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Lost Circulation, an Old Challenge in need of New Solutions!

Ahmed S. Amer, PMP
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NEWPARK FLUIDS SYSTEMS

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Agenda

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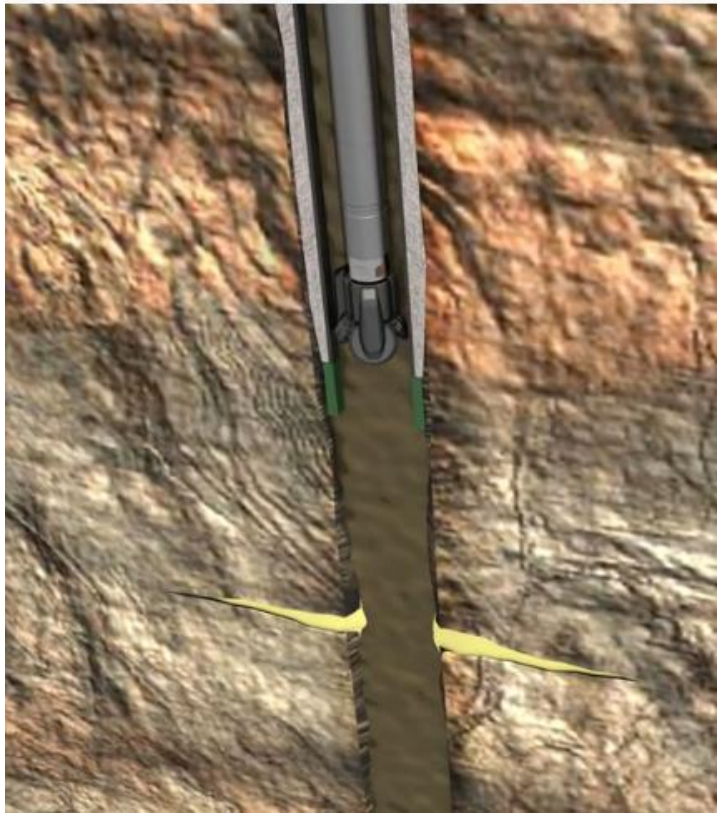
- Overview & Significance of Lost Circulation
- Solutions to Various Lost Circulation Scenarios
- Lost Circulation Solutions Design & Planning
- Laboratory Performance Testing
- Novel Approaches

Overview

- Lost Circulation: the loss of whole fluid into a subterranean rock while drilling, cementing, completing or running tubulars in a well
- Lost Circulation Materials (LCM) are not covered under API 13A standards
- Regional experience and sourcing varies
- LCMs have different HSE profiles depending on size, source and chemistry



The Impact of Lost Circulation

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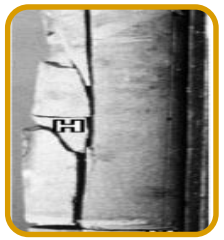
Impact

Probability

- **Loss of Well**
- **Well Control**
- **Poor Zonal Isolation**
- **Formation Damage**
- **Loss of Formation Evaluation**
- **Financial Losses**
- **Non-Productive Time (NPT)**
- Added logistics Complexity
- Additional Casing String
- Wellbore Instability
- Tool Plugging

