Molten Sodium Upgrading

Reactor → **Separator** →

H_2 or CH_4 → **Reactor**

Na → **Reactor**

Na salt → **Electrolytic regeneration**

Separator →

Ni, V, Fe

Make up Na → **Electrolytic regeneration**

Electrical Power → **Electrolytic regeneration**

Electrolytic regeneration → **Separator** →

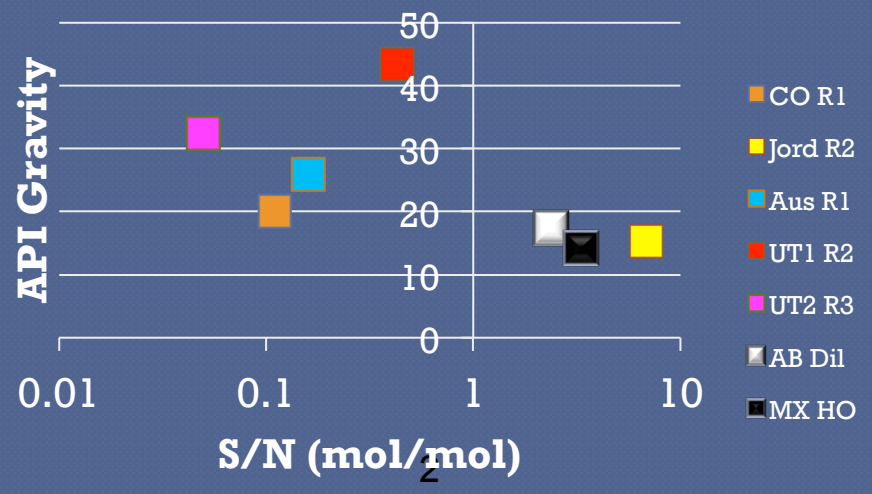
Sulfur

Simple Process

CERAMATEC®
TOMORROW'S CERAMIC SYSTEMS

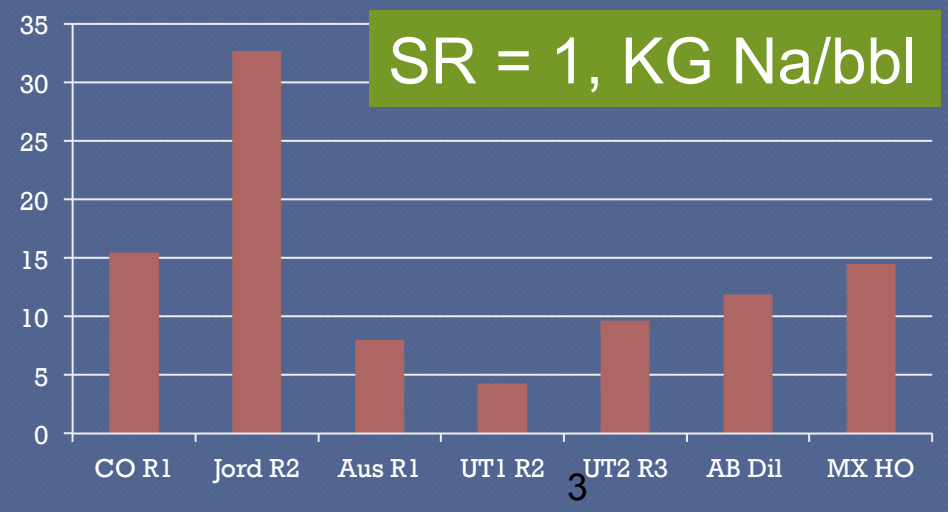
Feedstock Characterization

Feed	C (%)	H (%)	N (%)	S (%)	H/C (mol)	S/N (mol)	API
Colorado R1	83.57	10.80	1.90	0.72	1.55	0.11	20.1
Jordanian R2	77.27	9.03	0.55	12.96	1.40	6.88	15.3
Australian R1	84.10	11.30	0.97	0.55	1.61	0.16	25.9
Uintah 1 R2	79.50	11.83	0.48	0.70	1.79	0.43	43.4
Uintah 2 R3	84.70	11.63	1.36	0.22	1.65	0.05	32.4
Alberta Dil	79.40	10.47	0.47	3.83	1.58	2.37	17.4
Mexican HO	81.37	10.58	0.44	5.00	1.56	3.31	14.2



Stoichiometric Ratio?

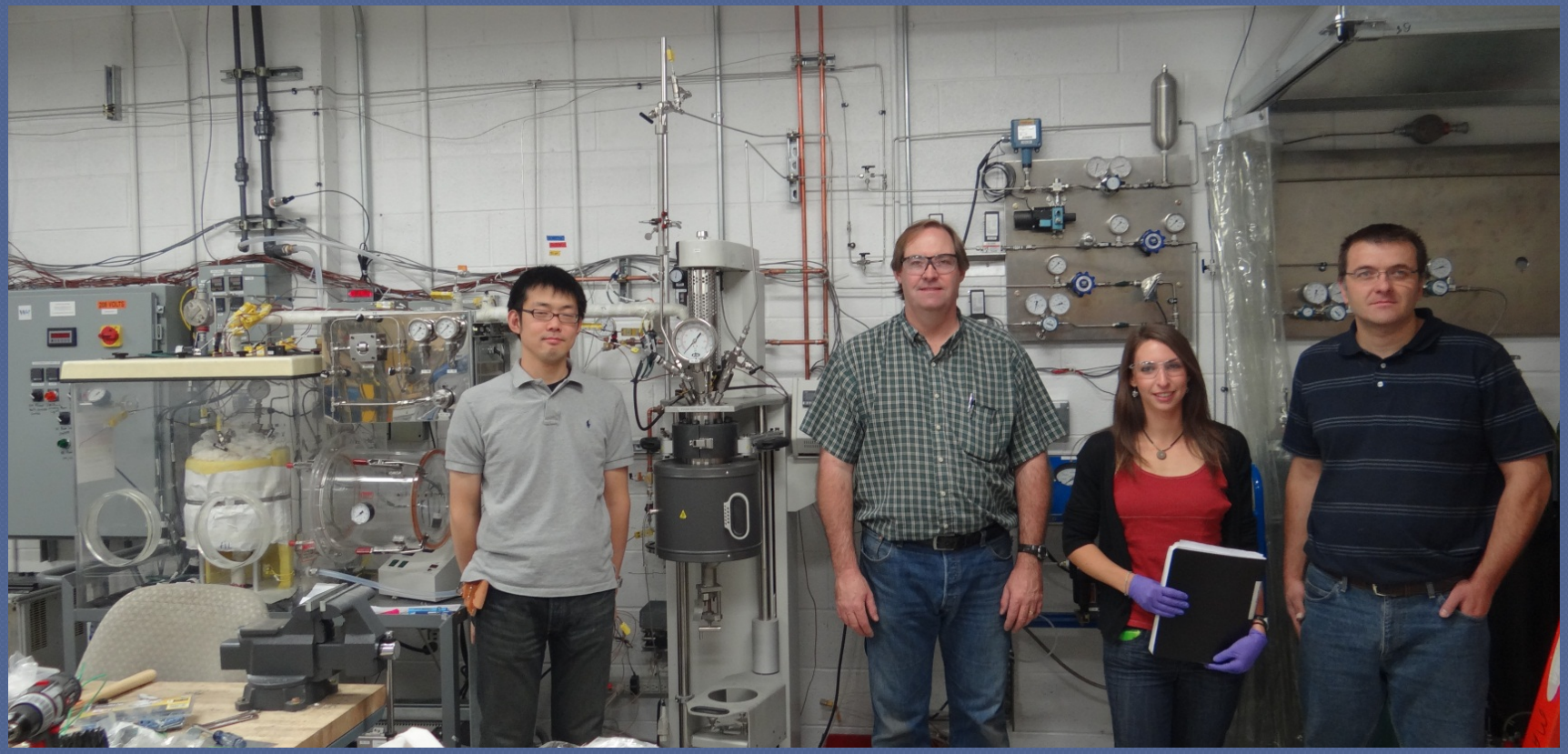
- Assume
  - 2 moles Na per mole S
  - 3 moles Na per mole N
  - Ignore metals and TAN – they come out too
- SR = Actual Na / Na based on assumption



