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Overview of Open Room Closure

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Outline

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- Filled Room vs. Open Room Closure
- Important Aspects of Open Room Closure
- Summary

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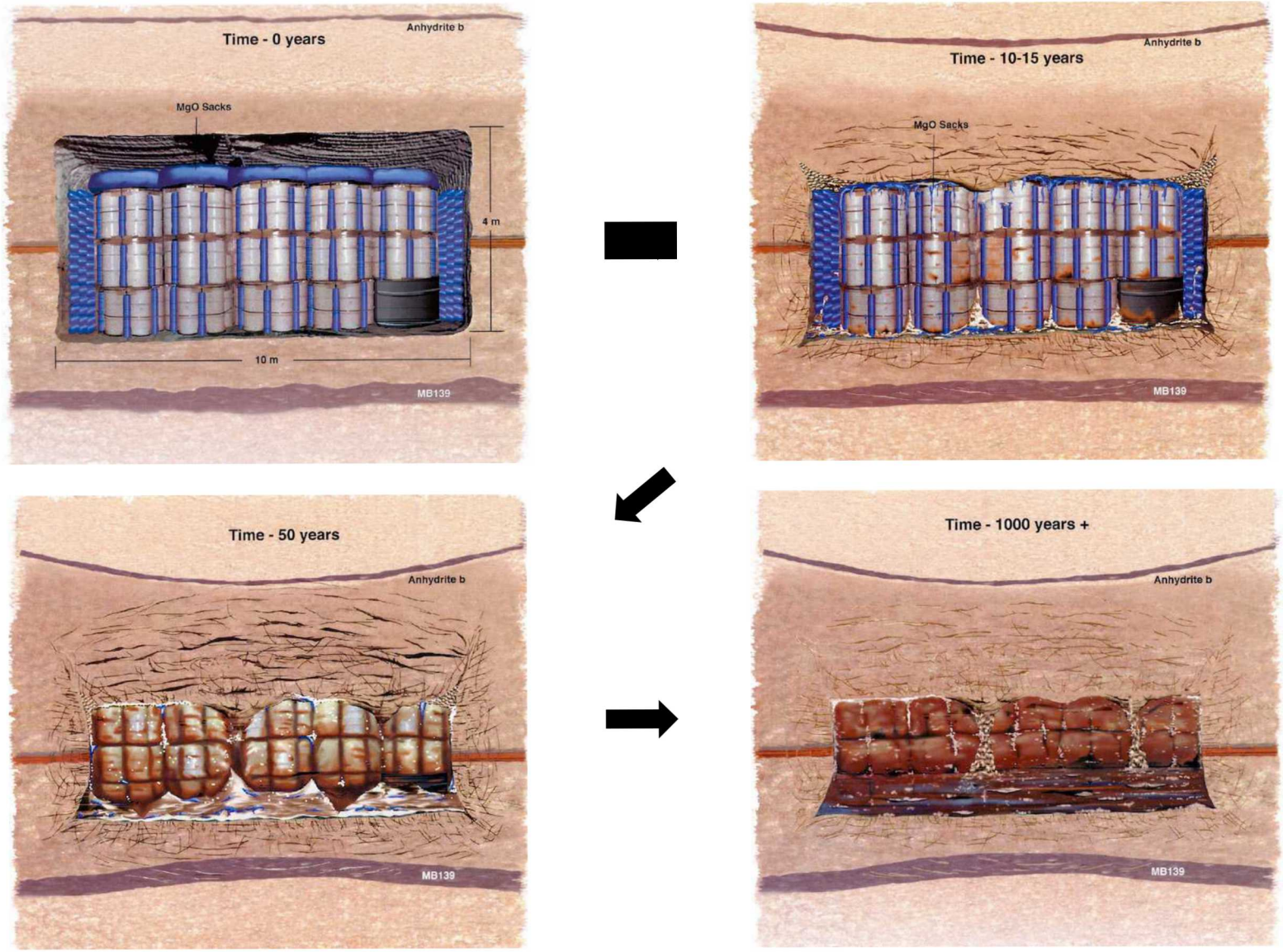
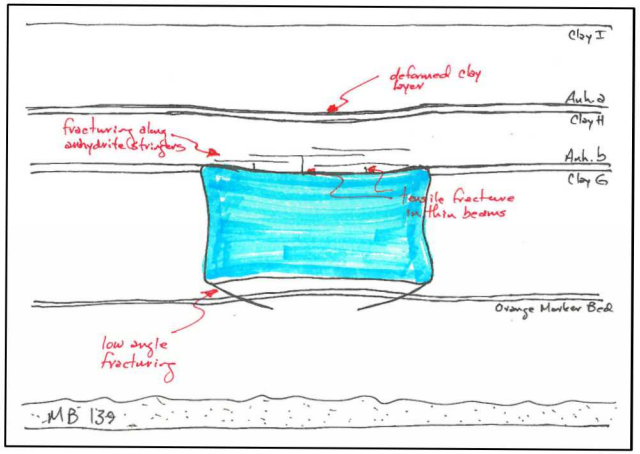
Filled Room vs. Open Room Closure

Filled Room Closure



Open Room Closure

1



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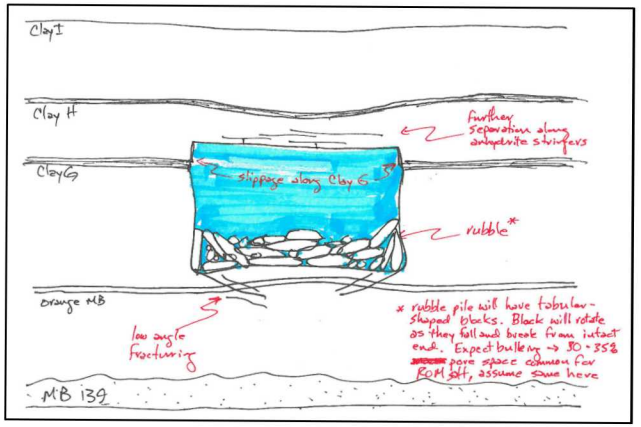

