RHEOL_GUI
A Matlab-based graphical user interface for the interactive investigation of strength

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Motivation

As a contribution to the Community Rheology Model we developed an intuitive tool for the exploration and study of strength profile. Built as a Matlab *Graphical User Interface* (GUI), this tool, called RHEOL_GUI, allows the user to define a stratigraphic column, associate to it a temperature profile, taken for example from the CTM, select for each stratigraphic layer rheologies and assumptions on pore fluid pressure and grain size, and compute a strength profile. The tool also allows the user to compute an effective rheology (relation between strain rate and integrated strength) for the lithosphere as a whole, which can used for further modeling.

Software access

RHEOL_GUI v1.0 is open-source and publicly available under the MIT license at **https://github.com/montesi/RHEOL_GUI** doi:10.5281/zenodo.1341844. The package contains a database of rheologies, both brittle and ductile, for several rock types, taken from the literature. Grain size can be specified a priori or allowed to adjust to obey one of several available piezometric relationships to address the possibility of weakening the lithosphere at shear zones through grain size reduction.

Usage

First, download the package from *https://github.com/montesi/RHEOL_GUI*. Open Matlab. Navigate to the directory where you store RHEOL_GUI (orr add the directory to the Matlab path) and start the GUI by typing `rheol_GUI` in the command line.

The software loads automatically a database of planetary environmental variables (`planet.mat`) and rock types (`rock.mat`), including several rheologies and grain size equilibrium relations, if available. The software loads a default structure and constructs a first strength envelope. You are now ready to adapt the model to your interest.

1) Setup the environment

- Choose your planet (gravity, surface pressure)
- Choose the tectonic environment: thrust, normal, strike-slip (affects brittle strength)
- Adjust the strain rate (affects ductile strength)
- Setup the temperature profile. There are three options:
  - → Linear: Specify surface temperature, geotherm, and mantle temperature
  - → Error function. Specify surface and mantle temperature, surface geotherm
  - → Custom file. Refer to an ASCII table of depth/temperature pairs (e.g. from CTM). Per convention, that file should have use extension `.thm` (THermal Model).

