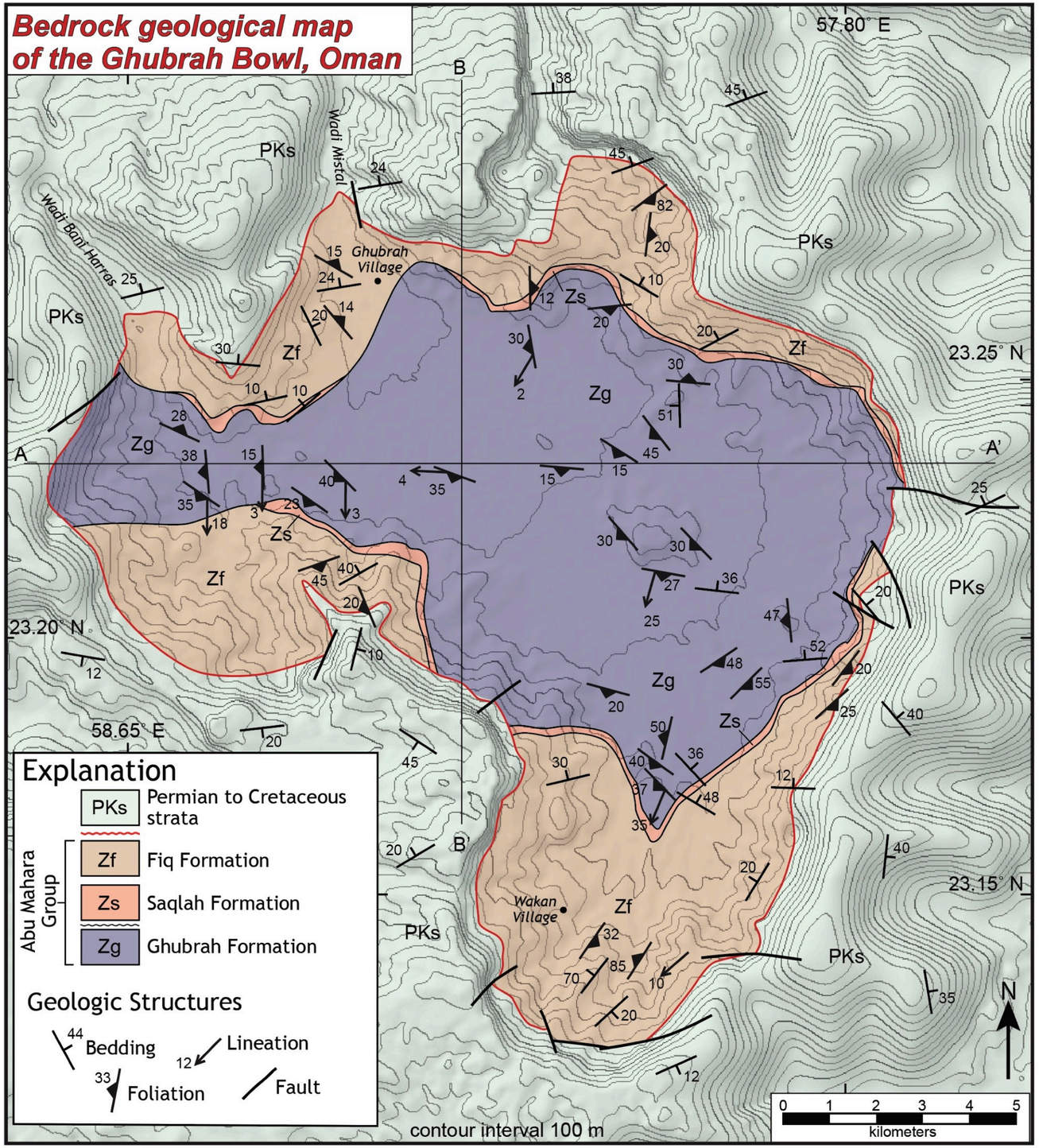
METHODS

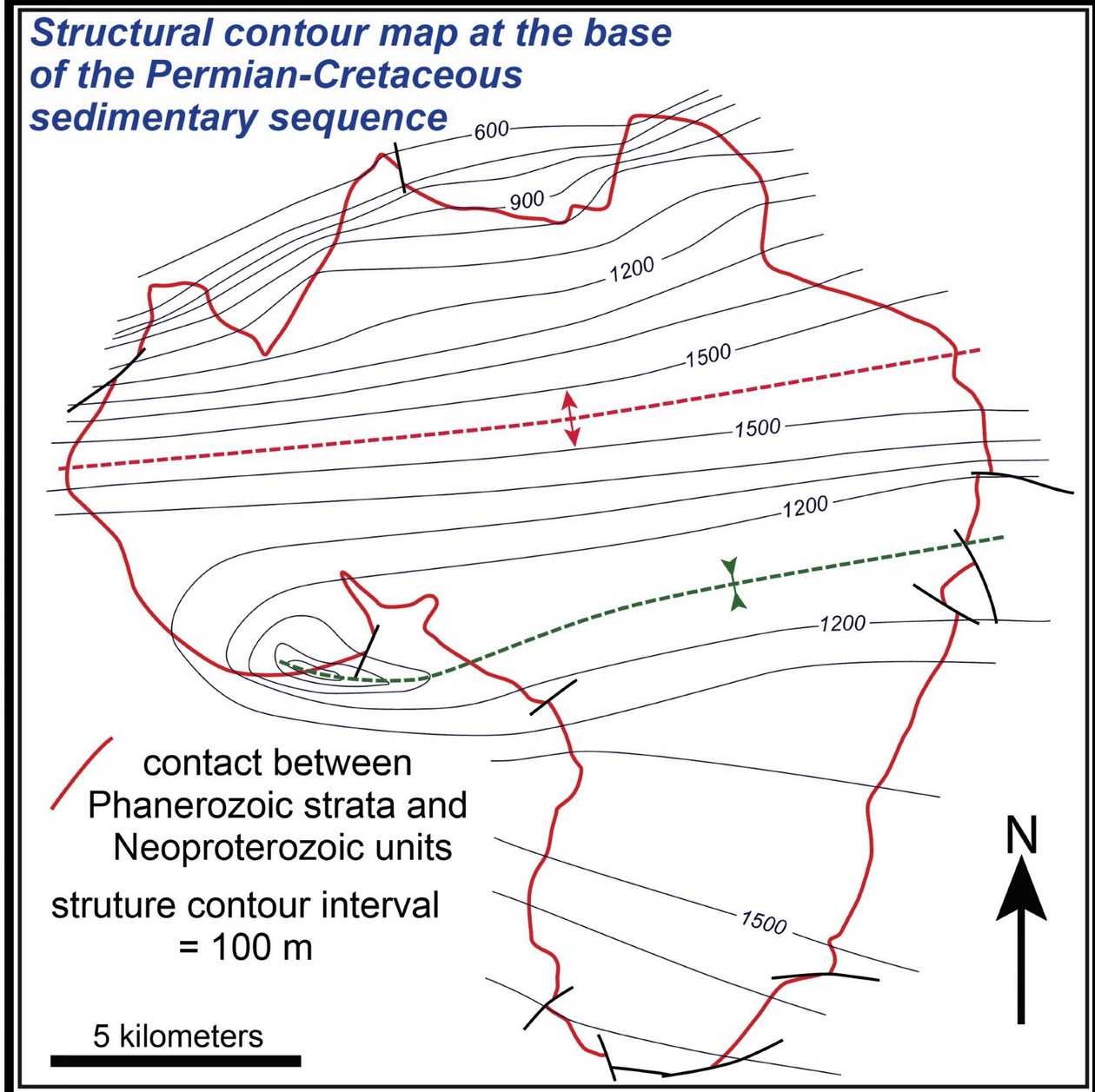
Field mapping, structural analysis, strain + vorticity analysis, petrologic analysis, and Ar/Ar geochronology


GULF OF OMAN
Iraq
Iran
Saudi Arabia
Yemen
Oman
Wadi Hawasina
Buwah
Hawasina Window
Jebel Nakhl
Muscat
Jebel Akhdar
Saih Hatat
Quriyat
Ibri
Nizwa
24°
23°
56°
57°
58°
59°
N
50 kilometers
Surficial deposits
Paleogene sedimentary units
Semail Ophiolite
Metamorphic sole
Hawasina sedimentary units
Permian and Late Cretaceous shelf carbonates
Pre-Permian basement units
Semail Ophiolite basal contact

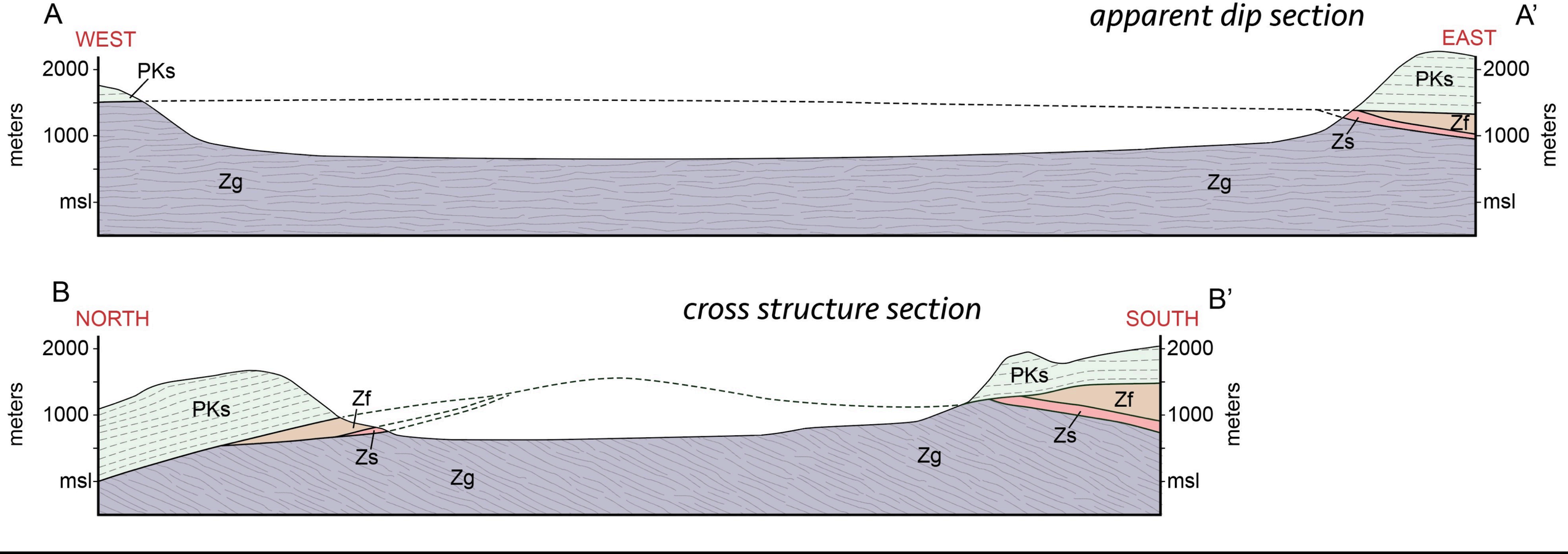


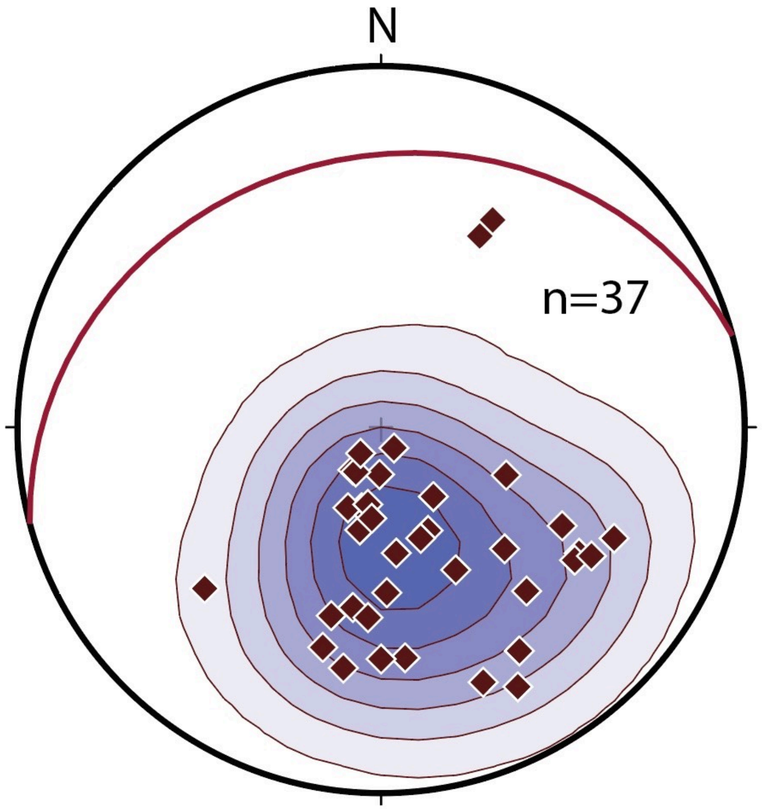
oblique aerial view to the north (photo by Éva Rosta)


Bedrock geological map of the Ghubrah Bowl, Oman
57.80° E
58.65° E
23.25° N
23.20° N
23.15° N
A
A'
B
B'
Wadi Mistal
Wadi Bani Harras
Ghubrah Village
Wakan Village
PKs
Zf
Zs
Zg
Explanation
Permian to Cretaceous strata
Abu Mahara Group
Fiq Formation
Saqlah Formation
Ghubrah Formation
Geologic Structures
Bedding
Lineation
Foliation
Fault
contour interval 100 m
0 1 2 3 4 5
kilometers
N

