A Halokinetic Drape-Fold Model for Caprock in Diapir-Flanking and Subsalt Positions

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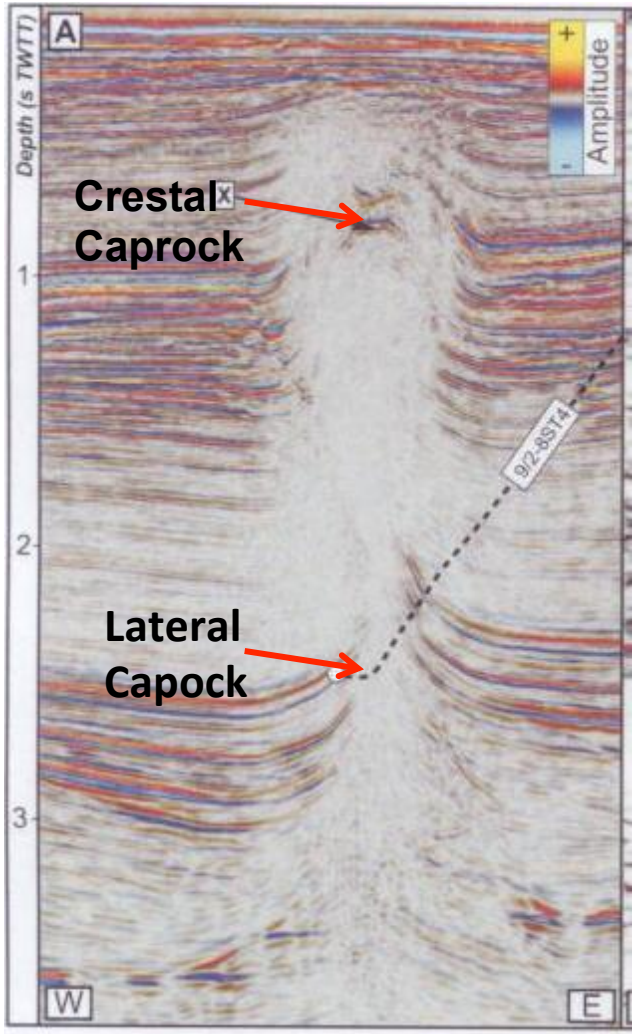
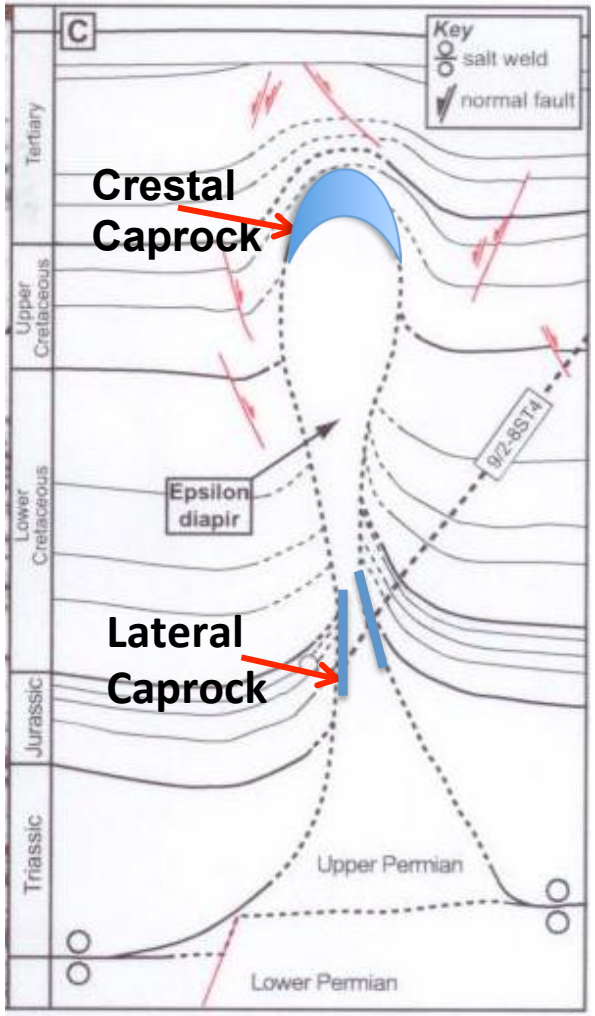
Subsurface "Lateral Caprock" Example
Epsilon Diapir, North Sea

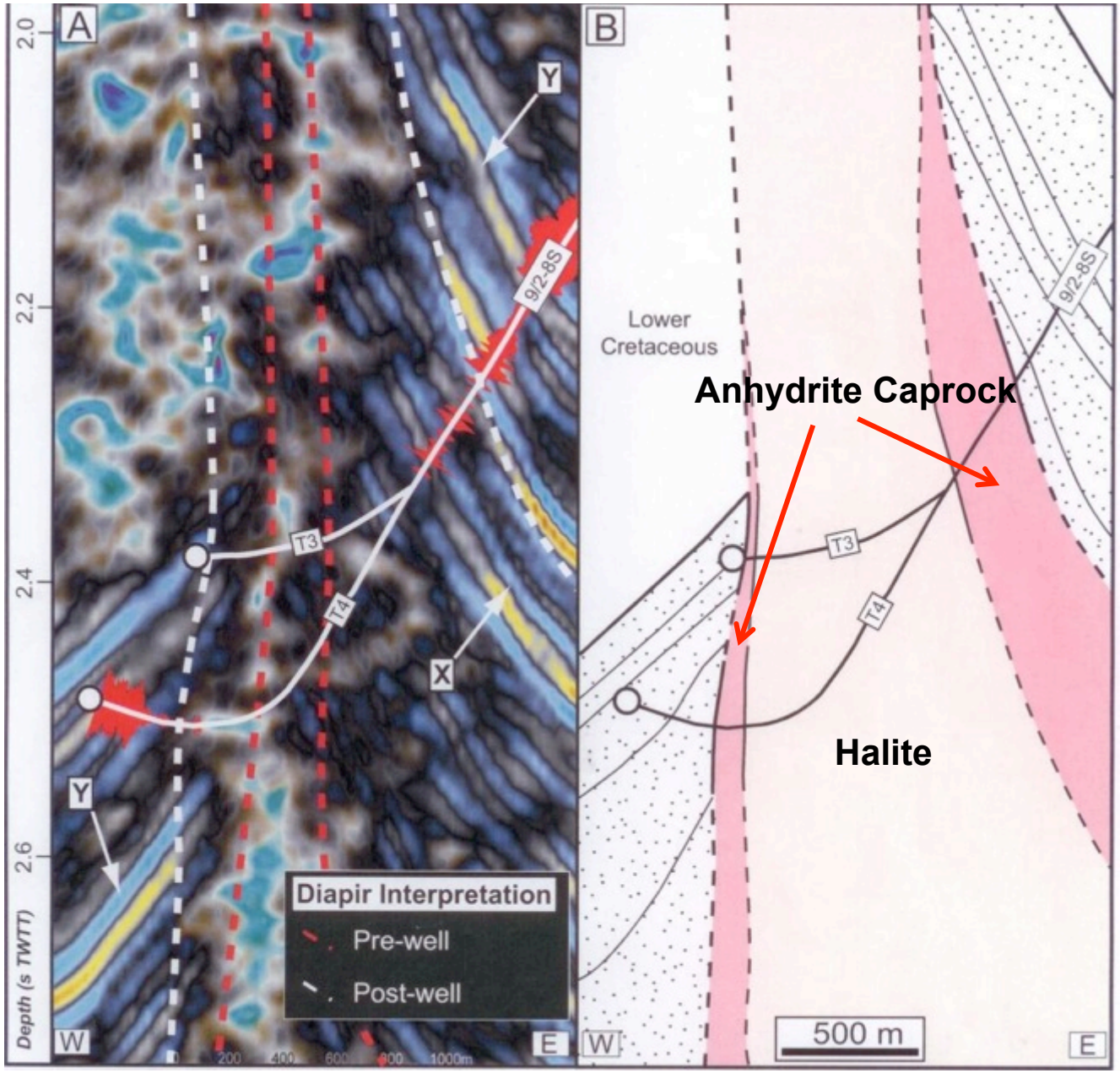




Jackson, C. A. & Lewis, M.M., 2012, Borehole Calibration of Salt Diapir Lithology;
In press –Journal of the Geological Society of London

Epsilon Diapir Lateral Caprock

Post-Drill Results



Jackson, C. A. & Lewis, M.M., 2012, Borehole Calibration of Salt Diapir Lithology; *In press –Journal of the Geological Society of London*

Hypotheses for Lateral Caprock Formation

①Formed *in situ* in diapir-flank position in a steeply dipping attitude?

②Formed in diapir-crest position in a horizontal attitude and was later displaced?

Why Should We Worry About How Lateral Caprock Forms?

