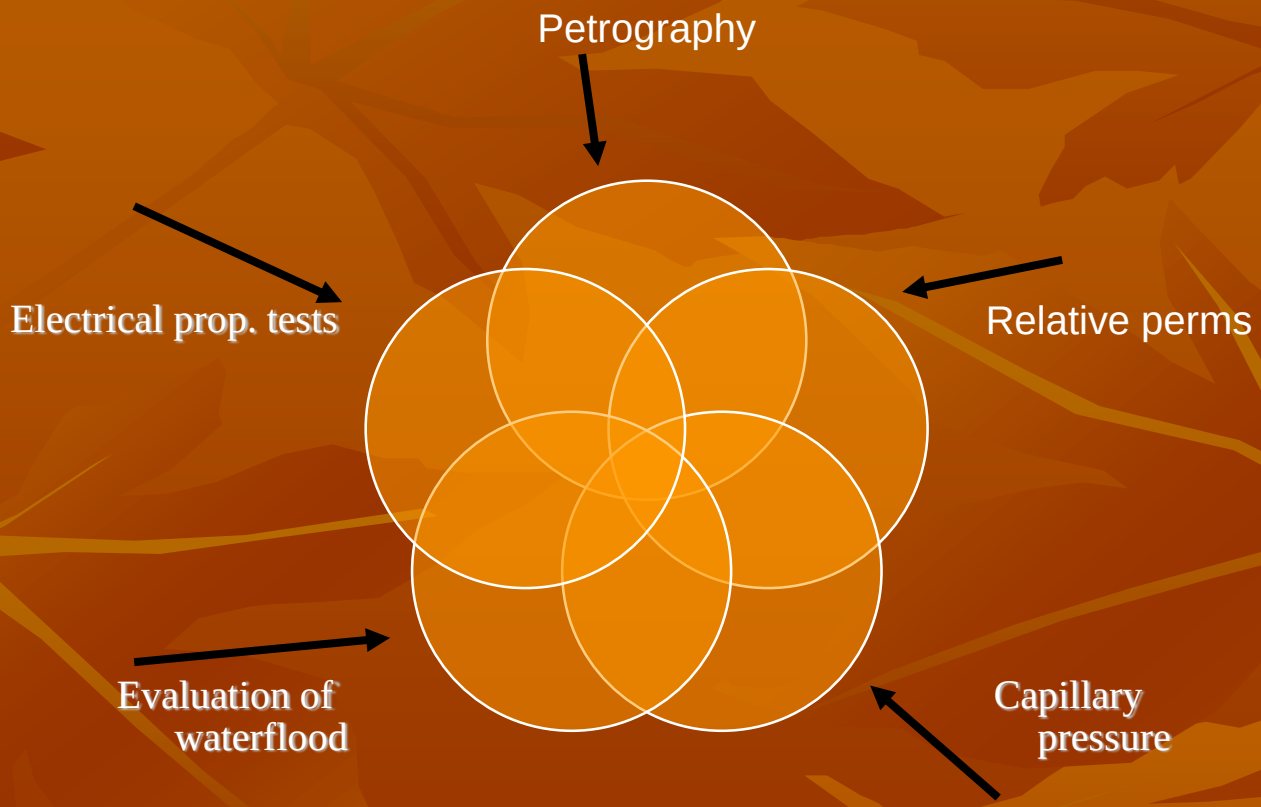
Torquay Formation
Reservoir Quality Assessment



By Kristina Hoffmann
Gambit Consulting Ltd.

Reservoir Evaluation Core Study Torquay Formation

- Sample selection (1-21;11-1; 3-6 W1)
- Petrography
- Wettability restoration for relative permeability tests
- Water-oil relative permeability tests
- Mercury injection capillary pressure tests
- Electrical property tests

