Automated well log interpretation for seismic inversion

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The problem
We want to know how the different rock types are distributed spatially in the subsurface

Seismic surveys show us reflections between surfaces in the ground which occur when the rock type/properties changes

http://geologylearn.blogspot.com.au

Fugro, Virtual seismic atlas
Seismic Inversion

We would like to turn the seismic from a time related distribution of reflections, to a depth related distribution of rock type.

Seismic inversion can attempt to do this, however, if we know how the velocity and impedance profiles of the different rock types vary with depth, we get faster more accurate inversions.
The problem is

- Impedance is sonic velocity x density
- Both velocity and density change down the well for each rock type
  - Compression (being buried and squashed)
  - Cementation
  - Fluids
  - Heat
- Rocks don’t fit neatly into categories (despite how much you want them too)
- For us cementation is the big problem
Martell 1
Automated well log interpretation

Well logs are run every time a new oil/gas well is drilled
There can be hundreds of logs
The logs are used to determine the type of rock in the well and the different properties of that rock.
We have automated this process so that it is

- Fast
- Non-subjective
- Repeatable
- Consistent across many wells
Expert Rules

Working with a petro-physicist, we derived a set of empirical rules to classify the rock types

First pass for distinctive lithologies

- Limestone: PEF > 4.0 be, GR < 45 APS, DTCO < 80us/ft.
- Coal: RhoB < 1.7, DTCO > 115 us/ft, NPhi > 0.6.
- Pyritic Material: ND > 0.2, RhoB > 2.71, PEF > 3.2
- Almost 100% Sandy Marl ND < 0.05, Nphi>0.15
- Salicious: 0.15 > ND > 0.05, RhoB < 2.4, NPhi > 0.25.

The remaining siliciclastic material:

- Shale: ND > 0.15.
- Fine to medium: 0.15 > ND > 0.10.
- Coarse to medium: 0.10 > ND > 0.05.
- Sand: ND < 0.05, Nphi<0.15
- Gas Sand: ND < -0.1
Iago 1 Clusters

Depth m

Velocity m/s

- coarse
- shale
- GasSand
- coa_med
- fin_med
Grouping the similar rocktype, a clearer picture emerged.

But boy its noisy why?

Iago 1 Lithology

- shale
- fin_med
- coa_med
- coarse
- saliceous
- limestone
- coal
- pyritic
- GasSand
Grouping across 4 wells

All wells Coarse

All wells Medium to Coarse
Velocity depth curves across 4 wells

All wells, all siliciclastic material sorted by grain size
Velocity v Depth

- Fine (shale)
- Fine to Medium
- Medium to Coarse
- Coarse

- Log. (Fine (shale))
- Log. (Fine to Medium)
- Log. (Medium to Coarse)
- Log. (Coarse)
Thank you

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