2) Build your structure

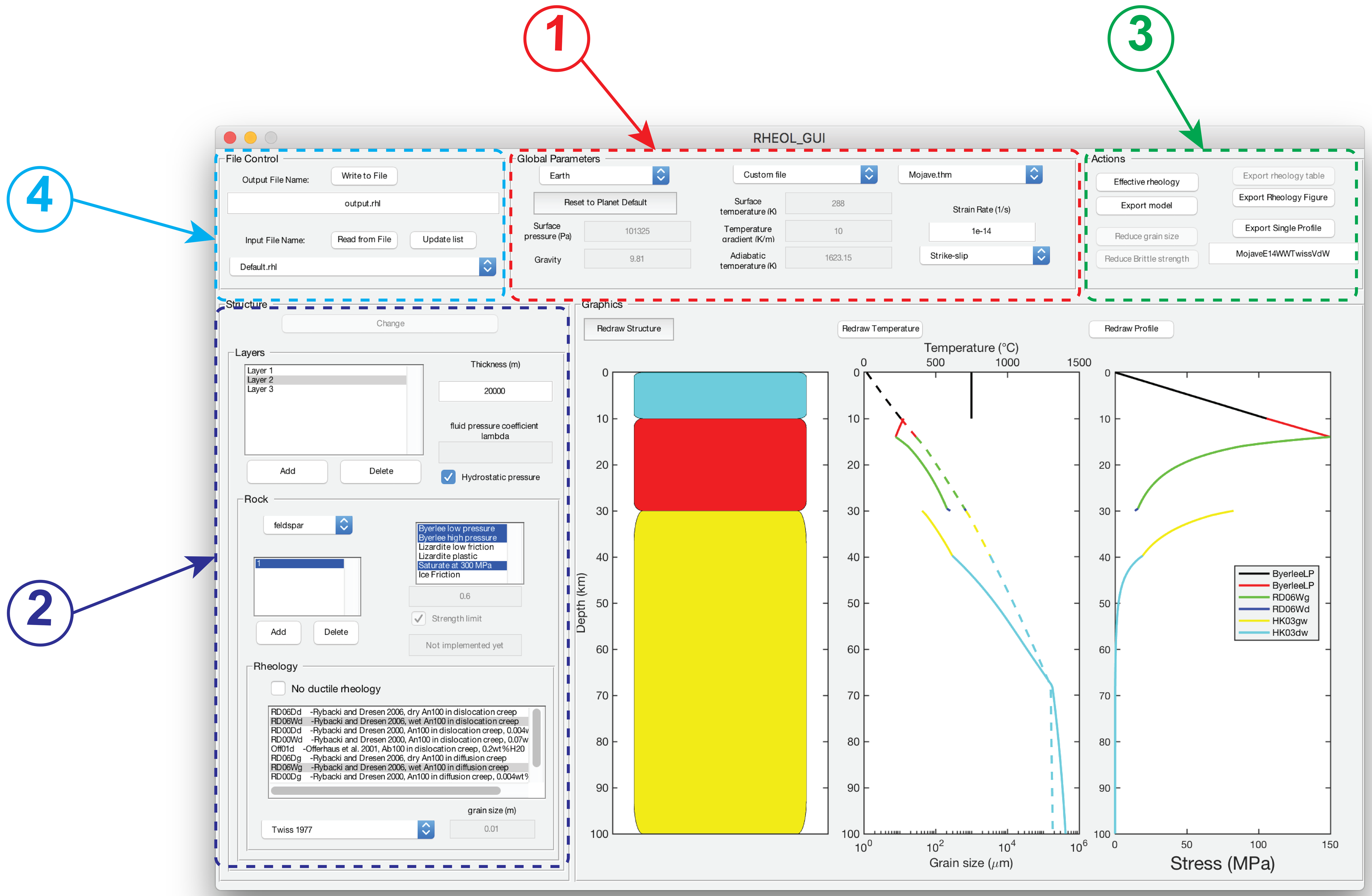
- Add and remove layers
- Change layer thickness
- Enable desired brittle failure criteria. Relations defined in `byerlee.m`
- Select pore fluid pressure (affects brittle strength). There are two modes:
  - → Hydrostatic: the effective pressure increases as $(\rho-\rho_w)g$
  - → Pore pressure coefficient λ: the effective pressure increases as $(1-\lambda)\rho g$
- Select rock type.
  - Rock density ρ is taken from `rock.mat`
  - Enable desired ductile flow laws. Relations defined in `rock.mat`
  - Specify grain size (Constant value or piezometer included in `rock.mat`)

3) Get some results!

- The graphics in the GUI show the stratigraphy (schematically), the temperature profile (dashed line), the grain size (solid line, middle panel), and the strength envelope, constructed following *Brace and Kohlstedt* (1980). These diagrams are update whenever the structure is saved.
- Export a PDF with the current temperature, grain size, and strength profile.
- Export the matlab structure that contains the current model as a binary `.mat` file.
- Calculate the effective rheology: Integral of the strength envelope with depth reported for various strain rates between 10^{-20} s^{-1} and 10^{-8} s^{-1}.
  - Export a PDF of the effective rheology figure.
  - Save a ASCII table with strain rate / integrated strength pairs, which can be used in various modeling activies (e.g. regional thin sheet models). the file will have extension `.rht` (RHeology Table).

