ML for Drilling Problem Identification

MATT ARRAN, ANDY KINGDON, MARK FELLGETT

British Geological Survey

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MOTIVATION

Geothermal district heating could substantially reduce the approximately 17% of UK carbon emitted for space heating[1], but well drilling's ~25% share of installed cost can double if problems are encountered[2].

To help ameliorate or avoid drilling problems, we aim to create:

- A database of previously encountered problems
- An on-line system for early problem identification

APPROACH

Anomalous incidents are identified with unsupervised machine learning:

1. Each drilling-relevant data feature is rescaled with a Yeo-Johnson transform.
2. An Isolation Forest algorithm assigns datapoints anomaly scores using measured depth and, in turn, each feature individually and then the combination of all features.
3. The measured-depth interval extending a given range either side of a high-anomaly-score datapoint is deemed part of an anomalous incident.

- The score threshold is chosen to identify a required density of distinct anomalous incidents
- This density and the incident range are tuned to match incidents to drilling problems identified by hand from DDRs, over wells other than Wytch Farm's.

DATA

We use legacy data from UK onshore hydrocarbon wells, publicly available from the North Sea Transition Authority[3]:

- Measurement-while-drilling (MWD) logs
- Daily Drilling Reports (DDRs)

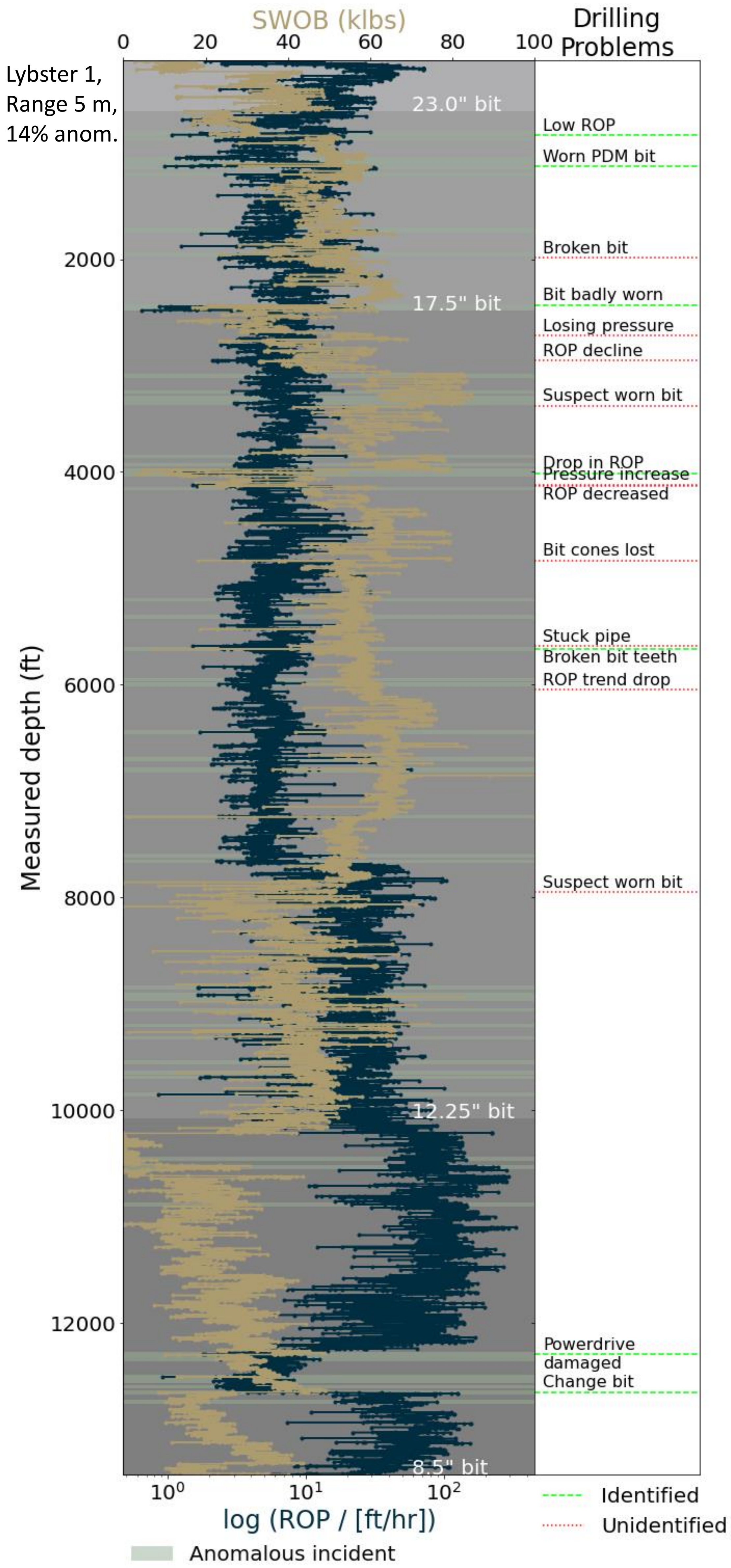
To reduce generalisation error, we select a diverse range of wells:

Interpreting DDRs requires time & expertise, provided by Kevin Mallin and Geolorn Ltd.

MWD logs have widely varying formats, features, error-generating processes, &c.

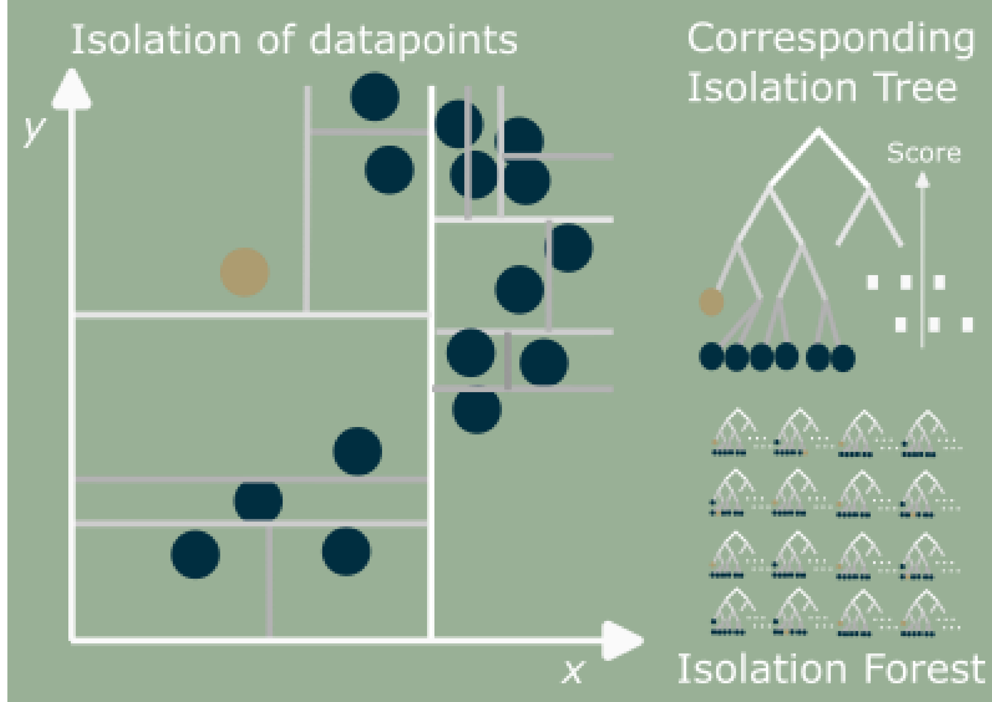
We therefore have:

- Too much data for manual methods
- Too few labels for supervised machine learning



