

# AMIDST

## Analysis of Masslve Data STreams

Use Cases in Drilling Domain

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① Automatic Formation Detection

② Mechanical Specific Energy

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## ② Mechanical Specific Energy



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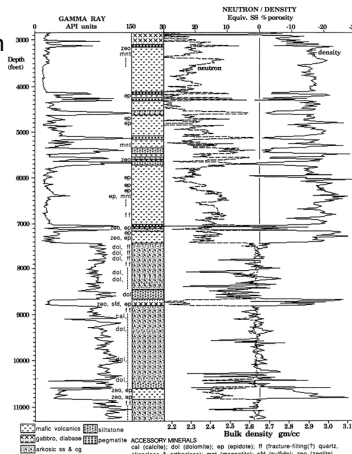


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- ▶ Better diagnostics of improper hole cleaning, instability and vibration issues

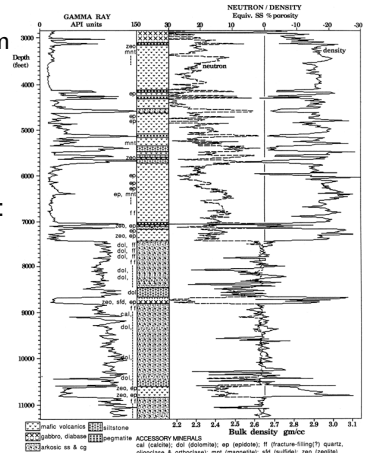


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- ▶ Identification top and bottom of reservoir
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- ▶ Detection of drilling inefficiencies (with MSE)
- ▶ Better diagnostics of improper hole cleaning, instability and vibration issues
- ▶ Important step on the path to automation

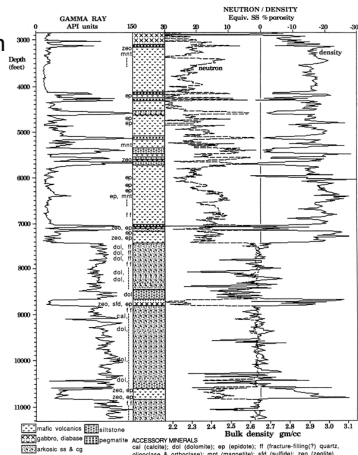
- ▶ Manual inspection of:
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  - ▶ Drilling parameters at the bit
  - ▶ Cuttings analyses at lag depth
  - ▶ Lithology chart



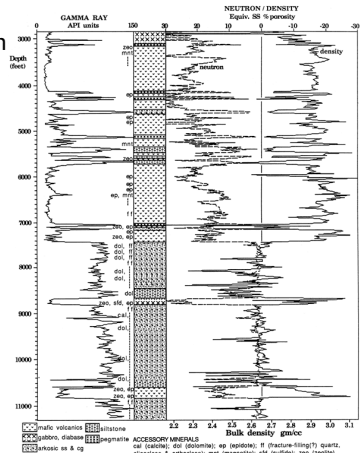
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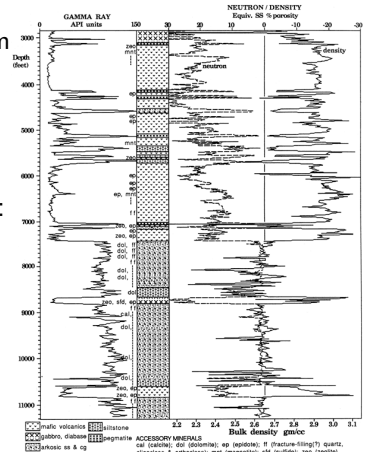
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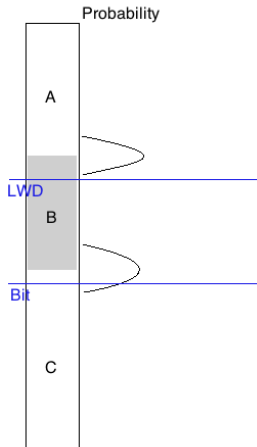


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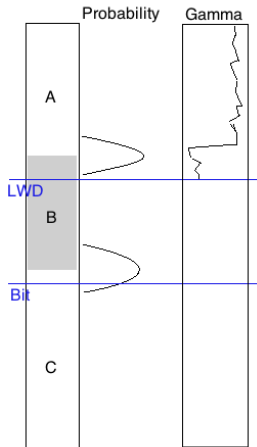
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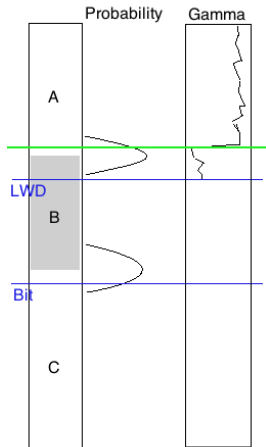




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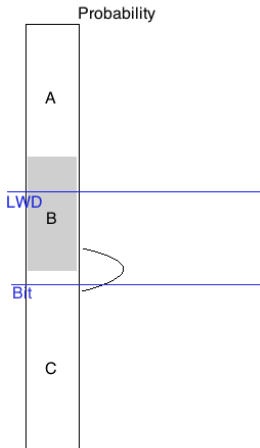


