Data Science for Geothermal Drilling Optimization collaboration with GeoS

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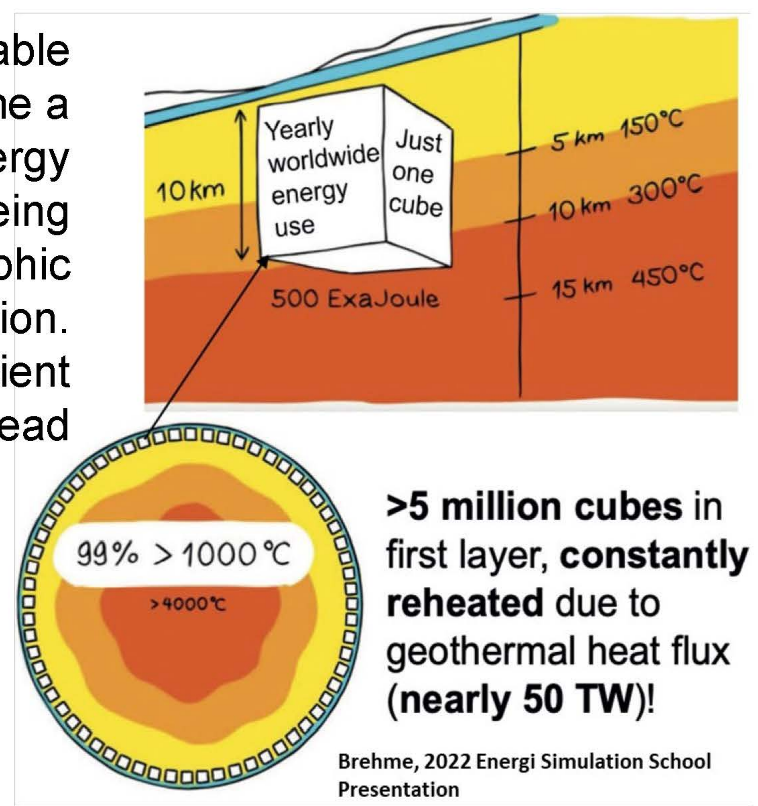
Geothermal Systems

