Hydraulic Testing in Geothermal Waters with Hydrogen Sulfide Gas Hycroft Mine, Nevada

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srk consulting 1974 40 2014

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1,370 to 1,920 m above mean sea level – receives about 20 to 30.5 cm of precipitation per year

Hycroft Mine

Winnemucca

Gerlach

Lovelock

Pyramid Lake

50 Km

Field Work 2010 - 2012

- 22 Piezometers – 1½ and 2 inch
- 16 Monitoring Wells – 4 inch
- 30 Airlift-Recovery and Slug Tests
- 20 Corehole Packer Tests

12-Hour Pumping Test

7-Day Pumping Test

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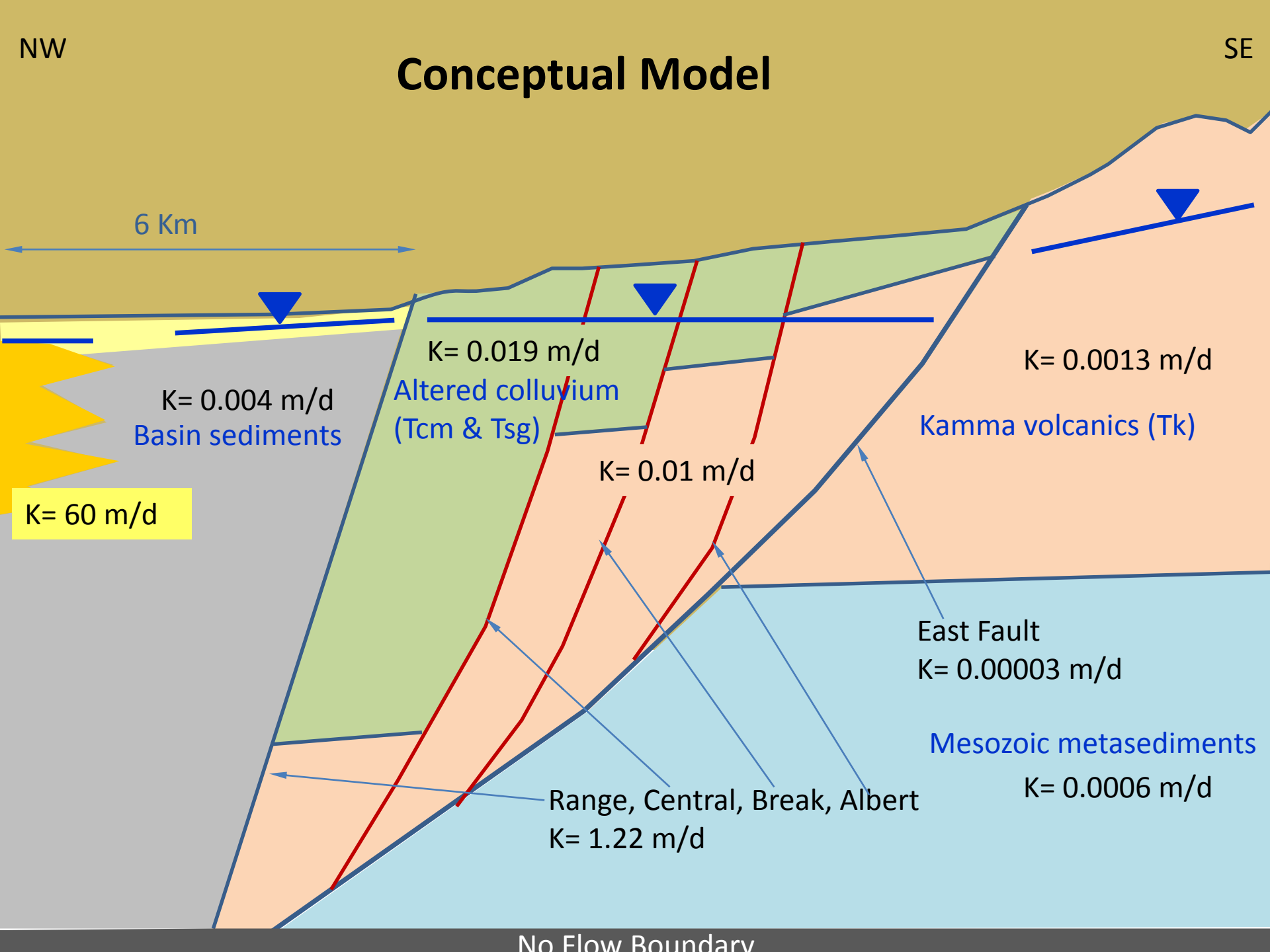
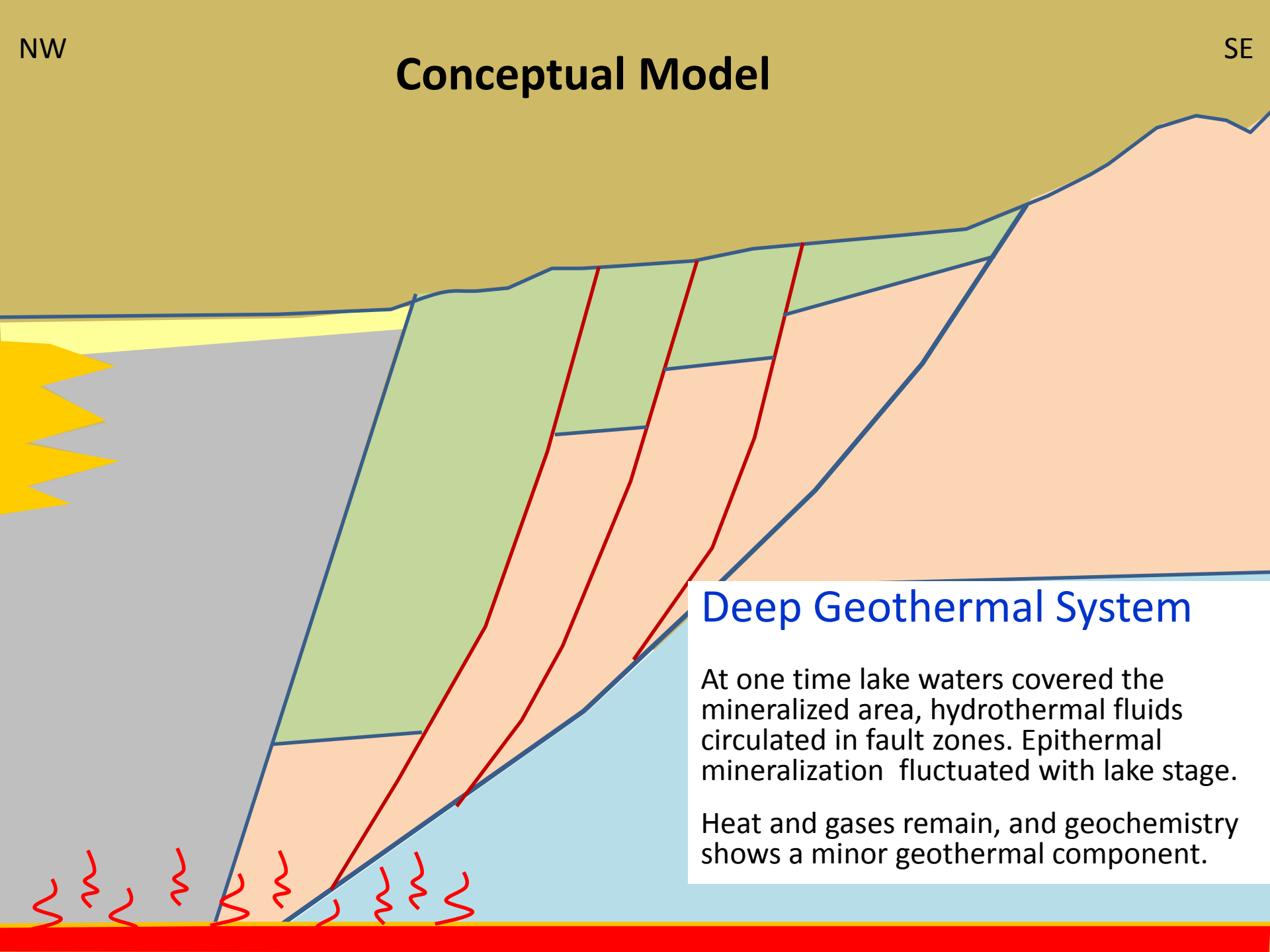

NW
SE
Conceptual Model
6 Km
K= 0.004 m/d
Basin sediments
K= 60 m/d
K= 0.019 m/d
Altered colluvium
(Tcm & Tsg)
K= 0.01 m/d
K= 0.0013 m/d
Kamma volcanics (Tk)
East Fault
K= 0.00003 m/d
Mesozoic metasediments
K= 0.0006 m/d
Range, Central, Break, Albert
K= 1.22 m/d
No Flow Boundary

NW

SE

Conceptual Model



Deep Geothermal System

At one time lake waters covered the mineralized area, hydrothermal fluids circulated in fault zones. Epithermal mineralization fluctuated with lake stage.

