Salt Tectonics in the Sivas Basin (Turkey): Outstanding Seismic Analogues*

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Search and Discovery Article #10884 (2016)**
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See similar article Search and Discovery Article #30312 (2014)

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Abstract

The Sivas Basin in Anatolia is likely the world's finest open-air museum of salt tectonic structures. It is an elongated Oligo-Miocene sag basin that developed in an orogenic context above the complex Taurus-Pontides suture. From Late Eocene to Late Miocene salt deposition, salt tectonics, and salt reworking occur in a north-verging foreland fold-and-thrust belt setting north of the Taurus. The result is an intricate system of salt ridges, minibasins, salt sheets, and successive canopies. The orogenic continental setting is markedly different from the deep marine-passive margin environment of the petroleum rich salt basins such as Angola or the Gulf of Mexico, but close to the Pricaspian Basin setting.

Despite huge difference in content and evolution the Sivas Basin provides outstanding outcrops of the classic geometries associated to the development of diapirs, i.e. halokinetic sequences along diapir walls, and associated stratal deformations. The Sivas Basin also presents more exotic structures such as 4-ways closed minibasins, megaflaps (thinned sedimentary sequences pinching out on top of diapirs and overturned during glaciers later development), and evaporites allochtonous sheets. Such structures are only observed in thick and highly deformed salt basins, and are rarely seen at outcrop: only in the Axel Heiberg area (Northern Territories, Canada - hardly accessible) and the Flinders Ranges (Australia).

Striking geometric analogies between these outcrops and seismic images from the classic petroleum province controlled by salt tectonics will illustrate the extraordinary quality of the Sivas basin as field analogue for the Gulf of Mexico, the Brazilian, Angolan, and Congo Margins. Some comparisons with analog models under scanner will also be shown.

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SALT TECTONICS IN THE SIVAS BASIN (TURKEY): OUTSTANDING SEISMIC ANALOGUES

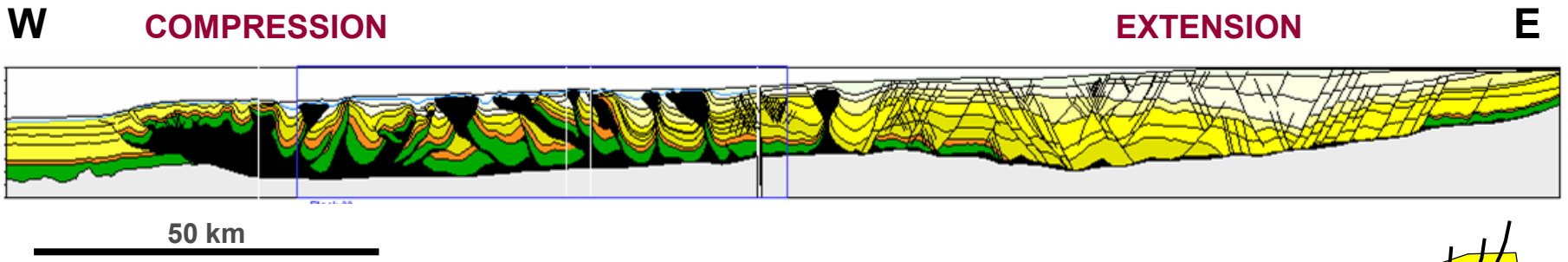
AAPG ICE field trip 2014

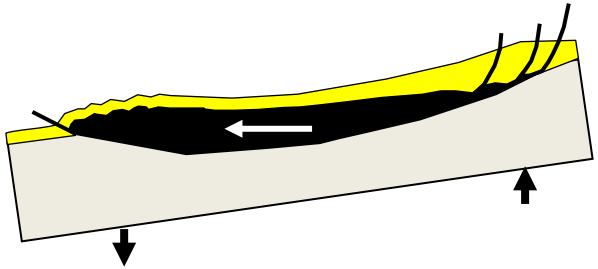
Jean-Claude RINGENBACH

Charlie Kergaravat, Charlotte Ribes, Alexandre Pichat, Etienne Legeay, Jean François Salel and Jean-Paul Callot

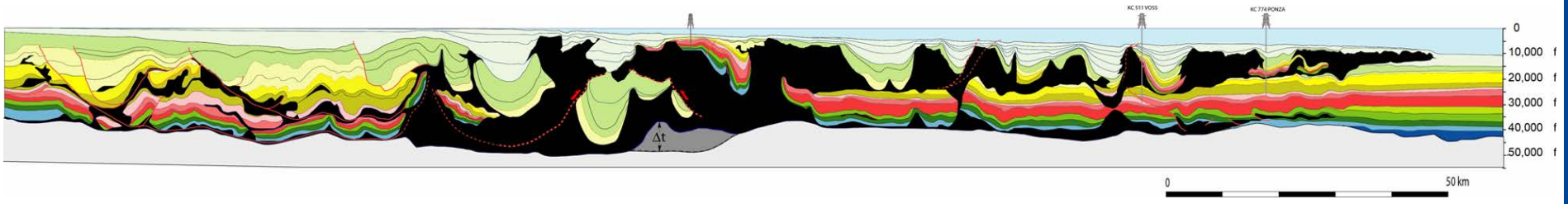
MARGIN'S GRAVITY TECTONICS SETTINGS

Gliding dominated (Angola)



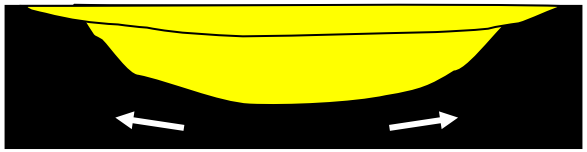


Spreading dominated (GOM)



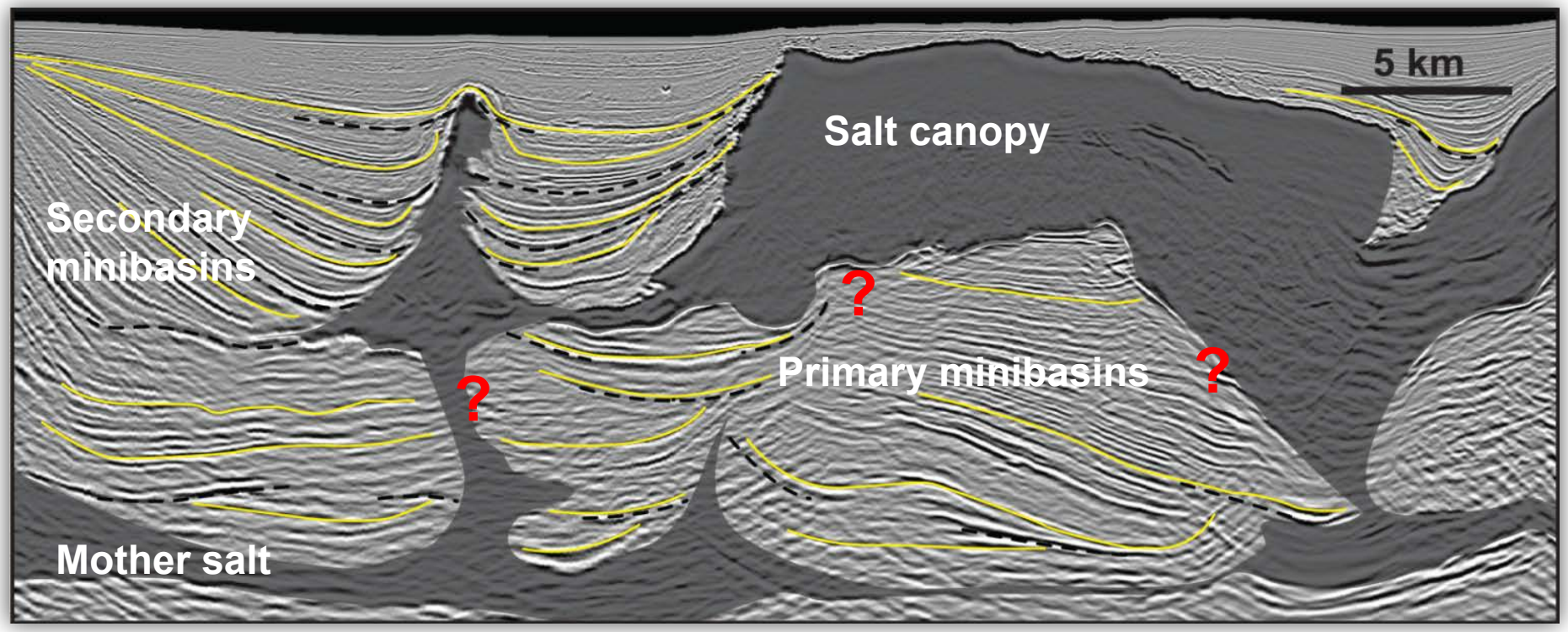
Two major petroleum provinces

Deep marine settings



WIDE AZIMUTH SEISMIC IS VERY GOOD BUT…

NEED FIELD ANALOGS AND MODELS

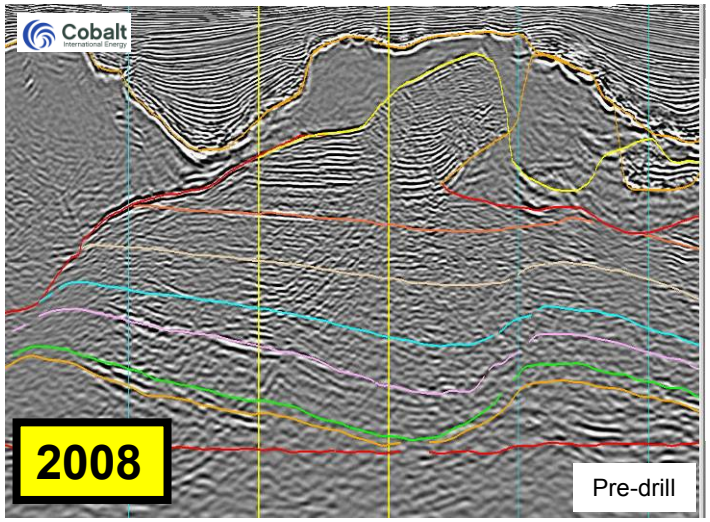


Important uncertainties

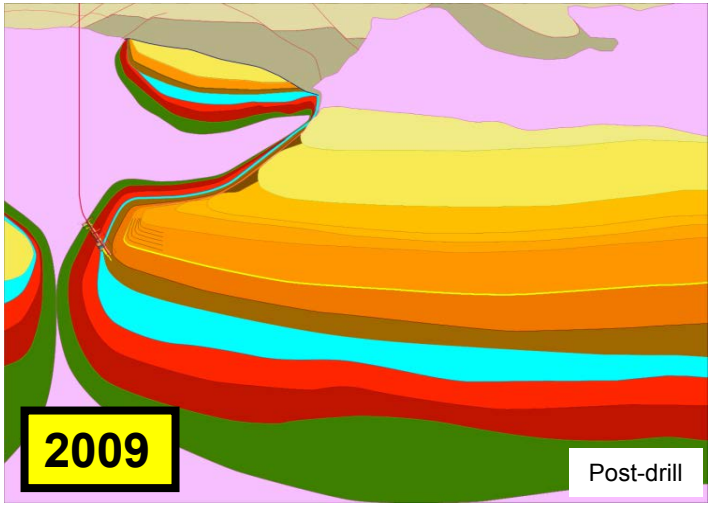
- ✓ Geometries against the salt walls
- ✓ Facies near the salt walls
- ✓ Sealing against/near the walls
- ✓ Diagenesis
- ✓ Fractures network…