Torquay Petrography 1-21-09-31W1

- P5 sandy dolostone

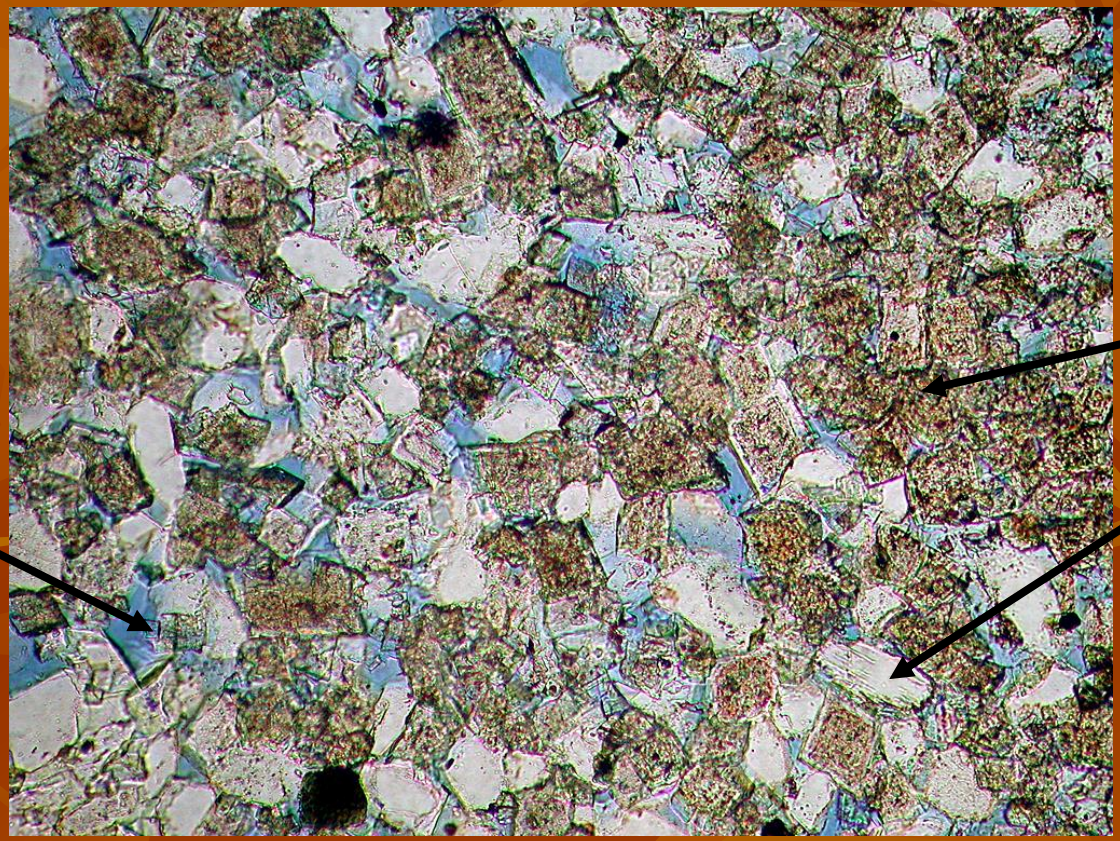
CA por. 15.8%
TS por. 8.7%
Perm. 2.0 md

Dolostone clasts

Clay and mud

x10

Torquay Petrography 1-21-9-31 W1 P5 sandy dolostone



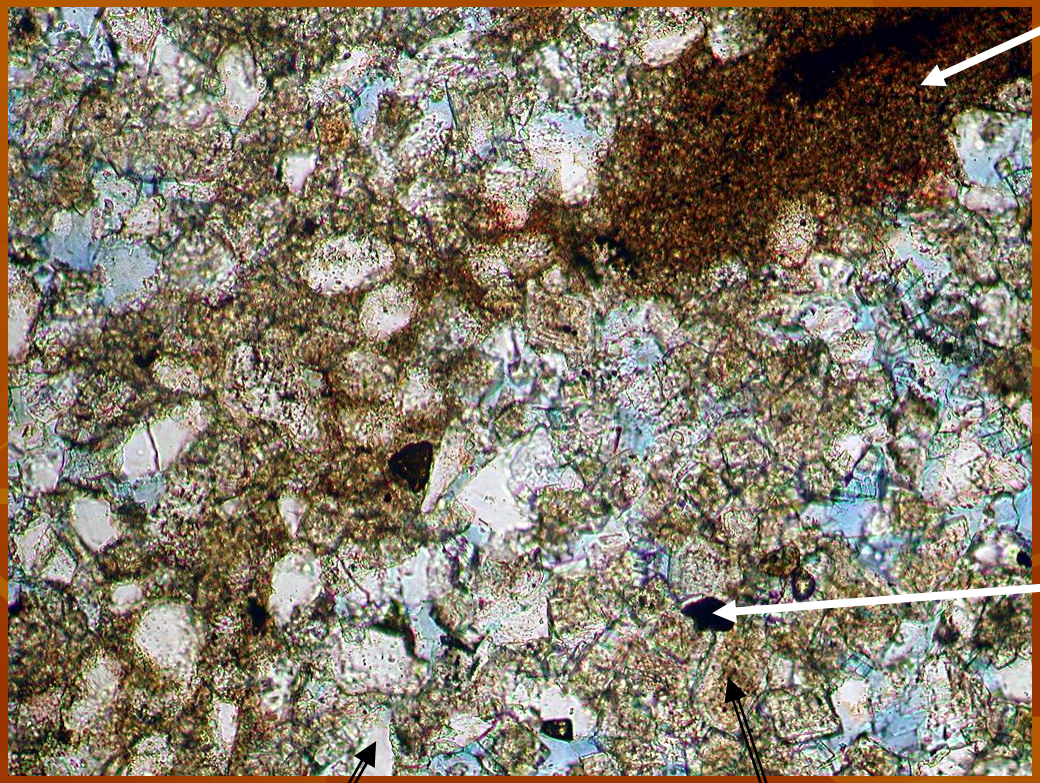
X 200

Torquay Petrography 3-6-9-30 W1 P7A silty dolostone

CA por. 15.9%
TS por. 9.3%
Perm. 2.13md

X 10

Torquay Petrography 3-6-9-30 W1 P7A silty dolostone



Compacted organic material and clay matrix

Residual oil

X 200

Quartz grains

Dolomite matrix