Heat and gases remain, and geochemistry shows a minor geothermal component.

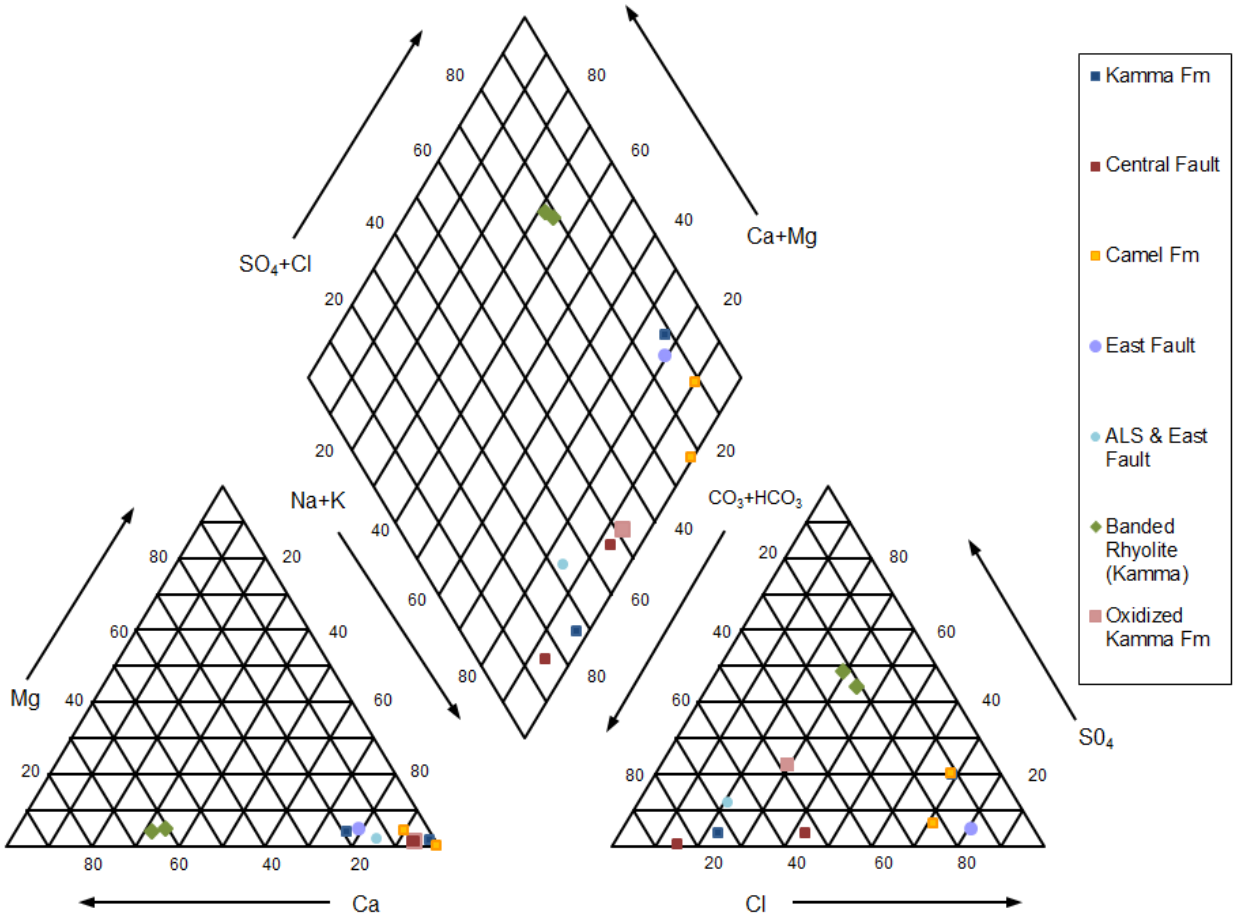
Temperatures in deep coreholes along faults can measure up to 95 °C

In peripheral areas and altered zones between major faults the temperatures are lower

H_2S gas occurs in many deep coreholes at concentrations exceeding 10 ppm.

One corehole released 2,000 ppm of H_2S.

(Note dearth of personnel around the rig)



Along faults, water chemistry is very basic, alkaline, and hot, with elevated fluoride and boron

Peripheral groundwater is more acidic, less alkaline, and lower in temperature

A total of 20 packer-isolated hydraulic tests were completed in 12 coreholes from 215 to 845 m bgs.

