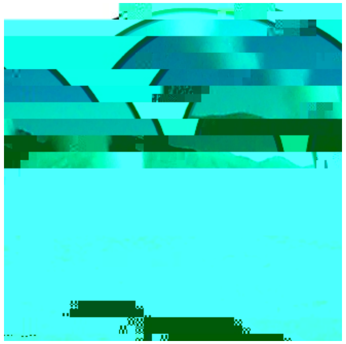
GEOTHERMAL ENERGY UTILIZATION



Rock

Casing

Cement

Well Considerations and Investigations for Future Developments

- Future developments in utilizing current wells for Geothermal Energy should include
  - the evaluation and appraisal of the prospects currently available
- Idea qualifying and investigative requirements of a prospect well would be
  - its current production status
  - its completion history
  - its workover history
  - and any diagnostics performed on the integrity of the well’s zonal isolation
- With numerous wells now having depleted resources in hydrocarbon and drilled into wet formation temperatures of 225 ºF or greater, they will become possible candidates for Geothermal Resources.

What's Available

- ü Collective Well Files
  - ü Histories of completions
  - ü Workovers
  - ü injection and production data
  - ü cost sheets
  - ü regulatory requirements and compliances met
  - ü problems addressed and solutions used
- ü Scrutiny can give indications of economical levels
  - ü Needed repairs or well deterioration conditions
- ü Often files are digitized giving a much faster and beneficial way to research wells

What's Available – Cont'

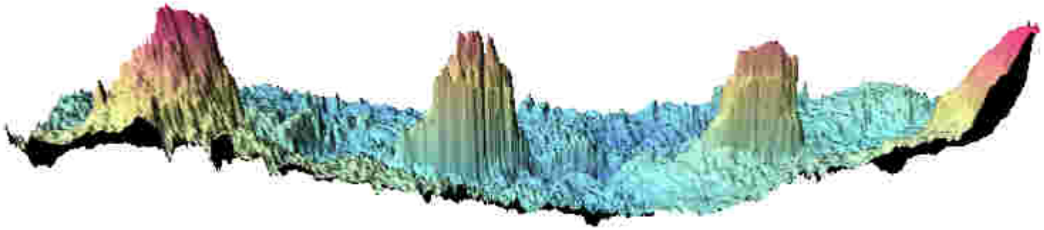
- Types of Data and Well History Available
  - Structured data collections
    - Some with reservoir conceptual modeled performance and evaluations/characterizations
  - Utilization of commercial software in capturing the performance and descriptions in graphical analysis, schematics, charts, data bases, etc.
  - Internal and External Networking Systems with data archives and communications linkages
- Other Resources
  - State Governments if they have produced the data
  - DOE if still assisting the Energy Sector
  - Commercial Resources – data at a cost

Data Collection

- Existing Data
  - Geological Description and Reservoir Understanding
  - Production and Injection History
  - Completion History and Well Construction
  - Production Equipment and Facilities
- Additional Data for Better Understanding
  - Production Tests
  - Tracers
  - Cased Hole Logging
  - Injection Analysis
  - Down Hole Video
  - Research and Developments

Data - Geological Description

- Depositional Environment
- Reservoir Geometry
- Fluid Saturation Distributions & Contacts
- Faults and Barriers
- Stratigraphic Boundaries
- Sedimentary (Laminates, Cross Bedding)
- Microscopic (Clays, Texture, Pore Geometry)
- Temperature Resources - Data



Current Casing Parameters

ü Was the casing string cemented to surface ?

ü Is there cement behind the casing ?

ü Where are water influx intervals ?

ü Where are fragile intervals with possible associated fractures ?

ü What is the extent and length of casing with erosion, pitting, and leaks ?

ü What is needed to give an extended well-life with production considerations or sources of new economic benefits

Addressing Completion Methods

Past & Present

ü

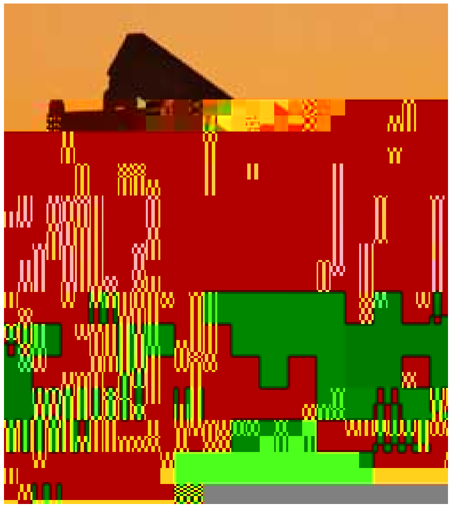
Repairing Wells for Long Term Zonal Isolation and Integrity

OBTAINING A GOOD ANNULAR SEAL

- ü Complete planning with the aid of accurate job models
- ü Proper well cleanout and drilling fluid preparation
- ü Proper centralization of the pipe
- ü Proper volumes and design of spacer
- ü Effectively designed slurries
- ü Pipe movement
- ü Continuous pumping
- ü Maximum flow rates
- ü Zero closed-in pressure during WOC time

Lack of Integrity and its Causes
Production Operations

- Influxes continuing following primary cementing
- Annular pressure differences causing cross-flows
- Casing pressure cycling during the well's productive life
- Perforating and initial acid breakdowns
  - Cracking cement sheaths
  - Removal of formation barriers
- Stimulation treatments going out of zone
- Injectants dissolving and eroding rocks



Cracked Cement Sheath

How does one use this information?

- Time – Lots of data and limited resources to evaluate
- Define what is needed to accomplish the desired long well-life for Geothermal Recovery
  - Initial Completion details and data give basis to estimate the well-life potential
  - Compare the completion details and data to what is referred to as the Best Practices
  - Query the completion information to determine if any problems were existent during the primary drilling and cementing operations
  - Investigate Well Bond-Logs and if needed run latest technology to gain a 360º view of the casing annulus
  - Study the well histories such as pin-hole-leaks or metal corrosion problems