Torquay Petrography 1-21-9-31W1 P 13 dolomitic sandstone

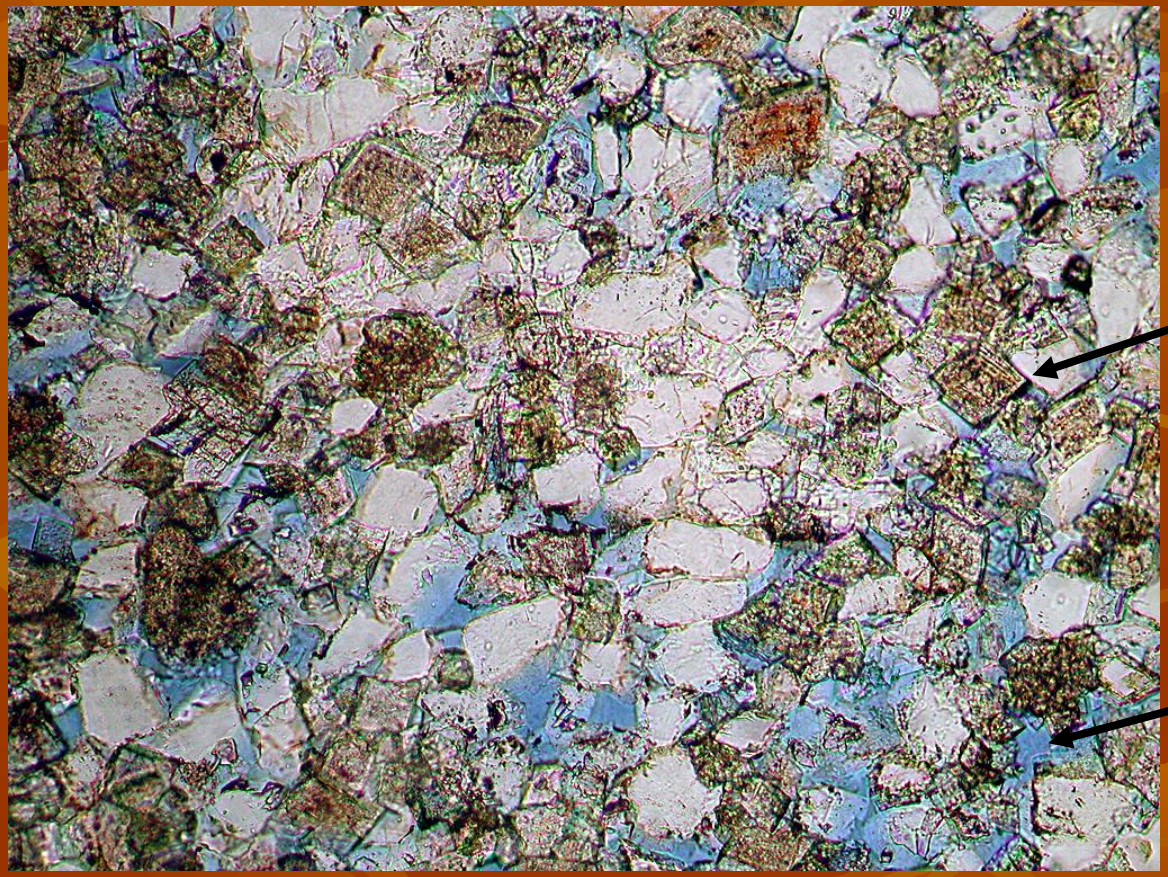
CA por. 17.8%
TS por. 13.7%
Perm. 68 md

X 10

Good reservoir quality, highly dolomitic sandstone with good effective porosity

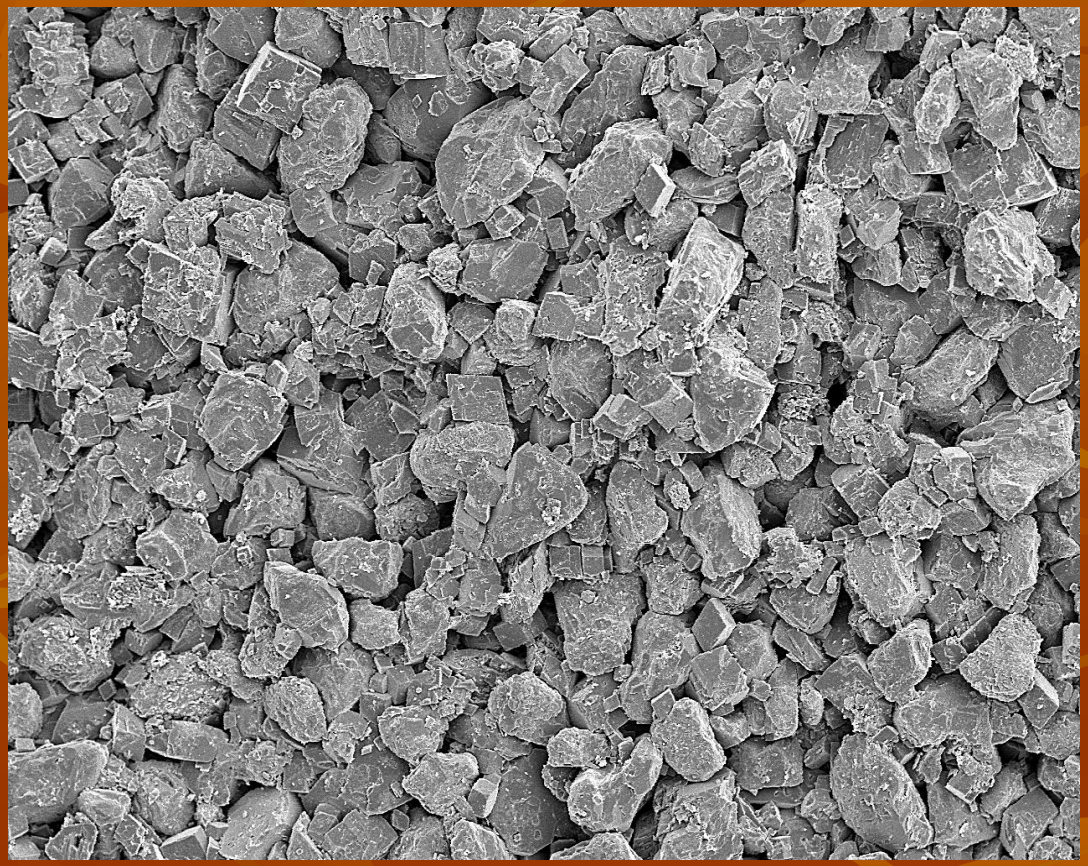
Torquay petrography 1-21-9-21 W1

- P13 dolomitic sandstone



X 200

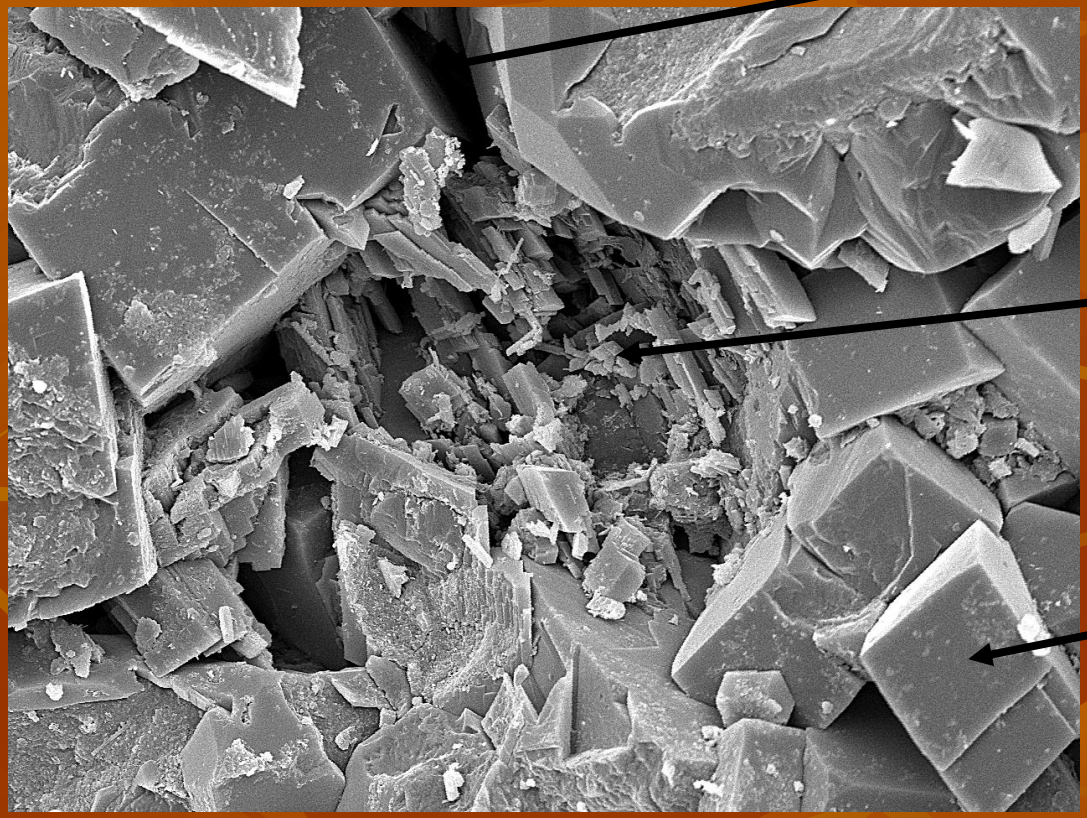
Torquay petrography (SEM) P13 dolomitic sandstone



Well sorted dolomitic quartzose sandstone

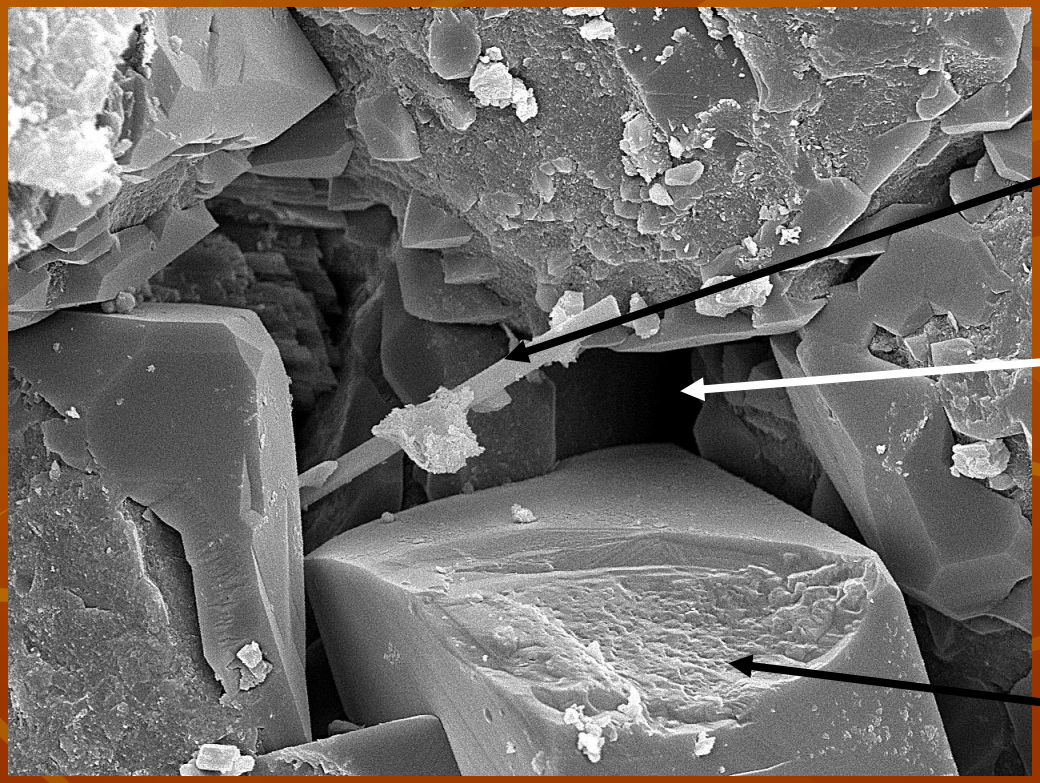
X 150

1-21-09-31 W1 (SEM) P13 cont.



