Technical Feasibility of Compressed Air Energy Storage in an Aquifer Storage Vessel

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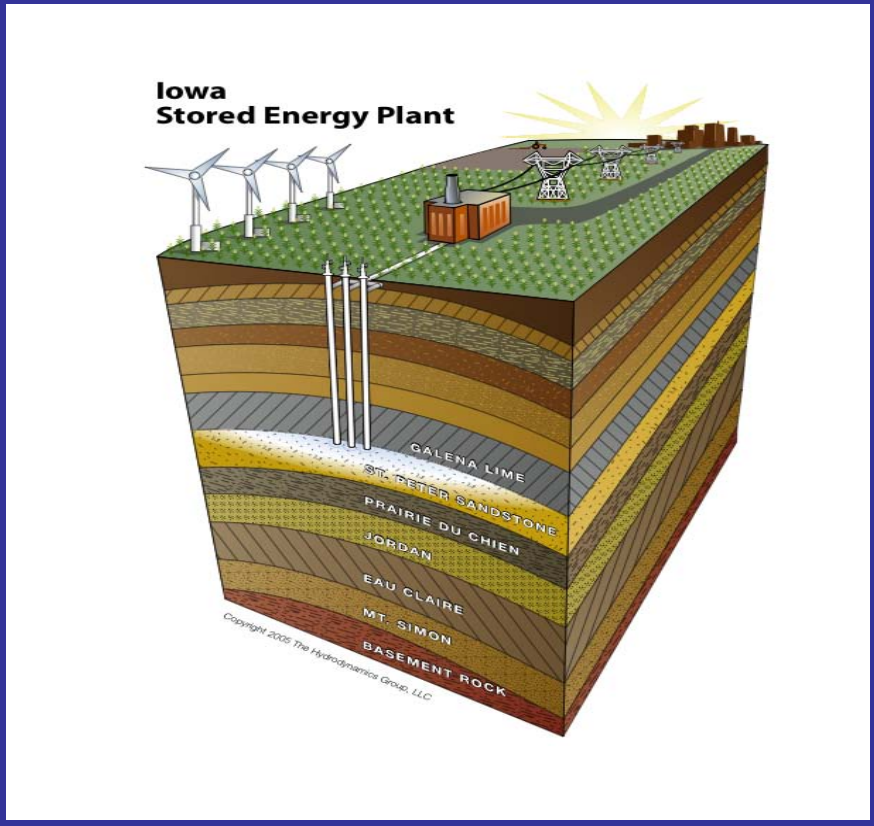
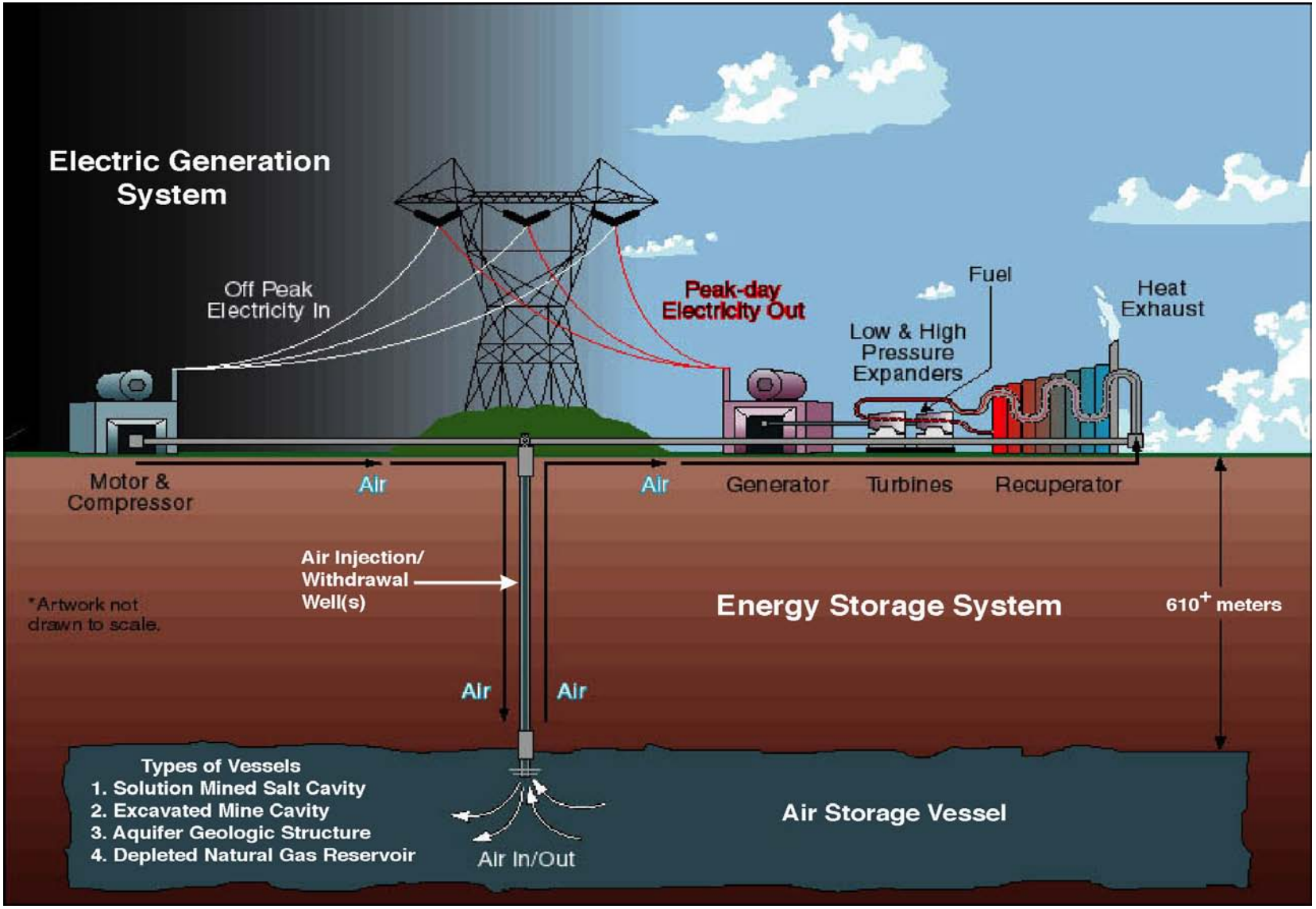
Studies in Mass & Energy Transport in the Earth

Presentation

- CAES Aquifer Technology
- Geological Framework of Iowa
- Dallas Center Structure
- Results of CAES Feasibility Simulation
- ISEP CAES Development Plan



How Does CAES Work?