1. Drilling Hazard?
2. Salt Flank Trap Integrity

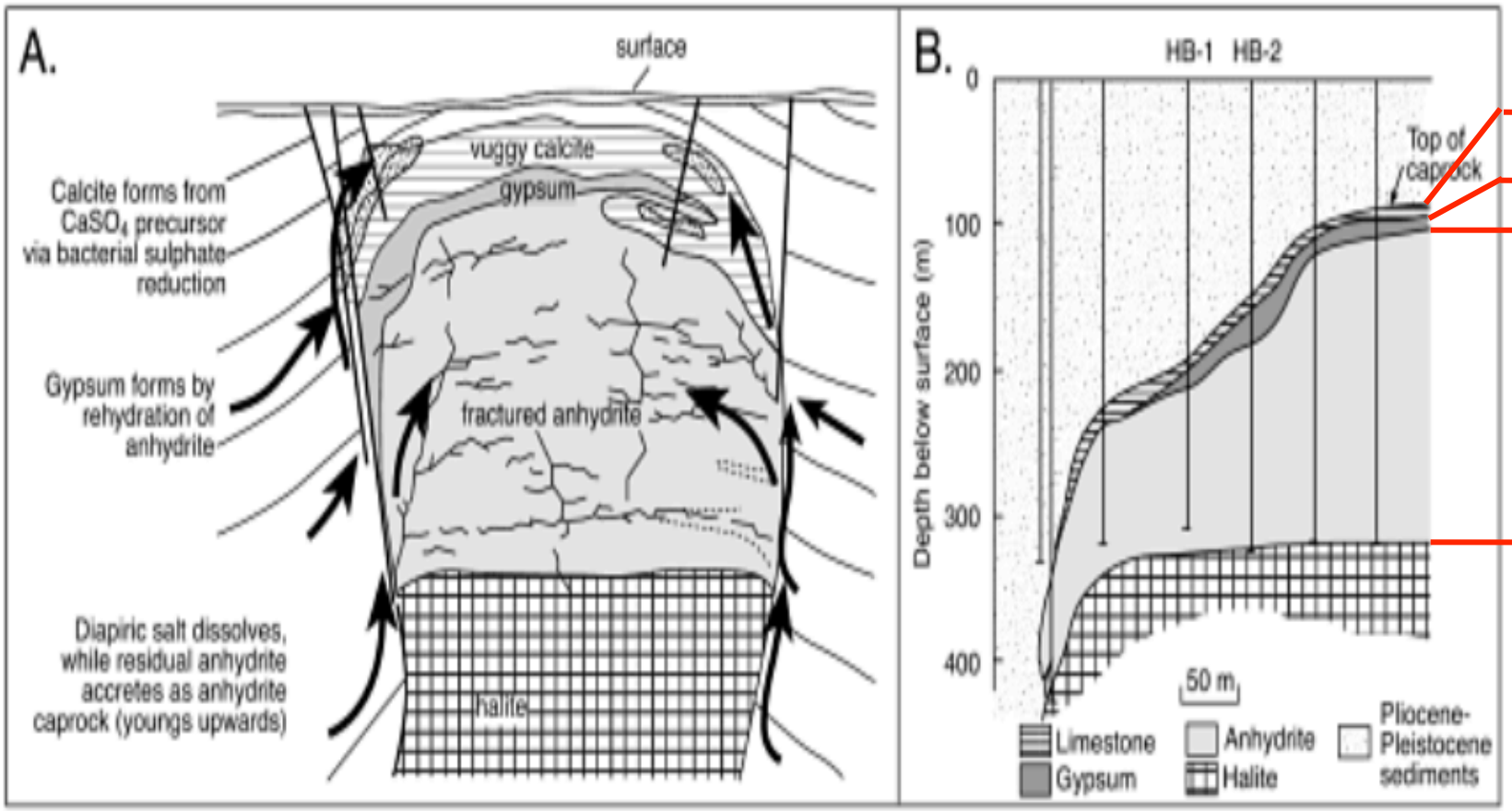
   Reservoir? *Spindletop*

   Seal?

   Migration pathway? Thief zone?
3. Basin-scale fluid migration

We need to understand the ***process*** *in order to increase* ***prediction****!*

Common Caprock Lithologies



Layered Caprock

Carbonate

Gypsum

Anhydrite

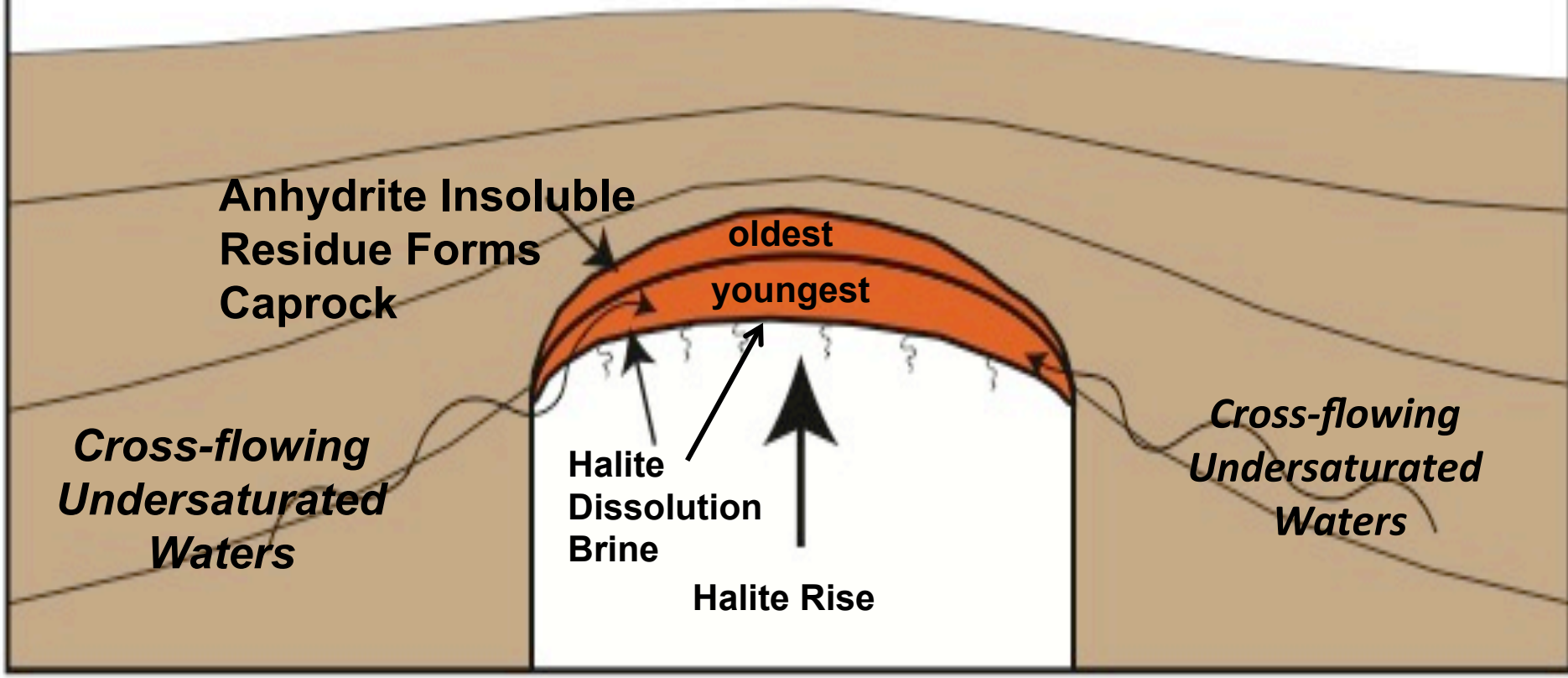
Halite

Figure 6.64. Caprock zonation. A) Caprock forms by the dissolution of the upper part of a salt structure once salt supply dwindles the rate of rise slows and it is flushed by undersaturated phreatic waters (black arrows). Dissolution of the halite leaves behind anhydrite that then accretes into an anhydrite caprock. The upper portion of the anhydrite unit rehydrates to gypsum that is then converted to limestone by bacterial sulphate reduction. B) Section of Hockley dome caprock showing relative thickness of the caprock zones and depth below the landsurface based on drilling (after Hallager et al., 1990).

Warren, 2006

Anhydrite Caprock Formation

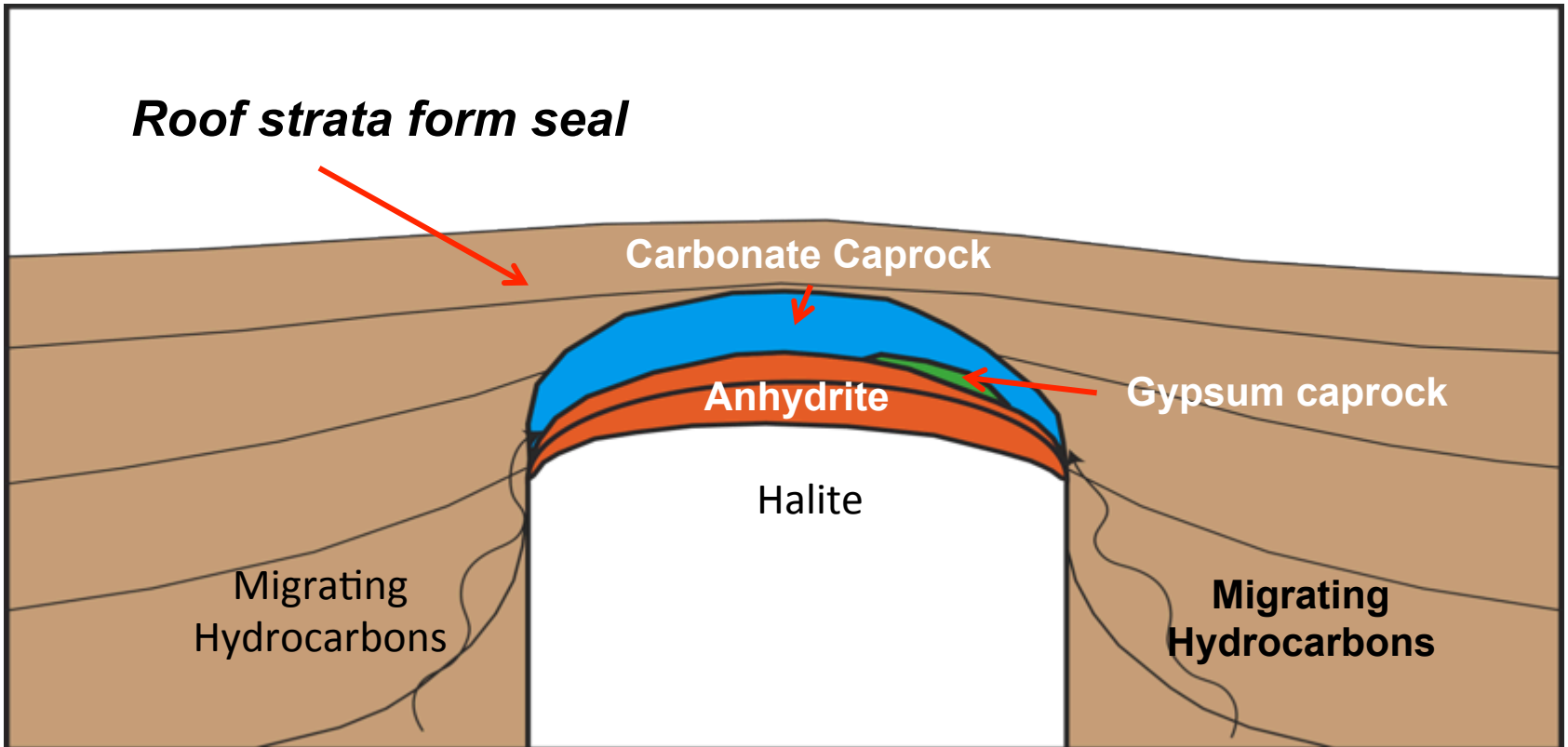
*Anhydrite insoluble residue accretes in cycles by underplating
*Creates roughly horizontal coarse-crystalline bands in central part of diapir; inclined near margins
* GoM diapirs average 5% anhydrite



