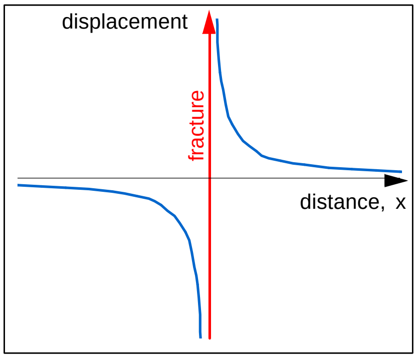
Appendix A

Useful Information

Displacement Discontinuities

Poly3D uses displacement discontinuities, which can be confusing at first, but once you understand the concept, it is not hard to apply. Simply put, a displacement discontinuity is a discontinuity in displacement. This discontinuity usually happens at a geologic discontinuity such as a joint, crack, fault, or fracture. The displacement is movement of the rock in any direction. If you look at the graph of this displacment in Figure 40, with horizontal distance from crack on the x-axis and the amount of displacement on the y-axis, you can see that the displacement is discontinuous at the crack, and continuous everywhere else. There isn't any rock in crack, so there cannot be any movement of the rock inside the crack.

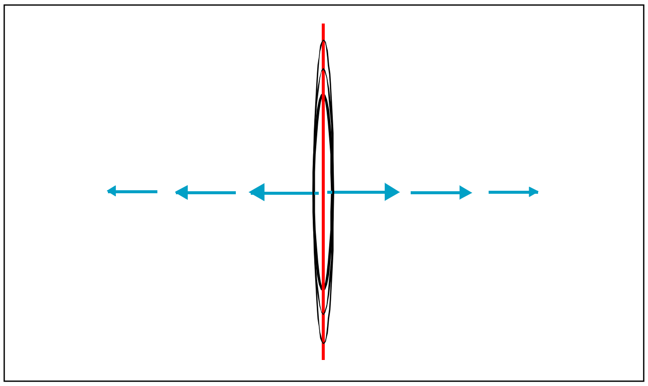
Figure 40: Graph illustrating a displacement discontinuity of the opening fracture in Figure 5. There is little displacement on the edges, but it increase as you approach the fracture. The displacement is discontinuous at the fracture.



distance: horizontal distance, x, from fracture
displacement: amount of displacement at a distance, x, from fracture

For example, consider the vertically propagating fracture shown in Figure 41. The displacement of the rock mass on both sides of the fracture are illustrated by the arrows. As you move farther from the crack the displacement decreases, as shown by the decreasing size of the arrows. At the center of the crack, the displacement is discontinuous because the arrows change direction at this interface. This can be seen by the asymptote in the graph in Figure 40. The interface would also be considered discontinuous if the arrows suddenly changed magnitude. In Poly3D, this fracture would be considered a displacement discontinuity because the displacement is discontinuous along the feature.

Figure 41: Vertical propagation of an opening mode fracture is illustrated with increasing ovals. The displacement field around the fracture is shown by the arrows. This fracture is a displacement discontinuity because arrows point opposite directions on opposite sides of the fracture.



Half-Space vs. Whole-Space

Throughout this manual, we talk about whole-space and half-space, so it's important to understand the difference between the two.

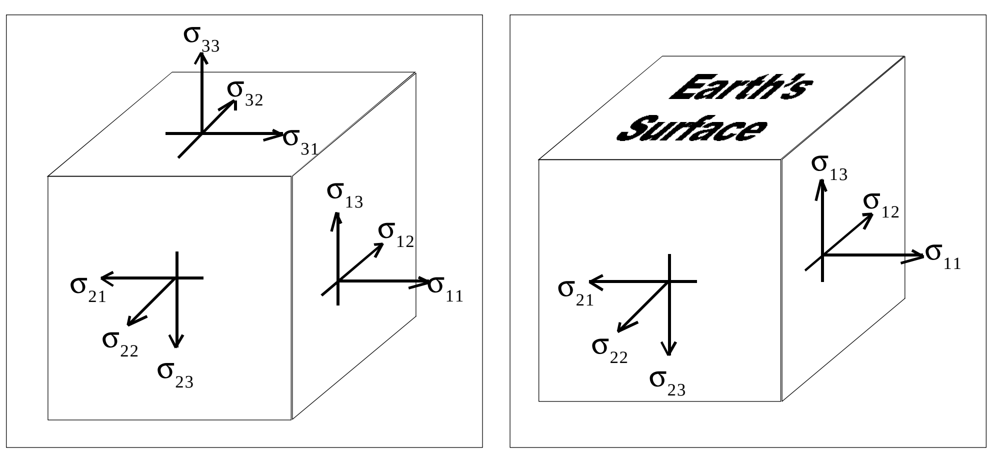
Space, simply put, is the volume of area that you'll be working with and is usually illustrated as a 3D block as shown in Figure 42. Poly3D, and most other numerical modeling programs, assumes this space to be occupied by some elastic material (such as non-ductile rocks at shallow depths). You will be able to define the elastic properties of this material (such as Poisson's Ration, Young's Modulus, Bulk Modulus, etc.) when you use this program. Although it is portrayed as measurable block, it can be assumed to be infinitly large, but will still be portrayed as a block.

