Supplementary Materials

Detailed Methodology for Surface Projection

The equation of the intersecting plane is defined as

$$Ax + By + Cz = D,$$

where

$$Ax_0 + By_0 + Cz_0 = D.$$

The origin of the intersecting plane is (x_0, y_0, z_0), and $< A, B, C >$ is the normal vector to the plane. In this case, the normal vector to the intersection plane is the dip direction vector. The dip direction vector is defined with dip direction (α) and dip angle (θ)

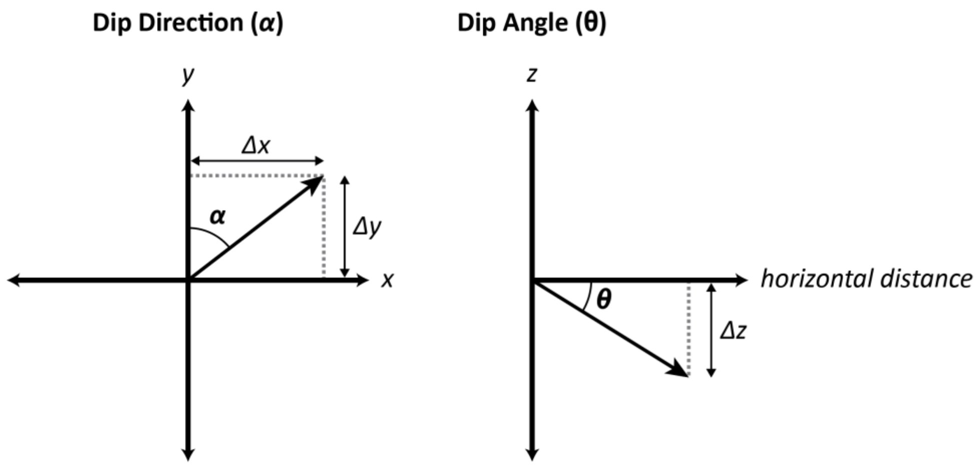

Figure 1. The change in dip direction (x and y) components are displayed as followed: $A = \sin\alpha\,(1)$ *and* $B = \cos\alpha\,(1)$*, when horizontal distance xy is 1. The change in dip (z) component would therefore be:* $C = -\tan\theta\,(1)$.

It is important to note that $sine$ and $cosine$ functions will change the signs of the vector appropriately for dip direction, e.g., $\alpha = 25$ and $\alpha = 155$ should have the same A and B values (i.e., the same magnitude of change in x and y component), but B should be negative.

For each point that needs to be projected, a line was defined oriented parallel to depositional dip:

$$\vec{r} = \vec{r}_0 + t\vec{v}$$

Where $\vec{r}_0$ is the point to be projected (x_i, y_i, z_i) and $\vec{v}$ is the dip direction vector $< A, B, C >$. The parametric equation of a line is defined as

$$x = x_i + At$$

$$y = y_i + Bt$$

$$z = z_i + Ct$$

Finding the point of intersection between the line and intersection plane, where the projected point must be both on the line and plane thereby satisfying both equations.

Substituting in the equation of the line

$$A_x + B_y + C_z = D$$

into the plane to get

$$A(x_i + At) + B(y_i + Bt) + C(Z_i + Ct) = D,$$

and then solving for t gets

$$t = \frac{D - Ax_i - By_i - Cz_i}{A^2 + B^2 + C^2}.$$

The equations for projected points are expressed in terms of initial points, orientation (trend and plunge) of dip direction vector, and origin of the intersection plane. So that when the projected points $(x_p,\ y_p,\ z_p)$ are solved

$$x_p = x_i + A\left(\frac{D - Ax_i - By_i - Cz_i}{A^2 + B^2 + C^2}\right),$$

$$y_p = y_i + B\left(\frac{D - Ax_i - By_i - Cz_i}{A^2 + B^2 + C^2}\right),$$

$$z_p = z_i + C\left(\frac{D - Ax_i - By_i - Cz_i}{A^2 + B^2 + C^2}\right).$$

In order to display these projected points on an intersection plane, 2-D coordinates for projected points need to be defined on the intersection plane by calculating the along strike (IP_x), and along dip (IP_y) distances relative to the intersection plane origin (Figure 2).