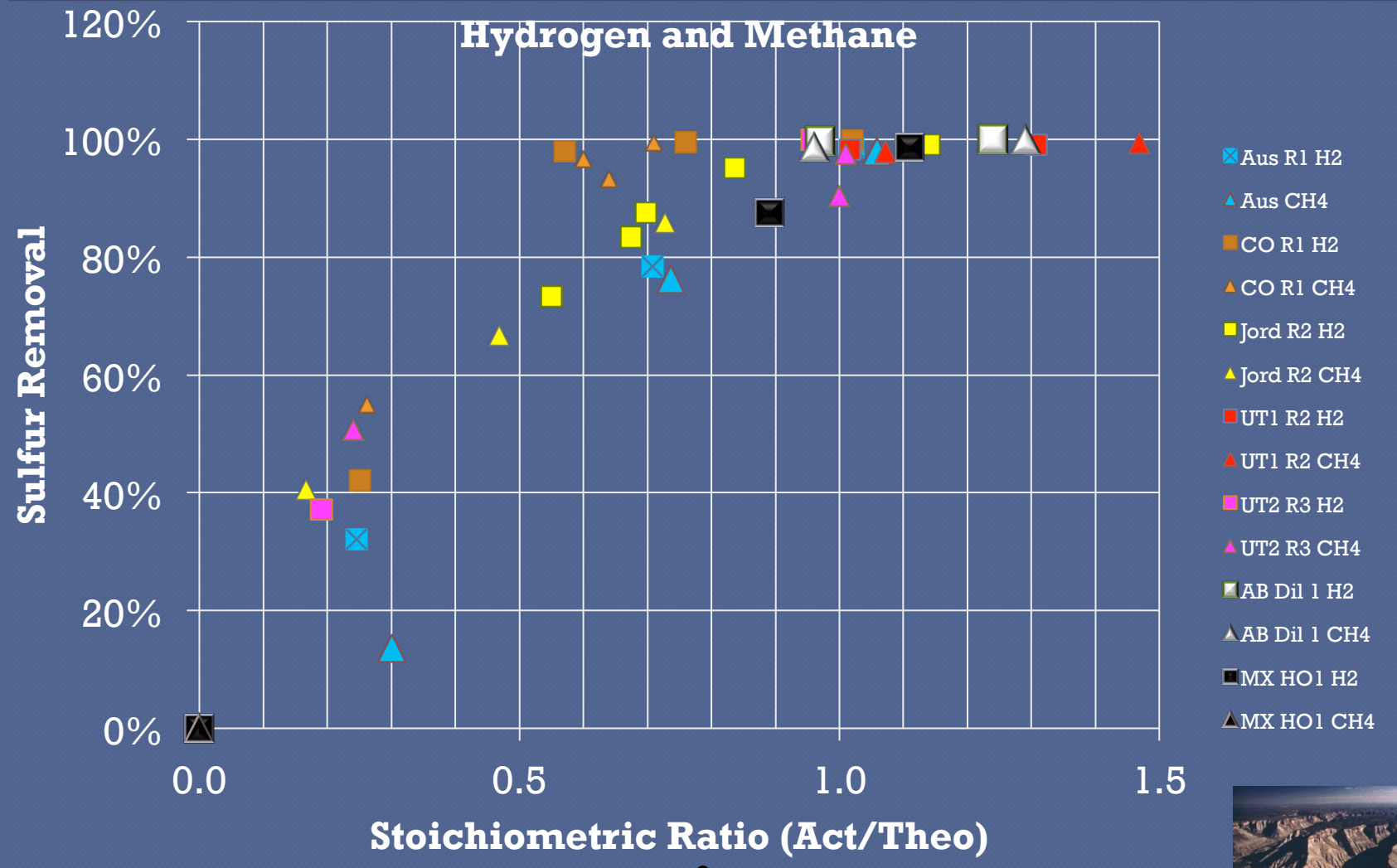
Old Laboratory set-up

- Existing Data
  - Shoot molten sodium into reactor at fast rate
  - Reaction of Na with S is fast – exotherm
  - Local thermal cracking – not ideal for good yield
- Data underway
  - Control rate of sodium addition
    - EM Pump
    - Conventional pumping of dispersions
  - Expect reduced thermal cracking
    - Expect yield improvement