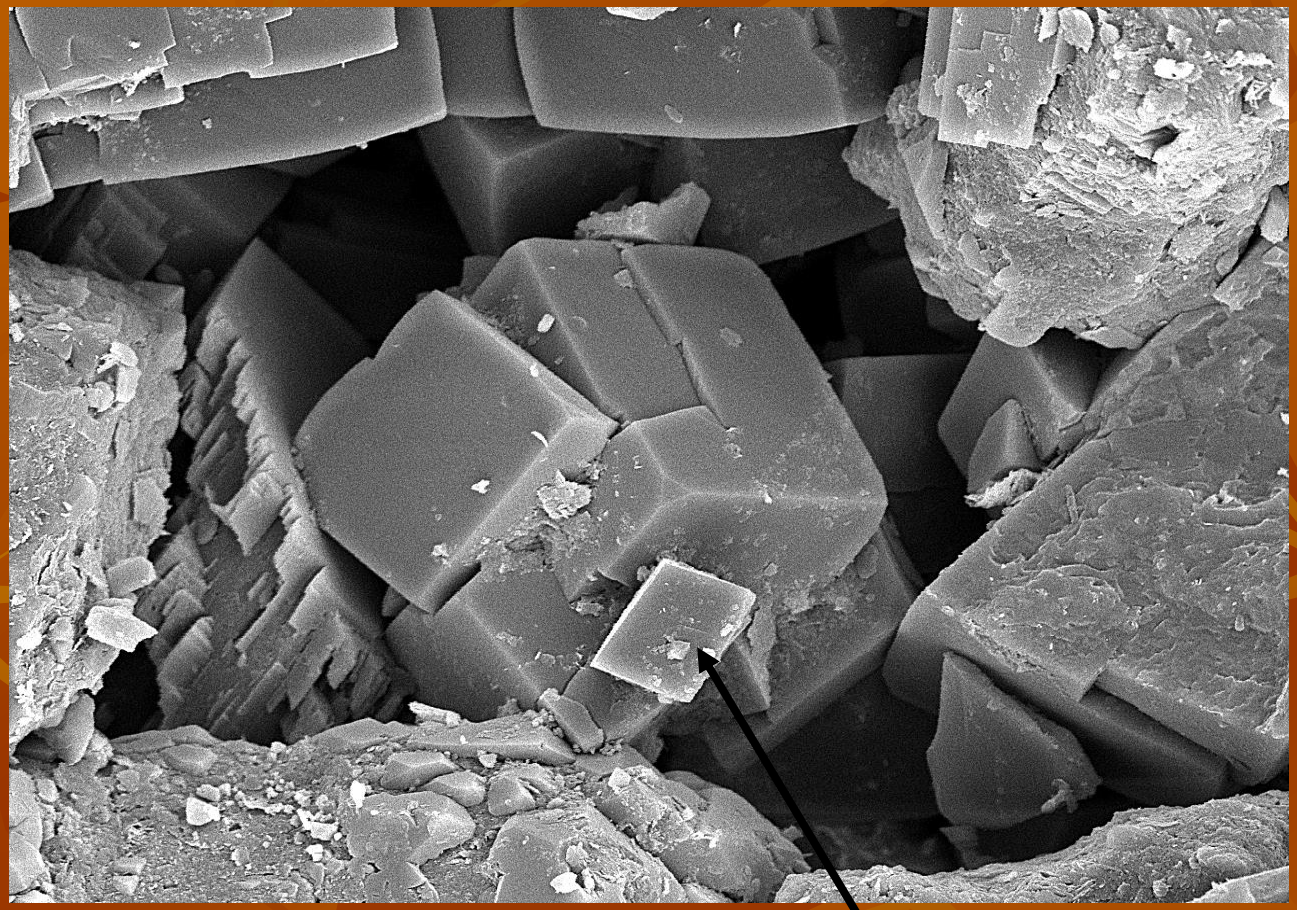
x1500

1-21-09-31 W1 (SEM) P13 cont.



X 2500

1-21-09-31 W1 (SEM) P9



X 2000

Dolomite cement

Petrographic Results

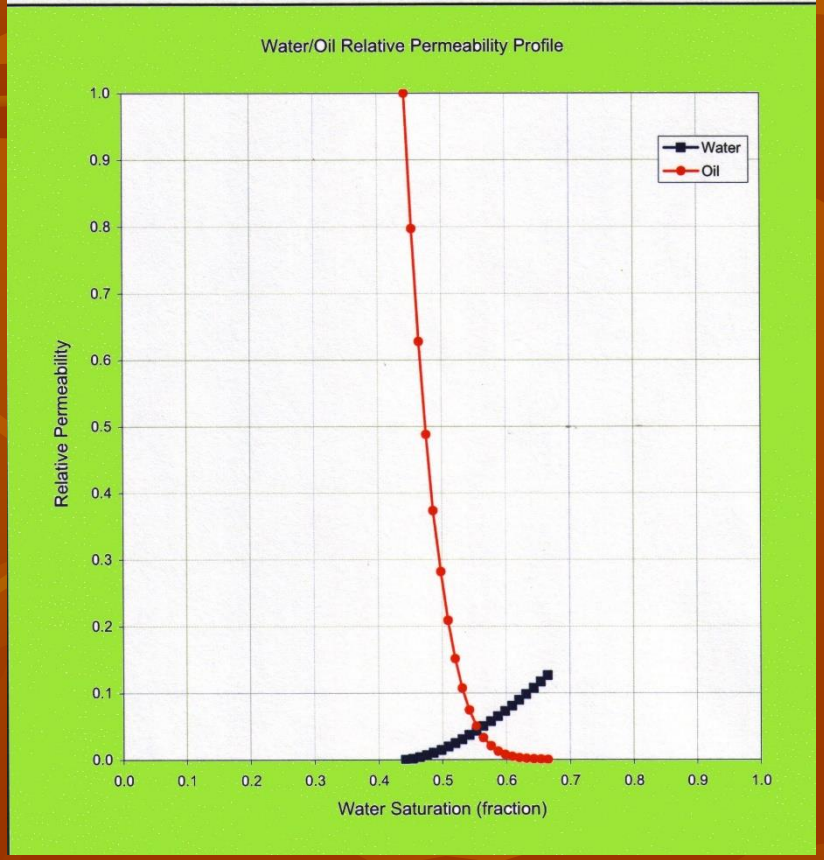
- Examined Torquay samples range from silty / sandy microcrystalline dolostone to dolomitic siltstone/ sandstone.
- Mean size of monocrystalline quartz, silt and sand grains varies from 0.05 to 0.078 mm.
- Grain size distribution: unimodal, moderately well sorted.
- Granual components include monocrystalline quartz grains, scattered rock fragments and detrital feldspar and carbonate grains.
- Matrix consists of mainly microcrystalline dolostone.
- SEM shows that sandstones contain small amounts kaolinite clay.
- Effective porosity is reduced by dolomite, calcite, and anhydrite cements.

