Recognition of Passive Salt Diapirism in the Rock Record*

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Abstract

Passive salt diapirs grow at or near the Earth's surface synchronously with the deposition of surrounding sediments. Recognition of passive diapirism in a basin can be problematic, especially when the salt has been substantially or even completely removed from the system due to dissolution. Yet understanding if, when, and where passive diapirism occurred is critical to structural restoration, burial history, and reconstruction of the tectonic evolution of basins. Additionally, the nature and integrity of hydrocarbon trap elements changes vastly when salt is involved, and passive diapirs greatly influence synkinematic reservoir distribution and quality.

The only "smoking gun" for passive diapirism is stacked halokinetic sequences adjacent to either a salt body or interpreted faults. When in contact with faults, which are in fact welds, halokinetic strata on both sides of the fault/weld dip away from it regardless of fault type. Growth strata associated with salt-cored detachment folds may superficially look similar to halokinetic sequences, but they do not display stratigraphic discordance or stratal truncation with the salt body and have a scale that widens as the overburden thickness increases. Salt-cored detachment folds may become passive diapirs when the fold crest is breached or significantly thinned permitting salt break out, in which case local drape folding is superimposed on longer-wavelength contractional folding. Inclusion of locally-derived detritus that includes non-evaporite clasts sourced from the layered evaporite sequence (LES) or caprock (gypsum/anhydrite or carbonate) in surrounding strata, strongly suggests passive diapirism. Other features that are not exclusive to it, but that hint at possible passive diapirism, are polygonal structural patterns and unusual

thrust map traces. Conversely, salt bodies with only structurally concordant and stratigraphically conformable overburden are not passive diapirs.

When developing structural plays in known salt basins, we highly recommend carefully assessing at what stages passive diapirism has played a role. Also, when working basins that have no reported salt, but were associated with the two major periods of continental break-up in Earth's history (i.e. late Neoproterozoic breakup of Rodinia and early Mesozoic breakup of Pangea), "faults" with unusual flanking stratal geometries or discontinuous igneous bodies along their lengths should be viewed with suspicion.

Selected References

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Talk Layout

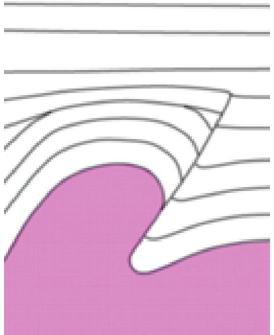
- Passive diapir definition
- Importance of recognizing if, when, & where passive diapirism occurred
- Ways to recognize passive diapirism
- Example of concept application
- Conclusions

Diapir vs Passive Diapir

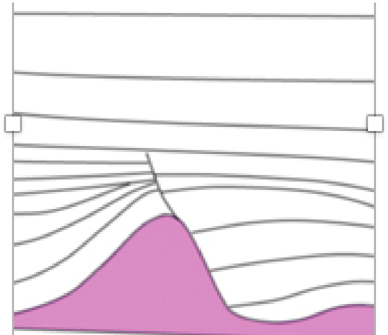
Mass of salt that has flowed in a ductile manner and has discordant contacts with the encasing overburden (*The Salt Mine*)

Syndepositional growth of a diapir as sediments accumulate around it (*The Salt Mine*).

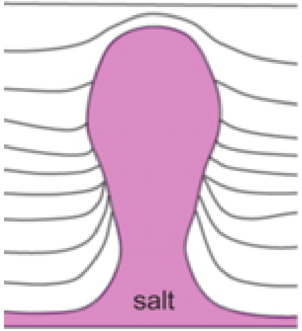
Thrusted, salt-cored anticline



Salt-cored normal fault (roller)



