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No data instead of big data – a novel approach to stress modelling

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No Data instead of Big Data
A Novel Approach to Stress Modelling

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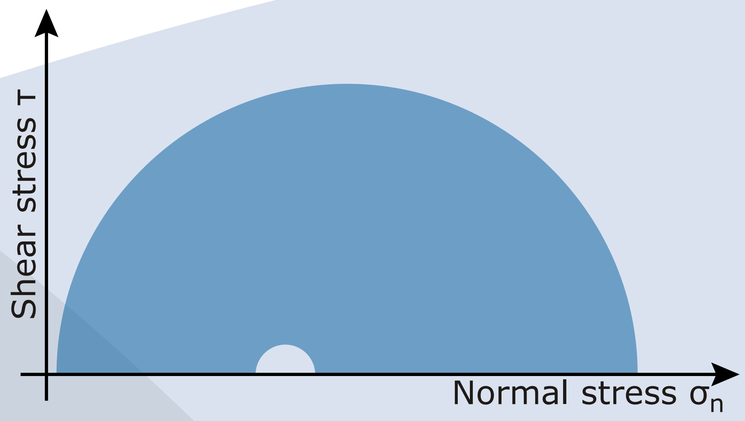
Knowledge of undisturbed stress state in the subsurface is of key interest for safety assessment of Deep Geological Repositories. However, stress magnitude data is usually sparse, the available data subject to large uncertainties, and the acquisition of new data is expensive. This highlights the importance of 3D geomechanical-numerical models that provide the full stress tensor throughout a volume of interest. Still, such a model needs some stress magnitude data for calibration. But what happens if no such data is available?

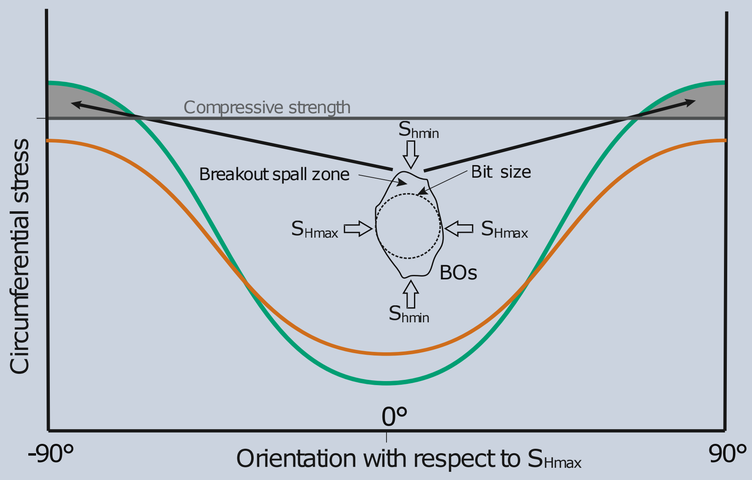
Define the range of all possible stress states

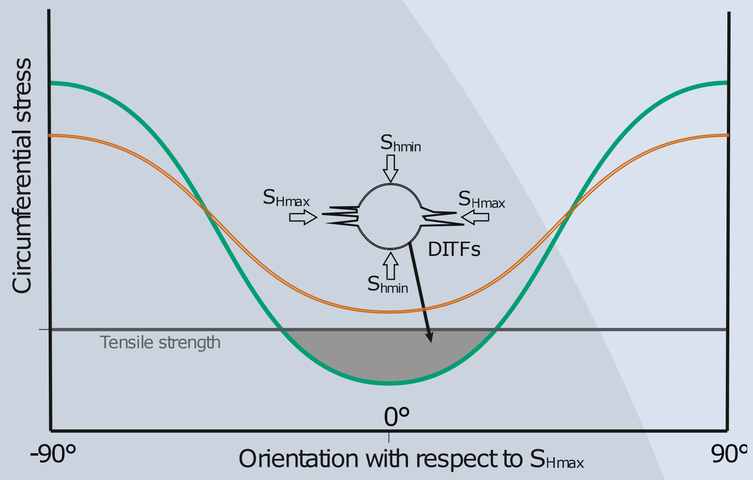
No pre-defined stress states by stress magnitude data is available. Instead, all stress states that are remotely possible are regarded. Theyare constrained by:
- No tensile stresses
- No excessively large stresses
- No horizontal stress rotation in an area with a stable stress orientation
- Assumptions on stress regime