Reservoir Evaluation Core Study Torquay Formation

- Sample selection (1-21;11-1; 3-6 W1)
- Petrography
- Wettability restoration for relative permeability tests
- Water-oil relative permeability tests
- Electrical property tests
- Capillary pressure tests

Water-oil rel. perm. test

Core stack I.D.:	#1	Average sample depth (m):	1045.37
Field:	Antler	Average porosity (fraction):	0.163
Formation:	Torquay Formation	Average Air permeability (mD):	2.04



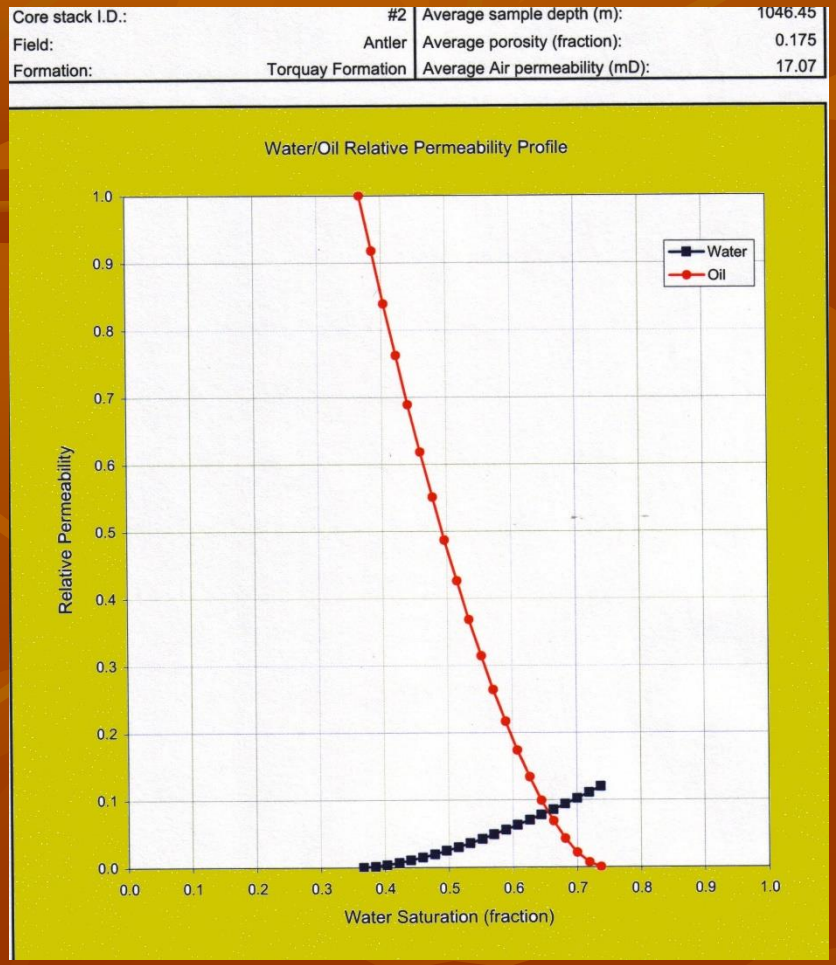
- Stack #1
- Medium quality rock

Water-oil rel. perm. stack #2

TABLE 7
WATER/OIL RELATIVE PERMEABILITY TEST CORE DATA SUMMARY - STACK #2

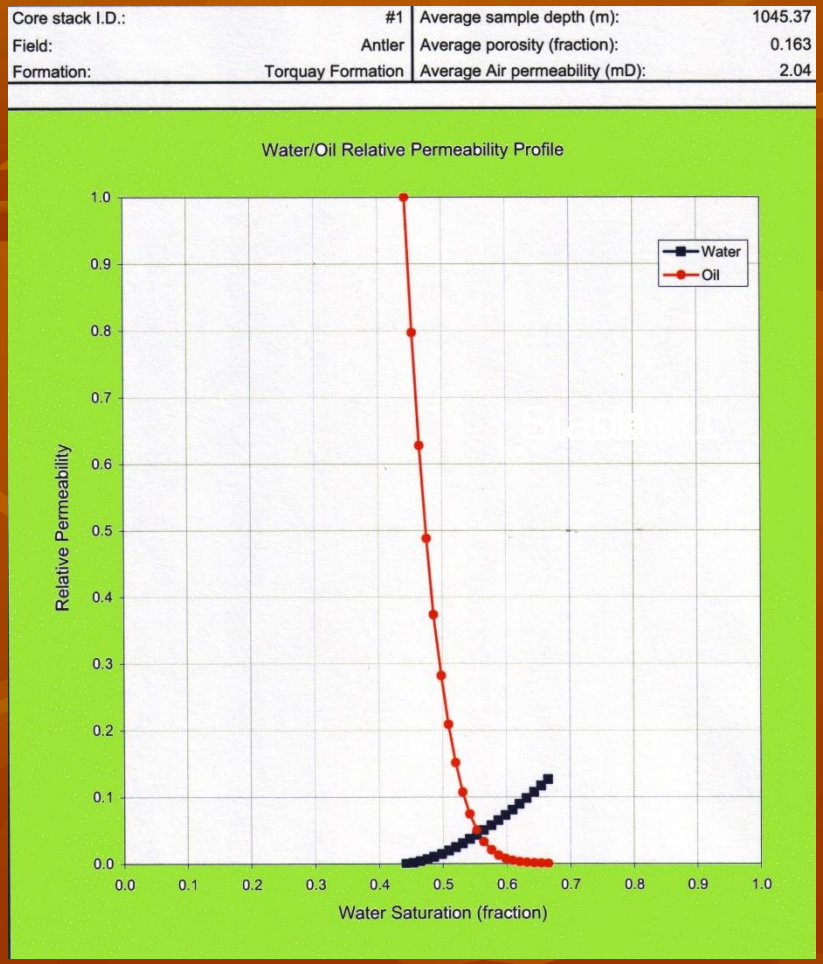
Sample Sequence from Inlet	Well I.D.	Depth m	Length cm	Diameter cm	Porosity Fraction	Air Permeability mD
P14	1-21-9-31W1M	1056.11	5.04	3.78	0.174	14.80
P5A	11-1-9-31W1M	1041.27	5.07	3.79	0.173	21.80
P8	11-1-9-31W1M	1041.98	5.16	3.71	0.178	14.60
Average:		**1046.45**	**15.27**	**3.76**	**0.175**	**17.07**