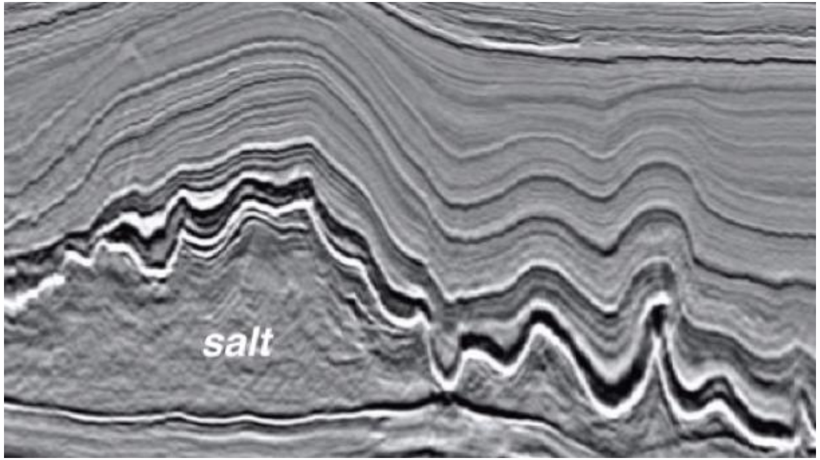
Passive (downbuilt)



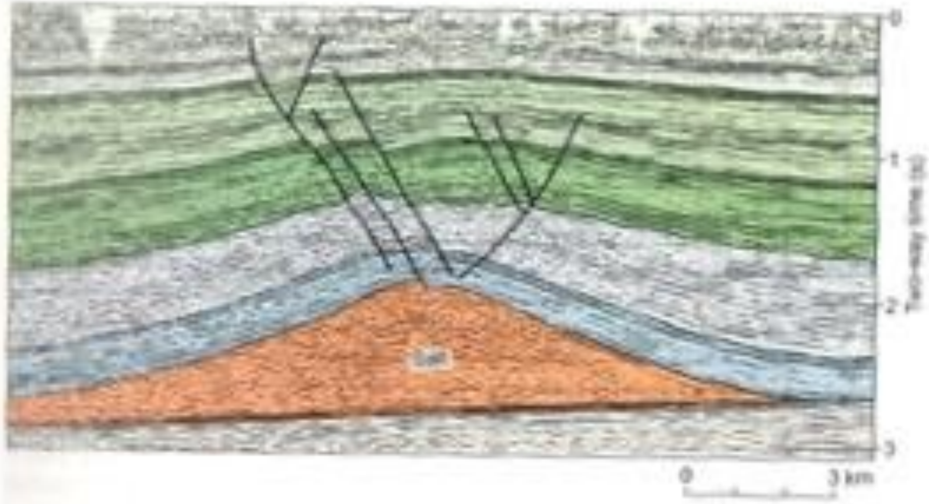
http://sp.lyellcollection.org/content/363/1/245

Structurally Concordant and Stratigraphically Conformable Overburden are not Diapirs!

- Salt-Cored Detachment Folds
- Inflated Salt Pillow



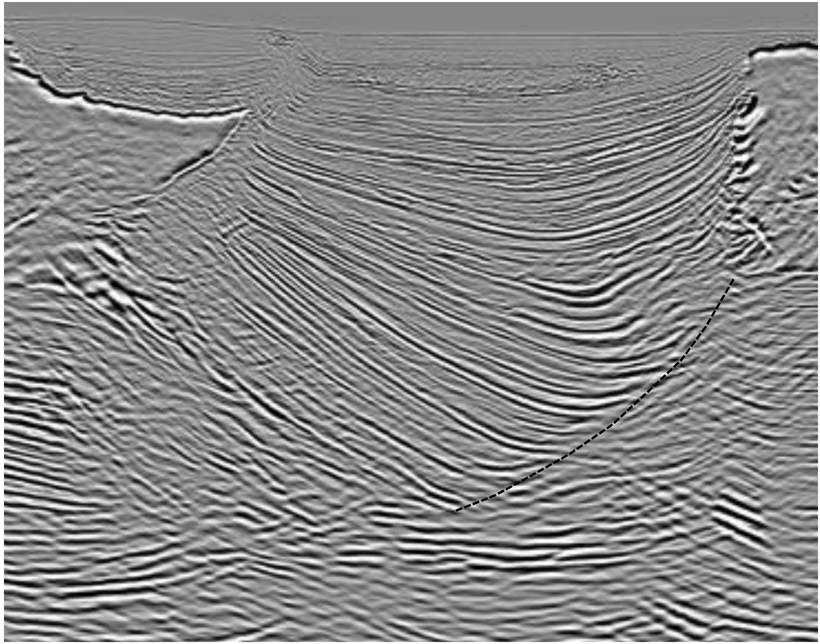
(after Twigger, 2015)