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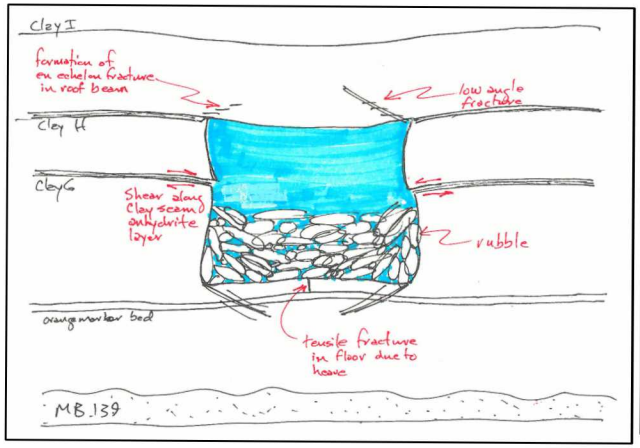

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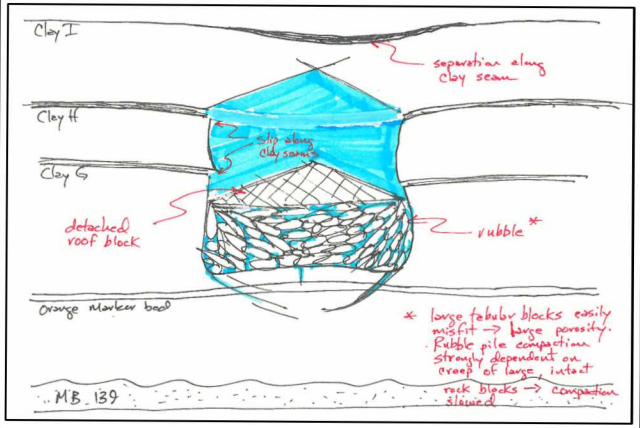

