Salt tectonics in the Inner Western Carpathians (Silica Nappe, Aggtelek Hills)

Investigating the role of inherited Triassic salt structures during the Alpine deformation

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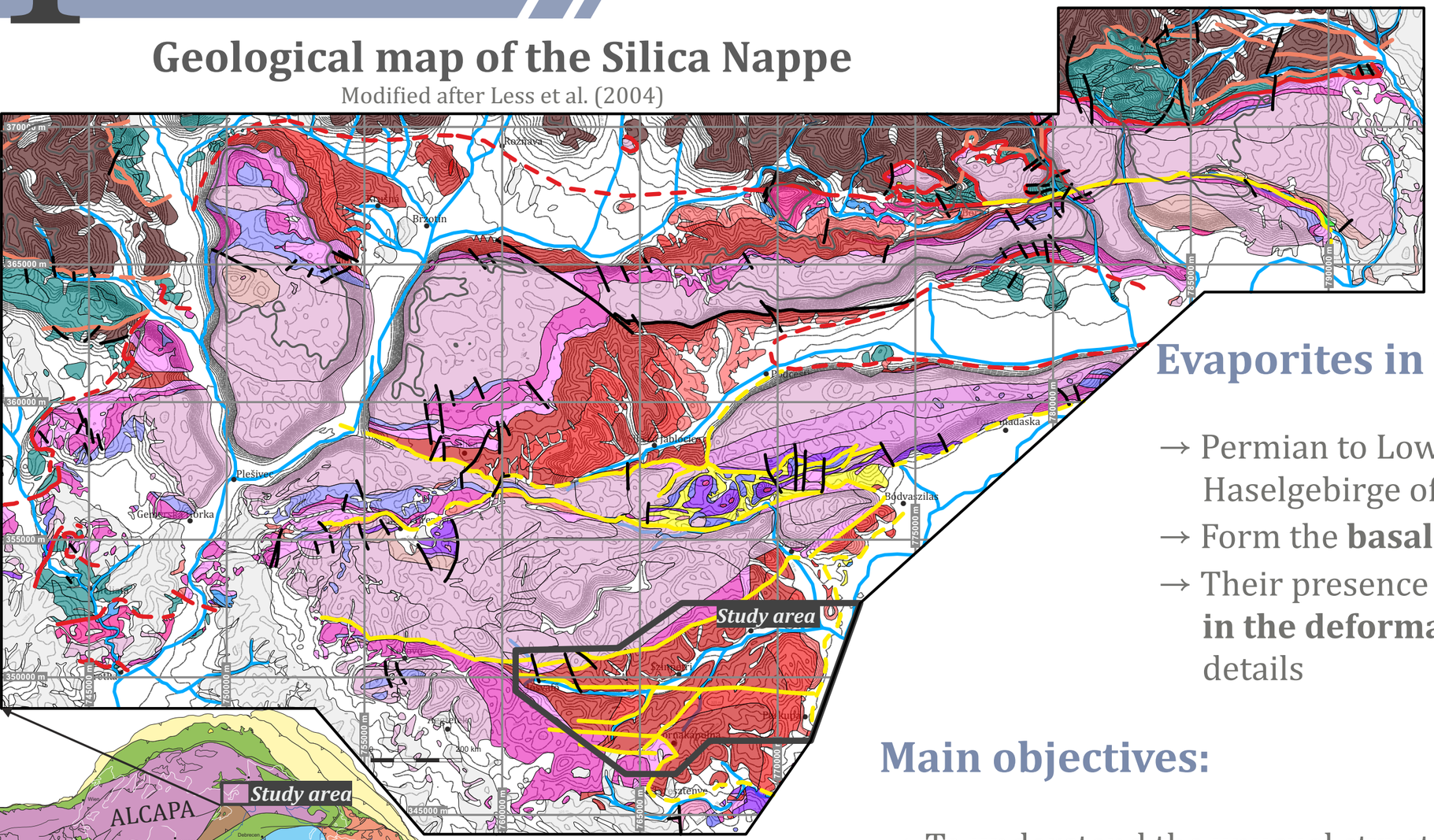


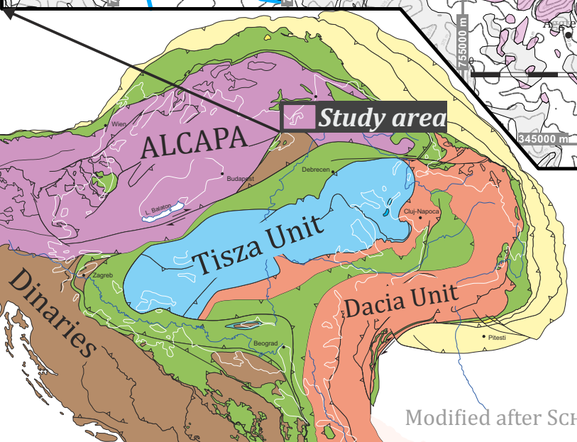
EGU General Assembly, Salt basins: from deposition to deformation - 7 May, 2020

1 Introduction

Geological map of the Silica Nappe

Modified after Less et al. (2004)





Modified after Schmid et al. 2008

Evaporites in the Silica Nappe:

→ Permian to Lower Triassic in age (similar to Haselgebirge of the Northern Calcareous Alps)

→ Form the **basal thrust plane** of the Silica Nappe

→ Their presence has been long known but **their role in the deformation has not been considered** in details

Main objectives:

→ To understand the unusual structural contacts in details

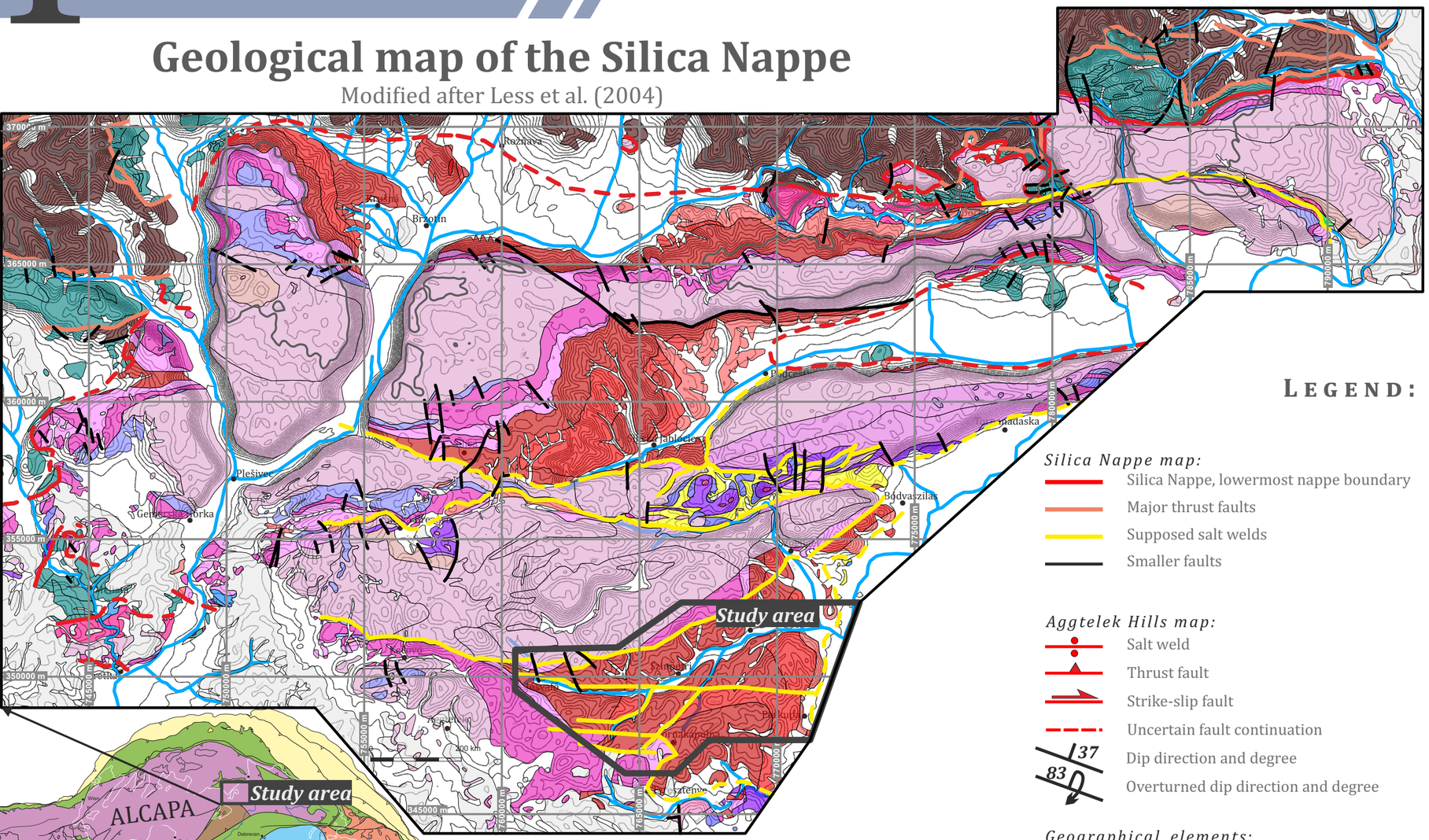
→ To understand the deformation geometry and kinematics of salt structures

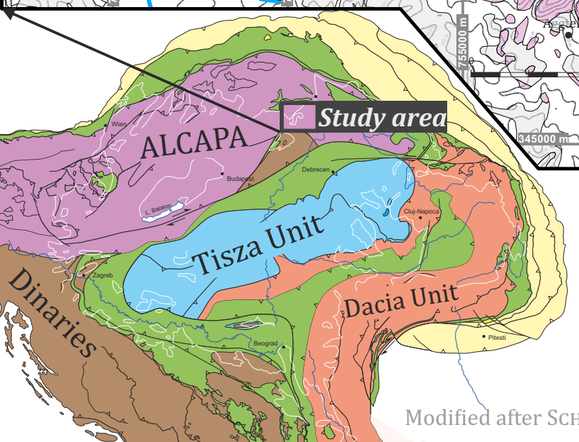
→ To determine the possible **timing of salt movements**

1 Introduction

Geological map of the Silica Nappe

Modified after Less et al. (2004)





Modified after Schmid et al. 2008

Legend:

Silica Nappe map:

- Silica Nappe, lowermost nappe boundary
- Major thrust faults
- Supposed salt welds
- Smaller faults

Aggtelek Hills map:

- Salt weld
- Thrust fault
- Strike-slip fault
- Uncertain fault continuation
- 37 / 83 — Dip direction and degree
- Overturned dip direction and degree

Geographical elements:

- Village boundary
- 200 m — Contour lines
- 349000 m — Coordinates
- Drainage
- Road
- Boreholes

- Quaternary
- Neogene formations
- Senonian marine carbonates

Silica Nappe:

- Jurassic formations
  e.g. Hierlatz, Adneth Limestones, Drnava Radiolarite

Upper Triassic:

- Norian platform carbonates
  Dachstein Limestone
- Upper Carnian to Norian basinal carbonates of variegated facies
  Hallstatt Limestone
- Upper Triassic basinal carbonates of grey facies
  Pötchen Limestone
- Upper Carnian to Norian carbonates of transitional facies
  Silická Brezová Limestone
- Middle to Upper Carnian platform carbonates
  Tosivec Limestone

Middle Triassic:

- Ladinian (to Carnian) platform carbonates
  Wetterstein Limestone
- Anisian to Carnian transitional limestones
  Nádaska, Derenk Limestones
- Anisian to Carnian intrashelf carbonates
  Schreyeralm, Reifling, Raming Limestones
- Anisian open platform limestones
  Steinalm Limestone
- $^{g}T_2$ — Anisian restricted platform carbonates
  Gutenstein Formation

Together: *Platform carbonates*

Lower Triassic:

- $^{sp\text{-}jl}T_1$ — Shallow marine vermicular limestones
  Szinpetri Limestone
  Szinpetri Member / *Jósvafő Member*
- $^{sm}T_1$ — Shallow marine mixed terrigenous-carbonate sediments
  Szin Marl
  A B C D E F *Members*
- $^{b}T_1$ — Shallow marine coarse siliciclastics
  Bódvaszilas Sandstone

- $^{p}P\text{-}T_1$ — Late Permian to Lower Triassic evaporites and rauhwackes
  Perkupa Evaporite

Meliata and Torna Nappes:

- Metamorphosed Mesozoic formations

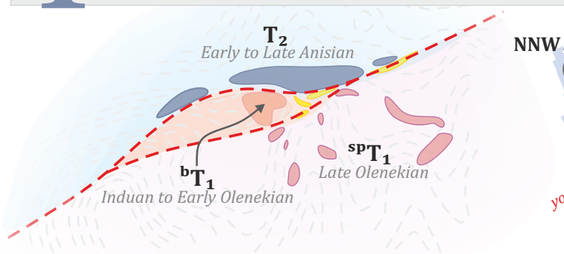
Gemer Unit:

- Metamorphosed Paleozoic basement

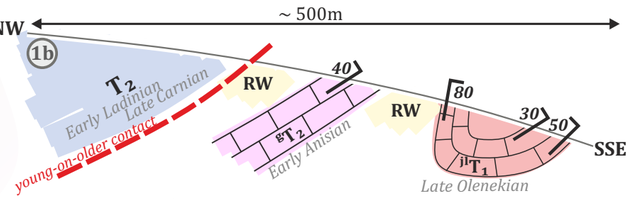
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2 Field observations