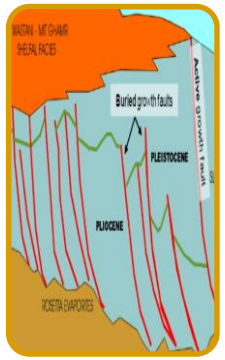
Lost Circulation Scenarios

Matrix Permeability



Natural Fractures

Induced Fractures

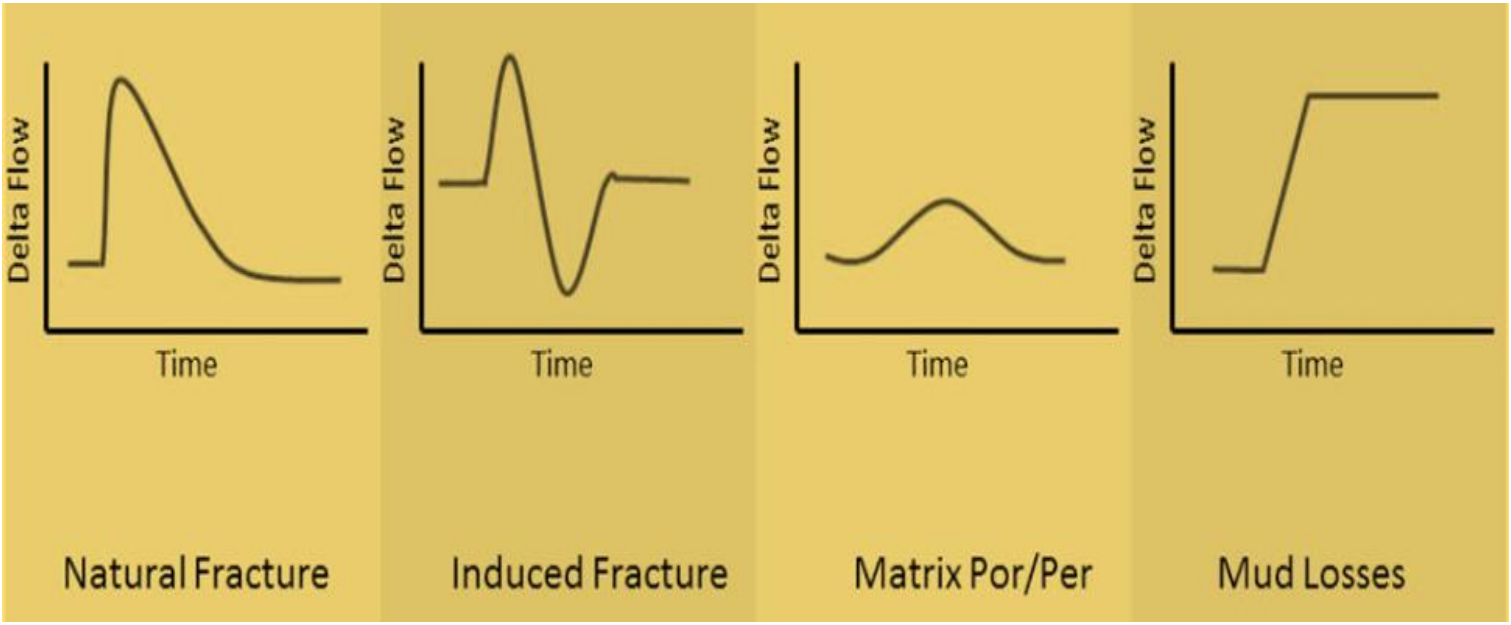


Faults

Vugs & Caverns

Classification vs Severity of Loss

Type of Loss	Typical Loss Rate
Seepage	10 - 20 bbl/hr
Partial	20 – 50 bbl/hr
Severe	50 – 150 bbl/hr
Total	> 150 bbl/hr



Lost Circulation Material Classification

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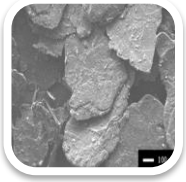
Type	
	Fibers
	Flakes
	Granules
	Settable Fluids

Granular Lost Circulation Material Lifecycle

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Raw Material

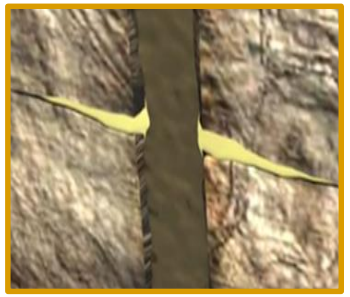
Grinding

Sizing

Mixing

Pumping

Sealing



Typical Lost Circulation Solutions

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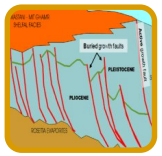
Matrix Permeability

Natural Fractures

Induced Fractures



Faults

Vugs & Caverns

Fluid Engineering

- Low Equivalent Circulating Density Fluids
- Hydraulics Modeling

Particulate Based

- Plugging
- Sealing
- Bridging

Chemical Based

- Thixotropic Fluids
- Settable Fluids
- Swellable Additives

Well Architecture

- Drilling & Tripping Practices
- Managed Pressure Drilling, Casing Drilling, etc.
- Geo-Steering

Lost Circulation Prevention Planning

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- **Prevention**
  - Low ECD Fluids
  - Hydraulics Modeling
  - Drilling Practices
- **Mitigation**
  - **Induced fracture**
    - Fit to Aperture Size
  - **Natural Fractures**
    - Fit to loss rate

Planning

Solution Development

- Material Type
- Concentration Limits
- Treatment Type

- Lab Tests
- QA/QC
- Plan Development

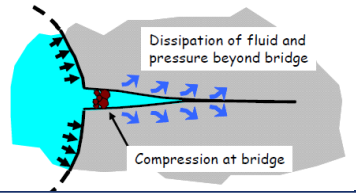
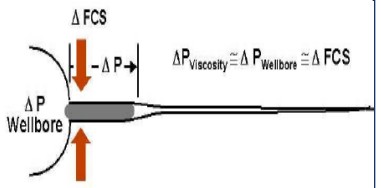
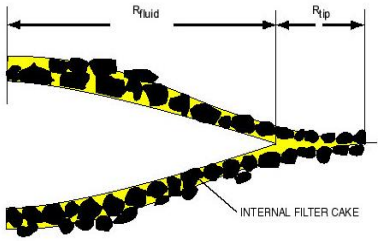
Validation