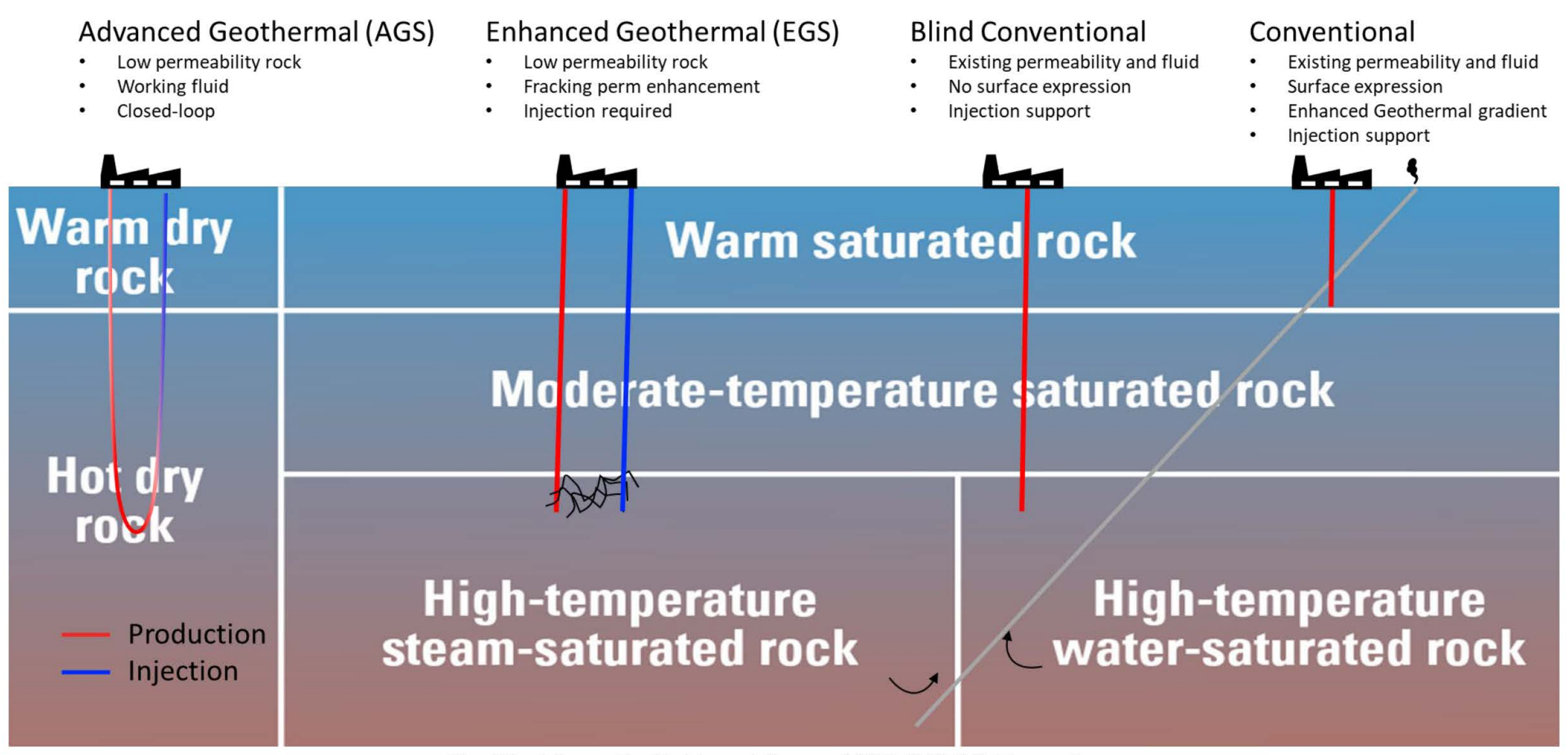
Geothermal energy is a massive renewable energy resource that has potential to become a much larger contributor to the world's energy budget. Various technologies are being developed to increase the geographic availability of geothermal electricity generation. All of them require innovative and efficient drilling technology to unlock widespread commercial development.



Where does the heat come from?

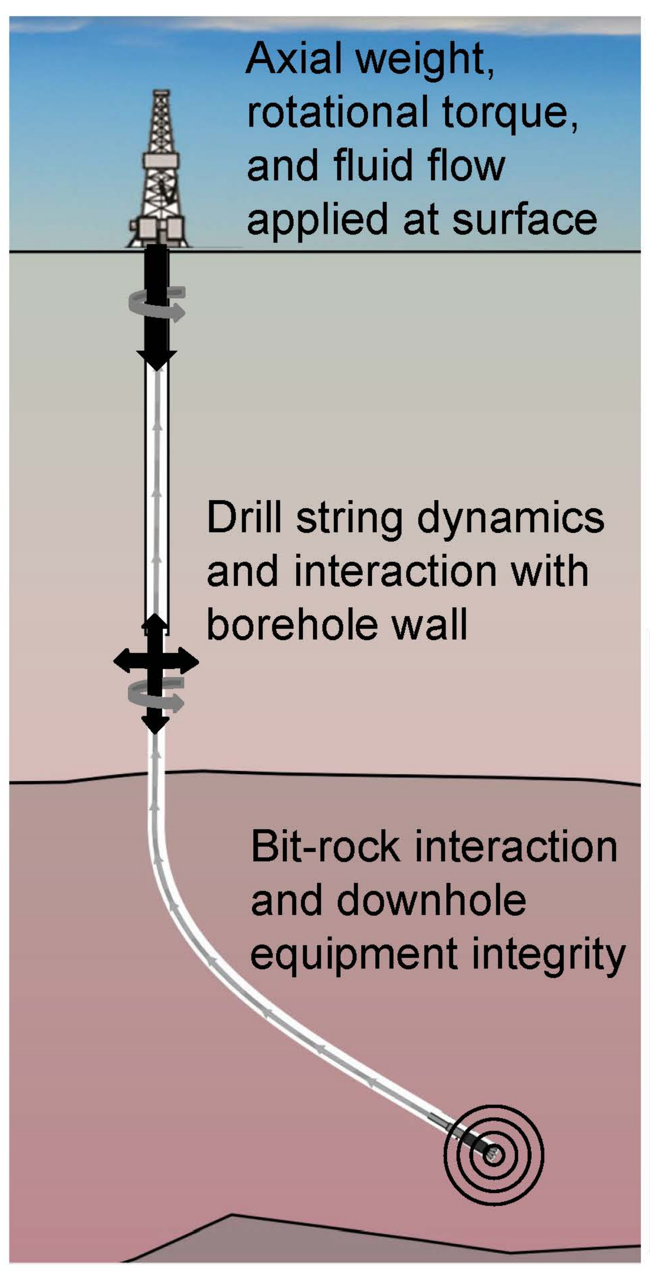
- Radiogenic heat - radioactive decay of isotopes
- Residual heat from the formation of the Earth

