Quartz microstructures from the Sambagawa metamorphic rocks, south-west Japan: indicators of deformation conditions during exhumation

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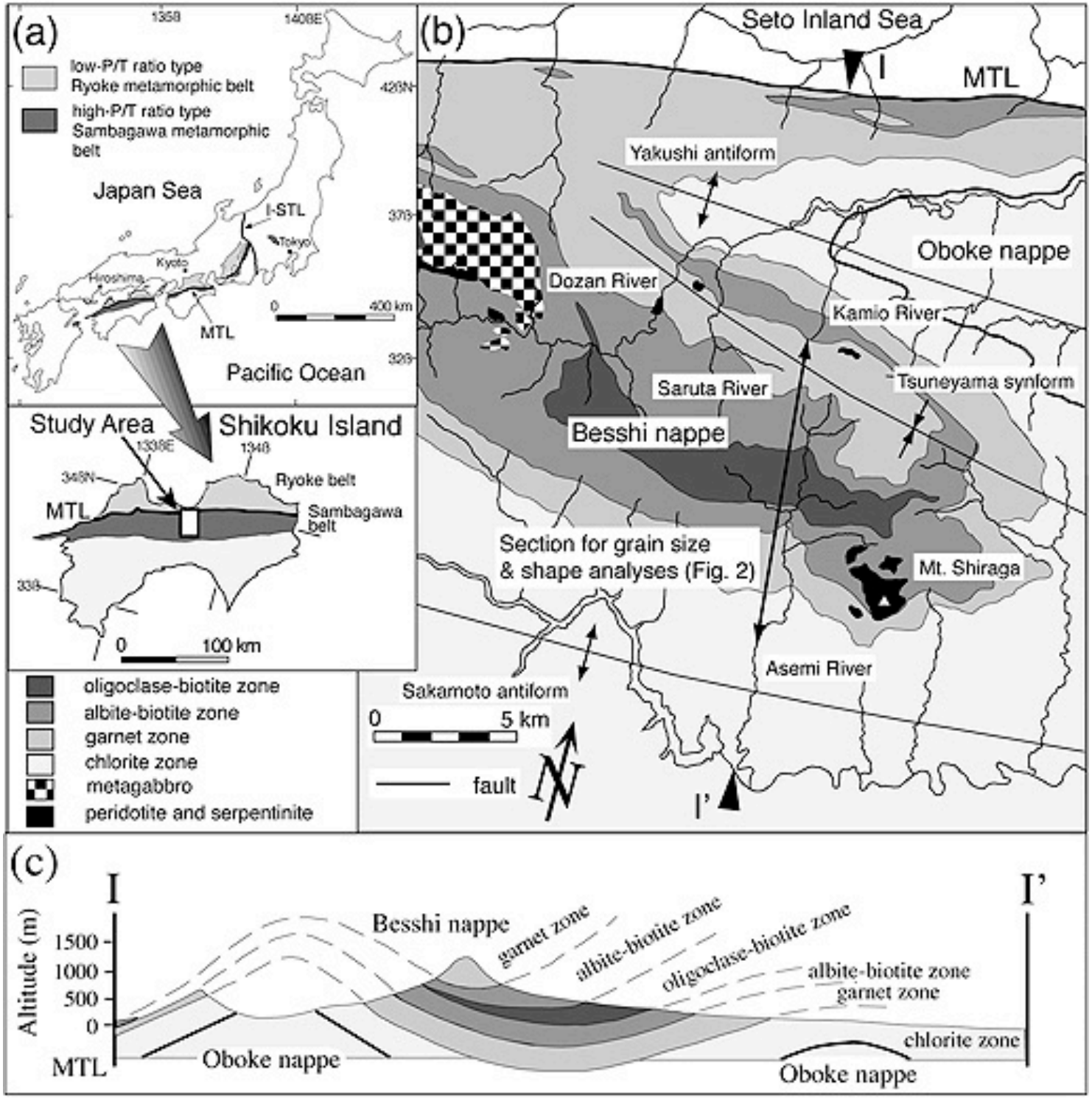
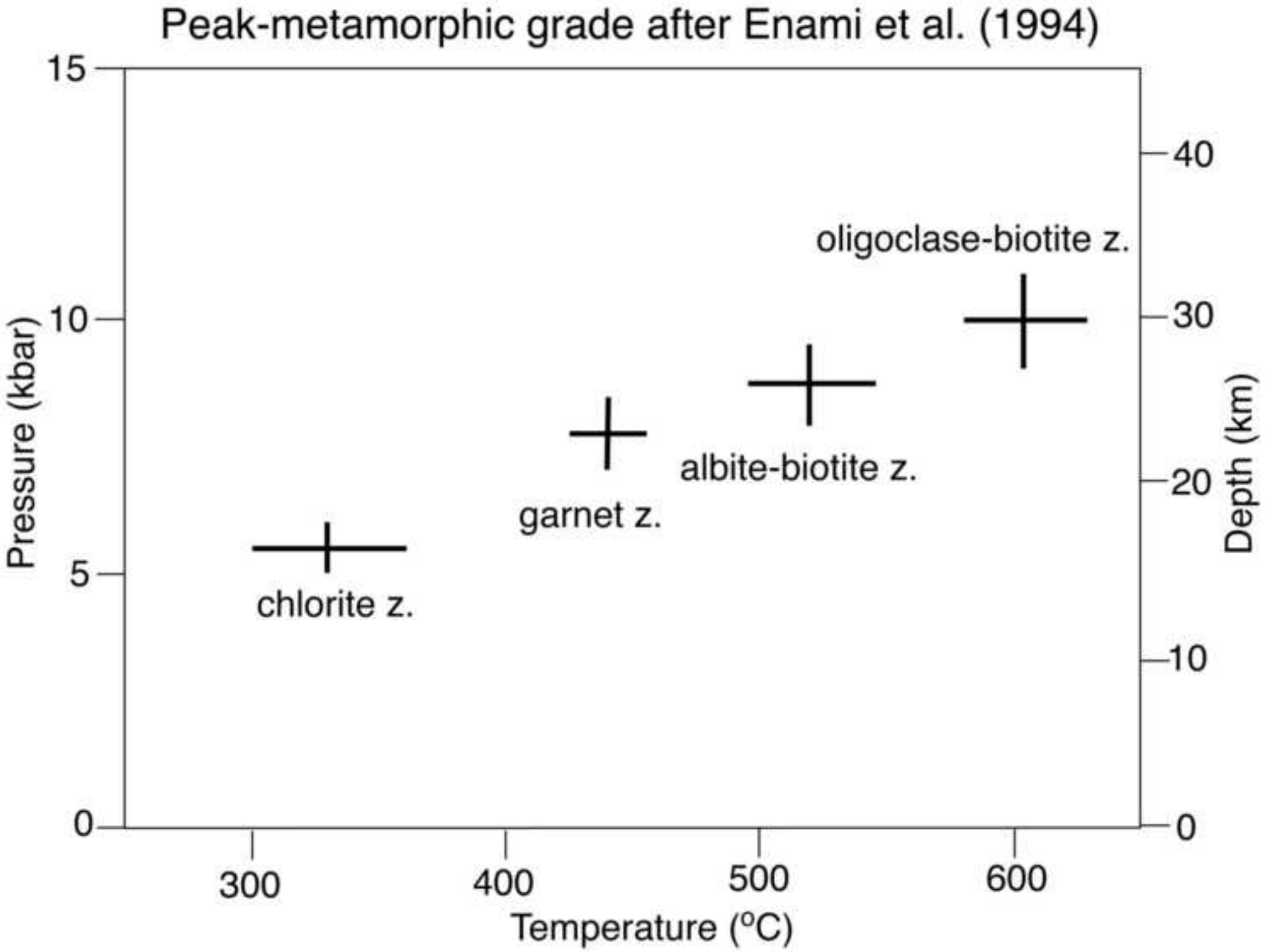
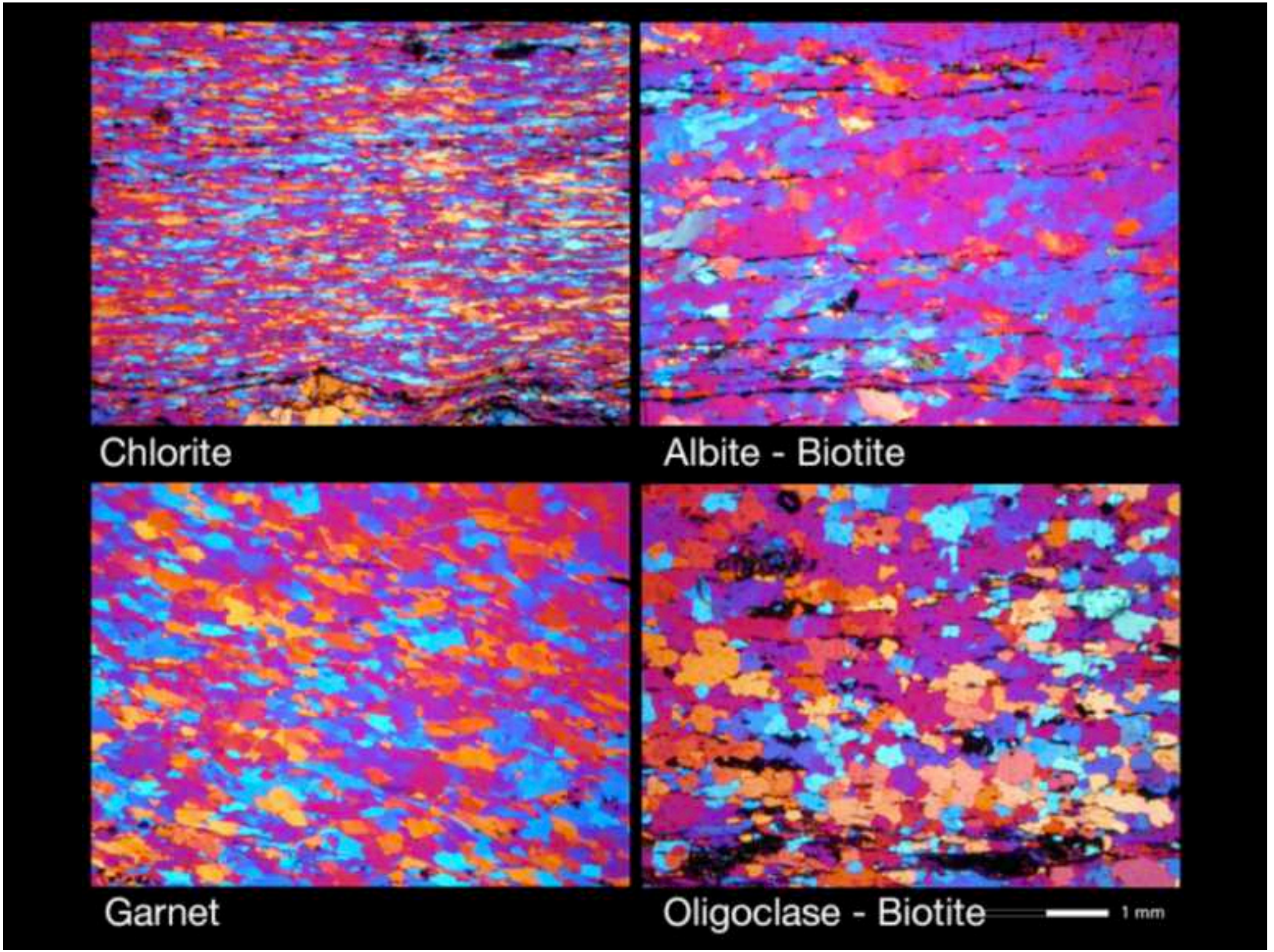
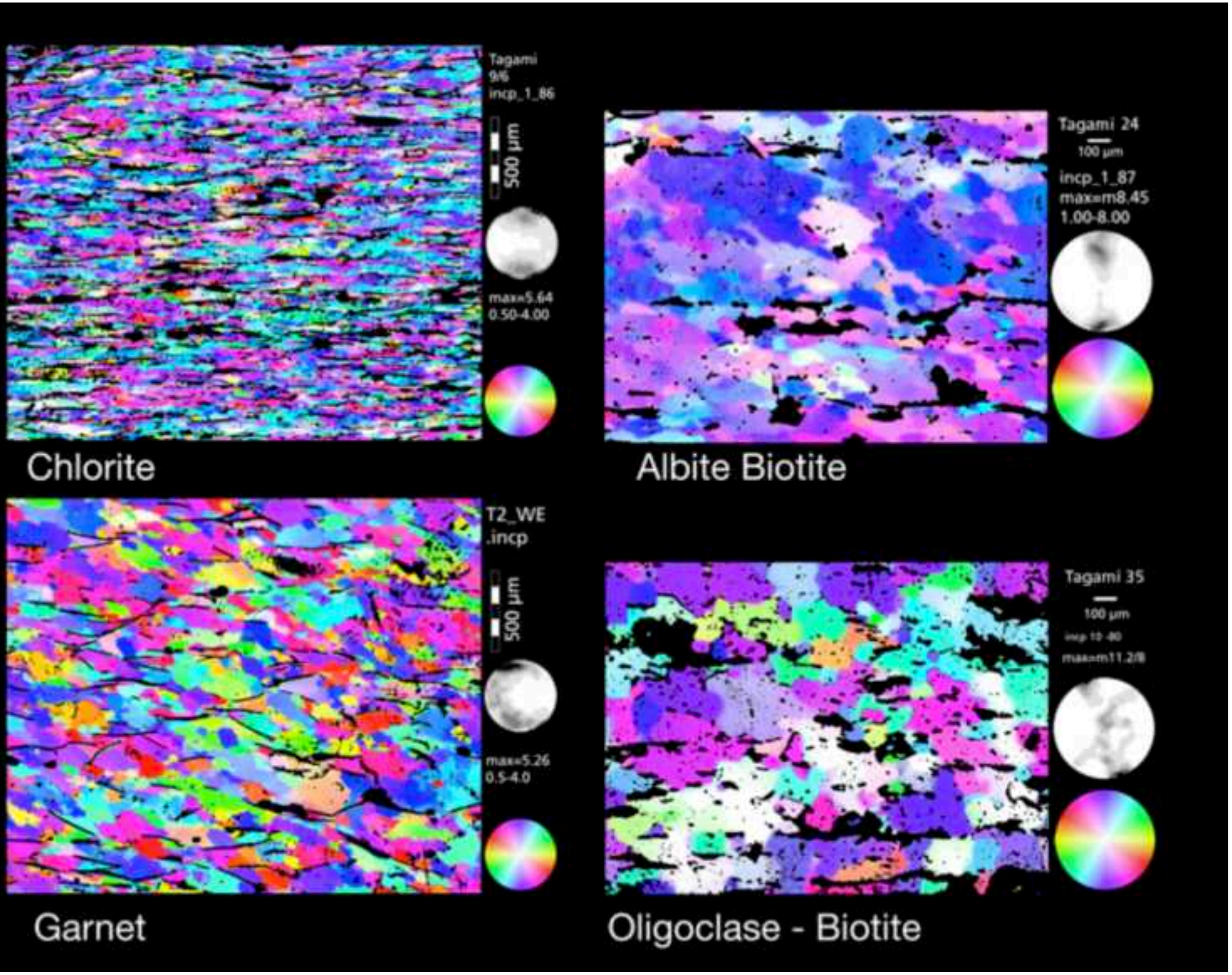
Outline of the research