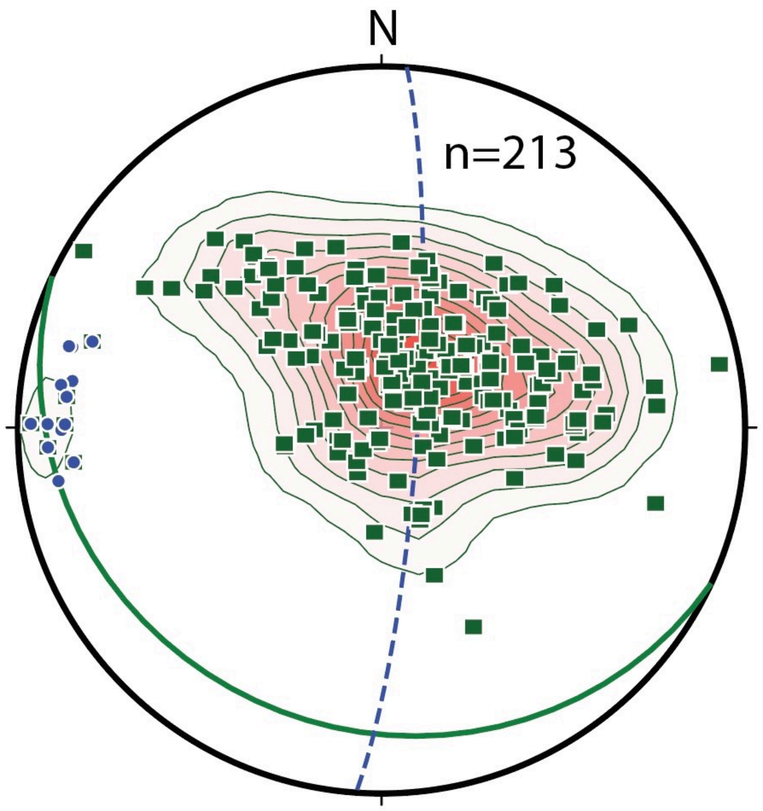

Structural contour map at the base of the Permian-Cretaceous sedimentary sequence
600
900
1200
1500
1500
1200
1200
1500
contact between Phanerozoic strata and Neoproterozoic units
struture contour interval = 100 m
5 kilometers
N

Cross sections of the Ghubrah Bowl



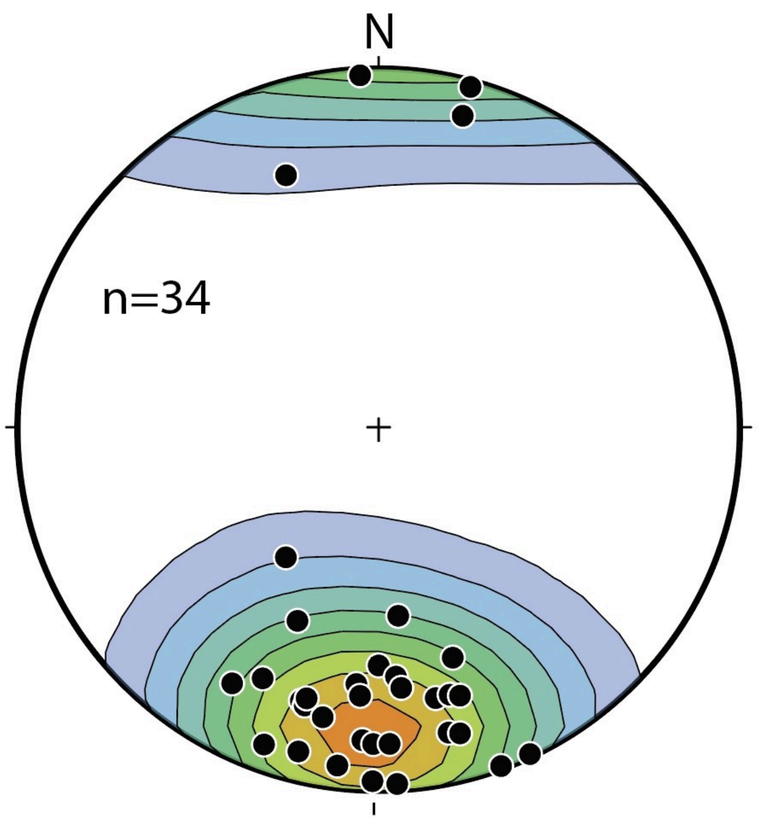


poles to bedding



▪ poles to foliation

• poles to spaced cleavage



elongation lineation

beds dip gently to moderately towards the north

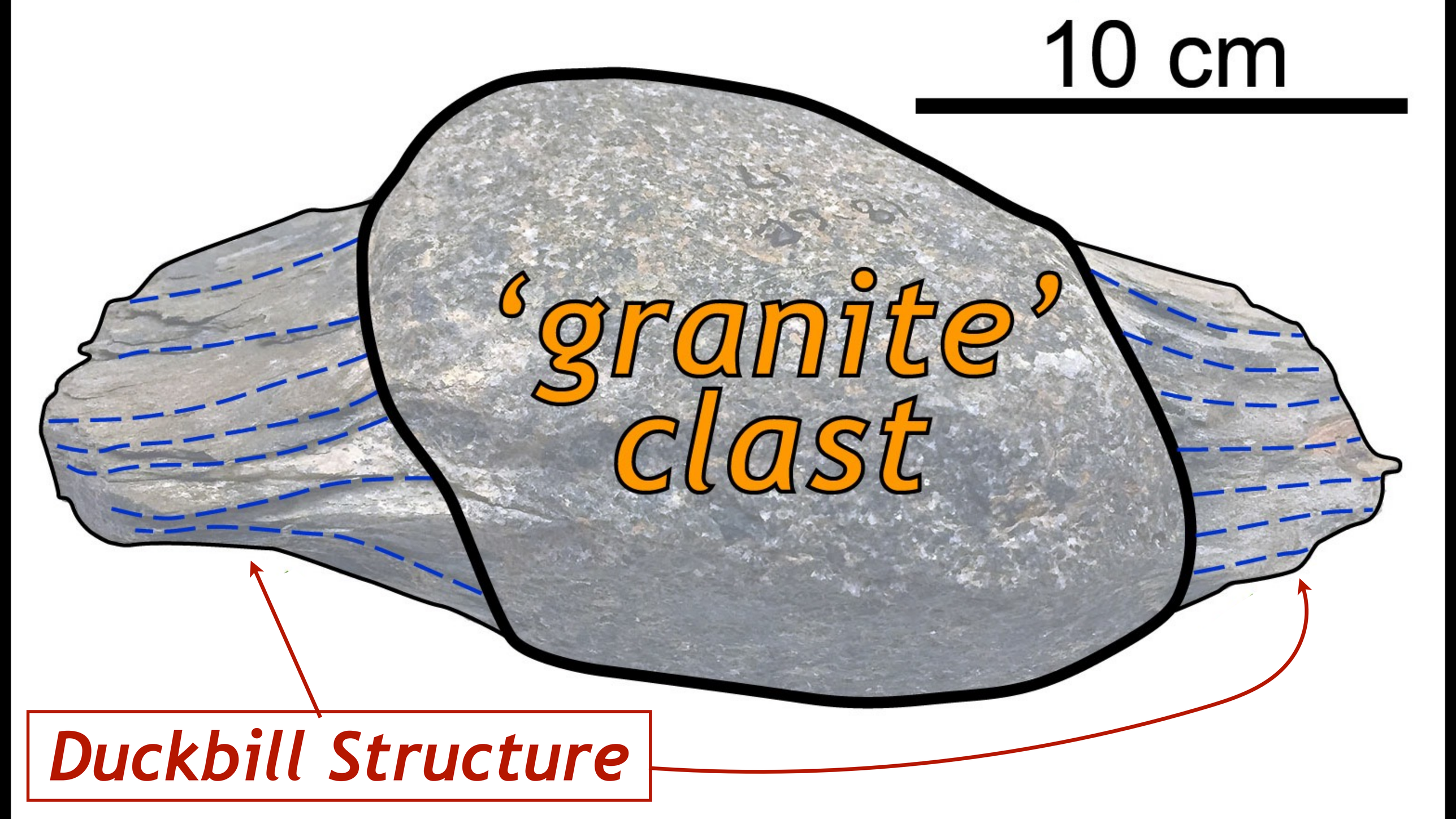
foliation dips towards the south

N-S striking steeply-dipping space cleavage

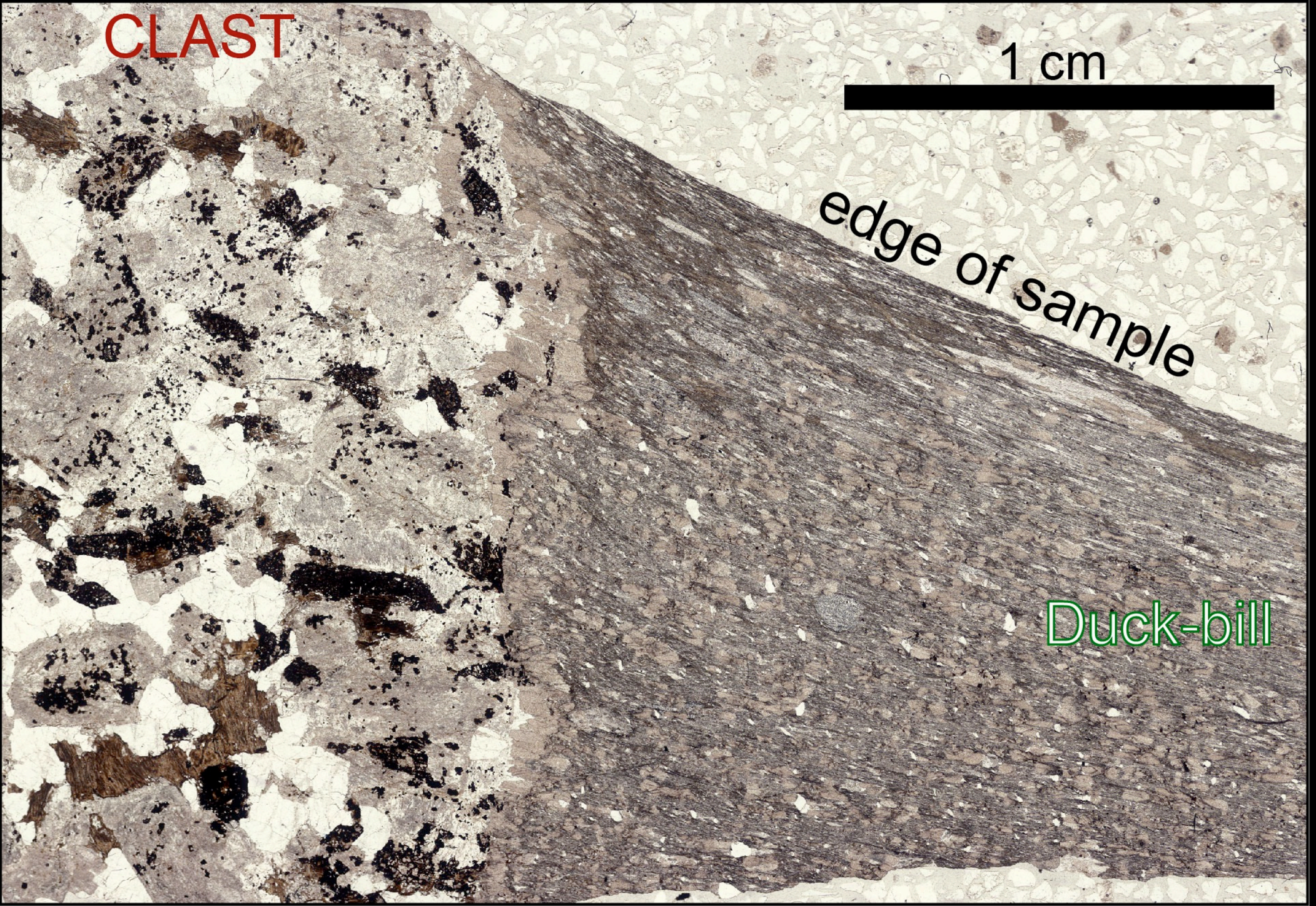
lineation typically plunges gently to the south