CAES Turbo-Machinery Operating Requirements

Equipment Manufacturer	Plant Size (MW)	Min. Inlet Pressure (psi)	Min. Flow Rate (lbs/MW/hr)	Total Min. Flow Rate (lb/hr)
Allison	15	200	9500	142,500
MAN Turbo	50	50	9500	475,000
Dresser Rand	134	830	9500	1,273,000
Alston	300	900	9500	2,850,000
Westinghouse (501D5)	350	750	9500	3,325,000
Westinghouse (501F)	450	750	9500	3,275,000

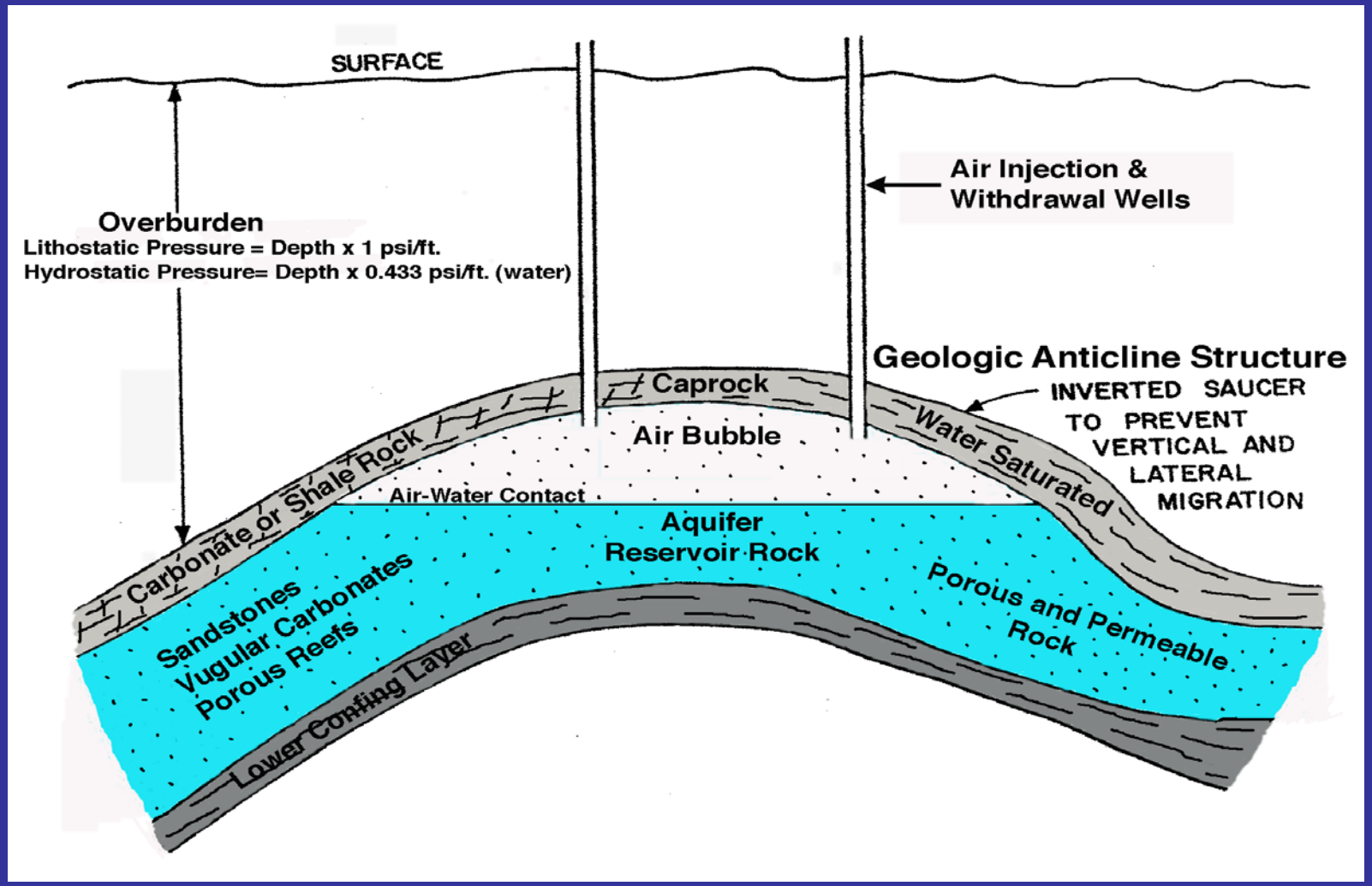
Earth Storage System Designs

All based on the concept of multiple geologic and hydrologic barriers.