A GEOLOGICAL FAIRY TALE

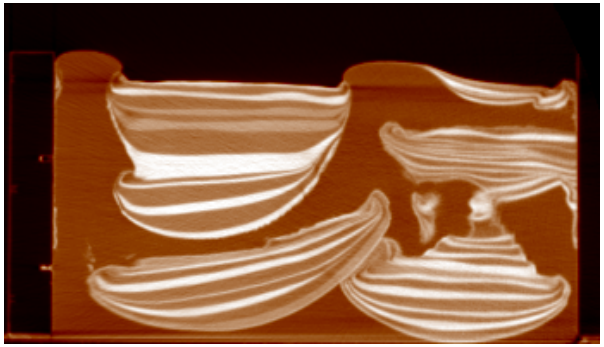
Subsalt GOM on Conventionnal 3D



Megaflaps : Ligurian, Heidelberg…



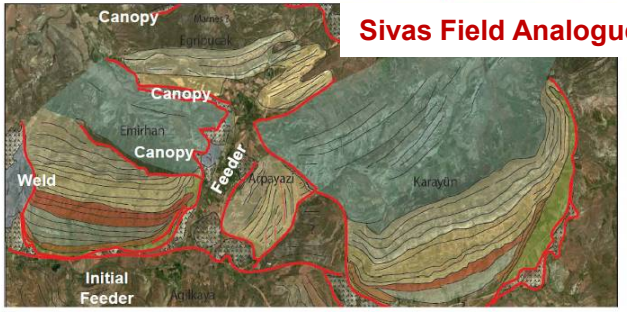
Analogue modeling



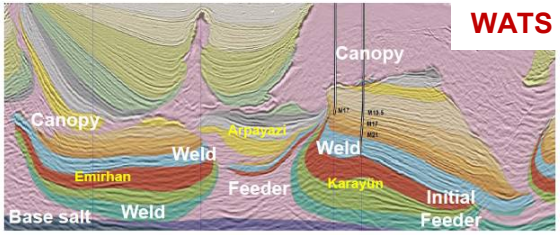
IFP for COBALT, Callot et al., 2016

2010

Sivas Field Analogue



WATS 3D



2011

TOTAL-UPPA
Structural Geology
Chair
Prof. JP Callot &

4 PhD students since 2012:
C. Ribes, C. Kergaravat
E. Legeay, A. Pichat


WNW
A
WSW
0
250m
A
ENE
1600m
1500m
1400m
1300m
INCEYOL MB
Karayün - Lacustrine
Karayün - Fluvial
S
EMIRHAN MB
Karayün - Fluvial
Gypsum
Gypsum
Karayün - Fluvial
ARPAYAZI MB
Karacaoeren - Marine
Gypsum
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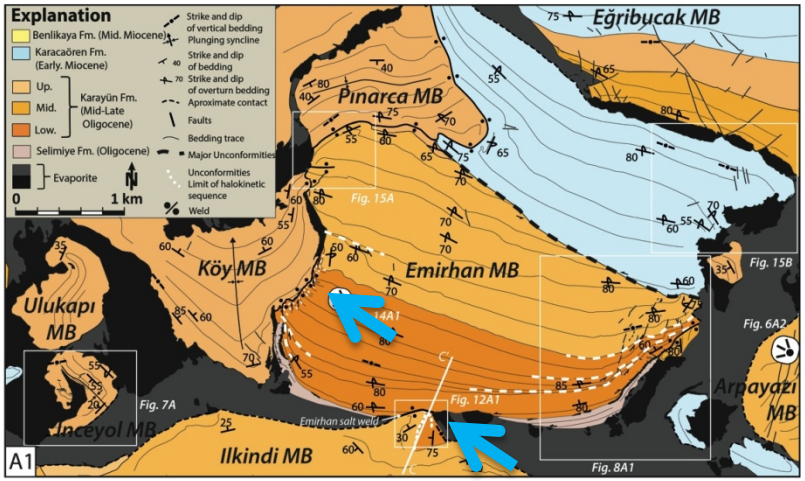
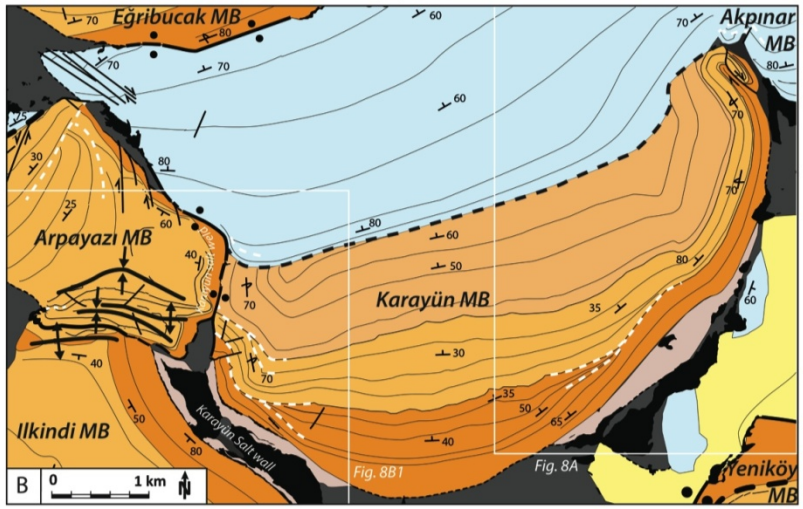
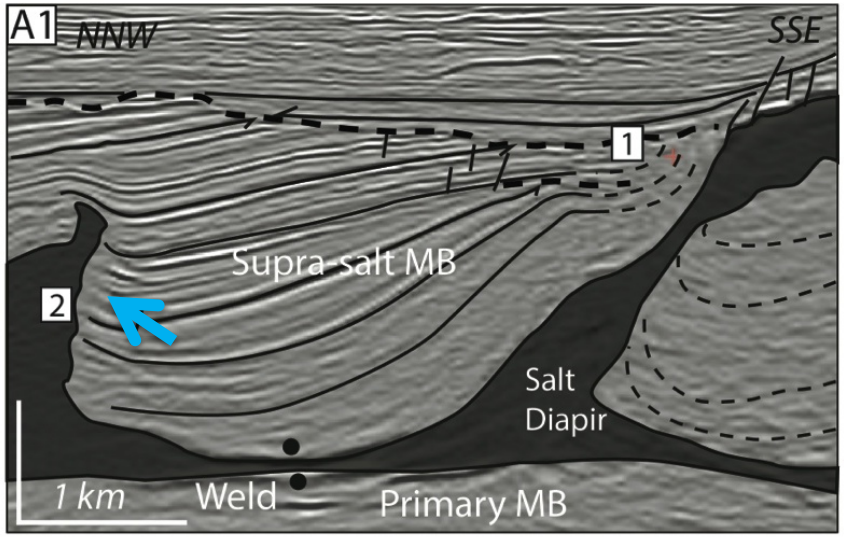
EMIRHAN MB
Karayün - Fluvial
Gypsum
ILKINDI MB

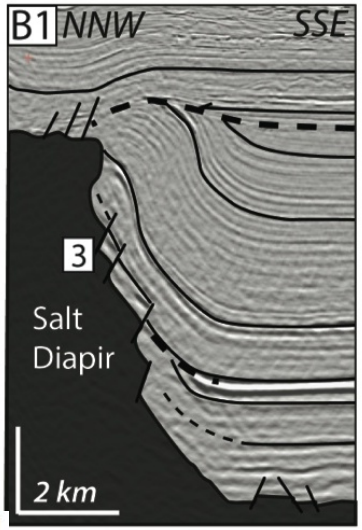
THE NOW FAMOUS EMIRHAN AND KARAYÜN MINIBASINS