Duckbill Structure


10 cm

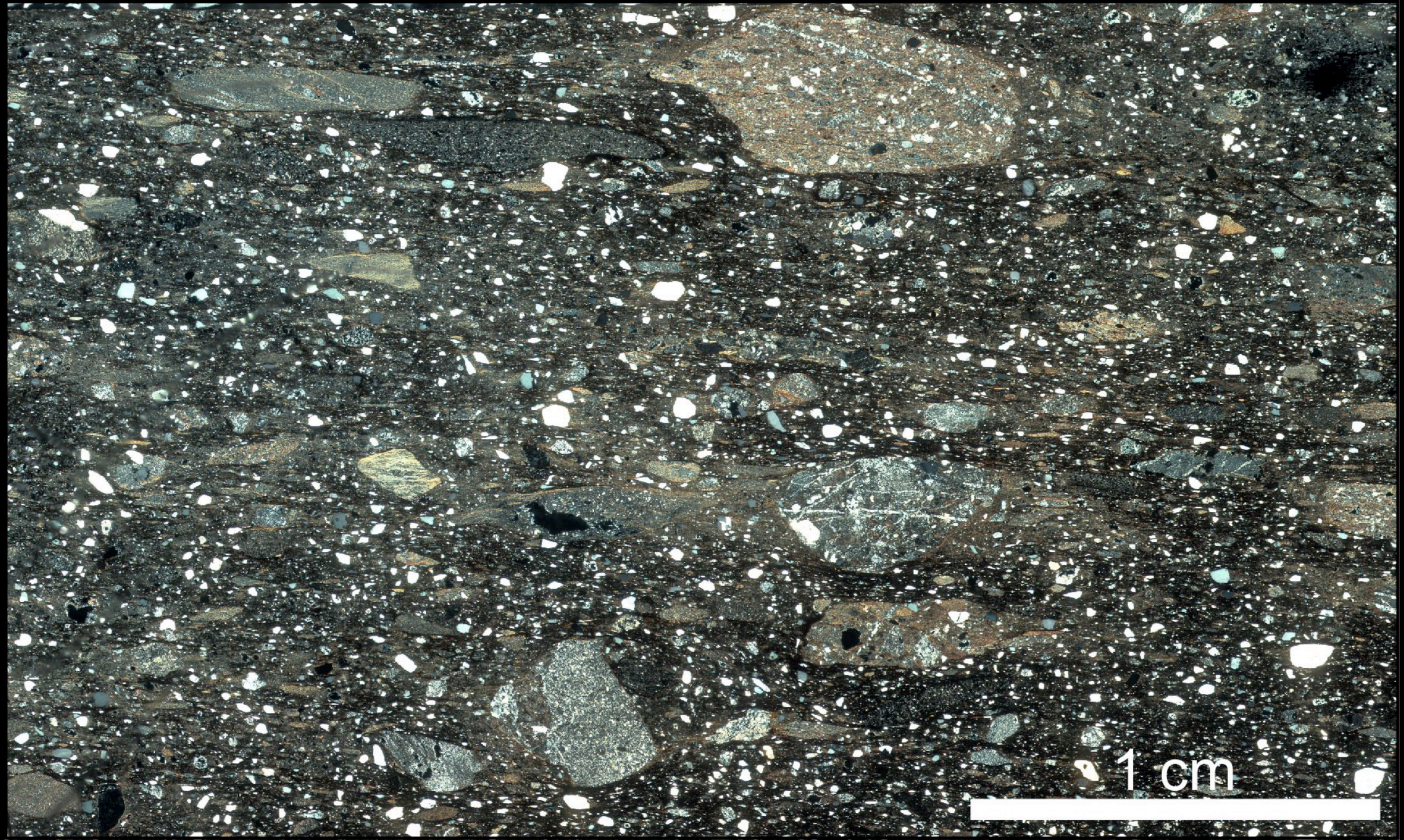

10 cm
'granite' clast
Duckbill Structure


Double Duckbill Structures
Duckbill
Sandstone clast
Duckbill
5 cm

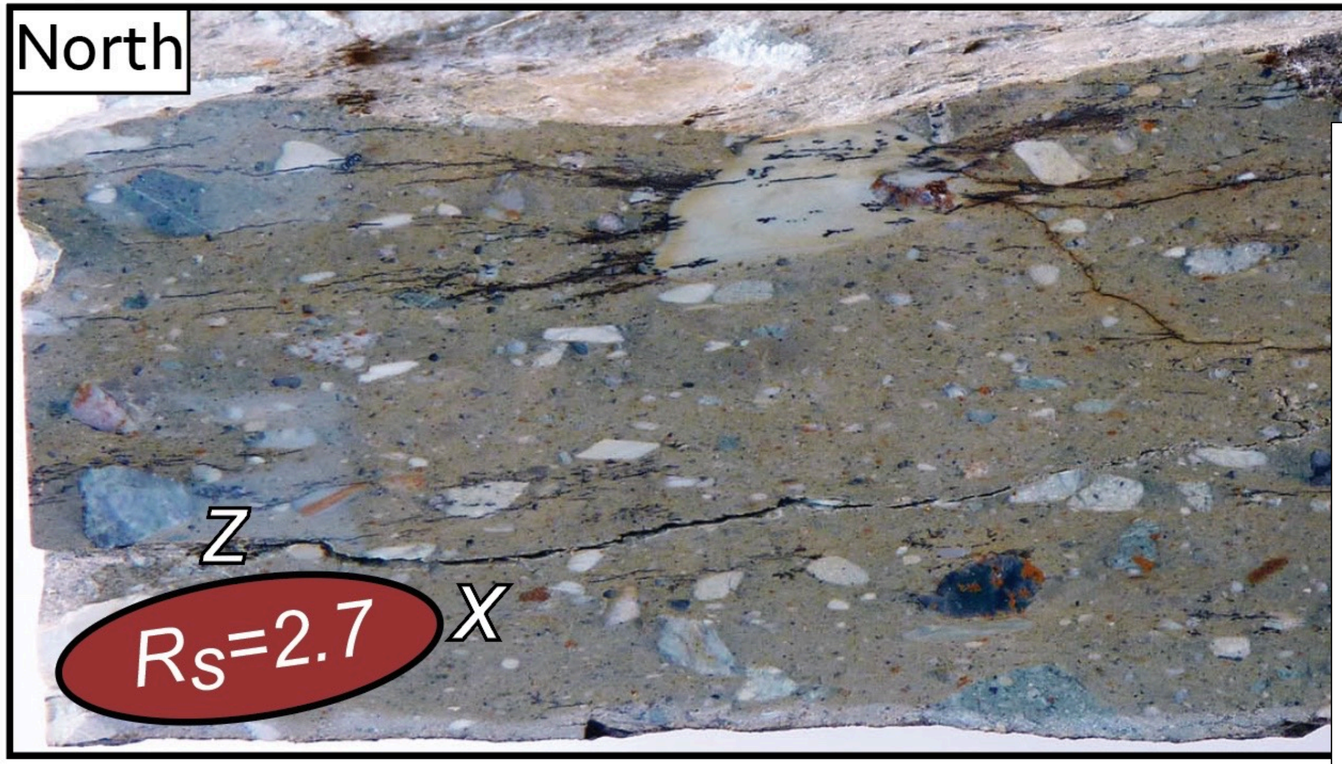


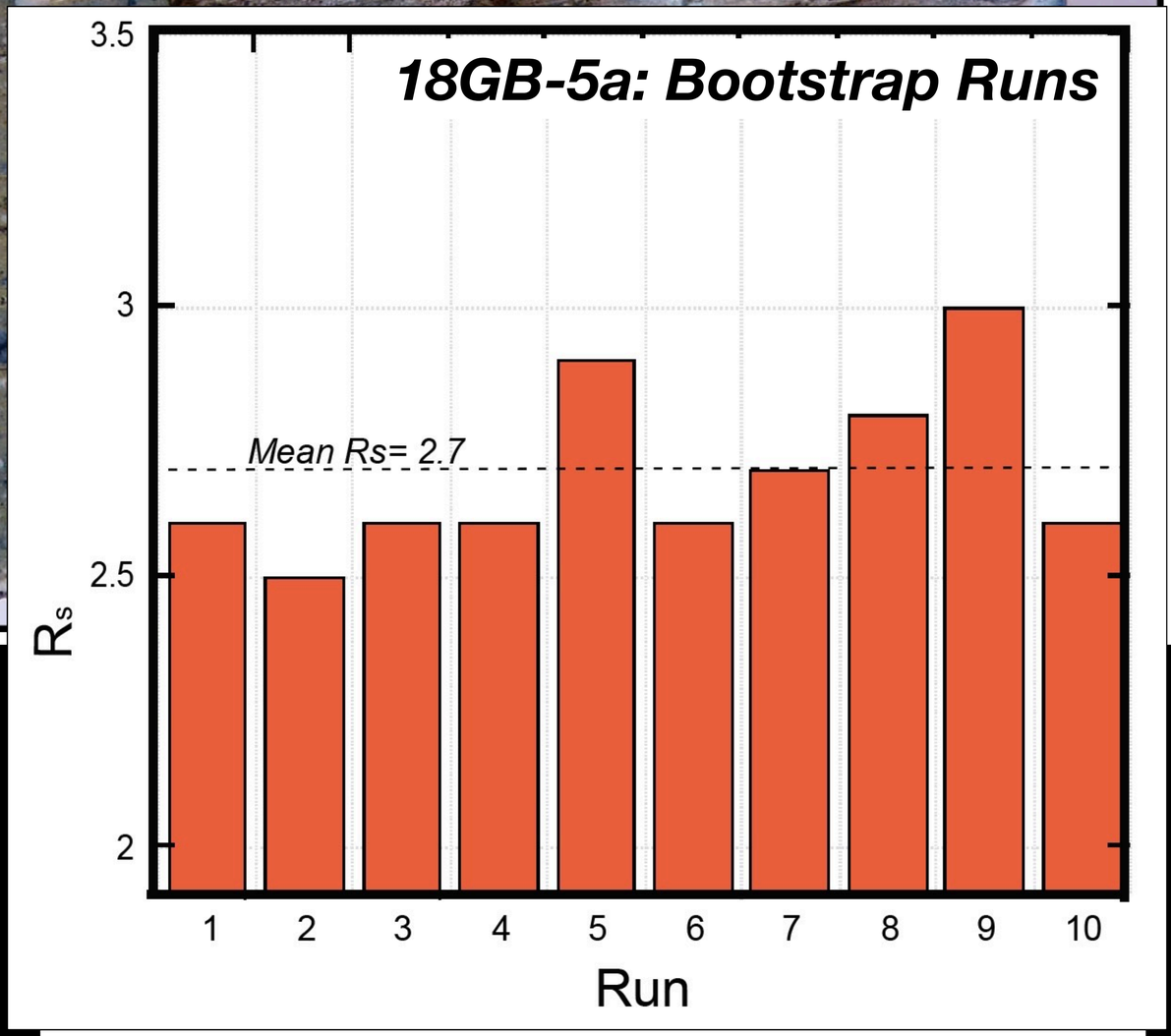
DUCKBILL mineralogy

sericite,
quartz,
± calcite
± chlorite


1 cm

Rf-phi Strain Analysis





On slabbed + polished surfaces

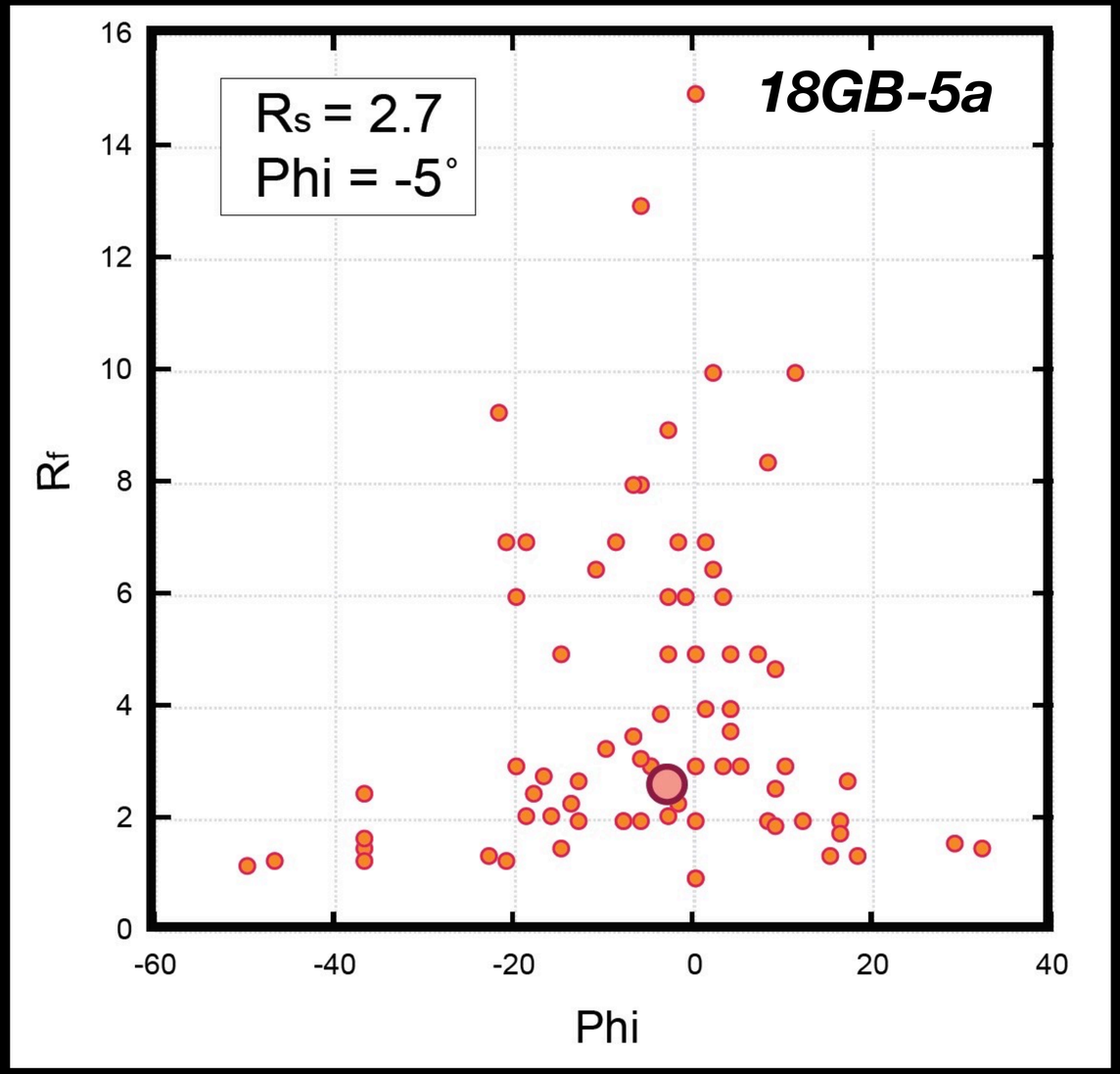
Multiple surfaces per hand sample