1 Unusual structural contacts

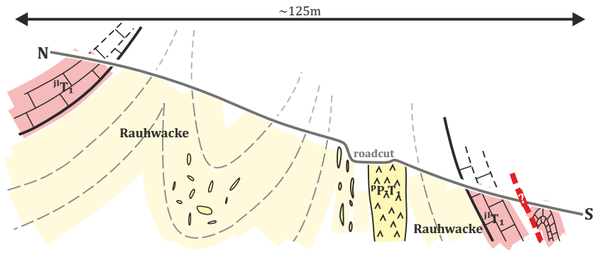


▲Isolated occurrences of older formations



▲Young-on-older contacts

2 Evaporite/rauhwacke-cored anticlines

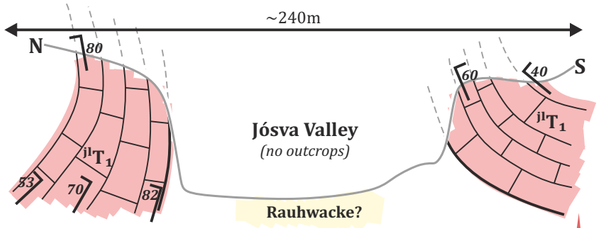


▲Sub-vertical rauhwacke zones in anticline cores

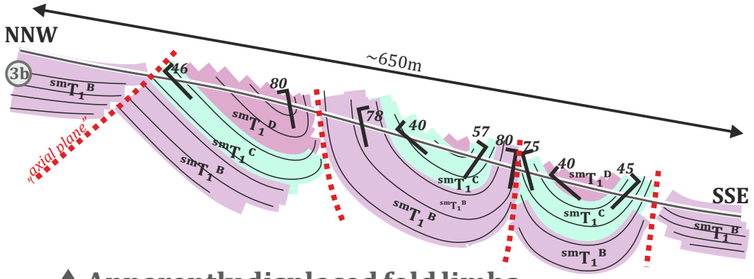


▲Rauhwacke samples from the Aggtelek Hills

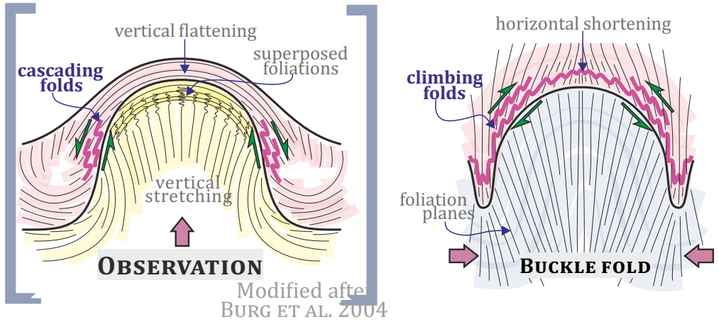
3 Unique fold geometries



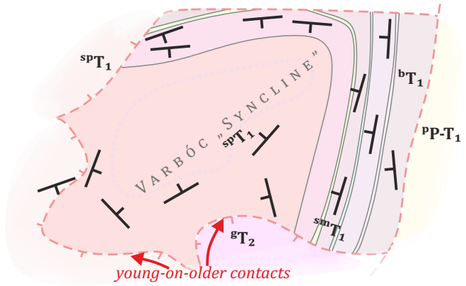
▲Tight to isoclinal cuspate-shape folds



▲Apparently displaced fold limbs

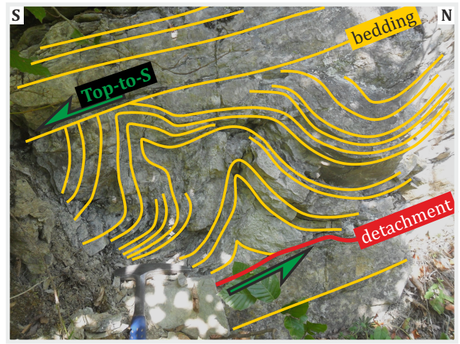


▲Reverse sense of shearing along fold limbs

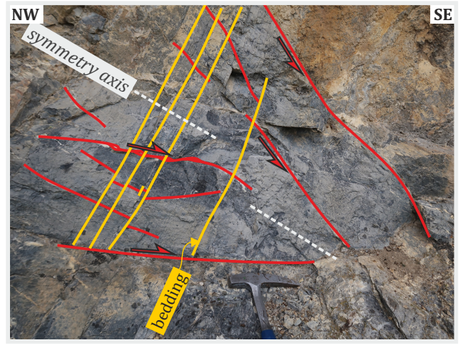


▲Bowl-shaped synclines

5 Syn-sedimentary/pre-tilt deformation

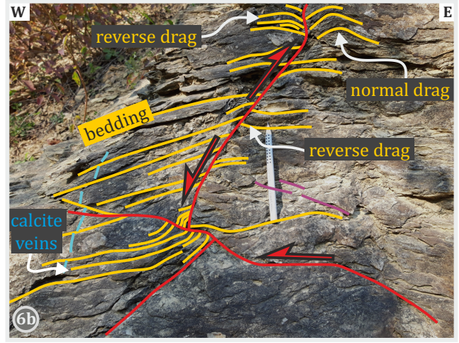


▲ Sedimentary slump folds



▲Syn-sedimentary and pre-tilt normal faults

There are also **pinch-outs and thickness changes** starting from the middle Early Triassic, but mainly from the start of the Middle Triassic.