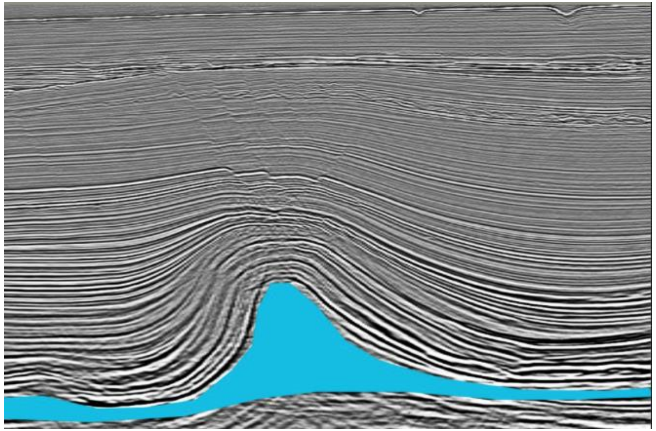
(From Jackson & Hudec, Salt Tectonics, 2017)

What's the Big Deal About Recognizing Passive Diapirism?

- Nature and integrity of hydrocarbon trap elements
- Nature of near-salt deformation styles
- Structural restoration
- Burial & hydrocarbon migration history
- Reconstruction of the tectonic evolution of basins



Salt-Cored Detachment Folds



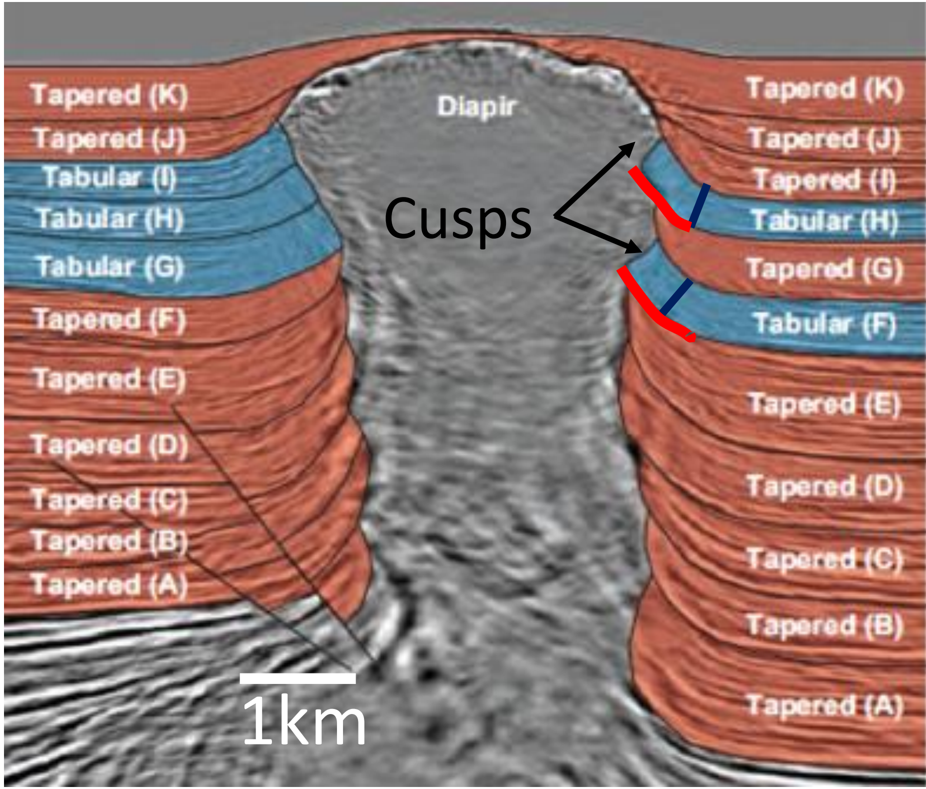
Courtesy Frank Peel & BHP

- Folding driven by tectonics or gravity
- Concordant & comformable strata above salt detachment
- Broad zone of folding
- Prekinematic =subparallel bedding in limbs
- Synkinematic growth strata onlap broad dome
- Polyharmonic folding/increase in wavelength as overburden thickens