- Collect oriented quartz schist samples along the Asemi-River route
- Measure the recrystallized grain-size of quartz (diameter of the equivalent circle) on the *XZ*-section with the NIH image
- Calculate the differential stress with a quartz recrystallized grain-size paleopiezometer after Twiss (1980)
- Infer the strain rate and deformation temperature from experimental constitutive equations
- Finally, discuss T-D-t path during exhumation

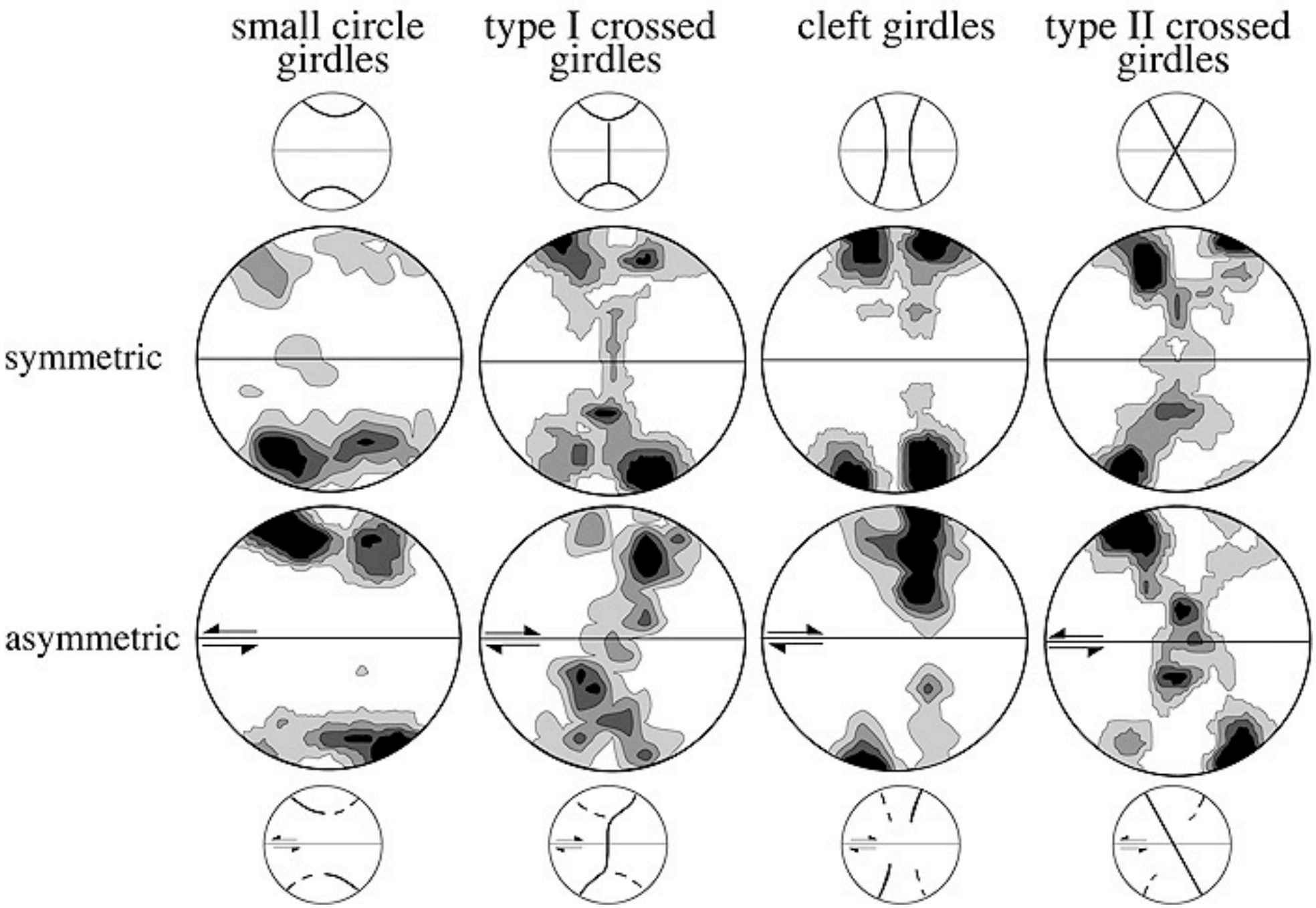

(a)
low-P/T ratio type
Ryoke metamorphic belt
high-P/T ratio type
Sambagawa metamorphic belt
Japan Sea
I-STL
Tokyo
Kyoto
Hiroshima
MTL
Pacific Ocean
0
400 km
Study Area
Shikoku Island
Ryoke belt
Sambagawa belt
MTL
0
100 km
oligoclase-biotite zone
albite-biotite zone
garnet zone
chlorite zone
metagabbro
peridotite and serpentinite
(b)
Seto Inland Sea
I
MTL
Yakushi antiform
Oboke nappe
Dozan River
Kamio River
Saruta River
Tsuneyama synform
Besshi nappe
Section for grain size
& shape analyses (Fig. 2)
Mt. Shiraga
Asemi River
Sakamoto antiform
0
5 km
fault
I'
(c)
I
I'
Altitude (m)
1500
1000
500
0
MTL
Besshi nappe
garnet zone
albite-biotite zone
oligoclase-biotite zone
albite-biotite zone
garnet zone
chlorite zone
Oboke nappe
Oboke nappe


Peak-metamorphic grade after Enami et al. (1994)
15
10
5
0
Pressure (kbar)
40
30
20
10
0
Depth (km)
oligoclase-biotite z.
albite-biotite z.
garnet z.
chlorite z.
300
400
500
600
Temperature (°C)