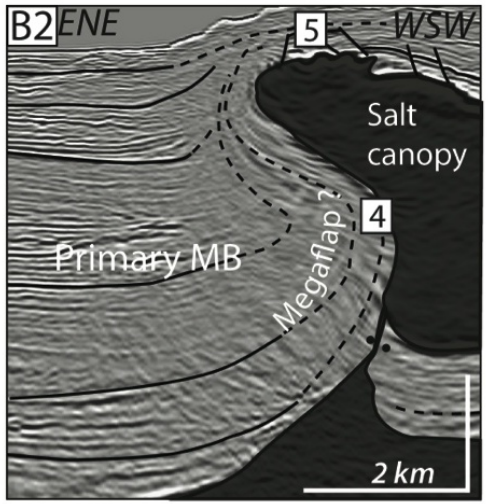




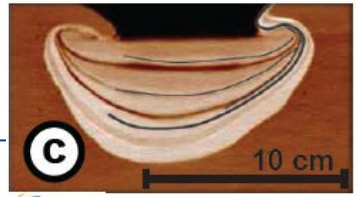
Kergaravat et al., submitted, 2016



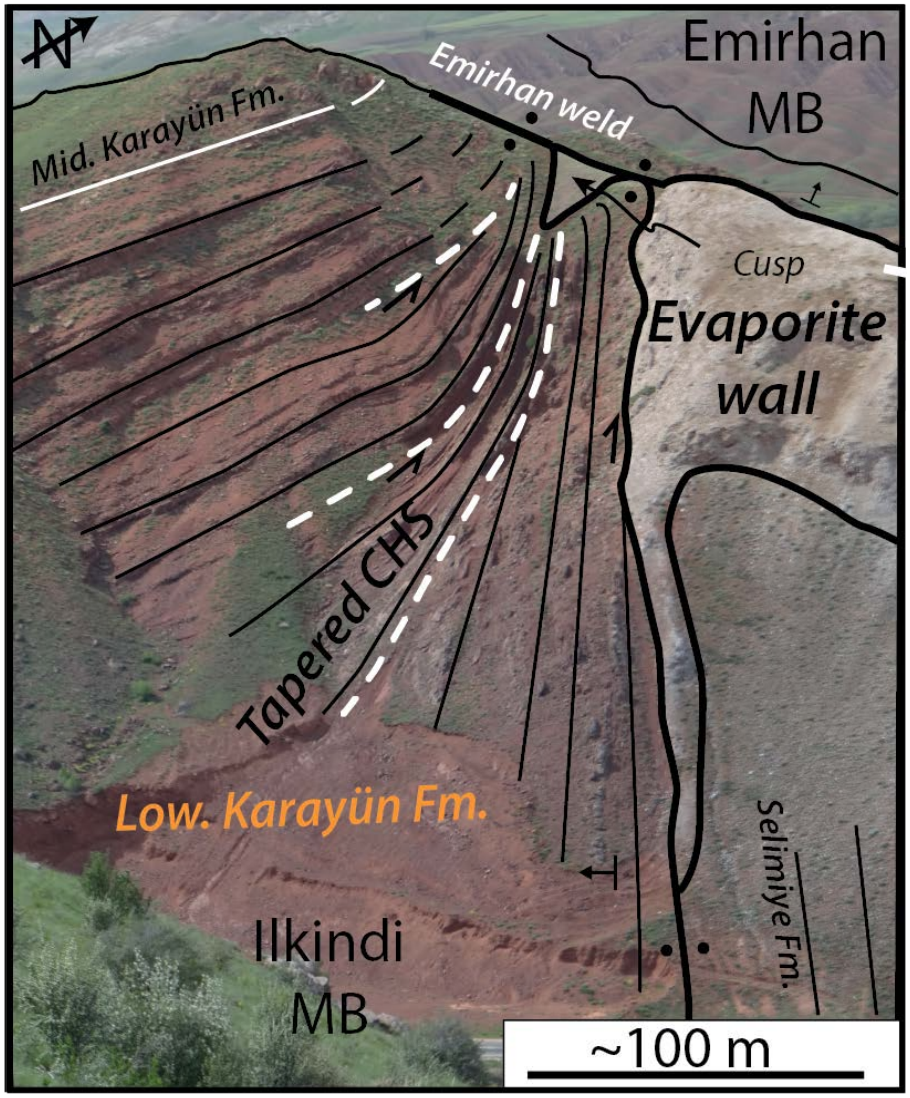


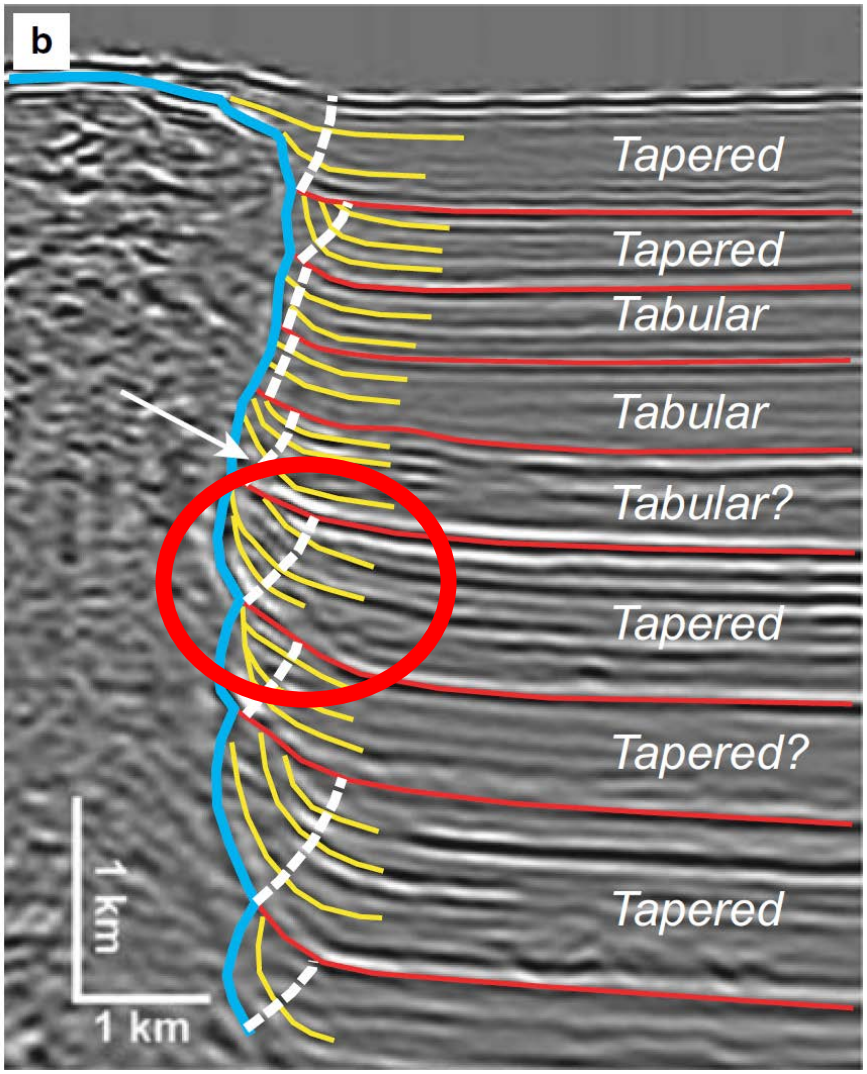


GOM



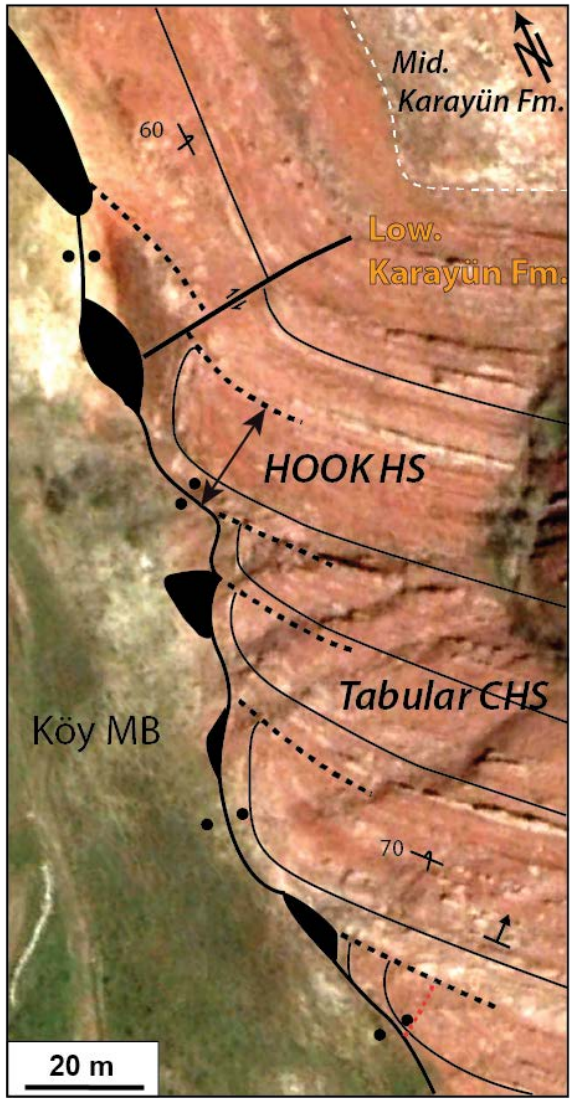
HALOKINETIC SEQUENCES: WEDGES



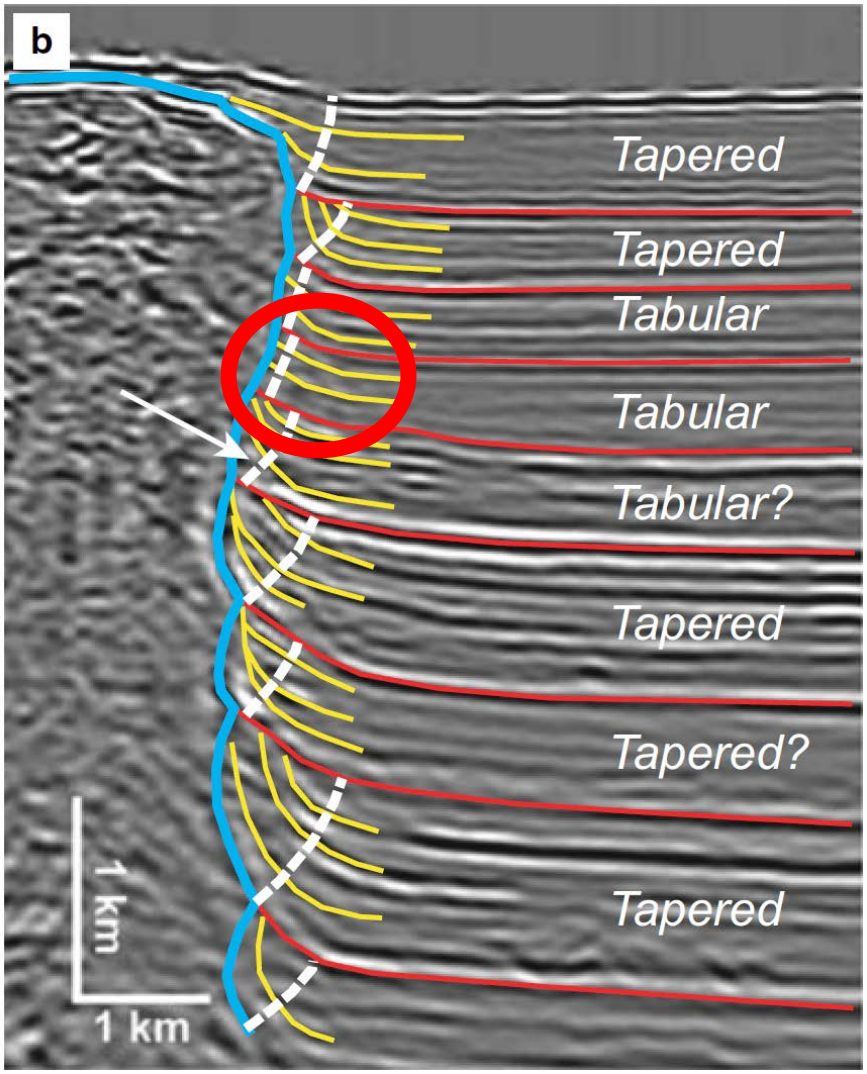


Giles and Rowan, 2012

HALOKINETIC SEQUENCES: HOOKS

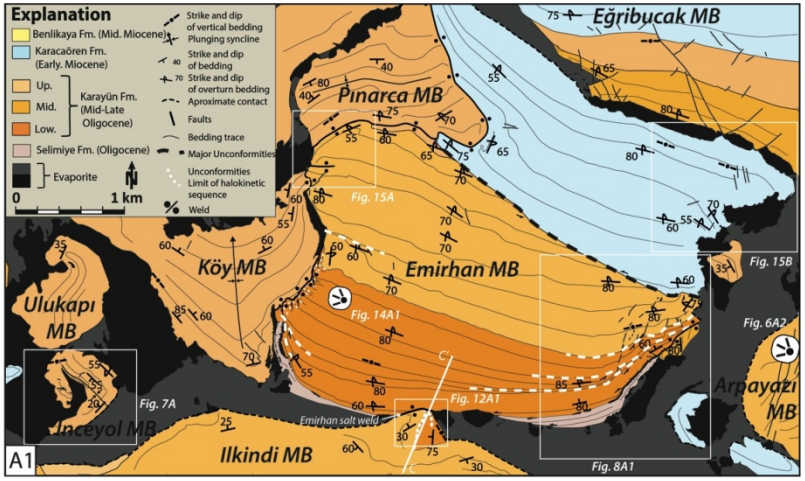


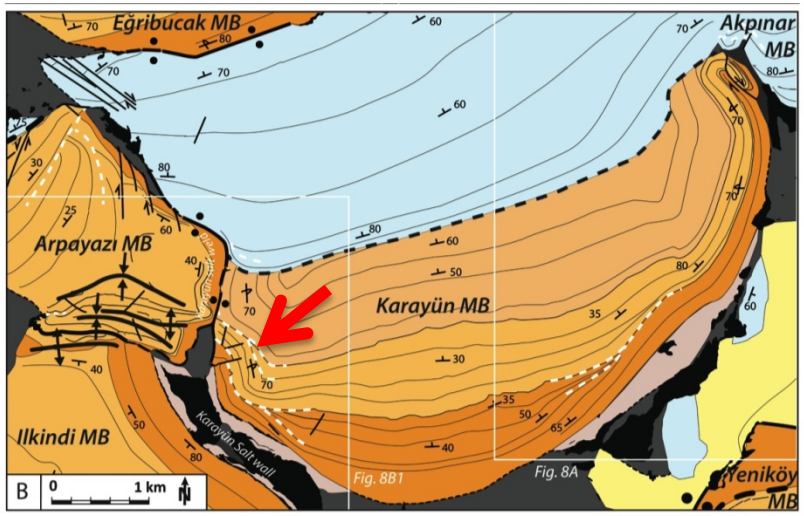
Kergaravat et al., submitted



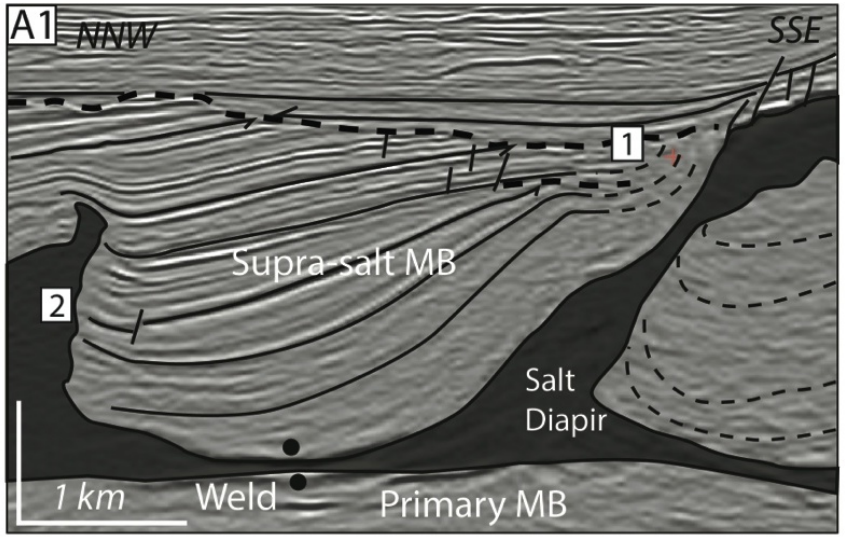
Giles and Rowan, 2012

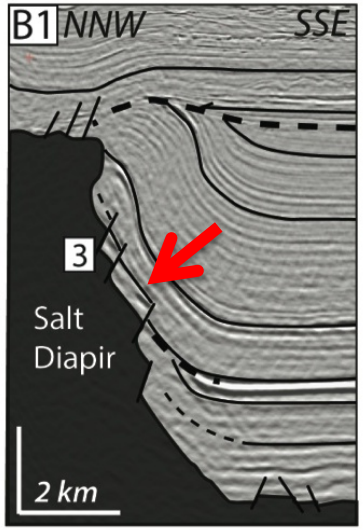
THE NOW FAMOUS EMIRHAN AND KARAYÜN MINIBASINS