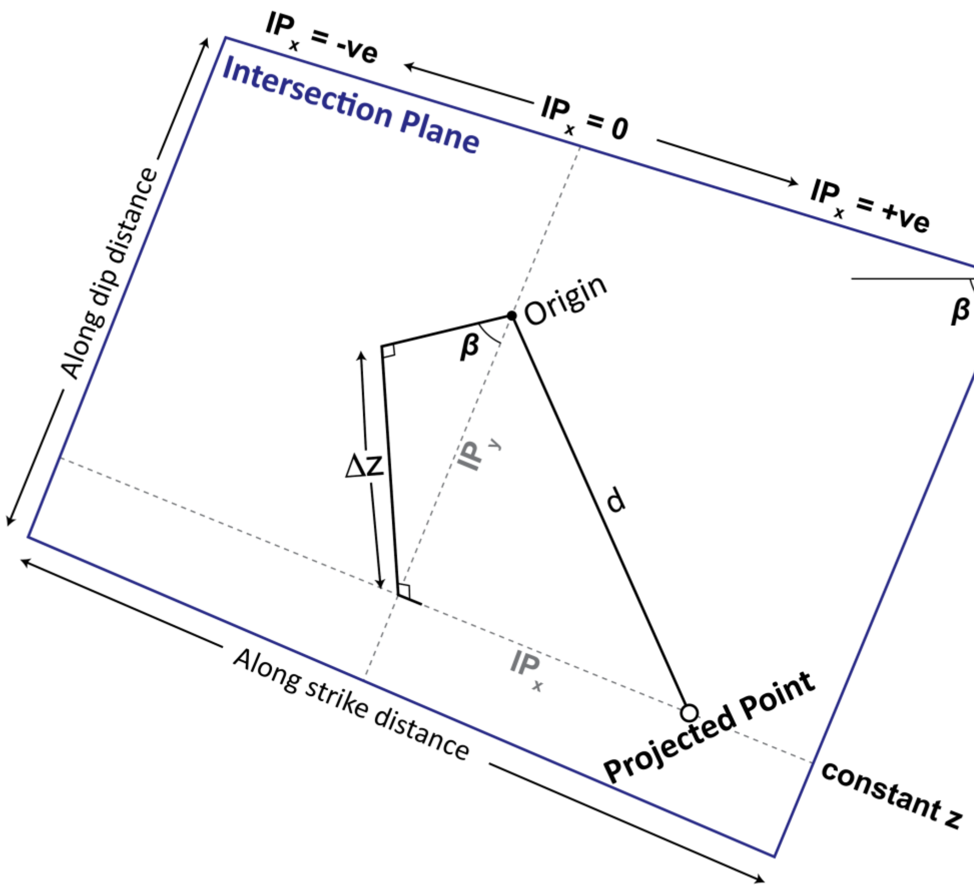

Figure 2. 2-D coordinate definition and projection, showing along dip and along strike distances in relation to the origin.

The origin of the intersection plane has coordinates (x_0, y_0, z_0), and the projected point has coordinates (x_p, y_p, z_p). β is defined as the dip of the intersection plane = $90 - \theta$, where θ is the dip magnitude of bedding. d is the distance between two points, which is

$$d = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}.$$

The along dip distance relative to the intersection plane origin is

$$ip - y = \frac{\Delta Z}{\sin\beta} = \frac{Z_p - Z_0}{\sin\beta}.$$

The along strike distance relative to the origin is defined as

$$ip - x^2 = d^2 - ip - y^2,$$

Therefore, when combined is

$$ip - x = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2 - ip - y^2}.$$

If $(ip - x)$ is the positive or negative solution to the square root, *i.e.*, whether the projected point is located to the left or right of the along dip line $ip - x = 0$ (Figure 3).

The equation for a 2-D line oriented in the dip direction that intersects the origin (x_0, y_0) is

$$y = (\tan\gamma)x + (y_0 - \tan\gamma\, x_0),$$

where γ is the angle between the line and the x-axis, determined from dip direction. For example, if

$$\alpha \leq 90, \text{then } \gamma = 90 - \alpha$$

$$90 < \alpha \leq 180, \text{then } \gamma = \alpha - 90$$

$$180 < \alpha \leq 270, \text{then } \gamma = 270 - \alpha$$

$$270 < \alpha \leq 360, \text{then } \gamma = \alpha - 270$$

Therefore, to calculate y along the line for projected x_p,

$$y = (\tan\gamma)x_p + (y_0 - \tan\gamma\, x_0).$$

If $y > y_p$ then $ip - x$ is positive, and if $y < y_p$ then $ip - x$ is negative (Figure 3).

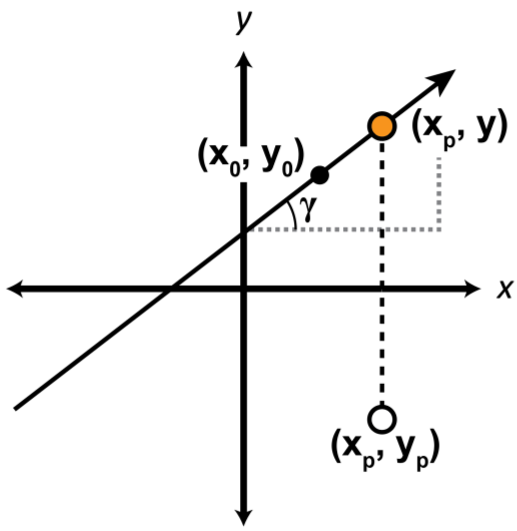

Figure 3. Plot to show the projected point location if y is greater or less than y_p.