Brownfields Enhancement Technology

Rigless Reservoir Rejuvenation

Immiscible Gas Stimulation

Delivered Globally by -

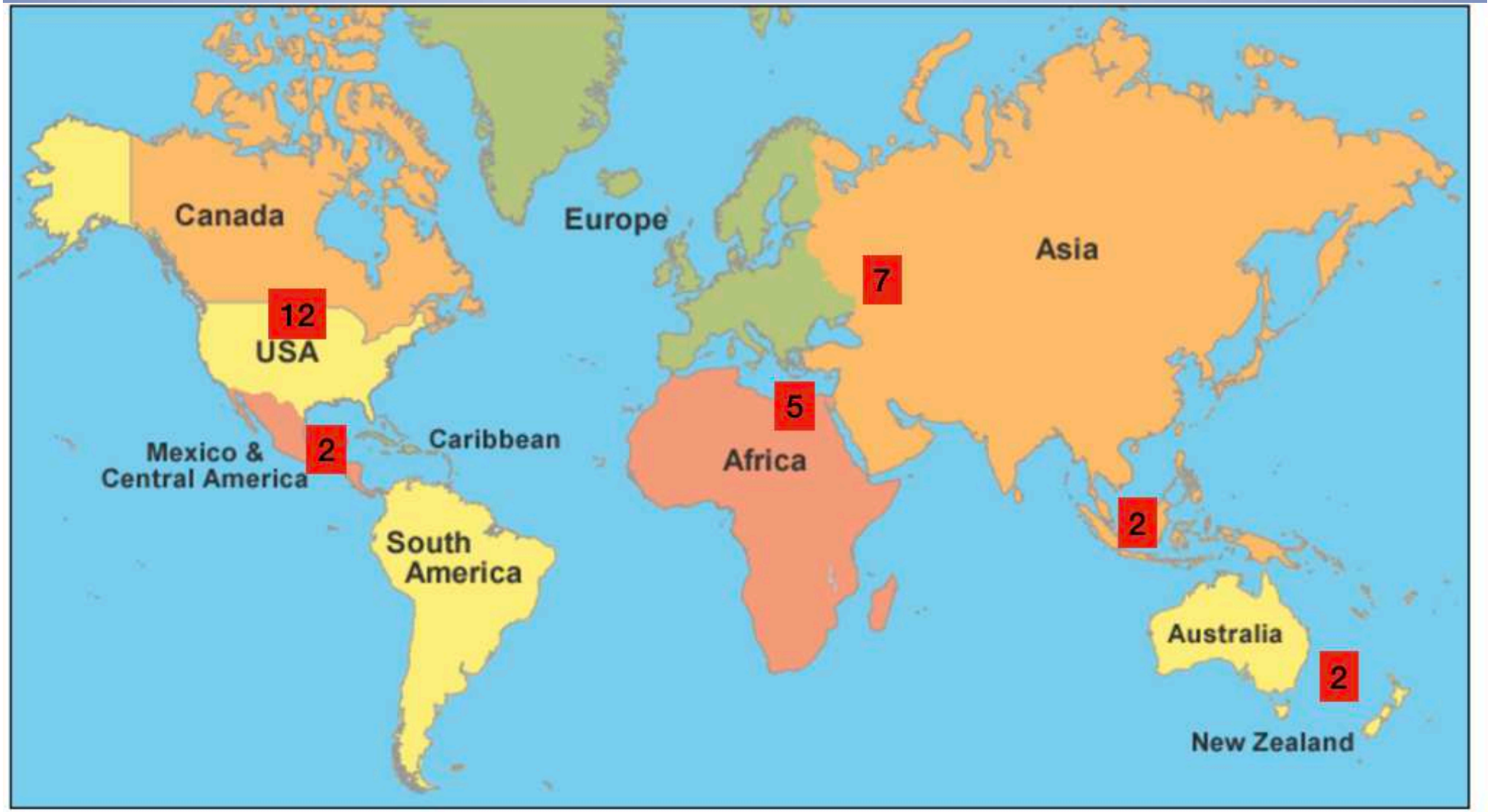
Air Drilling Associates

Brownfields Enhancement Technology Pte Ltd.

Immiscible Gas Stimulation (IGS)

BET provides expertise in designing and delivering IGS programs, ADA has extensive equipment and support globally and with a proven track record of delivering IG

Current ADA Immiscible Gas Unit Locations



Cost and Risk is a Major Consideration

P&A

$

Lowest complexity / cost

A
Non Rig Orientated
$

- Investigate
- RIH Slickline
- Drift, Sample
- Clear
- LIB, Camera
- Patch

B
Non Rig Orientated
$$

- HD Wireline
- Wireline
- Light CT
- Lateral Jetting
- Acid spotting
- Chemical Injection.
- Foam Lifting
- Immiscible Gas