RELATIVE BEARING
0 DEG. 360
ECCENTRICITY
0 1.0
DEVIATION
0 5.0

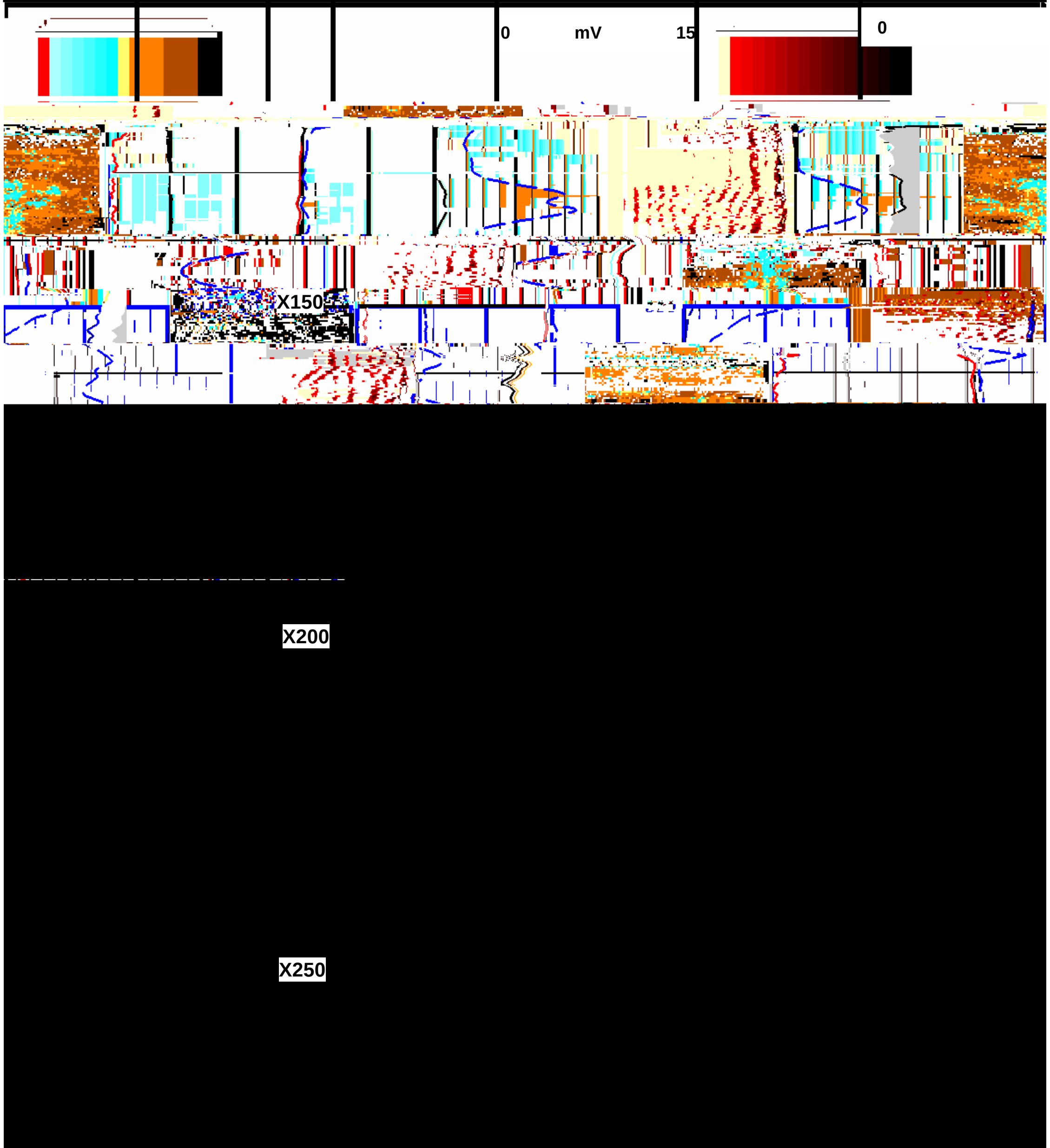
THICKNESS CURVES
0.2 IN. 0.4
AVERAGE
MINIMUM
MAXIMUM