Geothermal Development Technologies for Electricity Production

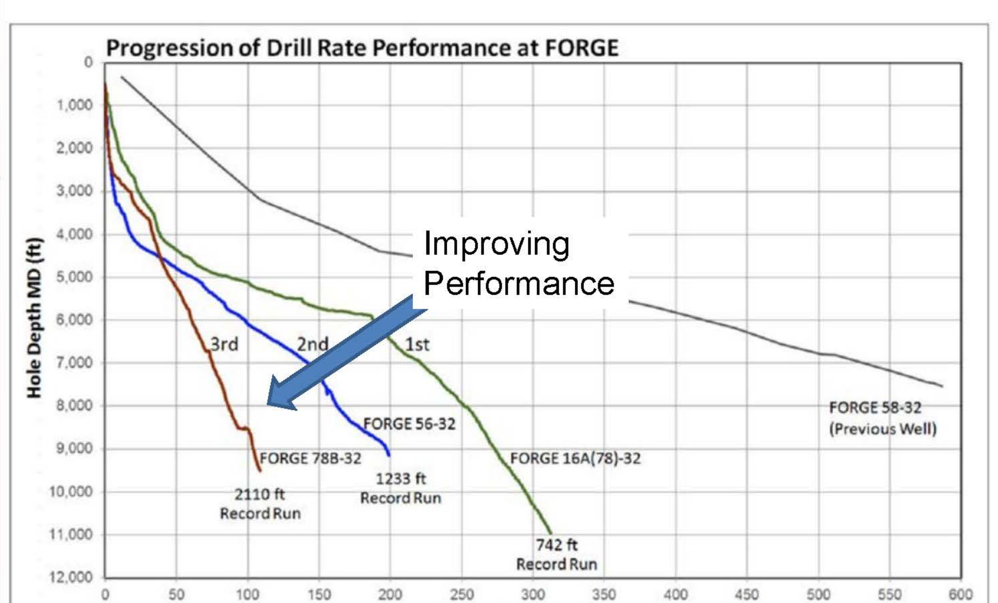


Modified from Duffield and Sass, 2003 (USGS Report)