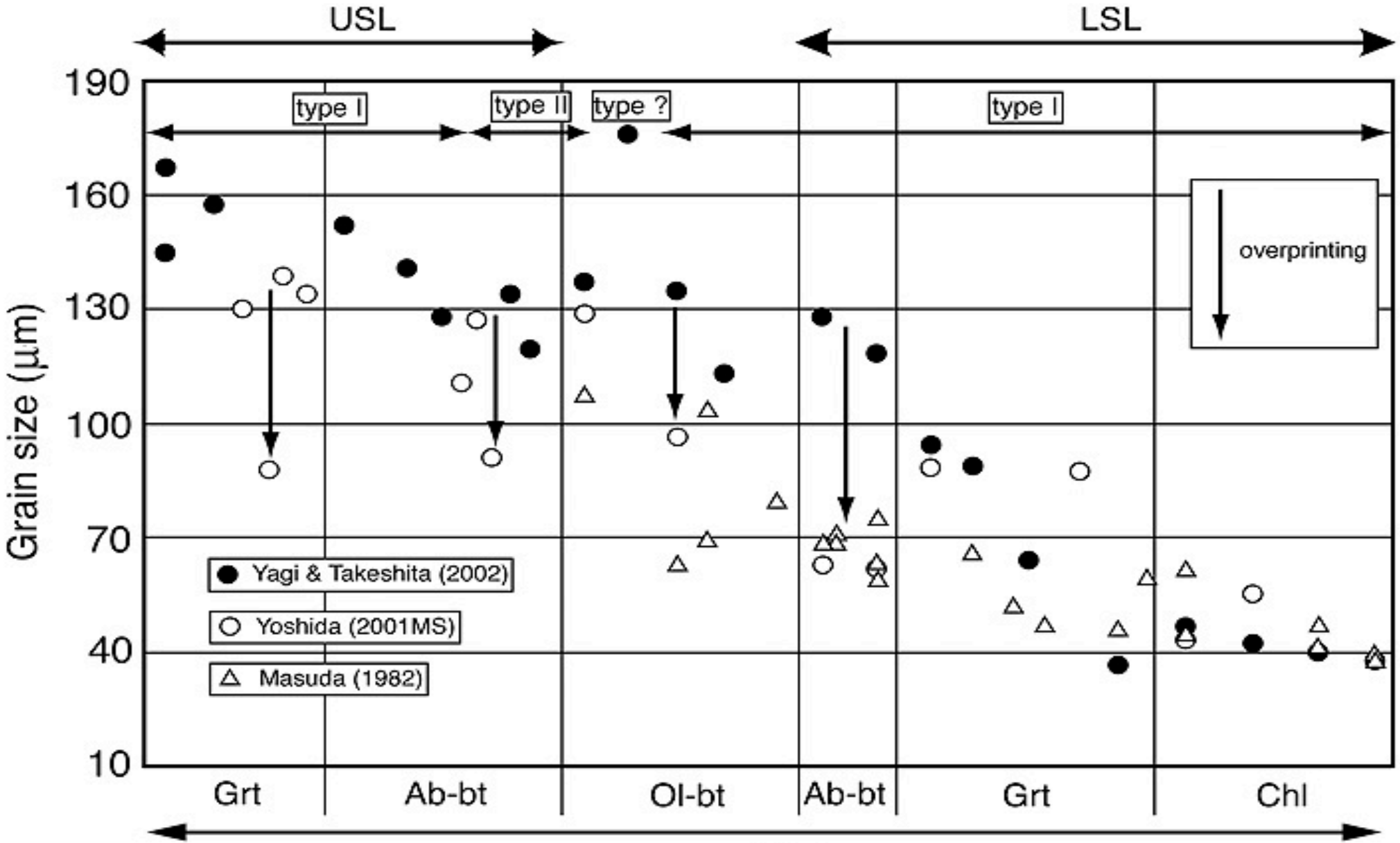

Chlorite
Albite - Biotite
Garnet
Oligoclase - Biotite
1 mm


Tagami
9#6
incp_1_86
500 µm
max=5.64
0.50-4.00
Chlorite
Tagami 24
100 µm
incp_1_87
max=m8.45
1.00-8.00
Albite Biotite
T2_WE
.incp
500 µm
max=5.26
0.5-4.0
Garnet
Tagami 35
100 µm
Oligoclase - Biotite

CPO Interpretation

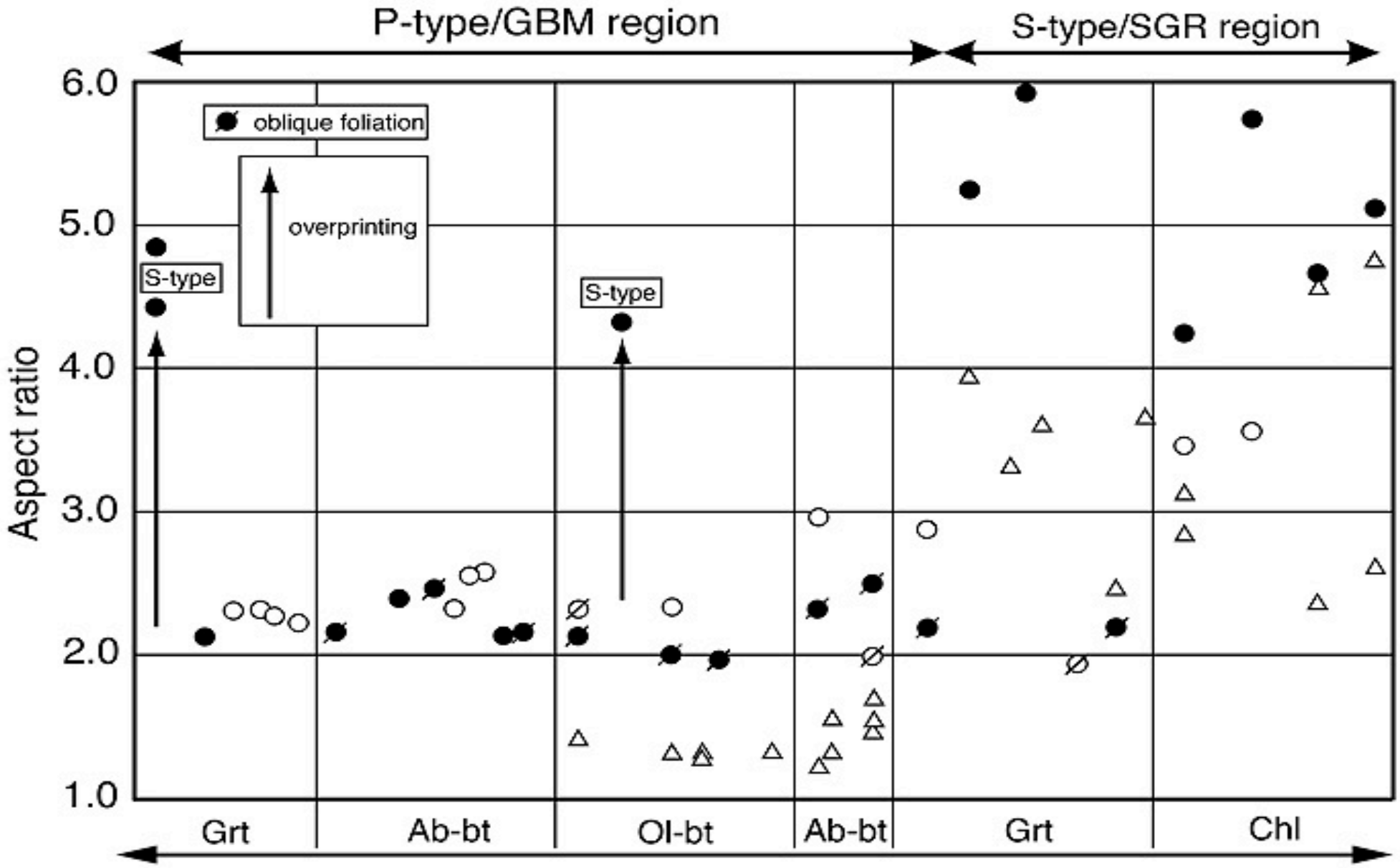


Grain size



Abbreviation: Chl, chlorite zone; Grt, garnet zone;
Ab-bt, albite-biotite zone; Ol-bt, oligoclase-biotite zone;
USL, upper structural level; LSL, lower structural level

