



Sand Production Forecasts of Unconsolidated Gas and Condensate Reservoirs



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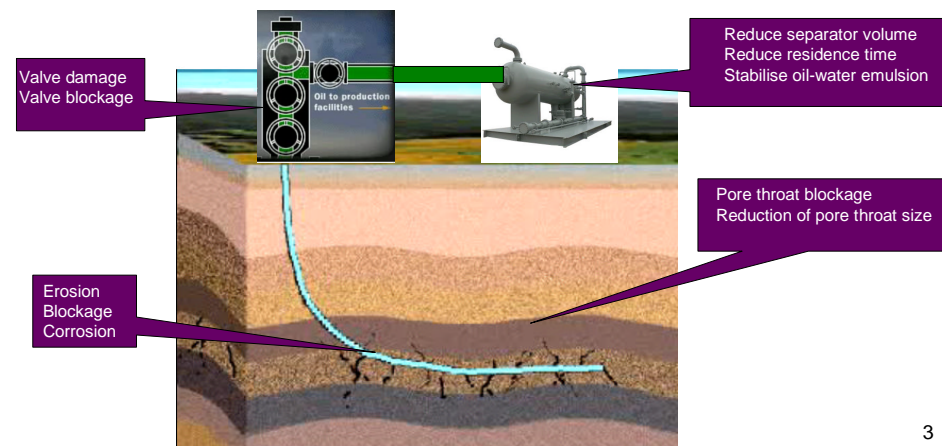
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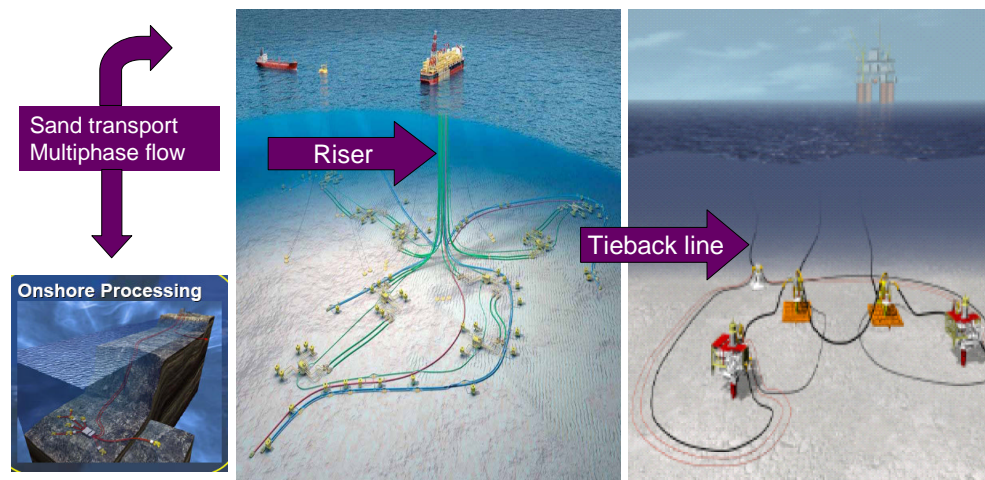
General sand management issues

