The program Slicken 1.0 will help you find the orientation of slip on any preexisting planes under a given stress state

Authors for the program Slicken 1.0

• **Hong Xu**

• *Rhodes College, 2000 North Parkway, Memphis, Tennessee, USA*

• ***Xu, ShunShun***

Universidad Nacional Autónoma de México, Centro de Geociencias, Boulevard Juriquilla No. 3001, Querétaro, Qro., CP 76230, México.

•***Nieto-Samaniego A. F.***
Universidad Nacional Autónoma de México, Centro de Geociencias, Boulevard Juriquilla No. 3001, Querétaro, Qro., CP 76230, México.

• ***Alaniz-Alvarez S. A.***

Universidad Nacional Autónoma de México, Centro de Geociencias, Boulevard Juriquilla No. 3001, Querétaro, Qro., CP 76230, México.

1. The geographical frame used for the program

A coordinate system is used in which the positive X_1, X_2, and X_3-directions coincide with north, east, and vertical downward, respectively (Fig. 1).

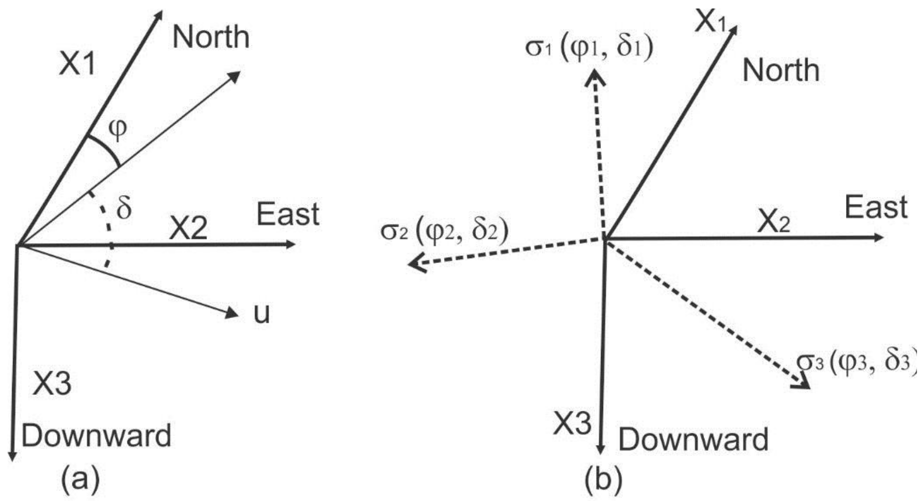


Figure 1

2. Basic hypothesis

We assume that faulting in the upper earth crust (above 15 Kms) occurs by brittle process:

1) Faults slip along the maximum resolved stress on the fault (e.g. Bott 1959).

2) The stress field is irrotational in both space and time.

3) Faulting occurs within isotropic rocks.

4) The faults are planar and slickensides are straight.

5) There is no displacement perpendicular to the fault plane.

The slip orientation depends on four factors: the three principal stress orientations with respect to the pre-existing fault, and the stress tensor aspect ratio: ρ = (σ_2-σ_3)/(σ_1-σ_3), $\rho \in [0,1]$, where $\sigma_1 \geq \sigma_2 \geq \sigma_3$ (e.g. Bott 1959, Angelier, 1979).

For the above assumptions, the predicted rake of slip (0° ≤ γ_p ≤ 360°) is then related to the respective influence of the fault-plane orientations and of the tectonic states. The analysis of this direct problem allows us to describe the geometry of the slip directions within any given tectonic state, as well as its evolution while the tectonic state varies.

Angelier, J., 1979. Determination of the mean principal directions of stresses for a given fault population. Tectonophysics 56, T17-T26.

Bott, M.H.P., 1959. The mechanics of oblique slip faulting. Geol. Mag. 96, 109-117.