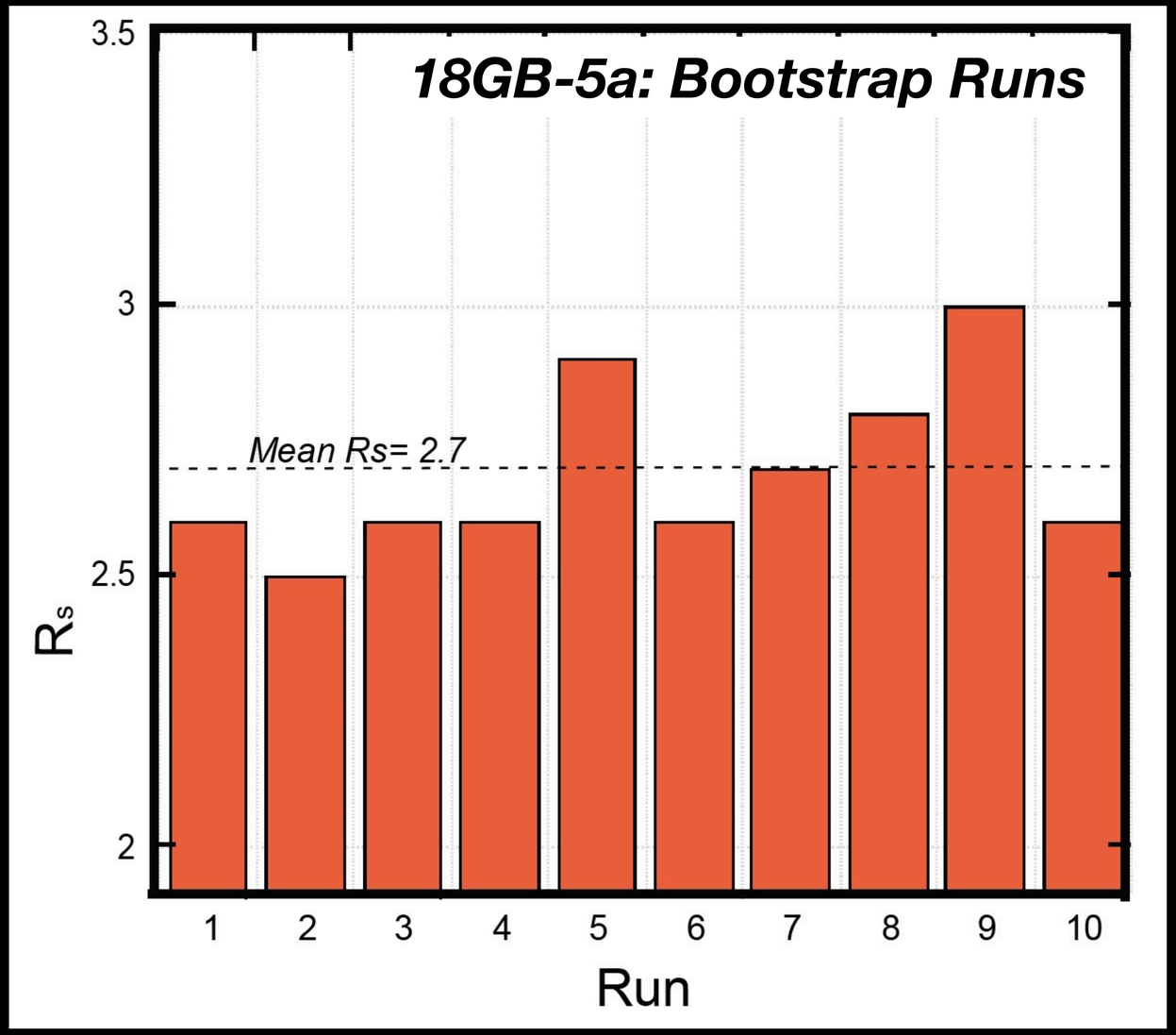
>50 class per 2D section

Bootstrap analysis to determine 'average' sectional strain

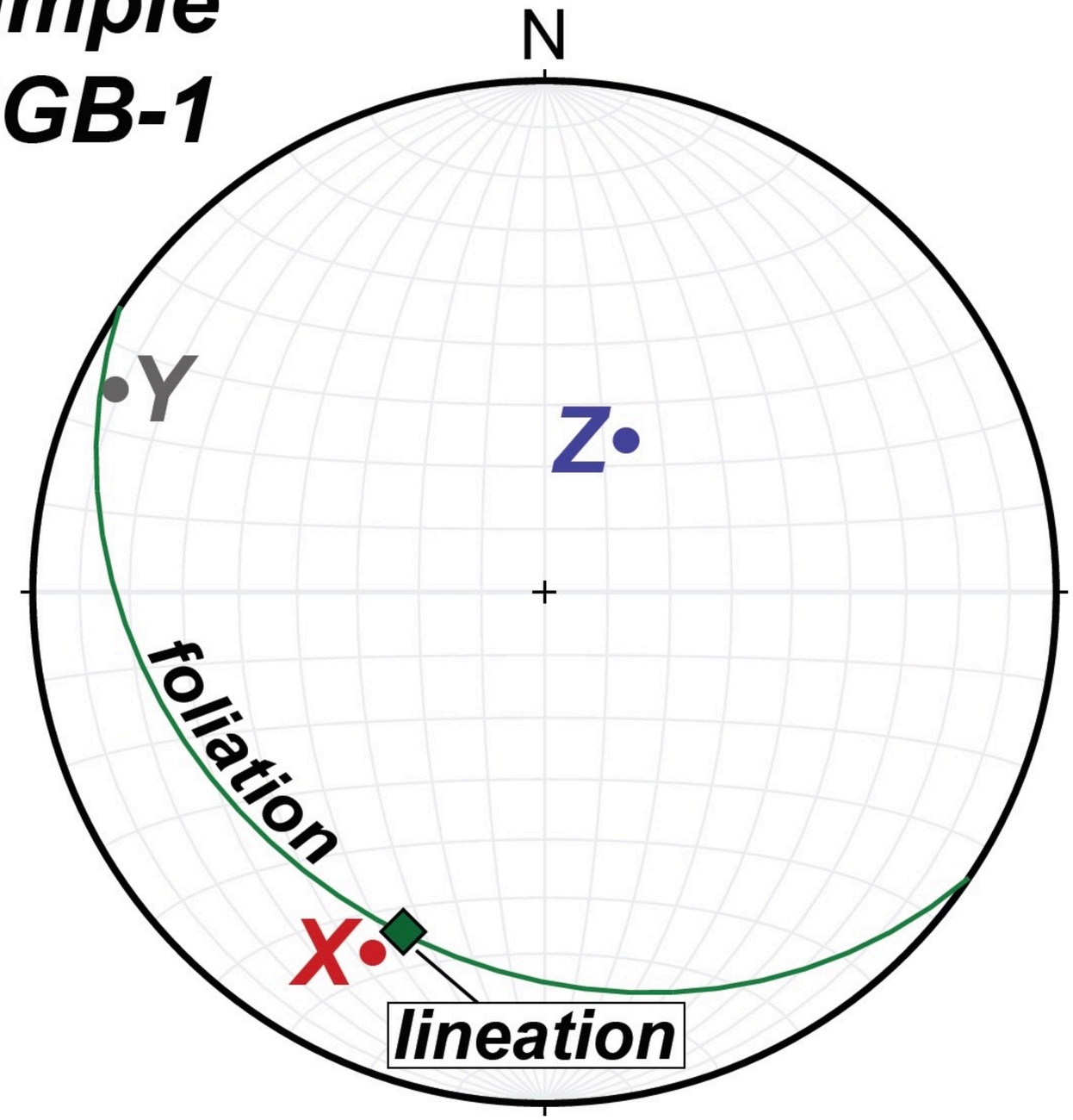
2D sections combined to determine 3D strain

Rf-phi Strain Analysis





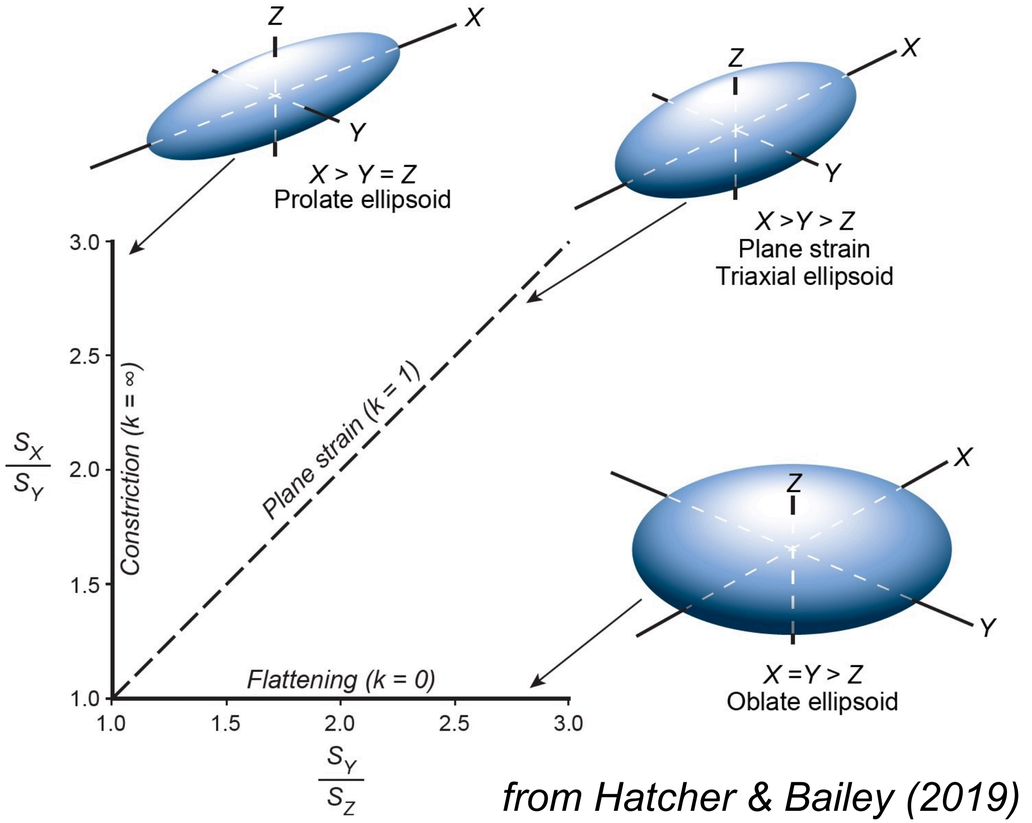
Sample 18GB-1



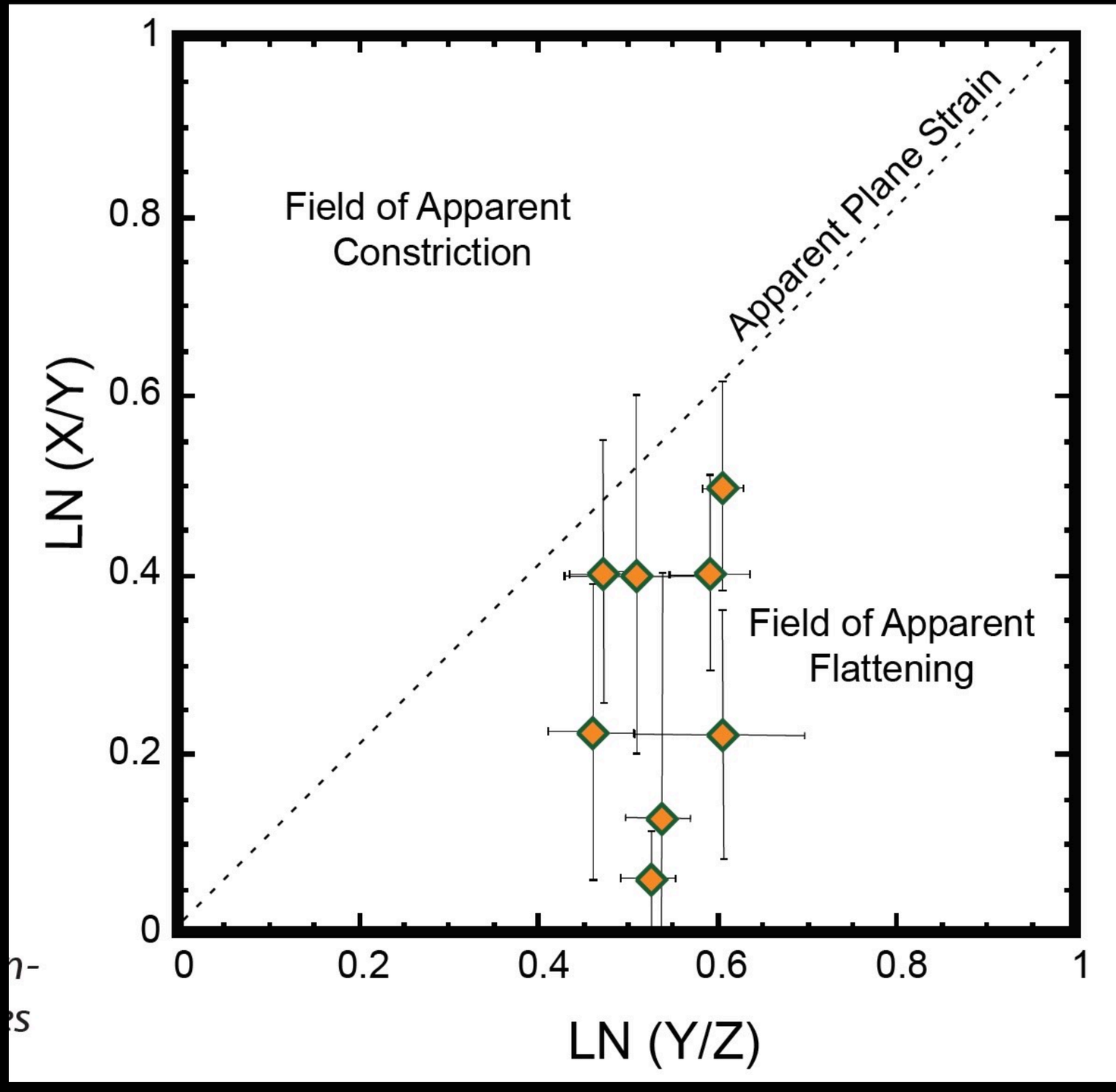
‘Average’ strain in diamictites

X/*Z* ratios: 3.0 to 1.8
narrow range in *Y*/*Z* space

Apparent Flattening Strain
(k = 0.2 - 0.9)



from Hatcher & Bailey (2019)