Carbonate Caprock Formation

Biogeochemical Process:

1) Anhydrite dissolution $CaSO_4 \rightarrow Ca^{2+} + SO4^{2-}$
2) Sulfate reduction by anaerobic bacteria (SRB) in hydrocarbons
   $SO_4^{2-} + CH_3COOH + 2\ H^+ \rightarrow HS^- + 2\ HCO_3^- + 3\ H^+$
3) Carbonate precipitation
   $2HCO_3 + Ca \rightarrow CaCO_3 + H + HCO_3$

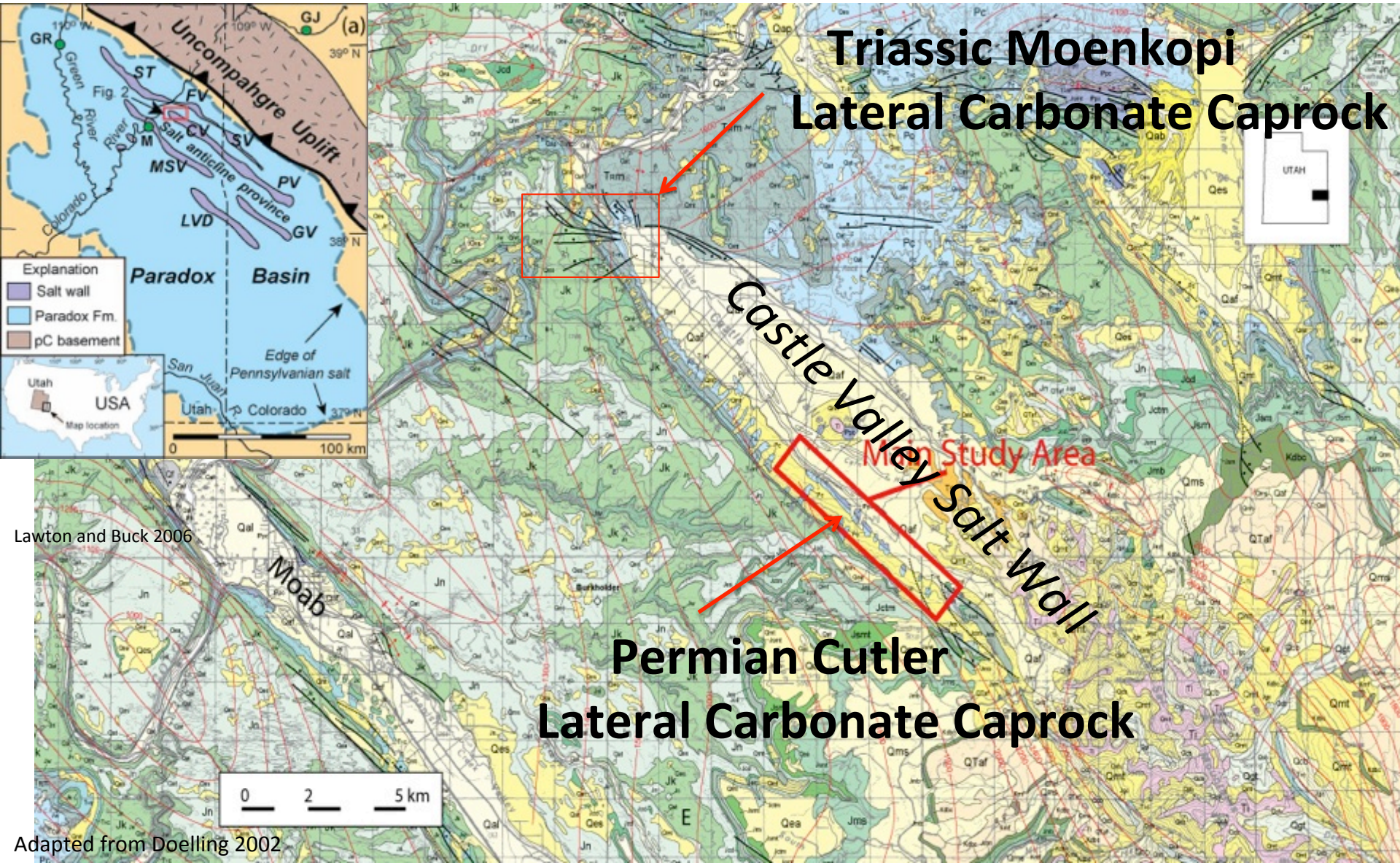


Lateral Carbonate Caprock Field Studies

① Castle Valley vertical salt wall, Paradox Basin, Utah

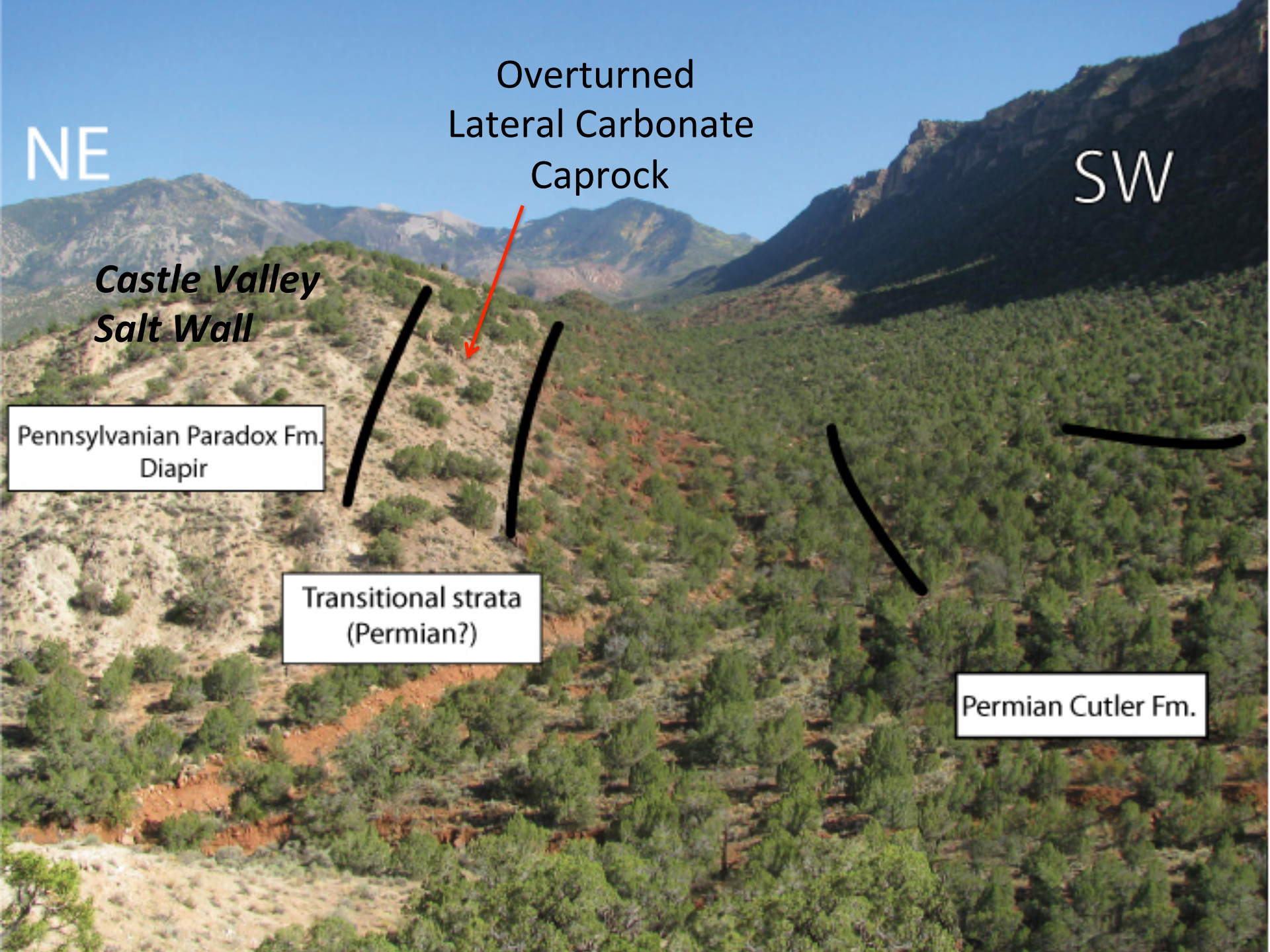
② Patawarta allochthonous salt sheet, Flinders Ranges, SA