- Formation >>> wellbore >>> subsea tieback >>> topside



General sand management issues

- Additional problem for subsea development >>> long tieback



General sand management issues



Choke Damage



**Choke Damage
Internal**



**Choke Flange
Damage**

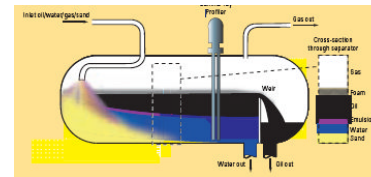


Corrosion

**Sand build up in
pipework**



Sand build up Separator



Sand prediction

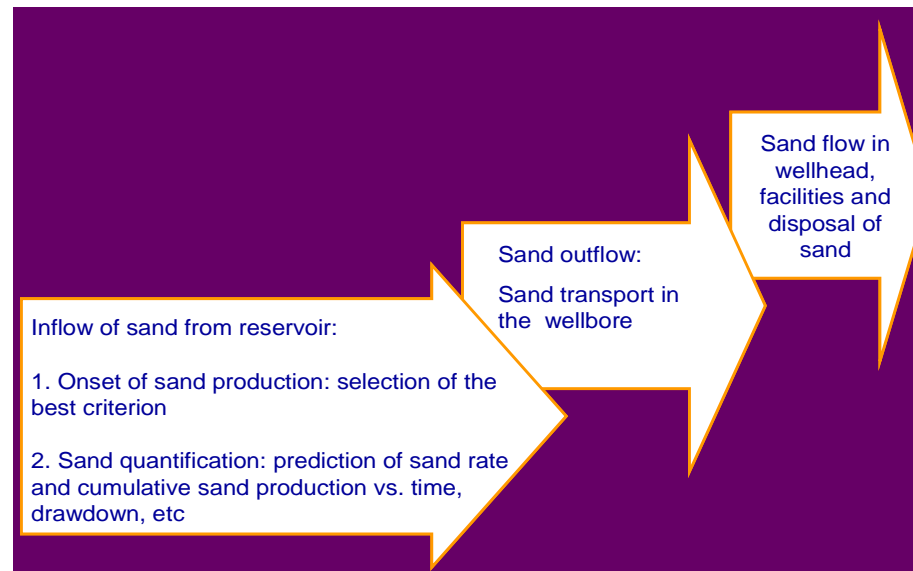
Why do we need sand production forecast?

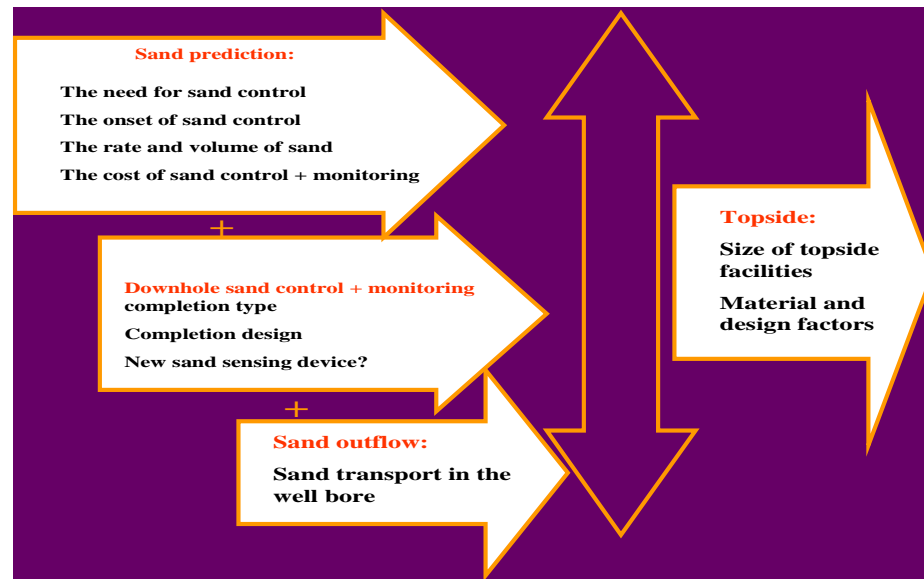
- To install sand control if necessary; If the formation will produce sand, when and in what quantity;
- To avoid sand control cost if there will be no sand production;
- Manageable sand production is beneficial:
 - Skin reduction because of growing high permeability region around the wellbore;
 - Reduction of pore throats blockage;
 - Absence of sand control skin;

Sand prediction approaches

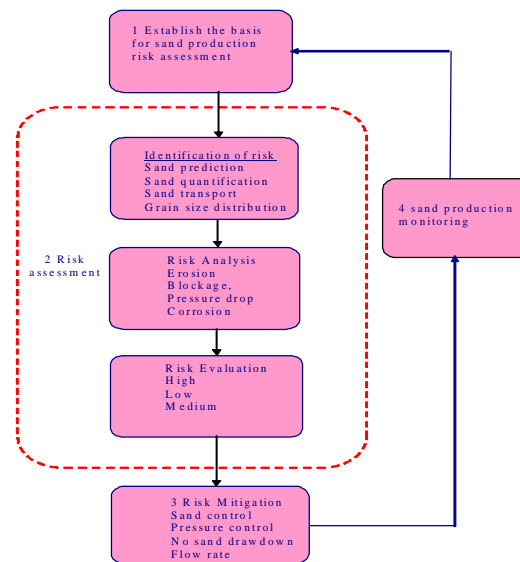
- Sonic log correlation with incidences of sand production – limited to the field for which it is developed
- Porosity – Density, Neutron & Sonic: high porosity formation >> 30% more likely to produce sand; low porosity formation << 20% less likely to produce sand
- Laboratory sand production experiment
- Theoretical and numerical modelling