While creating the input file, Poly3D will ask you to define the traction and displacement boundary conditions of your space. This refers to the stresses and strains on all sides of your space. These parameters are illustrated in Figure 42. The difference between half-space and whole-space is that half-space has one traction-free surface. In other words, there are no stresses on the surface. The earth's surface can be treated as a traction-free boundary which affects the distribution of stresses, strains, and displacements in the upper crust.

Half-space significantly increases calculation time because there are three times as many equations as whole-space. As a geologist, however, you should almost always work with half-space, unless:

1. You are solving a whole-space problem in solid mechanics unrelated to the earth sciences.
2. The geologic structures you are modeling and observation grids you define are buried very deeply relative to their length.

Figure 42: Space is illustrated as a 3D block. Traction boudary conditions (stresses/strains) are shown on each face of the block.



Elastic whole-space (traction boundary conditions on all faces)

Elastic half-space (top surface is traction-free)

Remote Stresses/Strains

When solving geologic problems, sometimes it is useful to apply far field "tectonic"stresses and strains. The remote boundary conditions that you will define in Poly3D represent a homogeneous stress/strain field over the entire elastic body. From these boundary conditions, Poly3D calculates the *total stress/strain* at a point. It does this by adding the components of remote stress/strain with the stress/strain arising from displacement discontinuities across all boundary elements.

For example, the horizontal tectonic forces shown in Figure 43 would be entered into Poly3D as the remote boundary conditions. Poly3D will calculate the stress/strain due to the displacement discontinuities and add them to the remote boundary conditions to get the total stress/strain at a point:

$$\text{stress}_{\text{remote stress}} + \text{stress}_{\text{displacement discontinuities}} = \text{stress}_{\text{total}}$$

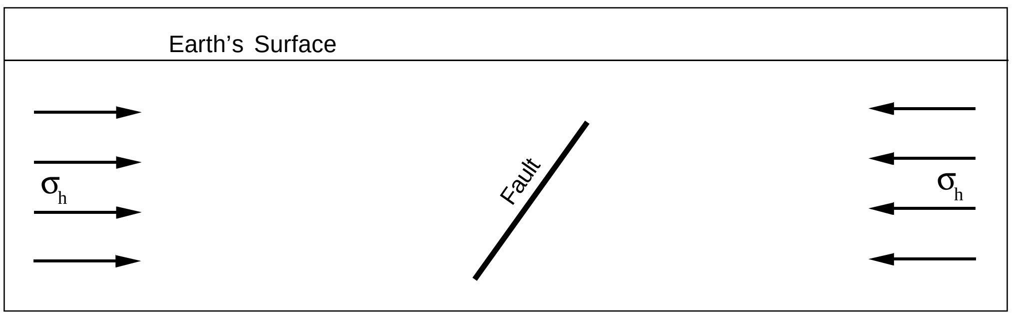
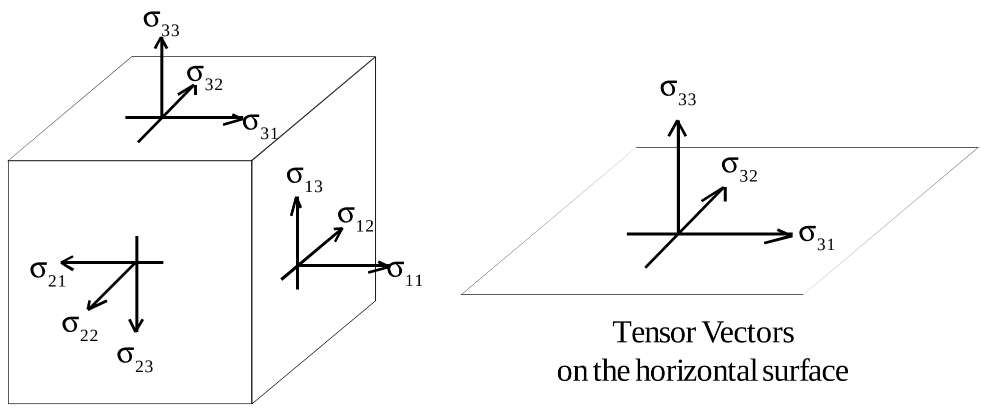


Figure 43: The horizontal teconic forces, σ_h, are the remote boundary conditions entered into Poly3D. Poly3D calculates stress due to displacement discontinuities to find the total stress at a point.

Tensors

Stress/strain components of 3-D systems can be resolved into 9 stress/strain components because each stress/strain vector acting on each of three planes can be resolved into three components of stress/strain, one normal and two shear components. The three components acting on each surface are considered the tensors of that surface.

Figure 44:
There are 9 stress/strain vectors in a 3-D system. The three stress/strain components on each surface are considered tensor vectors.



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