Passive Diapirs Have Halokinetic Sequences

- Drape folding of roof strata
- Process related to downbuilding
- Thinning & upturn <1km
- Tapered/wedges vs Tabular/hooks
- Local angular unconformities (red)
- Salt margin cusps at SB
- Axial fold trace varies between HS
- Strata often contain diapir-derived detritus or roof-derived detritus

See Giles & Rowan (2012) for details

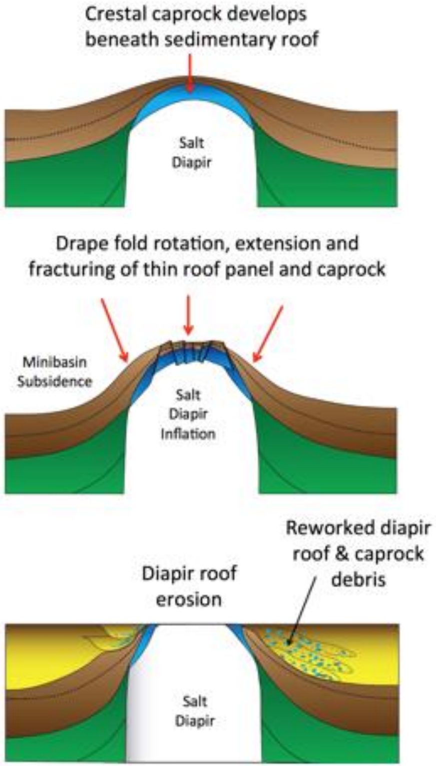


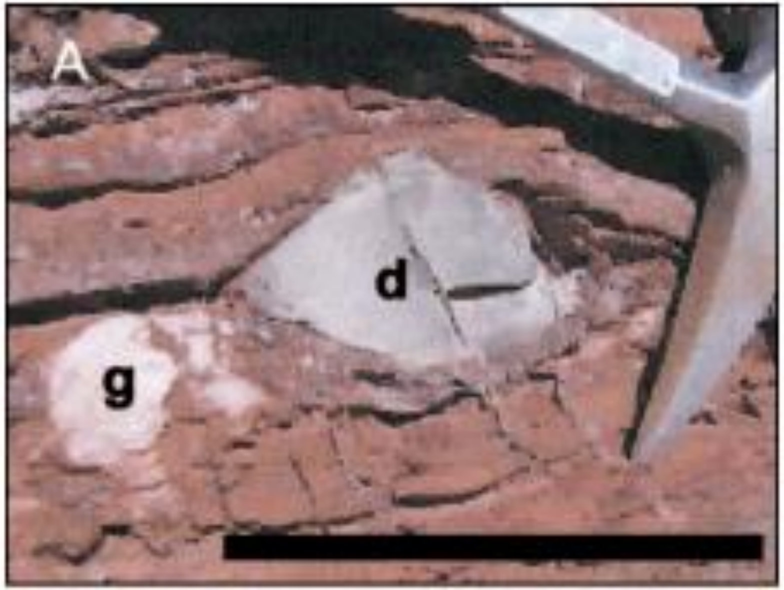
(Hearon et al., 2014).