AMPLIFIED AMPLITUDE
0 10
AMPLITUDE
0 100

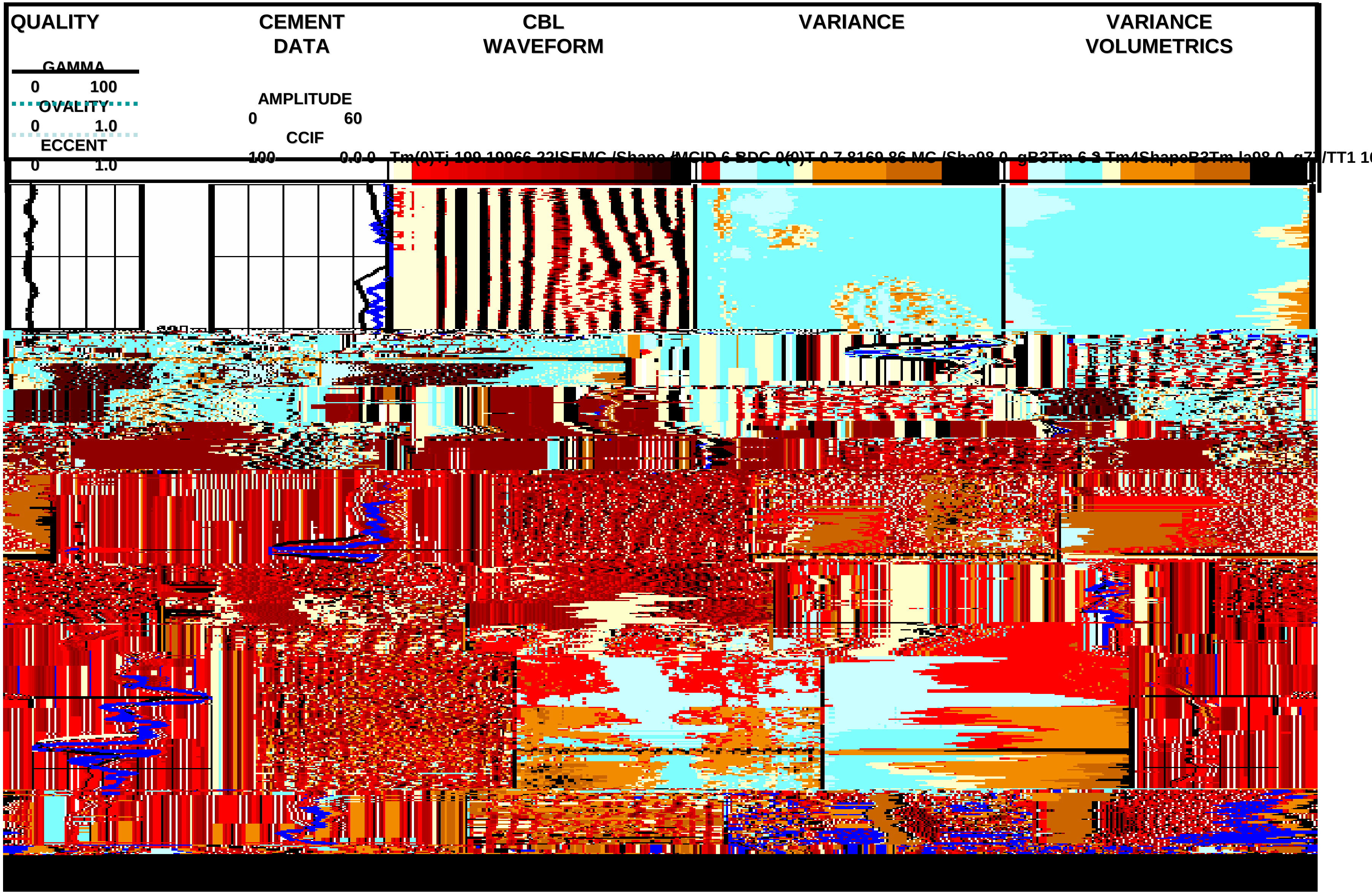
MICROSEISMOGRAM
200 1200

1 CBL 0
BOND INDEX
AVERAGE
IMPEDANCE
10 0

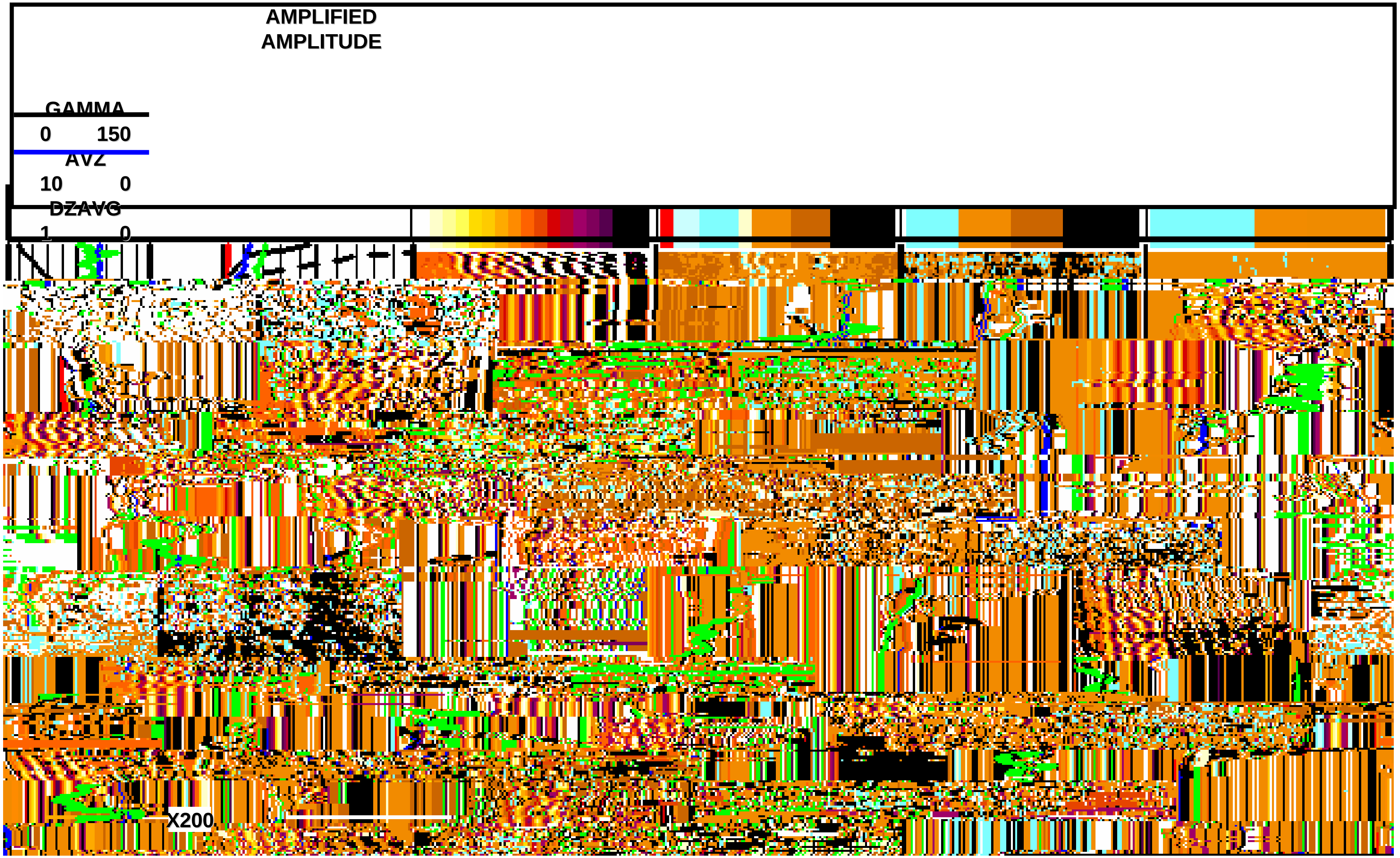
IMPEDANCE MAP



Example of Cement Evaluation Logs



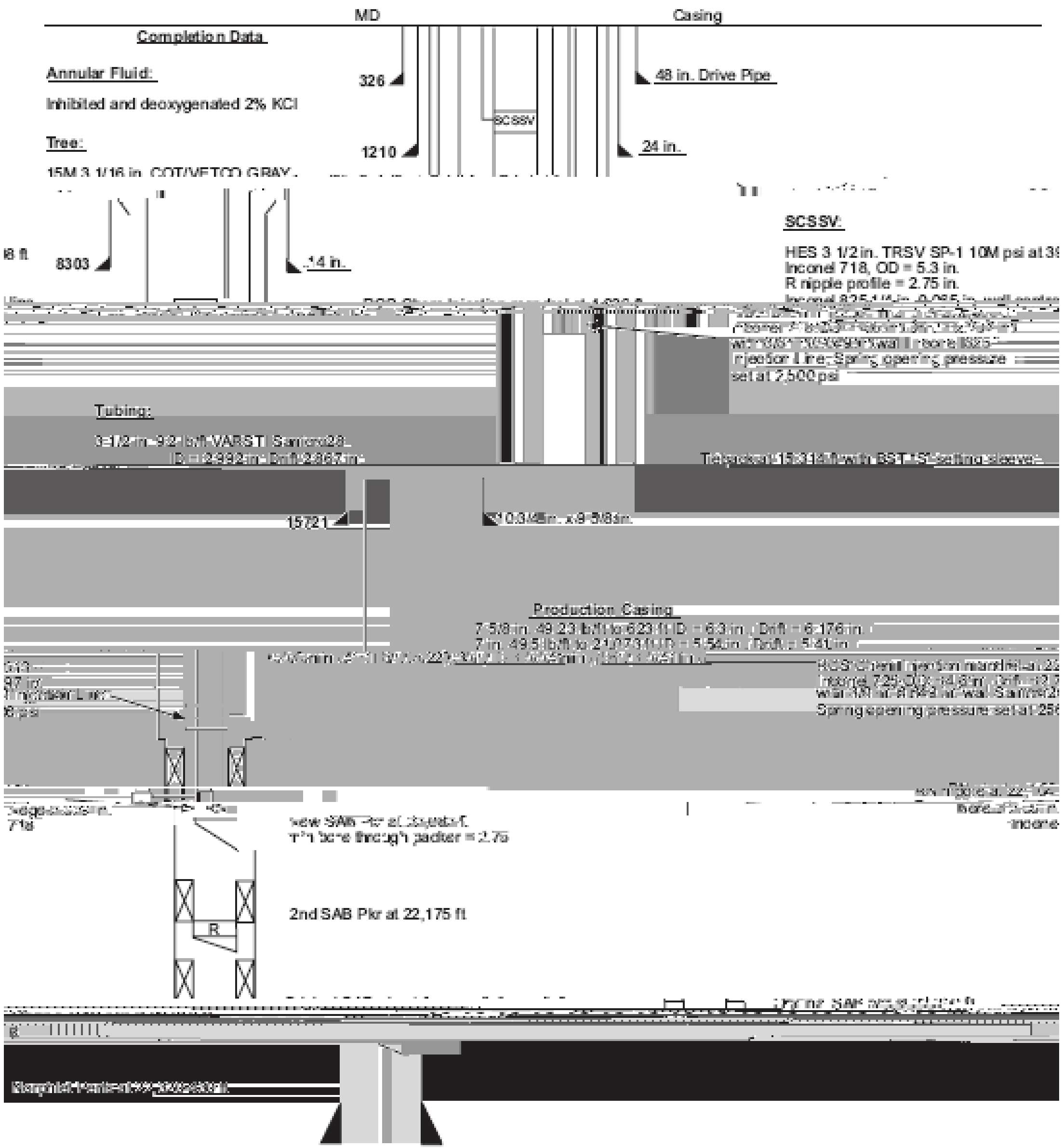
Foamed Cement Analysis in Bonded Pipe



Understanding the Complexities of the Well Completion

ü

Example of a schematic showing a well's completion and casing depths



Example well has:

Conductor Casing

Surface Casing

Intermediate Casing

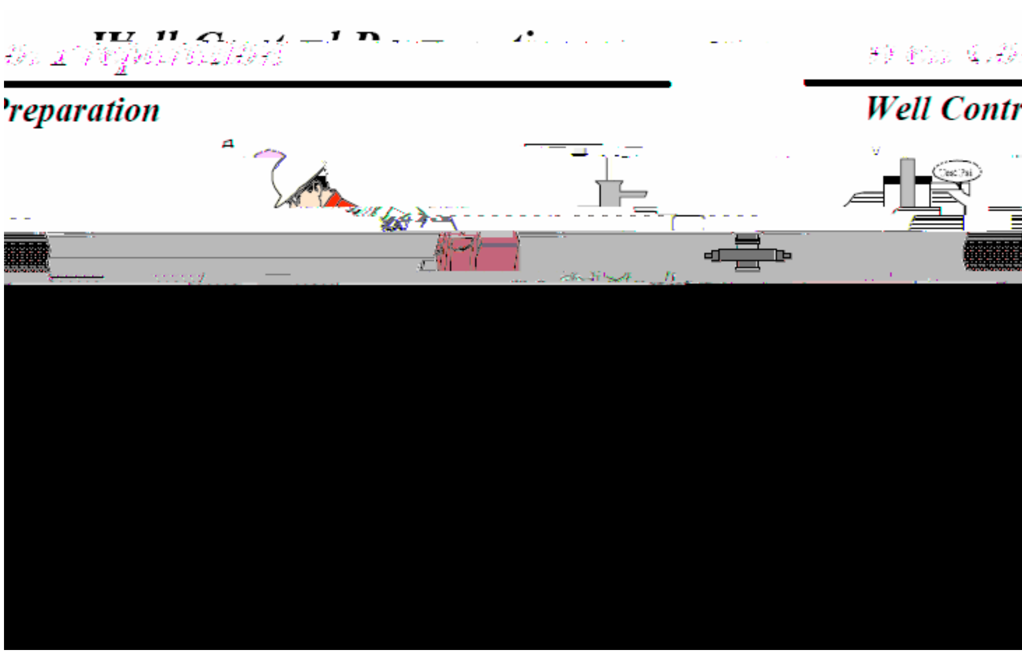
Drilling Intermediate

Production Liner

Various Completion Tools

How to Establish Well Integrity if Re-Entering a Well

Entering a Wellbore

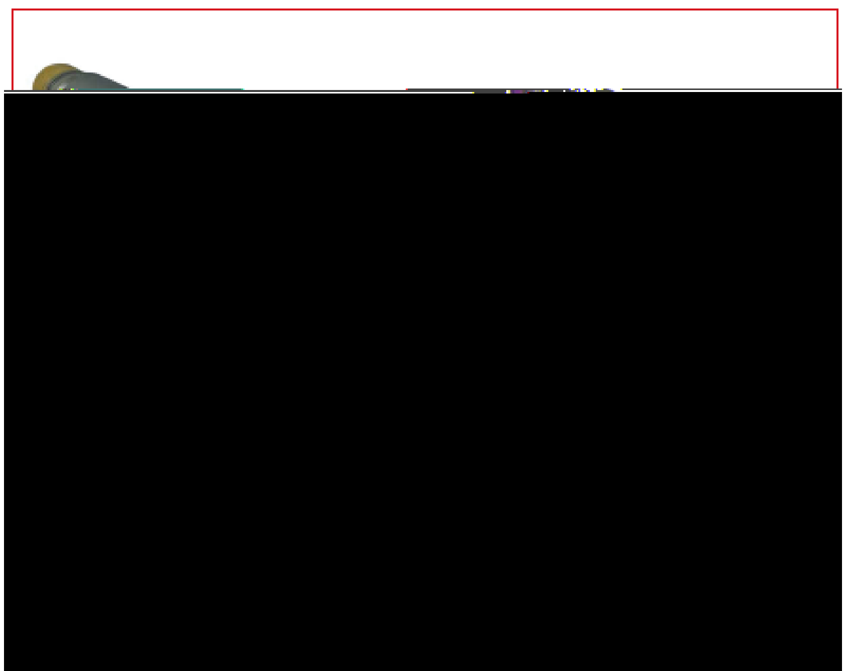


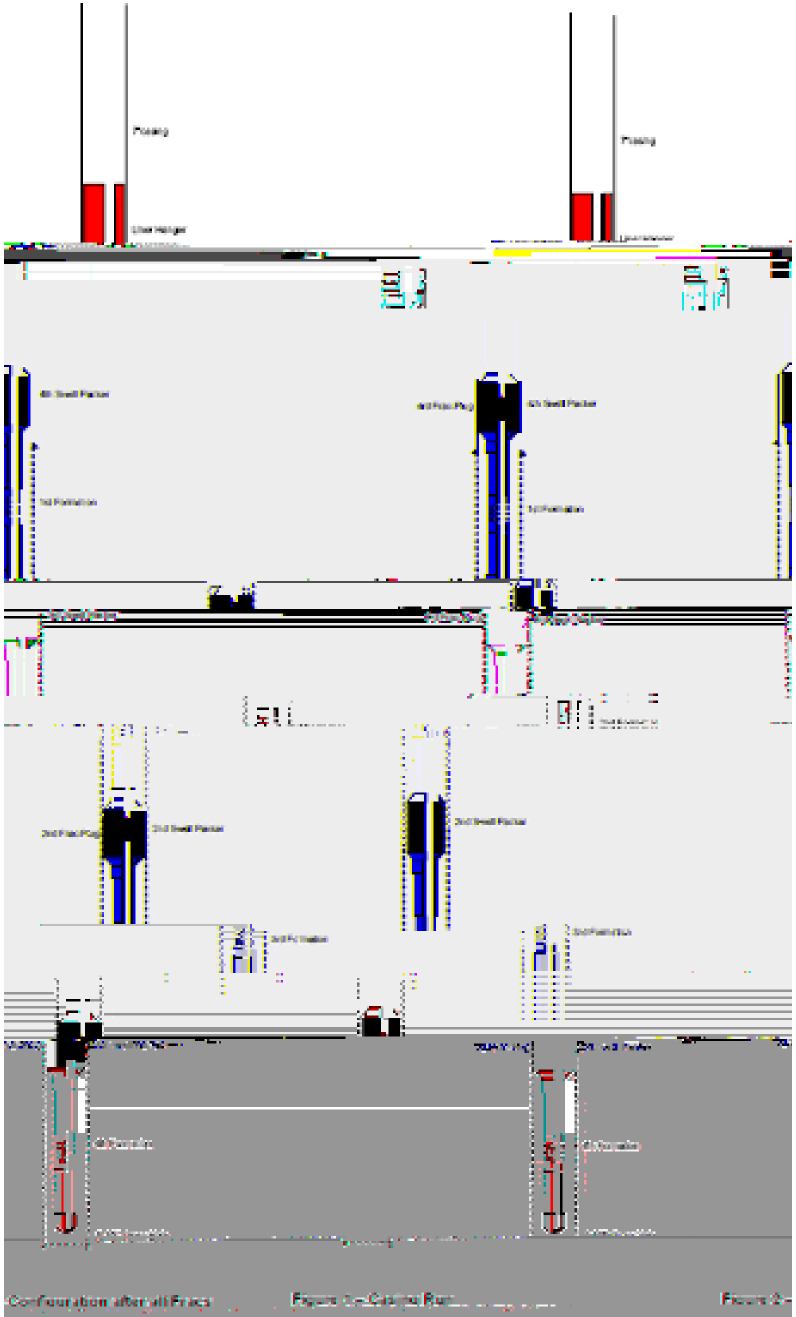
Emerging Technologies in Wellbore Stabilization