Water-Oil Rel. Perm. Test

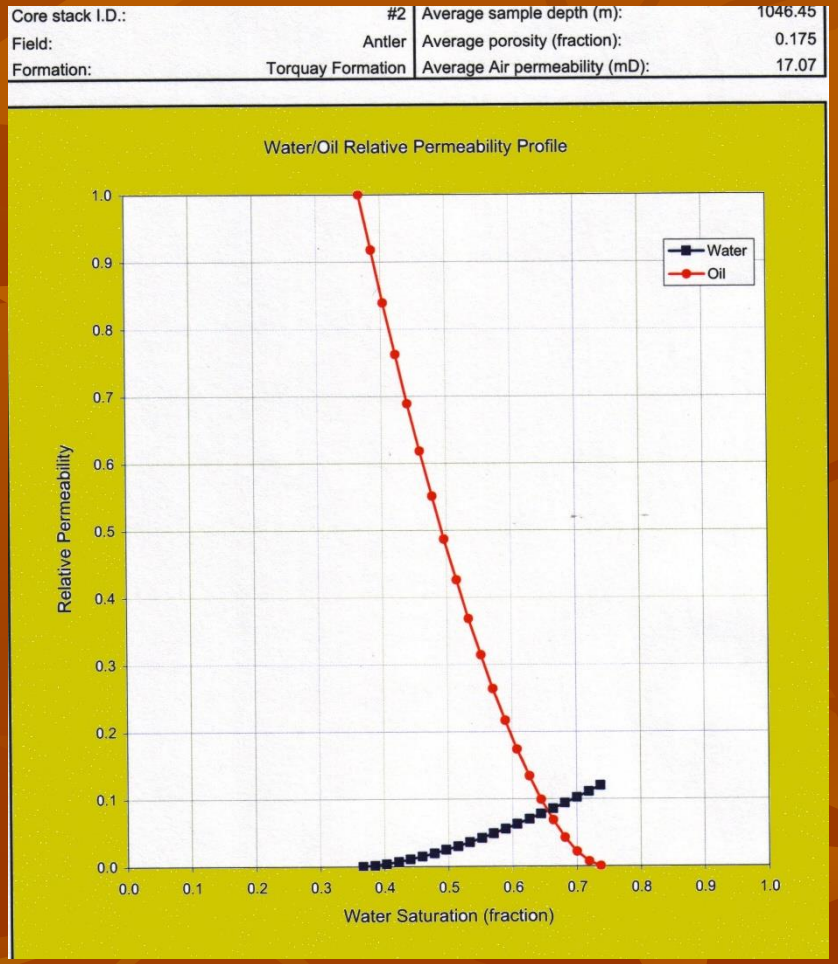


- Stack # 2
- Good quality rock

Oil-water rel. perm. tests

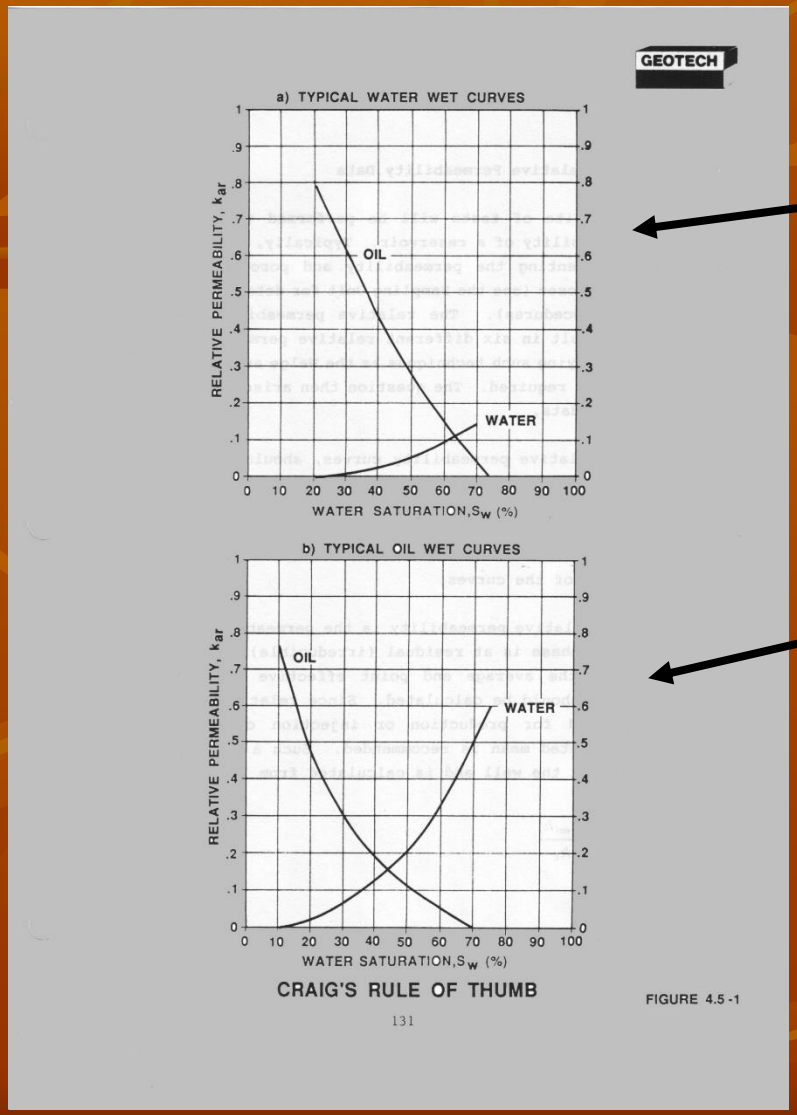


Aver. por. = 16.3%
Aver. Perm. = 2.04 md



Aver. por. = 17.5%
Aver. Perm. = 17.07 md

Typical water wet and oil wet curves

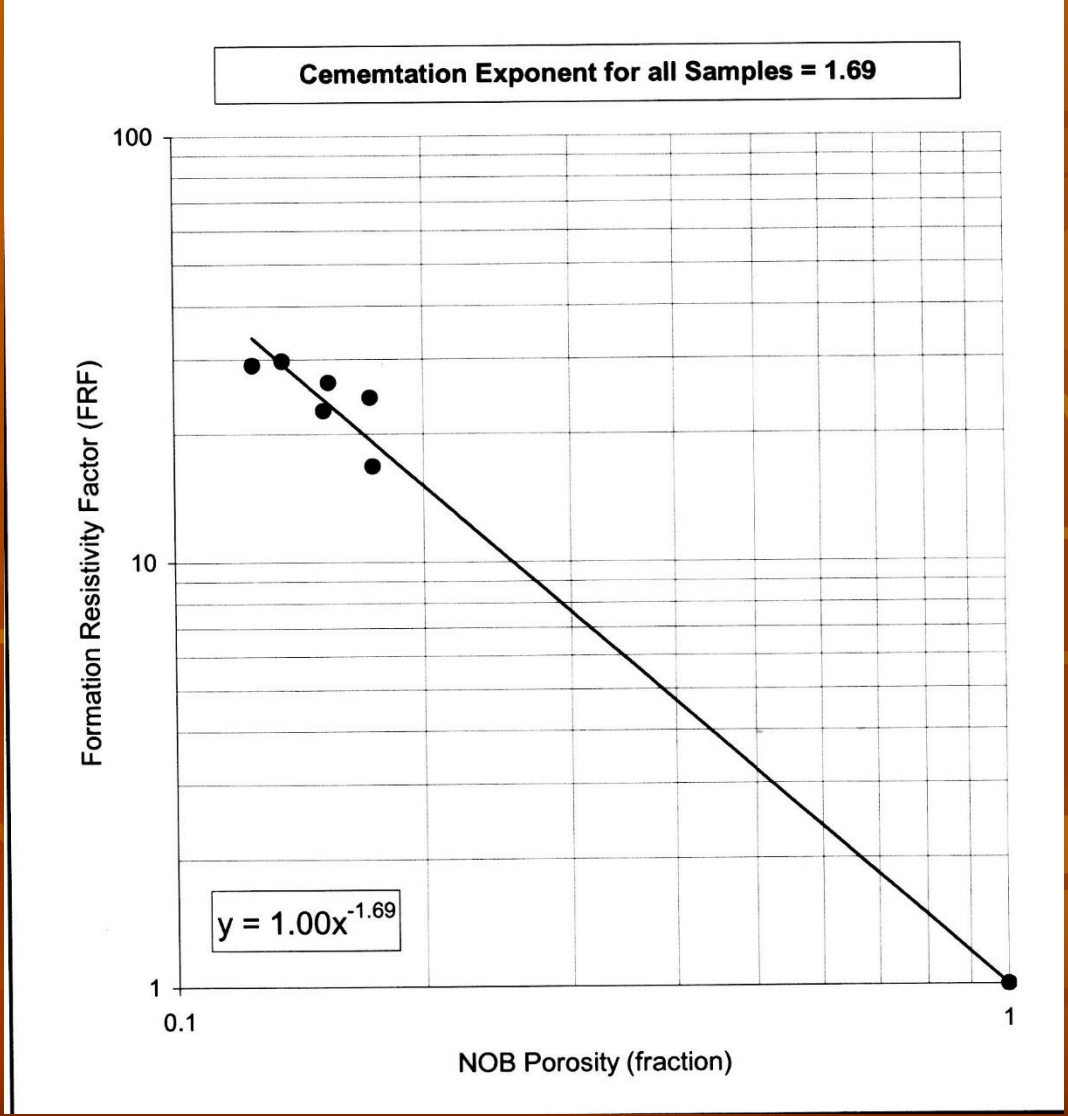


- Graig's Rules of Thumb
- Water – wet
- Swr > 20%
- Satur. for intersection of oil and water curves Sw > 50%
- Ratio of end point rel. perm. < 0.3
- Oil – wet
- Swr < 15%
- Satur. for intersection of oil and water curves Sw < 50 %
- Ratio of end point rel. perm. > 0.5

Reservoir Evaluation Core Study Torquay Formation

- Sample selection (1-21;11-1; 3-6 W1)
- Petrography
- Wettability restoration for relative permeability tests
- Water-oil relative permeability tests
- Electrical property tests
- Mercury injection capillary pressure tests

Torquay Formation Factor Test



M=1.69

Reservoir Evaluation Core Study Torquay Formation

- Sample selection (1-21;11-1; 3-6 W1)
- Petrography
- Wettability restoration for relative permeability tests
- Water-oil relative permeability tests
- Electrical property tests
- Mercury injection capillary pressure tests