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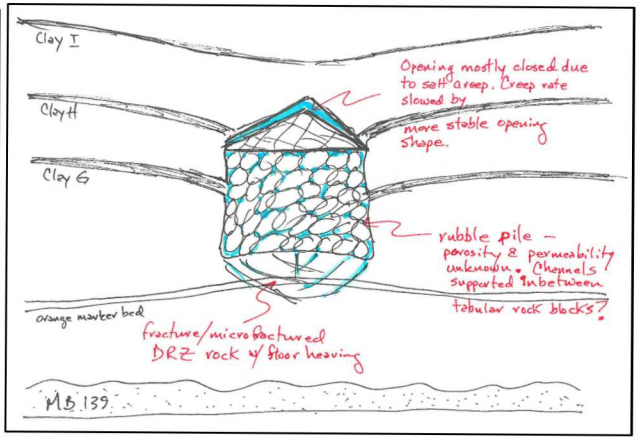
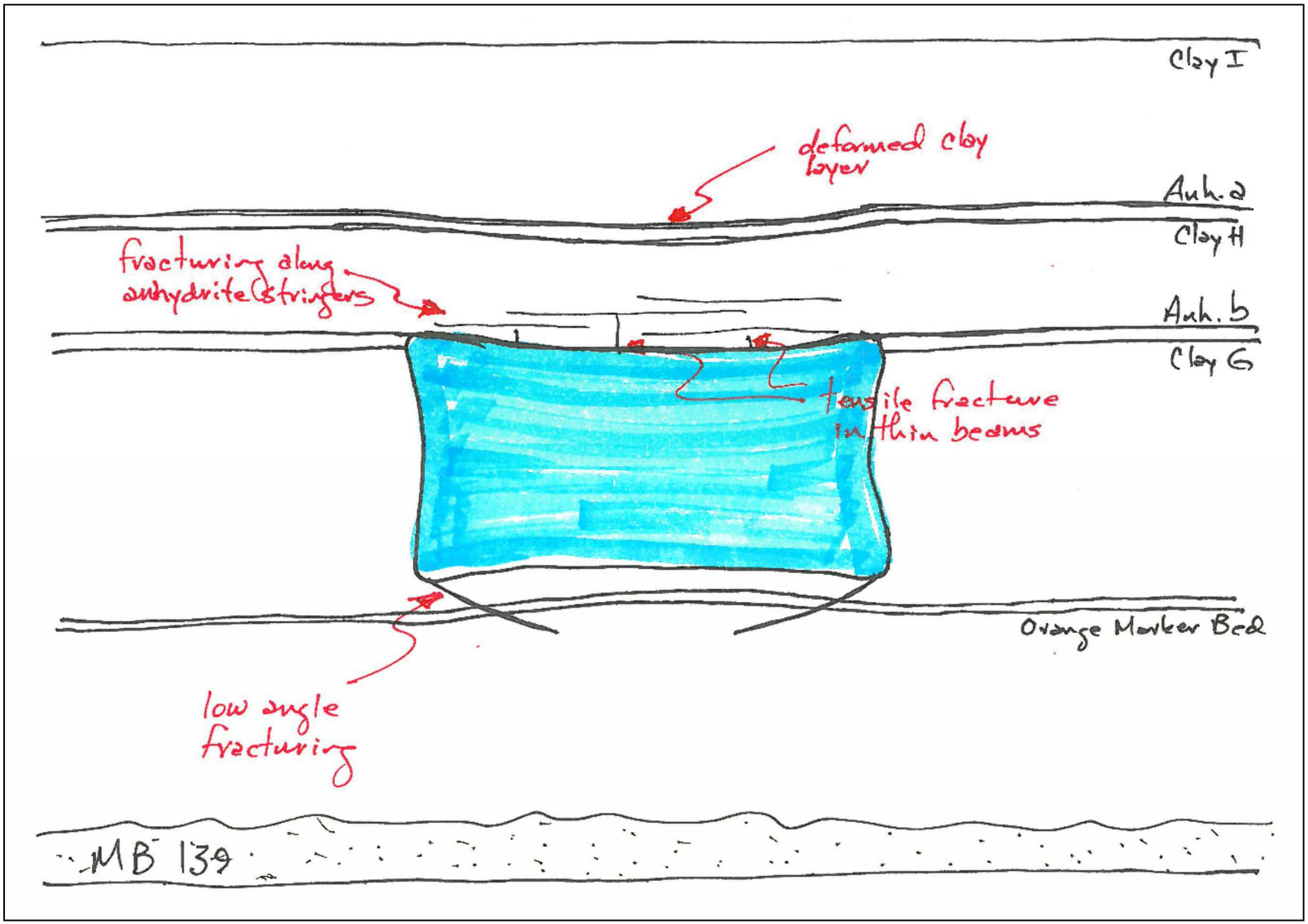
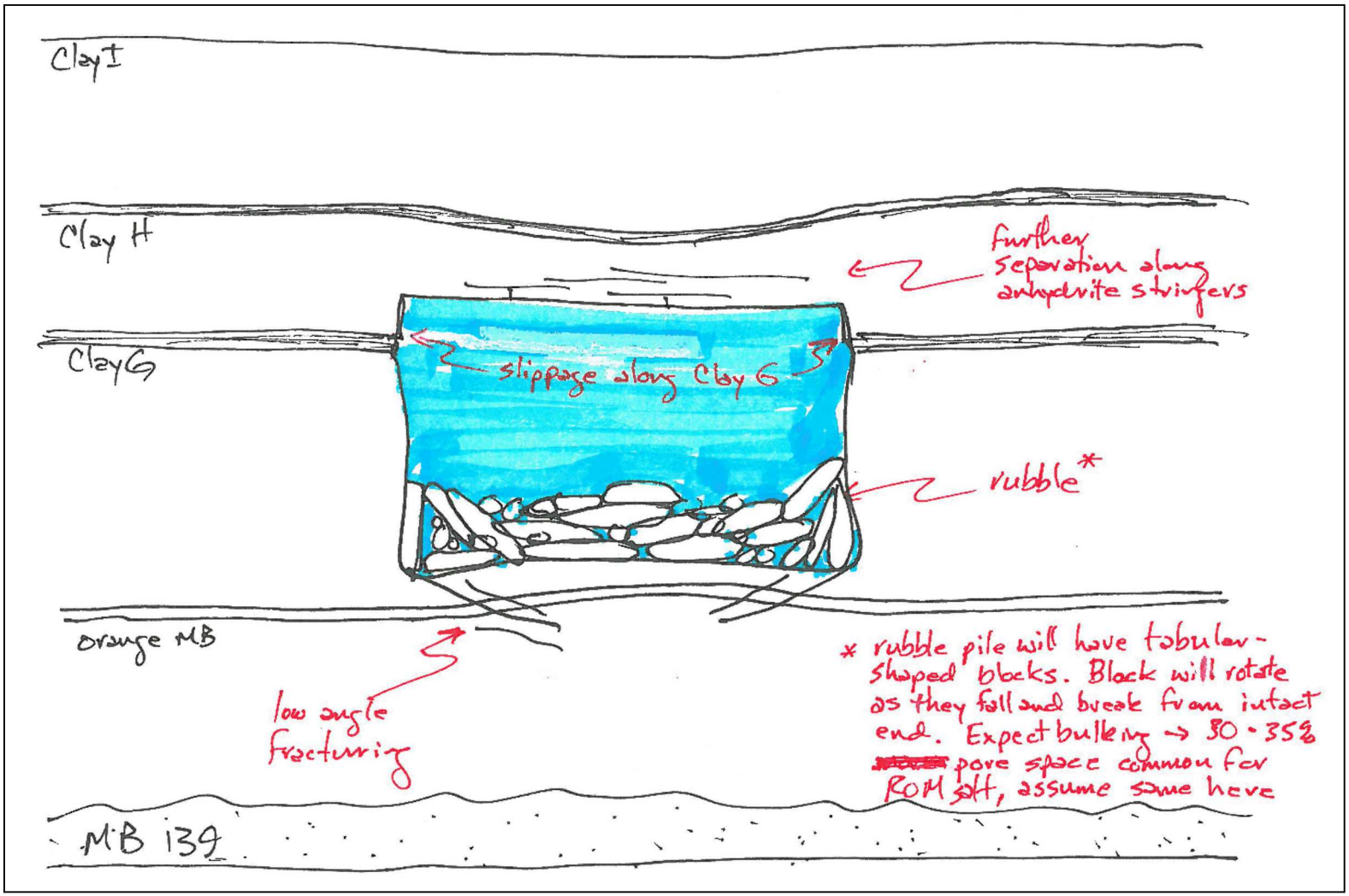