Diapir-Derived & Roof-Derived Detritus

Reworked detritus derived from:

1. LES
2. Caprock
3. Thinned roof

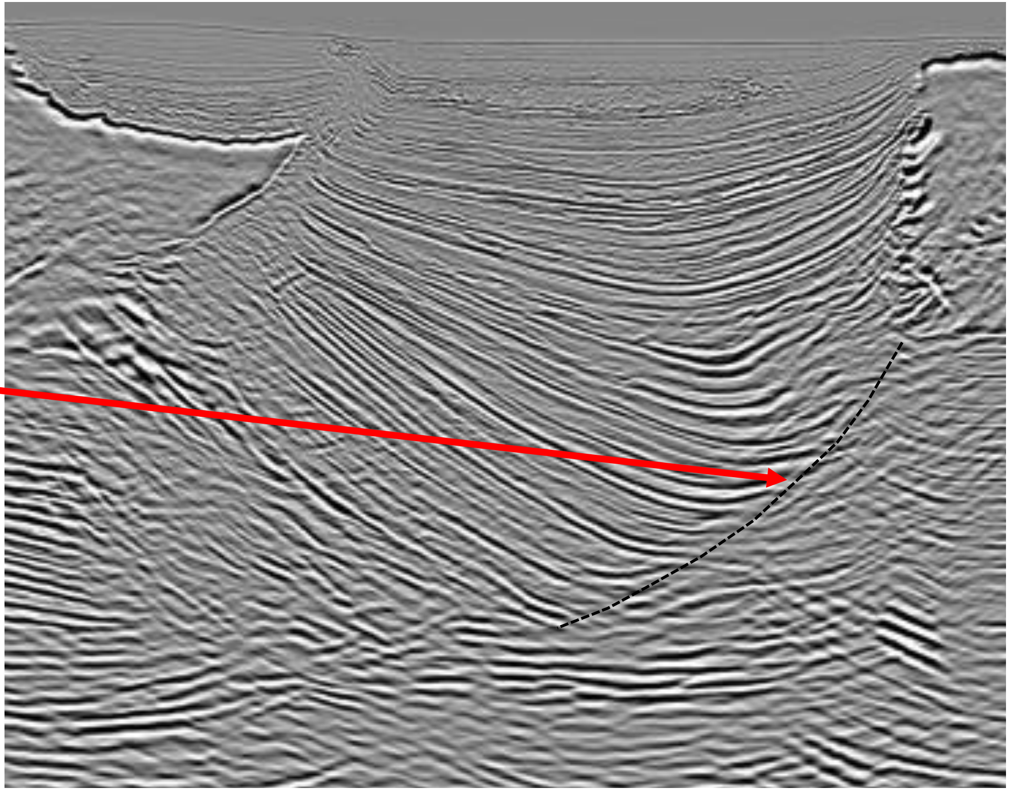




Diapir- derived clasts in Triassic Moenkopi Fm., Castle Valley Salt Wall, Paradox Basin (Lawton & Buck, 2006)

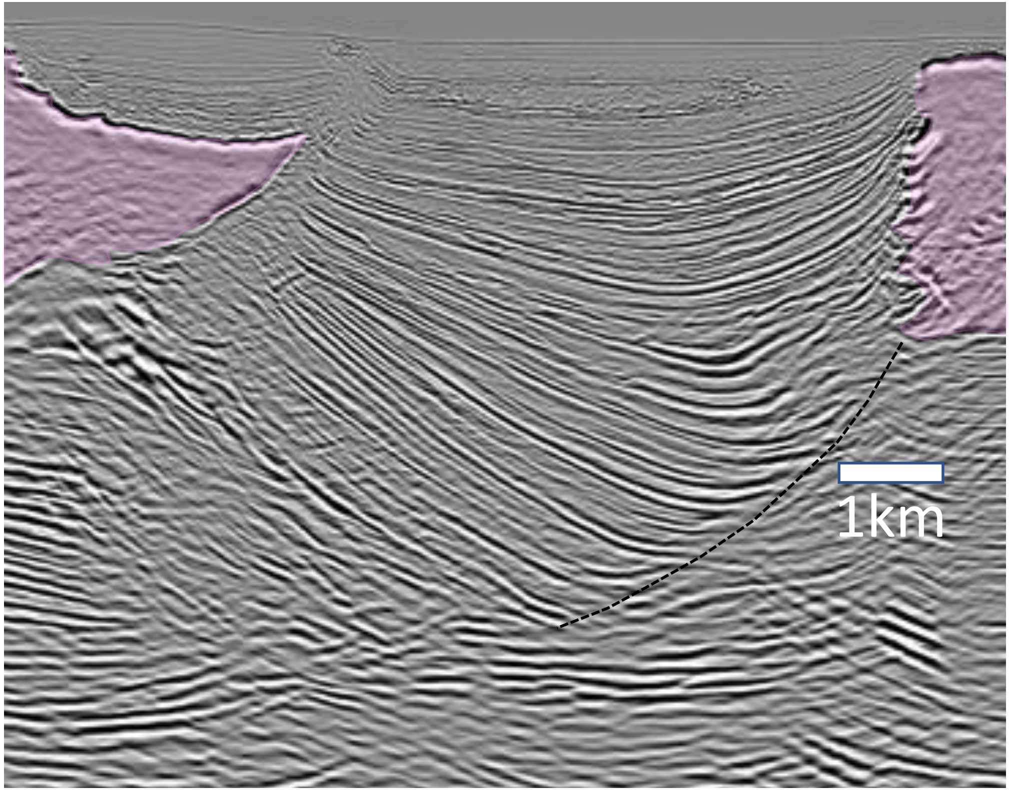
Apply the Concepts!