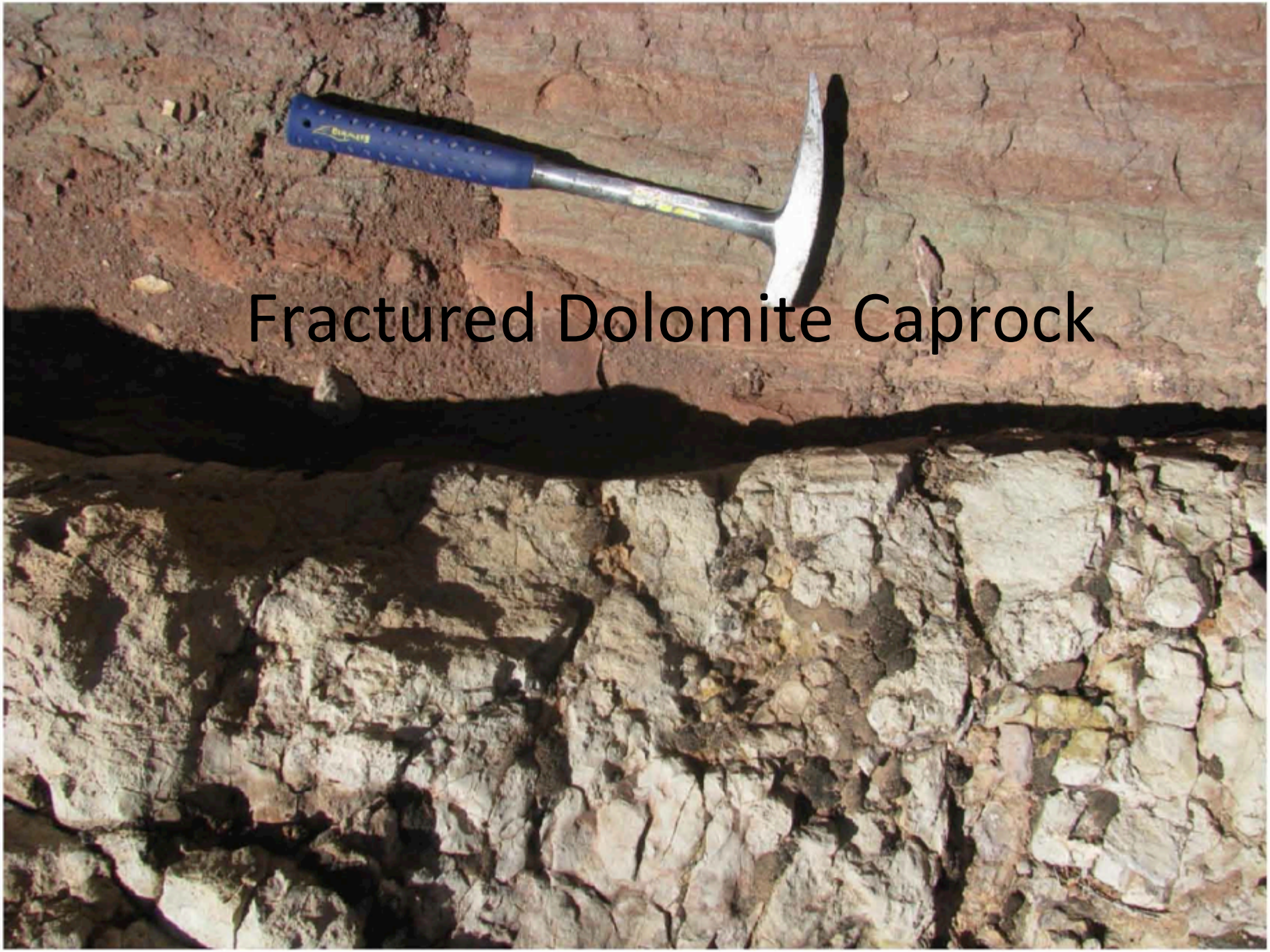
Castle Valley Salt Wall, Paradox Basin, Utah
Lateral Carbonate Caprock



Lawton and Buck 2006

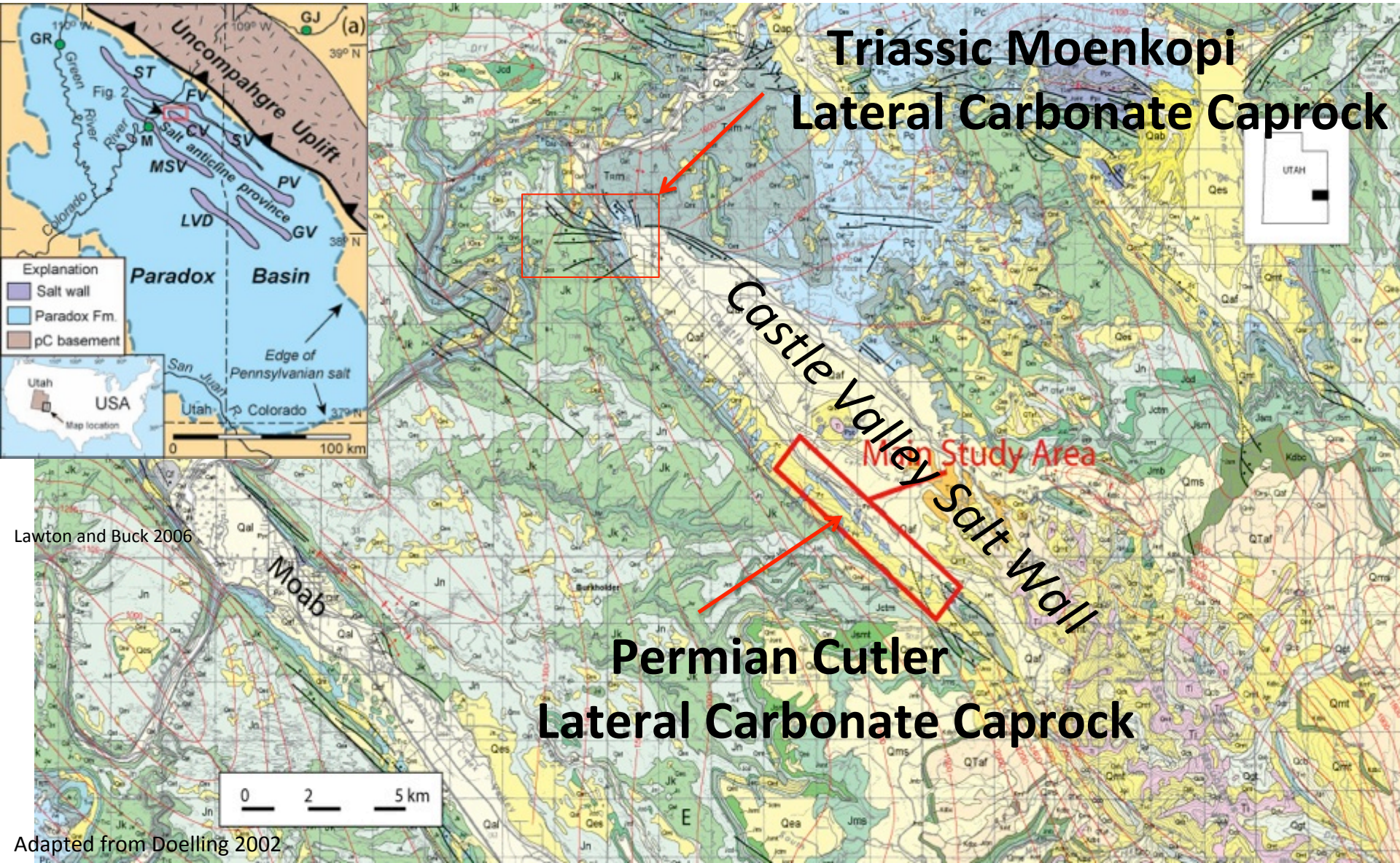
Adapted from Doelling 2002


NE
Overturned
Lateral Carbonate
Caprock
SW
Castle Valley
Salt Wall
Pennsylvanian Paradox Fm.
Diapir
Transitional strata
(Permian?)
Permian Cutler Fm.