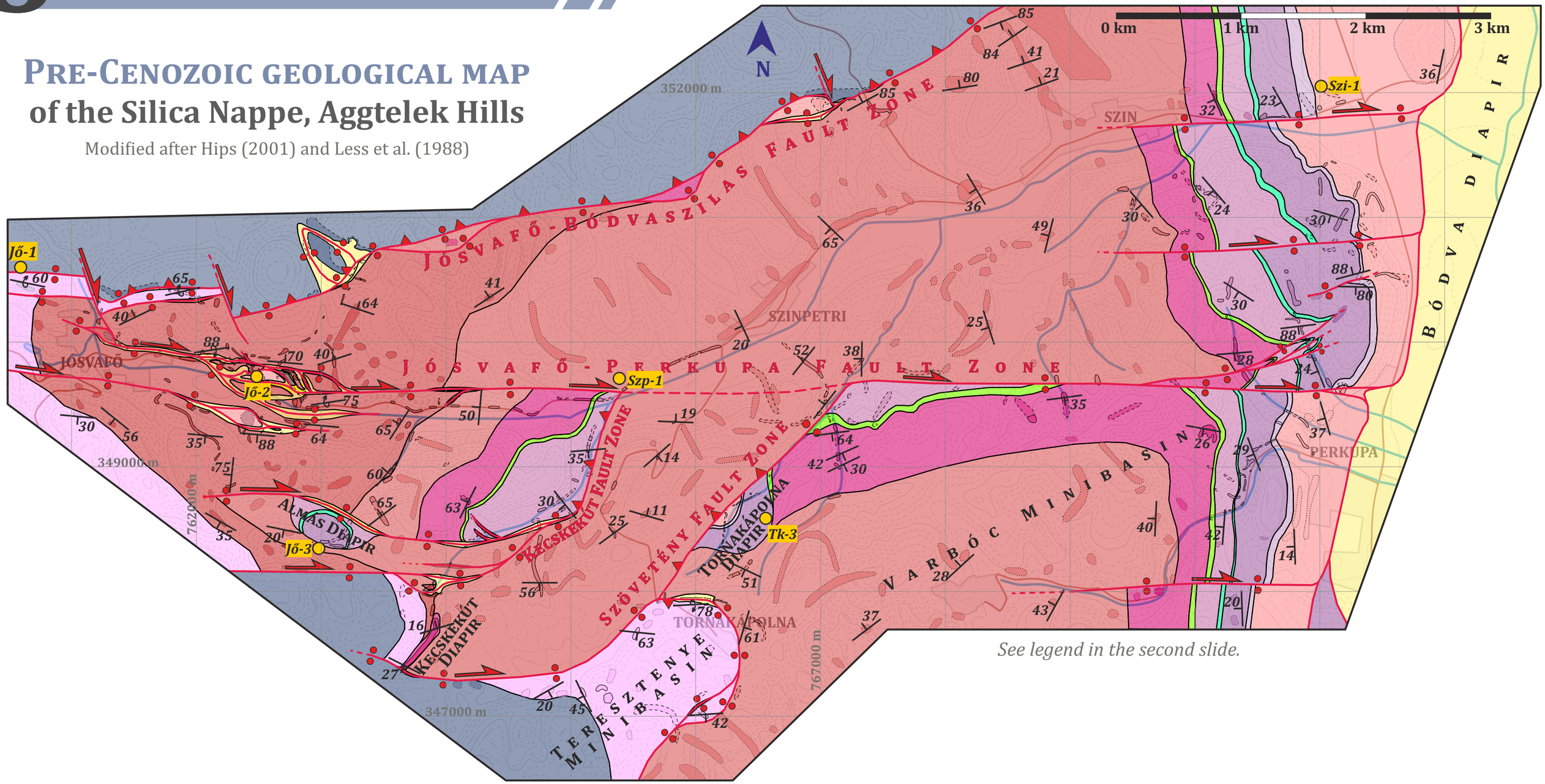
6 No major shortening in the synclines

◄ **Rare example of contractional structures,** partly reactivating, partly cutting the early normal faults.

3 Results & Discussions

Pre-Cenozoic geological map of the Silica Nappe, Aggtelek Hills

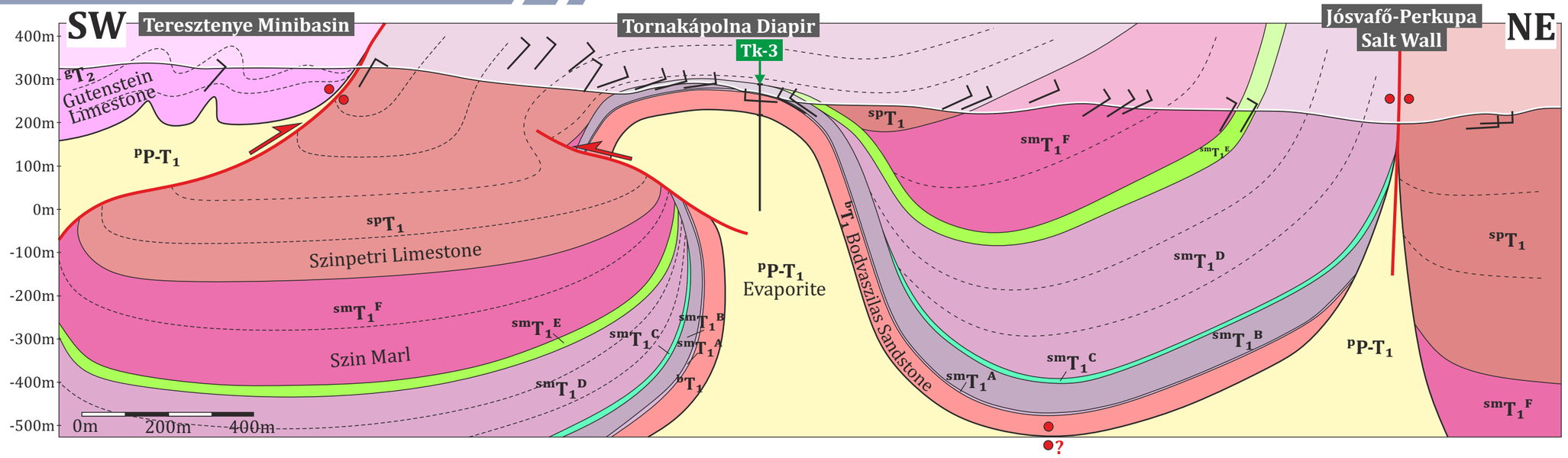
Modified after Hips (2001) and Less et al. (1988)



See legend in the second slide.

3 Results & Discussions

Triassic salt tectonics



Syn-sedimentary onset of salt tectonics

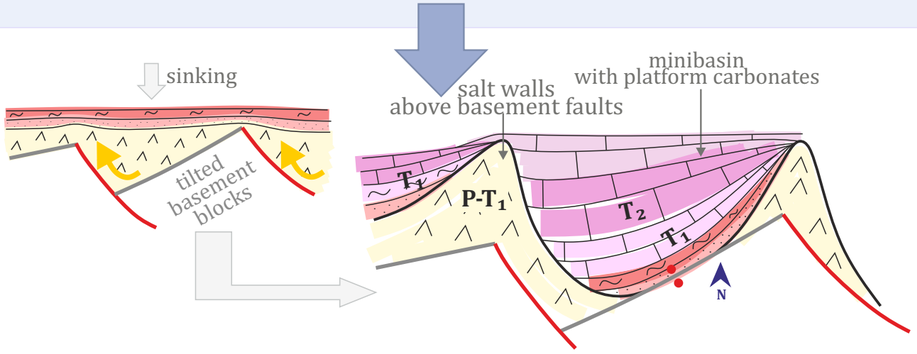
with respect to the latest Early Triassic sedimentation