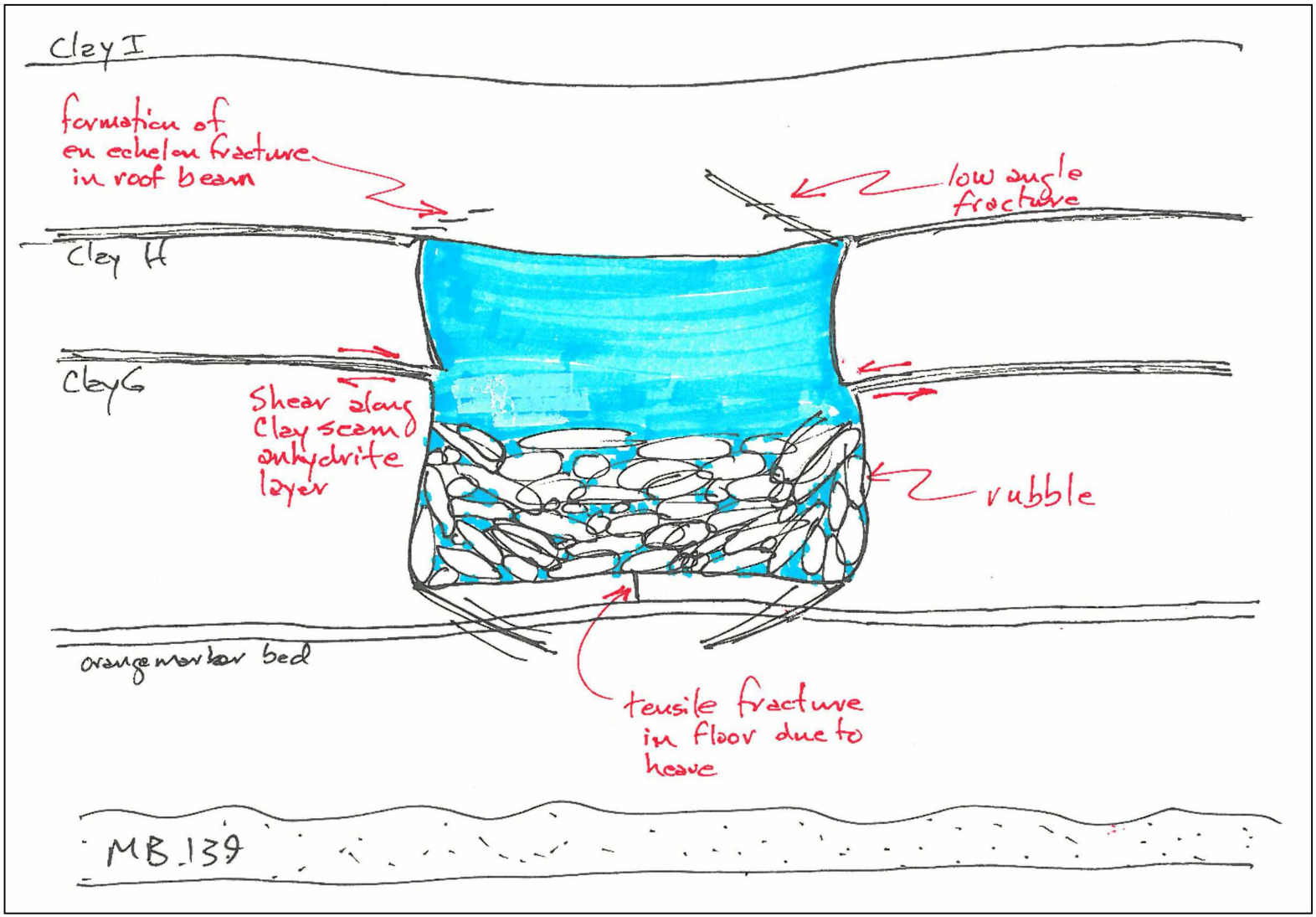
Open Room Closure 1



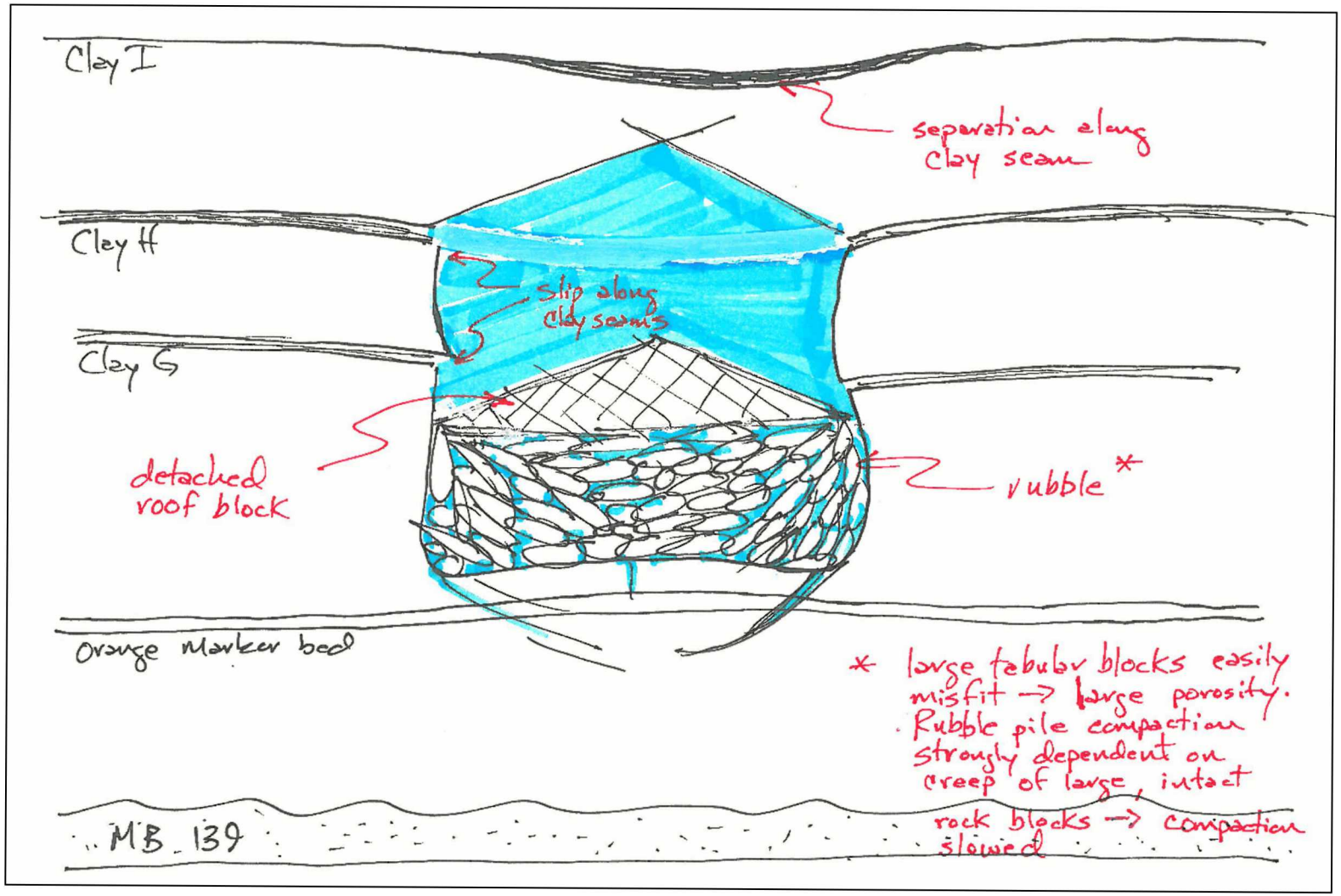
Open Room Closure 2



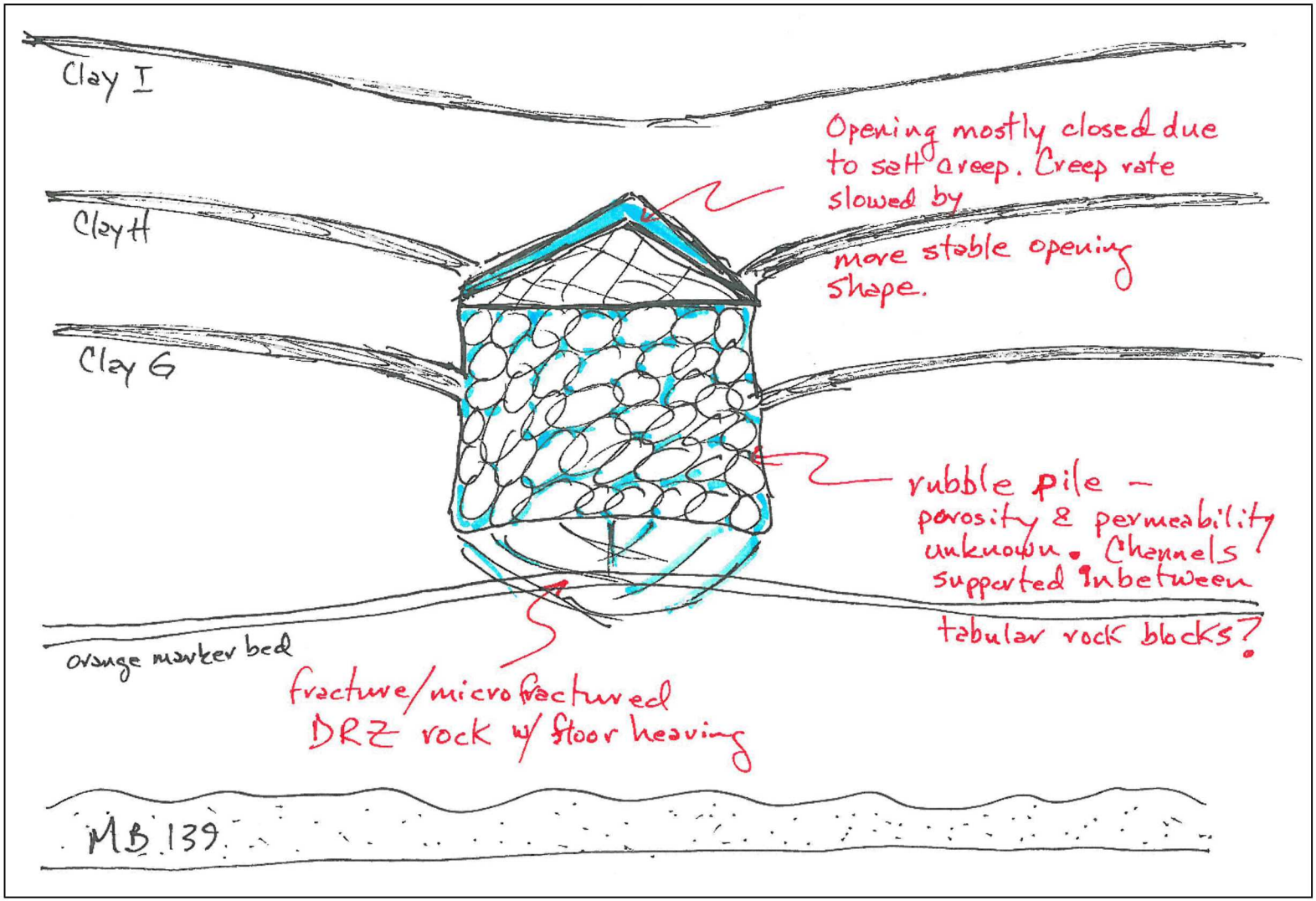
Open Room Closure 3



Open Room Closure 4



Open Room Closure 5



Upper Horizon Roof Fall at WIPP

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Lower Horizon Roof Fall at WIPP

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Floor Heave at WIPP

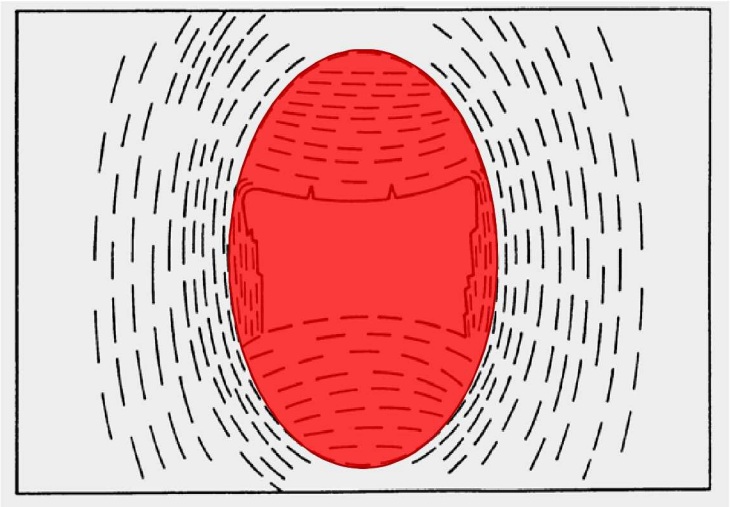
Important Aspects of Open Room Closure

Important Factors in Room Closure

- Creep behavior of salt
- Mechanical behavior of bedding plane interfaces
- Stratigraphy and mechanical behavior of non-salt strata
  - Anhydrite, clay, and polyhalite
- Backpressure on formation during closure
  - Air & microbial gas generation (included in porosity surface calcs.)
  - Brine
  - Solid debris
- Room shape
  - Altered by fractures, spalling, roof falls, and floor heave

Fractures in Open Rooms

- Occur under high shear and low confining pressure
  - Rectangular initial shape → more enduring, stable shape



- Controlled by layering and heterogeneity
  - Formation of stress induced fractures in roof and floor
  - Roof beam failure often occurs along the clay / anhydrite layers immediately above opening
  - Floor heave of salt / anhydrite separates at clay layers

- Requires sophisticated modeling approaches

Modified after Borns, D.J. and J.C. Stormont. (1989). *Delineation of the Disturbed Rock Zone Surrounding Excavations in Salt*. SAND88-2230C. Sandia National Laboratories. Presented at the 30th U.S. Symposium on Rock Mechanics, 19-22 June 1989, Morgantown, WV, Paper ARMA-89-0353.