Temperature had a deleterious effect on packer testing.

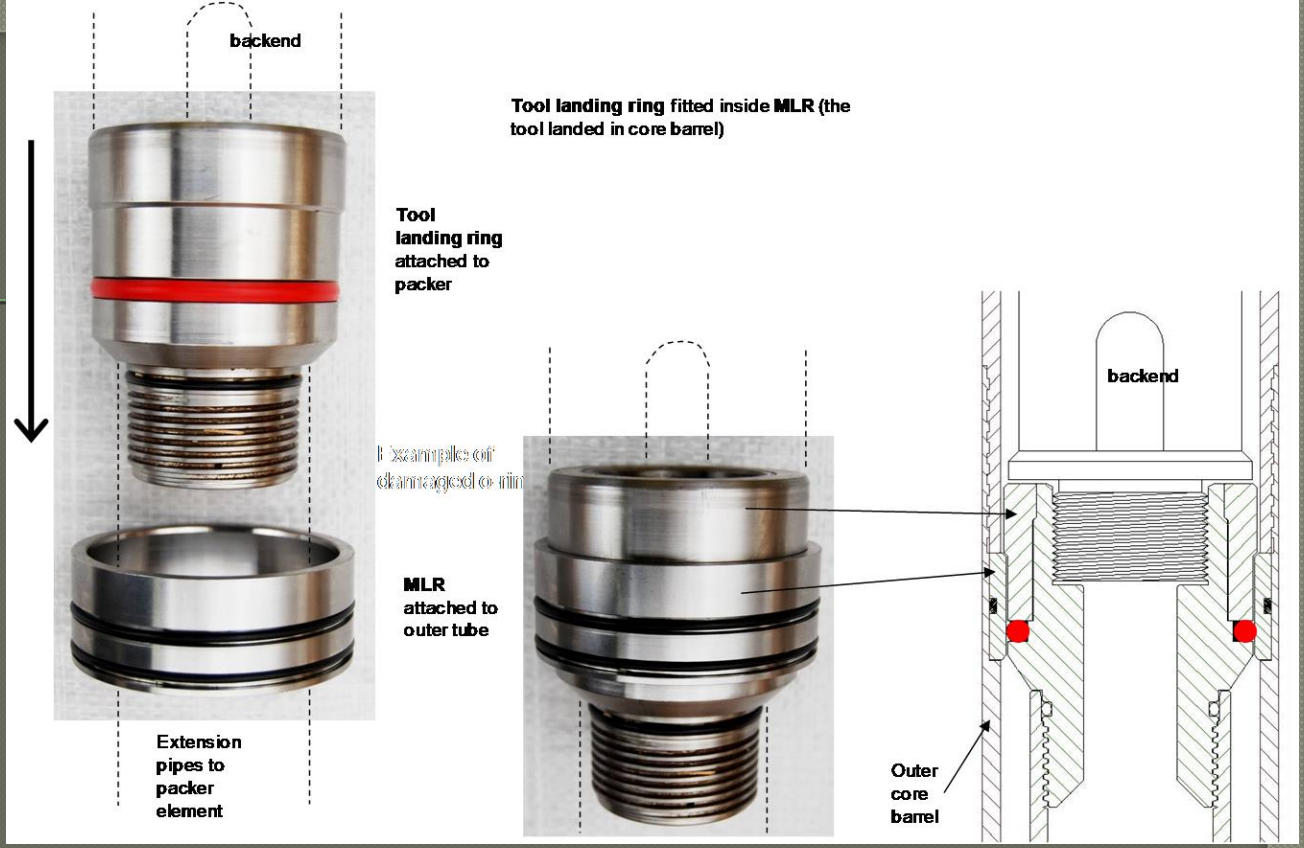
The standard rubber used in SWPS's packer element de-vulcanized.
SWPS's standard plastic landing rings also could not withstand corrosive water and high temperatures.

Mitigation:

IPI modified the packer equipment per SRK's specifications to include a high temperature modified landing ring (MLR)

and

a nitrile element (packer gland) to withstand higher temperatures.