Execution

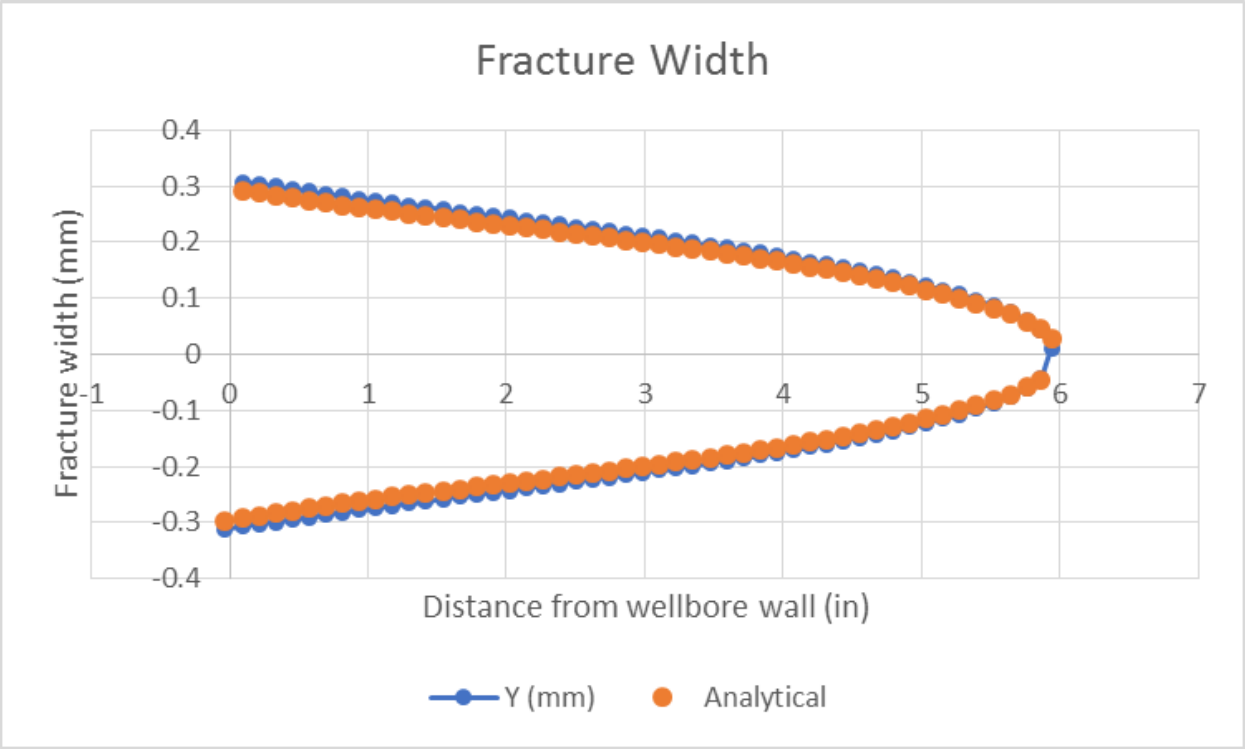
- ECD Management
- LCM Deployment
- Degradation Effects
- Tool Limitations