C
Non Rig Orientated
$$$

- Full 2" CTU
- Scale Milling
- Coil Tubing Fishing
- Acidize

D
Rig Orientated
$$$$

- Workover
- P&A
- Side-track
- Infill
- Lateral Jetting
- Etc

E
Full scale EOR
$$$$$

- CO2 flood
- Polymer flood
- Thermal flood
- etc

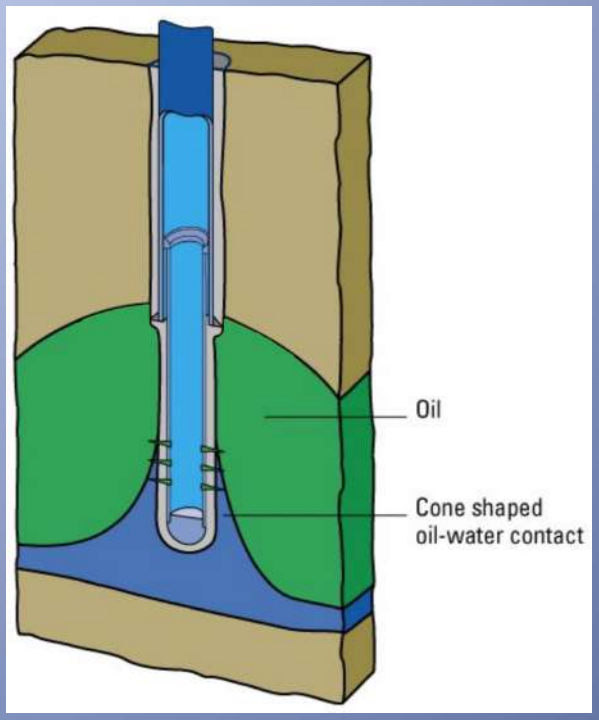
Highest complexity / cost

Risk

Increase in cost, planning, complexity, mobilisation time, operational time and HSE exposure.

Problem

- Low Oil Production
- High Water Cut
- Low Reservoir Energy / Drive
- Low Recovery:
  - Updip attic oil
  - Bypassed oil and low recovery factor



In '**vuggy**' carbonates…

and Fractures

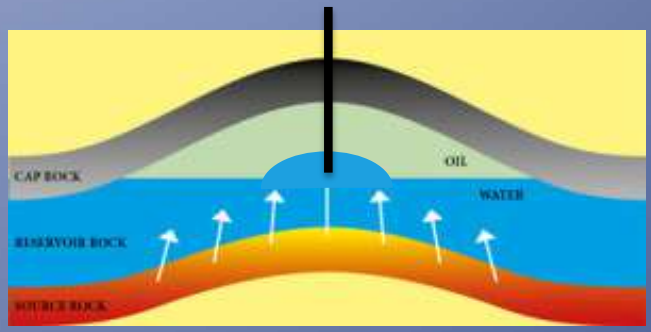
BET IGS Process

On-site gas generation

Immiscible Gas Blend

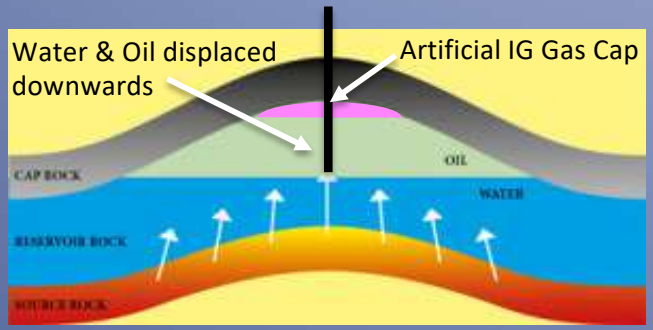
Connected to wellhead

Injected through existing completion



- Low Production
- High water cut

Injection



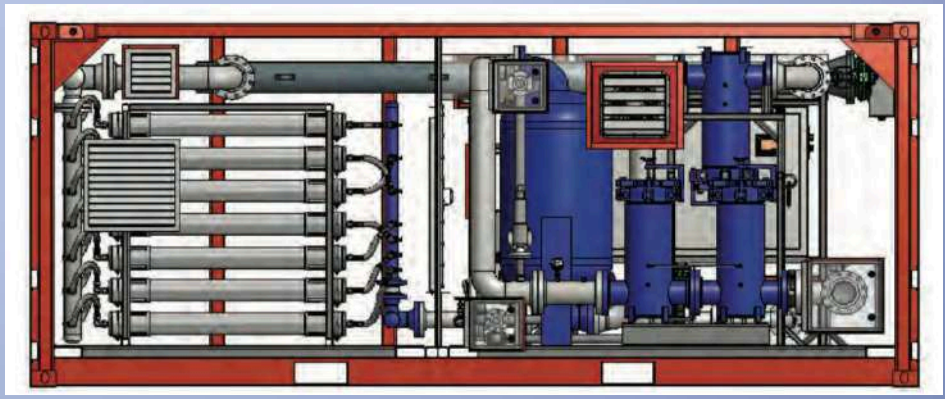
MORE OIL PRODUCTION

- Higher Production
- Low water cut

Immiscible Gas Delivery Spread

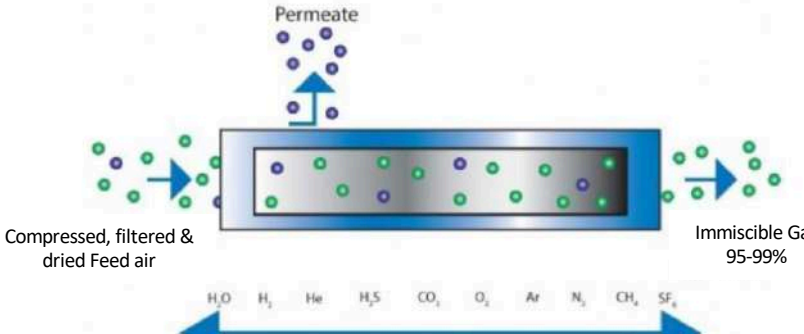
IGS Spread usually consists of:
4-5 Compressors
One Membrane Unit
One Booster, dosing pump & Ancillary equipment

