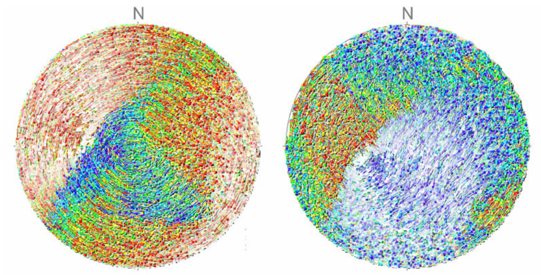

Welcome to

Ginkgo Method

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The Ginkgo Method visualizes the object function of fault-striation analysis (Yamaji, 2003). The programs, GinkgoMP and GinkgoVisualizer, are the main and post processors of the method for Windows OS. The main one input fault-slip data and output a text file that is loaded by the post processor to make two bitmap files. The files are combined by image processing software (Fig. 1).

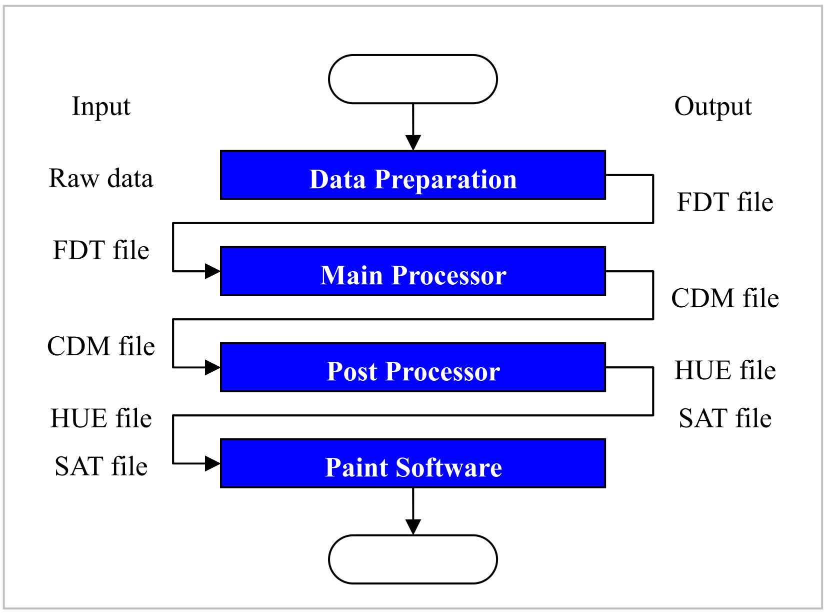

Fig. 1. Flowchart for Analysis.

Data Preparation

The main processor GinkgoMP loads fault-slip data that is contained in text files with the extension ‘fdt.’ The file should have the file format shown in Fig. 2a. Data are listed a fault per line. The first and second numbers of the line indicate the azimuth and plunge of the dip direction, the maximum inclination, of the fault plane. The third and fourth numbers indicate the azimuth and plunge of slickenside striations. The sense of fault, normal, reverse, sinistral, or dexitral, is indicated by the letter N, R, S, or D at the end of the line. Compare the data list in Fig. 2(a) and the stereonet in Fig. 2(b) that shows the data. The items in the lines are separated by one or more spaces.

(a)

	Orientation of Fault		Orientation of Striae		Sense of Movement	
1	330.8	5.9	289.4	4.4	N	↵
2	28.2	14.1	82.6	8.3	R	↵
3	247.0	20.0	167.5	3.8	D	↵
4	135.2	24.6	140.0	24.5	R	↵
5	39.2	28.4	67.0	25.6	R	↵
6	313.6	31.9	240.8	10.5	S	↵

(b)

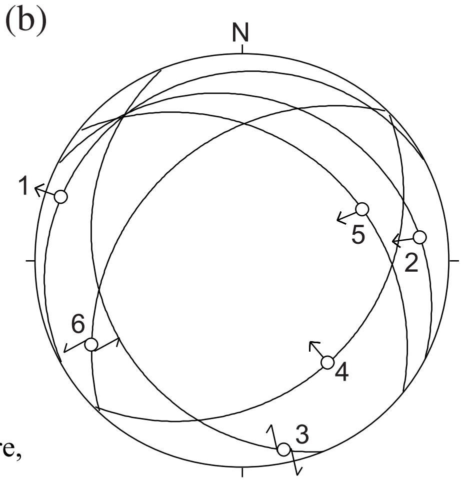

Fig. 2. (a) Format of fault-slip data. (b) Lower-hemisphere, equal-angle projection of the six faults listed in (a).