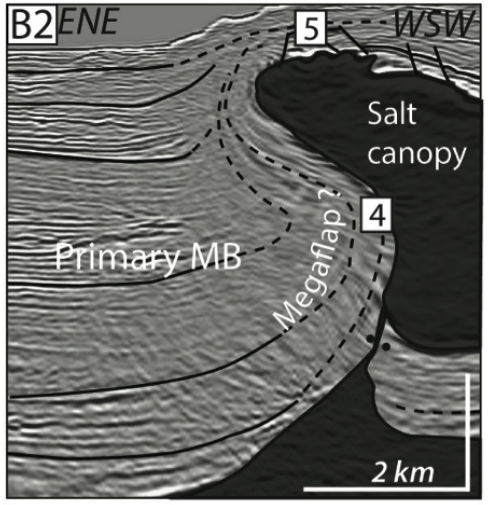




Kergaravat et al., submitted







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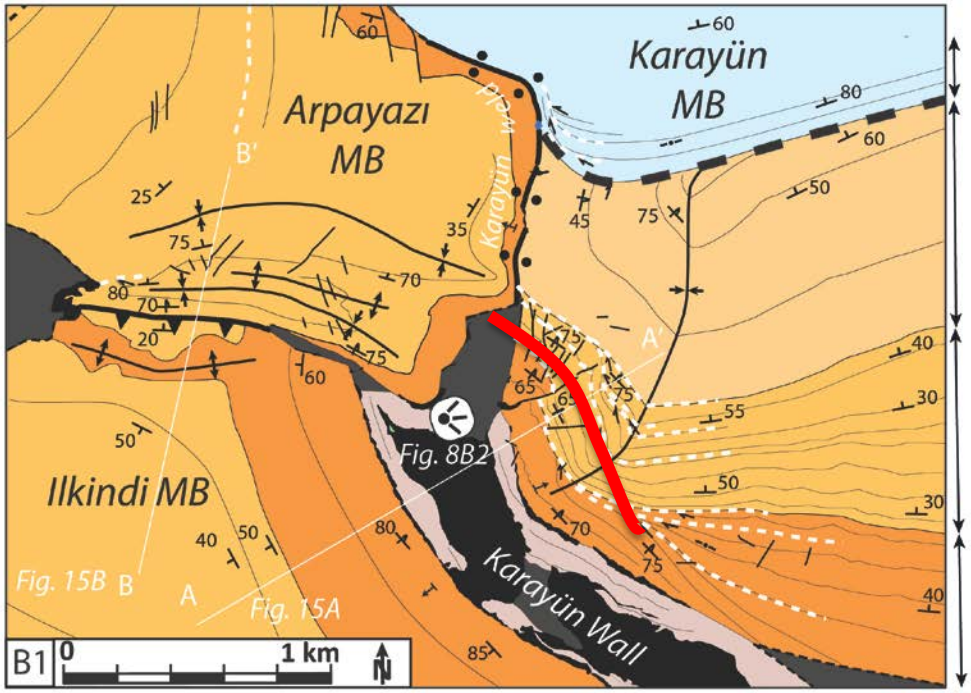
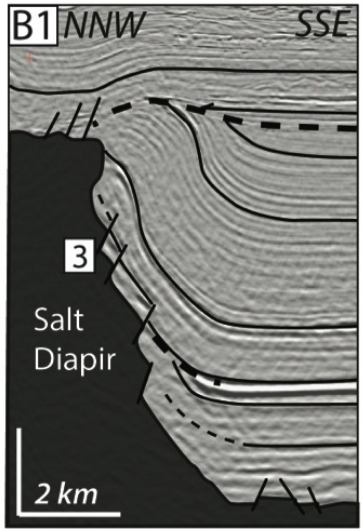
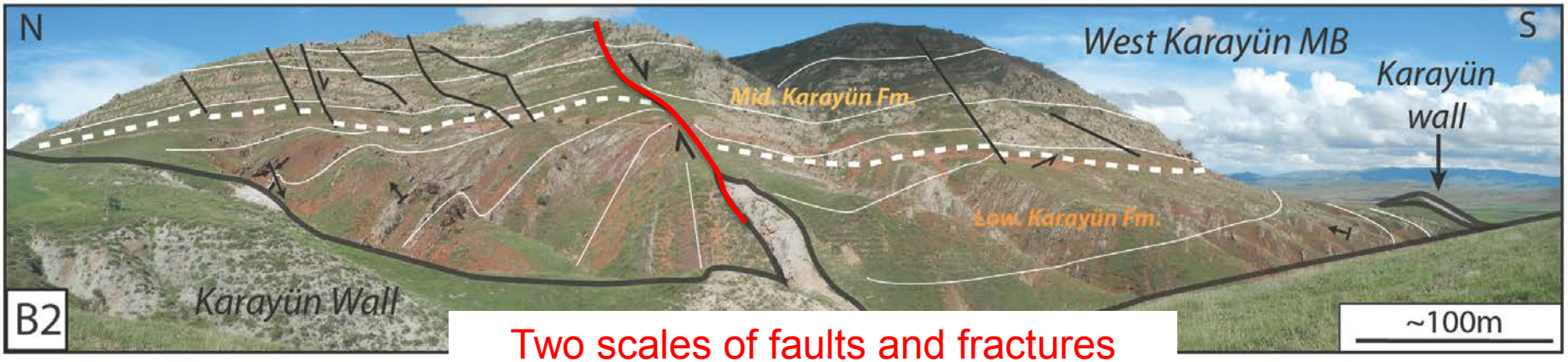
COMPOSITE HALOKINETIC SEQUENCES AND FAULTS



Kergaravat et al., submitted

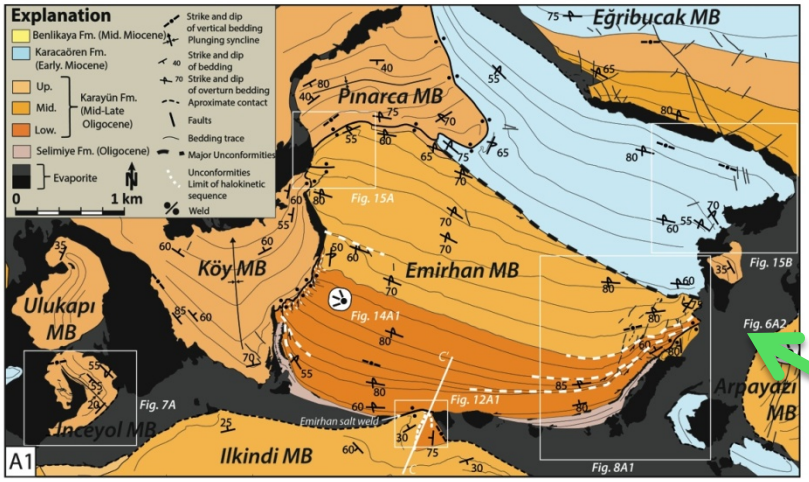
From seismic
to reservoir scale
Small faults and fractures

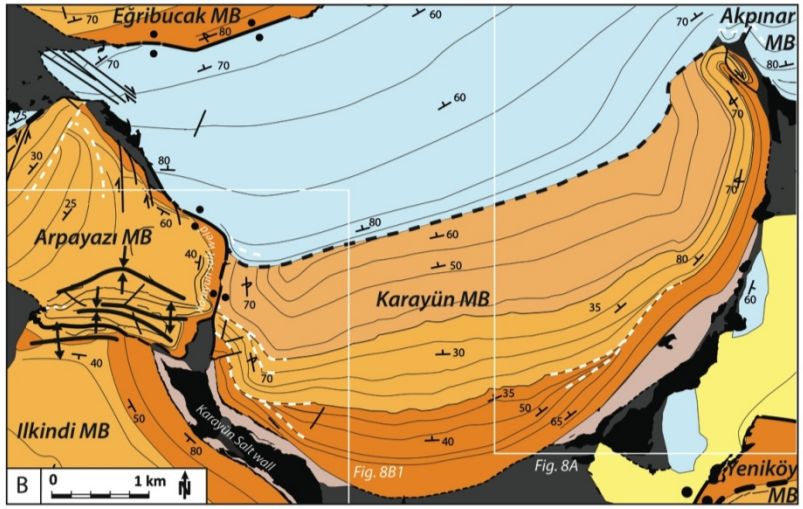


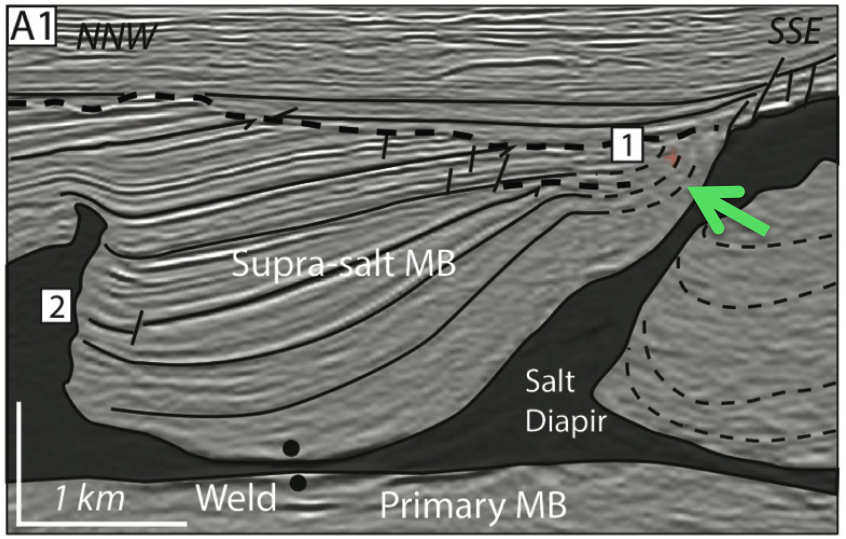


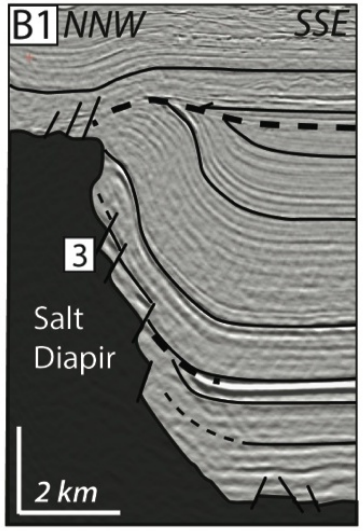
Two scales of faults and fractures

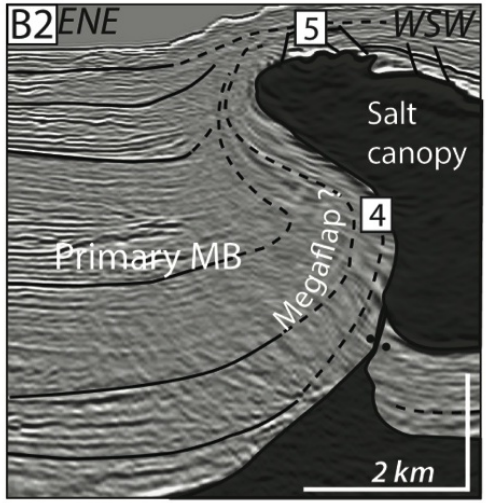
THE NOW FAMOUS EMIRHAN AND KARAYÜN MINIBASINS