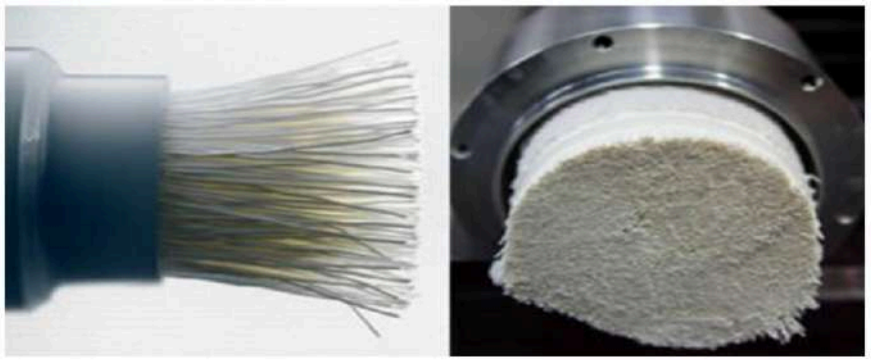
5 x Sullair 11500 SCFM Compressors running at 70% load



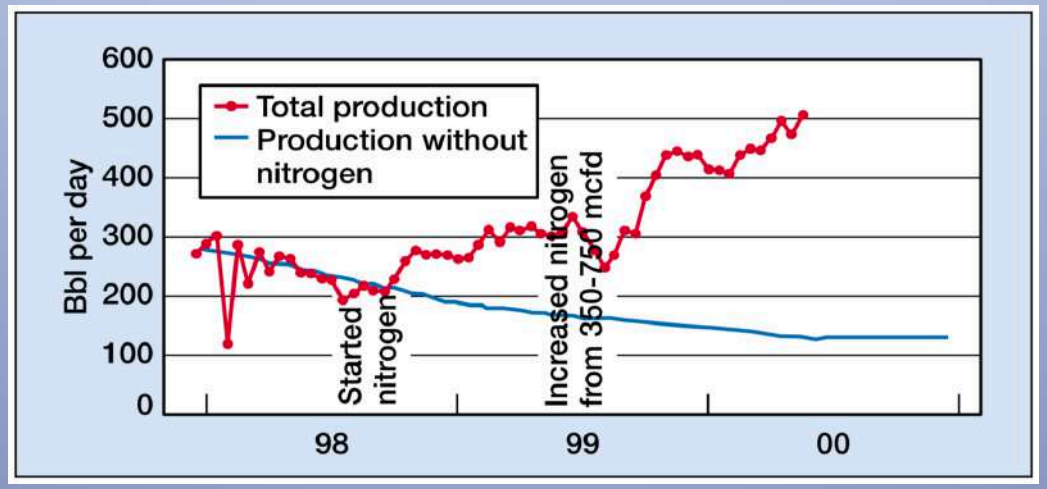
1 x Immiscible Gas Unit. 3000 SCFM (122,000 m^3/day).

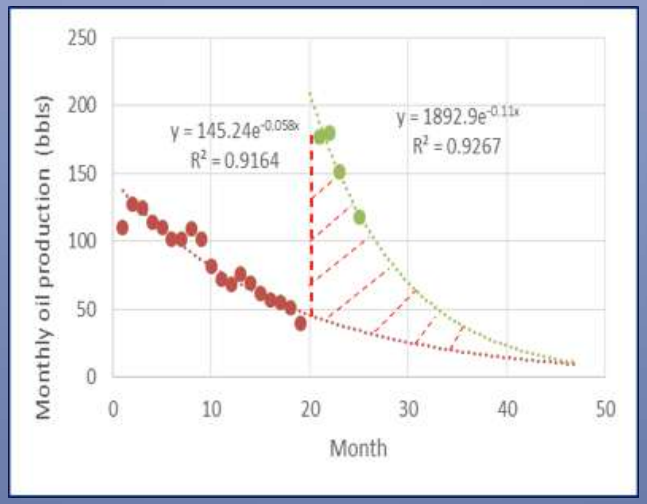
1 x Joy WB-12 Super Booster. 2500-2700 psi, 2500 SCFM Double Stage (Up to 5000 psi with 2 in series)