Effective Permeability of Open Rooms

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- Healing occurs under low shear and high confining pressure
- Closure/healing rate depends on the character of rubble pile or mating of fractures
- Permeability scale effect
  - Larger samples have higher permeabilities (more fractures)
- Fractures in brittle anhydrite close but don't heal
- Sources of permeability
  - Granular media in panel closures or rubble
  - Fractured media in DRZ and larger blocks
  - Flow channels will likely be present while rubble pile reorganizes, pieces of salt deform, and gaps slip
- Permeability as a function of porosity
  - Different relationship between granular, fractured, and open-channel
  - Different rock types respond differently to changes in stress

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Summary

Summary

- Open room closure
  - Fractures cause rectangular room shape → more enduring shape
  - Precise shapes difficult to simulate
    - Controlled by fracturing, layering, and heterogeneity
    - Numerical difficulties
  - Effect of gas and brine pressure in room is difficult to predict
- Open room permeability
  - Size of sample affects permeability
  - Healing rate varies with character of rubble pile
  - Porosity – permeability relationship is tenuous under laboratory conditions, and worse at the scale of a drift
- Open rooms will close and heal more slowly than filled rooms

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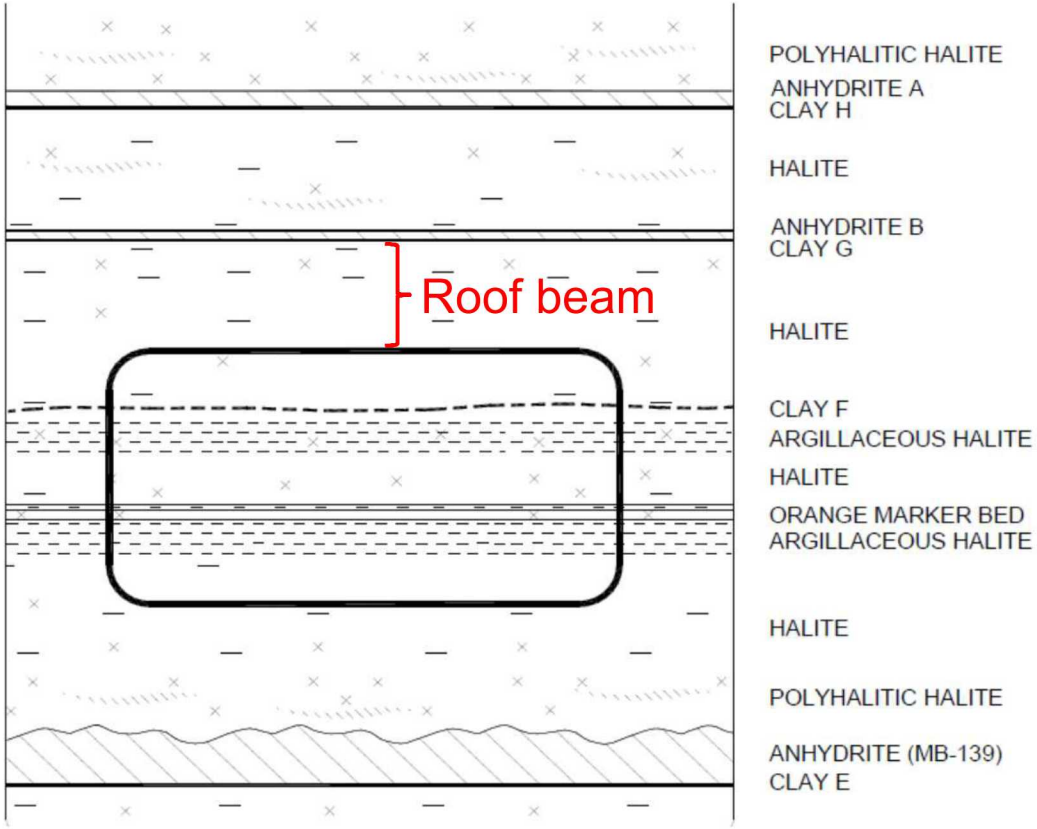
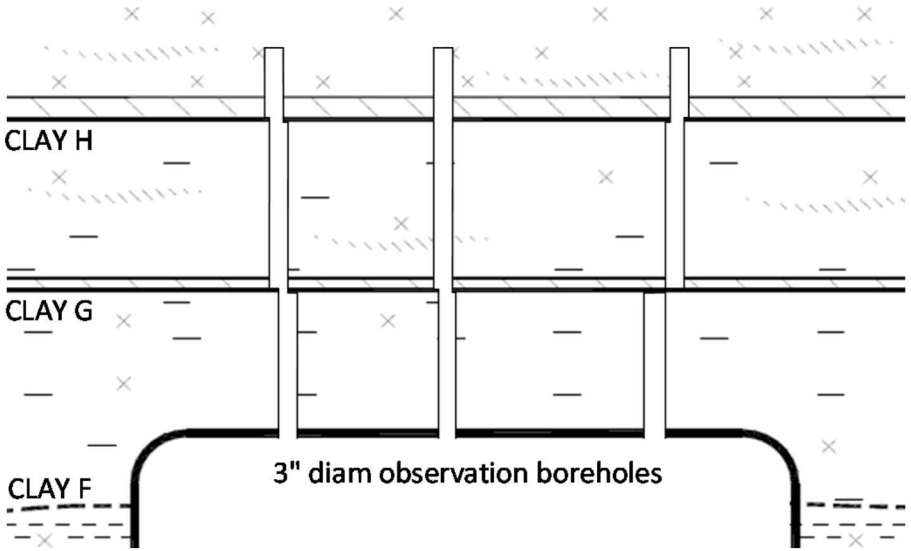
Extra Slides

Roof Beam Fracturing



Deformation of Roof Beams

- When an opening is excavated
  - The horizontal stresses confining the ribs are removed
  - The vertical stresses in the pillars are increased
  - The pillars vertically shorten and horizontally expand
- Horizontal expansion of pillars laterally compresses roof beams