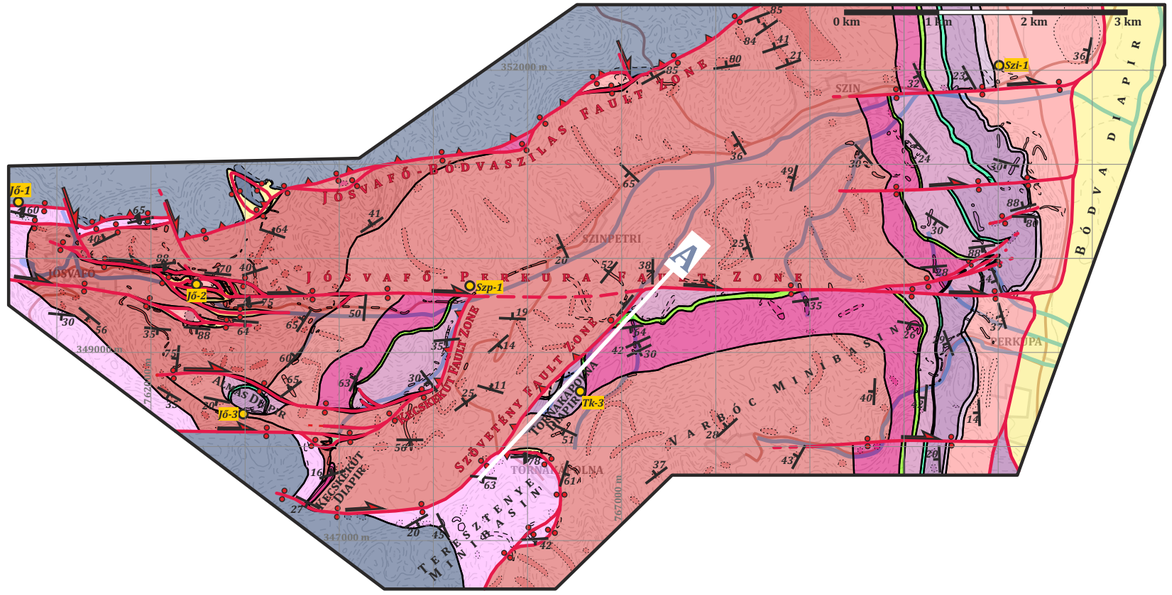
→ **Earliest salt movements** might have occurred **in the middle Early Triassic** (e.g. salt pillows).

→ Salt movements intensified by the **latest Early Triassic** when **salt walls, diapirs and minibasins formed → platform carbonate growth** from the late Middle Triassic is probably linked to evolution of salt structures.

→ The dominantly E-W striking salt walls might reflect **the original basement geometry.**

→ The first **tilting and folding event** is related to the Triassic evaporite deformation.





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Reconstructed TRIASSIC MAP OF SALT STRUCTURES in the study area

LEGEND:

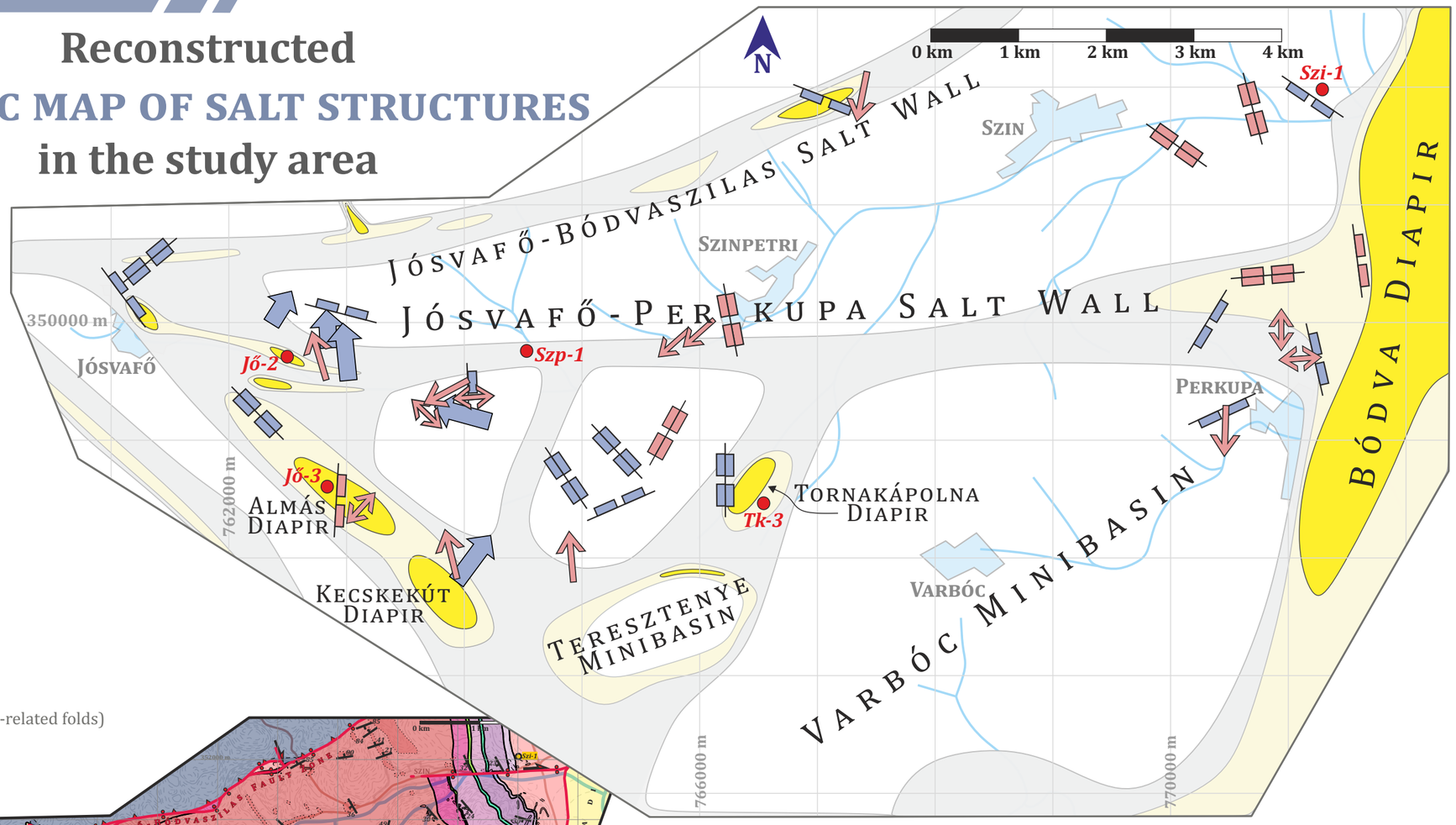
- 346000 m — Grid and coordinates (EOV)
- Villages
- Rivers and creeks
- Probable continuity of the evaporites in deeper levels
- Evaporites in shallow depths and rauhwackes
- Clear evidences for salt diapirs and/or Perkupa Formation
- Well that penetrated evaporites in shallow depths