Theories & Assumptions

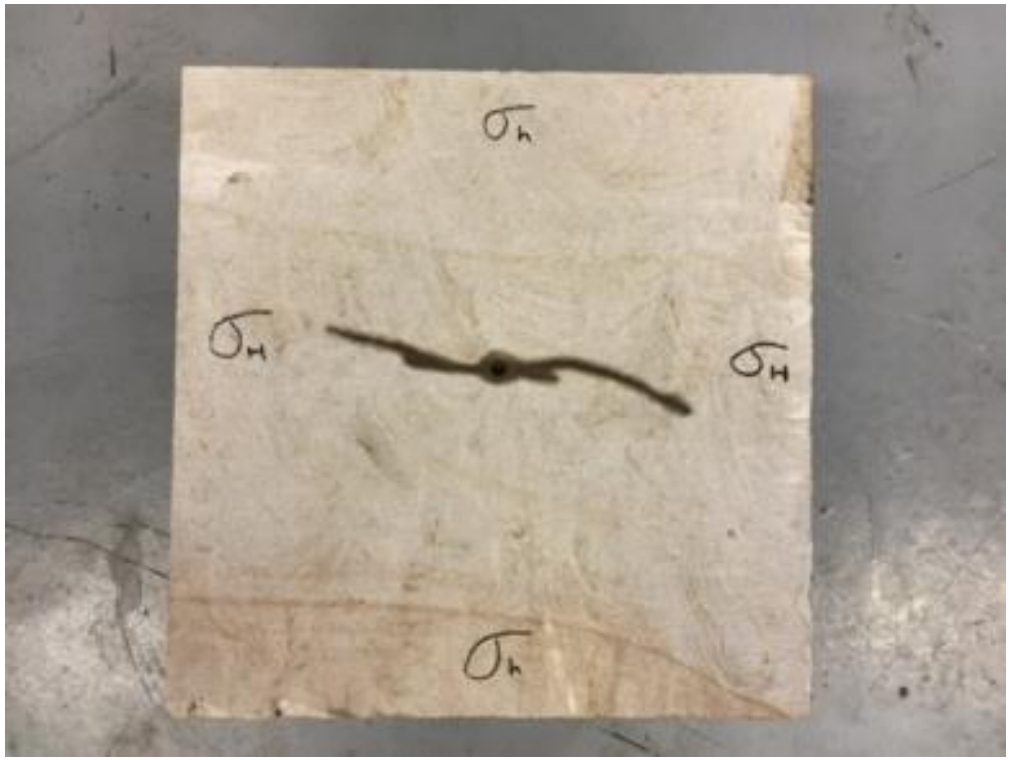
Diverse Views

Method	Material Type Important?	Material Size Important?	Rock Stress	Location of Seal
Stress Cage (2004)	Yes	Yes	Increases	
Fracture Closure Stress (2005)	No	No	Increases	
Fracture Propagation Resistance (2009)	Yes	Yes	Not Changing	

From Theory to Practice

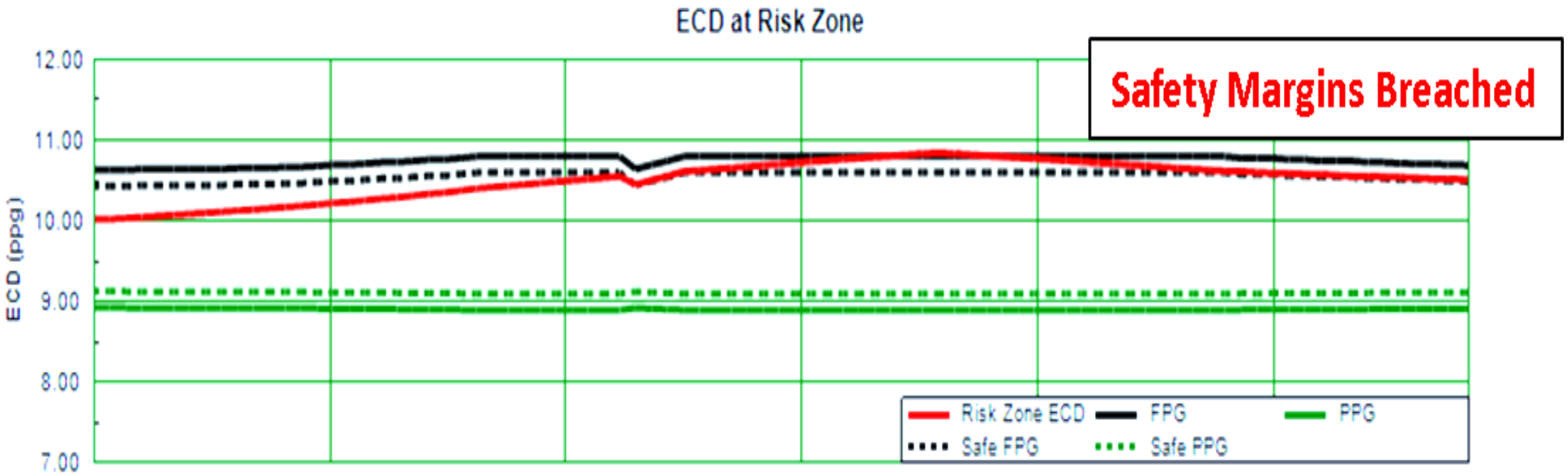


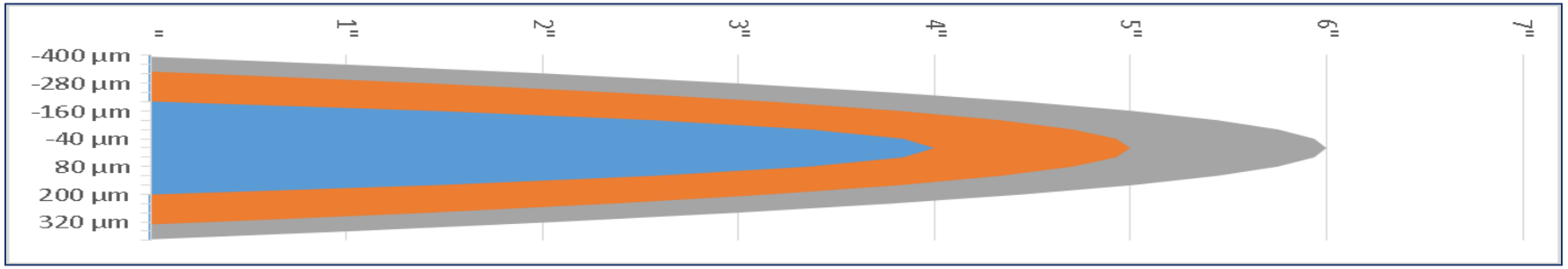
Fracture Width Prediction – Alberty (SPE-180296)