ü

Emerging Technologies in Wellbore Stabilization

- Easywell Swellable Casing Packer Technology
  - Utilizes a swellable packer run on casing or liner
  - Ability to swell when left static in either Oil or in Water
  - Capable of gaining a high pressure seal in annulus at designed points where the Easywell Packer elements were placed

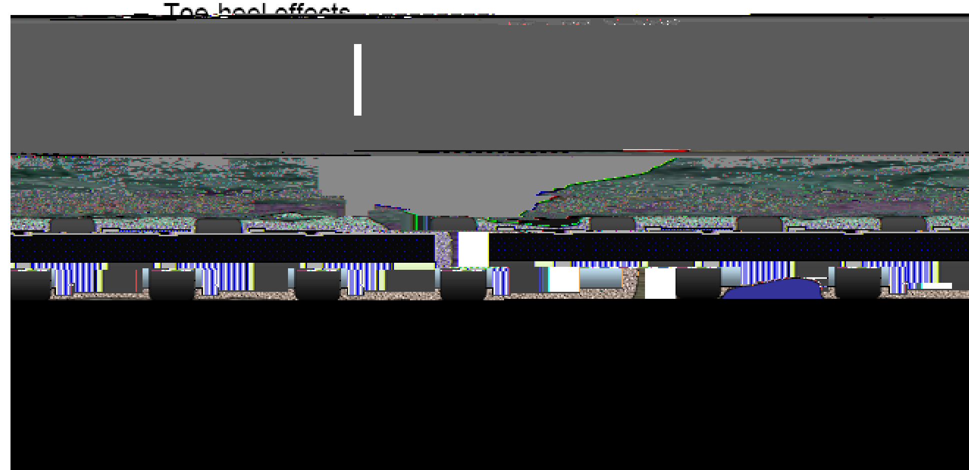




Emerging Technologies in Wellbore Stabilization

Easywell Packer System can be run in either a vertical or horizontal completion

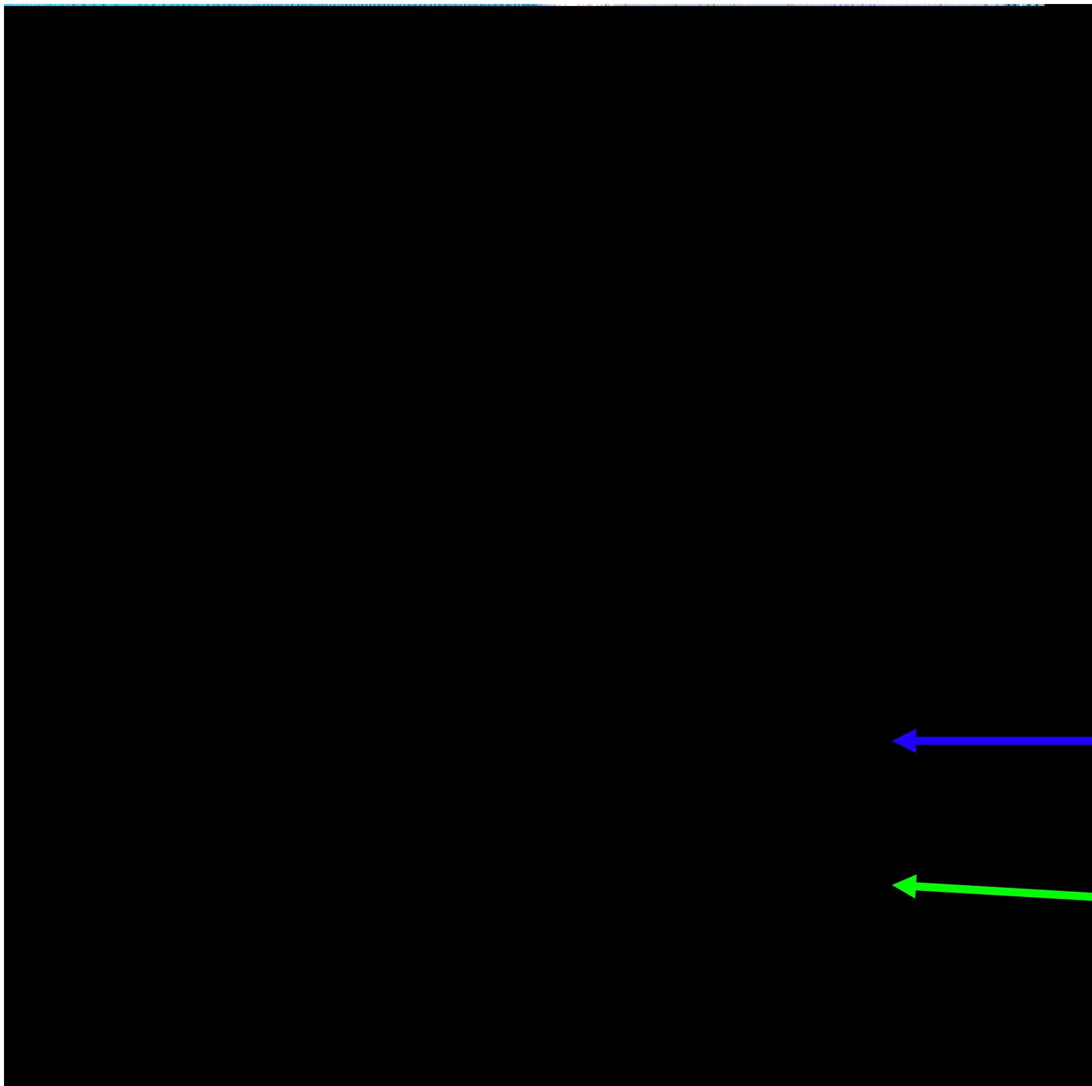
- Homogenous, low drawdown reservoir
  - Frictional flow
  - Toe-heel effects



Remedial Technologies

Wellbore Integrity Solutions for extended Well-life

Analysis of Results on Casing Integrity



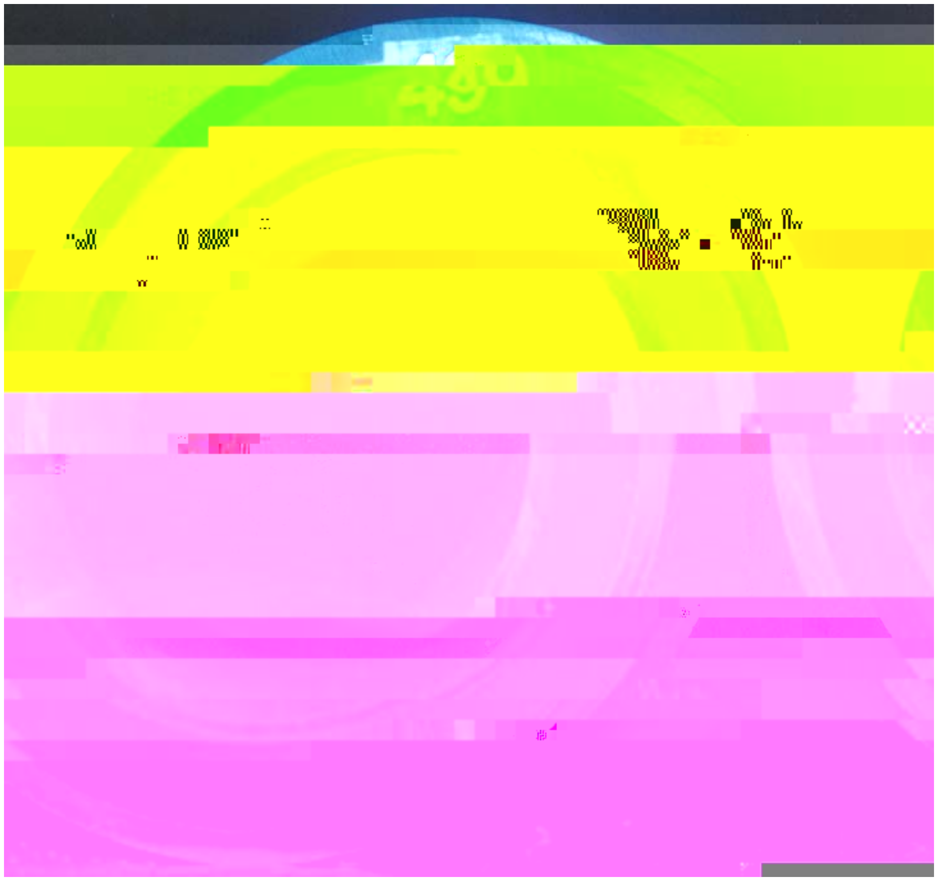
- Bond Log
- Measure Displacement Efficiency