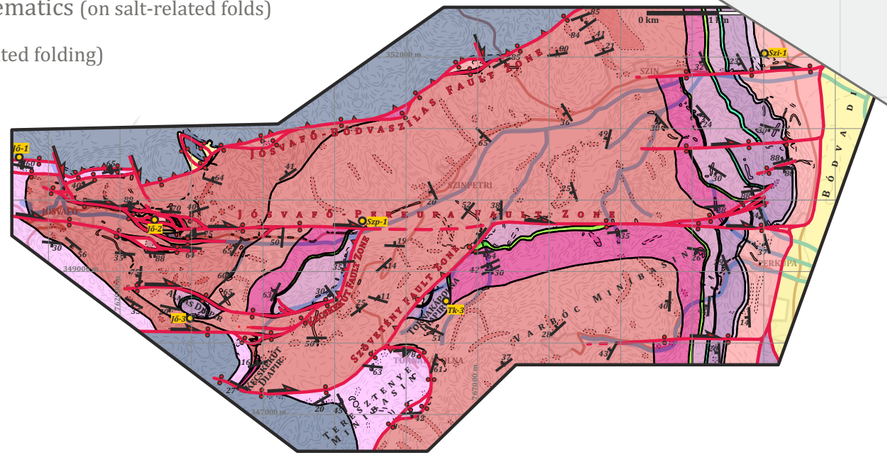
Syn-sedimentary deformation:

- Slump fold vergency (~paleoslope)
- Syn-sedimentary normal faults

Post-sedimentary pre-tilt deformation:

- Pre-tilt normal faults
- Layer-parallel slip with normal kinematics (on salt-related folds)
- Vergency of cascading folds (salt-related folding)



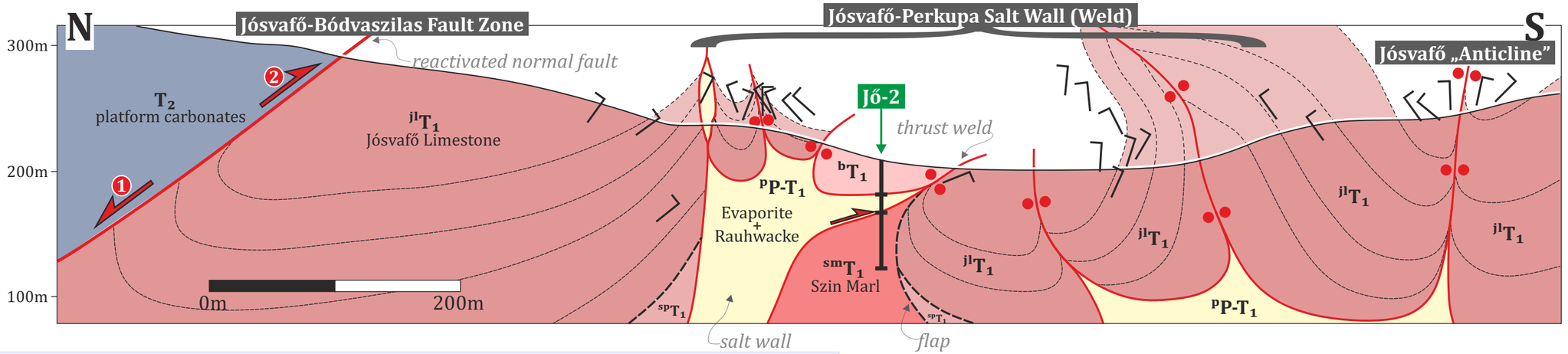


→ Variable slump folds and early faults, and salt-related folds are connected to the **growth of salt structures**.

→ The minibasins became the focus of the carbonate deposition.