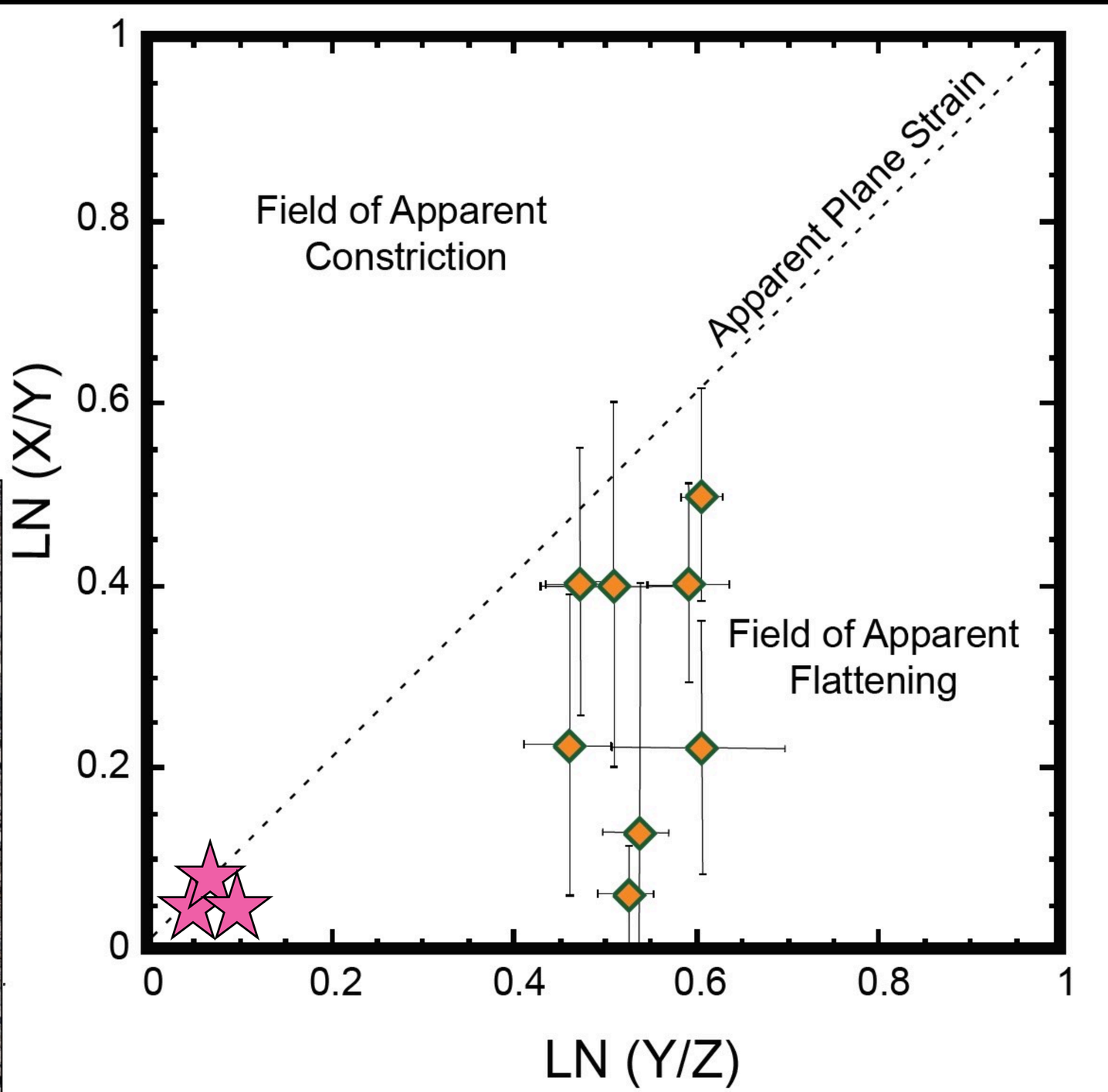


‘Average’ strain in diamictites

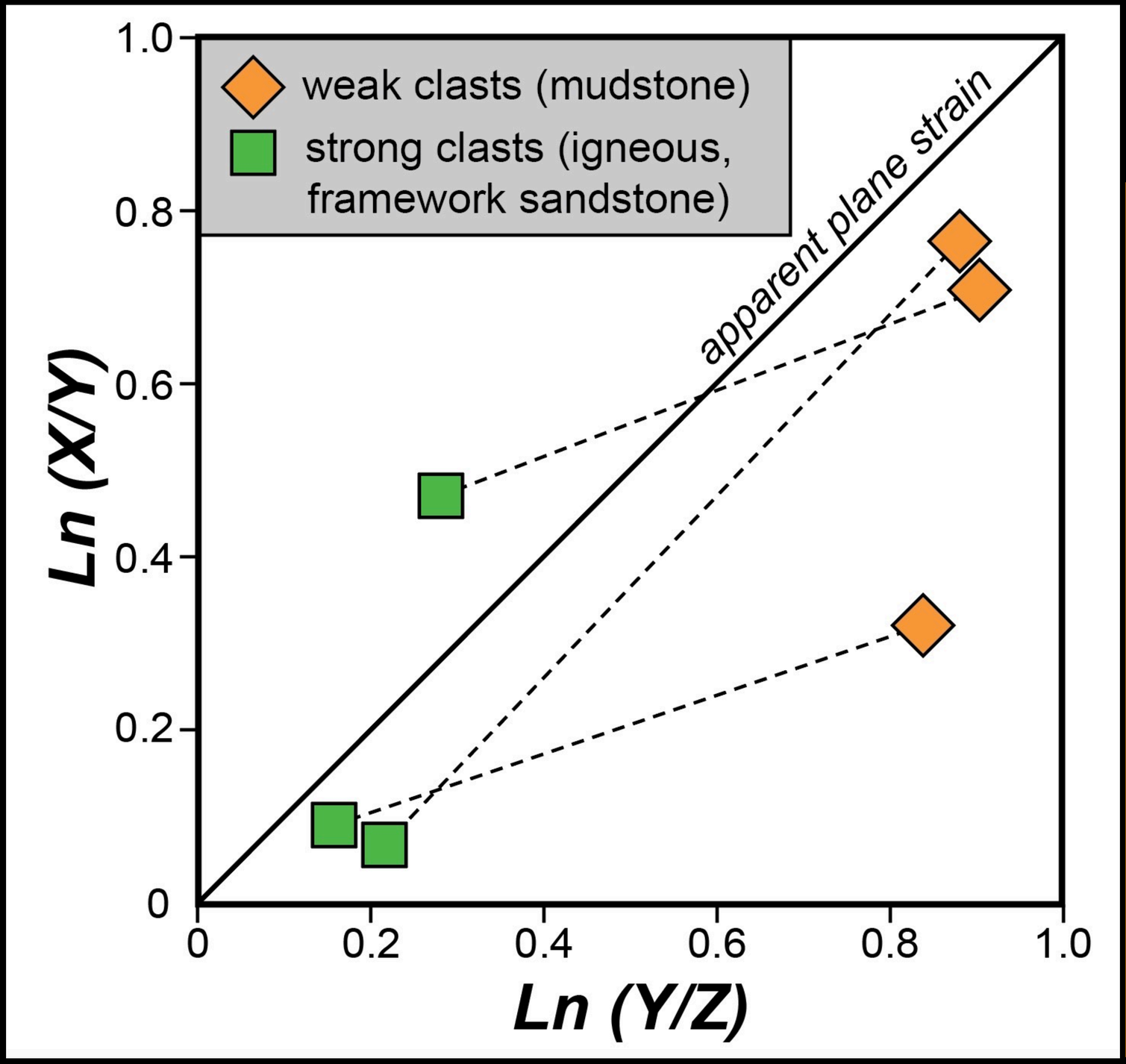
X/*Z* ratios: 3.0 to 1.8
narrow range in *Y*/*Z* space

Apparent Flattening Strain
(k = 0.2 - 0.9)