Fractured Dolomite Caprock

Vertical Permian Fluvial Cutler Channel Containing Diapir Roof & Caprock Clasts

Castle Valley Salt Wall, Paradox Basin, Utah
Lateral Carbonate Caprock

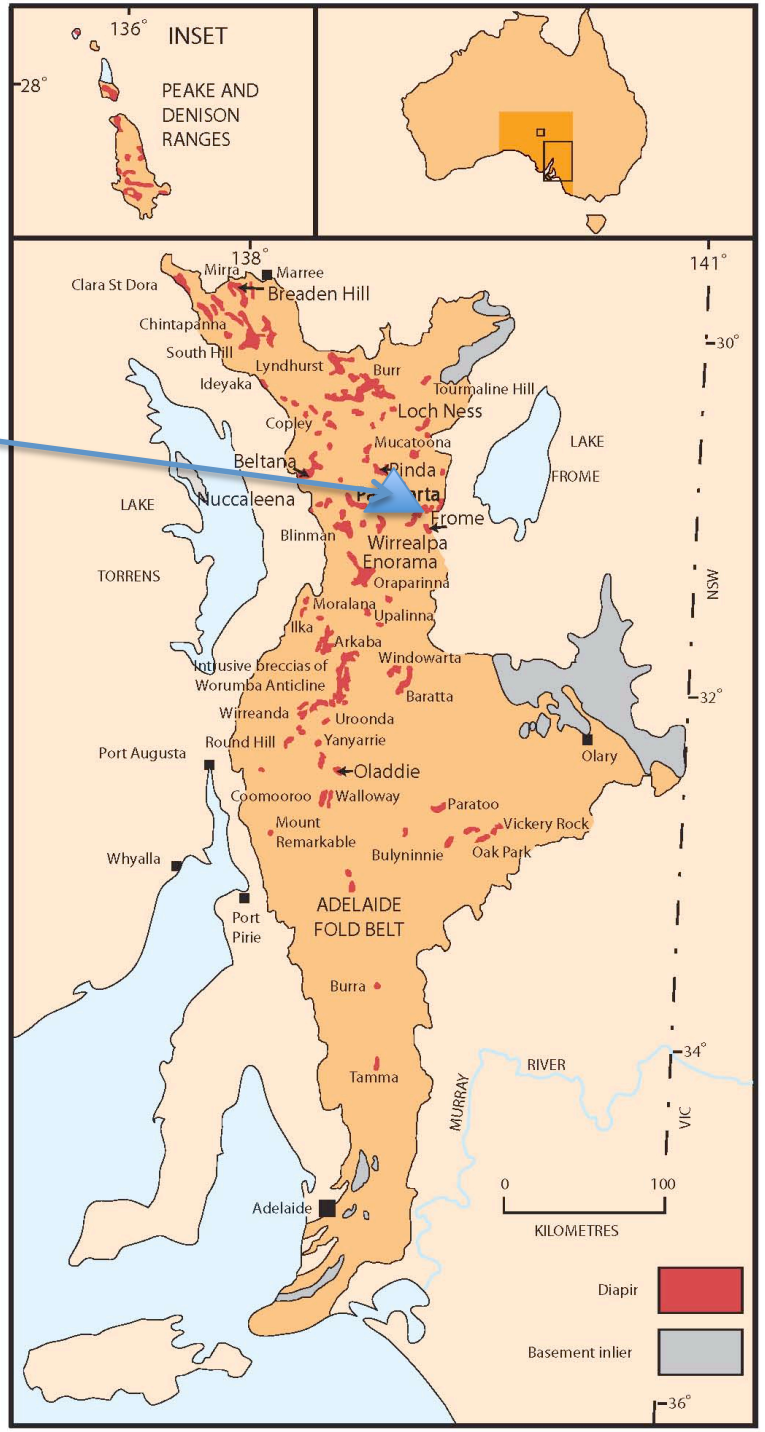


Lawton and Buck 2006

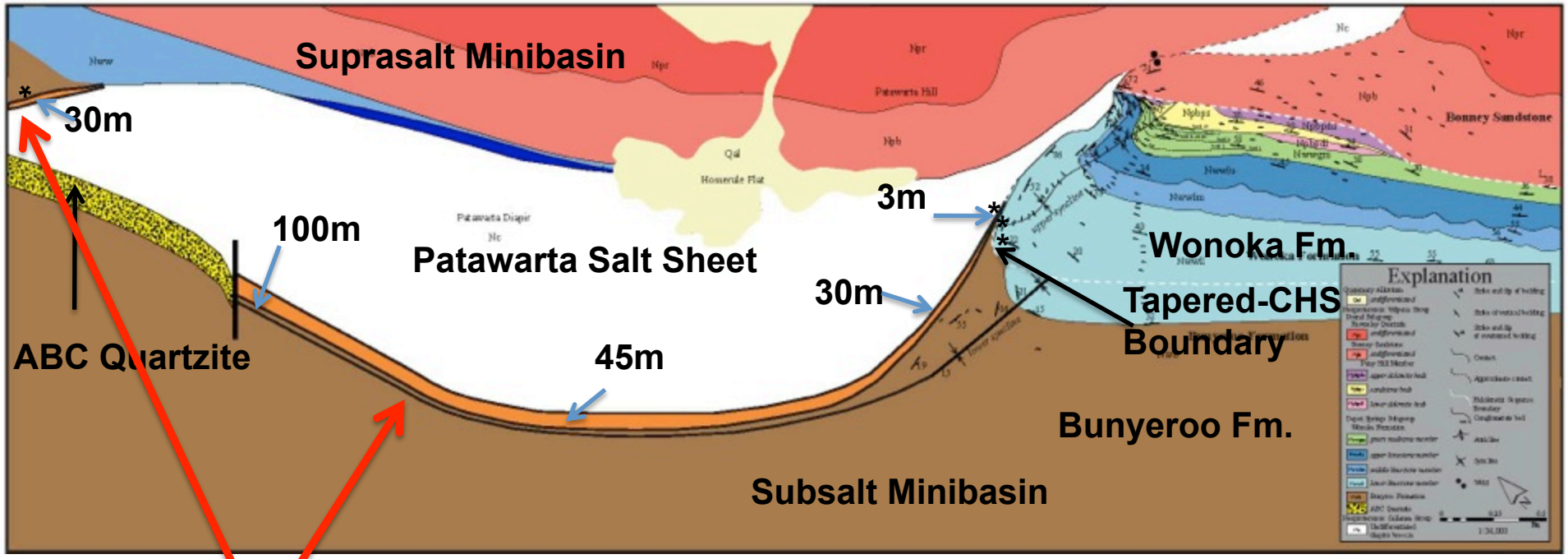
Adapted from Doelling 2002

Vertical Triassic Moenkopi Fluvial Channel Containing Diapir Roof and Caprock Clasts