4) File handling

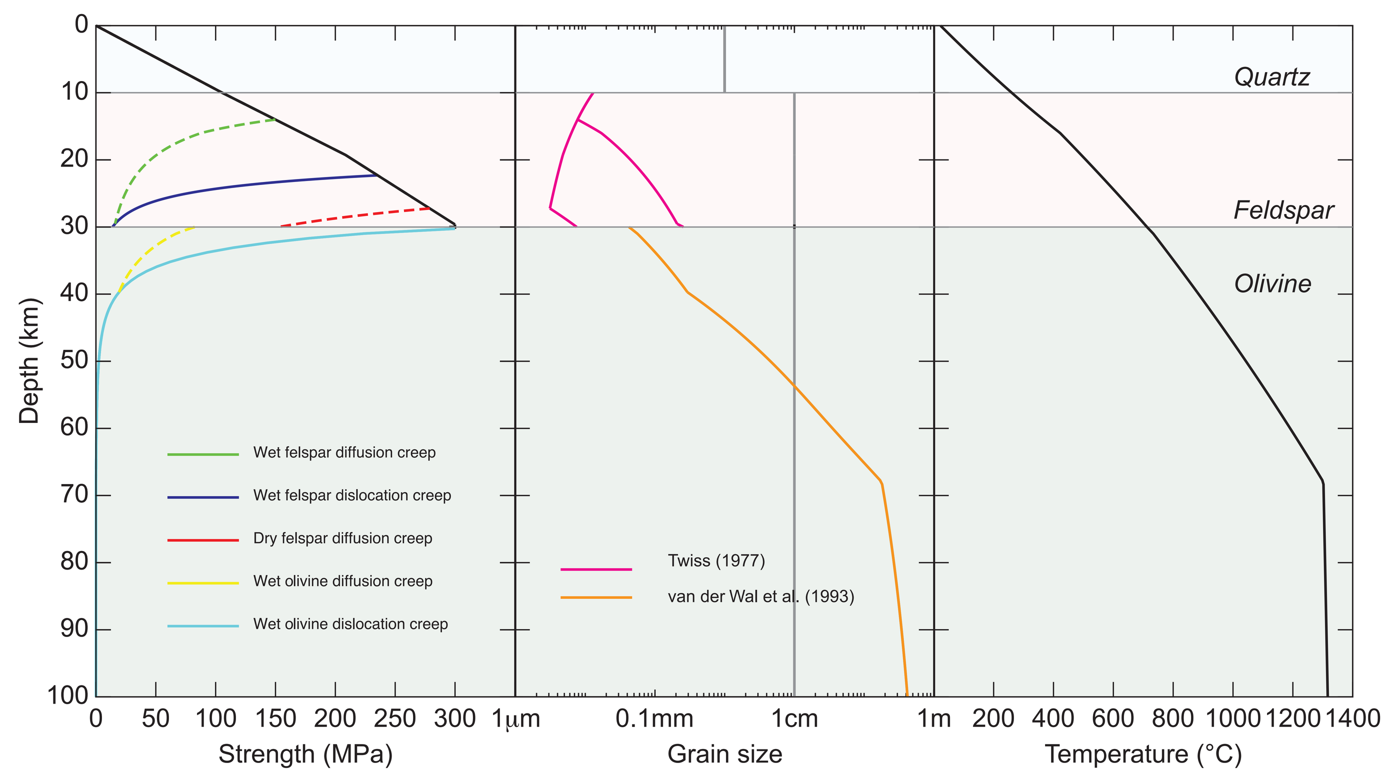
- The structure, including information on environment, selected rheologies, and grain size, can be saved a human-readable input. By convention, use extension `.rhl` (for RHeoLogy). You can save the current structure or load a preexisting model.