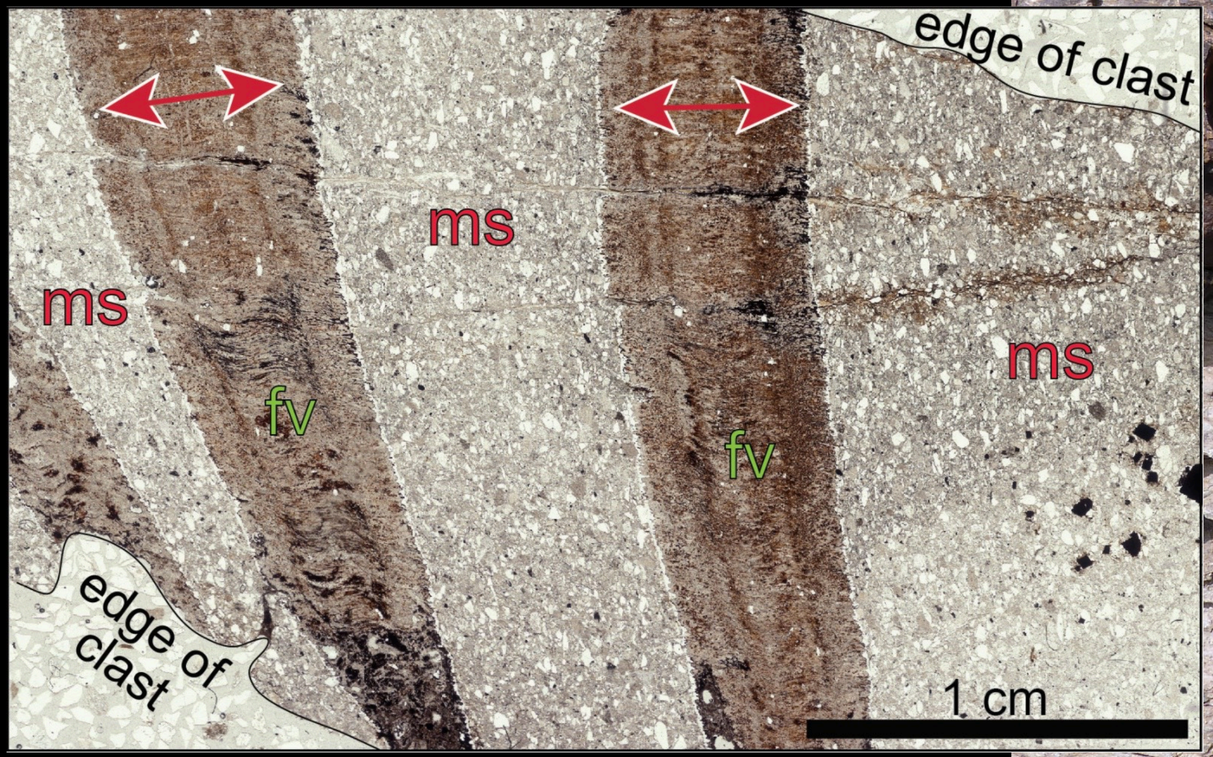
Strain in clast-supported arkoses

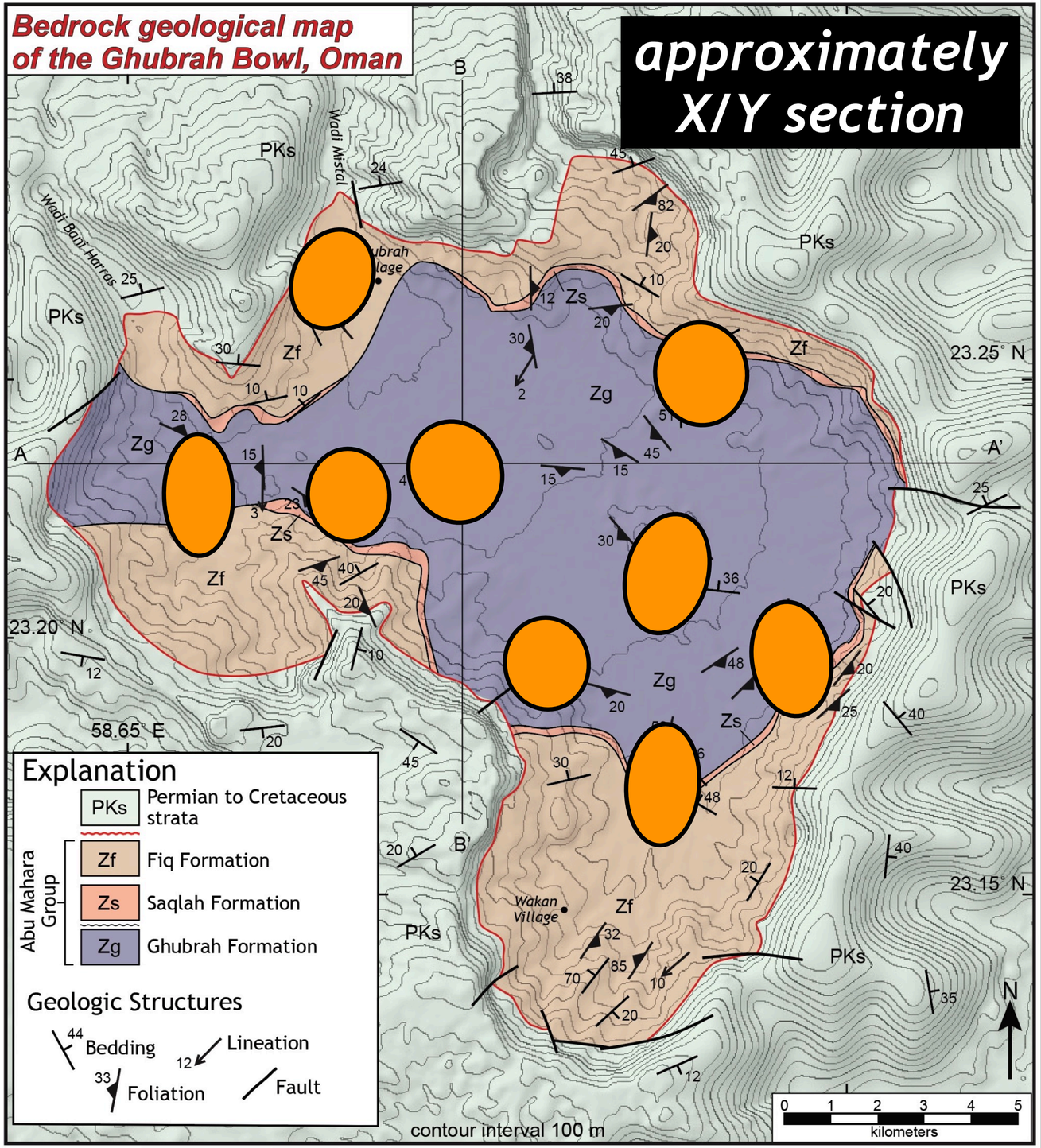


Strain Partitioning

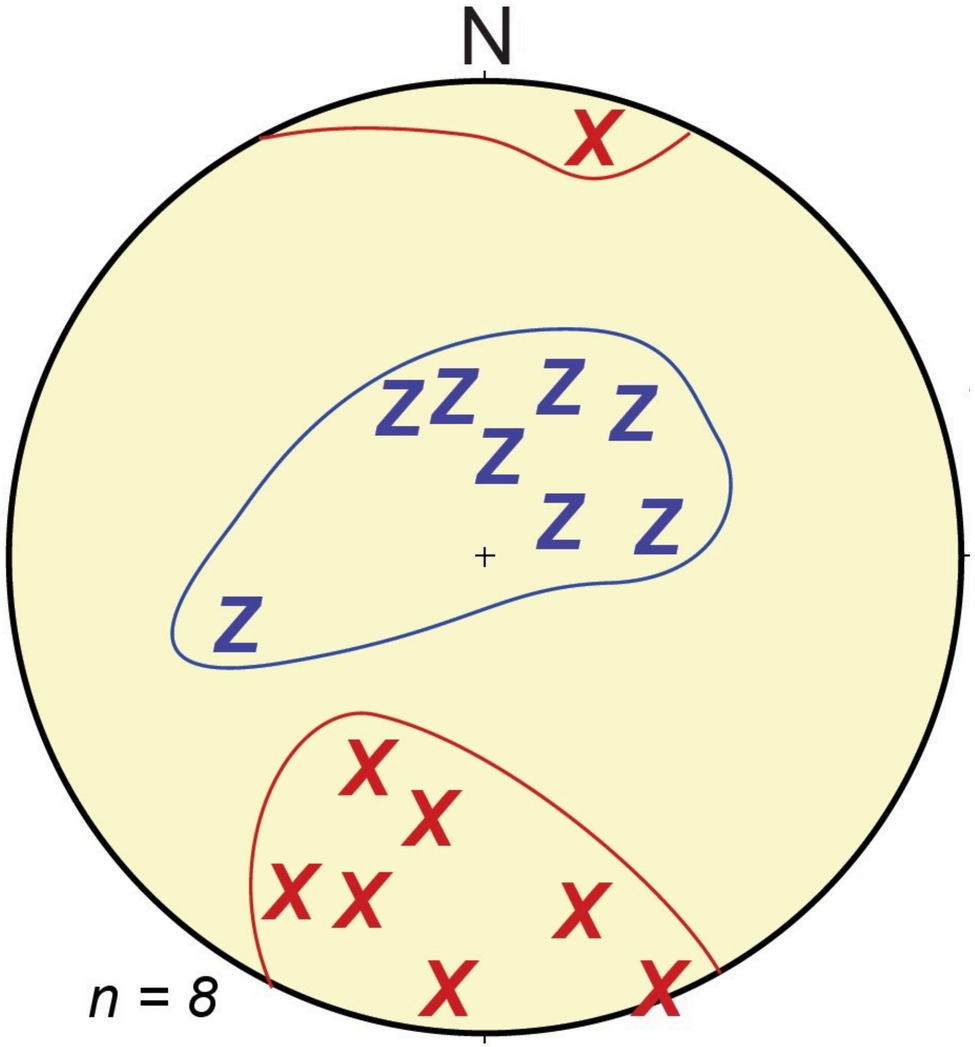


Strain Partitioning



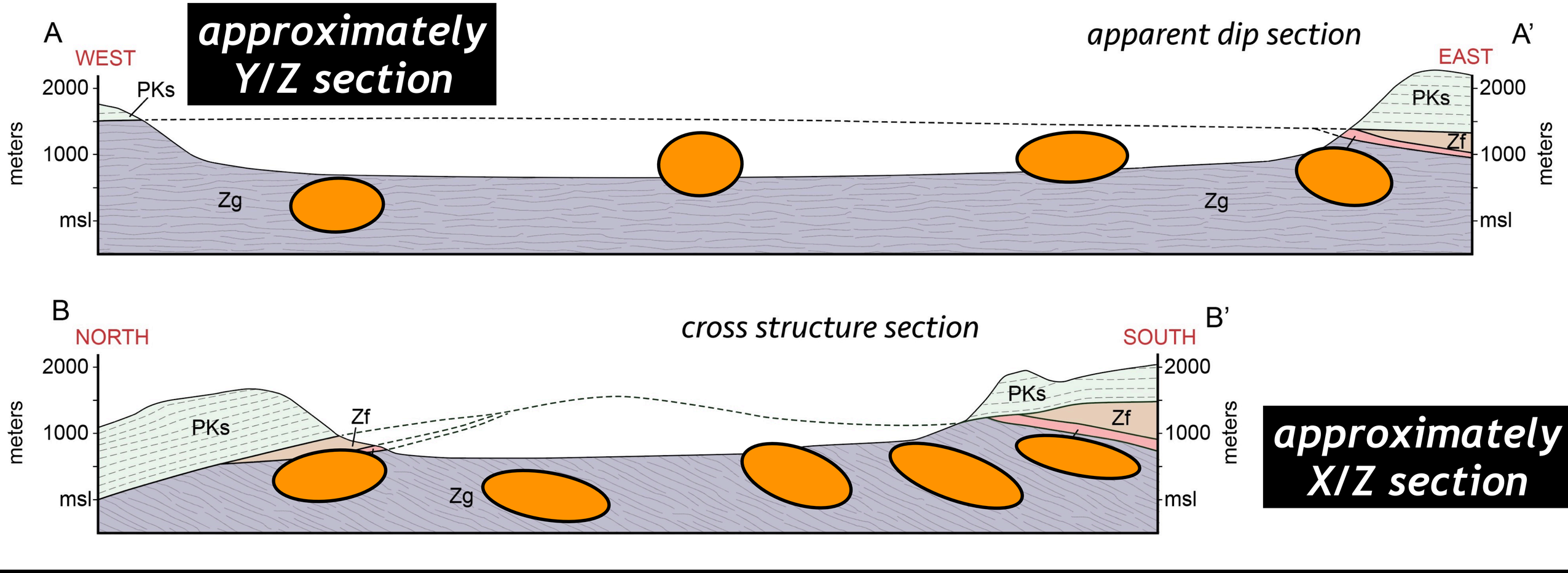


synoptic stereogram for principal strain axes



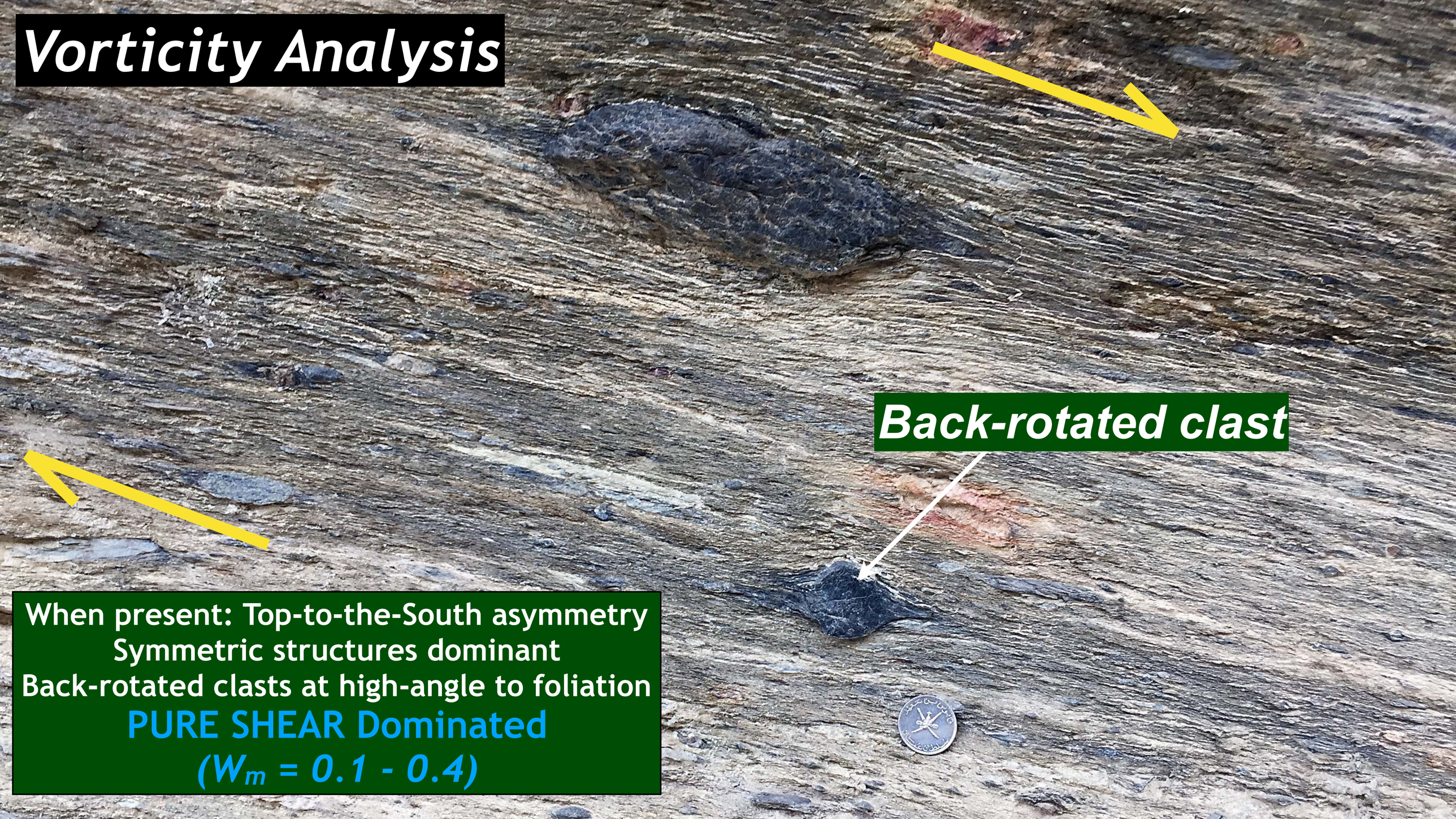
X maximum elongation

Z maximum shortening



Finite Strain Results

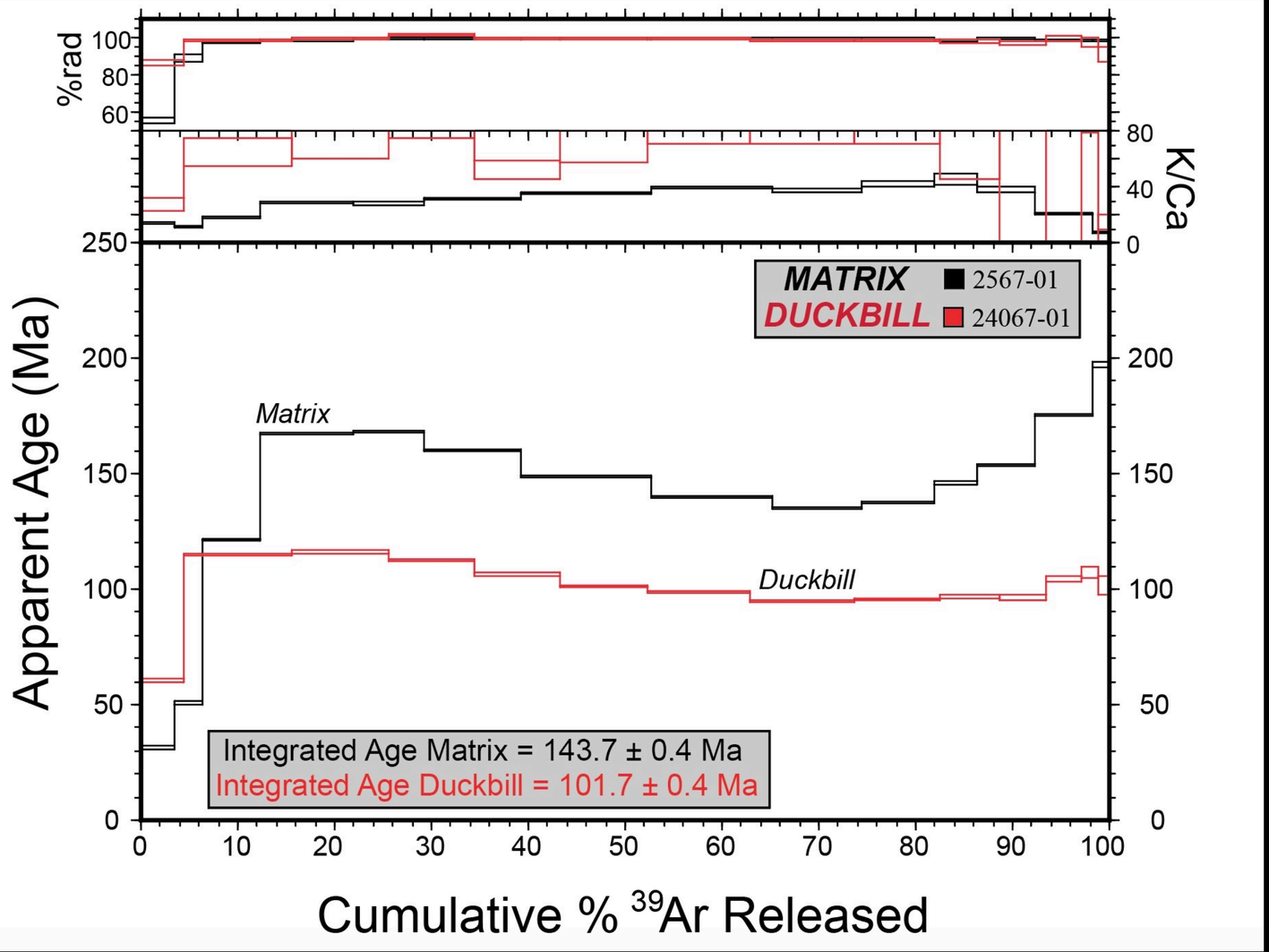
North/South elongation
subvertical shortening