Grain shape



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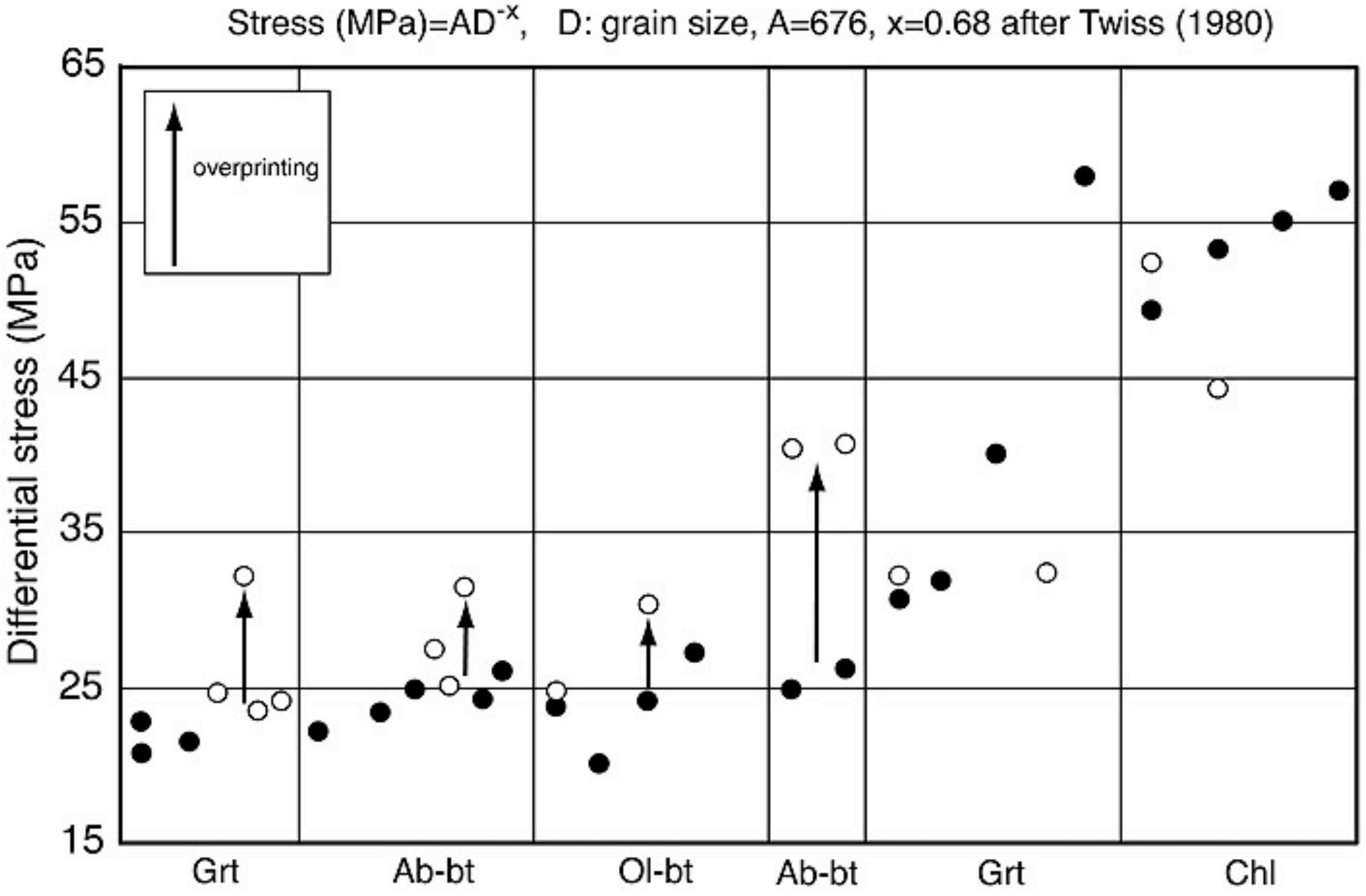
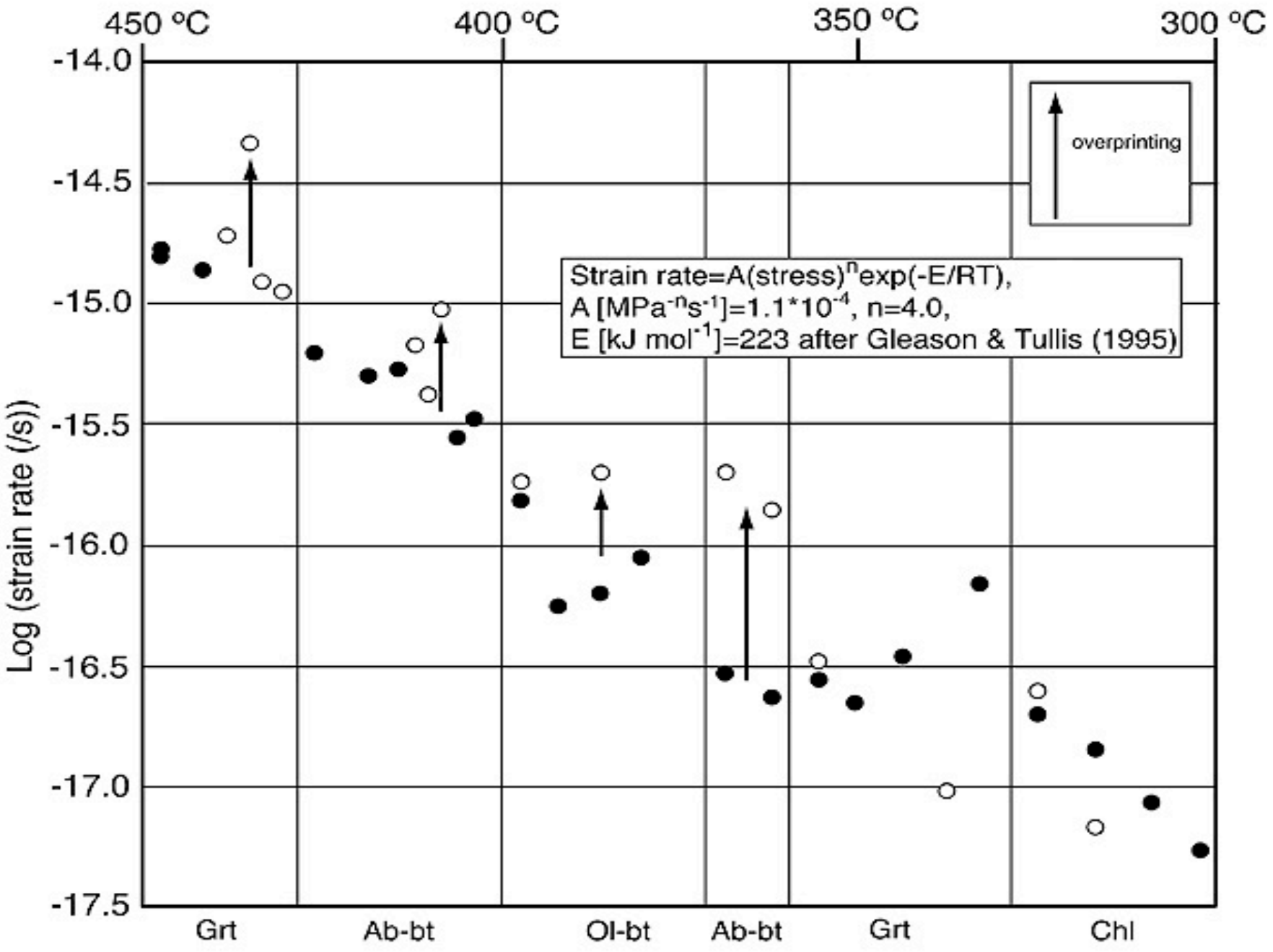
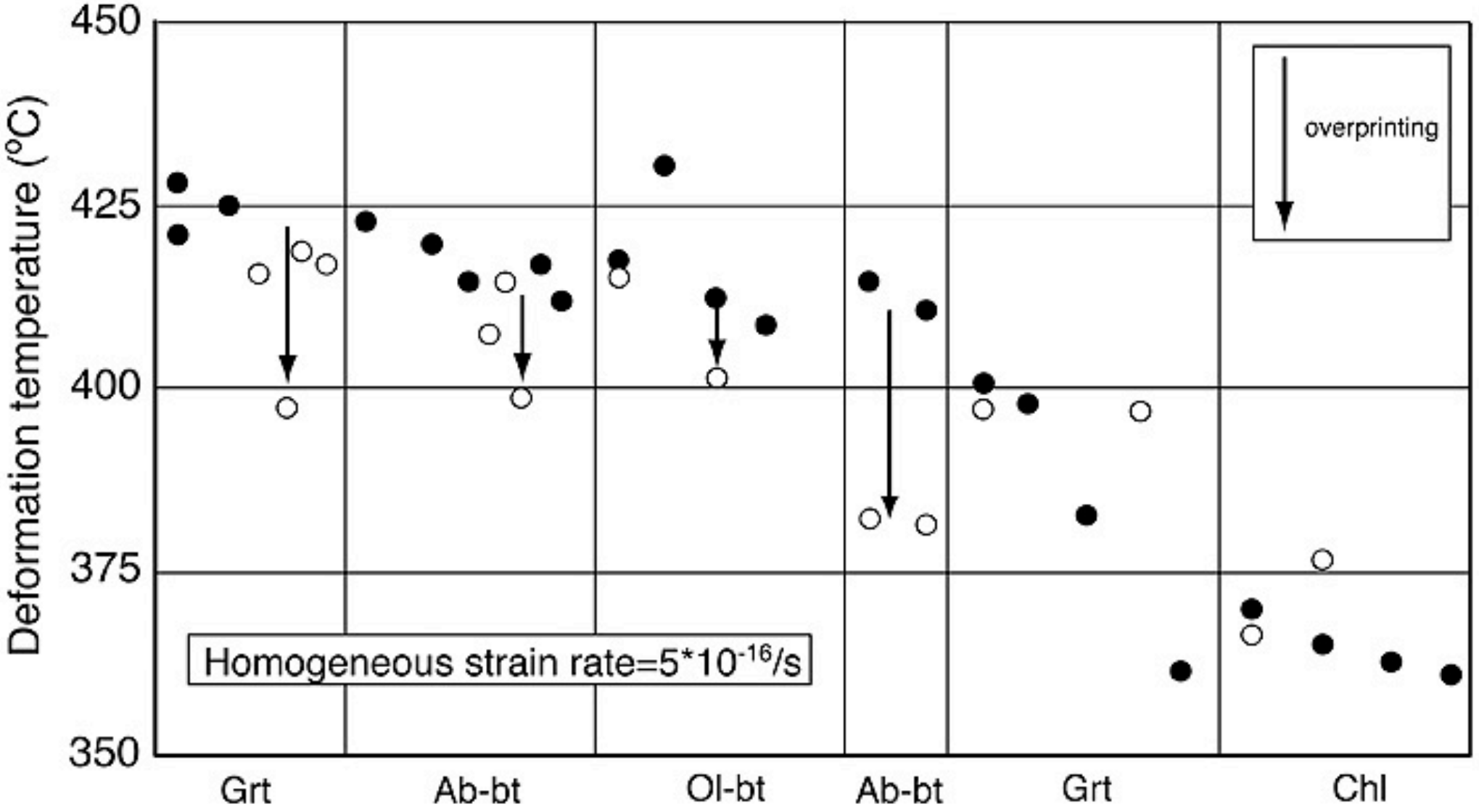
Paleopiezometry

