

A Portable Python-Based Fault Strength Analysis Tool

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Summary

This paper introduces a **portable, Python-based 3D Mohr Circle tool** designed to analyze slip tendency, dilation tendency, and fault reactivation potential on Windows systems. By leveraging Python's scientific libraries (e.g., NumPy, Matplotlib), the software computes resolved stresses on user-specified fault planes and visualizes them in interactive 3D Mohr plots and stereonet. The tool is **particularly suited for geothermal reservoir stimulation and induced seismicity assessment**, where accurately predicting shear slip or tensile dilation can help mitigate seismic hazard and optimize fluid-injection operations.

We present **two case studies** in which the software rapidly evaluated (1) the propensity for shear slip in a geothermal field undergoing injection-induced reservoir pressurization, and (2) fault dilation potential in a hydraulic fracturing scenario. Results highlight the efficacy of slip and dilation tendency analysis in identifying critical fault orientations. Moreover, the tool's user-friendly GUI lowers the barrier to advanced geomechanical assessments, facilitating scenario testing without specialized coding skills.

By integrating well-established slip/dilation tendency concepts (Morris et al. 1996; Zoback 2007) into an open-source platform, this portable solution extends the reach of 3D fault stability analysis to a broad audience. Future enhancements will incorporate more complex fault geometry handling and direct coupling to numerical simulators for heterogeneous stress-field modeling. Overall, the Python-based 3D Mohr Circle tool underscores the value of intuitive software in geomechanics, improving our ability to **forecast fault reactivation** and guide decision-making in seismic hazard mitigation and reservoir management.

Theory / Method / Workflow

Input Stress and Fault Data

- Users specify principal stresses ($\sigma_1, \sigma_2, \sigma_3$), fault orientations (strike, dip, rake), and optionally fluid pressure.

Computation of Slip and Dilation Tendency

- Based on $T_s = \tau / \sigma'_n$, $T_d = (\sigma_1 - \sigma'_n) / (\sigma_1 - \sigma_3)$, respectively.

Visualization

- The software generates 3D Mohr circles, stereonet, and color-coded fault planes indicating reactivation likelihood.

Case Studies

- Demonstrations include a geothermal injection scenario and hydraulic fracturing analysis, illustrating how stress changes alter fault stability.

Results, Observations, Conclusions

The tool reliably highlights fault planes prone to shear slip or dilation in two real-world scenarios, aligning with established slip-tendency literature.

Its Python-based design enables **platform-independent** deployment, user-friendly **GUI**, and straightforward integration with external data.

Comparative validation confirms it reproduces standard Mohr-Coulomb predictions and slip-tendency results, enhancing confidence in operational decisions (e.g., in-situ stress estimation, injection operation limits).

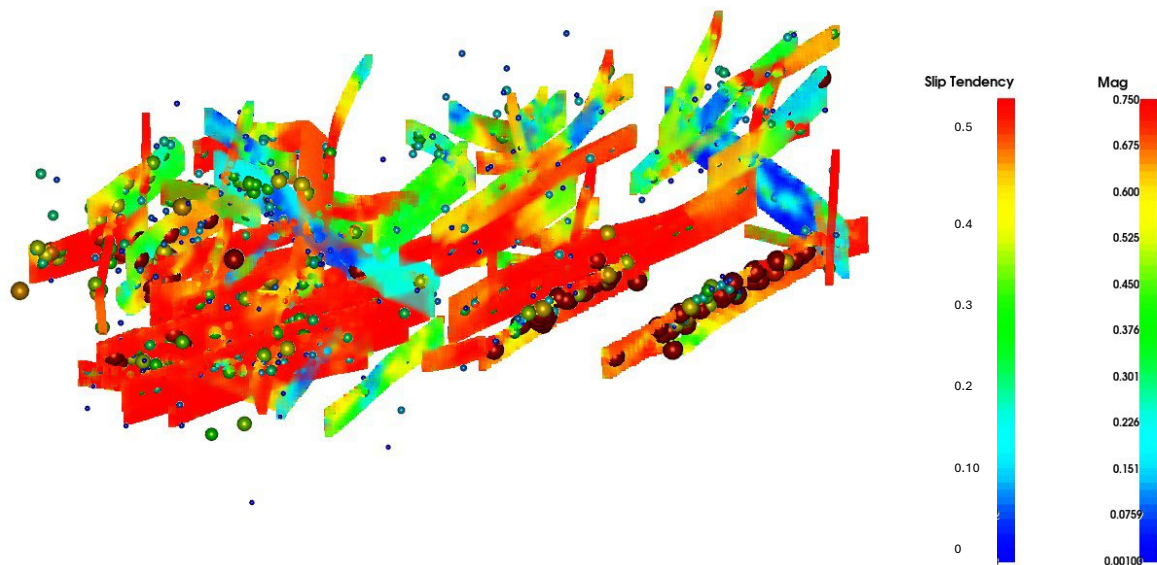


Figure 1. The slip tendency on a DFN of a well-pad in the Kiskatinaw Area of Northeastern British Columbia. The Spheres are the induced seismic events, whose sizes and colors are representatives of the earthquake magnitude.

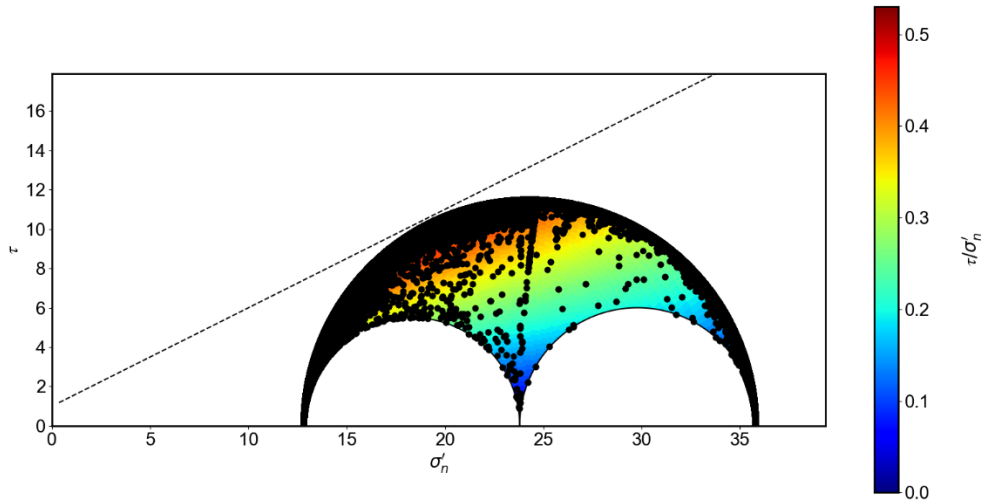


Figure 2. The 3D Mohr Circle Representation of the DFN in Figure 1

Novel/Additive Information

Introduces an **open-source** 3D Mohr Circle solution, **portable** on any Windows machine. Couples slip/dilation tendency algorithms with robust visualization, lowering the barrier to advanced geomechanical analysis. Informs **seismic hazard mitigation** by linking fault reactivation potential to injection-induced stress changes.

Acknowledgements

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References

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