3 Results & Discussions

Cretaceous shortening and welding



The inherited Triassic salt structures

strongly affected the Cretaceous deformation geometry

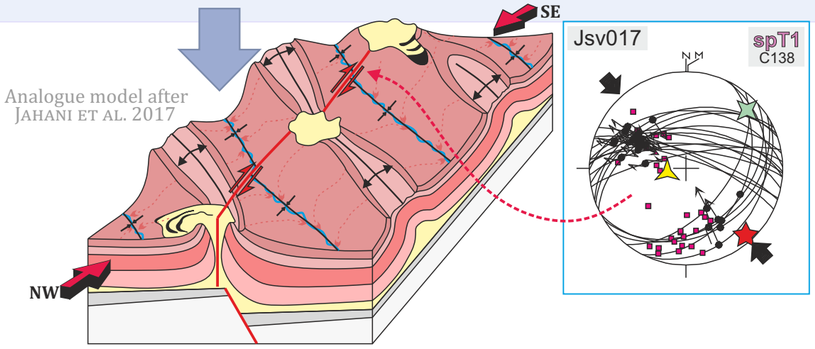
→ The internal parts of the minibasins were barely shortened — significant shortening occurred only at the salt walls.

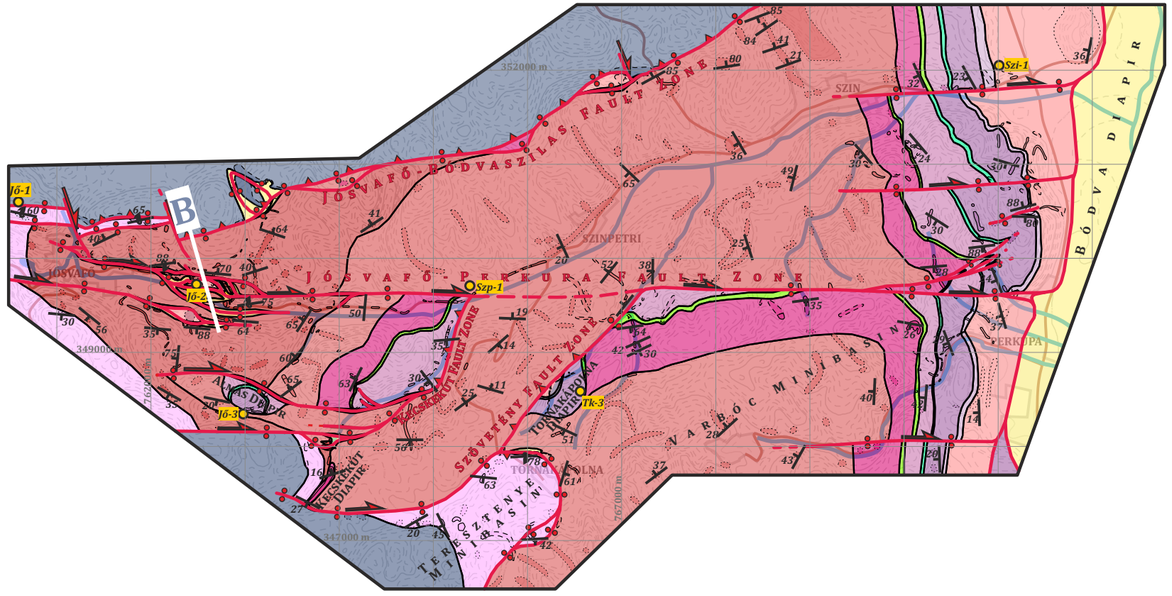
→ **Secondary salt welds** formed by the squeezing of inherited salt structures

→ **Young-on-older type thrust contacts** formed at the minibasin boundaries as the Cretaceous thrust displacement did not compensate the Triassic salt-related normal slip, even on largely reactivated faults.

→ The E-W striking salt walls were reactivated as **oblique dextral tear faults**.

→ The main tectonic transport direction seems to be **top-to-SE/S** — oppositely verging small-scale folds and thrusts are always controlled by pre-existing salt structures.





REFERENCES:

Burg J-P., Kaus B.J.P. & Podladchikov Y.Y. (2004): Dome structures in collision orogens: Mechanical investigation of the gravity/compression interplay — *Geological Society of America Special Paper* 380, 47-68.

Hips K. (2001): The structural setting of Lower Triassic formations in the Aggtelek-Rudabánya Mountains (Northeastern Hungary) as revealed by geological mapping — *Geologica Carpathica* 52/5, 287-299.

Jahani S., Hassanpour J., Mohammadi-Firouz S., Letouzey J., de Lamotte D.F., Alavi S.A. & Soleimany B. (2017): Salt tectonics and tear faulting in the central part of the Zagros Fold-Thrust Belt, Iran — *Marine and Petroleum Geology* 86, 426-446.

Less Gy., Grill J., Szentpétery I., Róth L. & Gyuricza Gy. (1988): Geological map of the Aggtelek-Rudabánya Mts. (1:25 000) — Hungarian Geological Institute, Budapest.

Less Gy., Mello J. Elečko M., Kovács S., Pelikán P., Pentelényi L., Peregi Zs., Pristaš J., Radócz Gy., Szentpétery I., Vass D., Vožár J. & Vožárová A. (2004): Geological map of the Gemer-Bükk area (1:100 000) — Hungarian Geological Institute, Budapest.

Schmid S.M., Bernoulli D., Fügenschuh B., Matenco L., Schefer S., Schuster R., Tischler M. & Ustaszewski K. (2008): The Alpine-Carpathian-Dinaridic orogenic system: correlation and evolution of tectonic units — *Swiss Journal of Geosciences* 101, 139-183.

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