Influence of Strike-Slip Fault Activity on the Topographic Evolution of the Eastern Alps: A Modelling Study

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Geological Setting
Introduction

- First analogue indentation experiments [Ratschbacher et al. 1991]
  - Introduction of lateral extrusion
  - Importance of strike-slip faulting

- First deformation modelling of E-Alps [Robl & Stüwe 2005]
  thin viscose sheet formulation [England & McKenzie 1982]
  2D FE code Basil [Houseman, England, Barr]

- BASIL code coupled with an erosion model [Stüwe et al. 2008]

- Stationary strike-slip faulting for BASIL [Robl et al. 2008]

- Non-stationary strike-slip faulting (presented work, [Lynn Evans, pers. com., Monash University])
First record of topographic evolution of E-Alps
[Frisch et al. 1998]

Initial condition for simulation
- Starting time 30 Ma ago
- Initial flat topography 200m
# Literature/strike-slip activities

<table>
<thead>
<tr>
<th>Abr.</th>
<th>fault name</th>
<th>time in [Ma] before recent</th>
<th>time history of strike-slip activity from literature</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0</td>
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<tr>
<td>PA</td>
<td>Periadnamic fault</td>
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<tr>
<td>DAV</td>
<td>Defreggen-Anrholz-Völz</td>
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<tr>
<td>SEMP1</td>
<td>Salzach-Ennstal fault</td>
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<tr>
<td>SEMP2</td>
<td>Ennstal-Mariazell-Puchberg fault</td>
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<tr>
<td>MM1</td>
<td>Mur-Mürztal fault – west</td>
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<tr>
<td>MM2</td>
<td>Mur-Mürztal fault – east</td>
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<td>PL</td>
<td>Pöls-Lavanttal fault</td>
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<td>MV</td>
<td>Möll-valley fault</td>
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<td>In</td>
<td>Inntal fault</td>
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- Plate boundary
- Strike-slip fault

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Rotation of Adriatic Plate: $0.52^\circ$/Ma

[Nocquet & Calais 2003]

Heuristic rectification approach:

- $\Phi \propto$ distance from Adriatic Plate
- $T \rightarrow$ compensate lateral extrusion

Result fits to [Linzer et al. 2002]
Boundary conditions

- **Fixed boundary conditions**
  - $u'_x = 0$, $u'_y = 0$
  - $HLENSC = s_c/L_0 = 5$
  - $BDEPSC = s_l/L_0 = 0.35$

- **Slip boundary conditions**
  - $u'_x = 0$
  - $\sigma'_x = 0$
  - $\sigma'_y = 0$

Velocity profile acting on boundary

$V_{\text{max}} = 3.6\text{mm/a}$
Topographic elevation after 30Ma of deformation

- No faults
- With faults
- With temporal varying faults
Map comparison

Topography about 400-1200m peak height below real world

- Glacial erosion
  [Sternai et al. 2015]

- Plate rebound
  [Willet, 2010]

- Asthenosphere upwelling
  [Lippitsch et al. 2003]
Topographic evolution

Recent
-10Ma
-20Ma
-30Ma

Fault activity
Silence?
Tauern Window exhumation

PA = Adriatic plate boundary

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Conclusion

- Final topography depends strongly on strike-slip activity patterns → backs up earlier findings

- Tauern Window exhumation strongly depends on activity patterns of faulting

- Maximum indenter velocity with $v_{\text{max}} = 3.6 \text{mm/a}$ over 30Ma
  - Rectification fits to Linzer et al. (2002)
  - Lower convergence rates than claimed in literature

- Stiffness control modelling of the Austroalpine instead of boundary condition modelling (e.g. Miocene roll-back at Carpathian arc)