Simple Listric Normal Fault? Or Weld?



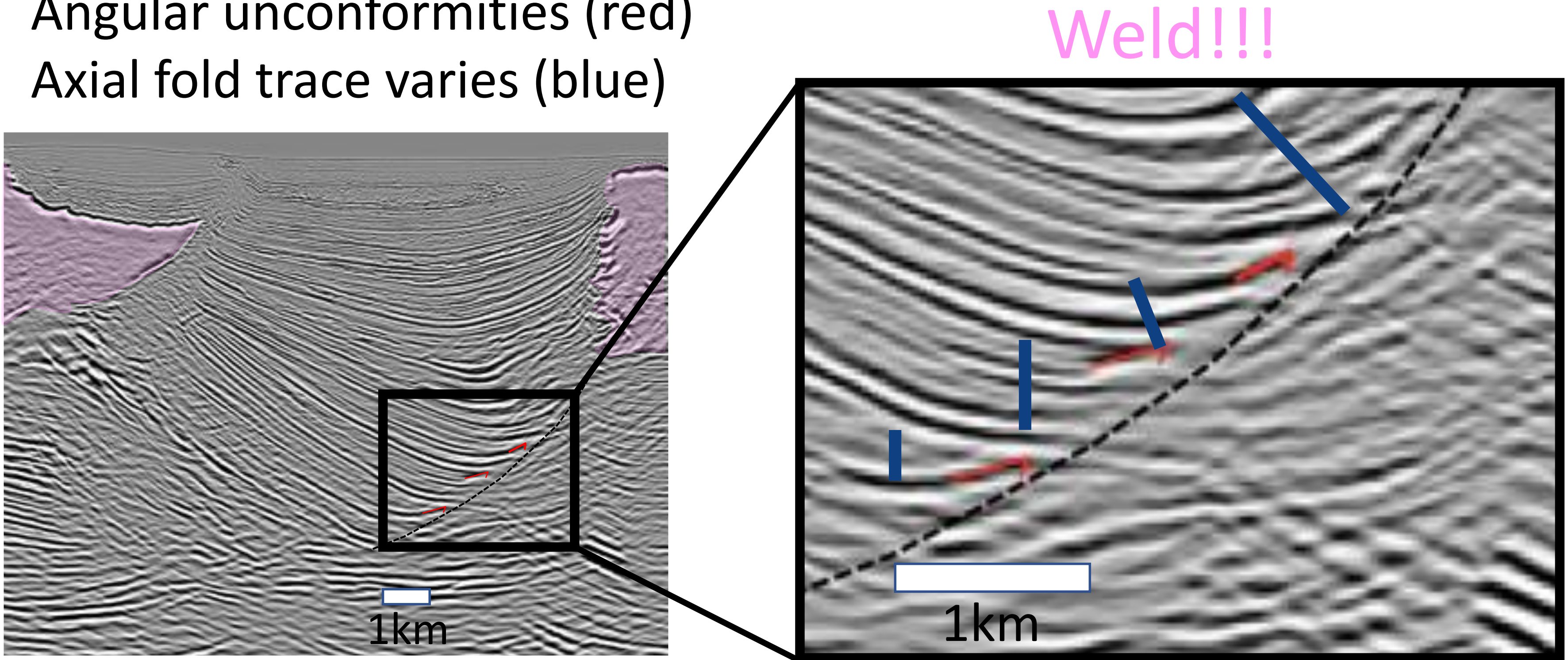
Step 1 Salt Body Framework

- Identify the no brainer salt bodies
- Shallow passive salt diapir above connects to salt pedestal below?



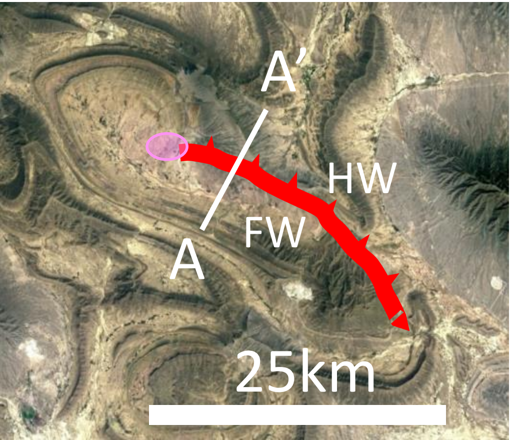
Step 2 Look for Halokinetic Sequences

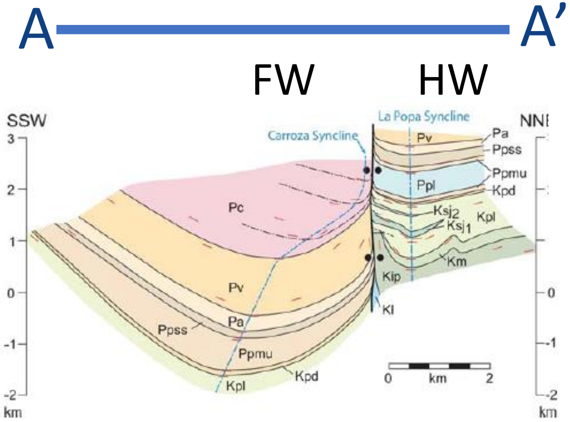