GinkgoMP, the Main Processor

GinkgoMP is the main processor of the Ginkgo method. Follow the four steps below to use the software. The software is a console program but uses Window’s common dialogue windows to specify file names.

1. Launch the executable file GinkgoMP.exe.
2. Select a data file in an open dialogue.
3. Enter a file name for the outputs of the program. If, for example, the name xxx is given, then the software outputs a text file named xxx.cdm. The post processor constructs two bitmap files from the ‘cdm’ file.
4. Enter an integer between 1 and 4 to choose a function.

GinkgoVisualizer, the Post Processor

The GinkgoVisualizer is the post processor of the Ginkgo method, and transforms an output of the main processor to two bitmap files. The files are combined later to form a color image by an image processing software such as Adobe Photoshop. Follow the following three steps to use the post processor.

1. Launch GinkgoVisualizer.exe (Fig. 3)
2. Choose File, Open from the menu bar.
3. Locate the cdm file you want to load, and click Open. If the file xxx.cdm is chosen, the program outputs the bitmap files xxx_hue.bmp and xxx_sat.bmp.

By default, the orientation of stress axes is represented by lower-hemisphere, equal-area projection. If equal-angle projection is preferable, click the Projection menu.

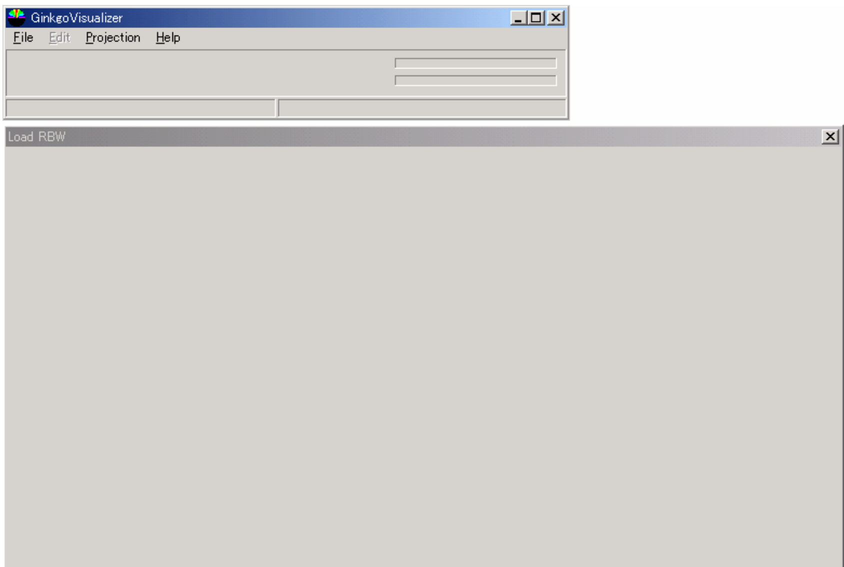

Fig. 3. Windows of GinkgoVisualizer.

Image Combining

The paired bitmap files with suffixes _hue.bmp and _sat.bmp are combined by painting software. In what follows, we call them as HUE and SAT files. The combining procedure is shown using Adobe Photoshop.

1. Load a SAT file into Photoshop.
2. Choose Image, Mode, Grayscale
3. Choose Area, All
4. Choose Edit, Copy
5. Load a corresponding HUE file
6. Choose Image, Mode, RGB Color
7. Choose Edit, Paste
8. Choose Layer, Options, and select Screen from the Painting Mode pull down menu
9. If necessary, choose Image, Adjust, Curves

Theoretical Background

The Ginkgo method visualizes the object function of stress inversion. The following is the brief explanation for the method. See Yamaji (2003) for detail.