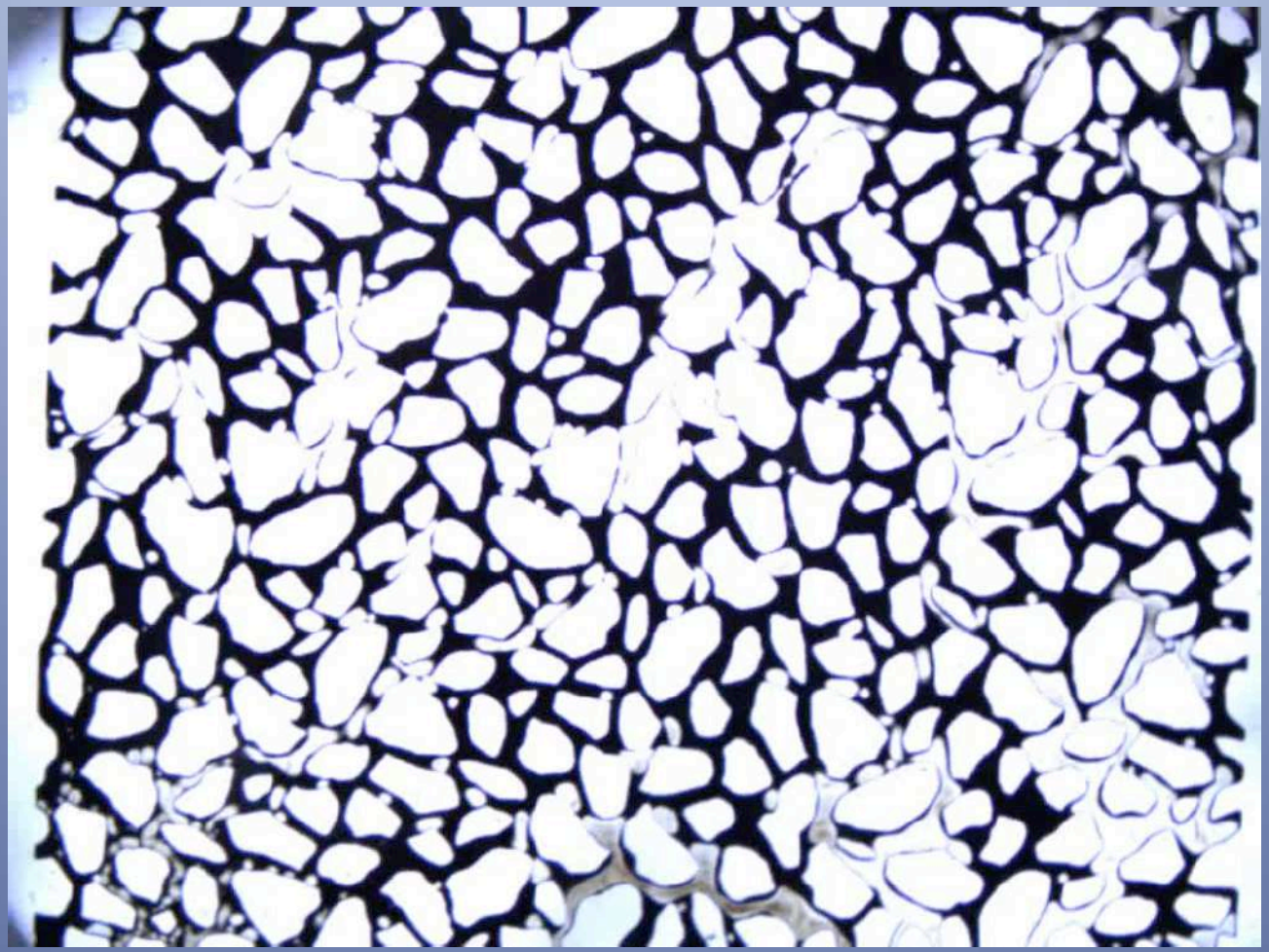
Immiscible Gas Stimulation "IGS" may be a solution to Operators of many suitable Brownfields:





IGS can be applied to significantly modify mature well / field decline curves

Immiscible Gas Updip Migration



Updip

Injection

Real time microscope images of Immiscible Gas injected into low permeability Clastic Arkose Sst, (K <0.09md) saturated with light, high wax and high asphaltene oil. 35.2° API

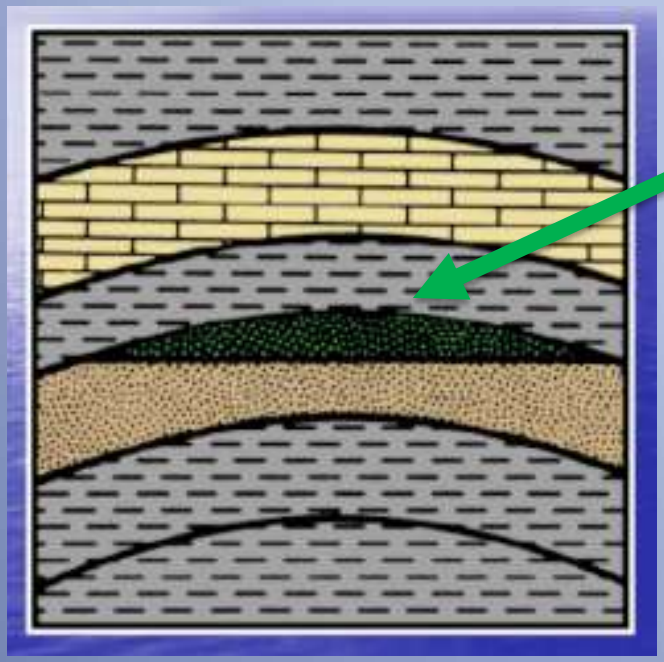
Reservoir Volumes and Pore Space Impacted by typical 3 day treatment.