Integrated sand management





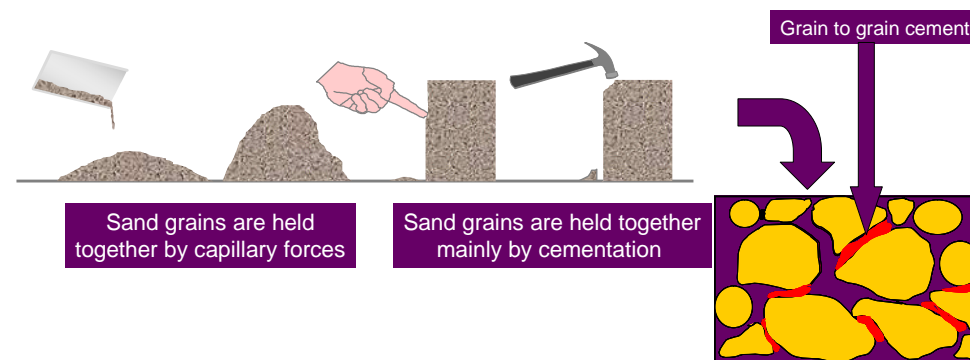
**Sand production and erosion
risks assessment integrated
with sand monitoring**



Basic theory of sand failure

- What?
 - Shear failure >>> drawdown + depletion driven
 - Tensile failure >>> production rate driven
 - Shear failure + tensile failure = rock failure
-
- How?
 - Shear stress or tensile stress > rock strength = failure

- Sand failure process
- Rock strength or cohesion provided & maintained by:
 - Capillary tension & grain to grain cementation

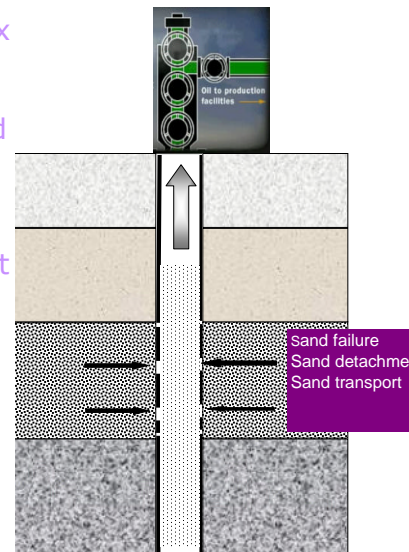


Sand production

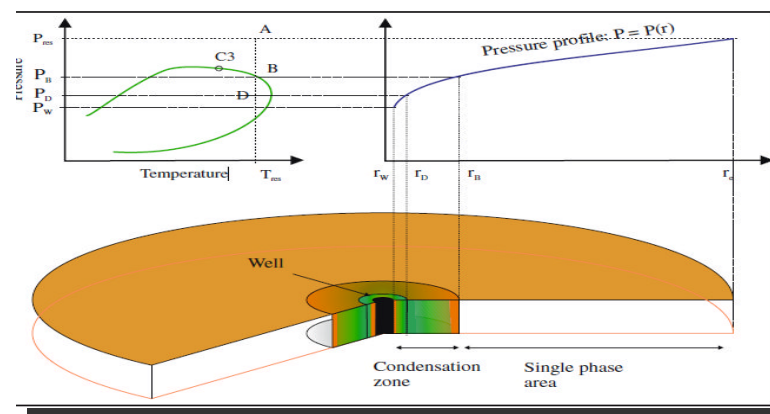
- Sand production is a complex physical process
- In-situ stresses $\gg \gg$ formation strength $\gg \gg$ fluid flow $\gg \gg$ particle motion
- Sand failure + sand detachment + sand transport



- Sand quantification



Condensate reservoir/well behaviour



Condensate reservoir development – what are the issues?