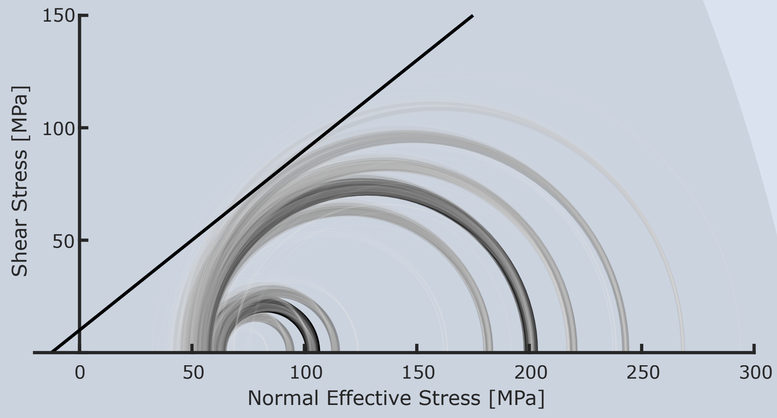
Reduce the possible stress states to likely stress states supported by indirect data

All kinds of additional and indirect information are used to assess the plausibility of each individual possible stress state. Information can be used such as formation integrity tests, observed borehole breakouts, or observed seismicity. If indirect information is in agreement with a certain stress state, this stress state has a higher probability.





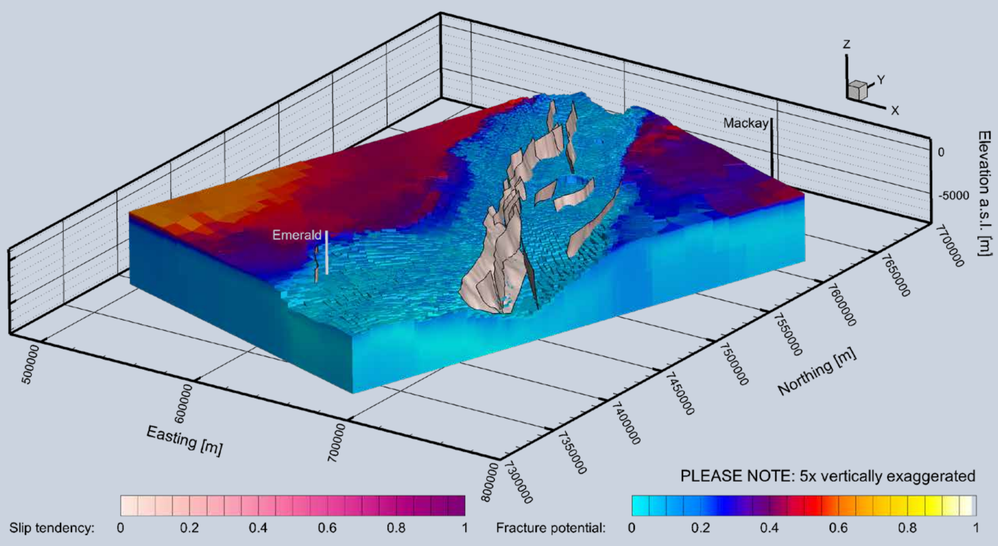
This procedure allows to asign weights to all possible stress states as well as to potentially pre-defined stress states. In both cases the predictive quality of the model is increased. In addition, the significance of the model is increased since now uncertainties in the modelled stress state are considered.