Drilling Optimization

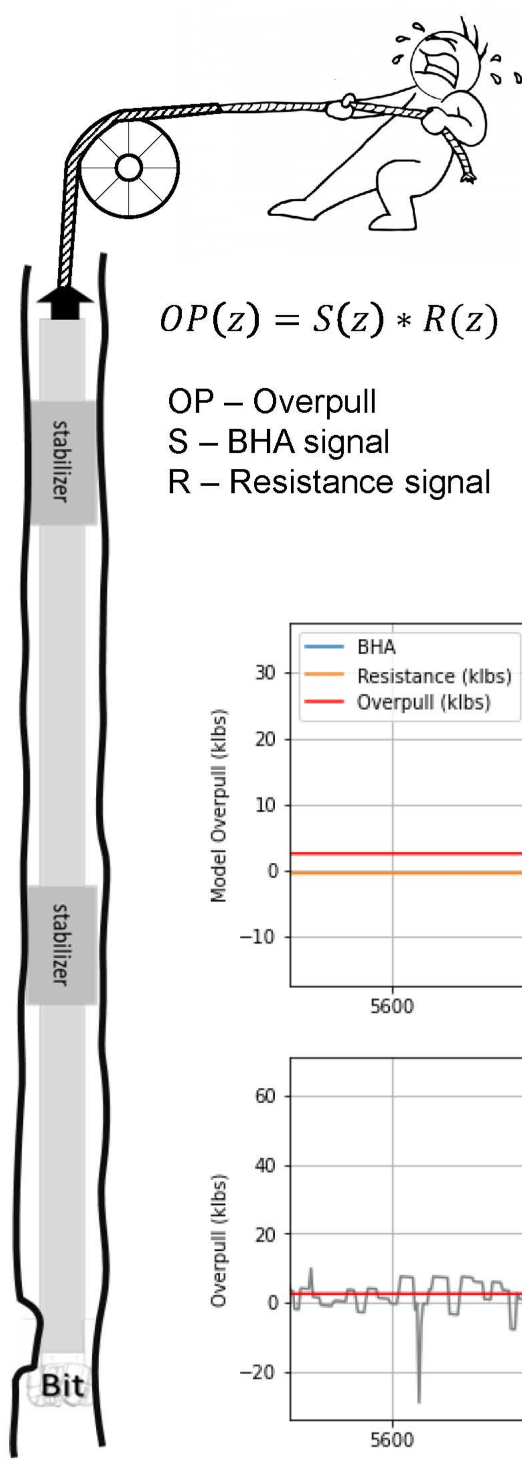


To enable geothermal electricity production anywhere, we will need access to depths in the range of 5-10 kilometers below the surface. These depths can only be accessed via boreholes. Drilling optimization reduces the time and cost required to reach target depths by applying the most effective drilling parameters while also minimizing equipment damage and maintaining borehole quality. Recent wells drilled into hot rocks are providing new data sets to better understand how to improve performance.