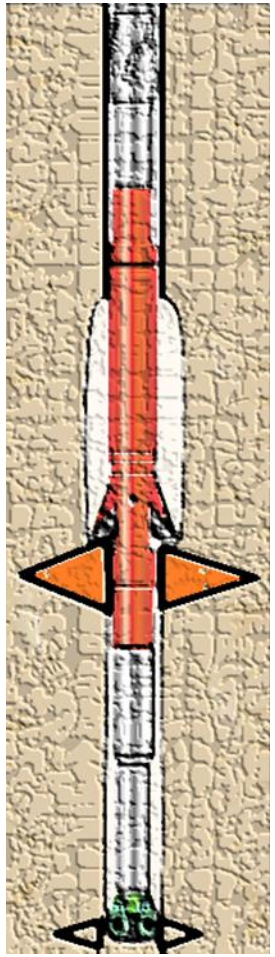


Courtesy of TUDRP

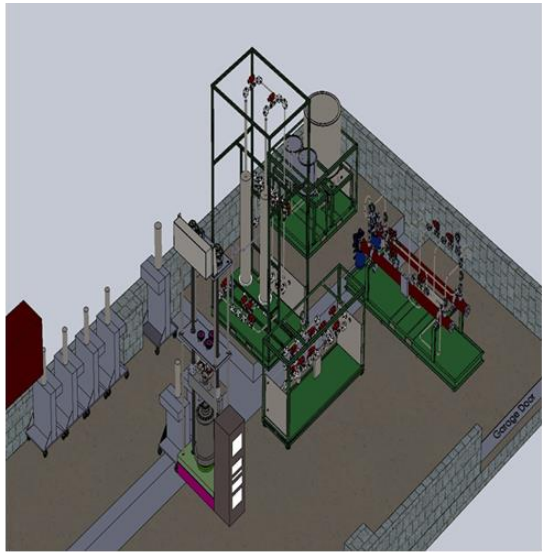
Fluid Performance & Modeling







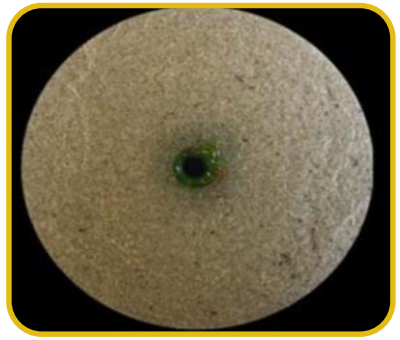
Test Equipment & Results



Unidirectional flow

Radial flow

Radial flow/Tri-axial stress



WBS Application – Decision Matrix

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Loss Zone Characterization	Loss Rate	50-100 bbl/hr			
	Loss Mechanism	Dynamic		Static	
	Loss Zone	Known	Unknown	Known	Unknown
Application Best Practices	Carrier Fluids	Base Oil/Water/Drilling Fluid		Base Oil/Water/Drilling Fluid	
	Bypass Sub / Through Bit	Through Bit (verify with downhole tools provider)		Bypass Sub (verify with downhole tools provider)	
	Product Treatment Level (lb/bbl)	Product A Product B Product C	14 ppb 16 ppb 20 ppb	Product A Product B Product C Product D	14 ppb 16 ppb 20 ppb 20 ppb
	Application Method	Spot Pill	Sweep	Spot Pill	Sweep
	Placement Method	Pump then pull		Pump then pull	

What about Current Industry Trends?

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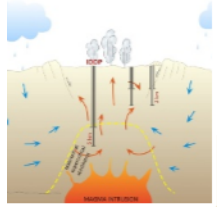
Cost Discipline

- Drill "Advantaged Oil" Fields
- Leverage Commodity Market
- Reduce R&D Spending

Data Science

- Transform Operations
- Drive Efficiencies
- Minimize Risk
- Optimize Production & Reserves