Depth Ft	Res Pressure	Depletion	Treatment days	m^3 Day Surface	Total Surface m^3	Downhole BBLS Pore space treated before migration up-structure	Downhole m^3 Rock Volume treated at 12% Porosity.
3000	799	500	3	120,000	360,000	42,168	55,866
5000	1165	1000	3	120,000	360,000	30,559	40,486
7000	1531	1500	3	120,000	360,000	24,506	32,468
9000	1897	2000	3	120,000	360,000	20,793	27,548
11000	2263	2500	3	120,000	360,000	18,291	24,233

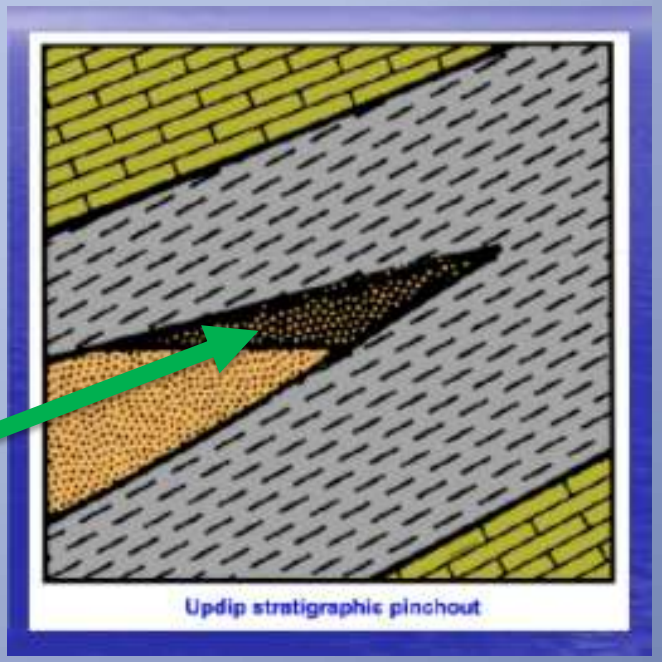
Using "standard" temperature gradient of 15F/1000' and "standard" hyrdostatic gradient of 0.433psi/ft

Features of BET IGS

- No CAPEX
- Lower OPEX per barrel
  - More efficient infrastructure utilization
- Fast payback from increased cash flow
- No rig support
- No explosives
- No hazardous materials
- Environmentally safe
- More oil from old oil fields
  - Lower water cut
  - Increased oil production rate
  - Increased ultimate recovery and reserves
- Works in carbonates, clastic and exotic fractured or dual porosity reservoirs
- Scalable from single well Cyclic Injection Applications (CIA) up to multi-well and whole field Stimulations
- Small mobilization and footprint
  - < 5 trucks onshore
  - One Workboat offshore