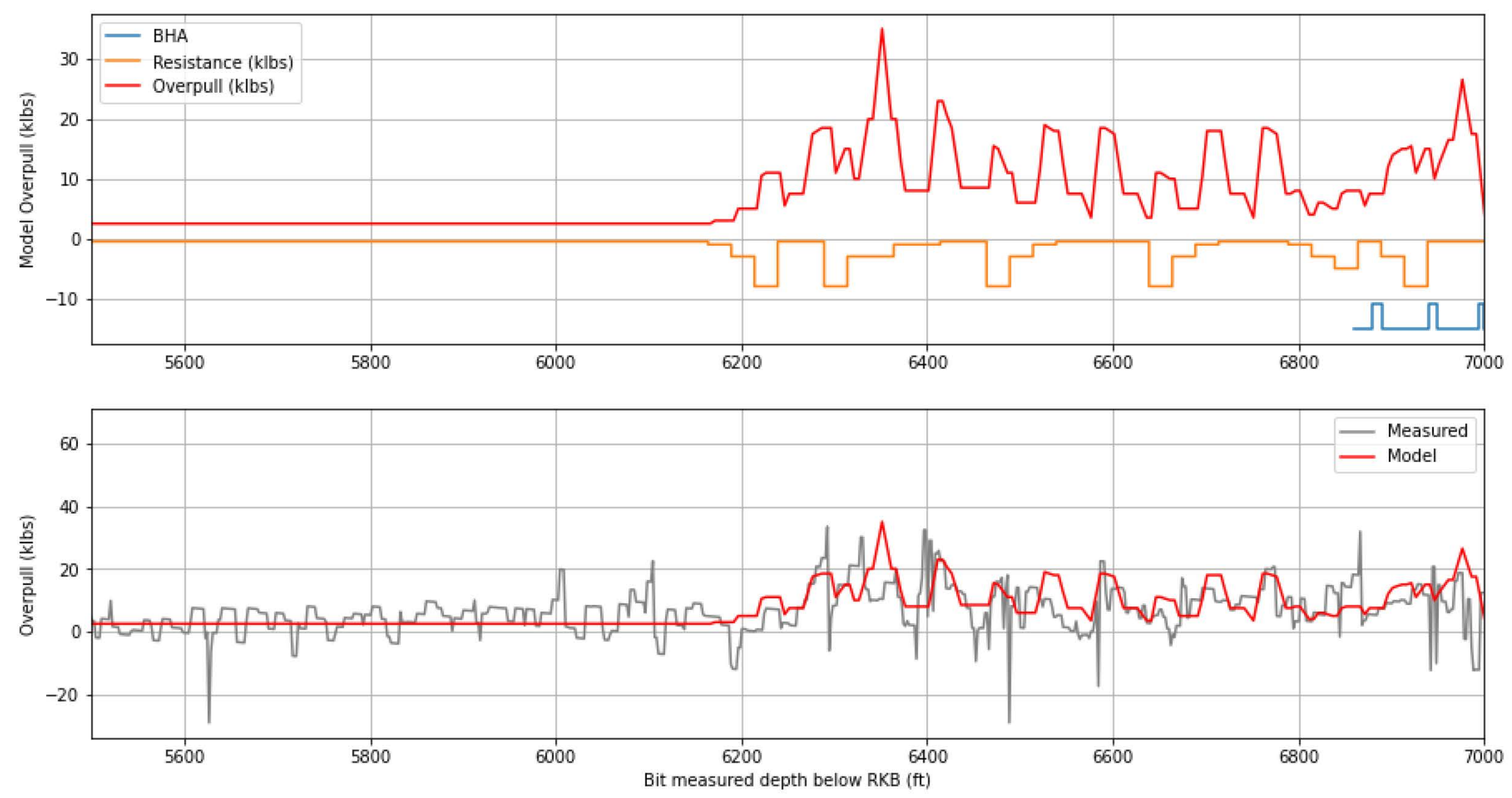


Dupriest et al. 2022 (IADC/SPE)

A Novel Data Science Approach to Borehole Dysfunction Analysis



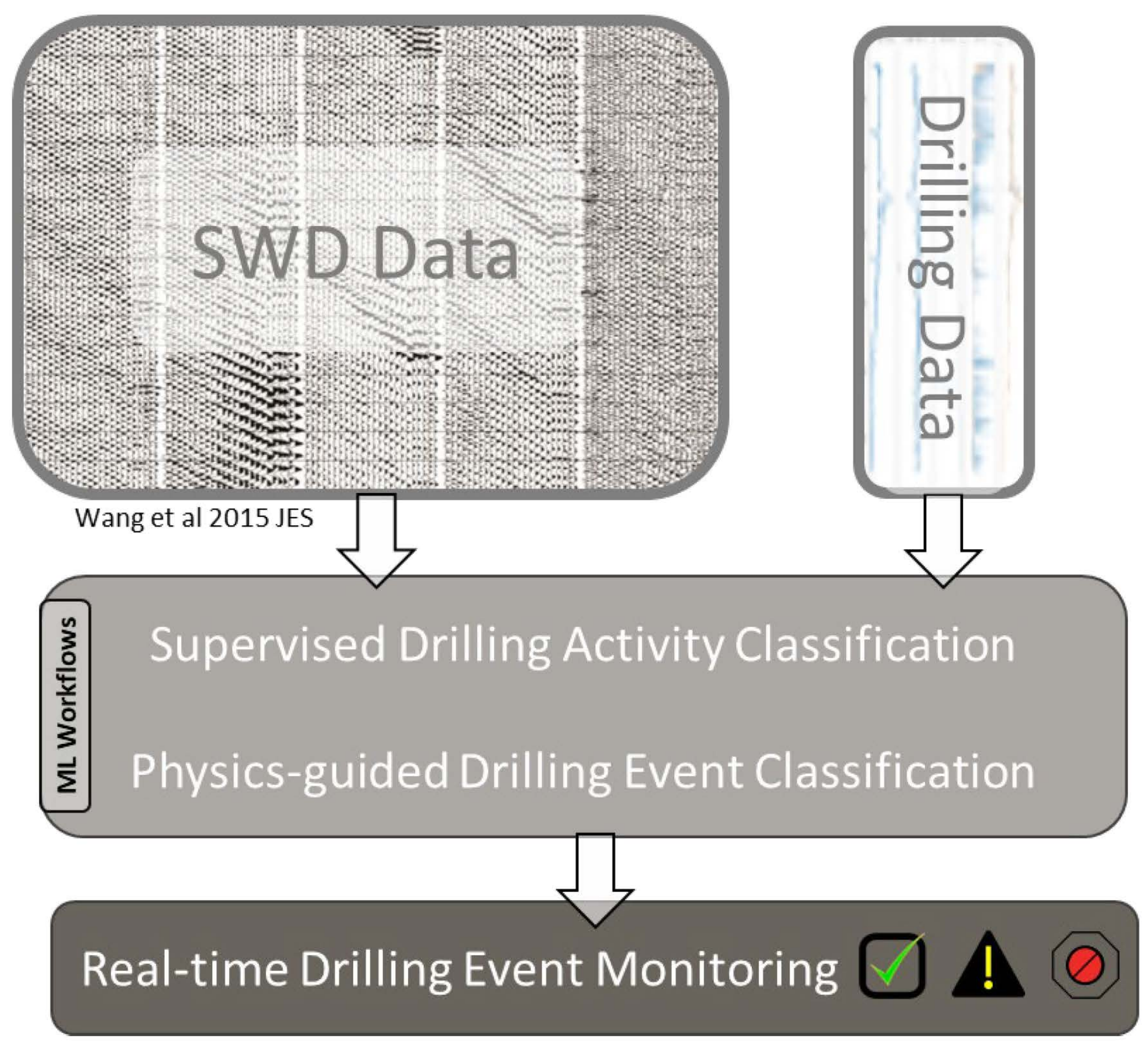
During drilling activities, monitoring the quality of the borehole is an essential task. Borehole dysfunctions such as constrictions, ledges, and differential sticking can cause significant amounts of non-productive time that decreases overall operational performance. The dysfunctions are most troublesome during tripping operations when the drill string is moved in and out of the borehole. Identification of dysfunctions before significant operational issues occur, such as stuck pipe, can allow proactive mitigating actions to reduce the impact on the tripping operation. Modelling methods for expected sliding friction for good borehole conditions provide a baseline for hook load operating parameters during tripping out of the borehole. Assuming the baseline hook load estimation is somewhat accurate, the anomalous high hook loads above baseline, referred to as overpull, provide measurements that should capture the resistance in the borehole due to dysfunctions.