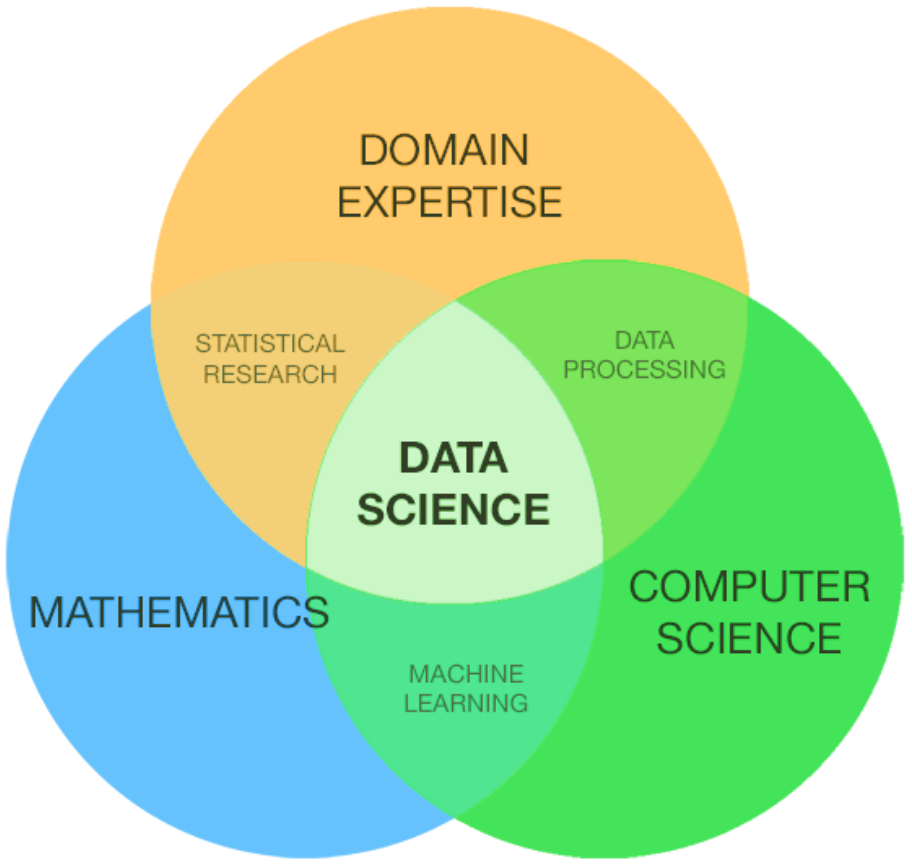


ESG Awareness

- Geo-thermal
- Department of Energy
- More Regulations
- Sustainable Products

Novel Approaches

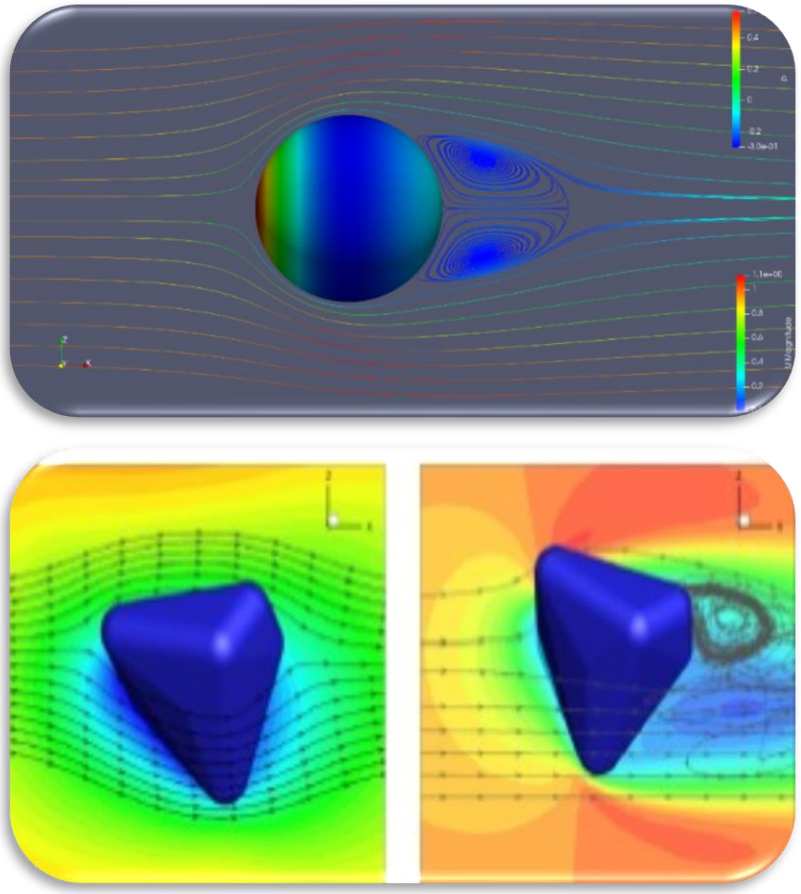
- Shape factor/blending algorithm
- Data Science Tools
- Novel Chemistries



Source: Palmer, Shelly. Data Science for the C-Suite. New York: Digital Living Press, 2015. Print.