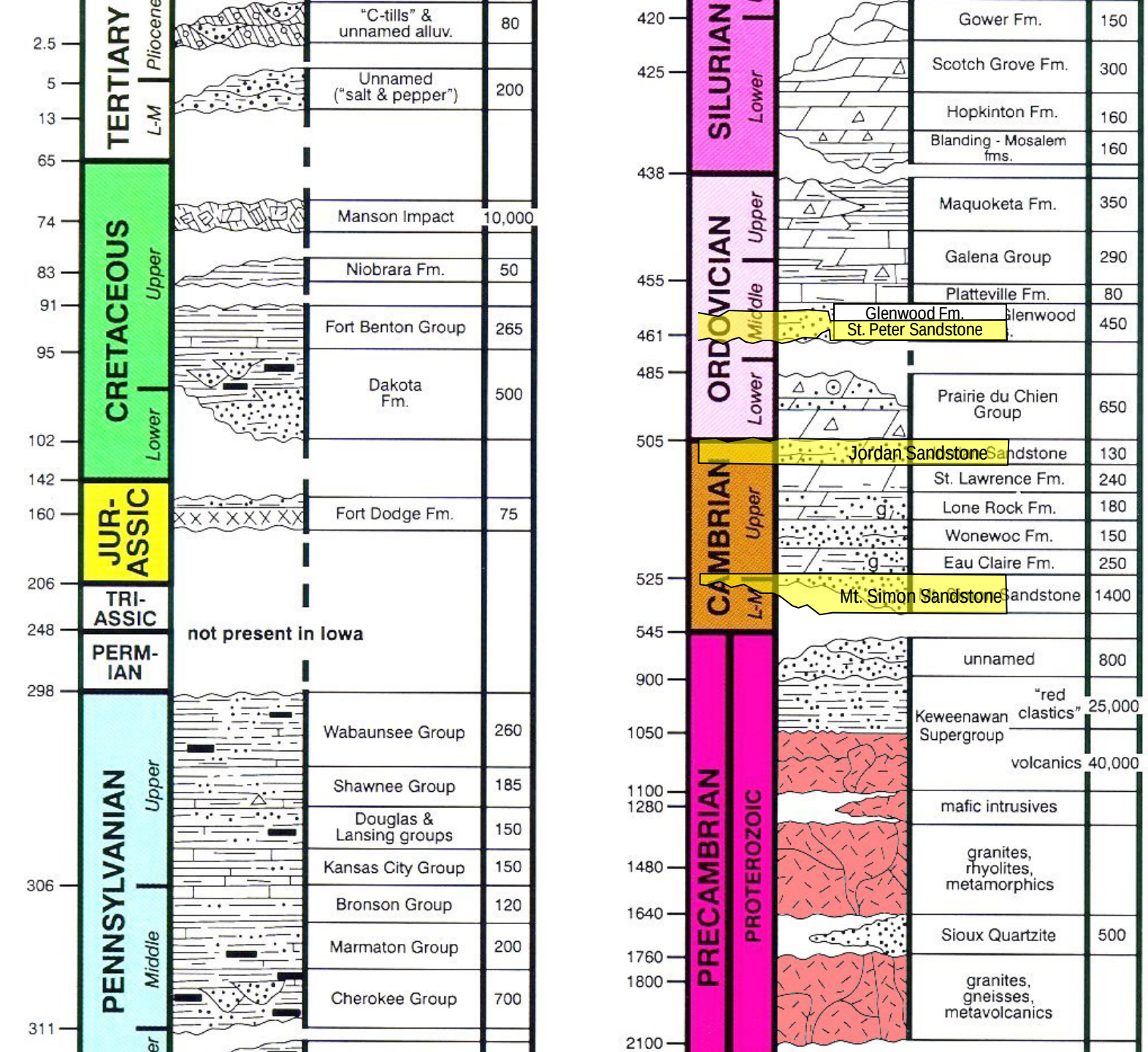
DESIGN CRITERIA

- Capacity: 5 to 10 BCF Total Vessel Volume
- Integrity of Vessel: <4% of Volume over a year
- Fluid Deliverability
  - 400#/sec = 464 MMscfd
  - Minimum Pressure - 830 psi