- Upturn and thinning on to “surface” from both sides (<1km)
- Angular unconformities (red)
- Axial fold trace varies (blue)

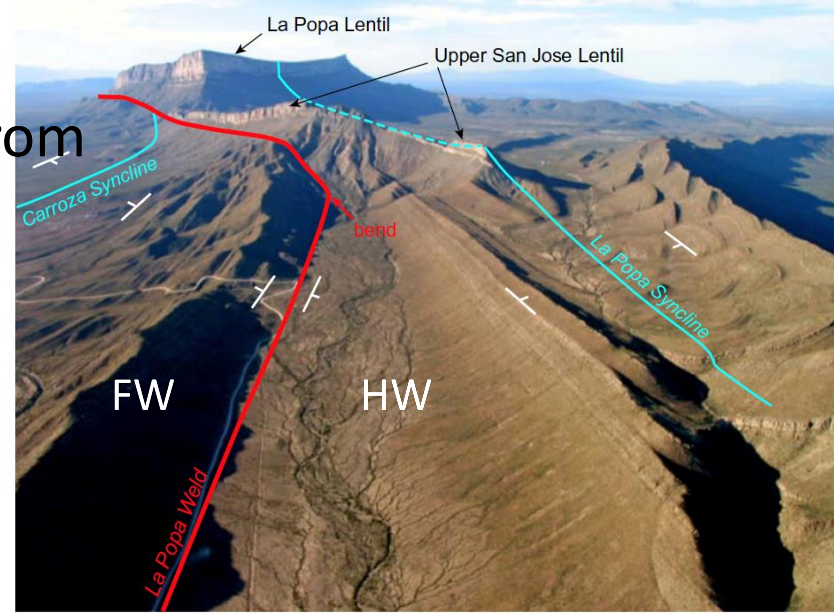


Unusual Fault Traces & Geometries

- Steep, concave thrust fault trace
- Bedding on both walls dipping away from the fault
- Fault terminates in a salt body