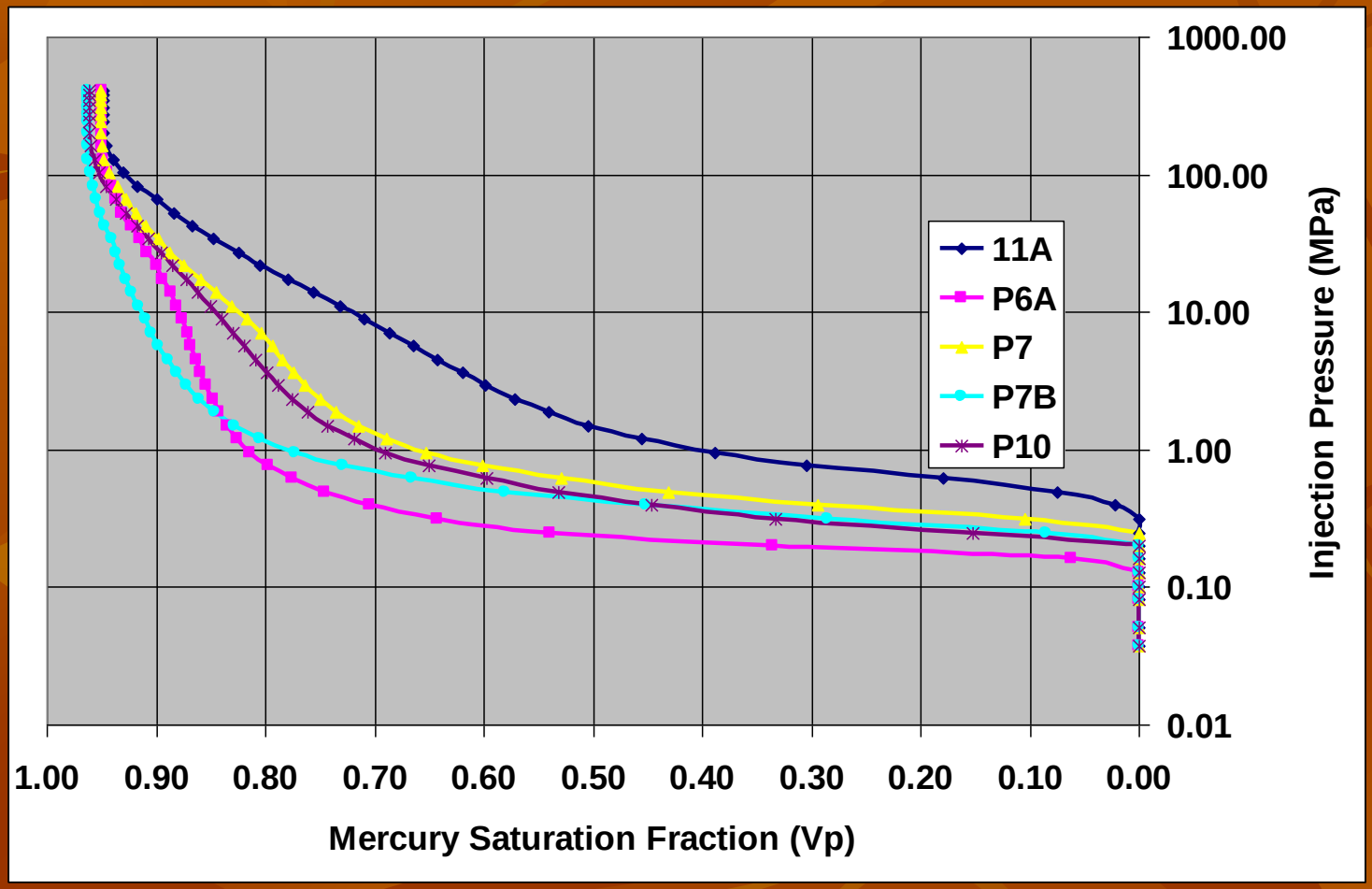
Capillary Pressure Tests

SUMMARY OF MERCURY INJECTION CAPILLARY PRESSURE RESULTS

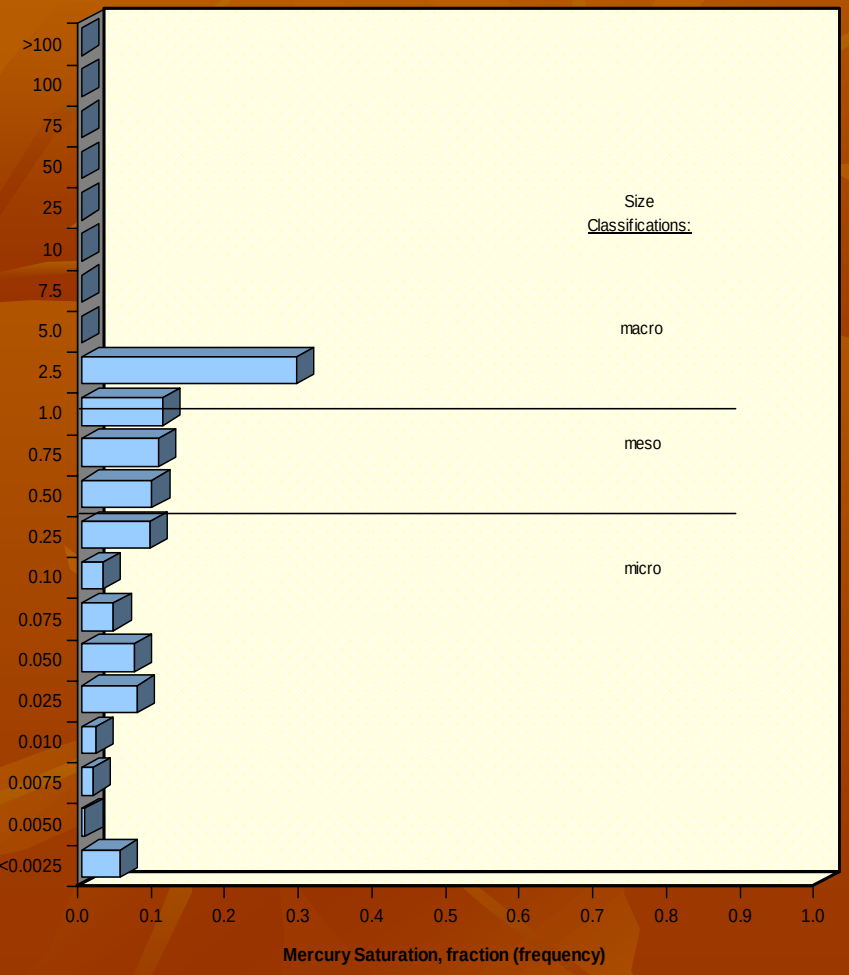
			AMBIENT CONDITION					
					MERCURY	MINIMUM WETTING PHASE	MEDIAN PORE	
				AIR	THRESHOLD	SATURATION	THROAT	
		DEPTH	POROSITY	PERMEABILITY	PRESSURE	AT 14 MPa	RADIUS	BIMODAL
Well_ID	SAMPLE	meters	fraction	millidarcies	MPa	fraction Vp	microns	yes/no
"1-21"	P10	1055.07	0.178	7.870	0.201	0.139	1.67	no, uni
"3-06"	11A	1055.07	0.134	0.880	0.314	0.244	0.513	yes
"11-01"	P6A	1041.50	0.184	48.60	0.128	0.113	3.120	no, uni
"11-01"	P7	1041.77	0.150	4.500	0.25	0.155	1.310	no, uni
"11-01"	P7B	1041.89	0.167	12.80	0.20	0.078	1.750	no, uni

Technique which is used to obtain an estimate of the amount of pore volume that is accessed by pores of any given radius.

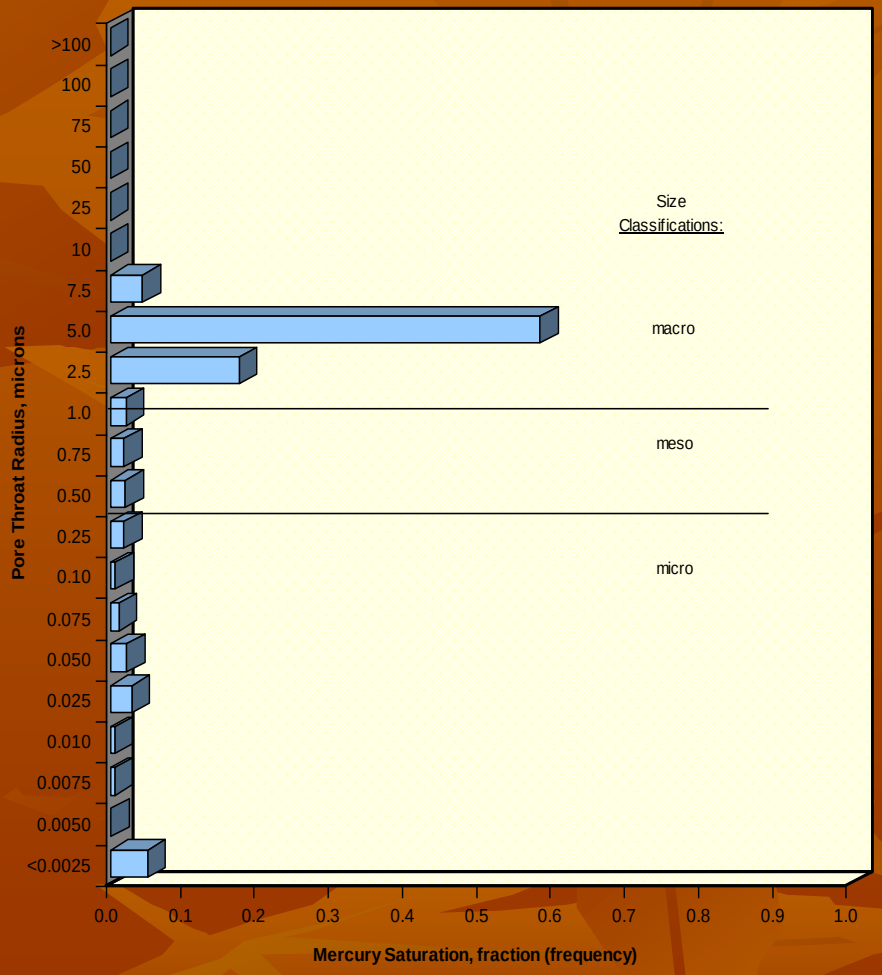
Capillary Pressure Tests composite plots



Pore Throat Size Radius



11A (3-6) por.13.4%; perm. 0.88 md



6A (11-1) por.18.4%; perm. 48.6md

Torquay Core Study Summary

- Relative permeability tests:
  - Initial water saturations: 0.36 and 0.44
  - Waterflood recovery: 0.40 and 0.59 oil in place
  - Strong indication of water-wet preferences
- Electrical property tests:
  - Composite cementation exponent m=1.69
- Capillary pressure tests:
  - Unimodal pore throat size distribution with majority of macropores

Recommendations

- To investigate feasibility of waterflood and evaluate potential problems experienced during waterflood:
  - Liquid-liquid incompatibilities:
  - Precipitation of alkaline earth metals (calcium, barium, strontium, magnesium)
  - Precipitation of iron, aluminum as insoluble carbonates, bicarbonates, sulphides.
  - Precipitation of oxidation-reduction reaction products
  - Liquid – matrix incompatibilities:
  - Clay swelling problems
  - Fines migration and plugging of pore throats
  - Dynamic displacement: relative permeability, wettability effects.
- To minimize formation damage drill with low fluid loss gel chem mud or consider compatible oil base mud and drilling underbalanced.