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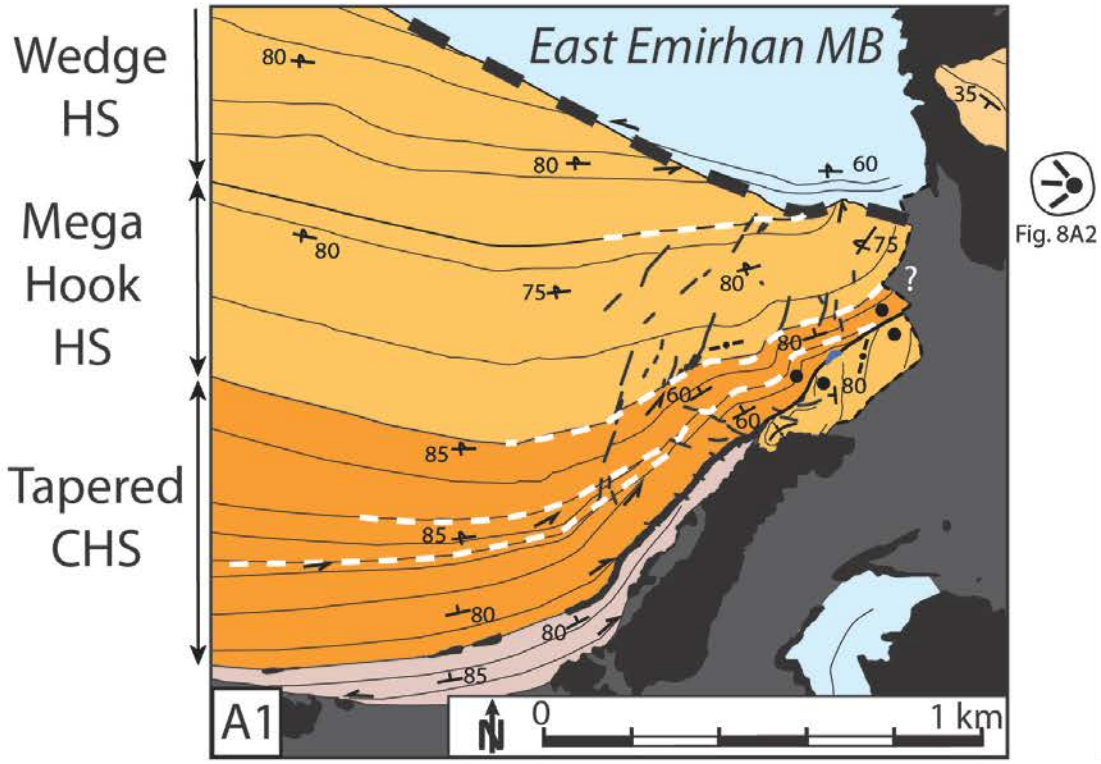
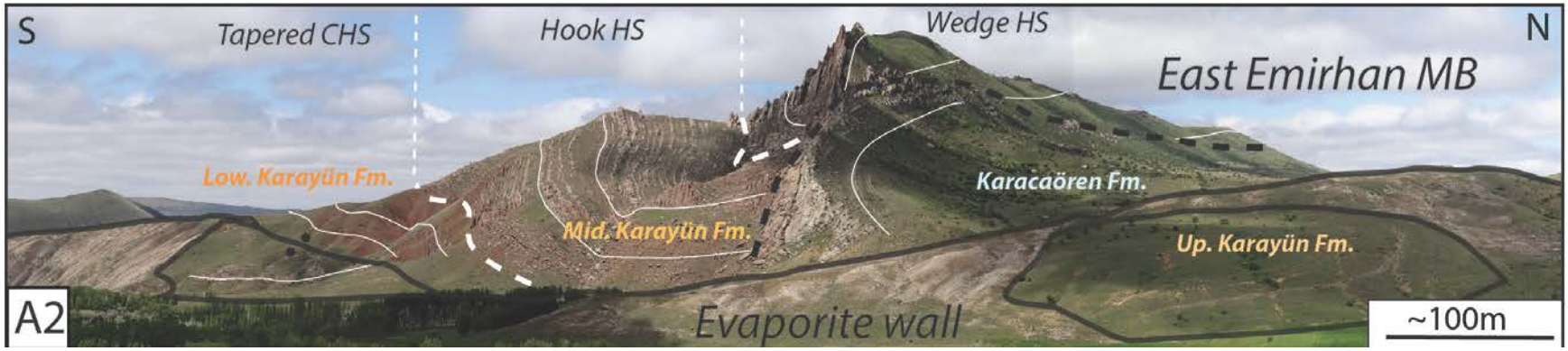
MEGAHOOK AND UNCONFORMITY





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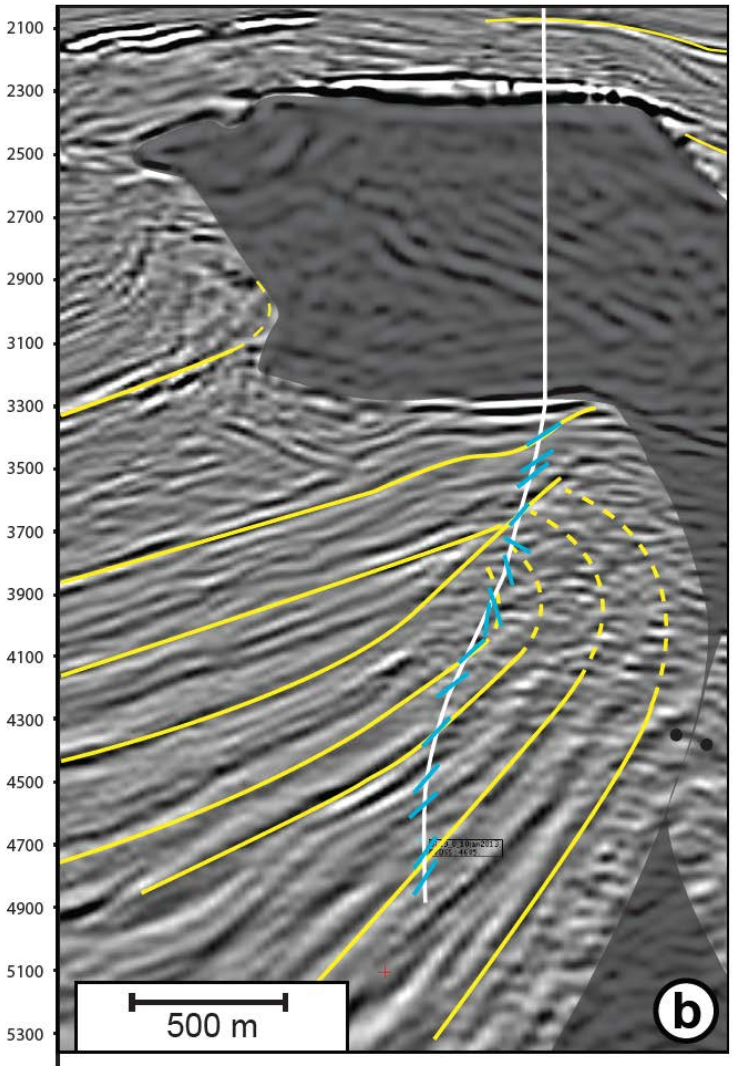

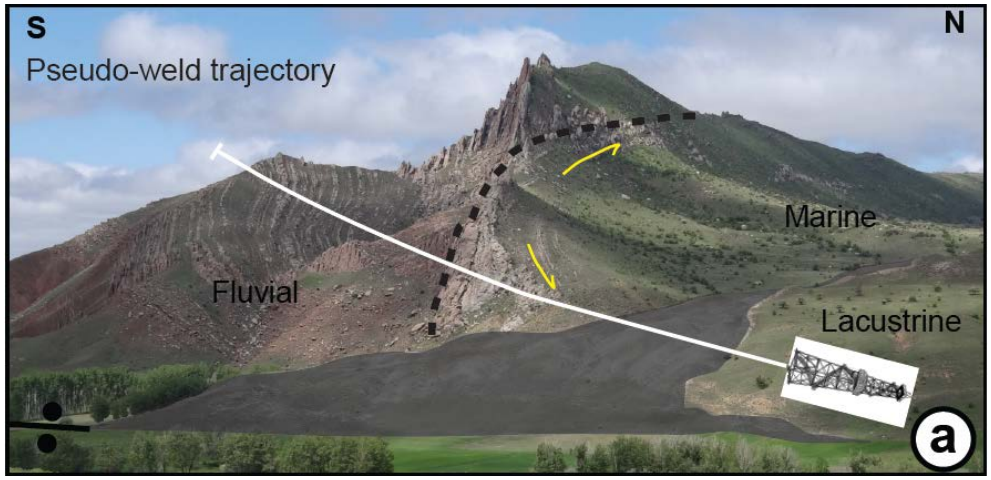

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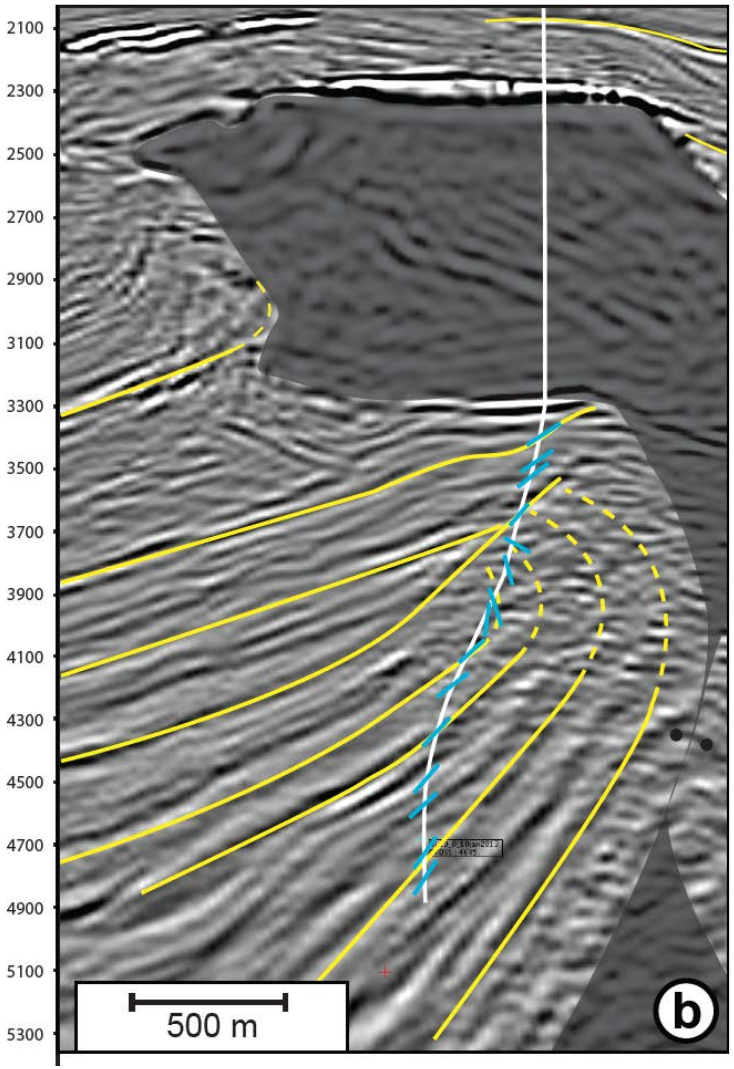
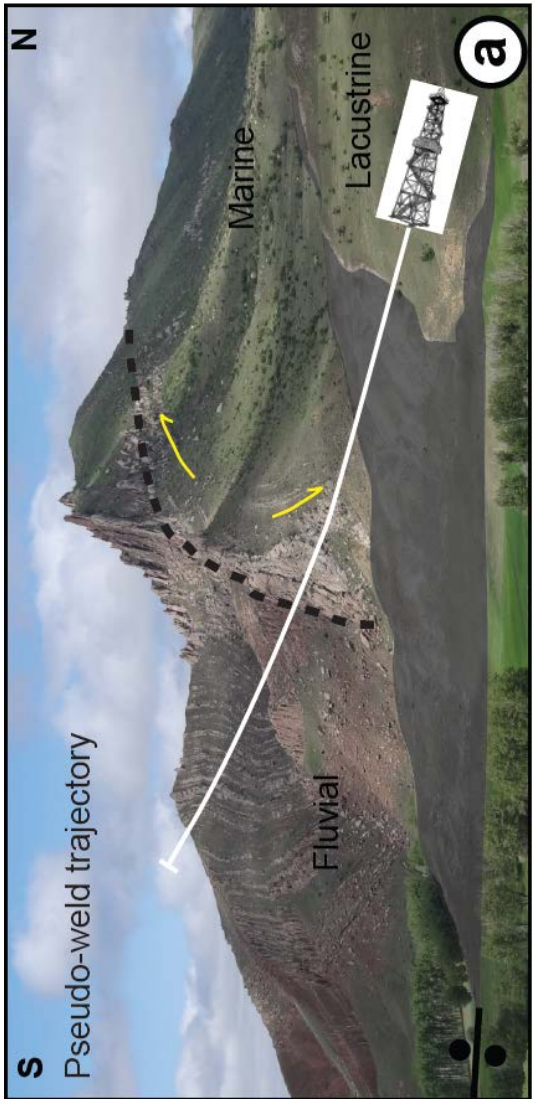
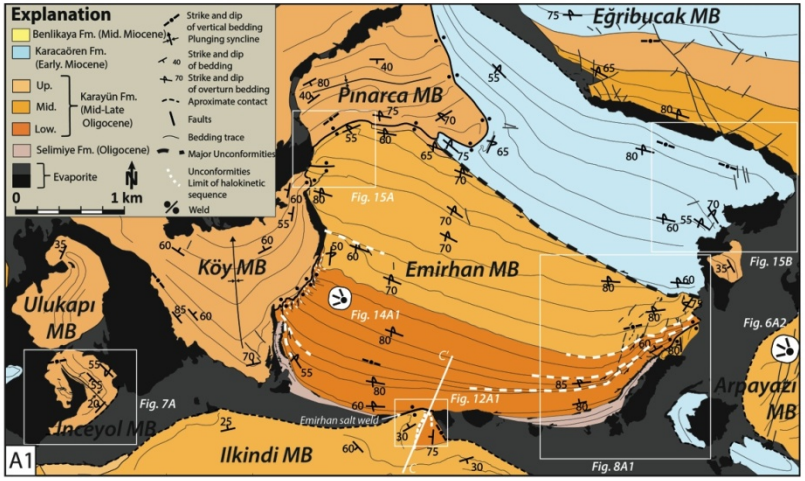
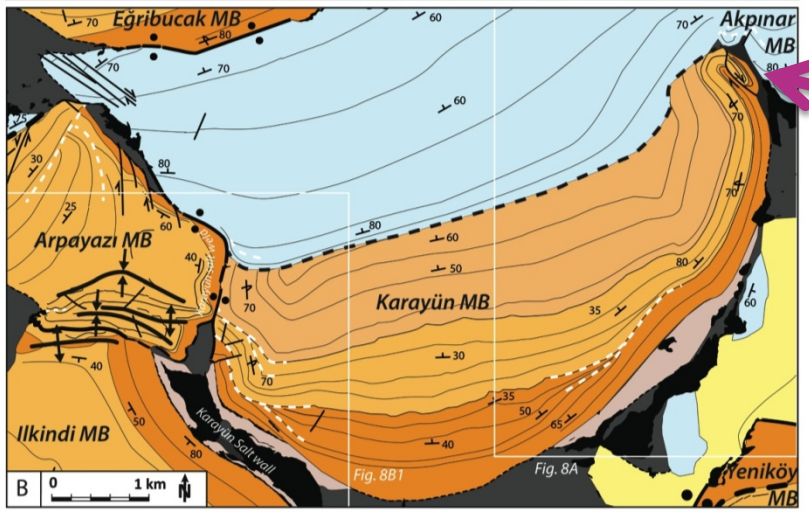
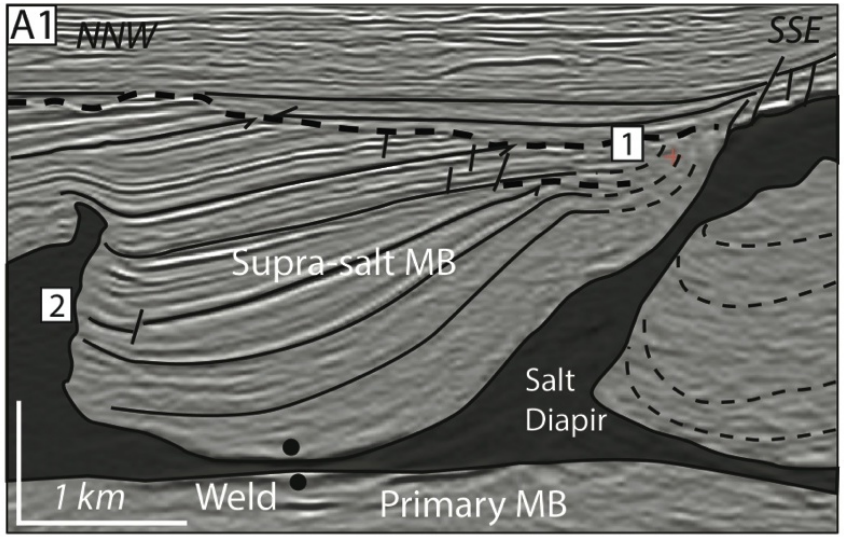