Creep – A Ground Control Challenge

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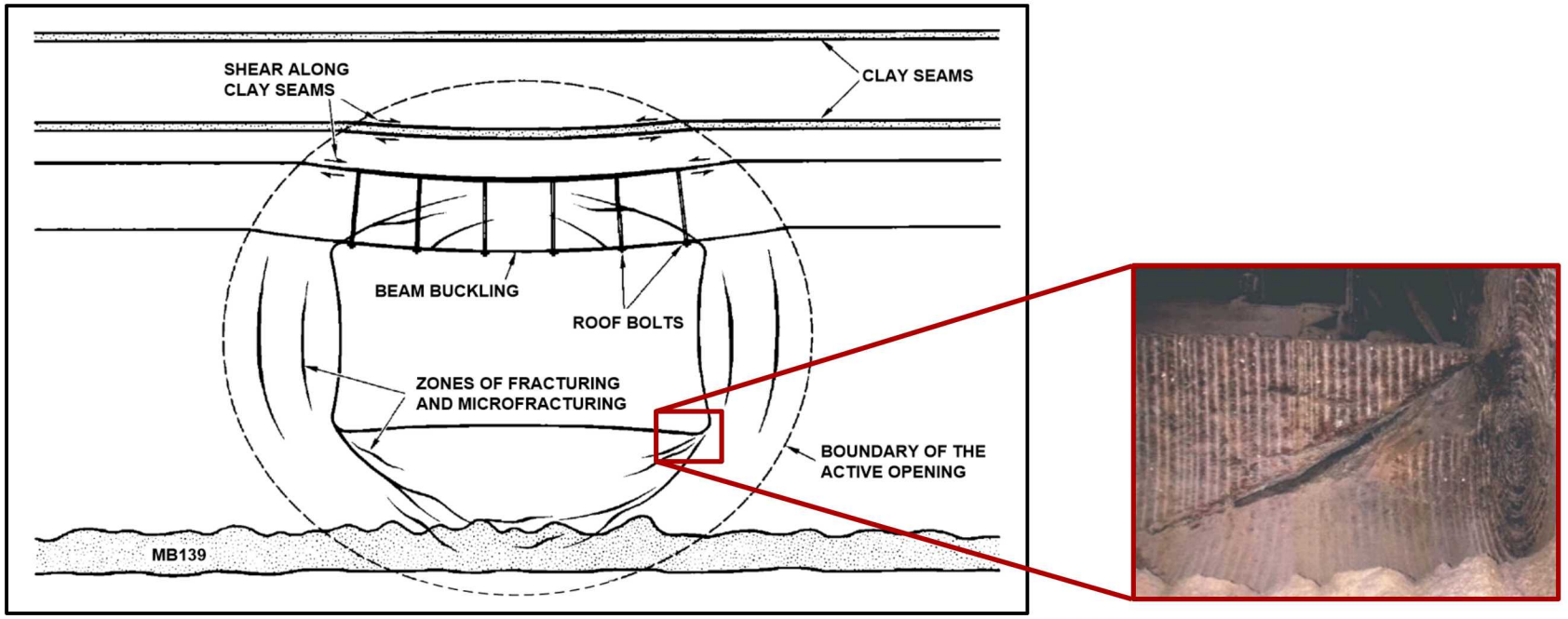
- Salt was chosen as the repository medium because it creeps and, over time, will close and seal underground openings
- While creep is desirable for containing hazardous waste, it also creates a multitude of ground control challenges
- Once an opening is made, a continuous process of deformation and associated fracturing is initiated
- Salt creep at WIPP causes
  - fractures in the roof, ribs, and floor
  - separations along clay seams and anhydrite beds
  - sagging (bellying) of the roof
  - roof falls, ribs spalling, and floor heave

Open Room Closure

- Creep models, such as Munson Dawson (MD), are appropriate when no discrete disruptive events occur
- Creep models are inadequate, however, for closure of open spaces, which are subject to disruptive events



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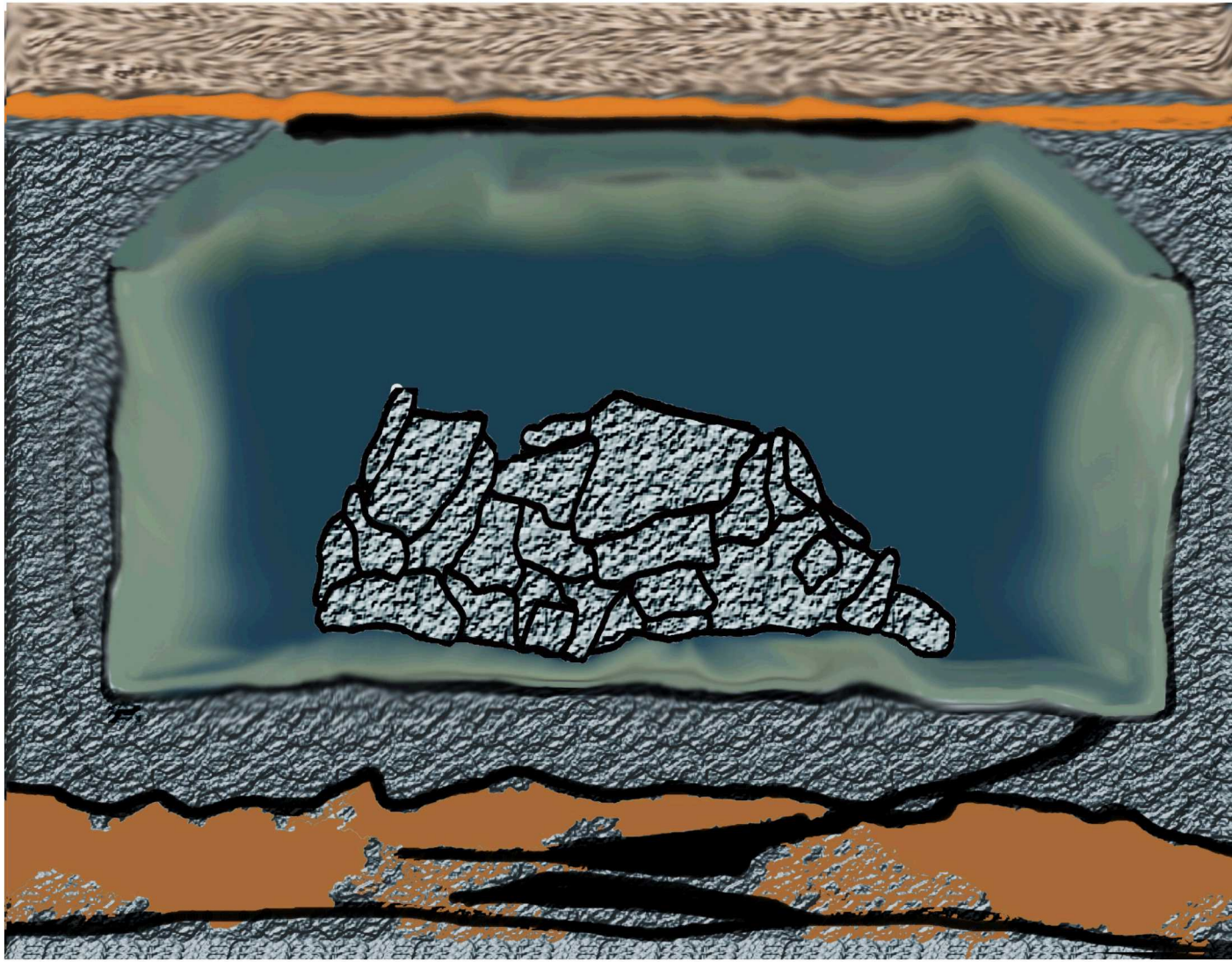
Empty Room