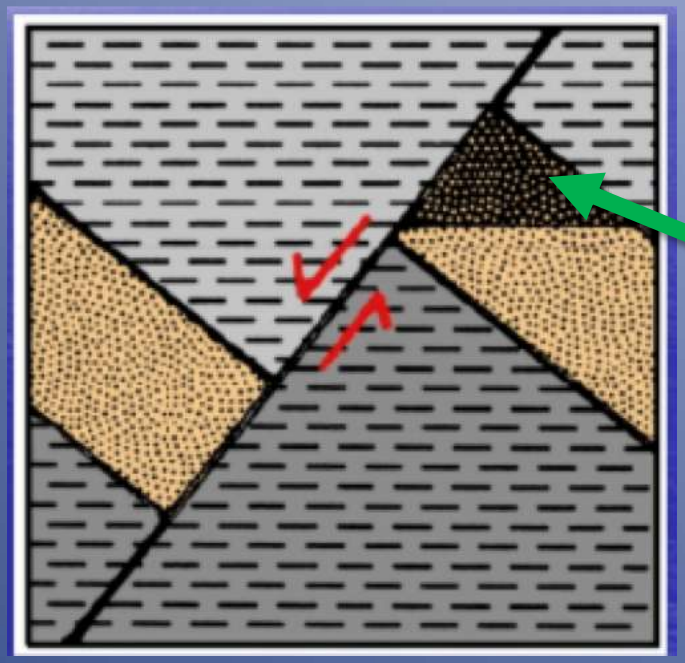


Good Cap Rock Seal

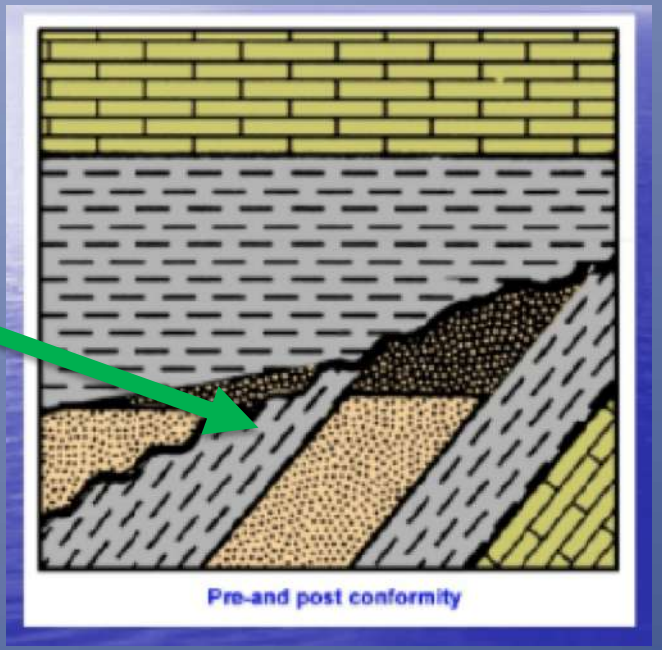


Updip Oil

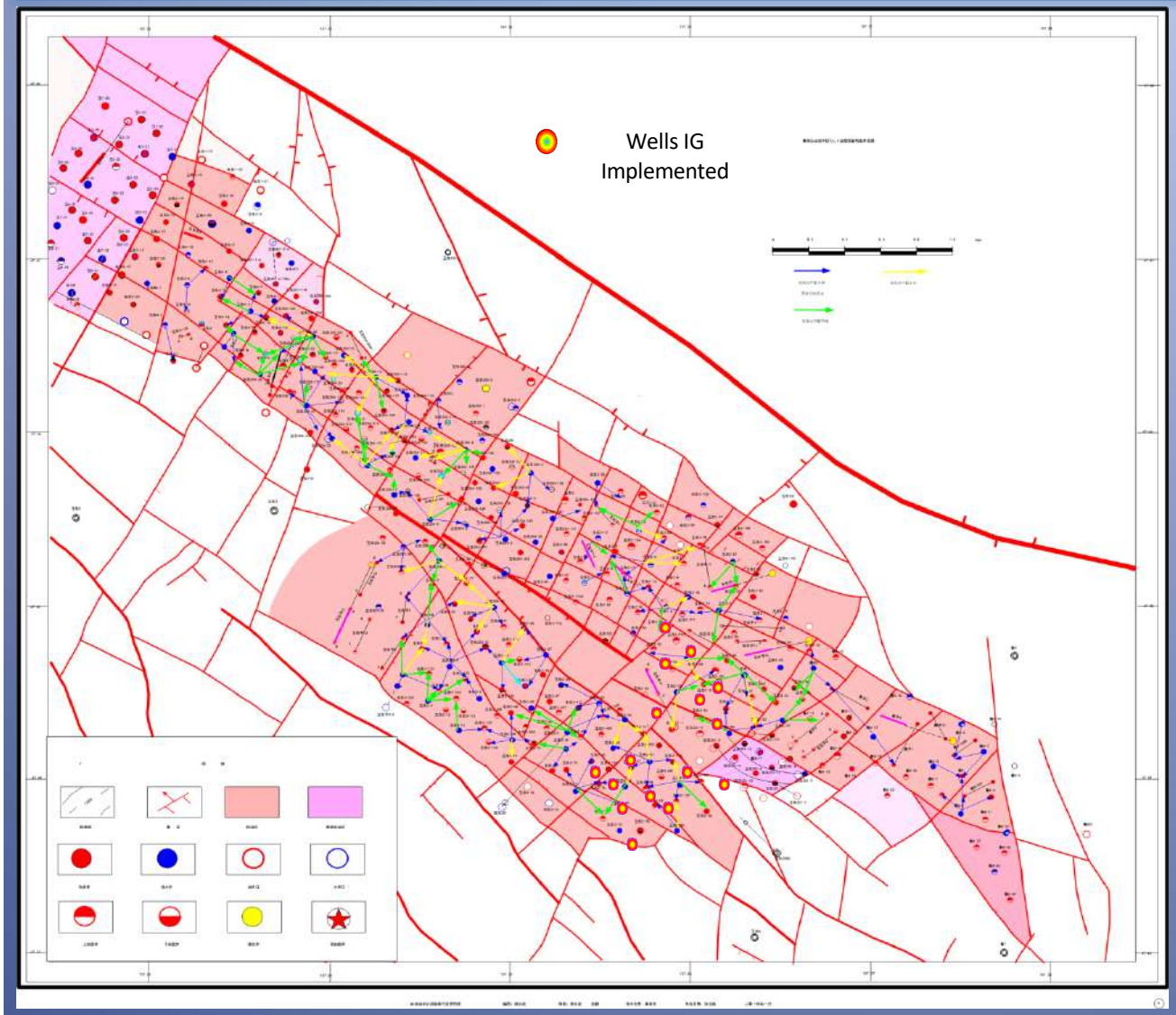
Works at macro “field scale” traps or at smaller scale within reservoir units



Vertical Permeability



Example of compartmentalized sandstone reservoir.