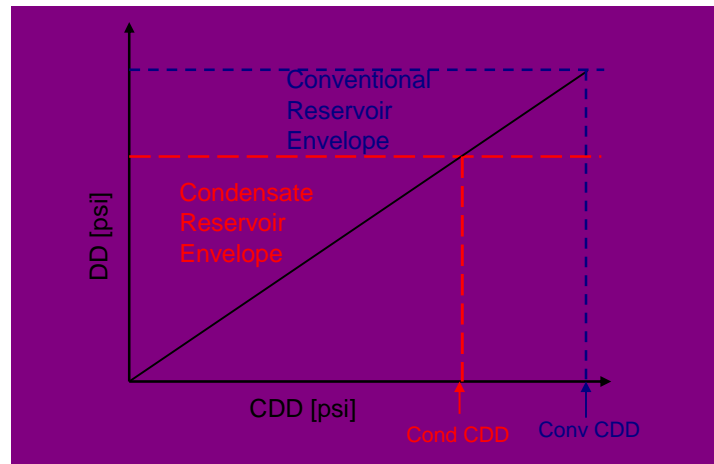
The issues

- Pressure drop
- Increased liquid concentration
- Reduced gas velocity
- Condensate banking

What are the implications for sand prediction?

- Sand production prediction – pressure drop, drawdown
- Sand transport model – multiphase flow, critical velocity
liquid hold-up, condensate banking

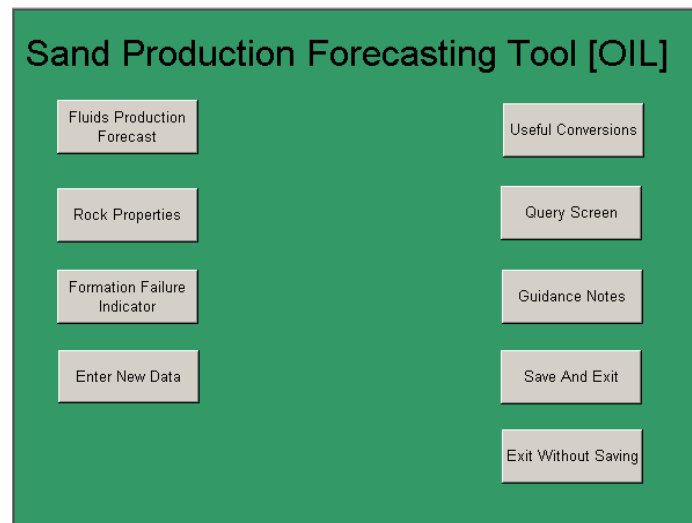
Critical drawdown (CDD) – condensate vs. conventional reservoir



Sand production forecasting tool (SPFT)

- Sand Production Forecasting Tool (SPFT)
- Semi-empirical model
- Incorporates 3 modified/ developed sand prediction techniques viz:
 1. Modified Formation Failure Indicator (TWC vs.. depth plot)
 2. Modified Mohr-Coulomb Failure Envelope
 3. Newly Developed Sand Quantification Computation
- Presented via VBA/ Excel
- Incorporates a time function into sanding prediction