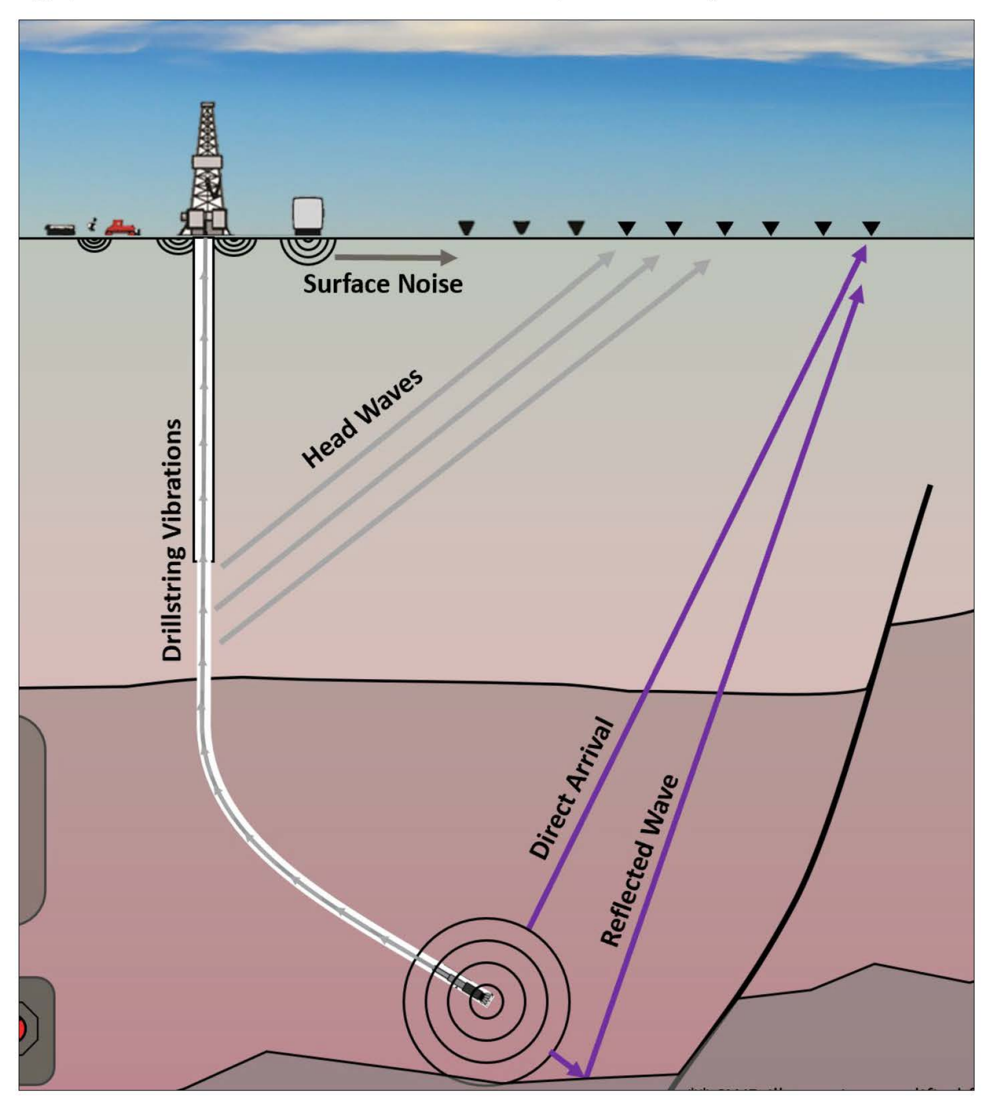


The focus of this study is to utilize overpull signatures and the drill string configuration to produce a resistance depth profile that can provide better depth resolution to place dysfunctions along the wellbore and also characterize the dysfunction mechanism. Initial steps of developing a forward modelling strategy using a source signal (i.e. the drill string) convolved with a resistance signal (i.e. the dysfunctions) to produce overpull signals show promising similarities to real overpull data.

Using bit-source SWD for physics-guided machine learning to detect drilling dysfunctions

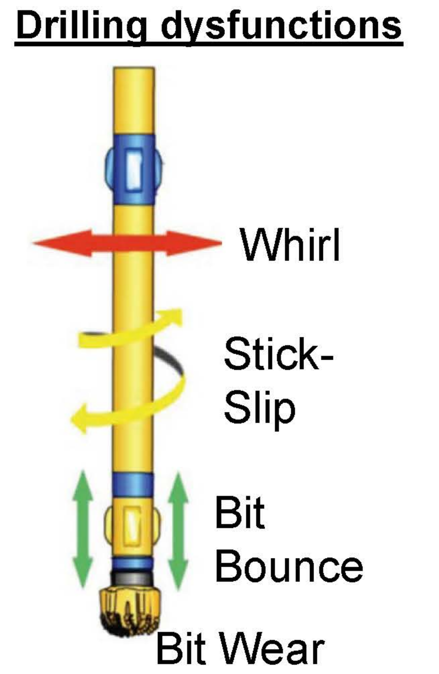
Drilling dysfunctions that occur during deep drilling are rarely observable due to the detection limitations of surface and downhole data. These limitations significantly reduce the ability of a control system, or a human operator, to adjust to optimal drilling parameters (e.g. rotary speed, flow rate and axial loading) to optimize performance. The proposed study will combine SWD and surface drilling data to help detect drilling dysfunctions in a physics-guided Machine Learning workflow. Vibrations created from the rock destruction process and dynamics of the drilling system will be recorded by seismic receivers at the ground surface as various seismic wavefields generated from the bit (e.g. direct arrival and reflected wavefields), the drillstring (e.g. vibrations and headwaves), and the surface (e.g. motors and moving vehicles). If the different wavefields can be identified and linked to drilling activities and performance, then insight into drilling dysfunctions, or lack thereof, can help support drilling parameter decisions to optimize performance.





Modified from Wang et al 2015 JES

Drilling dysfunctions



Li et al. 2021 (SVJ)

Detection Limitations

- Drill string attenuation
- Downhole telemetry
- High temperatures