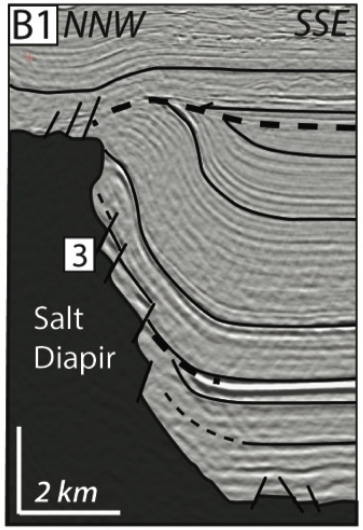


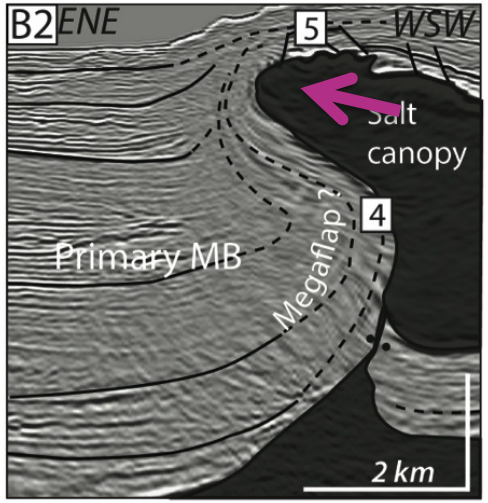
THE NOW FAMOUS EMIRHAN AND KARAYÜN MINIBASINS









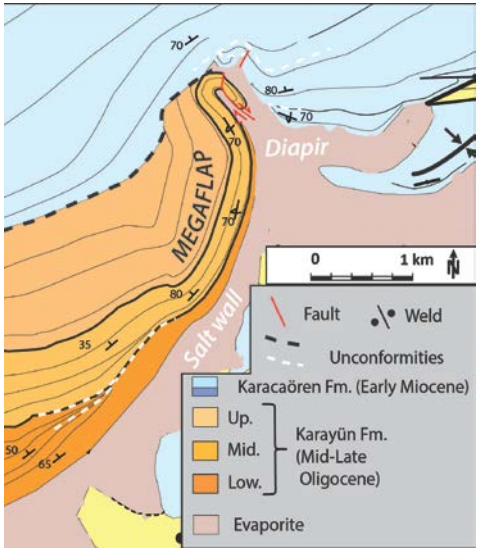


GOM

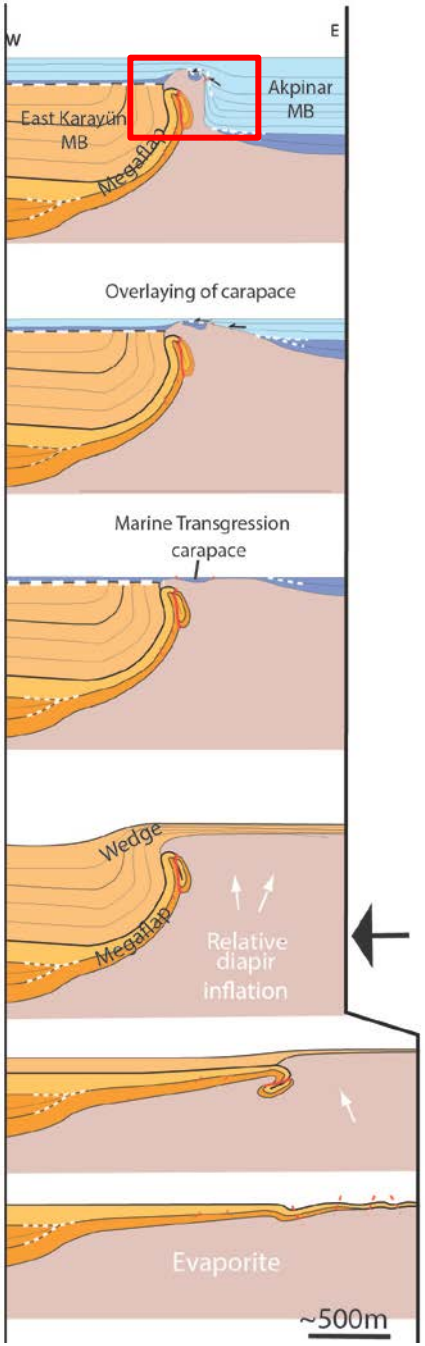
MEGAFLAP EVOLUTION

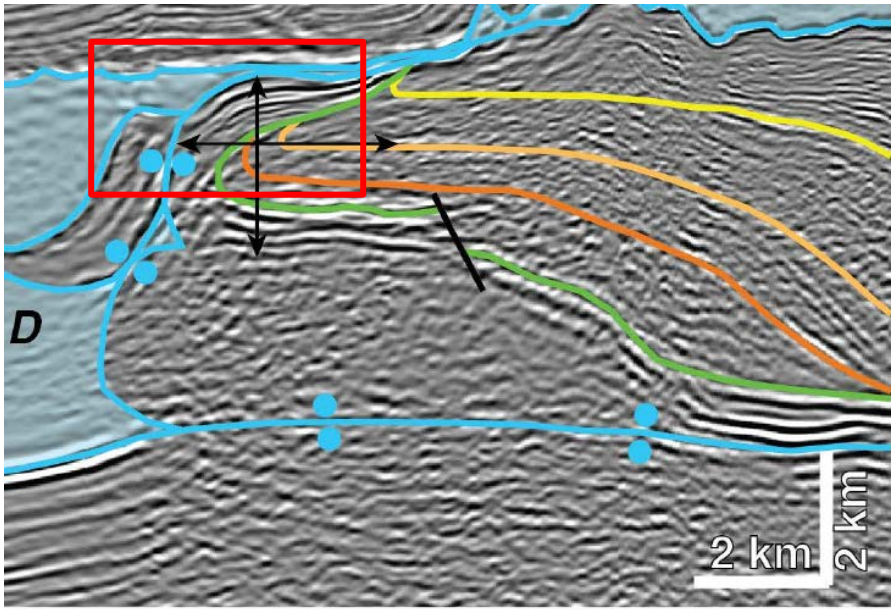
Complex tip geometries
Visible only on the field and FMI