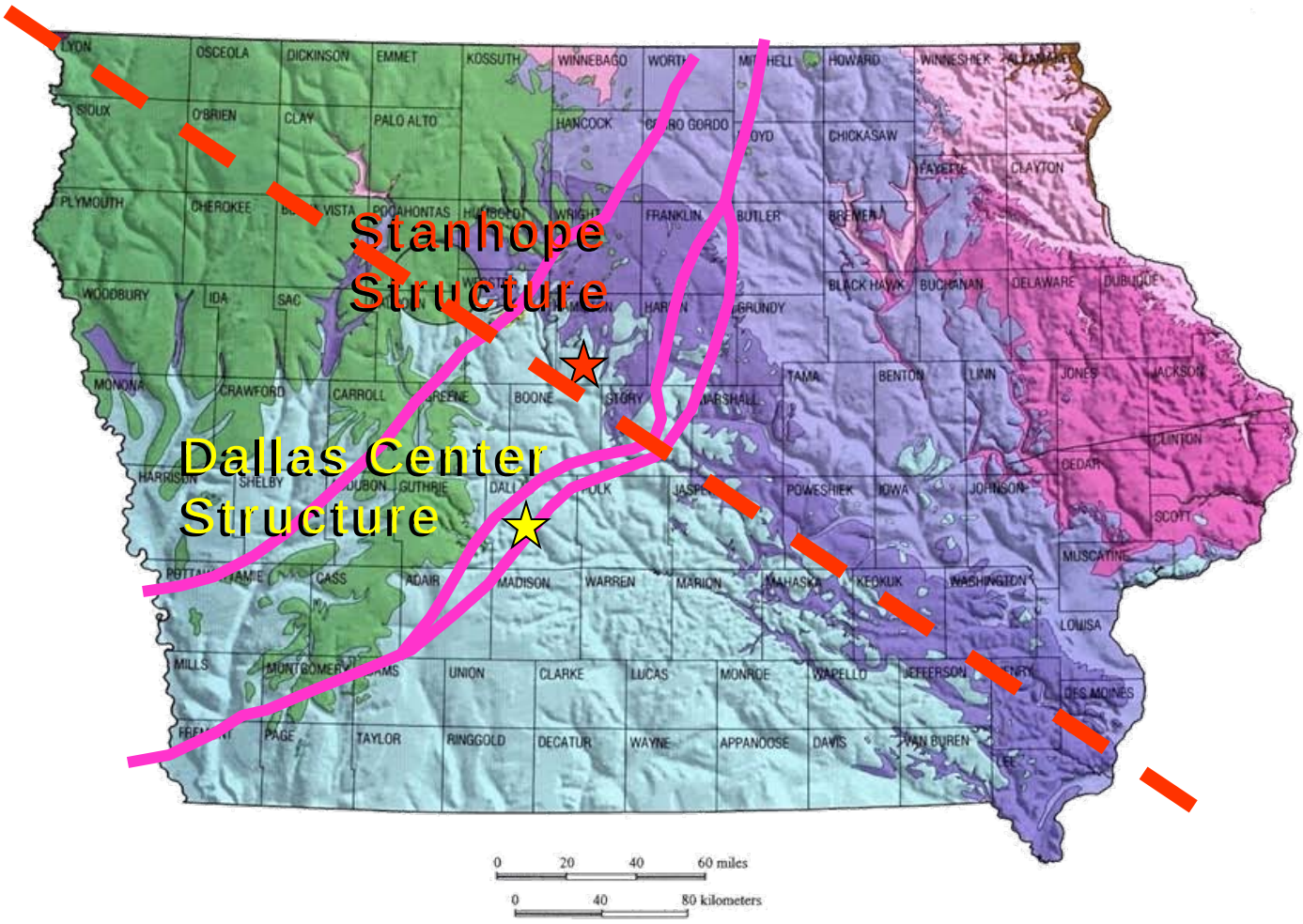
CAES Aquifer Storage System

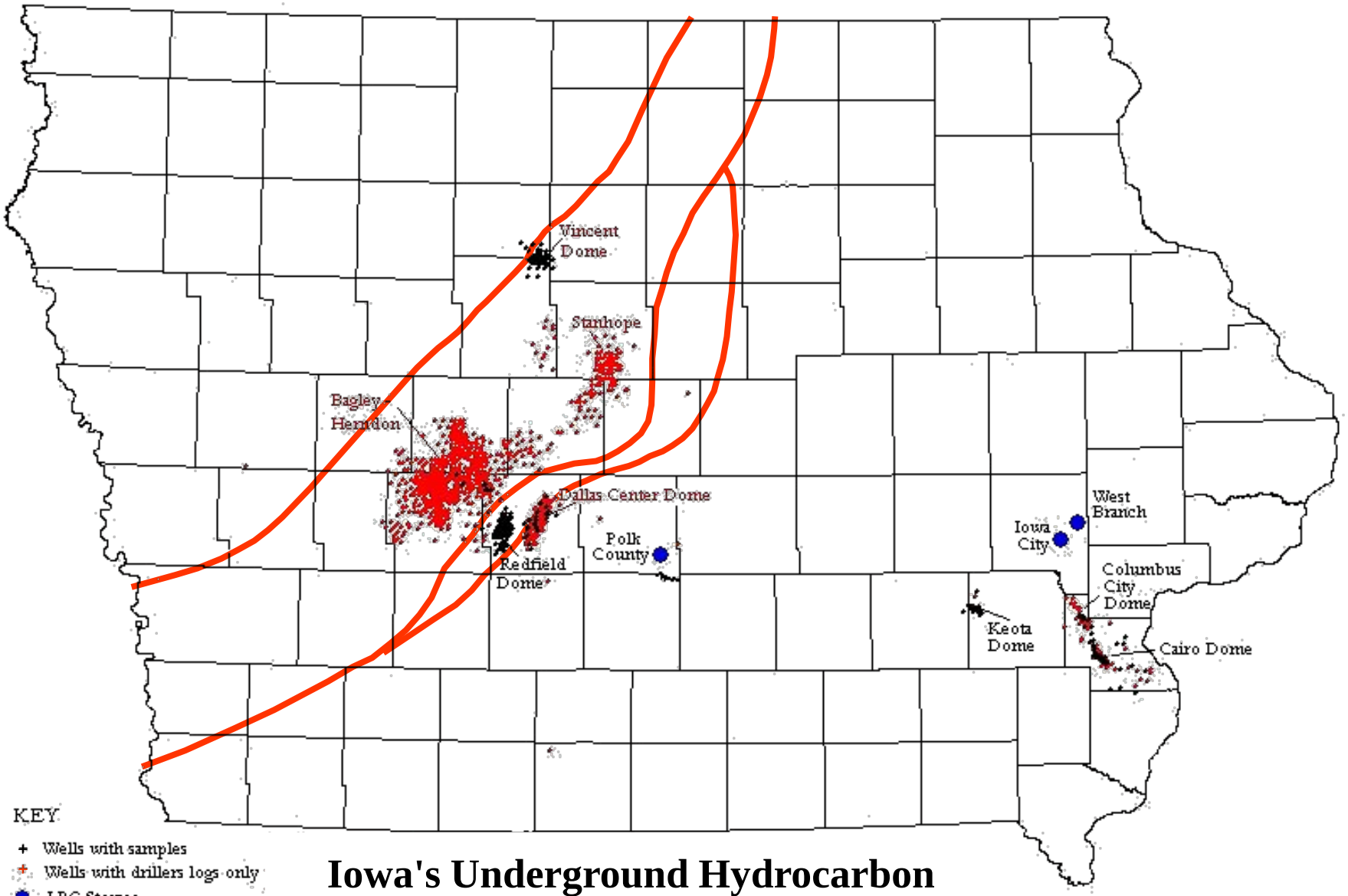


Geology of Iowa


2.5
5
13
65
74
83
91
95
102
142
160
206
248
298
306
311
420
425
438
455
461
485
505
525
545
900
1050
1100
1280
1480
1640
1760
1800
2100
TERTIARY
Pliocene
L-M
CRETACEOUS
Upper
Lower
JUR-ASSIC
TRI-ASSIC
PERM-IAN
PENNSYLVANIAN
Upper
Middle
SILURIAN
Lower
ORDOVICIAN
Upper
Middle
Lower
CAMBRIAN
Upper
L-M
PRECAMBRIAN
PROTEROZOIC
"C-tills" & unnamed alluv.
80
Unnamed ("salt & pepper")
200
Manson Impact
10,000
Niobrara Fm.
50
Fort Benton Group
265
Dakota Fm.
500
Fort Dodge Fm.
75
not present in Iowa
Wabaunsee Group
260
Shawnee Group
185
Douglas & Lansing groups
150
Kansas City Group
150
Bronson Group
120
Marmaton Group
200
Cherokee Group
700
Gower Fm.
150
Scotch Grove Fm.
300
Hopkinton Fm.
160
Blanding - Mosalem fms.
160
Maquoketa Fm.
350
Galena Group
290
Platteville Fm.
80
Glenwood Fm.
St. Peter Sandstone
450
Prairie du Chien Group
650
Jordan Sandstone
130
St. Lawrence Fm.
240
Lone Rock Fm.
180
Wonewoc Fm.
150
Eau Claire Fm.
250
Mt. Simon Sandstone
1400
unnamed
800
Keweenawan Supergroup
"red clastics"
25,000
volcanics
40,000
mafic intrusives
granites, rhyolites, metamorphics
Sioux Quartzite
500
granites, gneisses, metavolcanics

