Basement-involved thin- and thick-skinned tectonics: case study Alps

Adrian Pfiffner
University of Bern
Basement-involved tectonic styles

The topic: Thick-skinned ⇔ Thin-skinned style

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The Problem: Thin basement nappes ....
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.... overlying thickened continental crust
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Replacement of cover, folded thrust faults

(a) [Image of mountainous terrain]

(b) [Image of mountainous terrain]

NW

Piz la Motta

Piz Grisch

Permian Rolina Porphyry complex

Triassic carbonates

Early Jurassic breccia

Avers nappe (Bandnerschlielens)

Piz Alv

Schams nappe

SE

SSE

Trun submassif

Piz Dadens

Piz Tumpv

Cavisthau

Cavisthau nappe

Permain

L. Jurassic

Triassic

M. Jurassic

Crystalline basement

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Internal deformation of basement nappes: Tambo & Adula

adapted from Mayerat-Demarne 1994

based on Berger & Mercolli 2006

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Internal deformation of basement nappes: Suretta

Legend

- Cargneule
- Carbonate
- Quartzite
- Permian (Carboniferous?) sediments
- Rofna Porphyry Complex
- Stella Timun mass
- Porphyry, weakly deformed
- Porphyry, L-tectionite
- Gneiss, coarse grained
- "Augengneiss"
- Gneiss, fine grained
- "Augengneiss"
- Porphyry, mylonite

2 km

After Scheiber et al. 2012

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Internal deformation of basement nappes: Suretta

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Internal deformation of basement nappes: Bernhard

Bernhard nappe complex  East

after Scheiber et al. 2013

Bernhard nappe complex  West

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**P-T-t** paths for retrodeformation of cross-sections

based on compilation by Frey & Ferreiro Mählmann 1999

after Marquer et al. 1994
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Piemont Ocean subducted, Briançon microcontinent enters

Early Paleocene    65 Ma

Adriatic margin

Adriatic continental margin
Austroalpine nappe system
Mesozoic - Cenozoic
Crystalline basement / Upper crust
Lower crust
Oceanic crust

Distal European continental margin
Penninic nappe system
Lower Penninic/Valais Trough
Mesozoic - Cenozoic
Oceanic crust
Crystalline basement / Continental crust
Athenosphere

Middle Penninic/Briançon Rha
Mesozoic
Crystalline basement / Upper crust
Lower crust

Upper Penninic/Piemont Ocean
Mesozoic - Cenozoic
Oceanic crust

Southalpine nappe system
Mesozoic - Cenozoic
Crystalline basement / Upper crust
Lower crust
Lithospheric mantle
Athenosphere

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Briançon & Valais cover detached, basement descends

Early Eocene  50 Ma

~400 km convergence

Adriatic continental margin
Austroalpine nappe system

Adula N
Valais
Briançon
Piemont
Adula S

European continental margin
Helvetic nappe system

N

S

100 km

Aar
Gotthard
Lucomagno
Simano shoulder
Adula

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Basement nappes expelled upward

Late Eocene  40 Ma

Adriatic margin

European margin

N

S

Aar
Gotthard
Lucomagno
Simano
Southalpine

Adriatic continental margin
Austroalpine nappe system
Southalpine nappe system

Penninic nappe system

Middle Penninic/Briançon Rise

Upper Penninic/Piemont Ocean

European continental margin
Helvetic nappe system

Mesozoic - Cenozoic
Crystalline basement/Upper crust
Lower crust
Lithospheric mantle
Asthenosphere

Adriatic continental margin
Austroalpine nappe system
Southalpine nappe system

Mesozoic
Crystalline basement

Mesozoic - Cenozoic
Crystalline basement/Upper crust
Lower crust
Lithospheric mantle
Asthenosphere
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Onset of collision by entrance of thick continental crust

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Oligocene 32 Ma

N  European margin

Adriatic margin

S

100 km

~600 km convergence

European continental margin

Adriatic continental margin

Helvetic nappe system

Penninic nappe system

Upper Penninic/Piemont Ocean

Cenozoic magmatites

Bregaglia Pluton

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Continuing collision: backthrusting, squashing of margins

Early Miocene  19 Ma

~700 km convergence

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Final stage: crustal structure


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**Final stage: lithosphere structure**

Lithosphere structure after Lippitsch et al. 2003

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Evaporite layers allow detachment at low temperature and shallow depth.

Deformation of crystalline basement is controlled by quartz rheology, which requires higher temperatures attained at deeper levels.
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**Final stage: crustal structure and seismicity**

Deep earthquakes in the foreland ↔ shallow earthquakes in the Alps

Pfiffner & Deichmann 2014

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