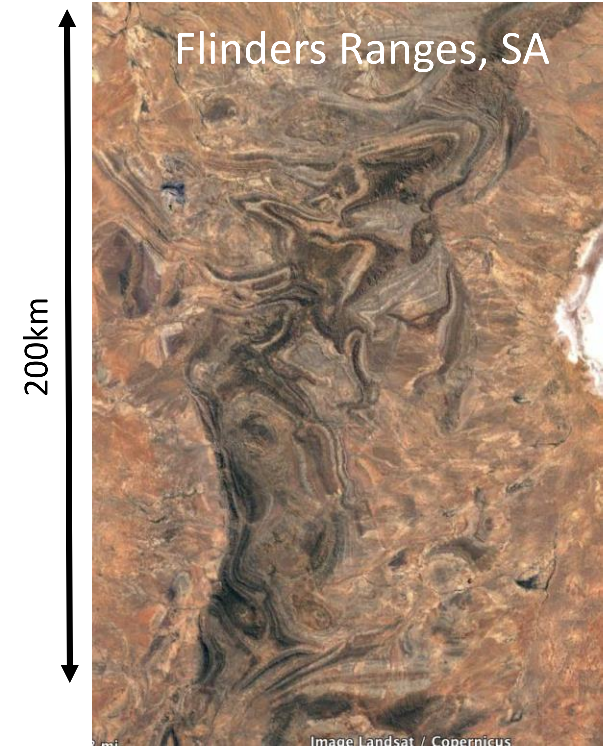


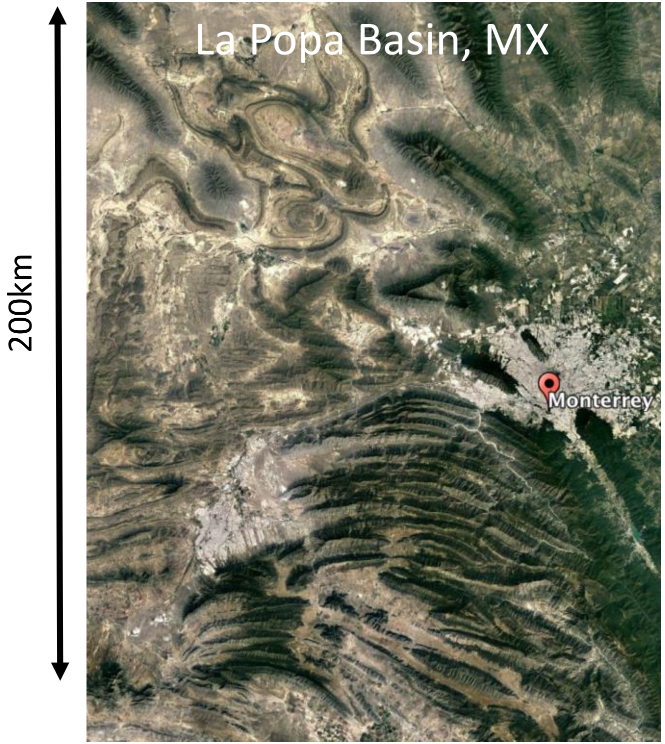




Example La Popa weld, NE Mexico
From Rowan et al. (2003)

Polygonal Dome & Basin Map Patterns





Conclusions

- Very important to know if, when, and where passive diapirism occurred
- Only smoking gun is “Halokinetic Sequences”
- Diapir-derived detritus in surrounding strata is great back-up
- Carefully review faults with strata that upturn & thin toward the fault on both walls

Conclusions *Cont.*

- Polygonal map patterns with sub-circular basins + highs or interbasin “ridges” composed of “Megabreccias” are suspect
- If working a known salt basin always double-check all structures, at all levels especially those associated with a salt detachment or salt body
- Pay close attention when working rift basins associated with Rodinian or Pangean rift break-up age, even if no salt previously recognized in the area