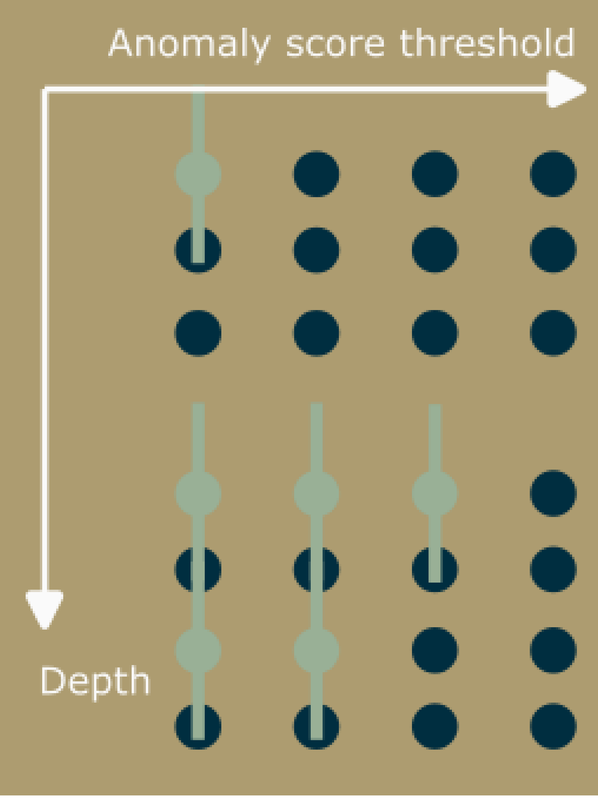
ISOLATION FOREST

Assigns each datapoint a score equal to the mean of its standardised height in *n* iTrees: binary trees that randomly subdivide samples



ANOMALOUS INCIDENTS

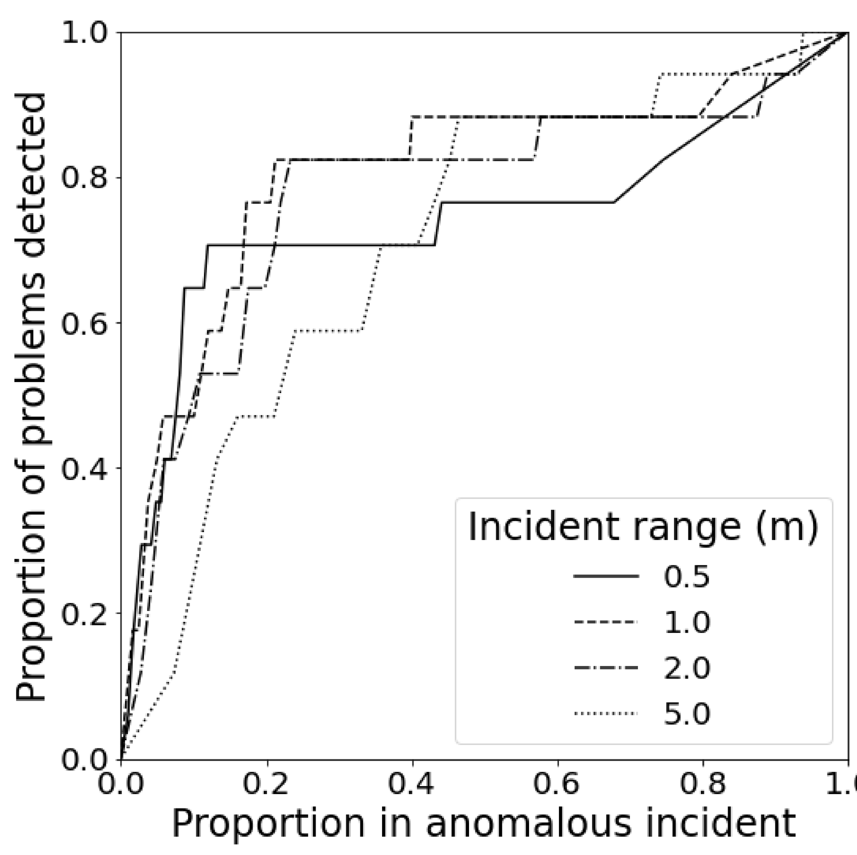
Discrete anomalous datapoints reflect continuous incidents, with proximate anomalies related to the same incident.



RESULTS

Automatically identified anomalous incidents correspond to manually identified drilling problems at a rate better than random chance, including for wells held out from parameter tuning.

Patterns are apparent in the problems identified, with sliding issues underidentified, but too few problems are recorded for statistical significance.



FURTHER WORK

- Extend analysis to UK offshore data, permitting system evaluation for specific problems.
- Evaluate on-line use of the system, with datapoints classified using only prior records.
- Integrate anomaly identification with new measurement devices and classification systems from the OptiDrill project.

ACKNOWLEDGEMENTS

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[1]: BEIS (2018), Clean Growth - Transforming Heating [2]: IRENA (2017), Geothermal Power: Technology Brief [3]: https://mapapps2.bgs.ac.uk/geoindex/home.html [4]: gridreferencefinder.com, openstreetmap.org

MATT ARRAN matarran@bgs.ac.uk

www.bgs.ac.uk