Neoproterozoic Patawarta Salt Sheet Flinders Ranges, South Australia

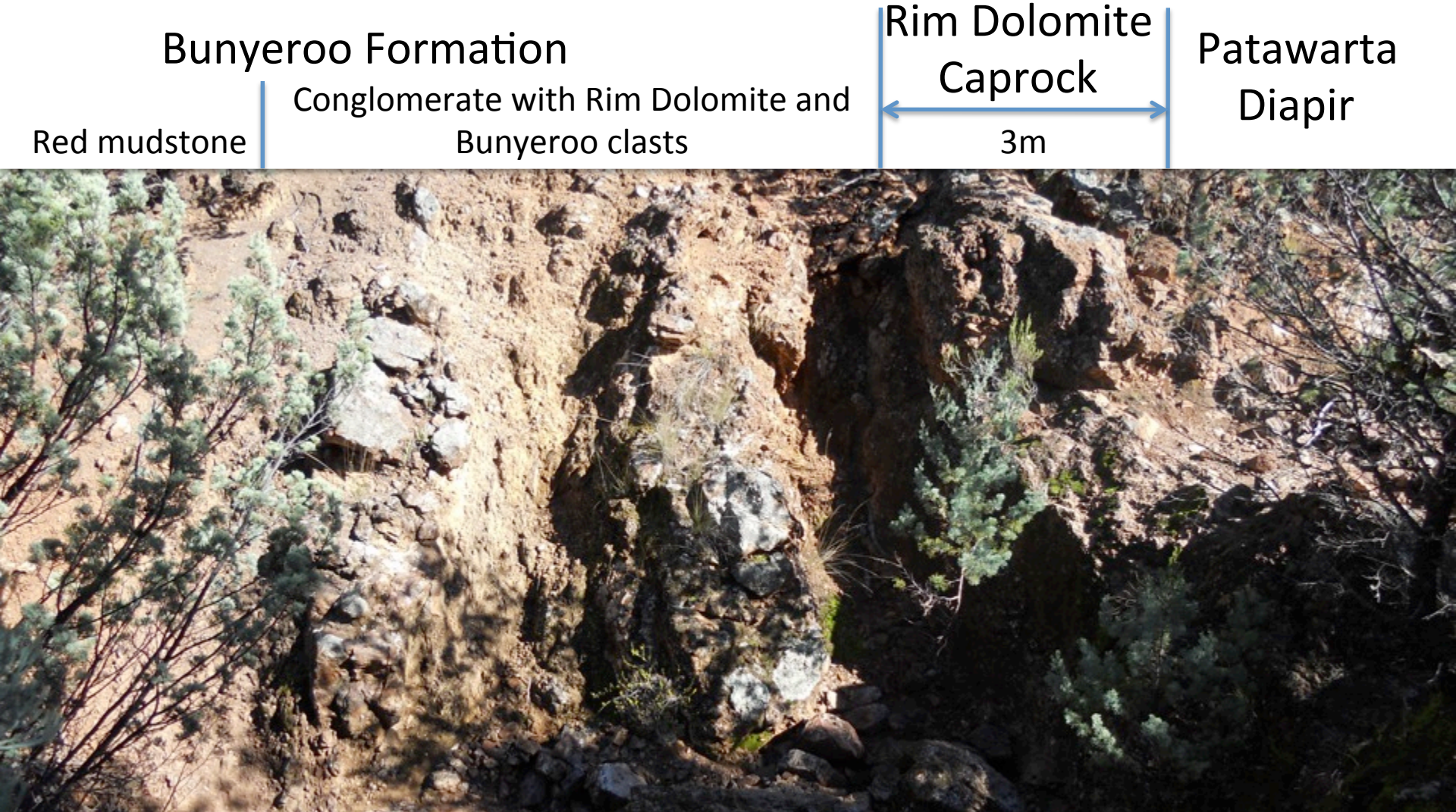


Neoproterozoic Patawarta Salt Sheet Suprasalt & Subsalt Carbonate Caprock



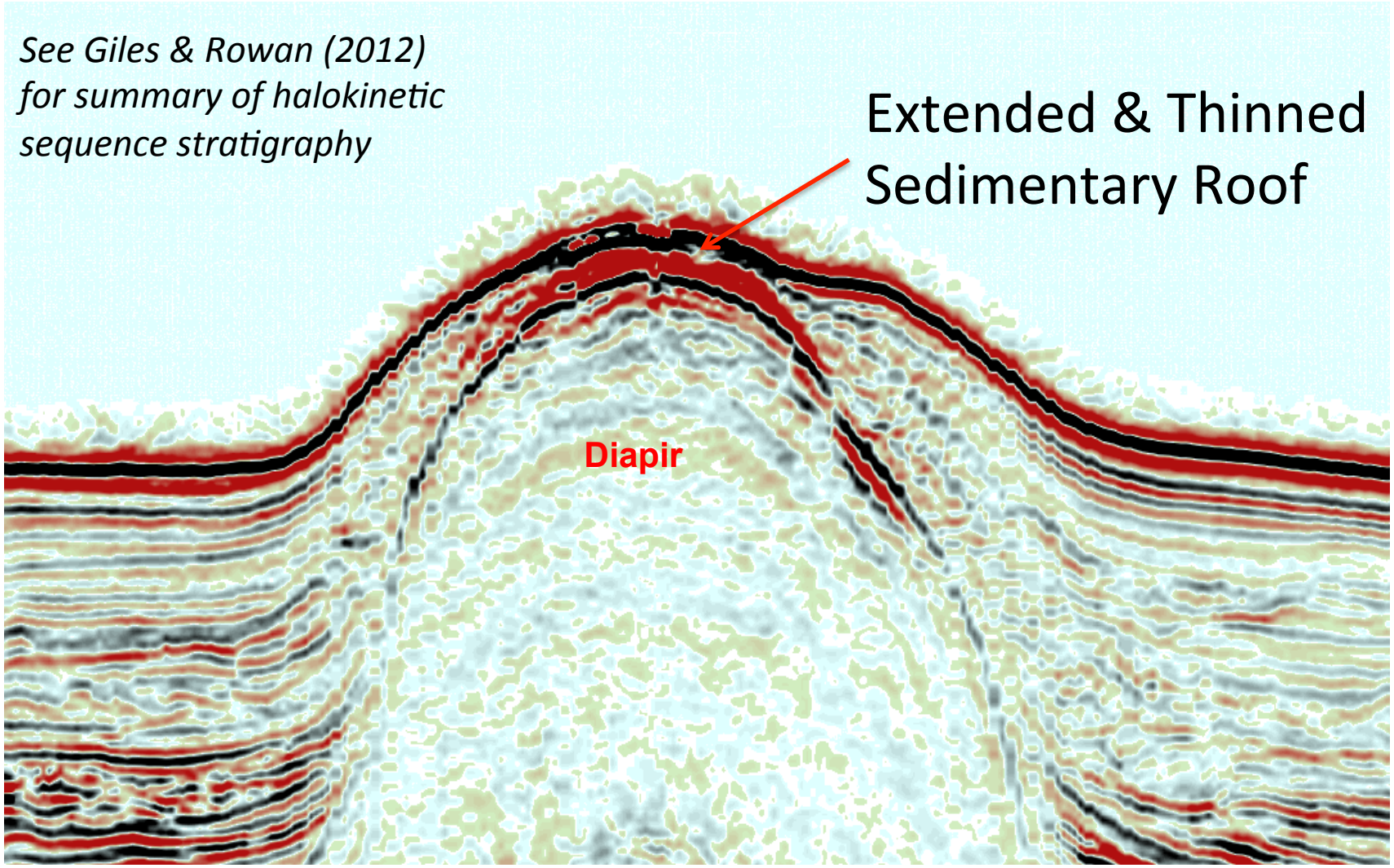
Lateral Caprock

Vertical Rim Dolomite Caprock Truncated by Wonoka Tapered-CHS Beds



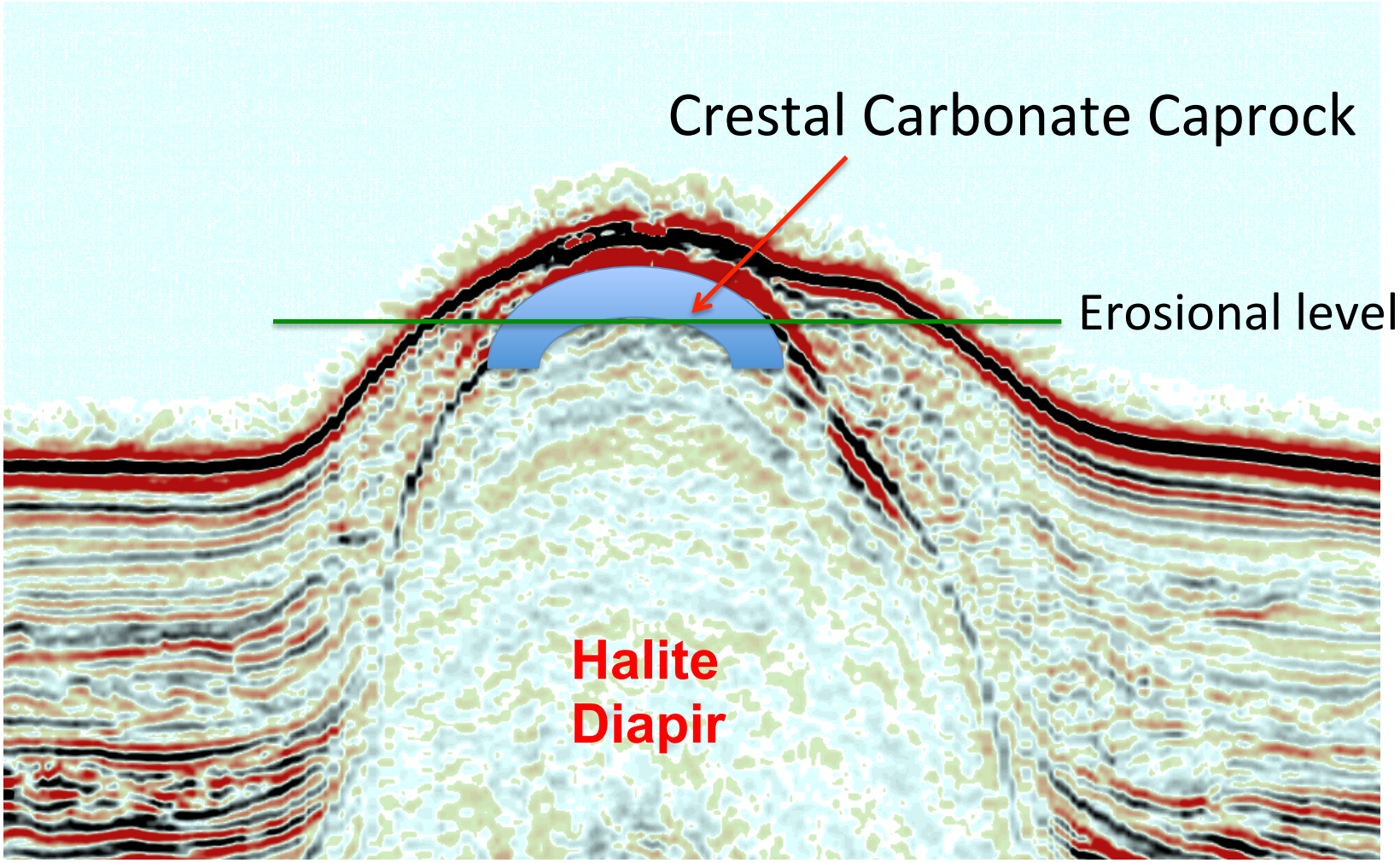
Vertical Bunyeroo Debris Flow Conglomerate Containing Diapir Roof & Caprock Clasts

Halokinetic Drape-Fold Concept



Data courtesy of C. Fiduk and CGGVeritas).

Halokinetic Drape-Fold Wedge

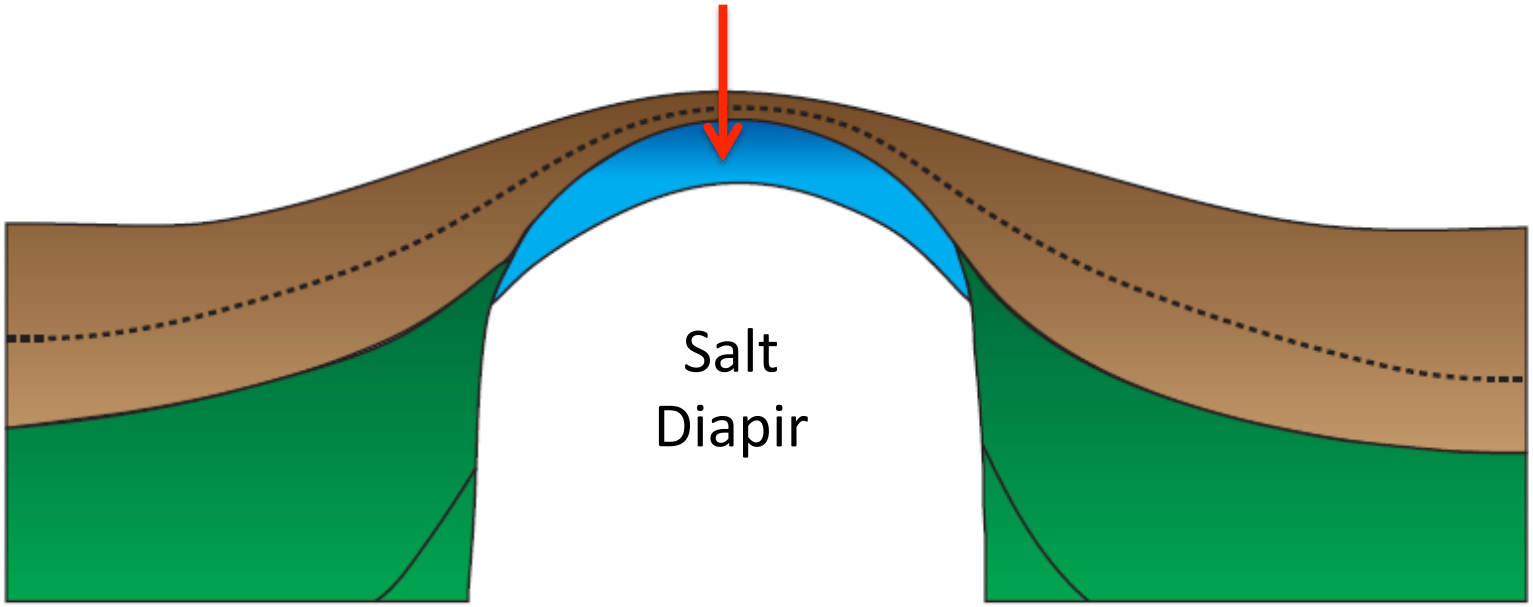


Top of diapir from the northern Gulf of Mexico showing draped wedge of overburden (data courtesy of C. Fiduk and CGGVeritas).