3. Installation

Since Slicken 1.0 is designed using Java SE 8.0, installation of the program is a quite simple procedure. Before installation, your computer should be installed Java SE 8.0. After you copy the program to your computer, run it and wait some seconds. The main window of the program will appear (Fig. 2).

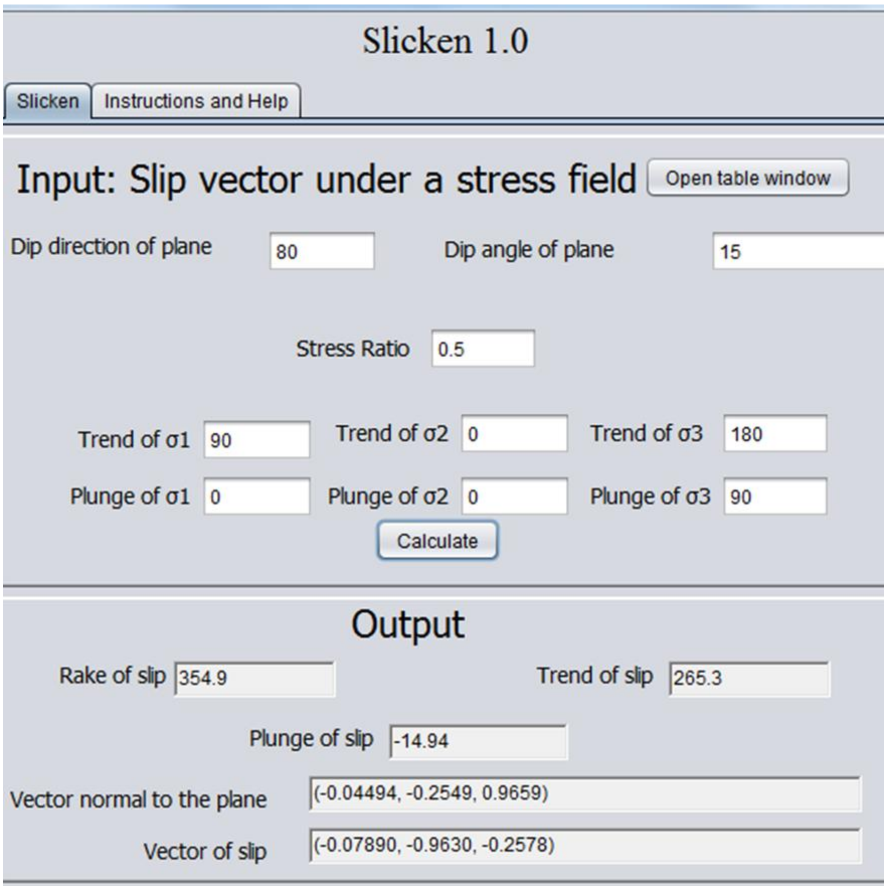


Figure 2

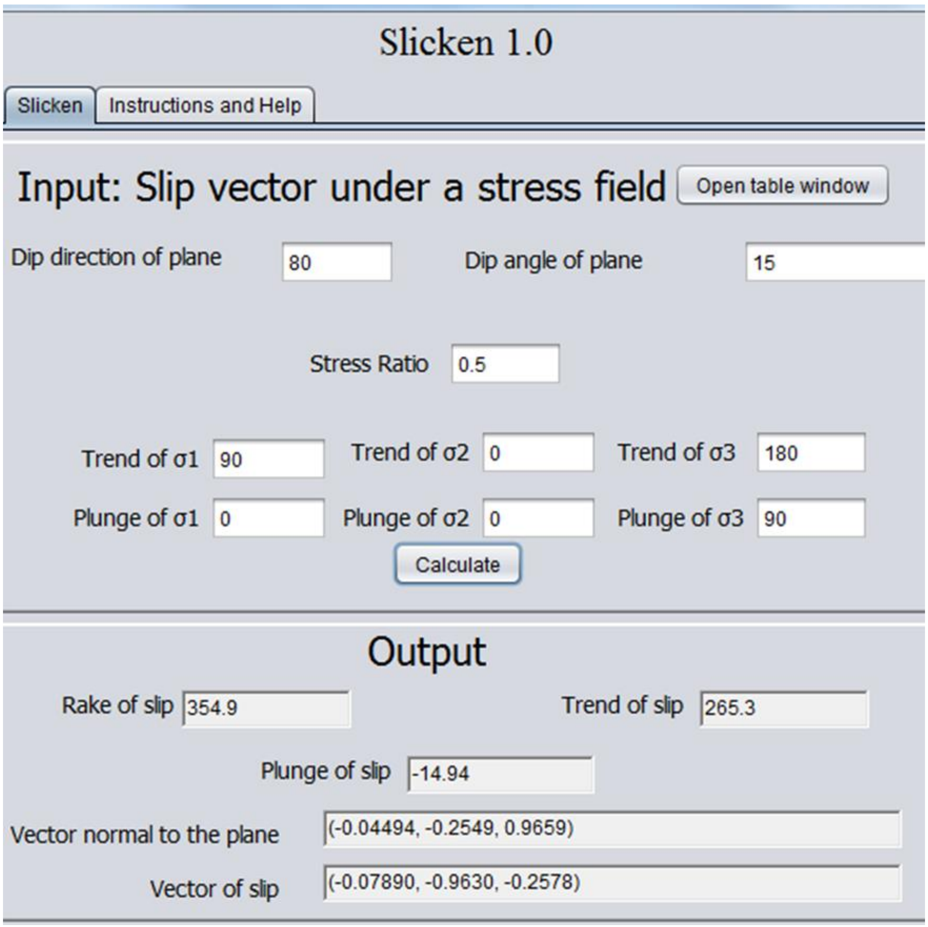
4. The Window of Slicken 1.0

The Slicken window, in which you are currently in, presents the user with three cases to perform slicken lines calculation. In all three cases, in order to use the algorithms, insert all the input values and press the bottom to perform the calculations. When this is done, the calculated output will be shown in the output section of the case and also in a separate window with an output table will appear.

Output table Window

The output table windows for each case allows you to see the output of current and previous calculations. It also allows to save and load files for ease of use and retrieval. The files are saved in UNICODE UTF-8 format with .slc1, .slc2, or .slc3 file extensions, for each case respectively.

5. The input and output data