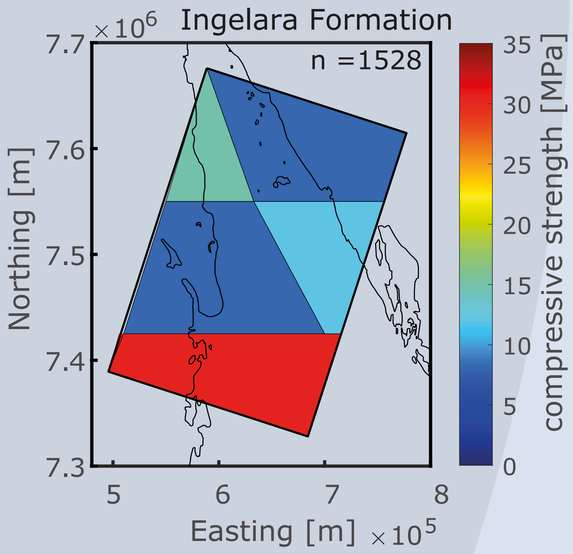


Learn from the model

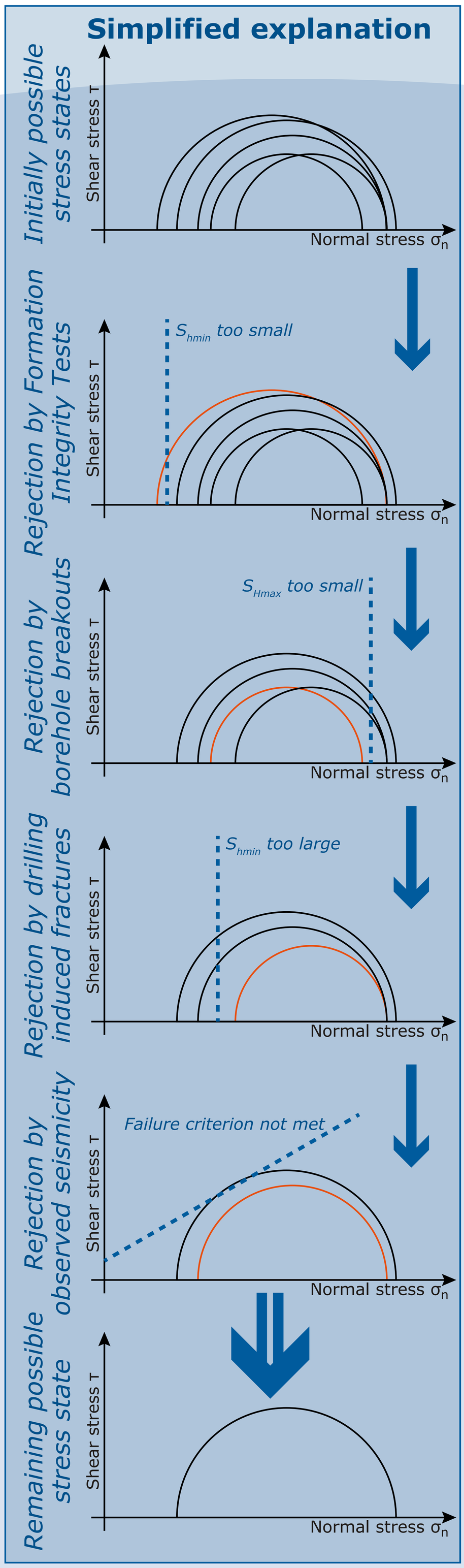
In addition to an increase in predictive quality of the modelled stress state, the model returns additional value. Regional and local anomalies or patterns in the agreement of indirect data can uncover or highlight characteristics of the modelled volume and initiate further research.

Here, this is exemplified in a model of the Bowen Basin (Queensland, Australia) where an extremely good fit to stress magnitude data is observed. However, the compressive strength required to create the observed borehole breakouts are laterally highly variable and suggest several different zones of the model.





Simplified explanation



Further reading

Ziegler, M. O., & Heidbach, O. (2023). Bayesian quantification and reduction of uncertainties in 3D geomechanical-numerical models. Journal of Geophysical Research: Solid Earth, 128, e2022JB024855. https://doi.org/10.1029/2022JB024855

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