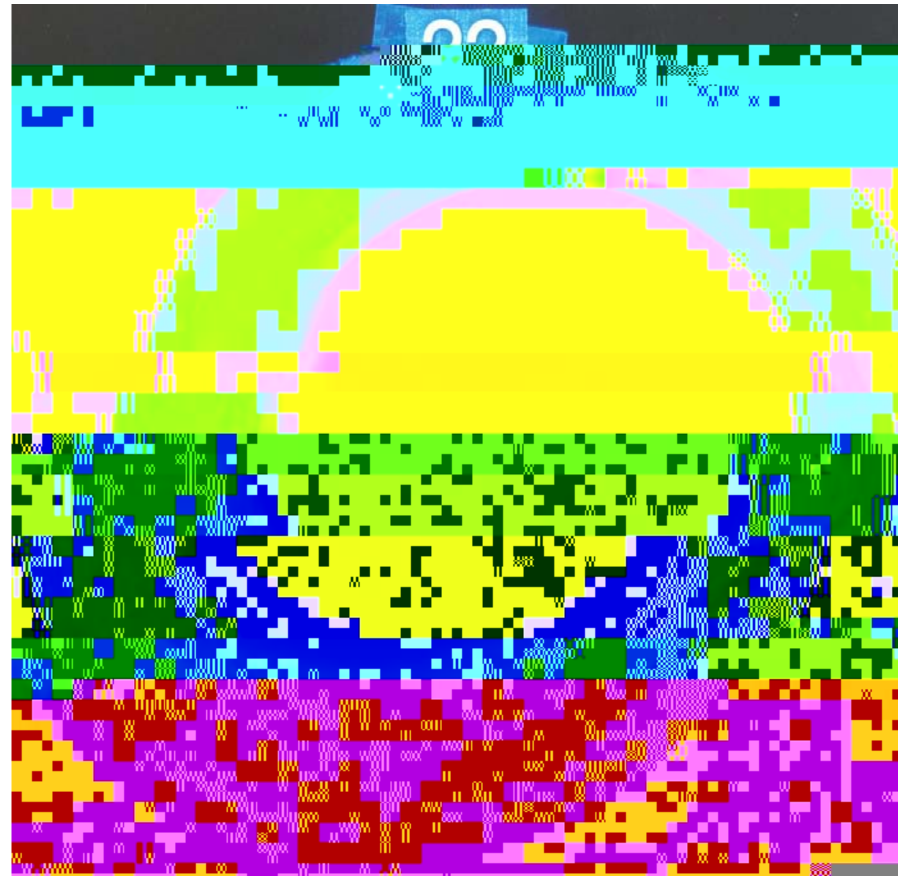
Casing Cementing Parameters
"Making a Decision"

- Is it easier to fix an invasion or loss circulation problem by changing directions annular placement is conducted ?
  - Where are gas influx intervals ?
  - Where are water influx intervals ?
  - Where are fragile intervals with possible associated fractures ?
- What is the extent and length of problem zones ?
- What is the easiest way to achieve zonal isolation ?
- What attributes are needed to achieve a successful remedy ?

Best Practices: Find and utilize the focal points in applications and placement methods