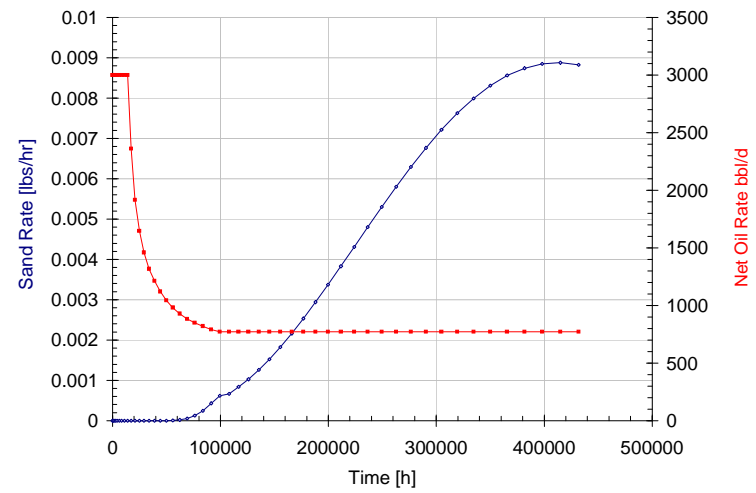
Sand production forecasting tool



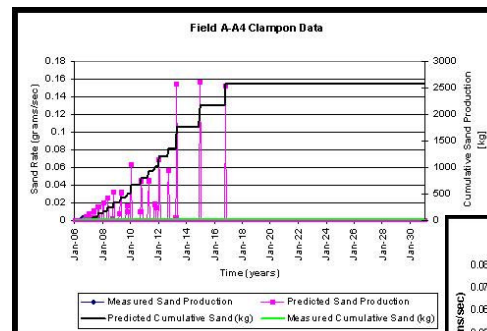
Required inputs into SPFT

- Rock properties: Poisson's ratio, UCS, porosity, permeability, Biot's stress
- Wellbore properties: Radius, deviation, azimuth
- Perforation properties: Phasing, Density, radius, length, deviation, azimuth
- Initial in-situ stresses
- Depletion effects on in-situ stresses
- Operational conditions: Drawdown

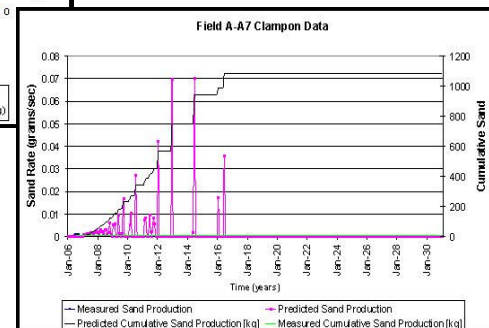
Sand prediction plot



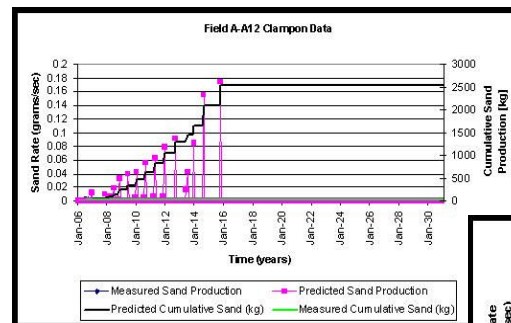
Validation on historical data – Fields A-A4 & A-A7



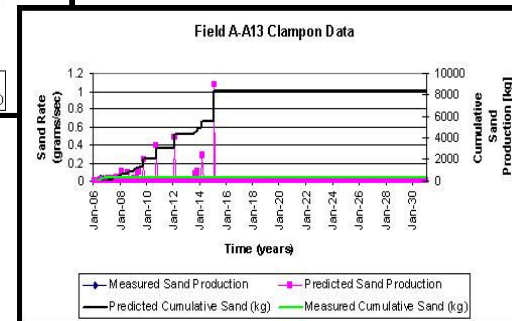
Results...Historical data spanned just 6 months in 2006.



Validation on historical data – Fields A-A12 & A-A13



Results...Historical data spanned just 6 months in 2006.



Validation on historical data – All field data

Well	Measured Average Sand Rate [grams/sec]	Predicted Average Sand Rate [in 2006] [grams/sec]	% Difference	Measured Time to Sand Production [months in 2006]	Predicted Time to Sand Production [months in 2006]
A .A4	0.001	0.0011	10.00	1-May	1-Aug
A .A7	0.001	0.0011	10.00	1-Jun	1-Dec
A .A8	0.01	0.012	20.00	1-Jun	1-Sep
A .A10	0.15	0.2	33.33	1-Jun	1-Apr
A .A11	0.02	0.015	25.00	1-May	1-Aug
A .A12	0.002	0.0025	25.00	1-Jun	1-Oct
A .A13	0.001	0.0012	20.00	1-Jun	1-Jul
A .B1	0.05	0.04	20.00	1-May	1-Apr
A .B2	0.2	0.18	10.00	1-Jun	1-Mar
A .B3	0.1	0.08	20.00	1-Jun	1-May
A .B4	0.5	0.45	10.00	1-Jun	1-Feb
A .B5	0.35	0.3	14.29	1-May	1-Oct
A .C1	0.01	0.012	20.00	1-May	1-May

Conclusions

- Sand production is a complex physical process...requires integrated approach for its management
- Level of accuracy obtained depends on the quality of data & data integration >>> data on well, reservoir, completions, stress regime, drawdown
- Sand production forecasts in gas condensate reservoir may be impacted by factors such as pressure drop, drawdown, condensate banking, liquid hold-up etc
- SPFT – sand production forecast tool; applicable in gas condensate reservoirs

Thank you for listening!!!

- Questions?