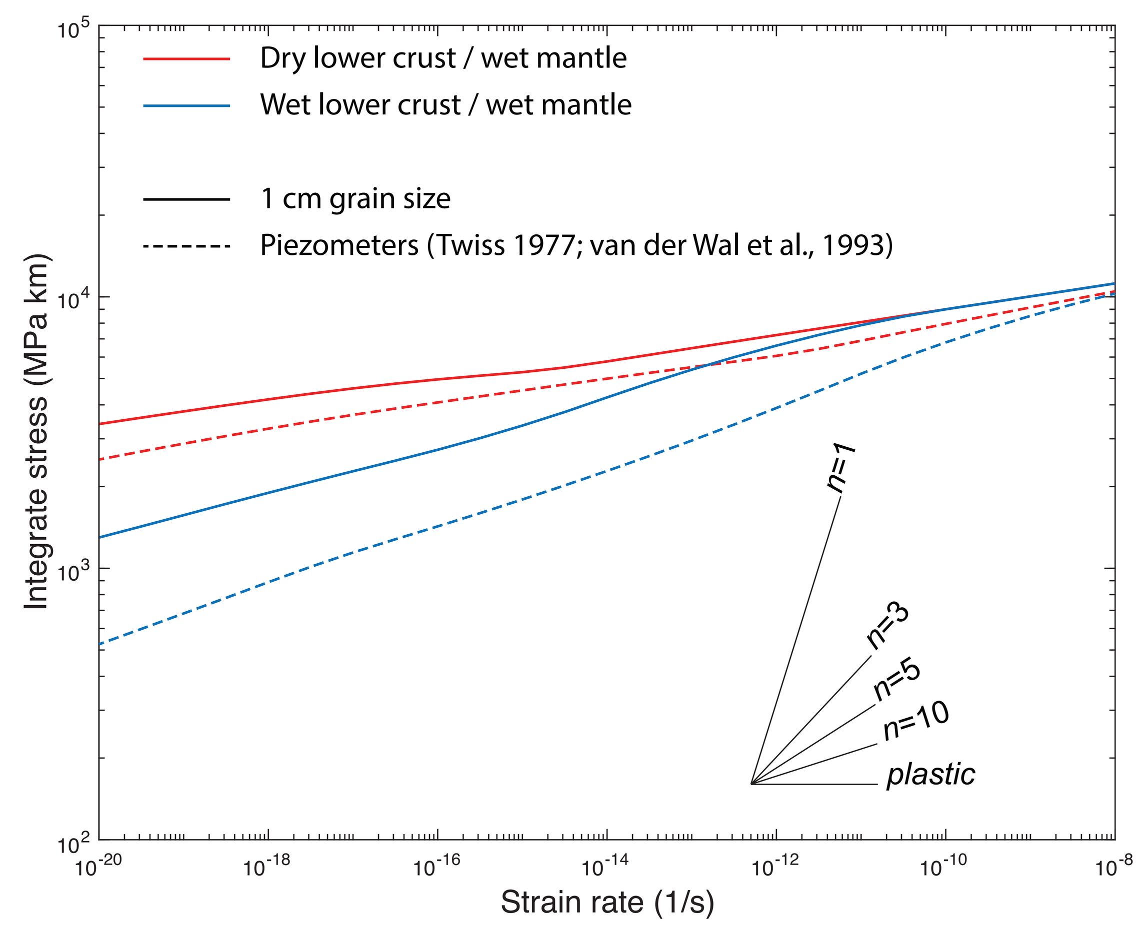
Demonstration

The default structure is inspired by the Mojave tectonic block. It includes a 30 km thick crust (10 km quartzite and 20 km feldspar) over a 70 km thick lithospheric mantle. The temperature profile was provided by Wayne Thatcher and is taken from the CTM.

Brittle failure obeys Byerlee's law, with a maximum strength of 300 MPa. Pore fluid pressure is hydrostatic in the crust and λ=0.2 in the mantle. Diffusion and dislocation creep flow laws are taken from *Hirth et al.* (2001) for quartzite, *Rybacki et al.* (2006) for feldspar, and *Hirth and Kohlstedt* (2004) for olivine. Wet or dry rheologies are used in feldspar and wet rheology (fluid-saturated) for the olivine.The figure below shows strength envelopes for a strain rate of 10^{-14} s^{-1} for for cases: wet or dry lower crust with grain size either fixed at 1 cm or obeying the piezometric relations of *Twiss* (1977) in the crust or *van der Wal et al.* (1993) in the mantle.



Integrated strength (figure below) is highly nonlinear, with an effective stress exponent in excess of 10. That is because, although ductile rheologies have *n* smaller than ~5, at least half of the stress is supported in the brittle regime, with an effective *n* of ±∞. This implies that, with regards to long-term tectonics, even a small change of stress can have a dramatic effect on strain rate. Changing grain size can increase strain rate by about two orders of magnitude, but, especially at low strain rate, the largest effect comes from changing the lower crust rheology from dry to wet, implying that details of mineralogy and hydration state are very important for lithospheric strength.



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