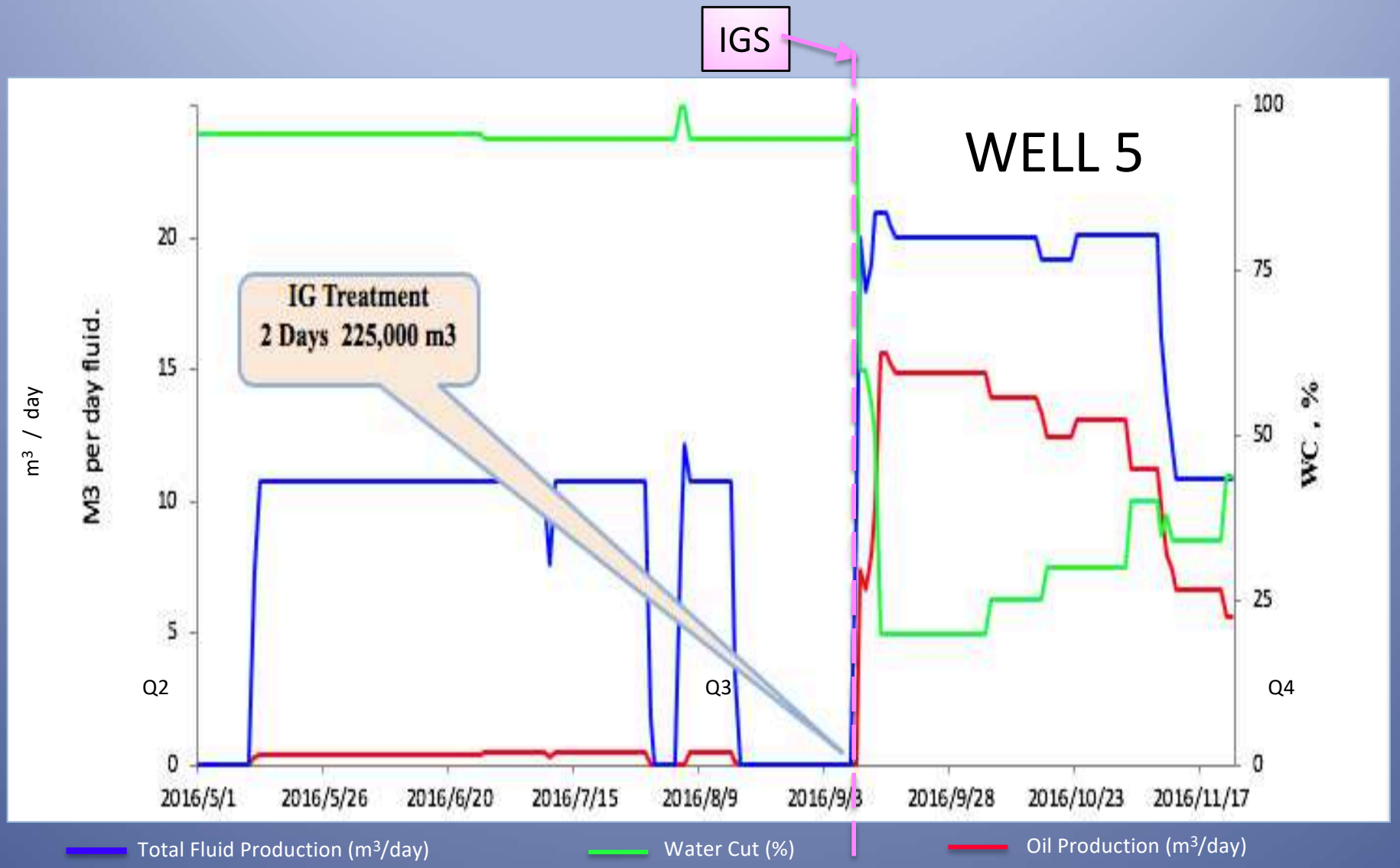
Reservoir Characteristics:

- Lithology: Fine sandstone
- Structure: Complex fault block
- Pressure/Temperature: Normal
- D= 2500-3600m
- φ= 11.2%-21.7% , K=305.6mD

Problems:

- Deficit of formation energy
- High water cut
- Low productivity of individual wells due to small drainage areas

IGS Results



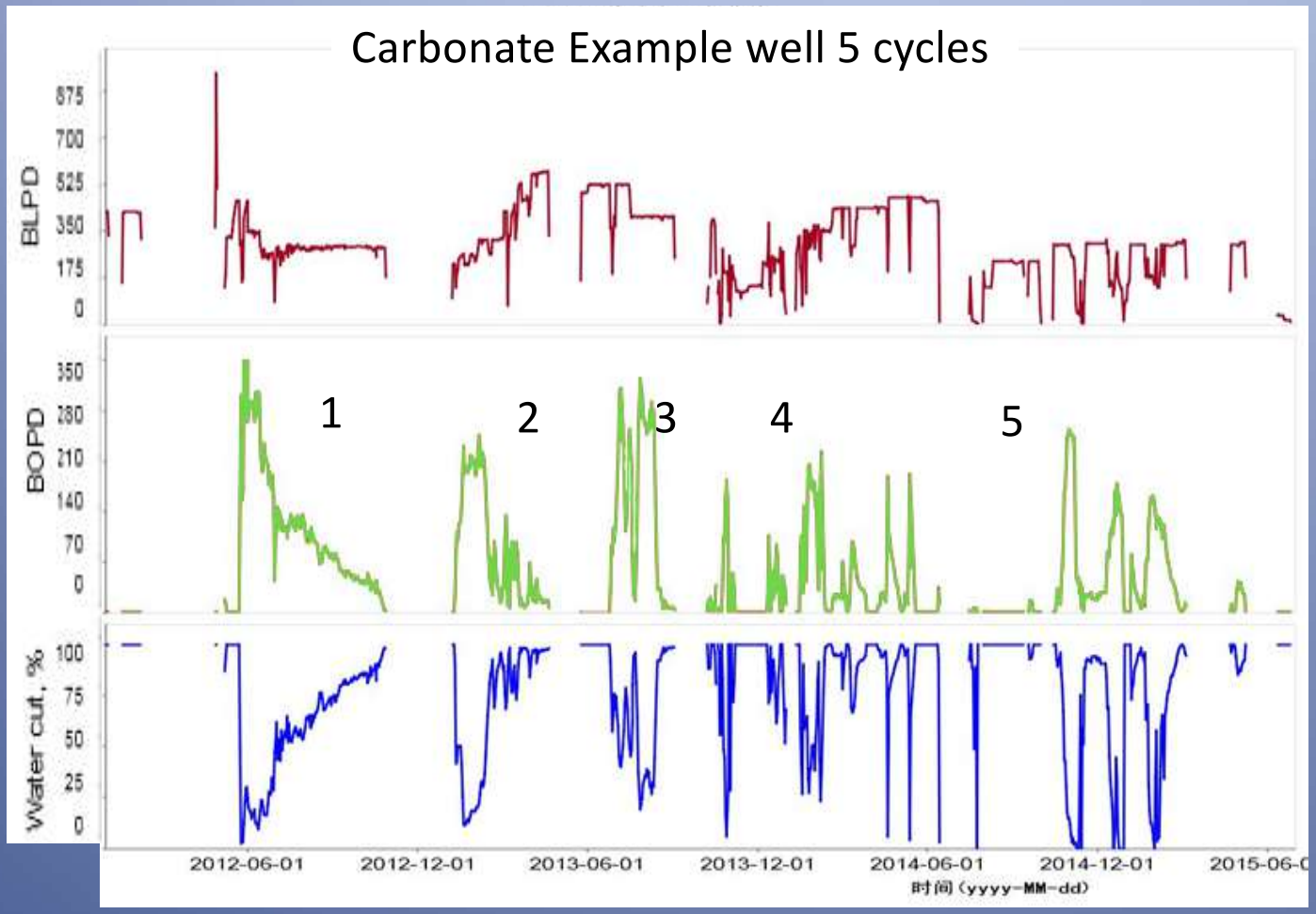
Production before IGS was 3.5 BOPD (95% Water Cut) After IGS was 98 BOPD with 25% Water Cut. Post IGS incremental Oil 5,900 Bbls in 70 days