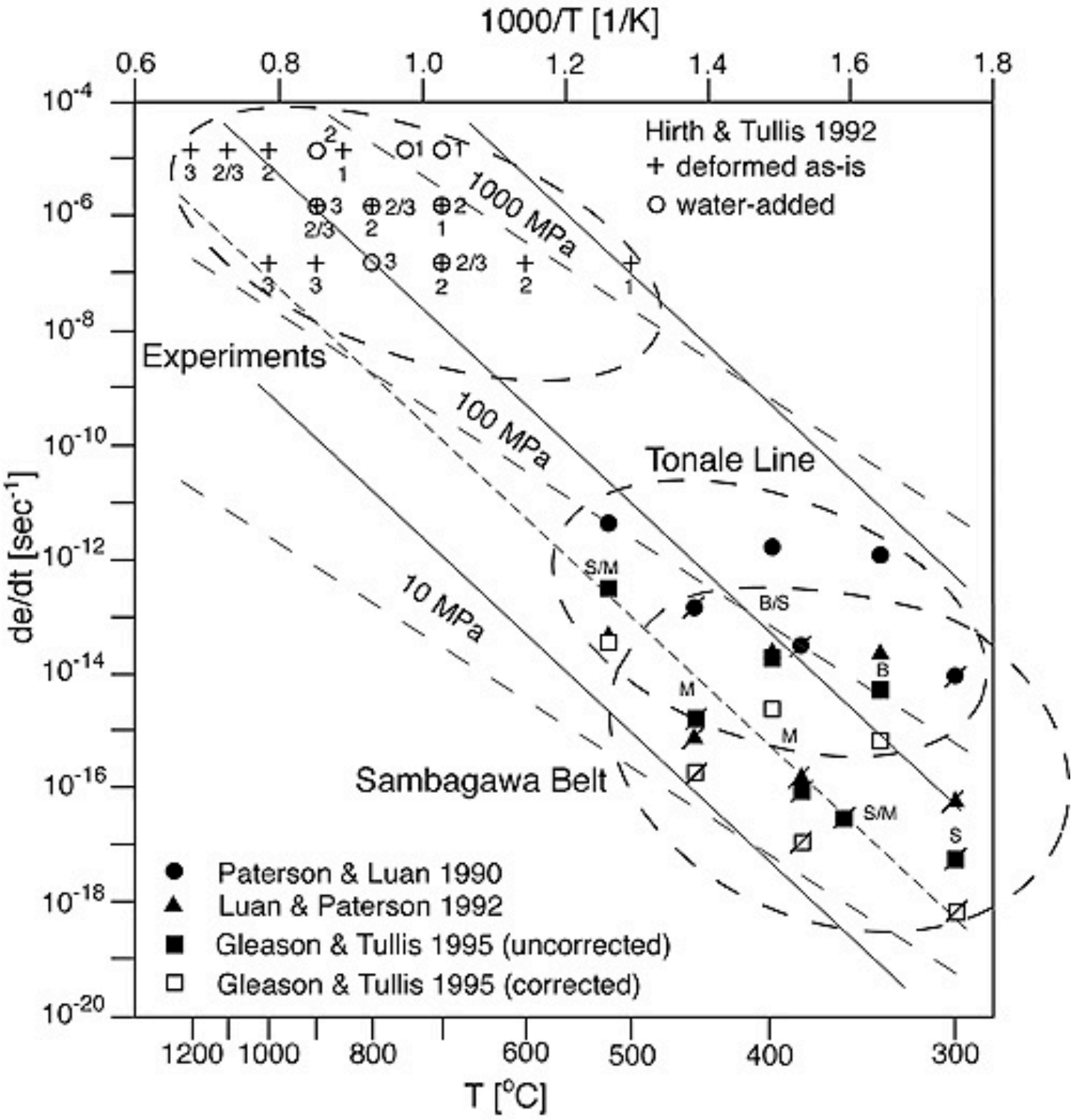


Infered strain rate

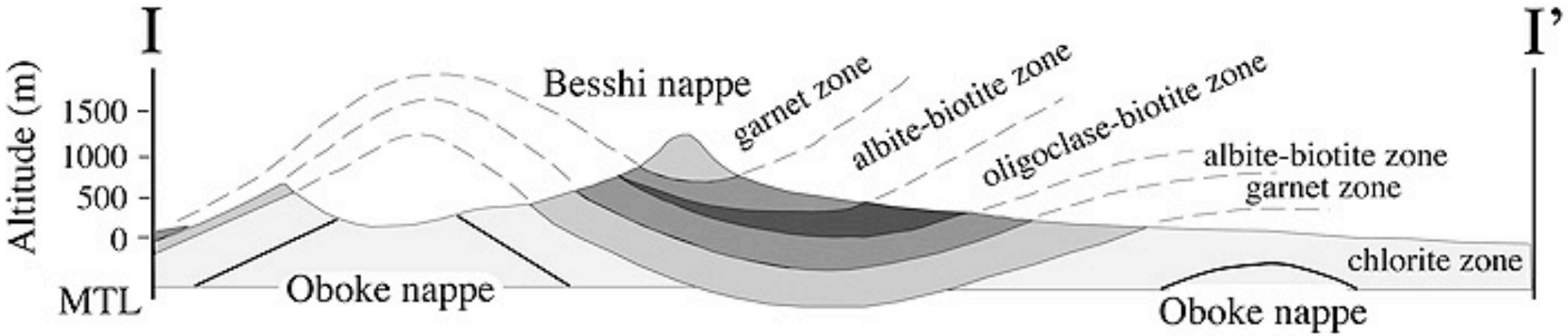


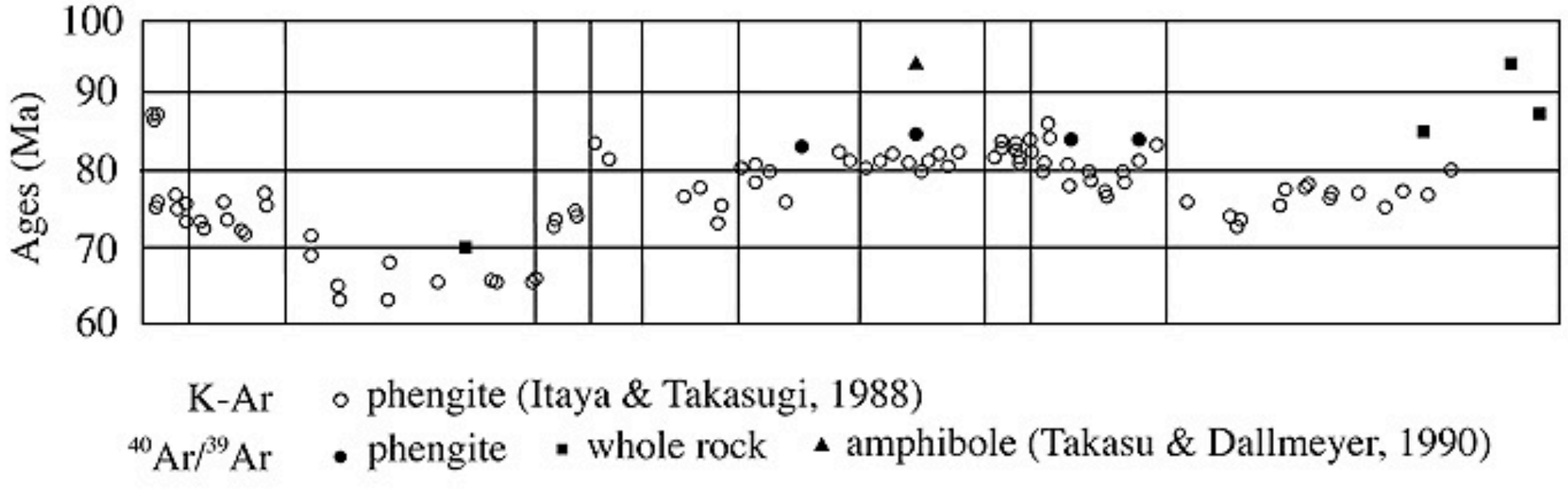
Infered deformation temperature




1000/T [1/K]
0.6
0.8
1.0
1.2
1.4
1.6
1.8
de/dt [sec-1]
10-4
10-6
10-8
10-10
10-12
10-14
10-16
10-18
10-20
Hirth & Tullis 1992
+ deformed as-is
o water-added
1000 MPa
100 MPa
10 MPa
Experiments
Tonale Line
Sambagawa Belt
S/M
B/S
B
M
S
Paterson & Luan 1990
Luan & Paterson 1992
Gleason & Tullis 1995 (uncorrected)