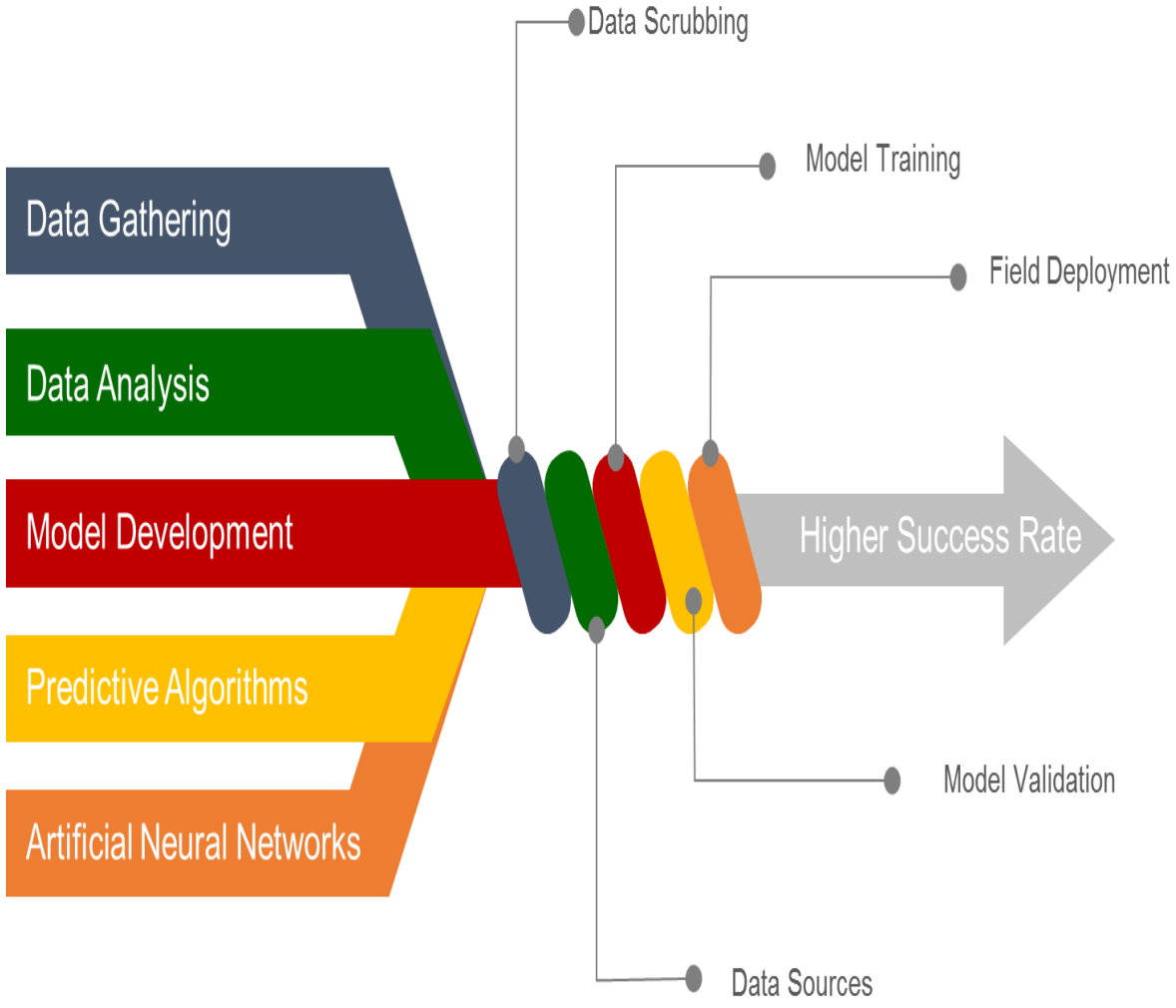
Novel Blending Algorithms

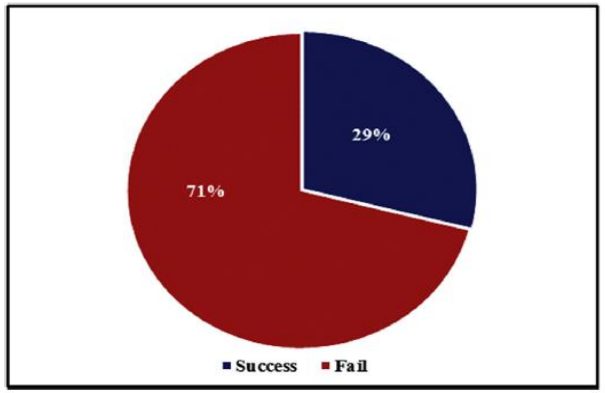
- Current models assume spherical particle for simplicity in calculations
- There are numerous shape factors that come in play (Sphericity, Aspect Ratio)
- Computational Fluid Dynamics (CFD) can address these issues



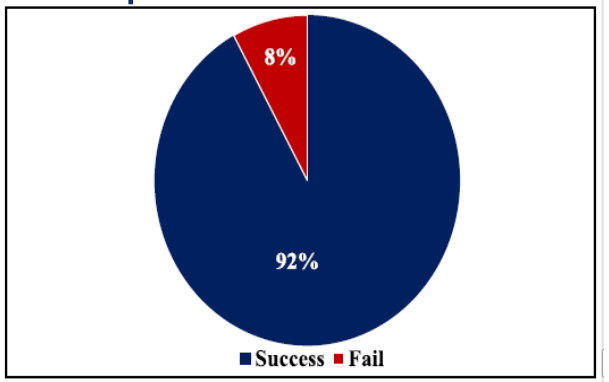
International Journal of Multi-Phase Flow, April 2018