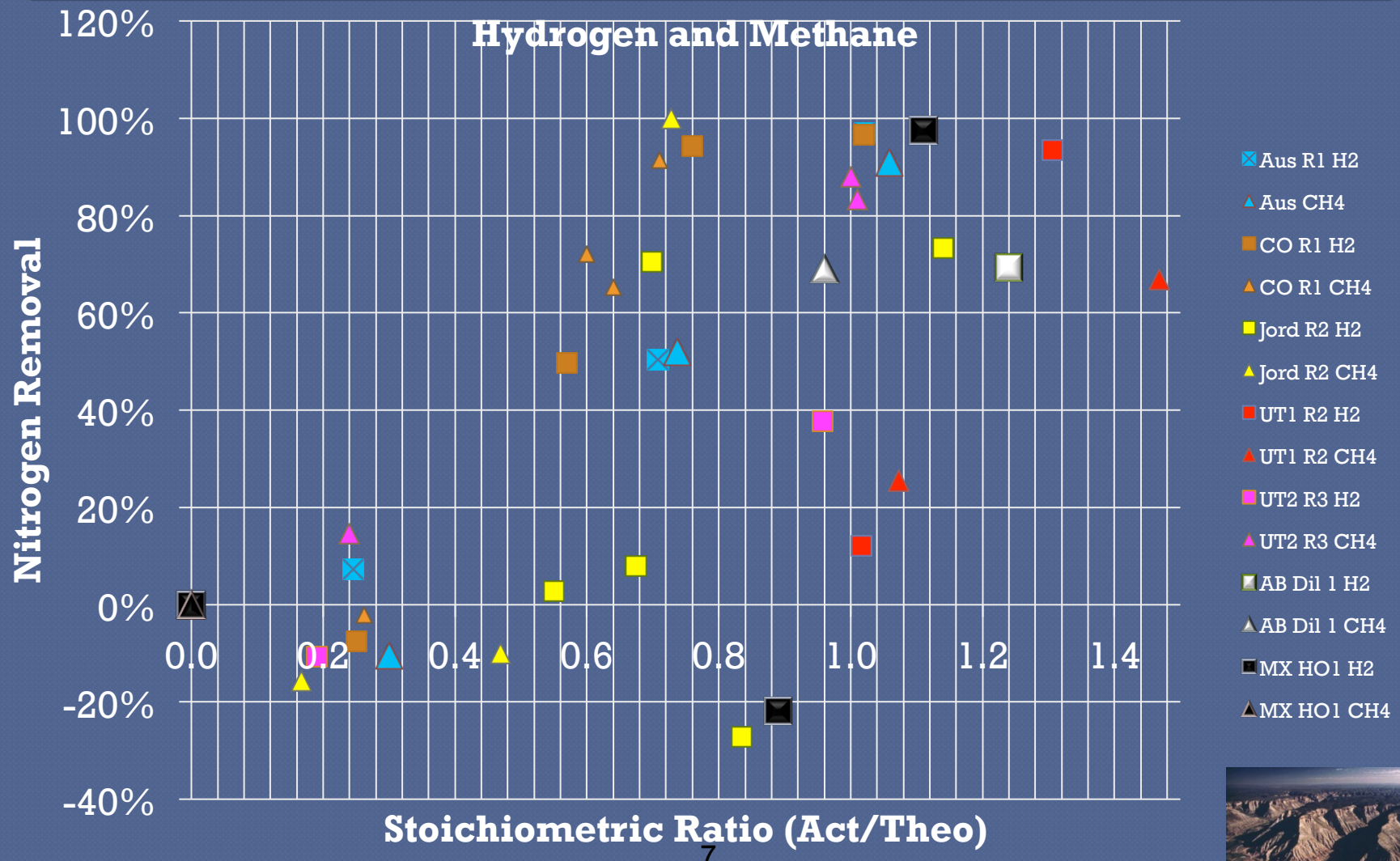
New Laboratory set-up



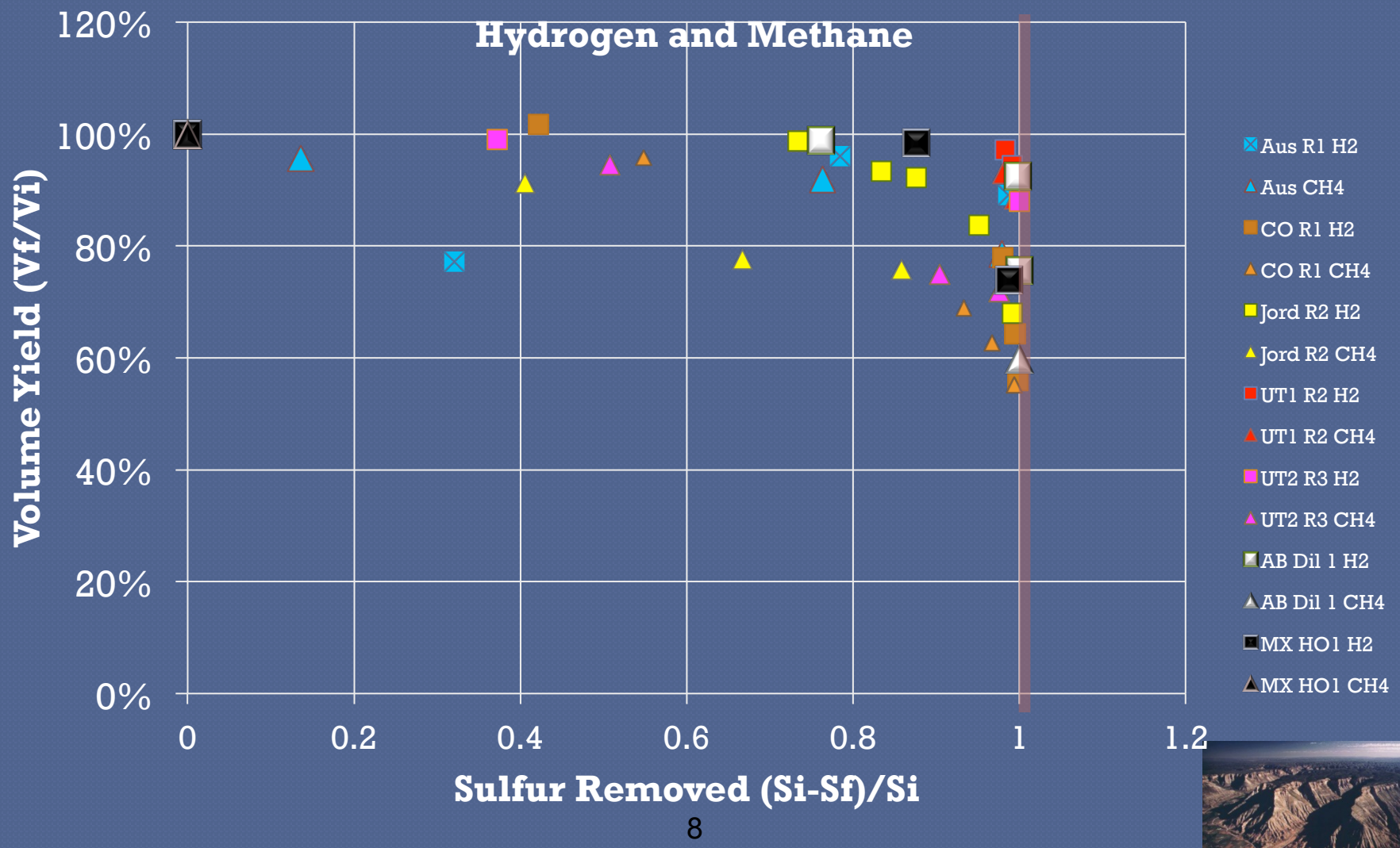
Sulfur Removal v SR



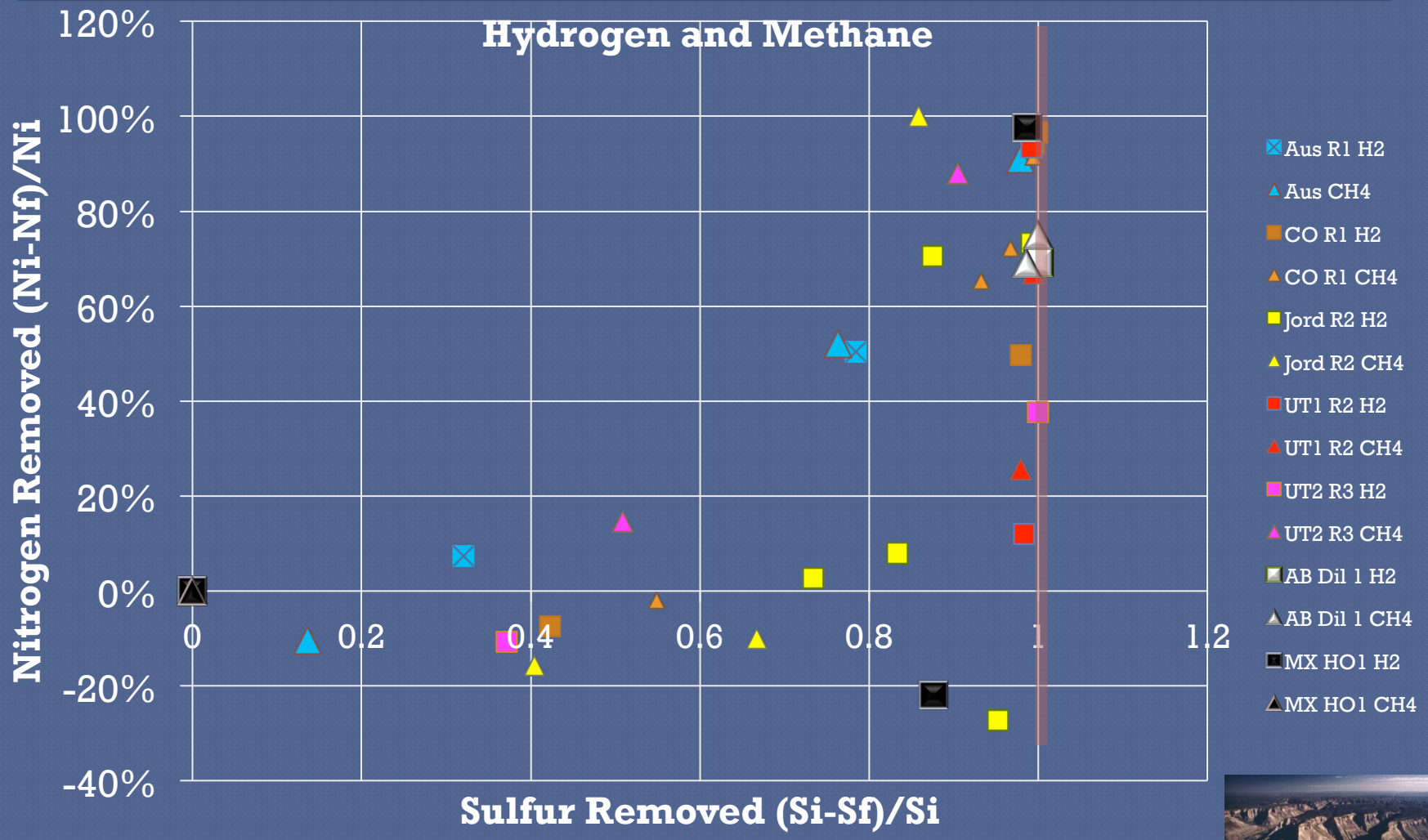
Nitrogen Removal v SR



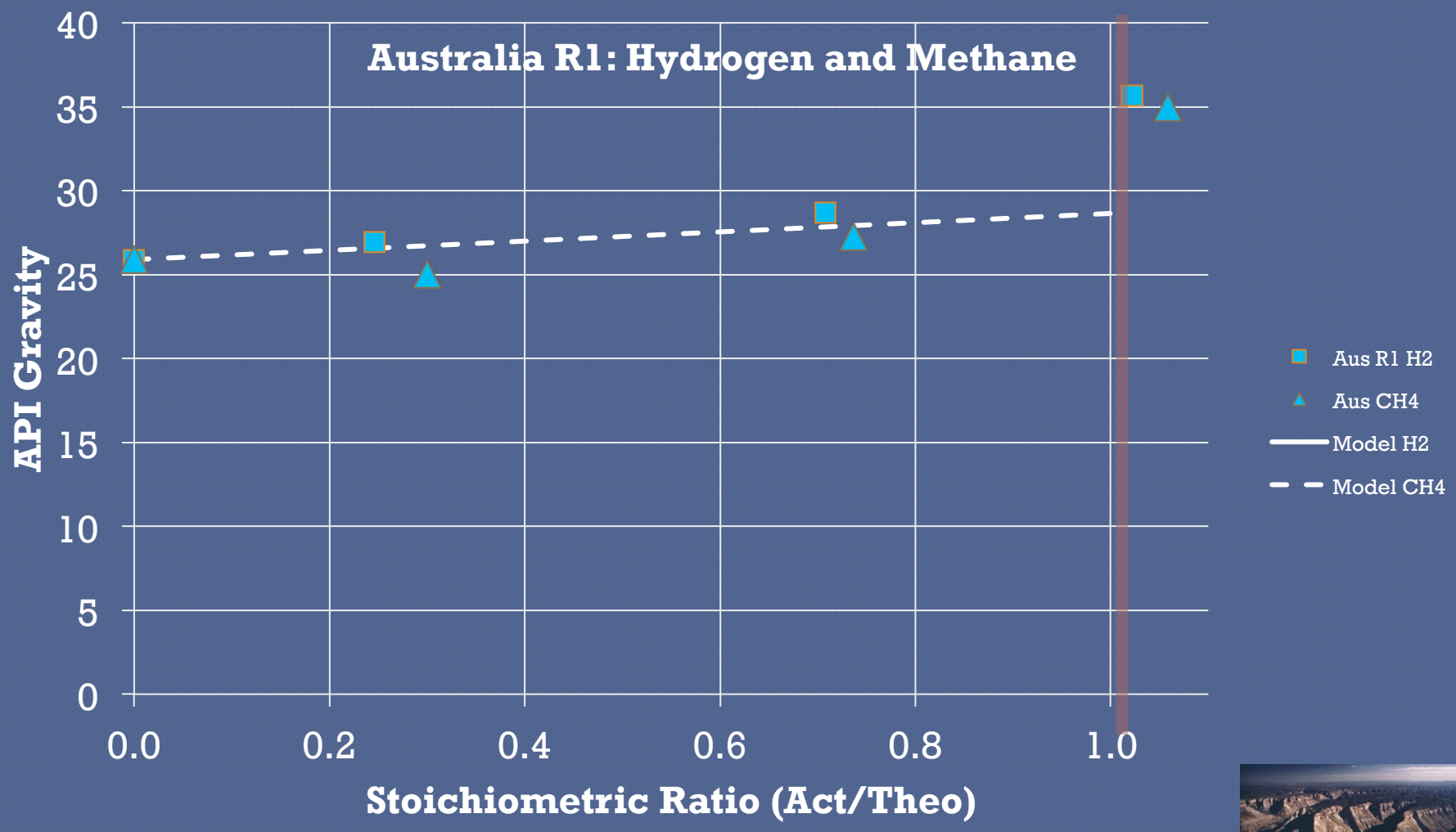