Gleason & Tullis 1995 (corrected)
1200
1000
800
600
500
400
300
T [°C]

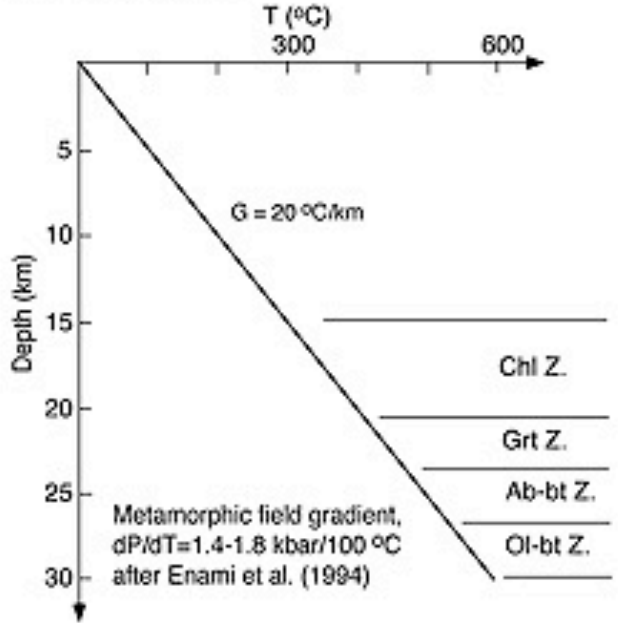
K - Ar dating


I
I'
Altitude (m)
1500
1000
500
0
MTL
Besshi nappe
garnet zone
albite-biotite zone
oligoclase-biotite zone
albite-biotite zone
garnet zone
chlorite zone
Oboke nappe
Oboke nappe

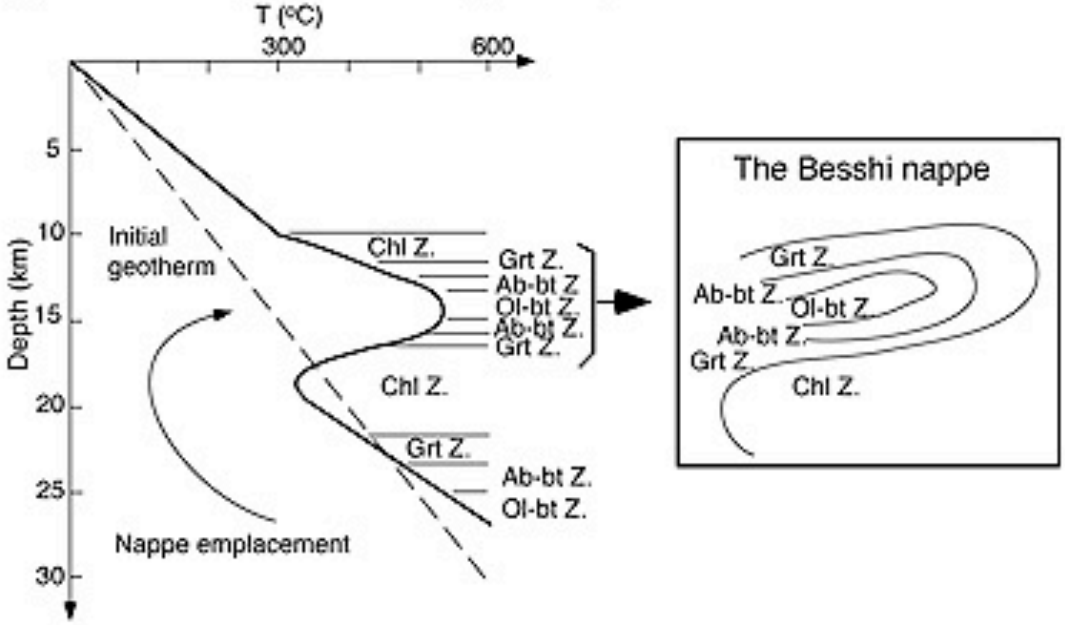

Ages (Ma)
100
90
80
70
60
K-Ar ○ phengite (Itaya & Takasugi, 1988)
40Ar/39Ar ● phengite ■ whole rock ▲ amphibole (Takasu & Dallmeyer, 1990)