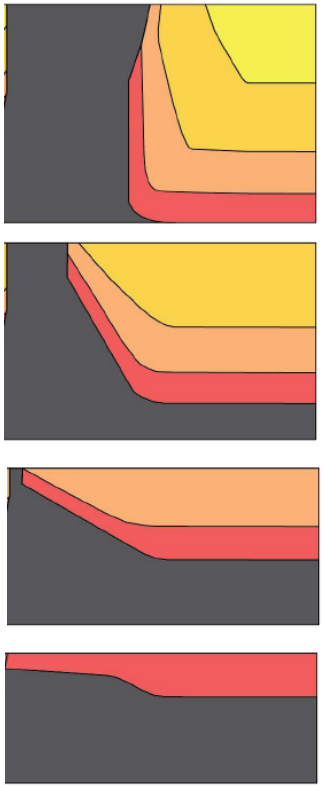
Without salt extrusion



Kergaravat et al., submitted







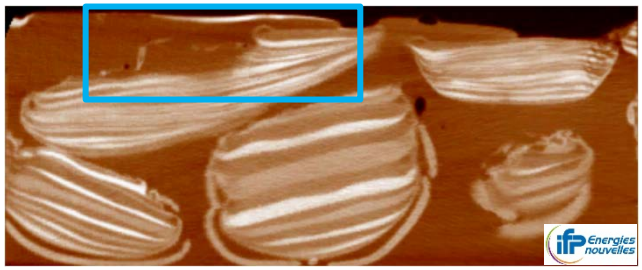
With salt extrusion
Below canopy

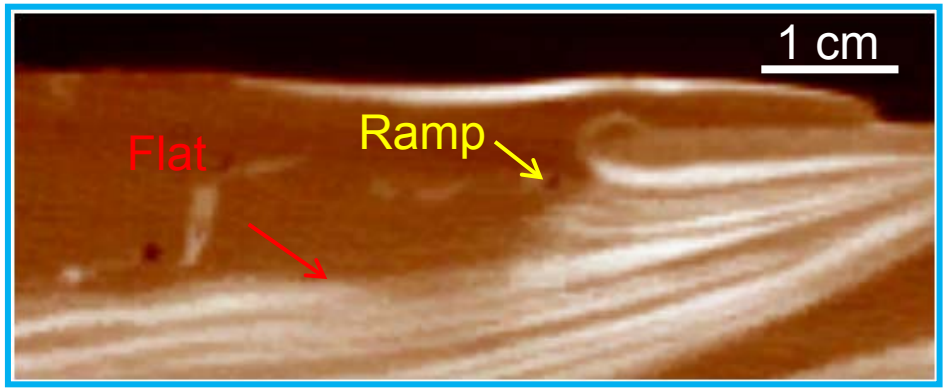
Limb rotation

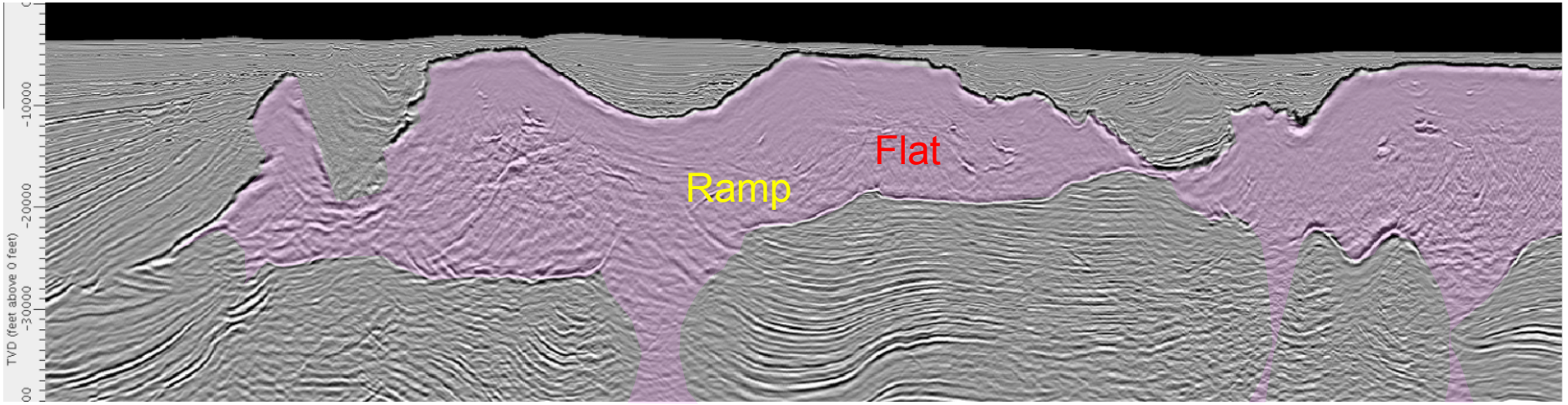
Rowan et al., 2016

TOTAL

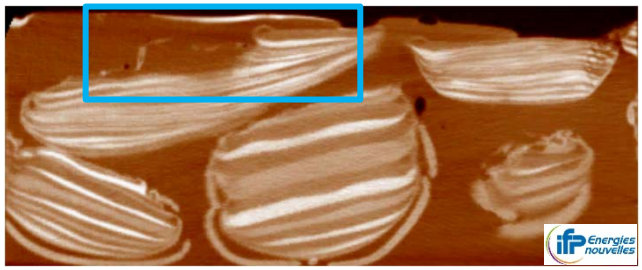
SALT SHEETS

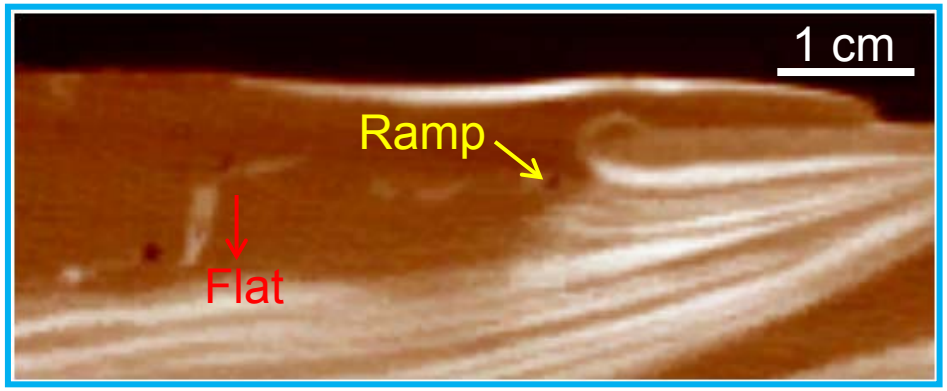


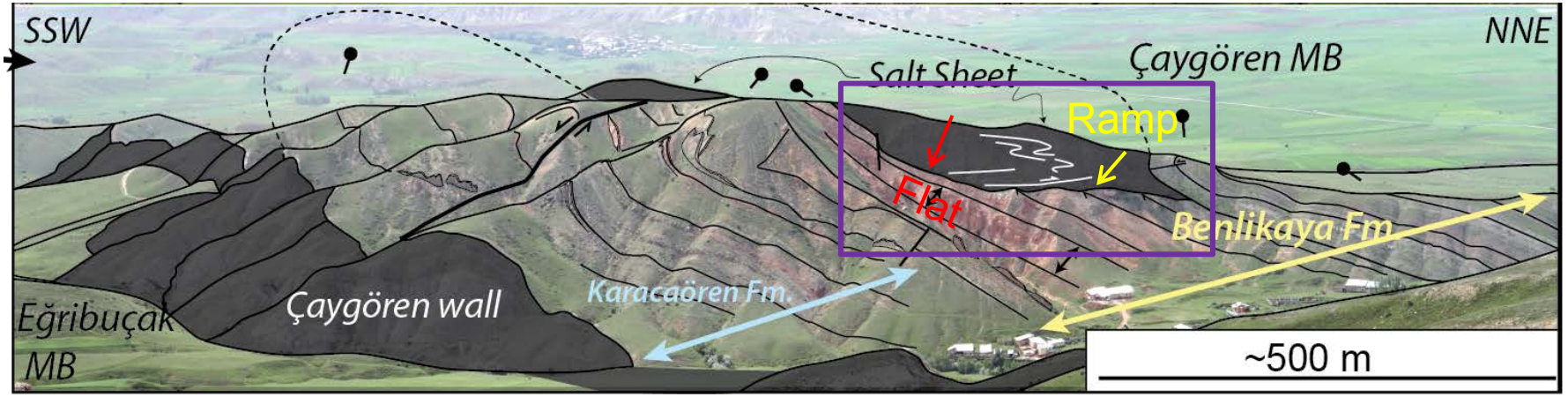

1 cm
Flat
Ramp

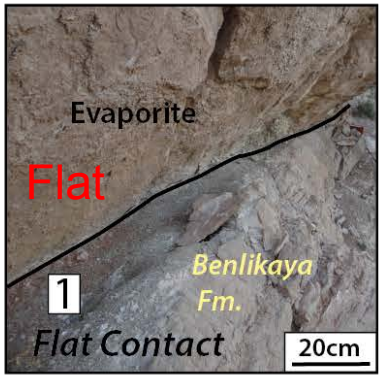

TVD (feet above 0 feet)
-10000
-20000
-30000
Flat
Ramp

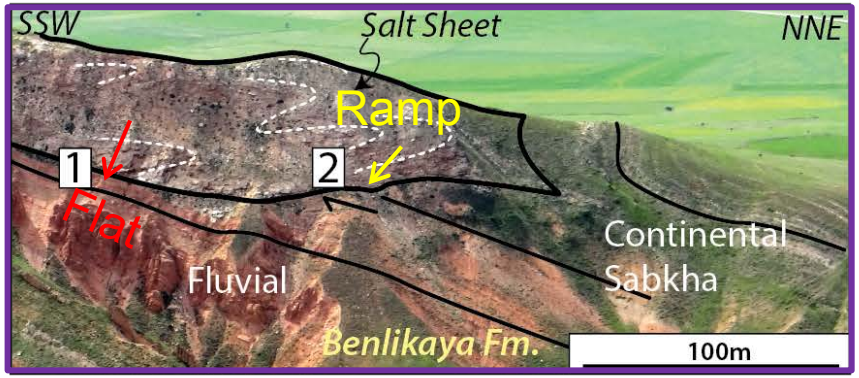
SALT SHEETS AT VARIOUS SCALES

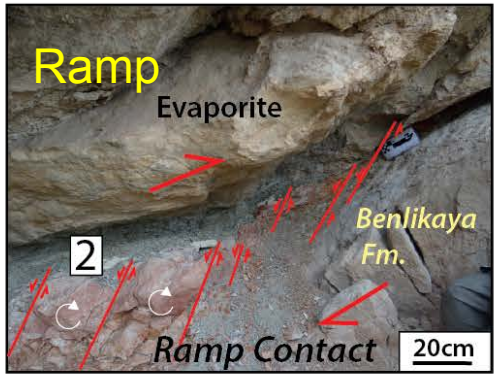






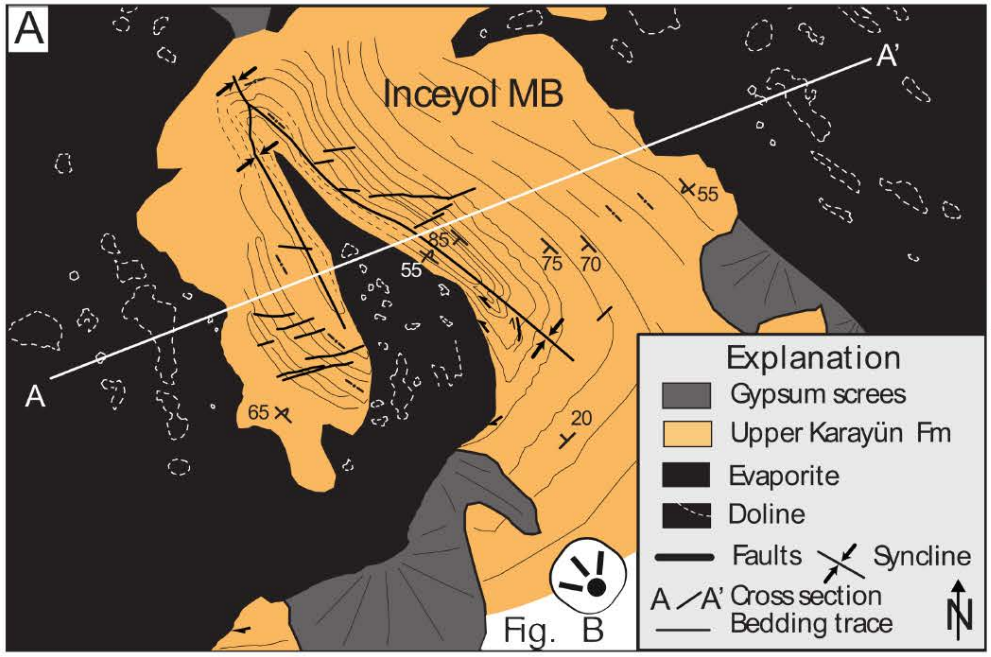


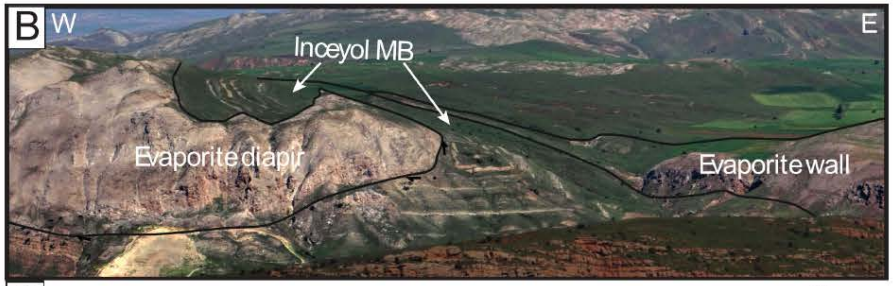


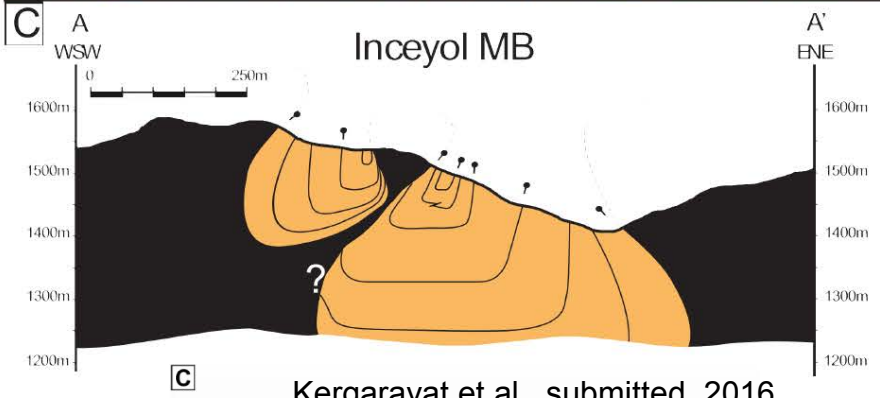


Kergaravat et al., submitted

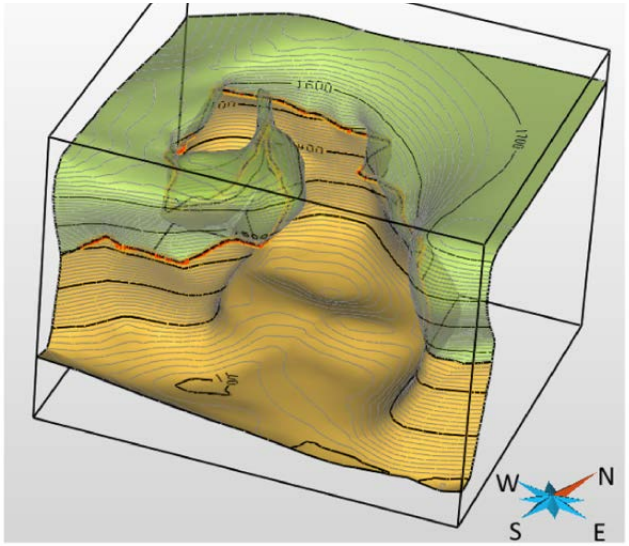
GOCAD 3D MODEL: INCEYOL MINIBASIN

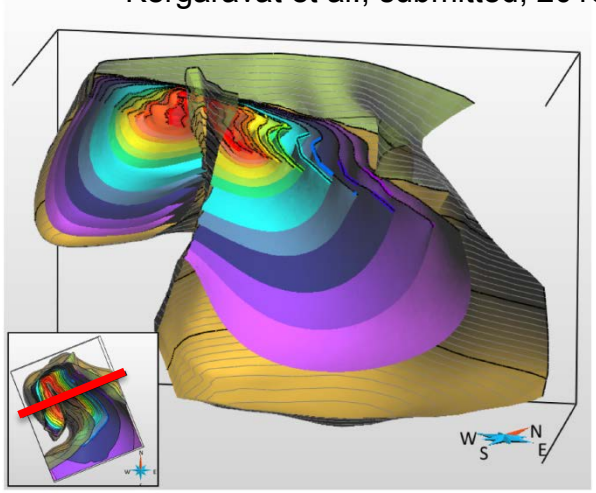




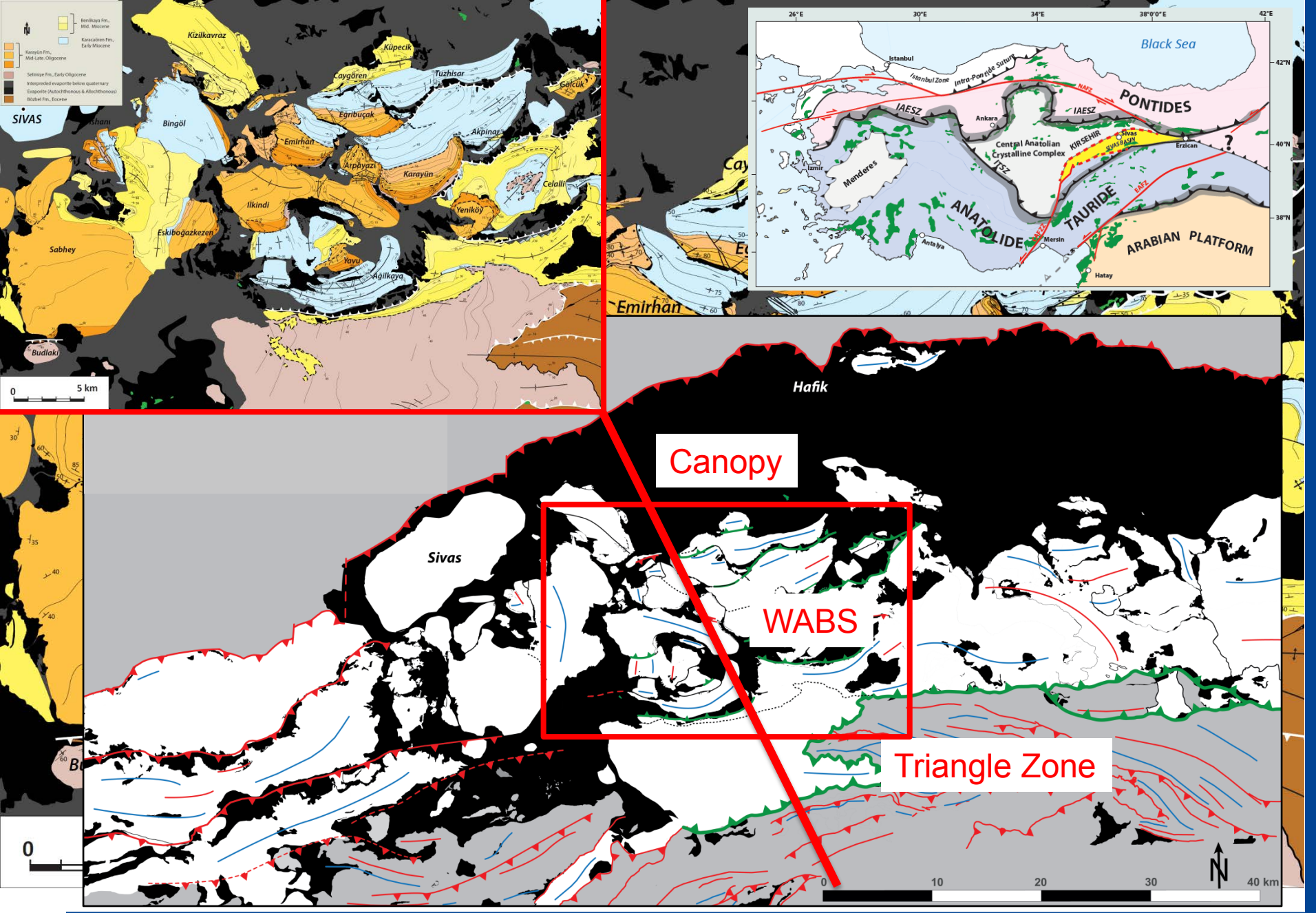


Kergaravat et al., submitted, 2016