Given fault-slip data, the optimal state of stress is determined for the data by maximizing the summation

$$F = f(d^{(1)}) + \cdots + f(d^{(N)}), \tag{1}$$

where N is the number of fault in the data and $d^{(i)}$ is the angular misfit between the observed and theoretical slip directions for the ith fault, and $f(d)$ is the decreasing function of d. The theoretical one is given from the Wallace-Bott hypothesis (Wallace, 1951; Bott, 1959), i.e., faults are thought to slip in the direction parallel to the resolved shear stress on the fault planes. The misfit is calculated with assumed stress tensors. The summation, F, depends on data and stress. The stress is represented, in this case, by the orientation of stress axes and stress ratio

$$\Phi = \frac{\sigma_2 - \sigma_3}{\sigma_1 - \sigma_3}. \tag{2}$$

There are four optional functions for $f(d)$ that the user should designate:

$$f_1(d) = \left(1 + \cos d\right)/2 \tag{f1}$$

$$f_2(d) = 180° - d \tag{f2}$$

$$f_3(d) = \begin{cases} 1 - \tan d & (d < 45°) \\ 0 & (d \geq 45°) \end{cases} \tag{f3}$$

$$f_4(d) = \left\{\tanh\left[10\left(30° - d\right)\right] + 1\right\}/2. \tag{f4}$$

Fig. 4 shows the graph of the functions.

The Ginkgo method visualizes the variation of F for various stress orientations and stress ratios. To this end, the σ_1- and σ_3-directions are plotted on paired stereograms, left and right, respectively.

The Ginkgo method is an extension of the right-dihedra method by Angelier and Mechler (1977). The latter uses stereograms to show the possible orientations of stress axes for given fault-slip data. The present method shows not only the orientations but also the possible stress ratios. Fig. 5 shows an example.

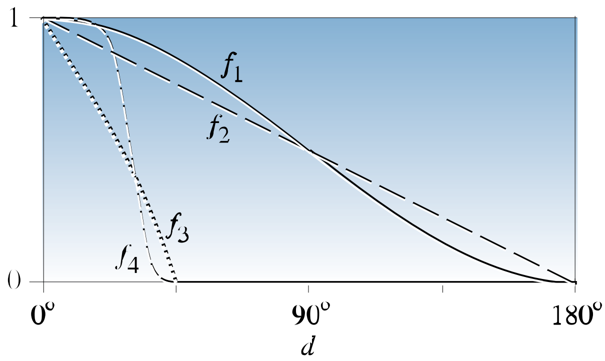

Fig. 4. Functions to evaluate the fit of faults to assumed stress.

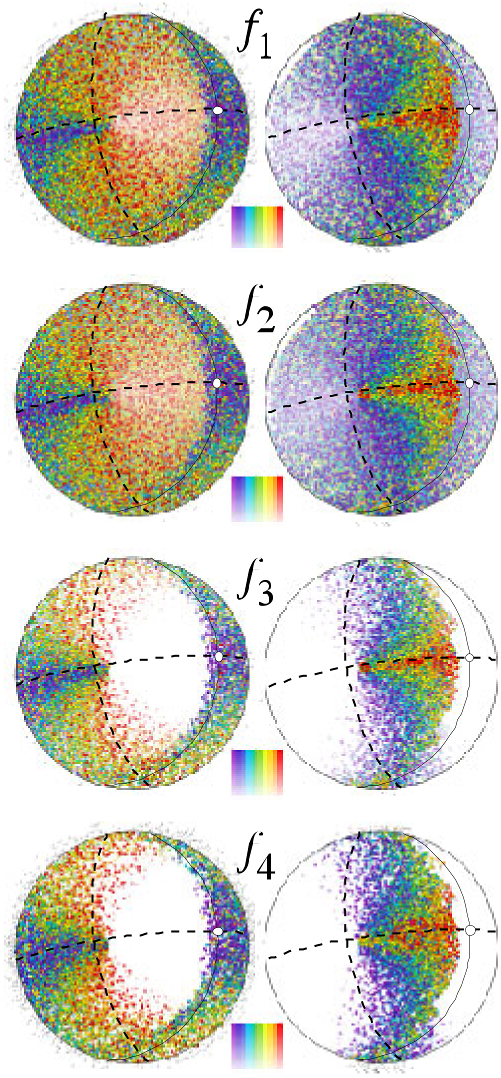

Fig. 5. The results of the Ginkgo method applied to a reverse fault with the functions in Eq. (f1)–(f4). Lower-hemisphere, equal-area projection. Left and right stereograms show the orientation of σ_1- and σ_3-axes, respectively. Open circle shows the slip direction. Smooth and dashed lines show the fault plane, and auxiliary plane, and the plane perpendicular to those planes. Note that the distribution of color dots are roughly bounded by the fault plane. Theoretically, the plane should exactly bound them. However, F is evaluated at computational grid points of which directions are separated by ca. 8 degrees.

References

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