Example IGS Case Study

Well	IG Used M3	Treatment Days	Avg BOPD New to Date	Avg new water cut	Op days to date	Inc Oil to date	Planned effective days
1	252,000	2	23	-71	84	9462	170
2	717,100	6	72	-51	63	4526	155
3	217,100	2	26	-45	102	2682	90
4	504,100	4	31	-38	104	3203	130
5	225,000	2	94	-70	63	5918	150
Avg 5 wells	**383,060**	**3**	**49**		**83**	**5158**	**139**
6	361,000		53	-58	31	1643	85
7	449,000		53	-74	26	1382	100
8	407,000		23	-3	49	1109	90
9	283,000		79	-68	25	1986	140
10	380,000		67	-62	29	1939	100

- Reduced lifting cost and reduced OPEX per Barrel
- Increased Production and Revenue
- Increased P1 Reserves under PRMS
- Benefits shown above are only for partial single cycle

Single Well Carbonate Reservoir



Cycle	Incremental oil BBLS
1	18,163
2	9,002
3	10,174
4	8,848
5	10,465
Total Inc Oil	56,652

- **Well was high water cut before IG treatment.**
- **It flowed after first cycle with a production rate of 525 bbl/d.**
- **Cumulative Incremental oil is over 56,652 BBLS after 5 cycles.**

Benefits of IGS to Operators

- **CASH FLOW POSITIVE –** throughout project life after 1st month
- **No CAPEX** - low initial cost & faster payback compared to other EOR methods
- **Reduced OPEX -** per barrel by reducing total liftings and increasing Oil production – more efficient use of existing infrastructure.
- **Rigless -** No need for Rig or down hole intervention with suitable candidates
- **Safe -** Minimal intervention time and cost, minimal HSE exposure
- **Green –** no toxic chemicals or greenhouse gasses used in the process and 100% environmentally friendly,
- **No Risk -** Can not adversely effect oil or damage reservoir quality
- **Extends field life -** defers abandonment costs
- **Increases Oil Reserves** under PRMS for whole of field
- **100% Upscalable** - can be implemented on a single well CIA up to whole field

Why IGS ?

- Differences with Miscible Gas (CO_2 or Natural Gas) Flood
  - Onsite gas generation using inert gas blend which is safe and environmentally friendly
  - No need to transport gas or spend CAPEX building permanent facilities
  - Less gas needs to be injected and no additional gas separation on produced oil
  - Non corrosive compared to CO_2 based methods
  - IGS prevents wax and Asphaltene precipitation.
- Differences with Immiscible Liquid (Water or Polymer) Flood
  - Superior downhole viscosity compared to liquids
  - Can access updip oil and incremental reserves
  - Works on a single well basis in CIA applications
  - No requirement for ongoing chemical costs
  - Gas expansion provides additional drive and better economics

Advantages of BET & Global Partners

- **BET**
- Focus on Brownfield Enhancement Technologies
  - Extensive technical expertise
    - Candidate well selection
    - Reservoir & process modelling
    - Job Planning and Economic Modelling
  - Technical and Operational Support
- **ADA**
  - Proven Track Record with major operators worldwide
  - Safe and Successful local Operations throughout the world
  - Extensive local technical and operational expertise and support
  - Optimal equipment located in all producing regions with capacity available at short notice.

Thank you

Air Drilling Associates

Brownfields Enhancement Technology Pte Ltd.