Volume Yield v Sulfur Removal



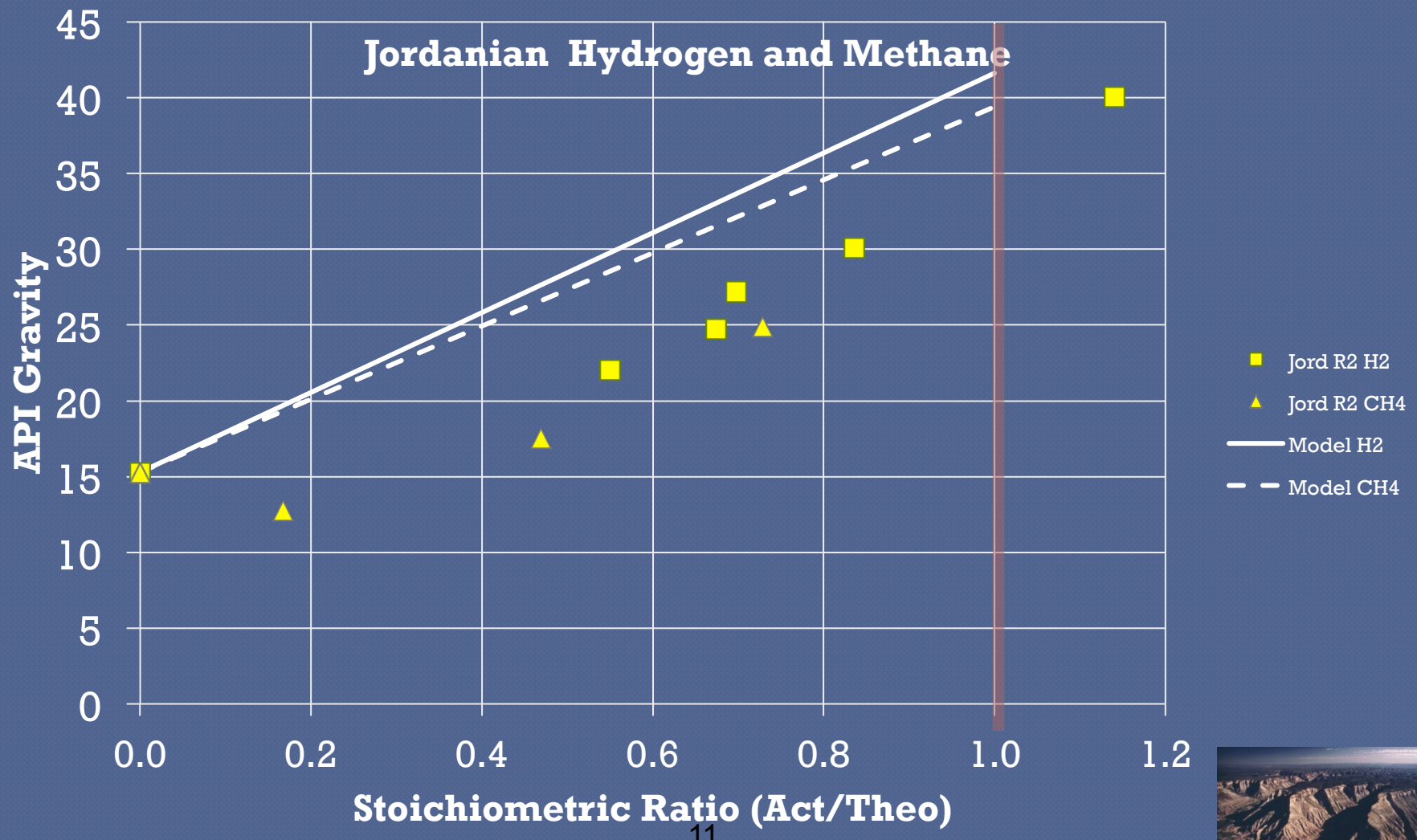
N removed v S Removed



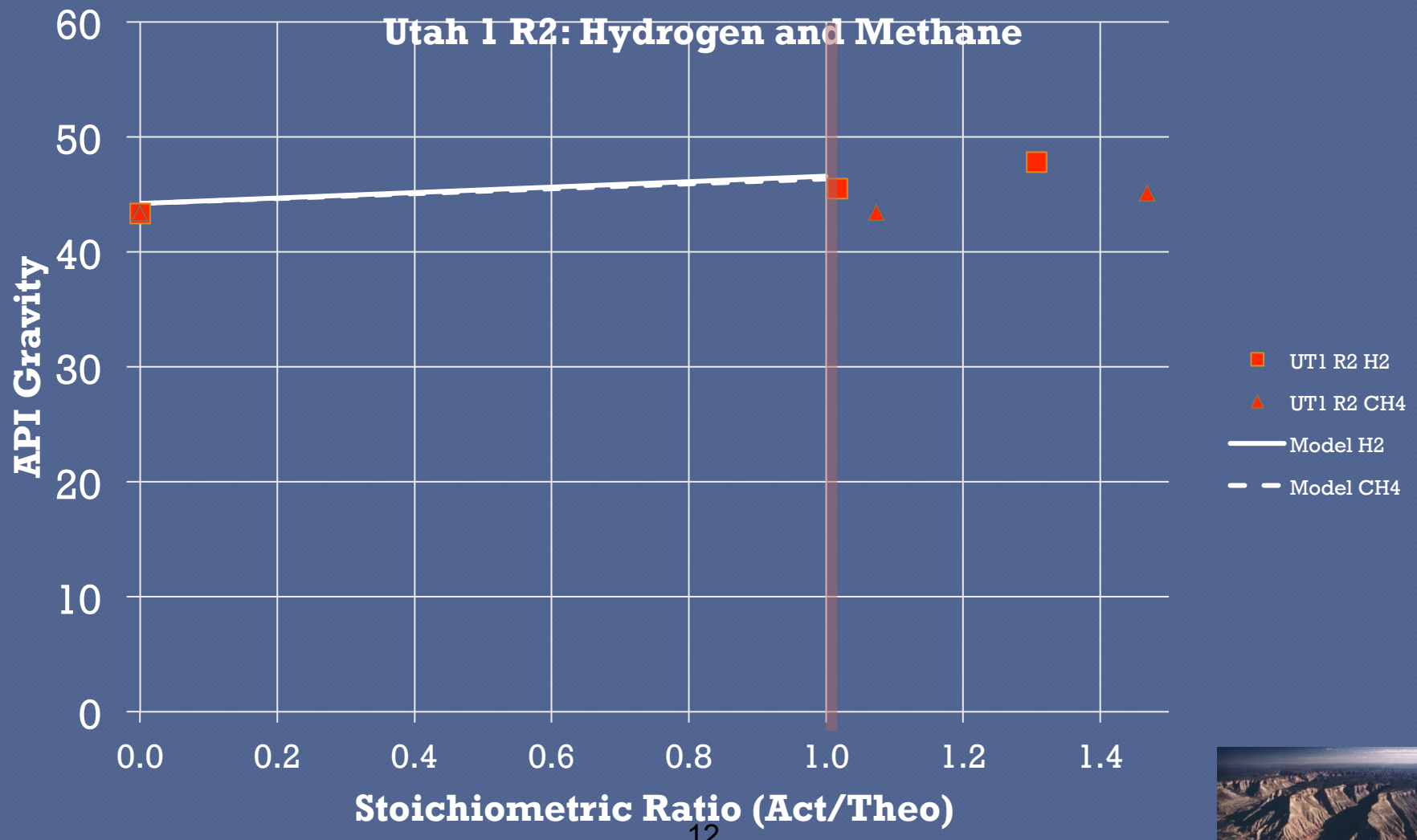
Aus R1 API v SR



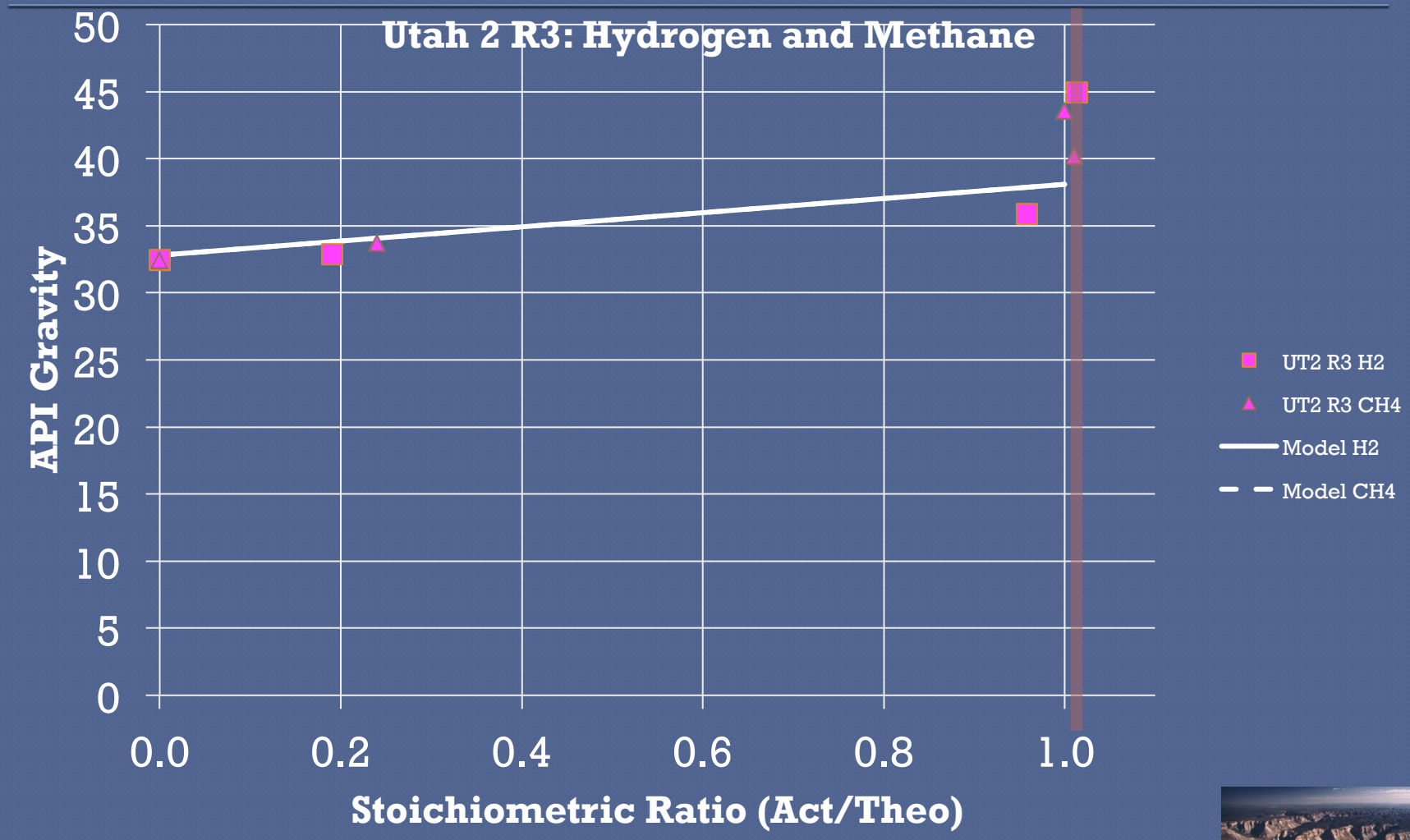
Jordanian R2 v SR