Halokinetic Drape-Fold Model

Step 1 Diapir Crest Caprock Formation

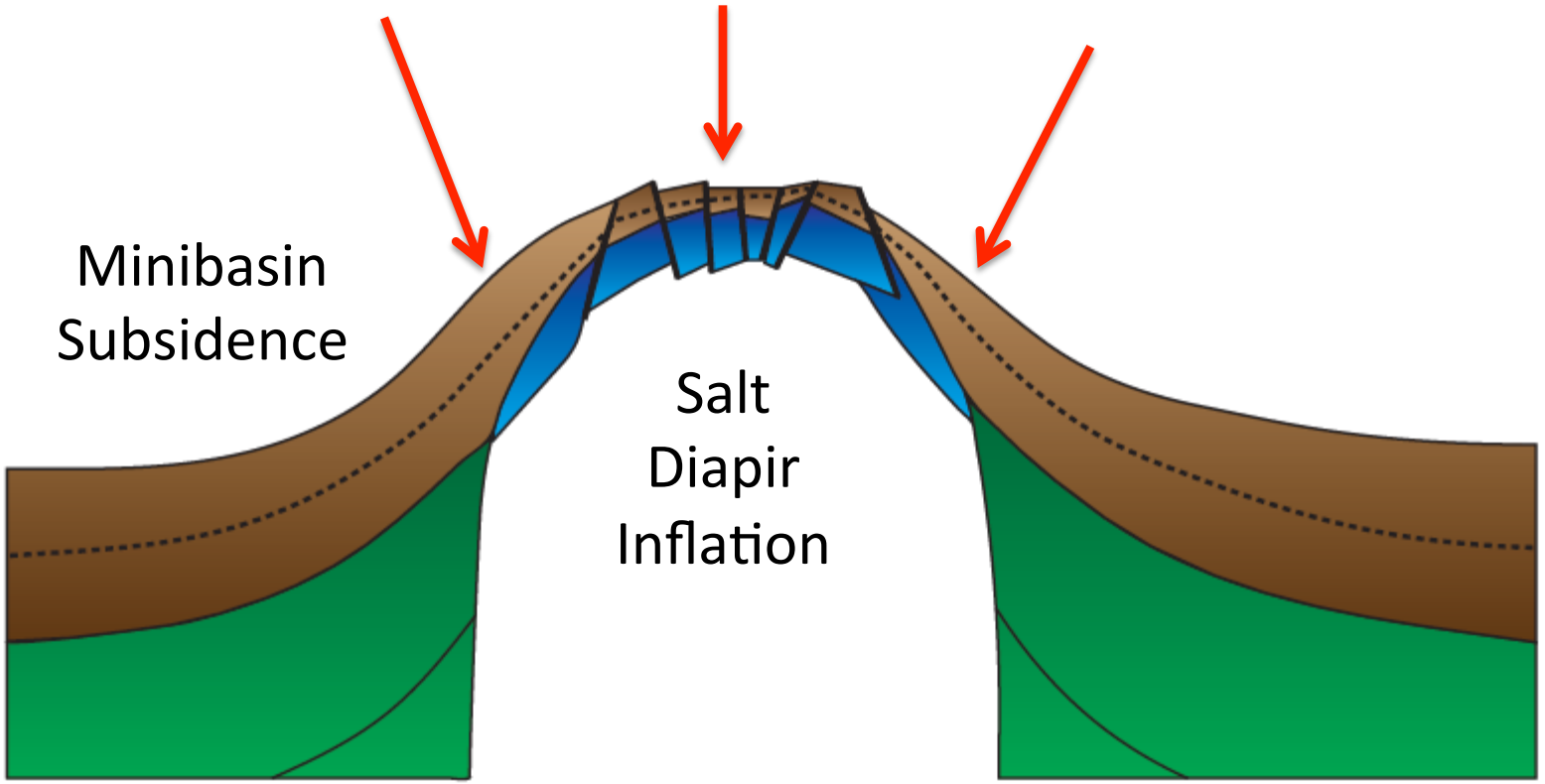
Crestal caprock develops
beneath sedimentary roof