BEDROCK GEOLOGIC MAP OF IOWA
1998



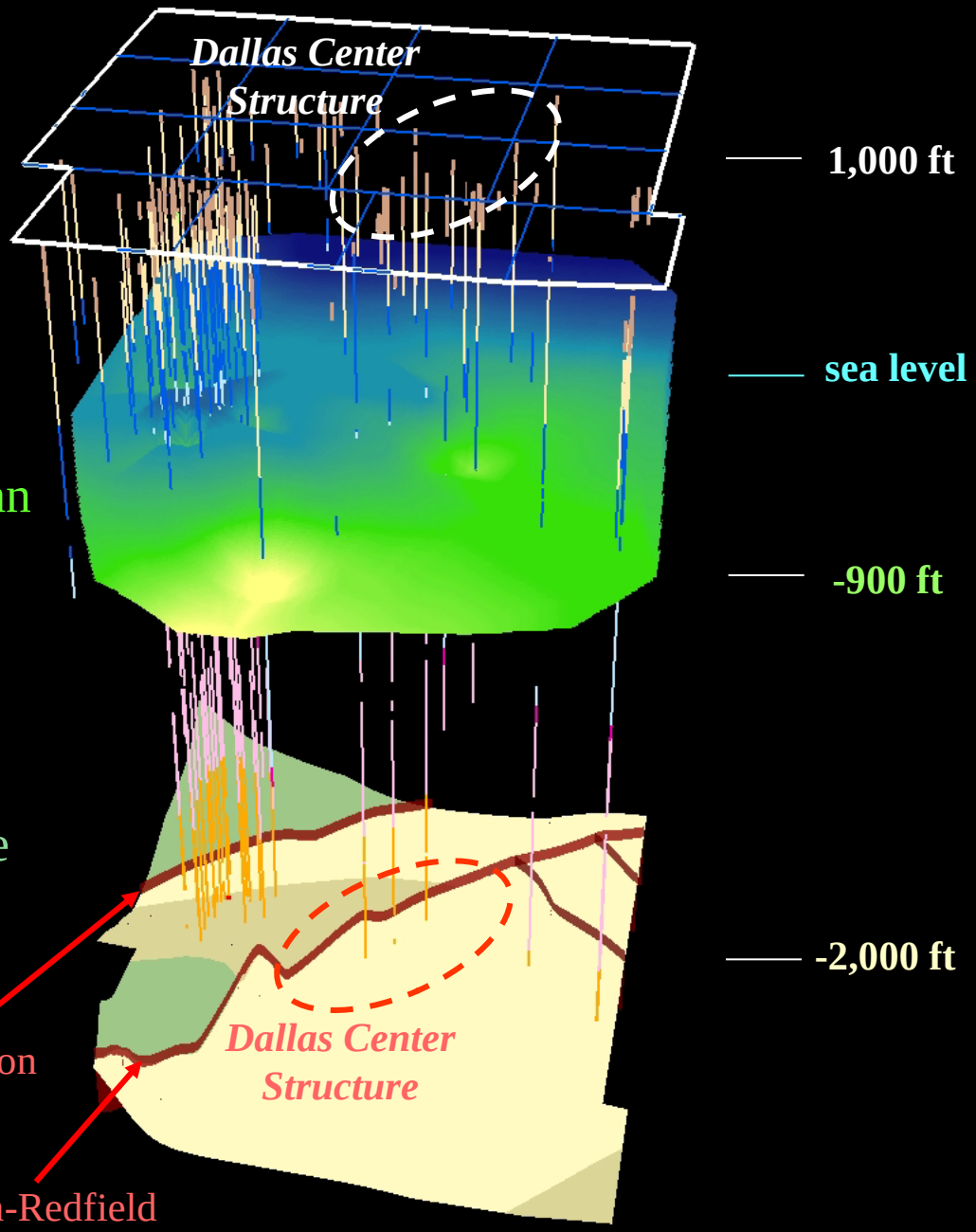


Iowa's Underground Hydrocarbon Storage Structures

Dallas Center Structure

Geological Evaluation

Dallas County

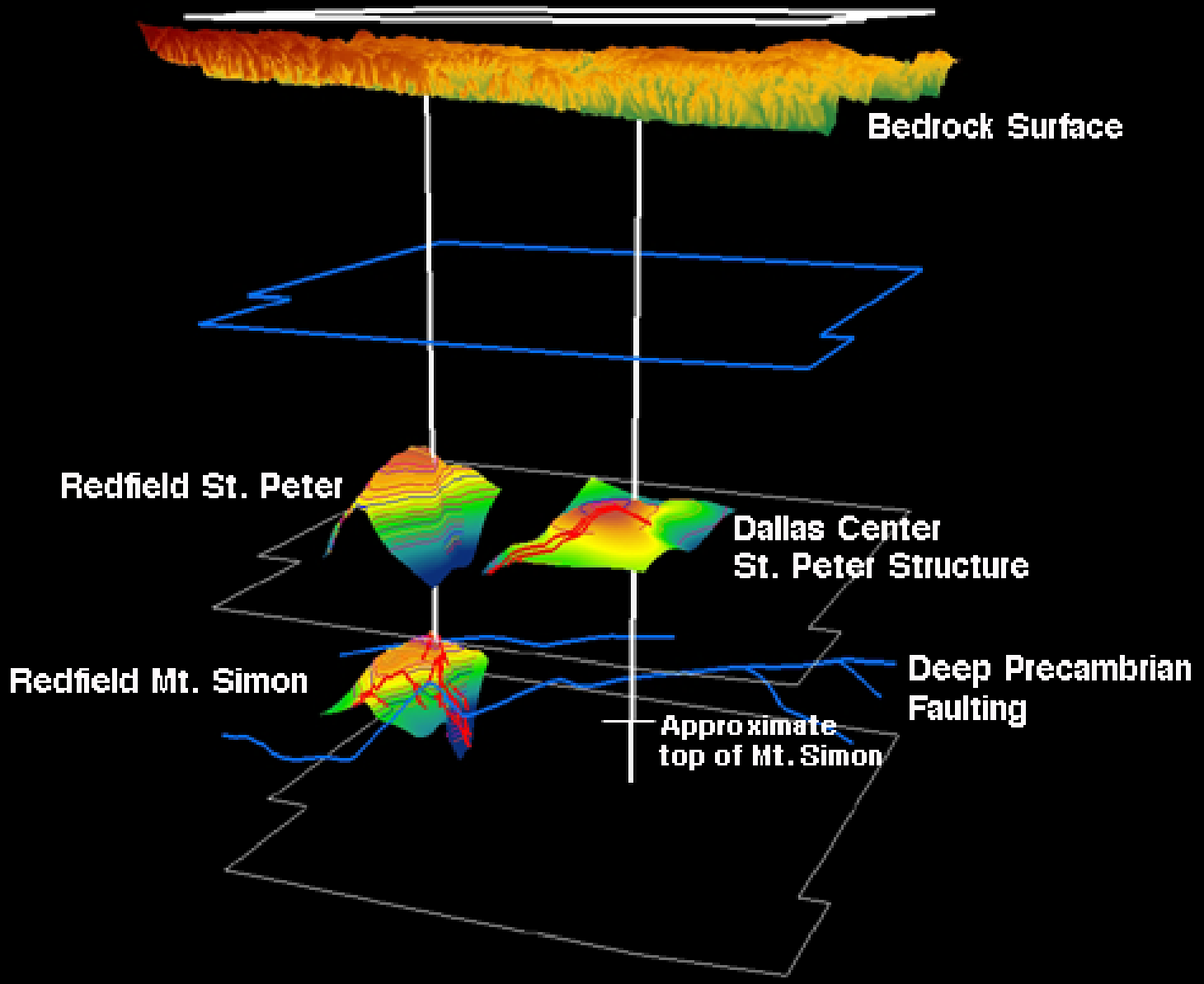


elevation of the top of the Devonian

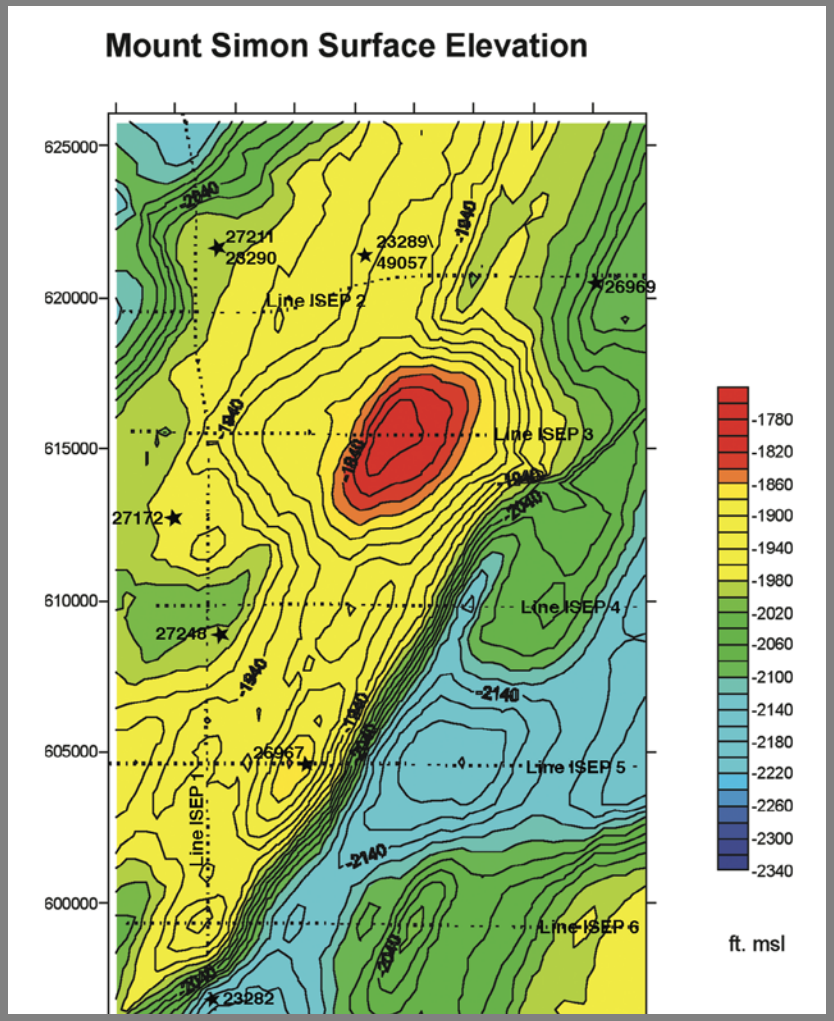