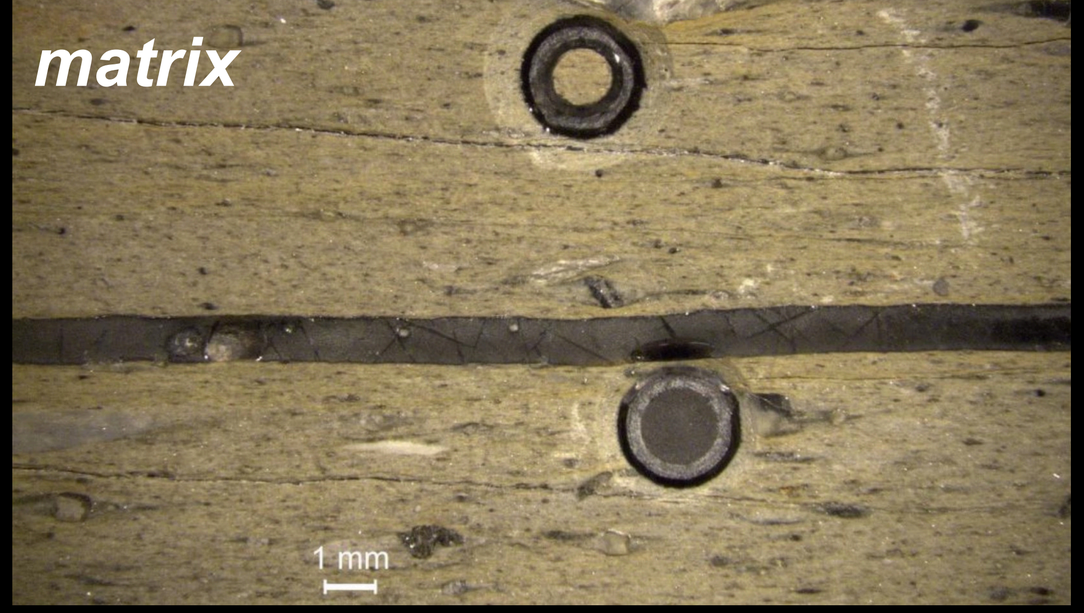

Vorticity Analysis
Back-rotated clast
When present: Top-to-the-South asymmetry
Symmetric structures dominant
Back-rotated clasts at high-angle to foliation
PURE SHEAR Dominated
(W_m = 0.1 - 0.4)