#We also eliminated the packer altogether in some tests

PVC well casings effective only in peripheral areas

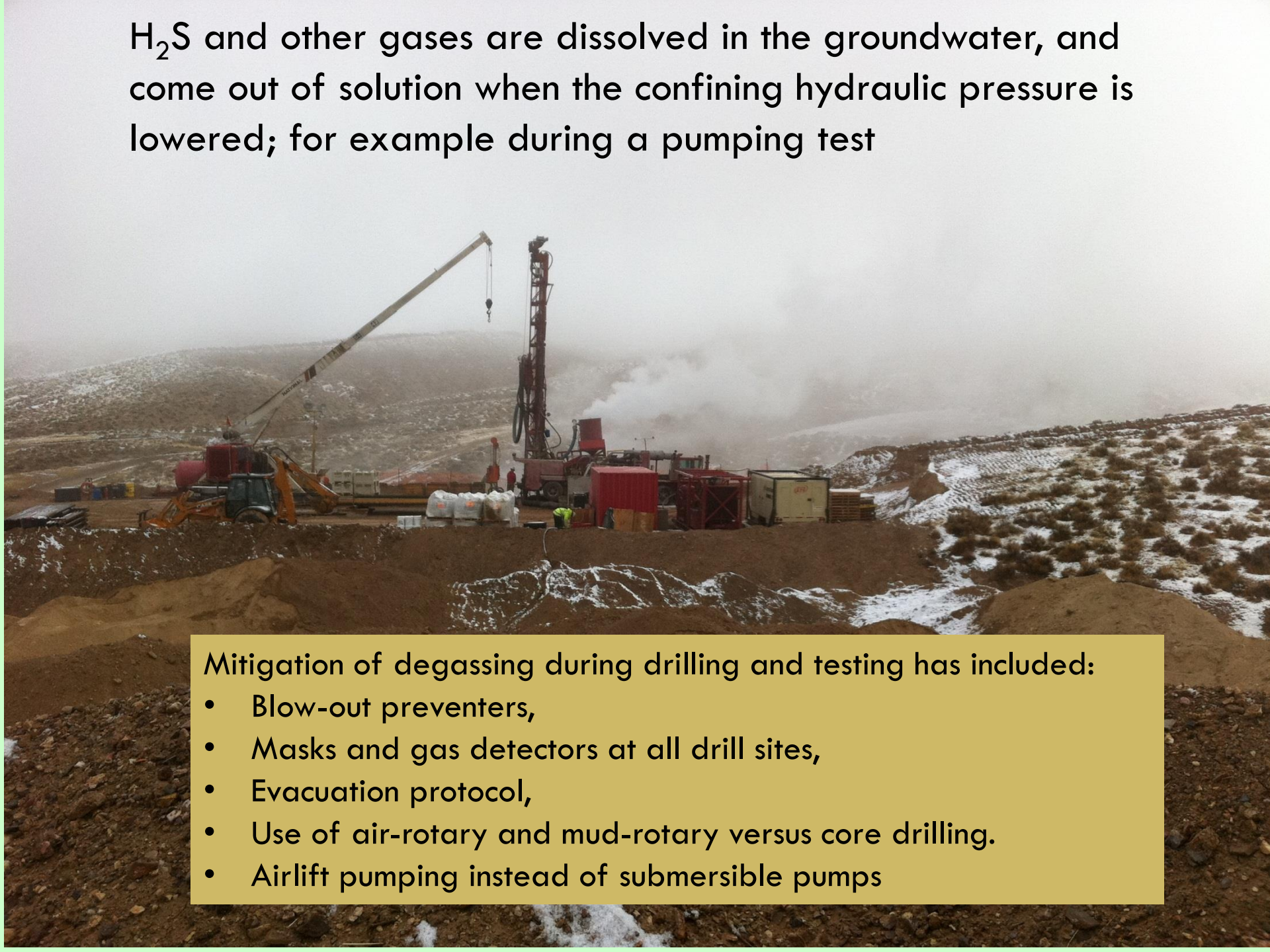
Chlorinated poly-vinyl chloride (CPVC)
1.5-inch casing for deep corehole piezometers

"Resilient" to temperatures up to 95°C,
These did not work as well as advertised
(commonly collapsed during grouting above cement basket)

Fiberglass Reinforced Epoxy Casing:
75% silica glass and 25% epoxy

Temperatures to >100 °C
Pressure to > 24 Mpa
pH from 1.5 to 12

H_2S and other gases are dissolved in the groundwater, and come out of solution when the confining hydraulic pressure is lowered; for example during a pumping test



Mitigation of degassing during drilling and testing has included:

- Blow-out preventers,
- Masks and gas detectors at all drill sites,
- Evacuation protocol,
- Use of air-rotary and mud-rotary versus core drilling.
- Airlift pumping instead of submersible pumps