geology of the Precambrian surface

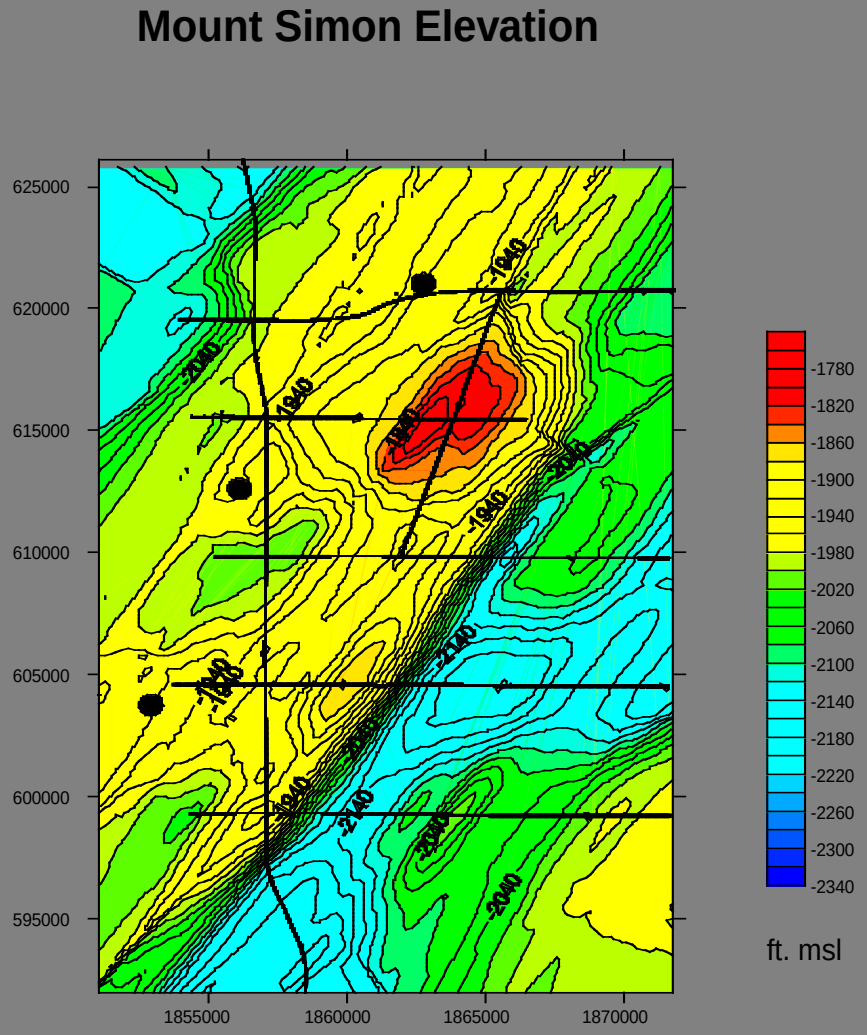
Perry-Hampton Fault System

Thurman-Redfield Fault System


Bedrock Surface
Redfield St. Peter
Dallas Center
St. Peter Structure
Redfield Mt. Simon
Deep Precambrian
Faulting
Approximate
top of Mt. Simon

