GLY 4200C

LAB EXERCISE 5

Symmetry

Symmetry may be defined as correspondence in size, shape, and relative position of parts on opposite sides of a dividing line or median plane or about a center or axis. The external appearance of a mineral may reflect its internal crystal structure and show various elements of symmetry. The internal symmetry of the structure is always present, regardless of whether it is manifested in the external form of the crystal.

There are three types of symmetry element - an axis, a plane, or a center (point). There are several types of symmetry operation which may be performed about a symmetry element. It is important to note that an operation is always an action (such as rotation) which takes place around a symmetry element (such as an axis). The types of symmetry element are described below:

Symmetry axes - An axis is a line. If rotation through a fixed number of degrees around an axis leaves the object in an identical configuration to its original position, then the axis is a symmetry axis. Symmetry axes are described in terms of the number of "folds". A two-fold axis involves rotation by 180°. (360° is a full circle. This may be described as a one-fold axis, useful as an identity operation. 360°/2 is 180°, hence a two-fold.) This may be illustrated in the following drawing:

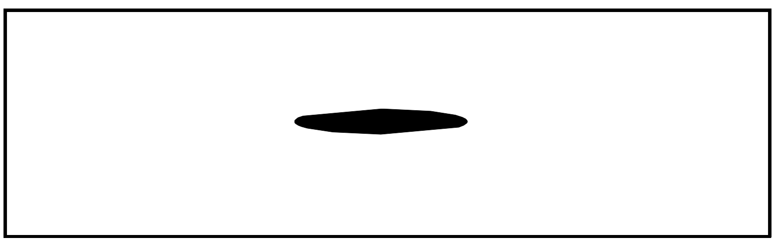

Figure 1

The symbol in the center is known as a diad and marks the location of a two-fold axis in a rectangular box.

A three-fold axis involves rotation by 120° (360°/3 = 120°). Each rotation must produce an identical configuration, hence there are three such configurations. Figure 2 illustrates a three-fold axis in an equilateral triangle. The letters A, B, and C are labels. The points they represent are actually indistinguishable. The central symbol is a triad.

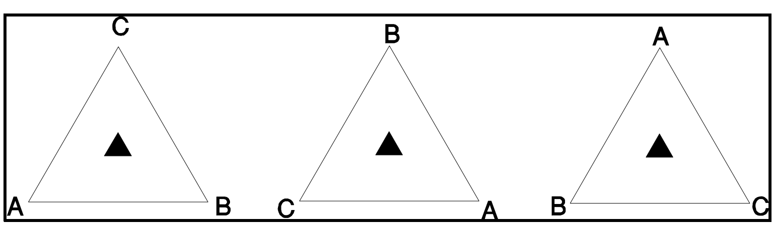

Figure 2

A four-fold axis involves rotation by 90° (360°/4 = 90°). A square has a four-fold axis, as shown in Figure 3. Note that any four-fold axis necessarily includes a two-fold axis. However, the two-fold axis is not ordinarily counted when describing the symmetry elements of an object. It is understood that it exist.

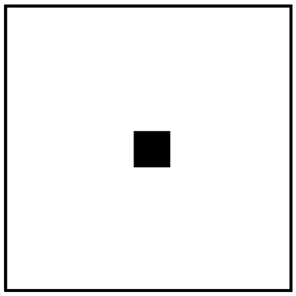

Figure 3

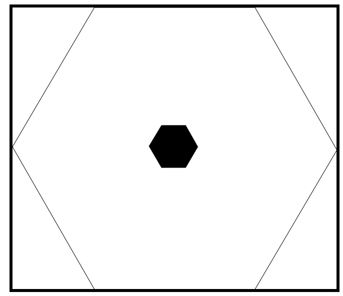

Figure 4

A six-fold axis involves rotation by 60° (360°/6 = 60°). A regular hexagon has a six-fold axis. Each six-fold includes a three-fold and a two-fold, but these are disregarded (see Figure 4).

Although other rotation axes, such as eight, twelve, or twenty-four-fold are possible, they are not used in the symmetry descriptions of minerals.

Mirror-Plane - A plane through an object, chosen so that each feature on one side of the plane has an exactly equivalent feature on the other side, in a mirror-image relationship, is said to be a mirror plane. Mirror-image relationship means that any point, such as A in Figure 5, has an equidistant point B on the opposite side of mirror plane CD which may be connected to A by a normal (perpendicular) to the plane.

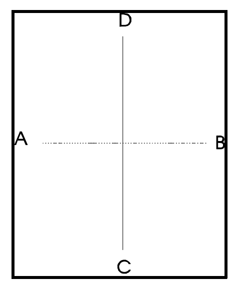

Figure 5

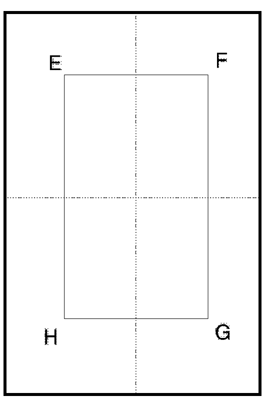

Figure 6

Object EFGH in Figure 6 has two mirror planes, as shown.

The pentagon IJKLM in Figure 7 has only one mirror plane.

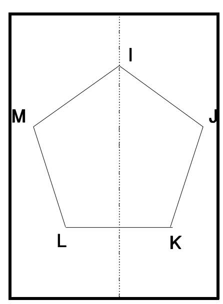

Figure 7

Inversion center - (Also called a Center of Symmetry). The operation associated with this element is called inversion. To invert an object, every point on the surface of that object is (mentally) passed through the "center" to a point on the other side of the center at the same distance from the center as the resulting point.

Interaction of Symmetry elements - Some symmetry elements interact on each other to produce additional elements. A four-fold axis normal to a two-fold axis produces an additional two-fold axis. Suppose z in Figure 8 is a four-fold and x is a two-fold axis. Rotation by 90° around z changes x into y. Since x is a two-fold axis, y must be two-fold also.

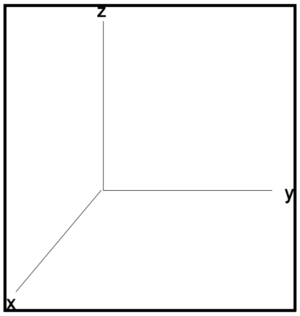

Figure 8

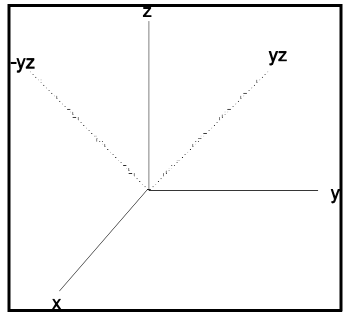

Figure 9

Similarly suppose the xz plane is a mirror plane. Then a two-fold axis along yz will be converted into an additional two-fold axis along -yz (Figure 9).

CD-ROM - The section on Symmetry Operations should be reviewed.

LAB EXERCISE

1. Examine the plastic models 1-15. Determine which symmetry elements each has, and how many of each element are present. Write your answers on the sheet provided.

2. Compare the regular octahedron (#2) with various distorted octahedra (#'s 7, 13, and 14). Describe the distortion of each model and the effect the distortion has on symmetry.

3. Compare the regular octahedron with the cube (#1) with regard to symmetry.

4. To complete the assignment find three objects outside of the classroom. Name and sketch each. Indicate all of the symmetry elements present. Try to use distinctive objects. Cereal boxes, etc. will not earn full credit. You may disregard markings and writing on the object for the purpose of determining symmetry.