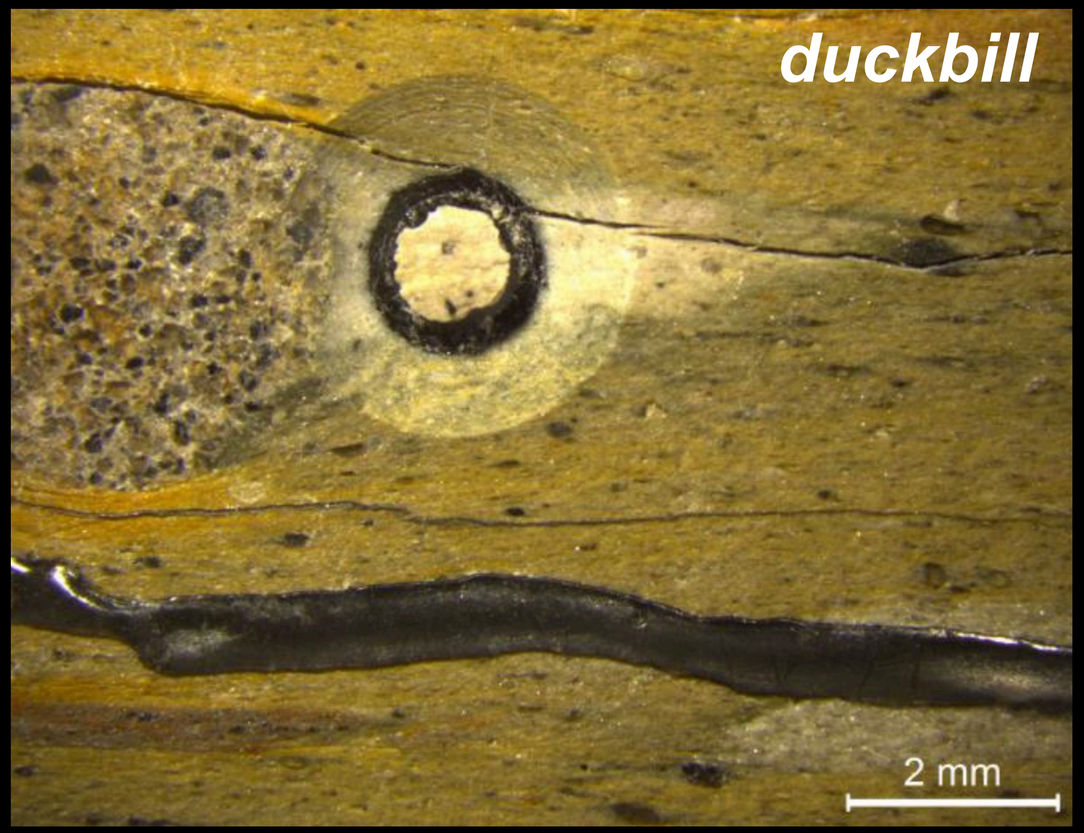
Geochronology

Ar/Ar analysis @ US Geological Survey

drilled out matrix, duckbills, + clasts

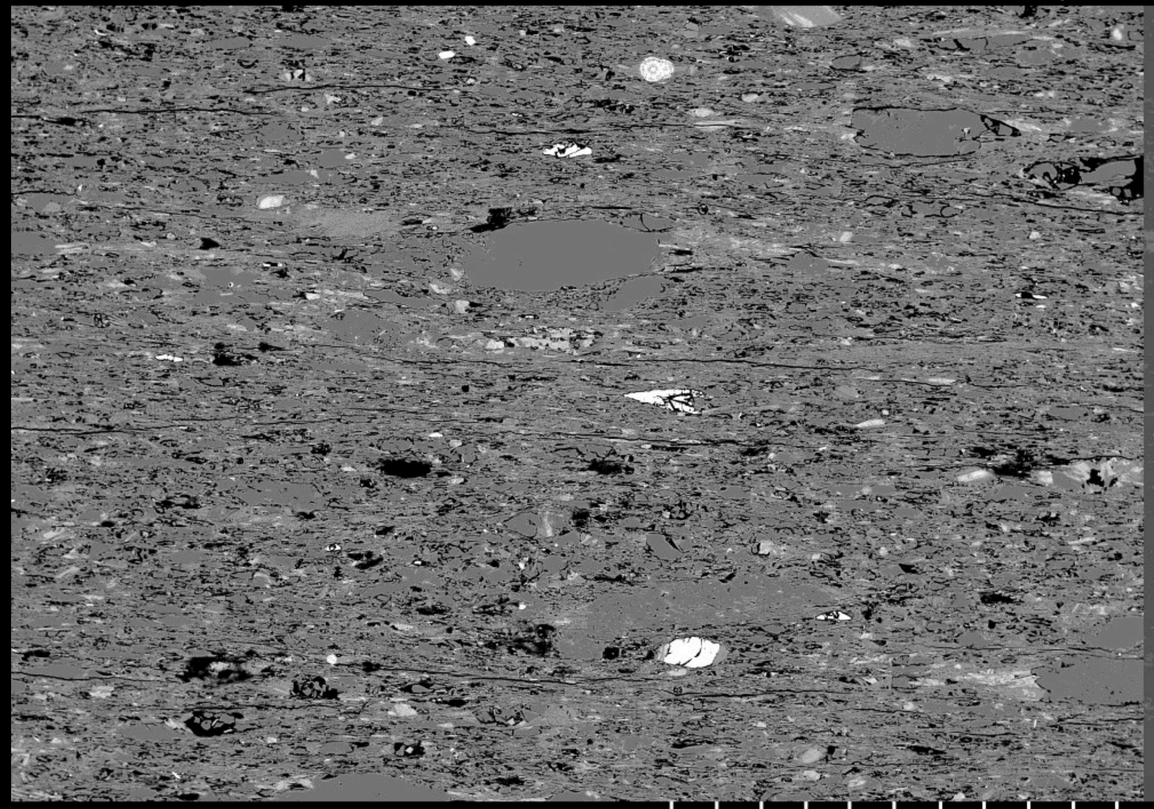


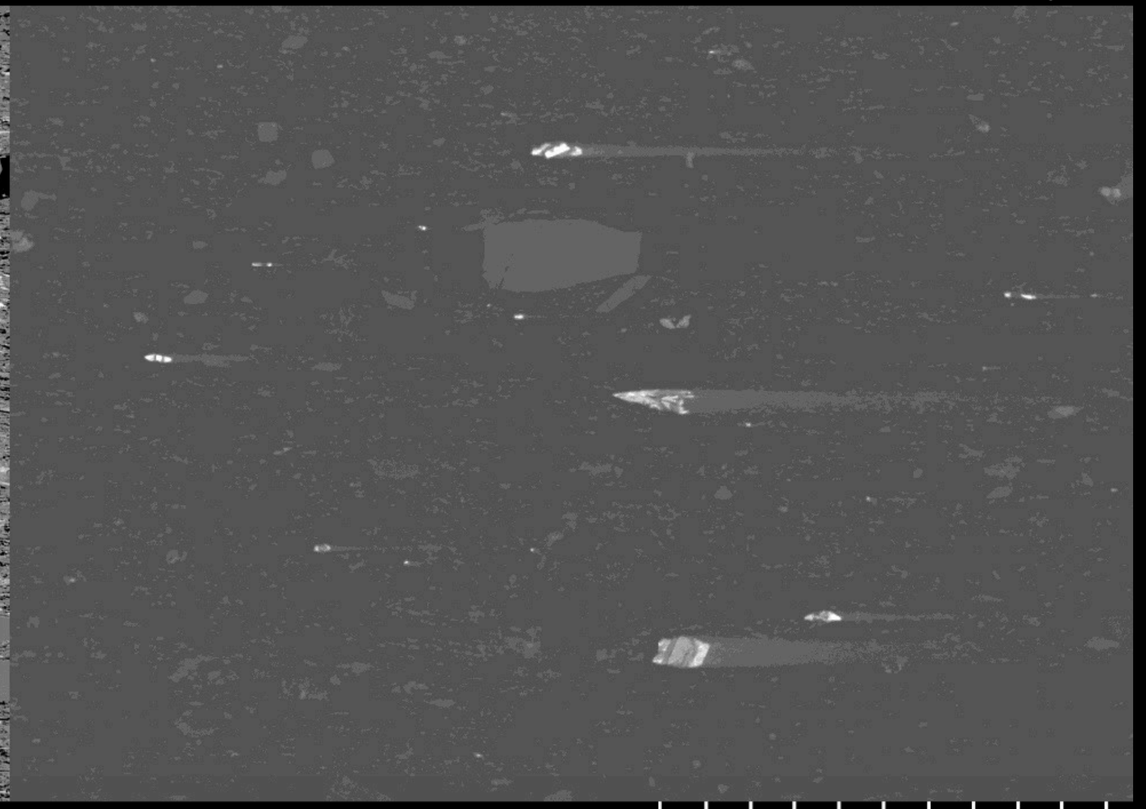




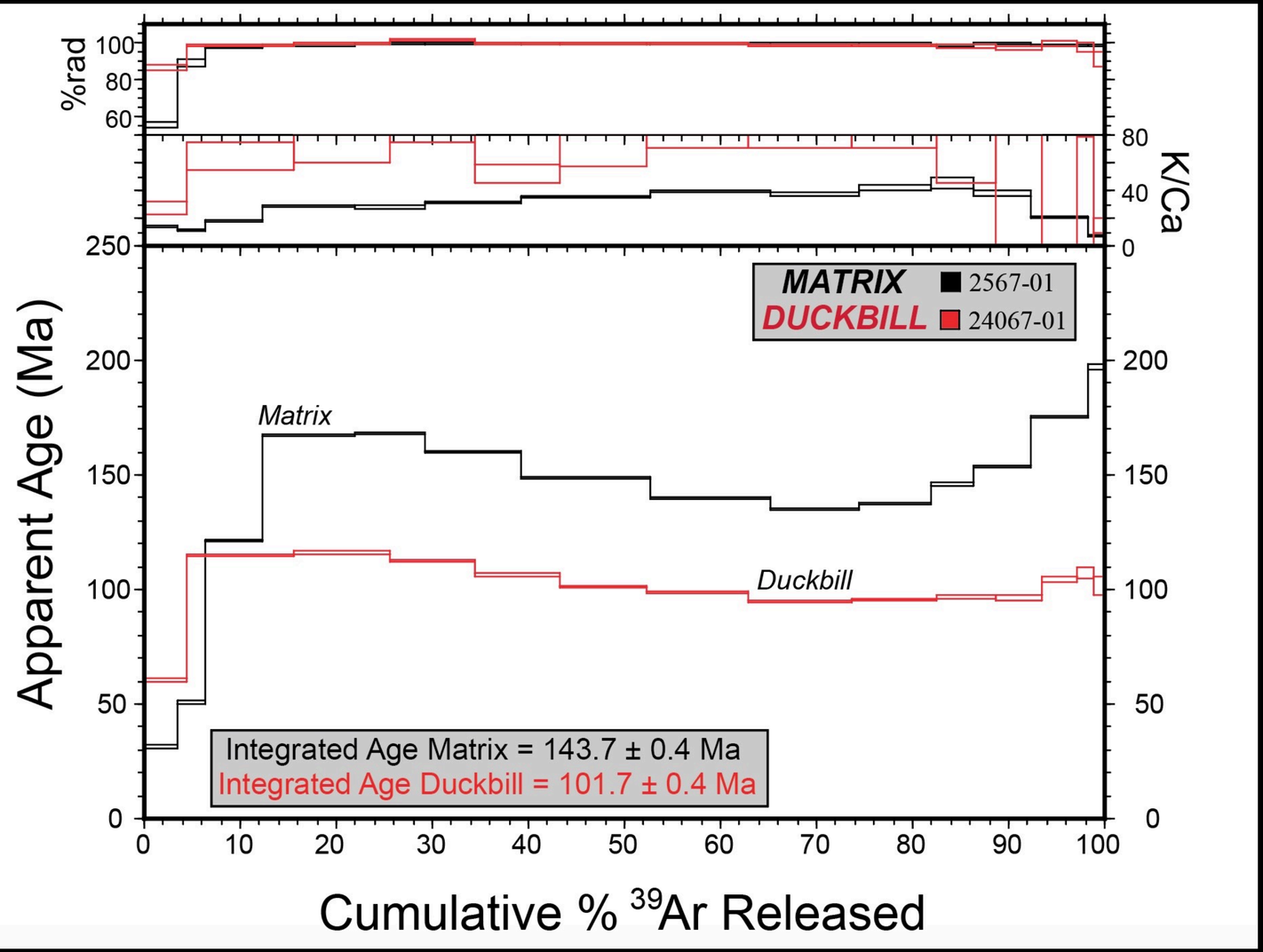

USGS 10.0mm x150 BSE-ALL 10/29/2019
300µm

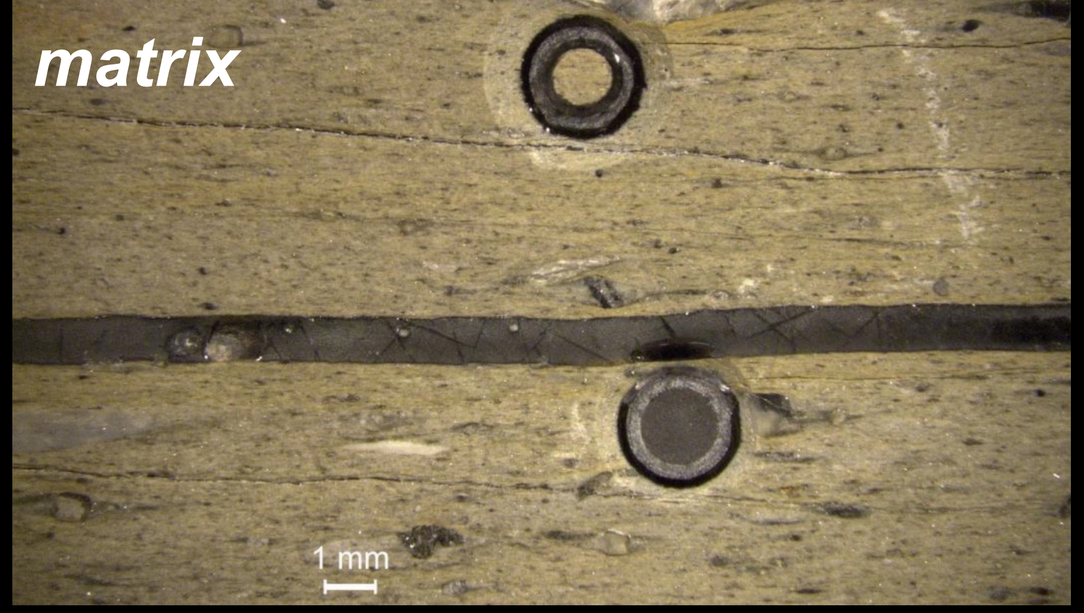

USGS 10.0mm x150 UVD 10/29/2019
300µm

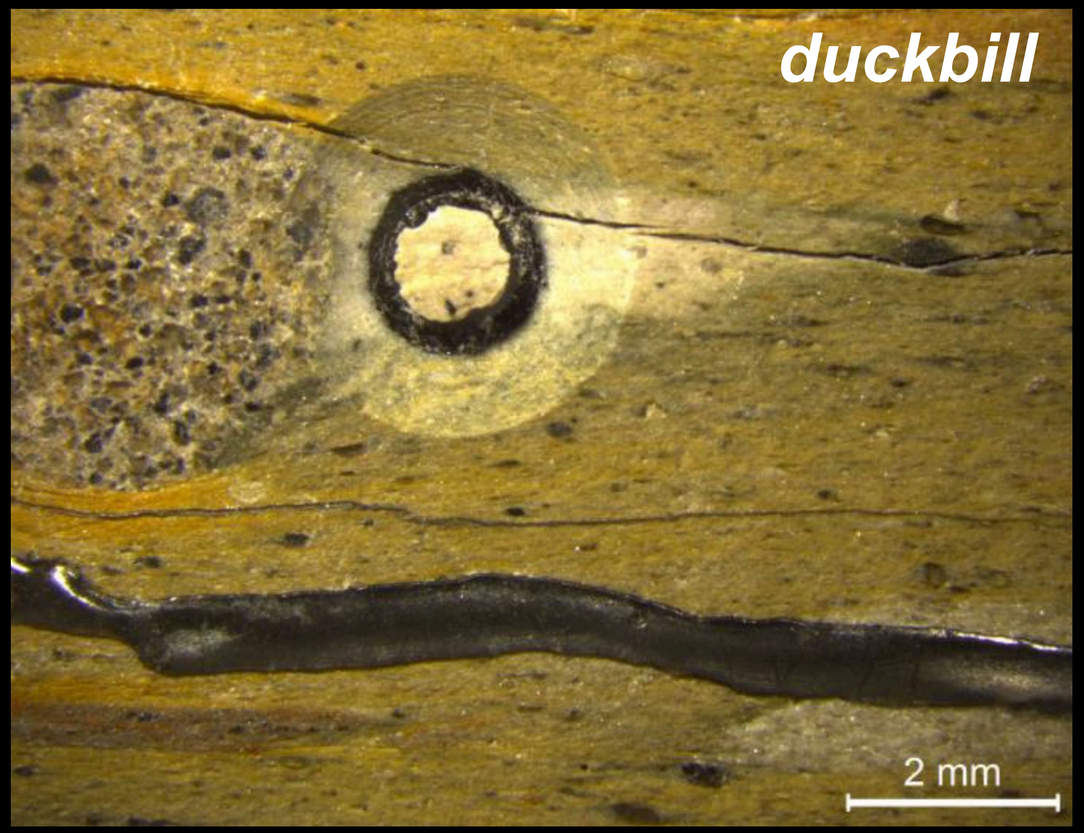

USGS 10.0mm x100 BSE-ALL 10/29/2019
500µm


USGS 10.0mm x100 UVD 10/29/2019
500µm

muscovite growing below closure T
this is messy business!
syntectonic growth @ ≤90 Ma







Contents lists available at ScienceDirect

2017

Marine and Petroleum Geology

journal homepage: www.elsevier.com/locate/marpetgeo

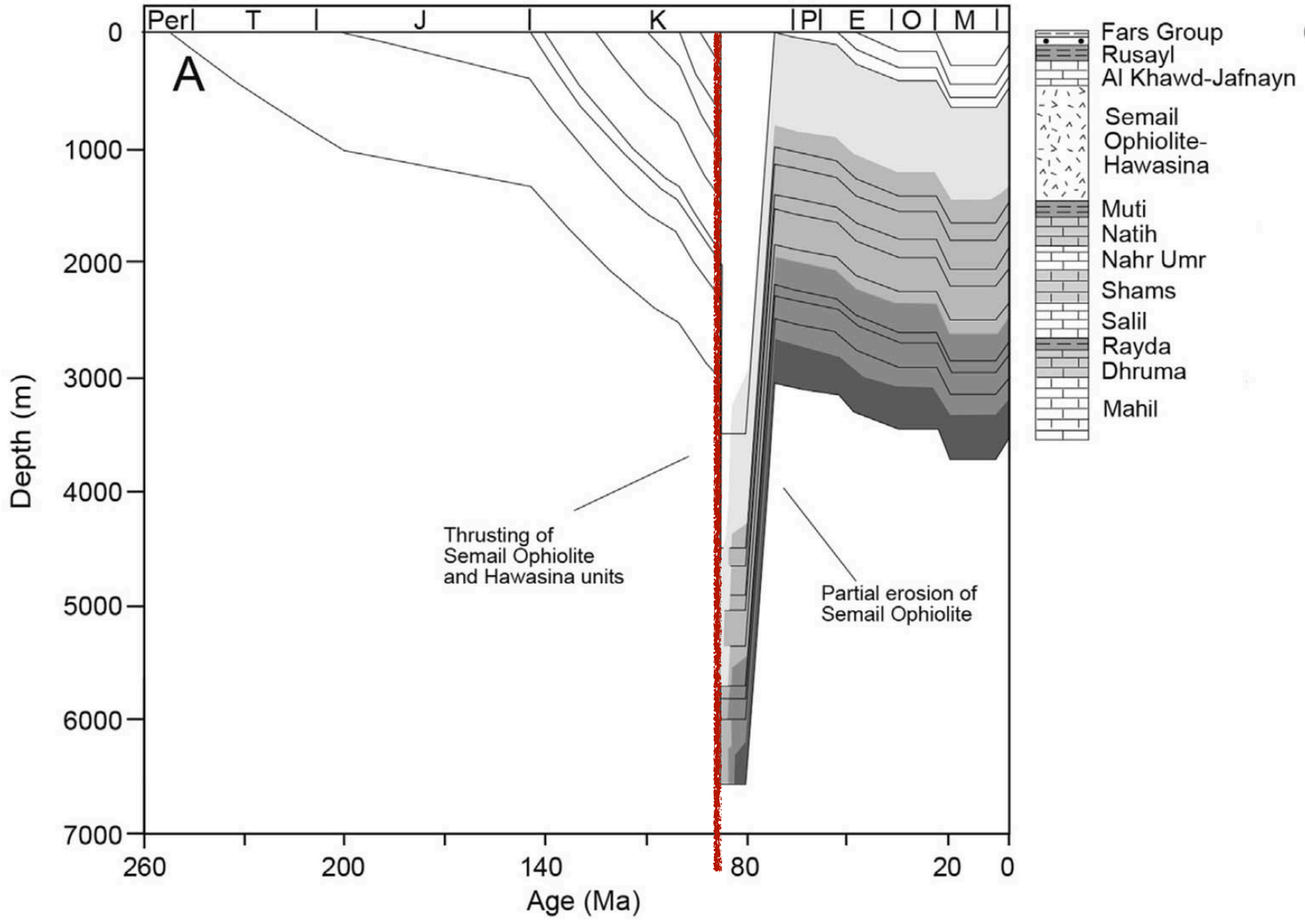
Research paper

Estimating original thickness and extent of the Semail Ophiolite in the eastern Oman Mountains by paleothermal indicators

L. Aldega [a, *], E. Carminati [a], A. Scharf [b], F. Mattern [b], M. Al-Wardi [b]

[a] Dipartimento di Scienze della Terra, Sapienza Università di Roma, Rome, Italy
[b] Earth Science Department, Sultan Qaboos University, Muscat, Oman

1D thermal modeling indicates that the sub-ophiolite units of Jebel Akhdar were overthrust by ***4.5 km-thick*** Samail Ophiolite and Hawasina units in ***the late Cretaceous***



CONCLUSIONS

Cryogenian diamictites in northern Oman experienced:
moderate 'whole rock' strain that involved
north-south elongation and ***subvertical shortening***
with significant ***strain partitioning***

Deformation occurred under ***chlorite-grade conditions***
Argon geochronology is messy with mixed ages, but
syntectonic muscovite grew after ***~90 Ma***

Deformation is associated with ***southward emplacement***
and ***loading*** by the Oman ophiolite & Hawasina Group
over the **autochthonous sequence**