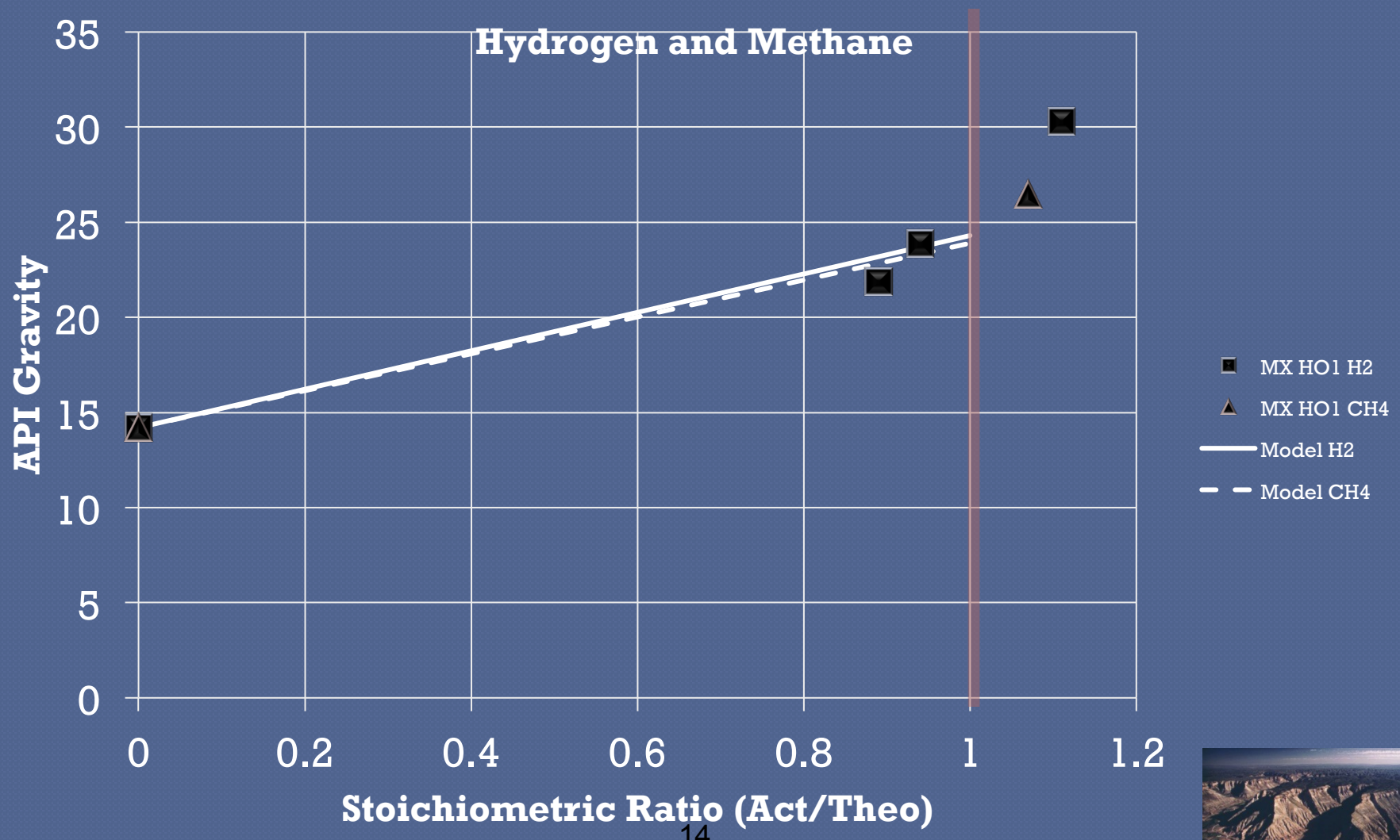
UT 1 R2 API v SR



UT 2 R3 API v SR

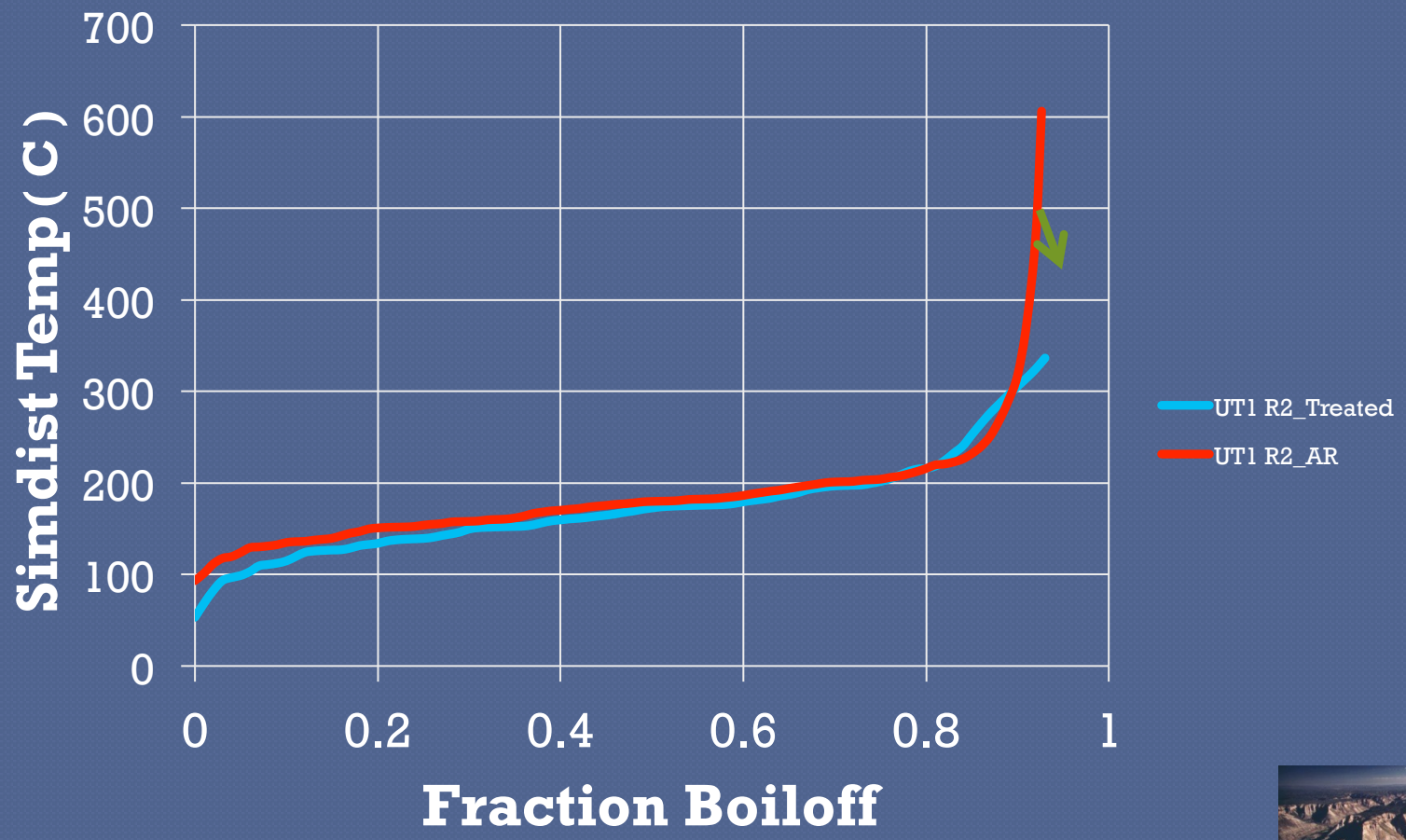


Mexican Heavy Oil 1 API v SR



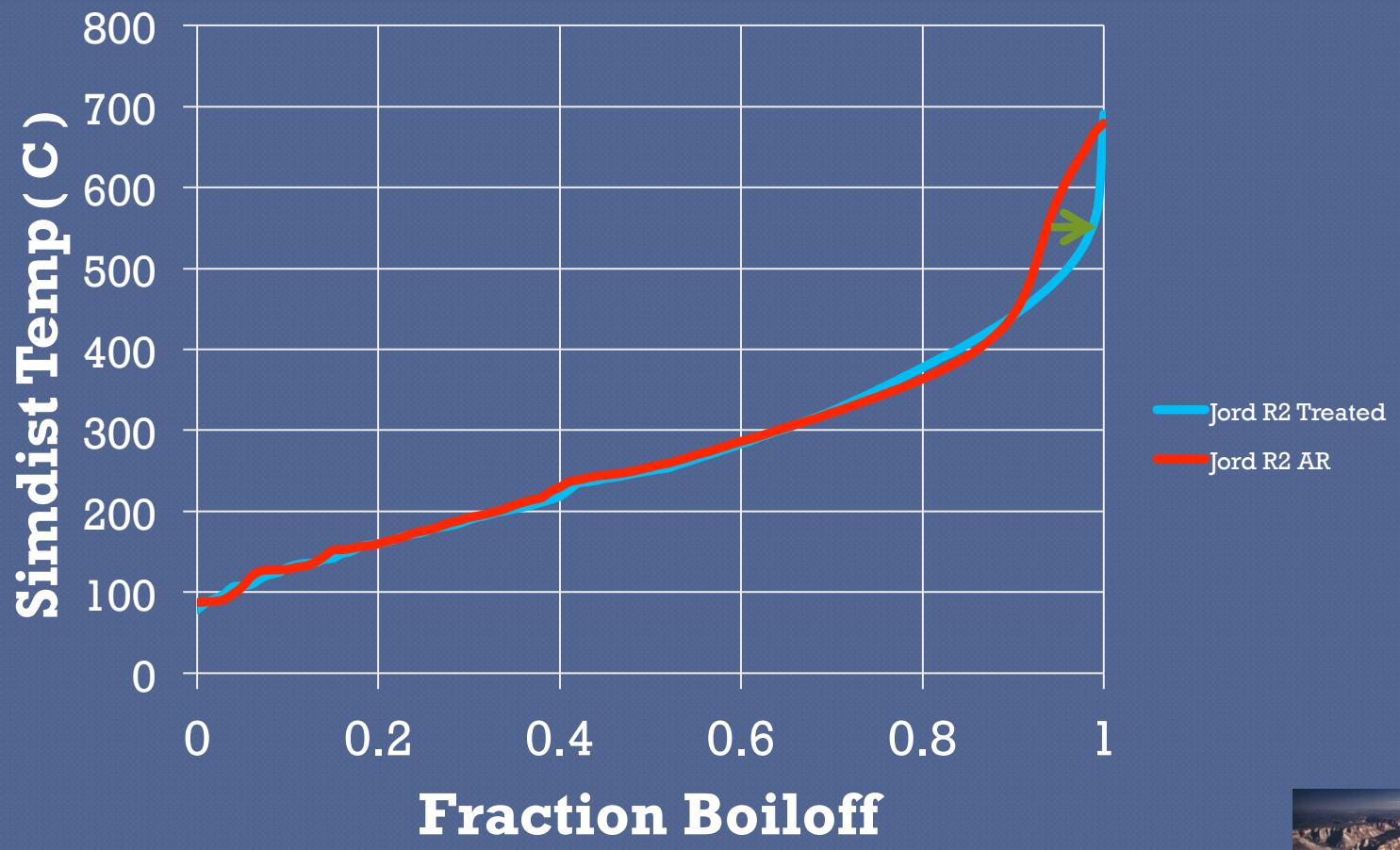
Uintah Basin Shale Oil Simdist