ZoneSeal vs Conventional Cement



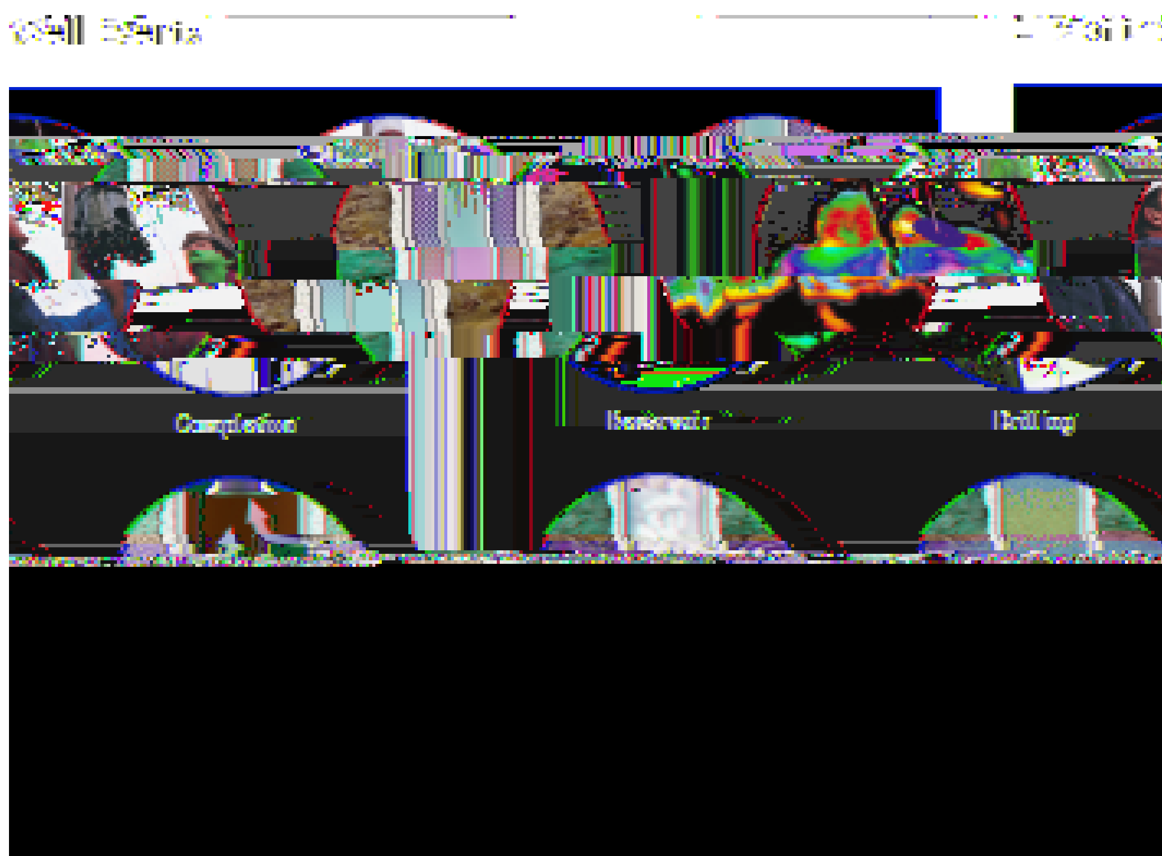


Cementing High Temperature and Pressure Wells

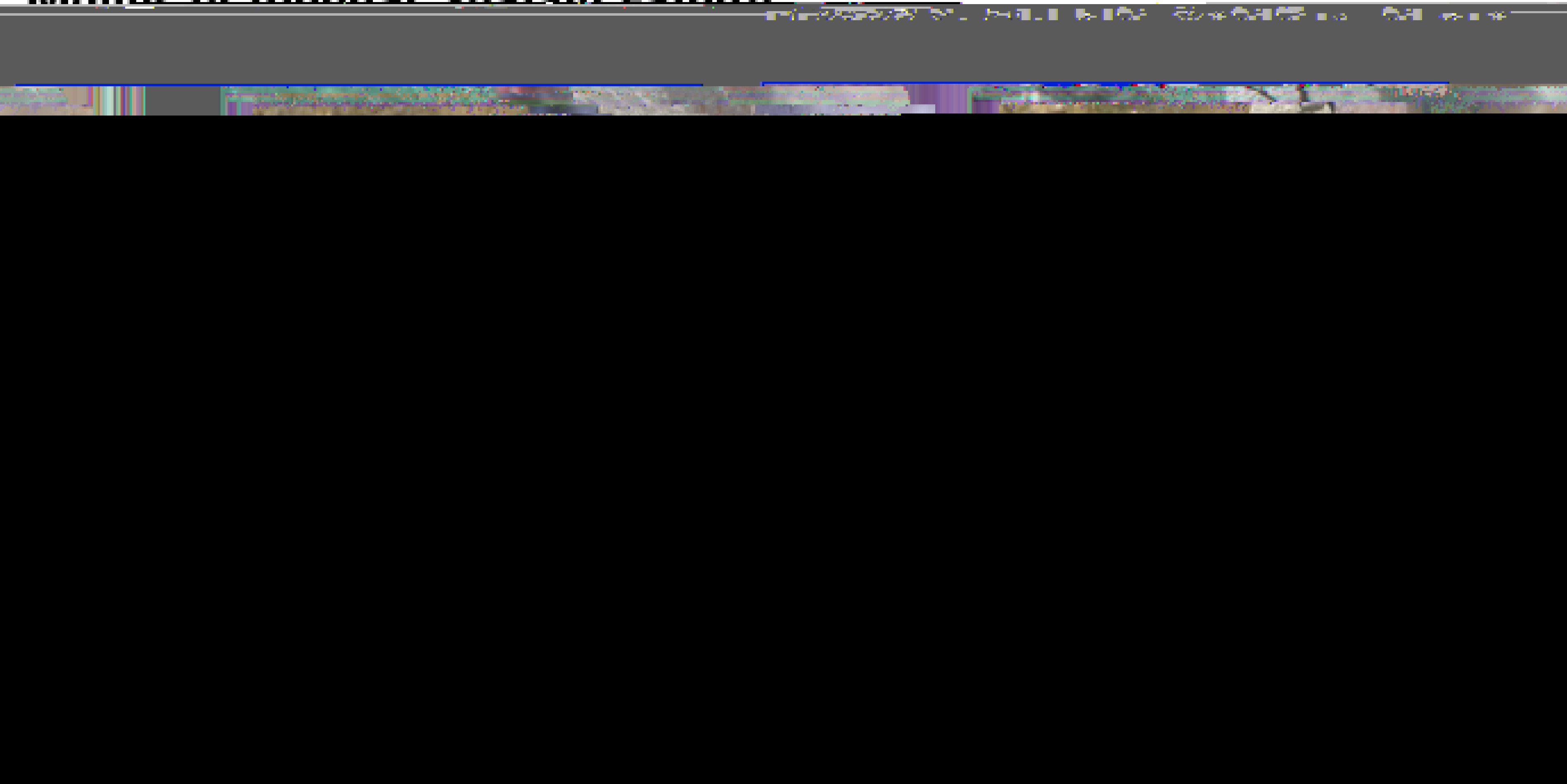
- General Issues
  - Zonal Isolation
  - Support Casing
  - Temperature Cycling
  - Low Fracture Gradient Formations
  - Exposure to Steam
  - Variable Hole Sizes
  - Long Well Life
- Specific Issues
  - High Steam Pressure
    - > Fracture gradient
    - 550 to 600 deg. F.
  - Frequent Cycling
    - 10 to 15 cycles per year
  - Long Pay Interval
    - ~1/3 of total well depth
    - Maintain zonal isolation for 2 or 3 intervals
      - 5 to 10 years each

Reverse Circulating Cement Designs

- Utilizing what the well gives you to make a better annular seal
- Utilization of energized slurries means it does not care which