Fracture pattern

Separation at clay seam

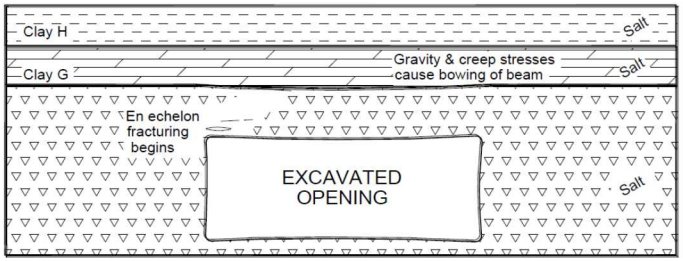
Room shape more stable and rubble pile

Net effect: Room closure slows down



Fracture Development in Lower Horizon

PHASE 1



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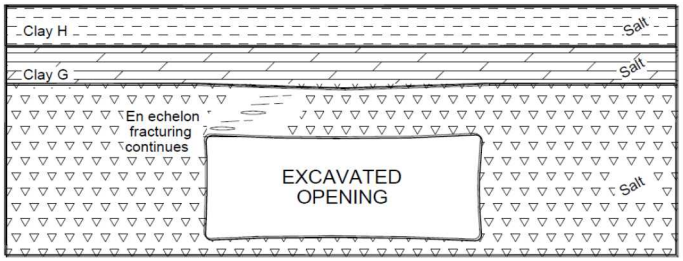

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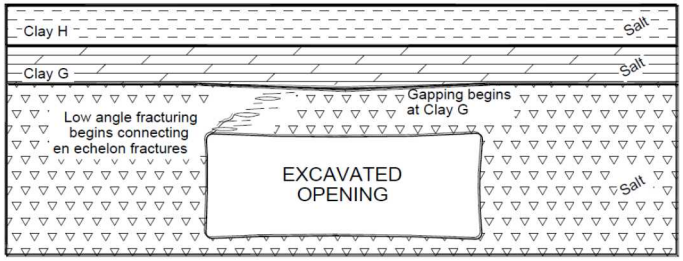

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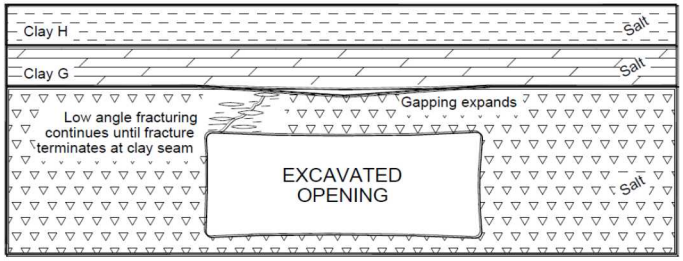

Fracture Development in Upper Horizon

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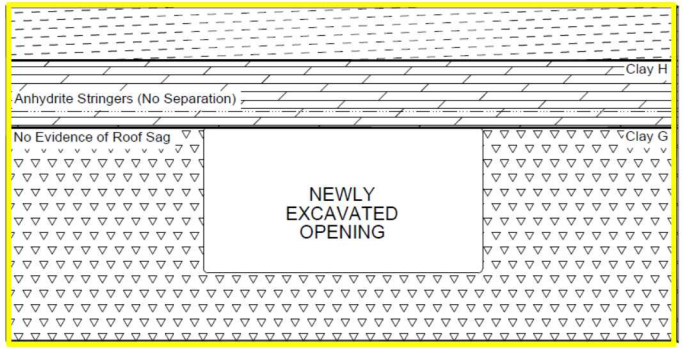

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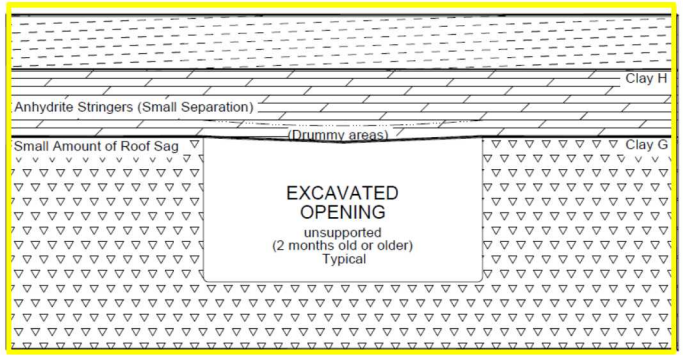

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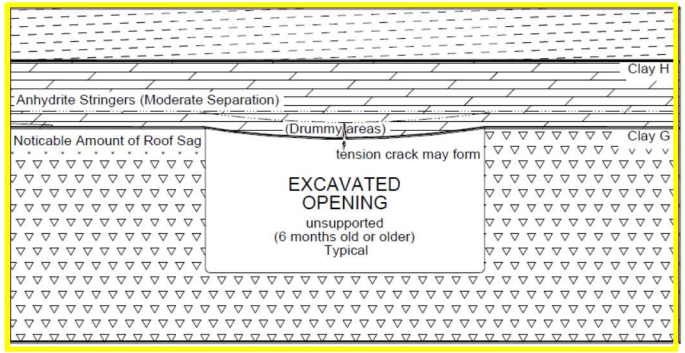

Examples of Damage and Fracture of Salt in Upper Horizon