High boiling fraction eliminated



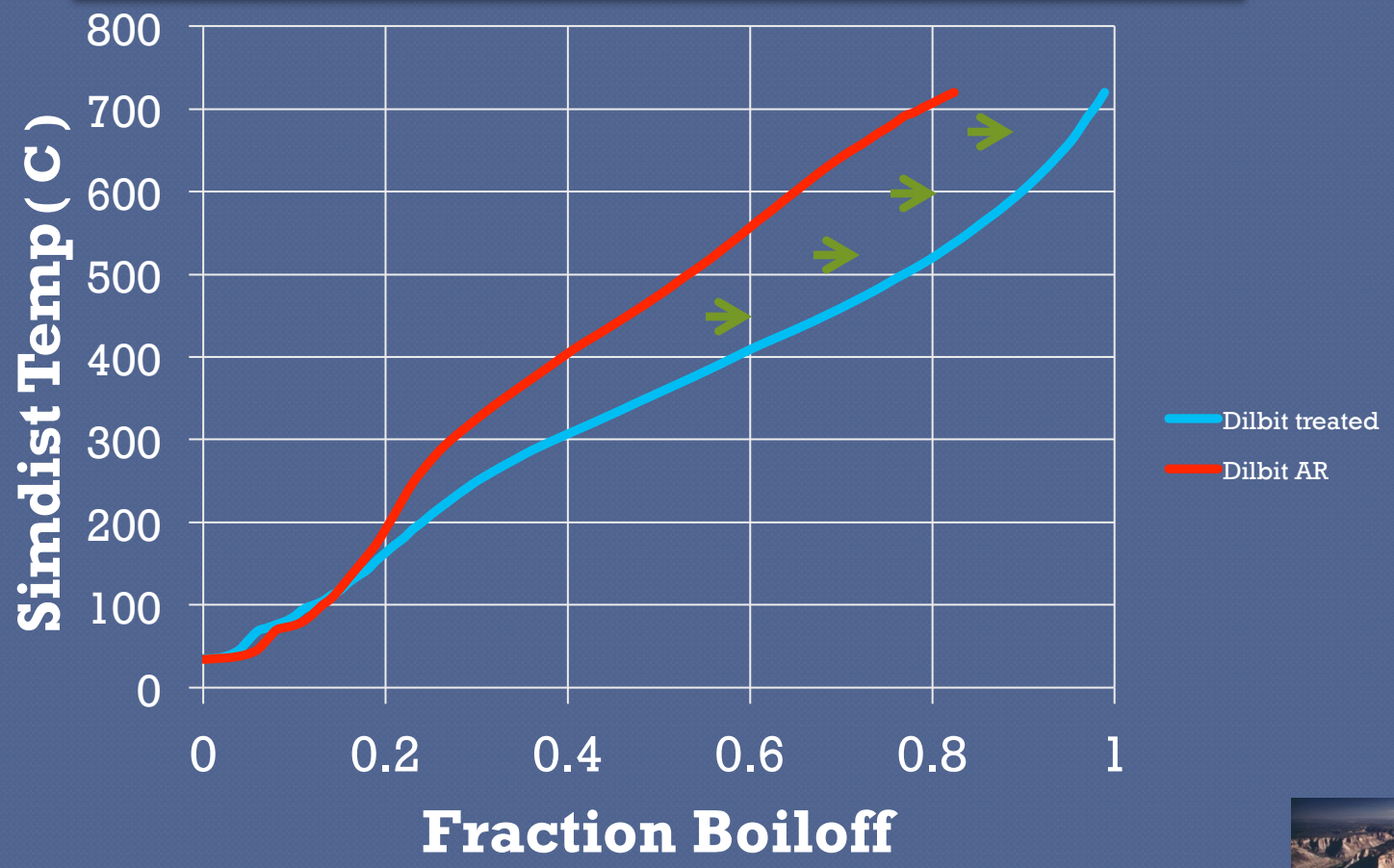
Jordanian Oil Shale Simdist

Mostly the same boiling but with dramatically reduced sulfur



Diluted Bitumen Simdist

Fractions boil at lower temperature
"Resid" fraction is reduced



Emissions

SO_2 Emissions = 0

CO_2 Emissions = less

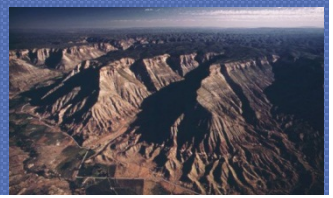
Summary

- Molten sodium upgrading demonstrated small scale
- Margins and returns look attractive
- Emissions can be reduced

Contact Information

- John Gordon
- johng@ceramatec.com
- (801) 631-5961

- For Canada
  - Neil Camarta
  -
  - neil.camarta@fieldupgrading.com
  - (403) 470-0141

Acknowledgement

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