Dallas Center Mt. Simon Structure





Well location

Dallas Center CAES Simulation

Approach

✓1. Redfield Gas Storage Simulation

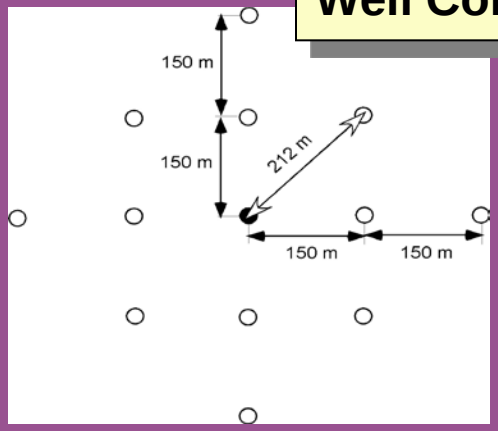
✓Dallas Center CAES Simulation

Bubble Development & Air Cycling Plan

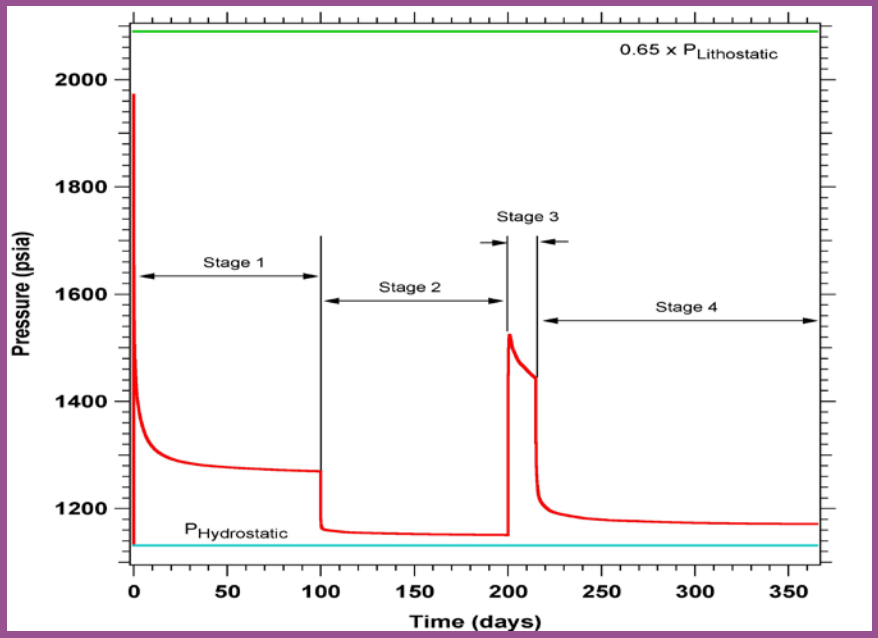
Potential Pressure Spike: Solution

- Well Configuration
- Staged Development

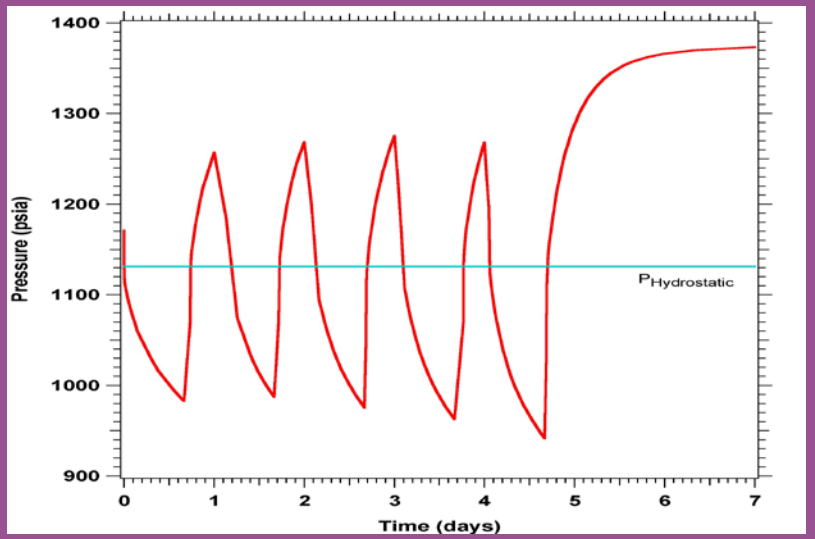
Well Configuration



Create a Bubble

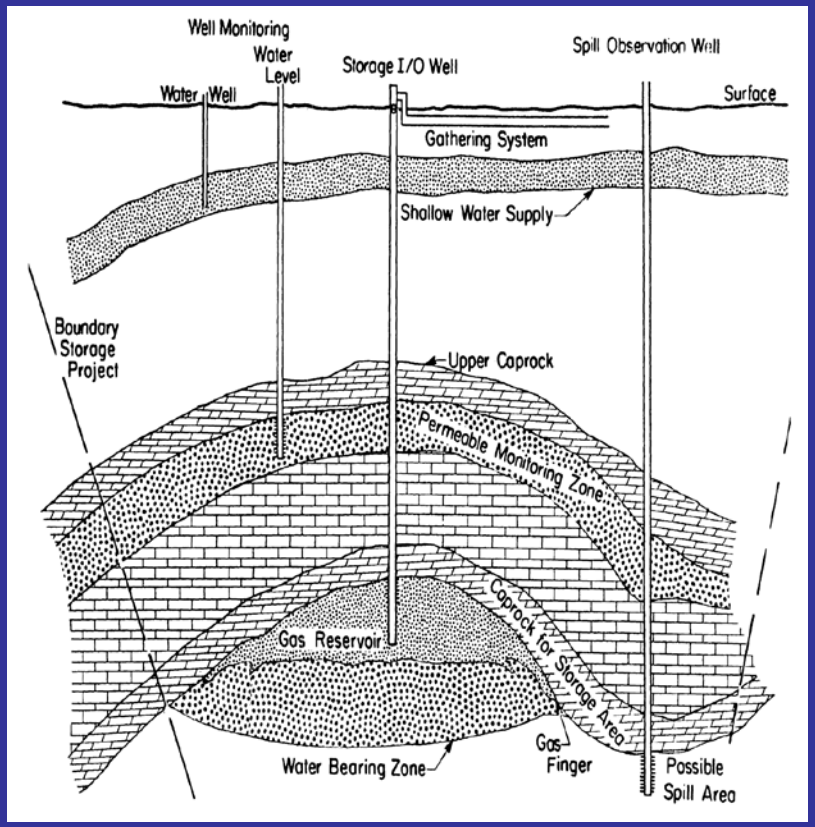


Cycle Air



Conclusions from Model

- Dallas center CAES project technically feasible.
- Adequate geological storage structure to support two 134 MWe CAES units.
- CAES system performance feasible-good match to turbines.
- Complex development plan.
- Site merits further investigation



Dallas Center CAES Development Plan

Exploratory Drilling Program

- Site, lease and permit exploratory test wells (two wells)
- Drilling Contract Bid
- Drill & Coring 2 Exploratory Wells
- Geophysical Logging
- Laboratory Core Analysis
- Conduct Water Pumping Test
- Eventually Test Inject Air into Structure
- Model Test Results for CAES Design

Develop Dallas Center CAES Plant

- Project & Environmental Permitting
- Design Power Plant & Order Equipment
- Drill & Construction 11 New Air Injection/Withdrawal Wells
- Pump Air Into Structure to Create Commercial Air Bubble
- Build Power Plant
- Operate Power Plant

Iowa Geological Survey

DNR

M.G. Eischeid drill rig, 1987

Thanks,
Michael l King