Completion
Drilling

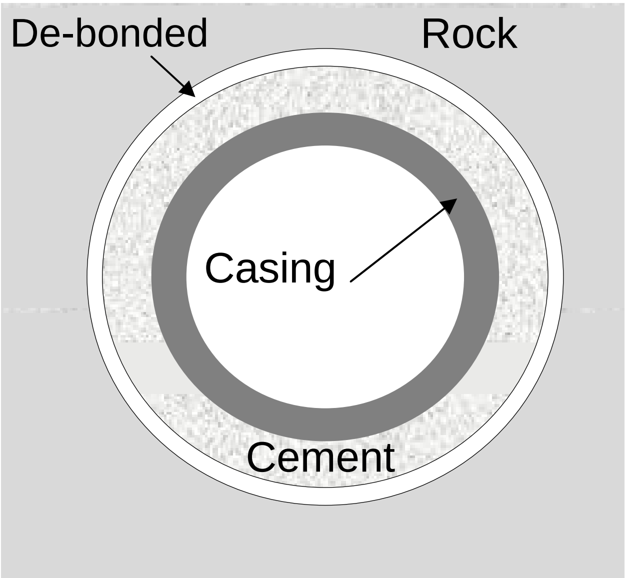
Modes of Annular Sealant Failure



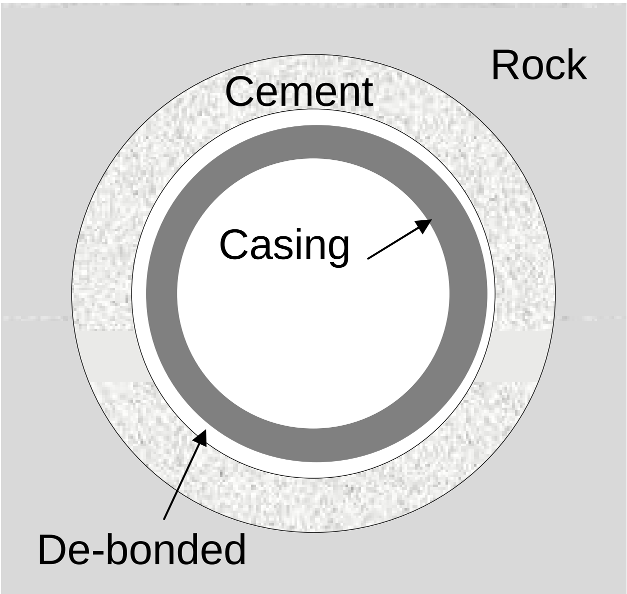
Modes of Cement Failure

- De-bonding

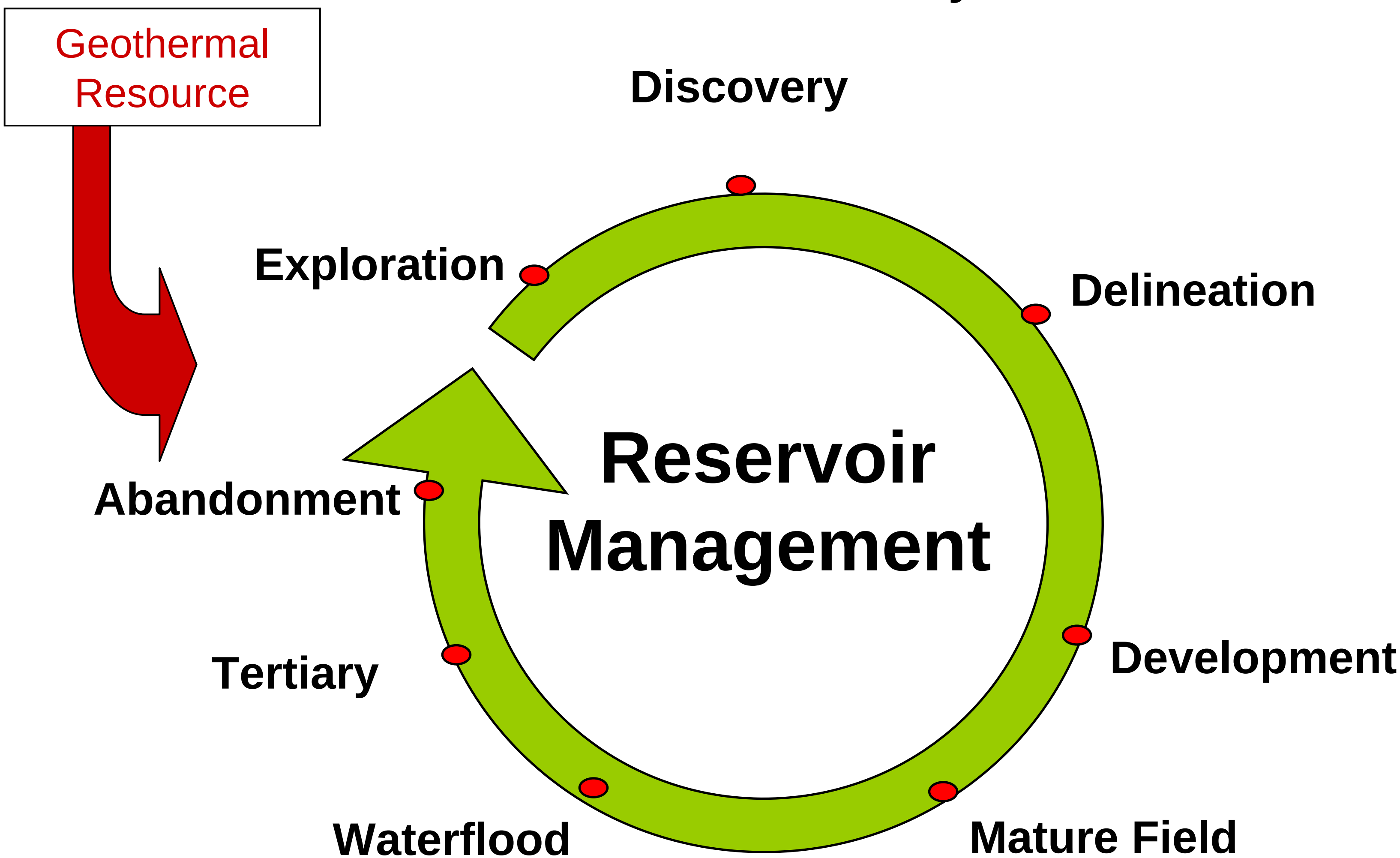
@ rock-cement interface



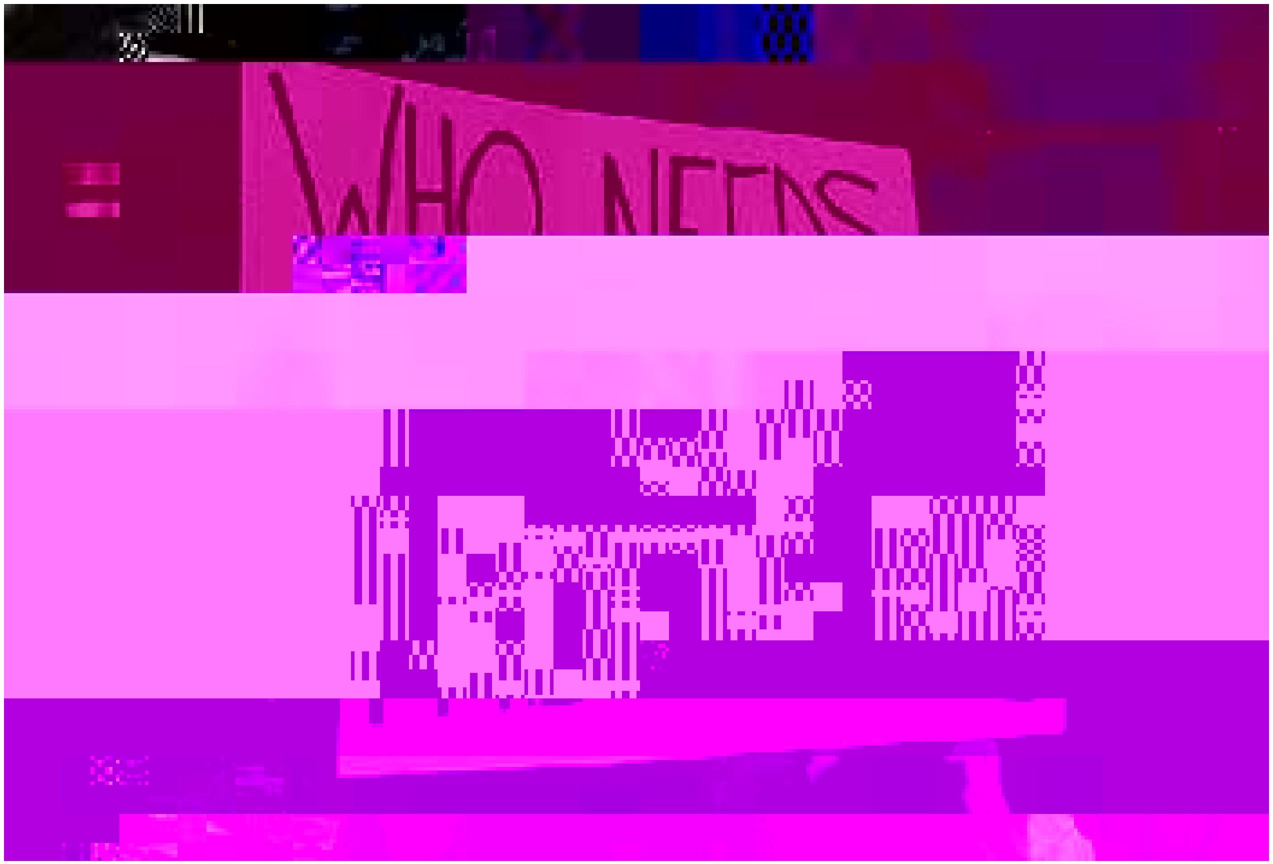
@ cement-casing interface



Reservoir Life Cycle



PRODUCTION


WHO NEEDS