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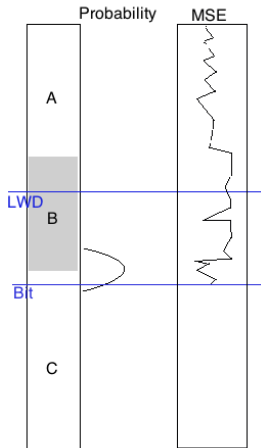


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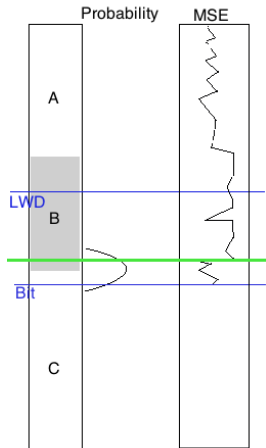
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  - ▶ Detect *changes* in drilling parameters
  - ▶ Decide what is the most likely lithology chart above the bit



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- ▶ And there are data driven approaches...

# Data Driven Approach to Formation Detection



## ► Classification problem

Offset data  
from formation A

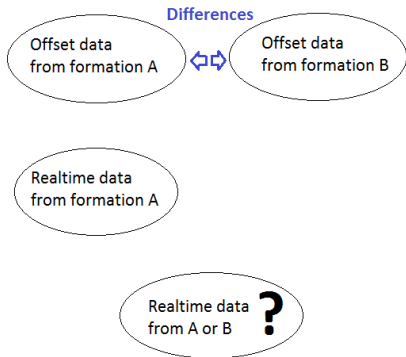
Offset data  
from formation B

Realtime data  
from formation A

Realtime data  
from A or B

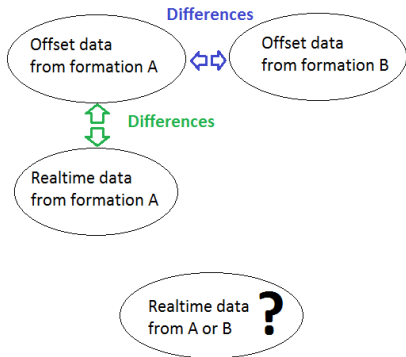


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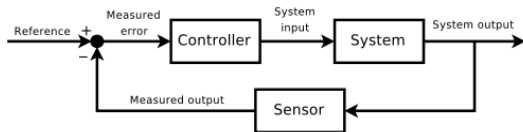
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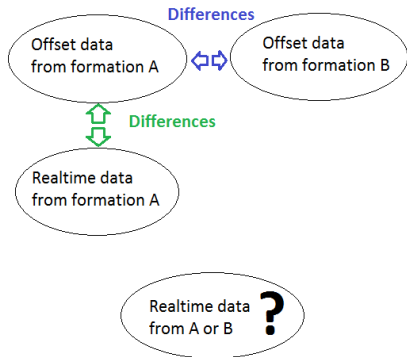
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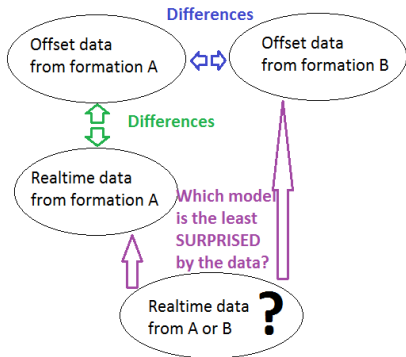
- ▶ Classification problem
- ▶ Data is time series
- ▶ Data is control response pairs
  - ▶ Flow  $\rightarrow$  pressure
  - ▶ RPM  $\rightarrow$  torque
  - ▶ WOB, RPM, flow  $\rightarrow$  ROP



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► Definition:

$$MSE(d) = \frac{\sum_{k \in S} W_k d_k + \frac{\pi}{30} \sum_{k \in S} T_k N_k t_k}{\pi r^2 \sum_{k \in S} d_k}$$

$S$  is set of data points that are measured less than a distance  $b/2$  from the current depth  $d$ .  $d_k$  and  $t_k$  are depth and time increments.  $W_k$ ,  $T_k$  and  $N_k$  are weight, torque and rotation speed at measurement  $k$ .

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- MSE is a measure of compression strength of the formation, but also how effective the drilling operation is.



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- Challenges with this measure:

- What is downhole torque? Estimate from surface or differential pressure?
- Drifting of WOB. When is it calibrated?
- How to set the smoothing parameter  $b$ ?

- Definition of normalised RMS-measure:

$$RMS = \frac{\sum_{i=1}^n (S_i - f(MSE_i))^2}{\sum_{i=1}^n (S_i)^2}$$

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- ▶ RMS is a measure of how well the shape of MSE fits the shape of the sonic data.
- ▶ Advantages:
  - ▶ More intuitive interpretation of MSE graphs when compared with downhole data.
  - ▶ Potential input to formation detection at the bit algorithm.

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