5.1. Input data

"Dip direction of plane" is the dip direction of the plane or fault plane that user want to resolve.

"Dip angle of plane" is the dip angle of the involved plane or fault plane.

"Stress ratio" is the known stress tensor aspect ratio that is in the form $\rho = (\sigma_2 - \sigma_3)/(\sigma_1 - \sigma_3)$, $\rho \in [0,1]$.

The directions of the three principal stresses are inputted by their trends and plunges: Trends of the three principal stresses (*i* = 1, 2, 3) and Plunges of the three principal stresses (*i* = 1, 2, 3), where $\sigma_1 \geq \sigma_2 \geq \sigma_3$

5.2. Output data

"Rake of slip" is the rake value (γ_p) of the slip on the (fault) plane ($0 \le \gamma_p \le 360$).

Eight types of slip sense are defined according to the values of γ_p: (1) Normal-sinistral: $5<\gamma_p<85$; (2) Normal-dextral: $95<\gamma_p<175$; (3) Reverse-sinistral: $185<\gamma_p<265$; (4) Reverse-dextral: $275<\gamma_p<355$. (5) Sinistral lateral: $0 \le \gamma_p \le 5$ and $355 \le \gamma_p \le 360$, (6) Dextral lateral: $175 \le \gamma_p \le 185$; (7) Pure normal: $\gamma_p = 85 \le \gamma_p \le 95$; (8) Pure reverse: $265 \le \gamma_p \le 275$.