Collon et al., 2016

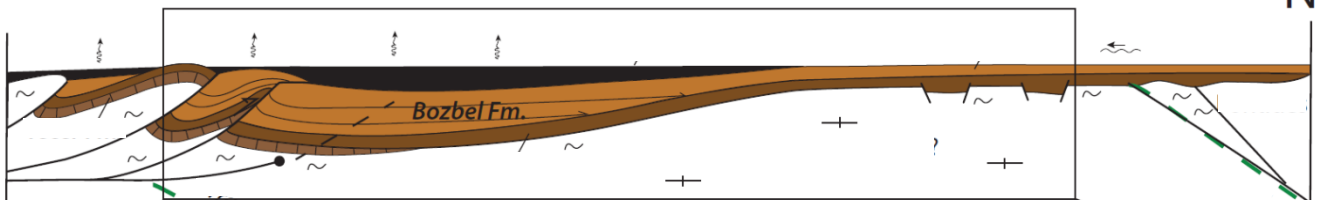


THE SIVAS SALT MACHINE

Thrust wedge

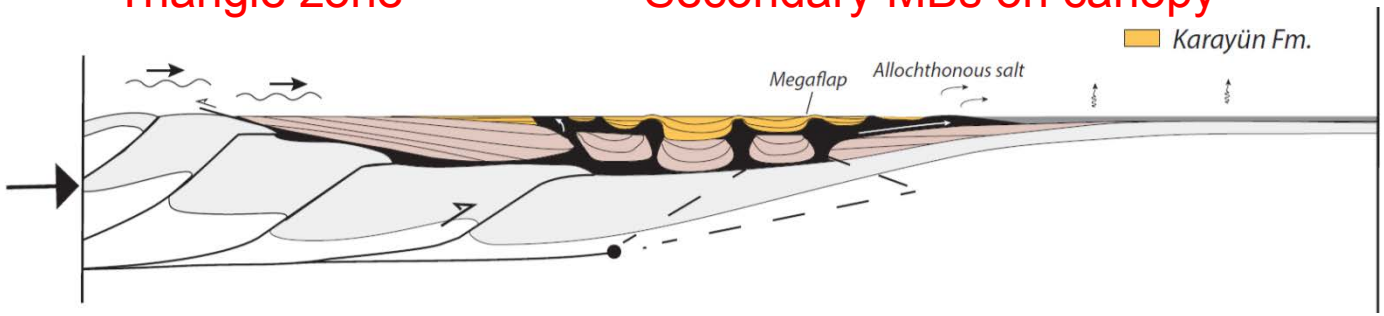
Salt basin in a foreland

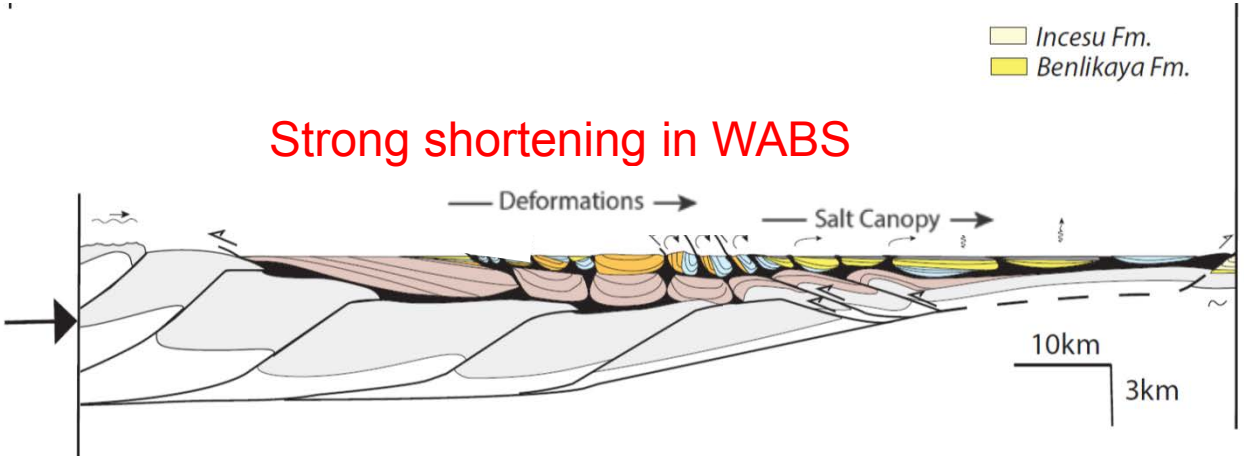
S N



Triangle zone

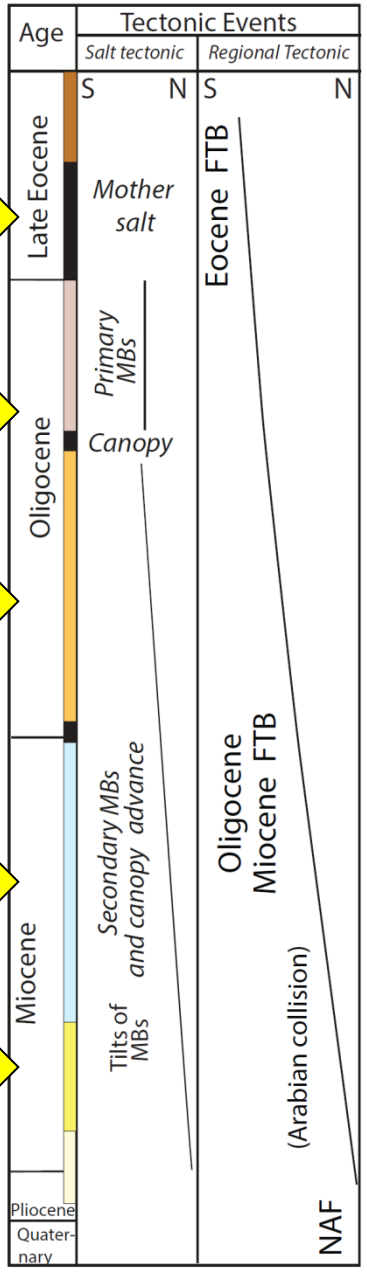
Secondary MBs on canopy





Strong shortening in WABS

Kergaravat et al., 2016



SIVAS ANALOGUE - HOW FAR

- Similarities with DO provinces:
  - Geometries and evolutions

- Differences with DO provinces:
  - Orogenic context vs passive margin context
  - Fluvial to very shallow marine sediments vs shelf to bathyal
  - Makes it difficult to compare facies distributions and diagenesis

- Large stock of evaporite is a strong driver whatever the tectonic system.
- Canopies act as a decoupling layer vs basement déformation
- Influence of tectonics context increases with salt withdrawal. Toward a typical Foreland FTB

A MOVIE: « salt tectonics + Sivas » in YouTube

COMING SOON: 3D Drone acquisition of the best outcrops

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