Halokinetic Drape-Fold Model

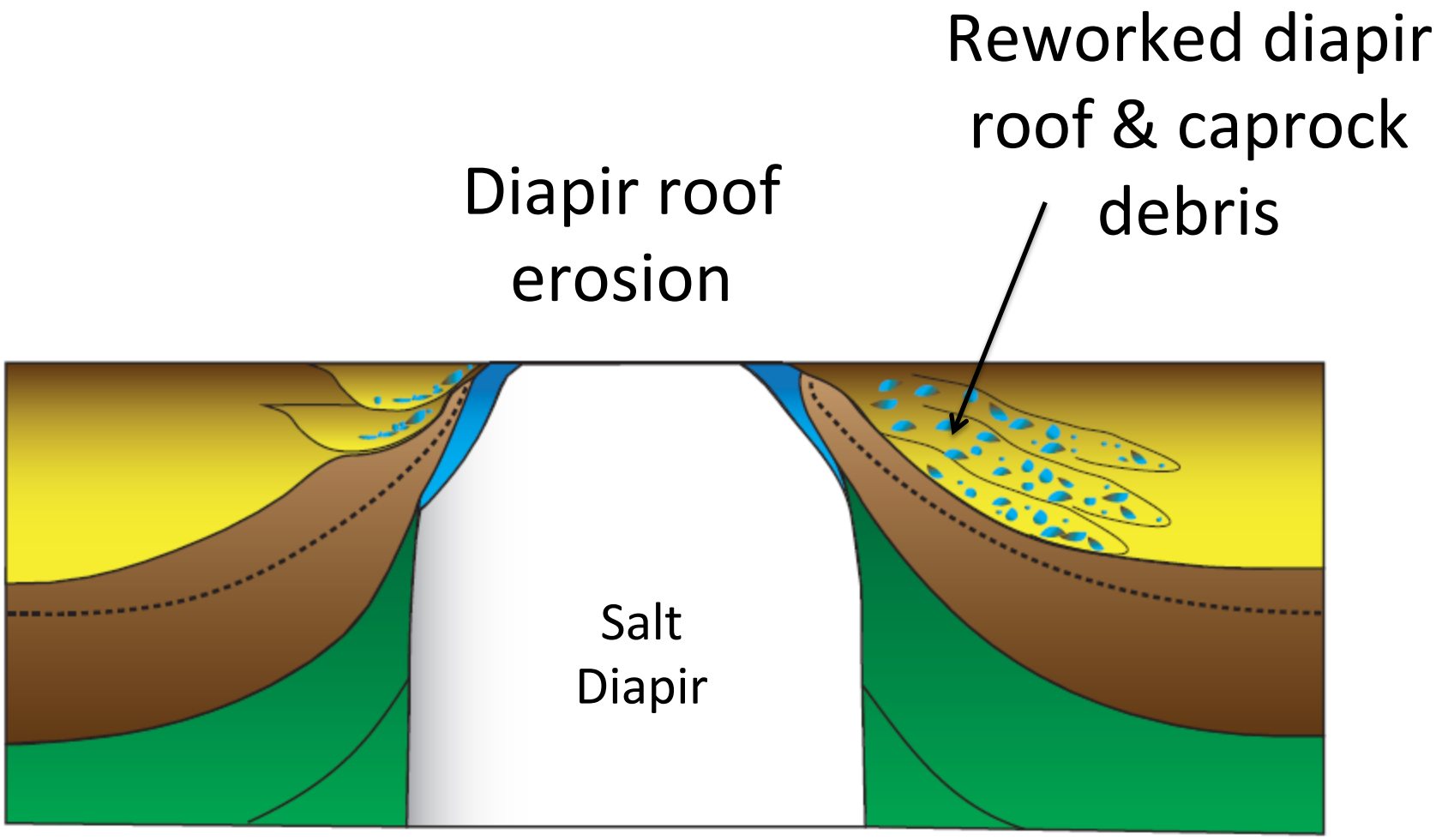
Step 2 Diapir Inflation & Drape-Folding

Drape fold rotation, extension and fracturing of thin roof panel and caprock



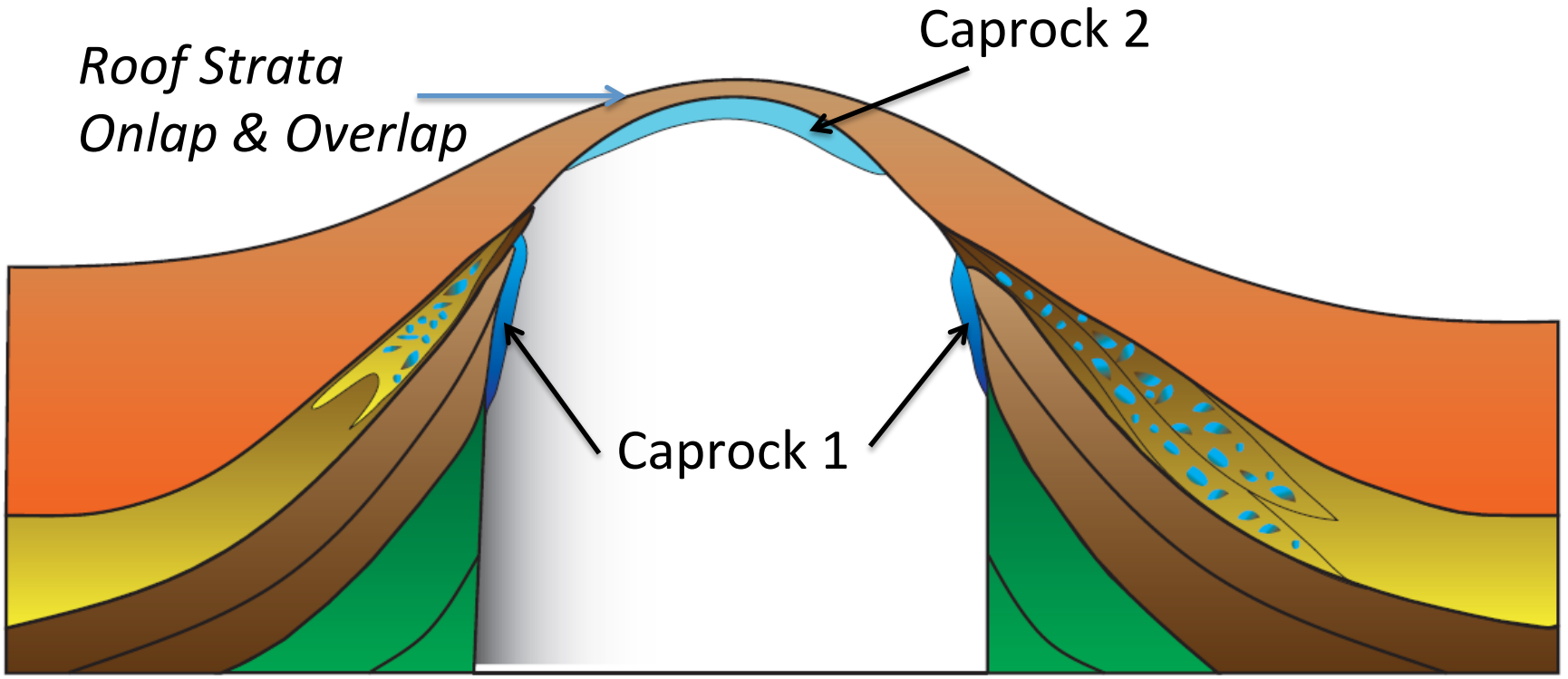
Halokinetic Drape-Fold Model

Step 3 Diapir-Roof Erosion

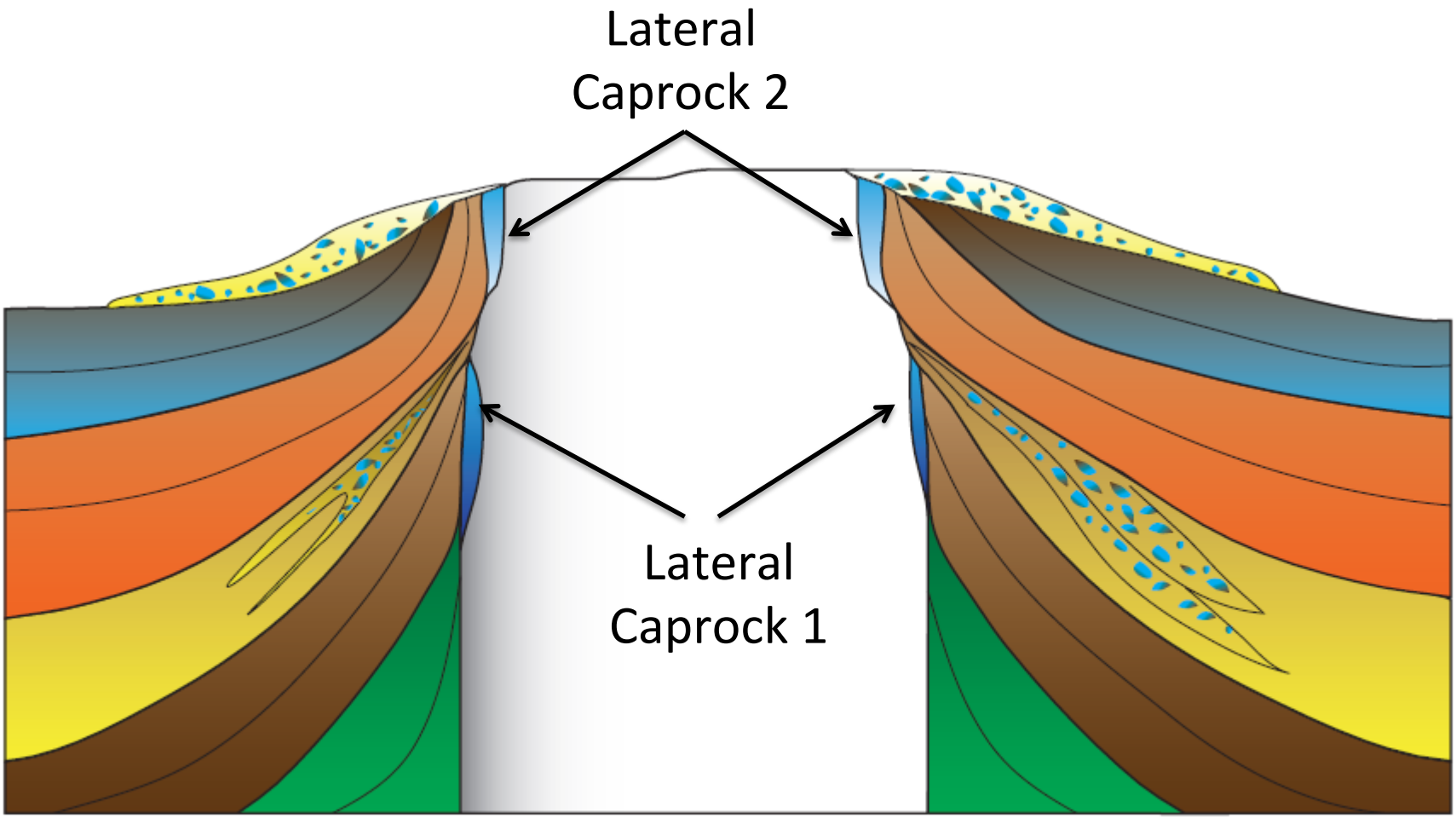


Halokinetic Drape-Fold Model

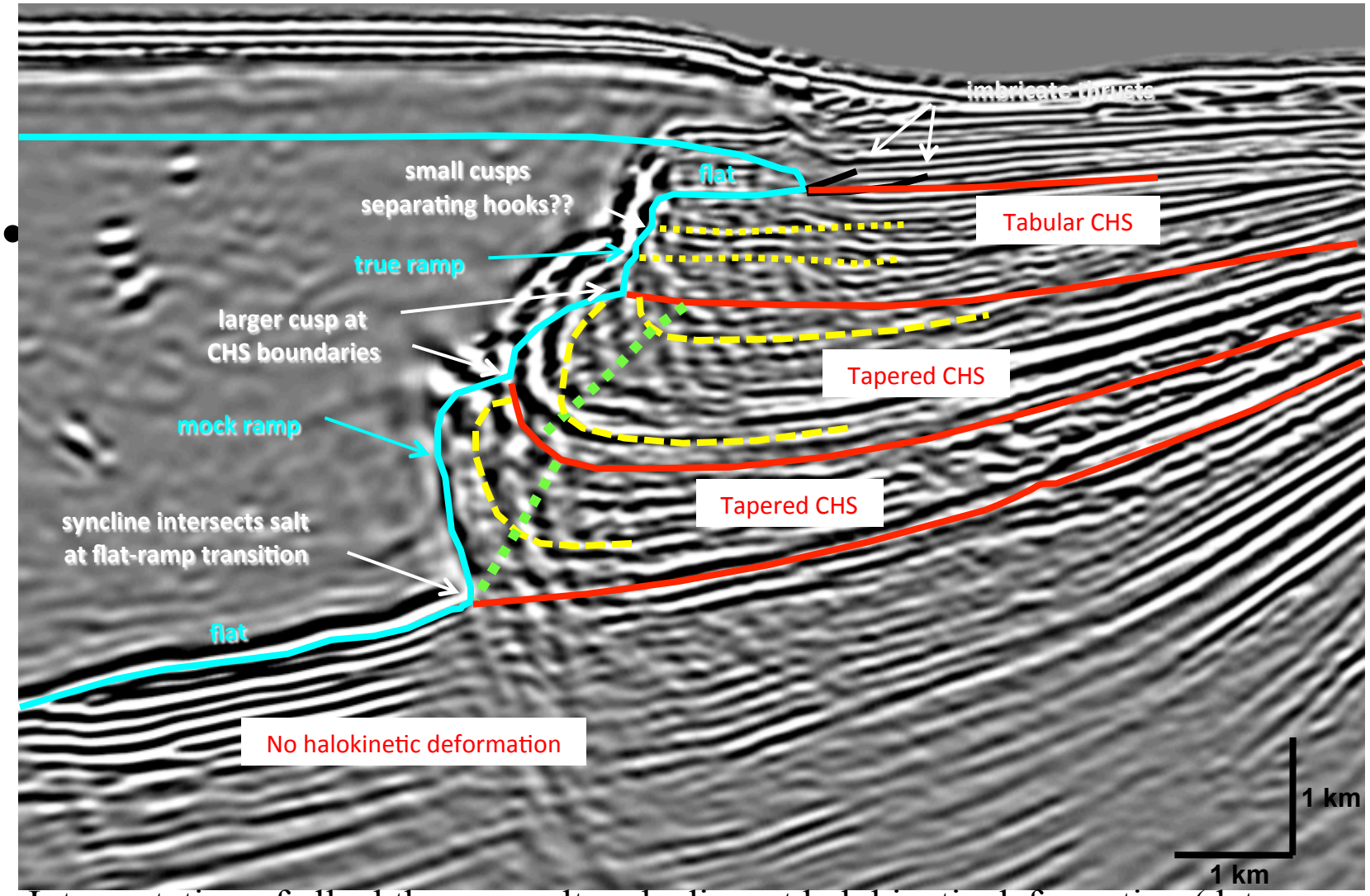
Step 4 Diapir Onlap & New Caprock 2 "Event"



Lateral Caprock “Events”



Allochthonous Salt and Subsalt Caprock Events



Interpretation of allochthonous salt and adjacent halokinetic deformation (data courtesy of C. Fiduk and CGGVeritas)

Conclusions

- Lateral caprock initially forms in a diapir-crest position and is rotated to a flanking or subsalt position by the process of halokinetic drape-folding.

- Lateral caprock forms as part of a halokinetic drape-fold "event" during passive diapirism and can be tied to the surrounding halokinetic sequence stratigraphy.

- A single diapir may have several "lateral caprock events".

- "Lateral carbonate caprock events" require hydrocarbon migration & trapping events that can be roughly dated by the age of the outboard halokinetic sequences.

- Caprock traps maybe compromised with continued halokinesis.