Data Science Applications





Pre-predictive models



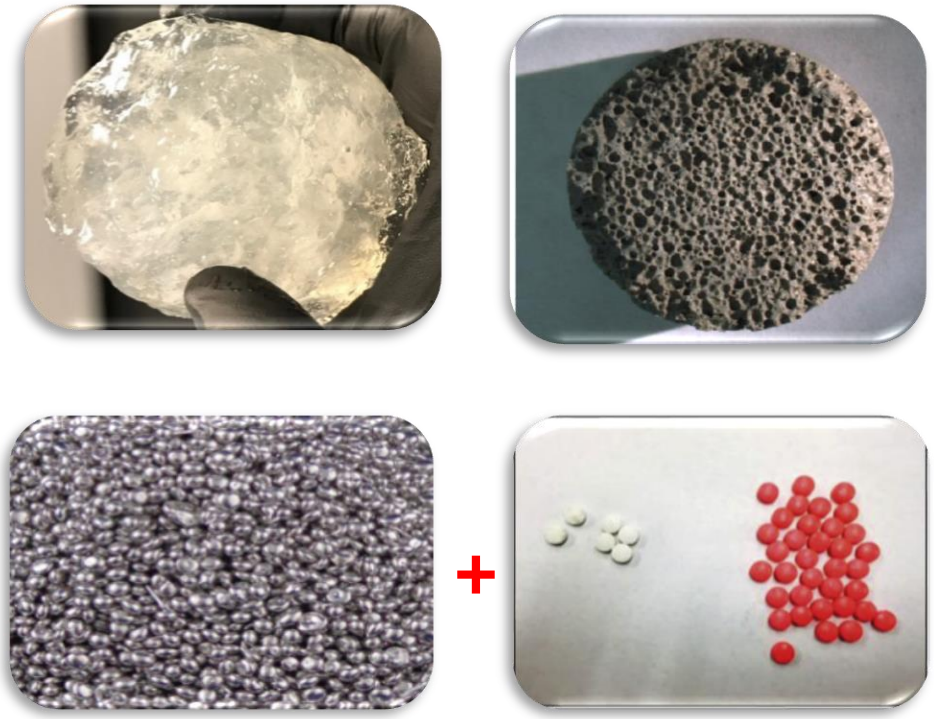
Post Predictive models

Blue=Success

Red =Failure

Novel Chemistries

- Settable Water-Based Fluids
  - Polysaccharides
  - Di-valent Mixed Metal Oxide
- Settable Non-Aqueous Fluids
  - Expandable Silicates
  - Geo-Polymers
- Novel Solutions
  - Eutectic Metals
  - Shape Memory Polymers
  - Nano-technology based additives



Summary

- **The Future**
  - Collaboration is key to success
  - Data Science can have a significant impact on predicting losses
  - Novel chemistries offer new solutions where particles application are limited due to size
  - Lost Circulation should be explored as an opportunity to inject cuttings and fluids to subsurface formation within the regulatory and engineering limits.

Additional Resources

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- Al-Adwani et al. 2012. Real Time Advanced Surface Flow Analysis for Detection of Open Fractures. June 4-7, 2012. SPE 154927.
- Amer, A. et al. 2019. Addressing the Challenges of Lost Circulation Using Novel Chemistries, Test Equipment and Data Science Tools. April 9-10, 2019. AADE-19-NTCE-056
- Amer, A., et al. 2017. Common Misconceptions Regarding Lost Circulation Treatments. AADE National Technical Conference, Houston, April 11-12, 2017. AADE-17-NTCE-093.
- Amer, A., et al. 2016. Revisiting the Ideal Packing Theory with a Novel Particle Approach. SPE Asia Pacific Oil & Gas Conference, Perth, Australia, 25-27 October 2016. SPE-182487-MS. https://doi.org/10.2118/182487-MS
- *API 13A: Specification for Drilling Fluids Materials*, 8th edition. August 2010, Reaffirmed July 2015. Washington, DC: API.
- Al-Hameedi, A.T.T., et al. 2018. Using Machine Learning to Predict Lost Circulation in the Rumaila Field, Iraq. SPE Asia Pacific Oil and Gas Conference, Brisbane, Australia, October 23-25, 2018. SPE-191933-MS. https://doi.org/10.2118/191933-MS
- Alsaba, M., et al. 2014. Review of Lost Circulation Materials and Treatments with an Updated Classification. AADE Fluids Technical Conference, Houston, April 15-16, 2014. AADE-14-FTCE-25.
- Howard, S., et al. 2017. HPHT Formation Fluid Loss Control without Bridging Particles. AADE National Technical Conference, Houston, April 11-12, 2017. AADE-17-NTCE-110.
- Evren M. Ozbayoglu, AADE Fluids Management Group Meeting, Houston, May 17th ,2018.

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