Thermal history

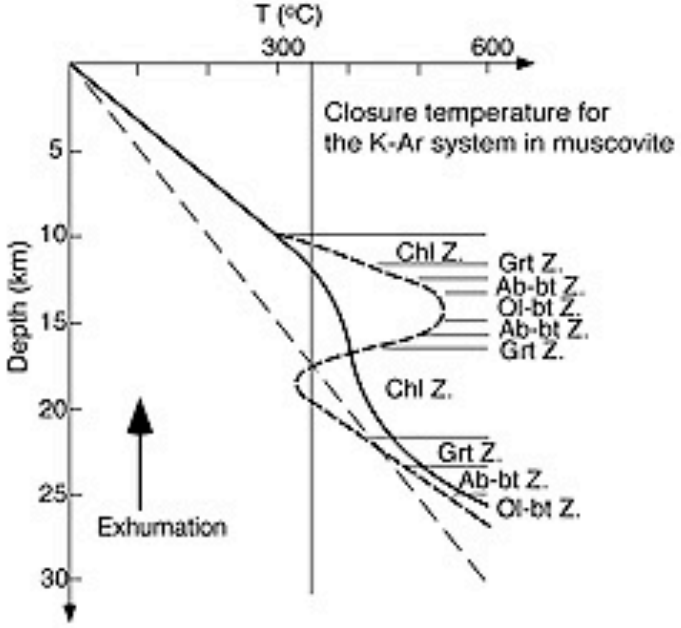
(1) Initial state



(2) Immediately after the nappe emplacement

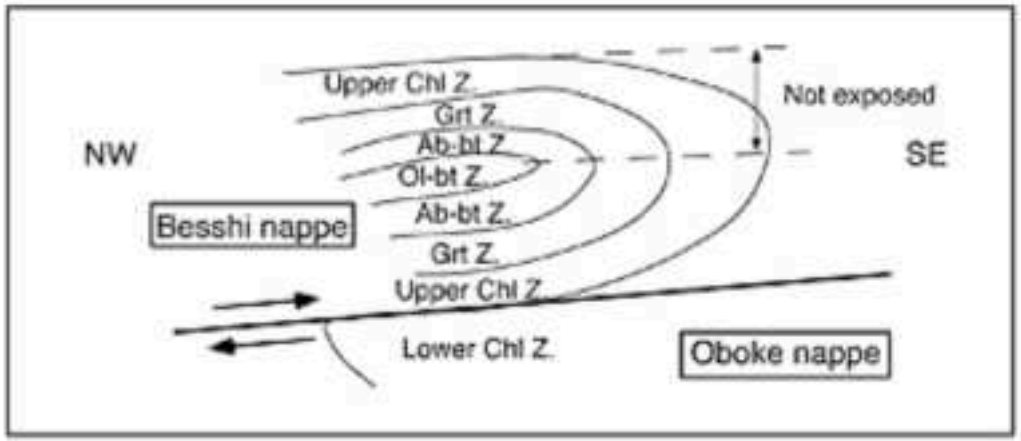


(3) At a few (ca. 1) Ma after the nappe emplacement

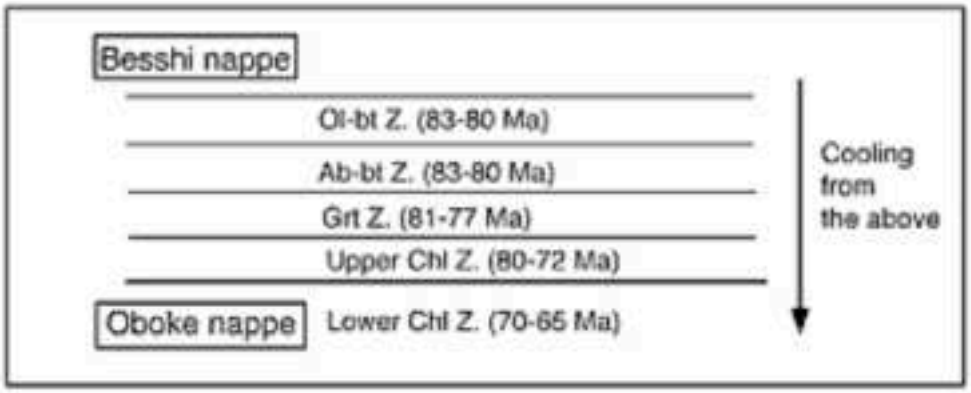


Structural evolution

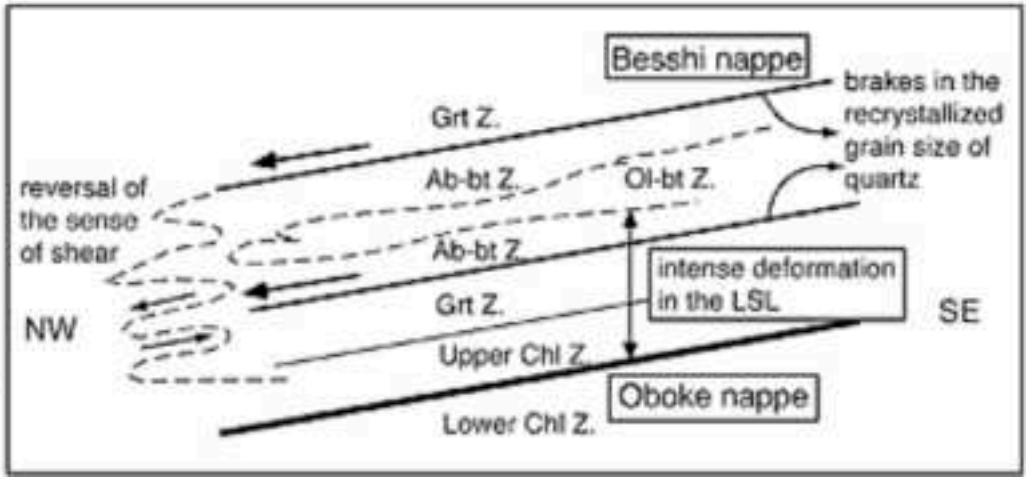
Stage I. Emplacement of the Besshi nappe (rapid cooling)



Stage II. Acquisition of the phengite K-Ar ages



Stage III. Late stage overturned folding and normal faulting



Conclusions

- CPO: type I crossed gridle dominates, type II in albite-biotite zone of upper structural level
- grainsize: 40 µm - 160 µm, increasing with structural level
- shape: S-type P-type (SGR-GBM) transition at boundary garnet to albite-bitotie zone
- microstrcutures do NOT reflect peak metamorphism - but exhumation history