"Trend of slip" is the trend (φ_p) of the slip on the (fault) plane ($0 \le \varphi_p \le 360$).

"Plunge of slip" is the plunge (δ_g) of the slip on the plane. Normal sense: $0<\delta_g<90$; Reverse sense: $-90<\delta_g<0$; Strike-slip sense: $\delta_g = 0$.

"Vector of slip" is the unit vector ($\vec{v}_p$) of the slip on the (fault) plane.

"Vector normal to plane" is the unit vector ($\vec{n}$) normal to the (fault) plane.

6. Some remarks

The program will display a reminding pop-up indicating that the resultant data may not be accurate when $\theta_a < 5°$ for the regimes of extension and strike-slip and $\theta_b < 5°$ for the regime of compression, where θ_a is the angle between the fault normal and the minimum principal stress, θ_b is the angle between the fault normal and the intermediate principal stress.

In the field works, there are measurement errors (ε) of the strike or dip direction of a fault plane. For the extension regime, when the value $\varepsilon > 8°$, the rake error due to the error of dip direction (ε) will be large enough that the inferred rake direction by using the program cannot be used. On the other hand, for the compression and strike-slip regimes, we denote the critical value of ε to be 10°. When clicking the display button, a reminding window will pop up.

Note that the negative plunges ($-90° < \delta_g < 0°$) of the shear refer to those faults with reverse displacement components (upward movement of the hanging-walls), whereas the positive plunges ($0° < \delta_g < 90°$) of the shear indicates those faults with normal displacement components (downward movement of the hanging-walls). In this paper, the term ‘rake’ is used, rather than ‘pitch’. The rake and pitch are two terms for a measurement of a slickenline on a fault surface. Thus, for convention of this paper, the angle of rake (γ_p) is measured clockwise within the fault plane being considered, from the right strike when viewing in front of the plane (Fig. 4a). Nevertheless, the pitch is measured from the two strikes or dip direction to the slickenline or shear regardless of the sense of the slickenline (Fig. 4b). Currently, the rake varying from 0° to 360° or from -180° to 180° is commonly used in seismology, whereas the pitch varying from 0° to 90° or from 0° to 180° is usually used by structural geologists. Generally, for the reverse faults, the rake is not equal to the pitch for a same slickenline. However for the normal faults, the rake may be equal to the pitch of the shear.

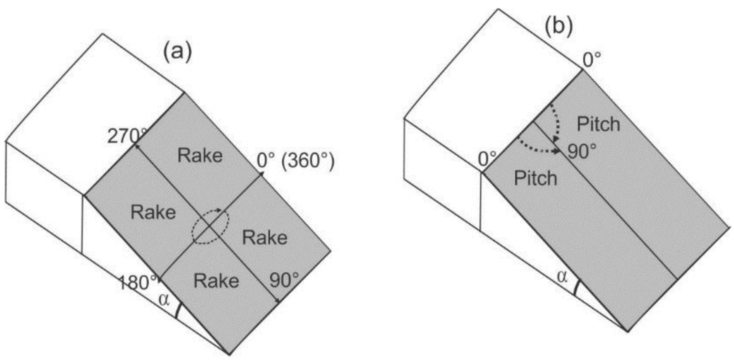


Figure 3.

According to Fig. 3, for $0° \leq \gamma_p \leq 90°$, the value of pitch ($p$) is equal to γ_p, written as

$p = \gamma_p$

For $90° < \gamma_p < 180°$, the value of pitch is in the form

$p = 180 - \gamma_p$

For $180° \leq \gamma_p \leq 270°$, the pitch is calculated by

$p = \gamma_p - 180$

For $270° < \gamma_p < 360°$, the pitch is in the form

$p = 360 - \gamma_p$

The above equations indicate that for the reverse faults, the rake is not equal to the pitch for a same slickenline. However for the normal faults, the rake may be equal to the pitch of the shear.