EENS 2110	Mineralogy
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Twinning, Polymorphism, Polytypism, Pseudomorphism

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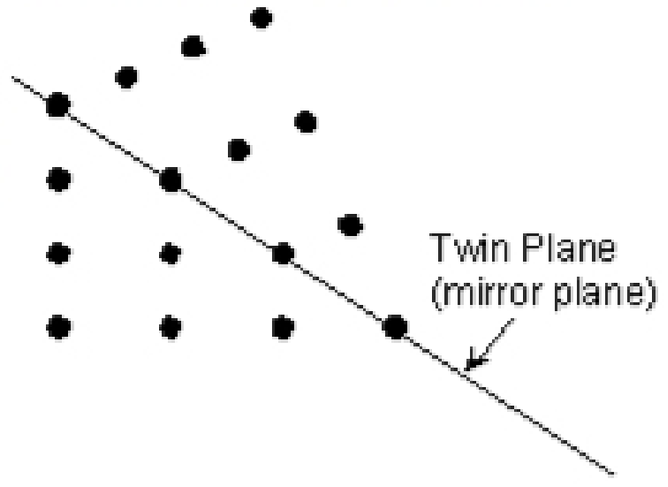
Twinning in Crystals

Sometimes during the growth of a crystal, or if the crystal is subjected to stress or temperature/pressure conditions different from those under which it originally formed, two or more intergrown crystals are formed in a symmetrical fashion. These symmetrical intergrowths of crystals are called twinned crystals. Twinning is important to recognize, because when it occurs, it is often one of the most diagnostic features enabling identification of the mineral.

What happens is that lattice points in one crystal are shared as lattice points in another crystal adding apparent symmetry to the crystal pairs. Twinning, because it adds symmetry, never occurs in relation to the existing symmetry of the crystal.



Symmetry Operations that Define Twinning

Because symmetry is added to a crystal by twinning, twining can be defined by the symmetry operations that are involved. These include:

- Reflection across a mirror plane. The added mirror plane would then be called a ***twin plane***.
- Rotation about an axis or line in the crystal. The added rotation axis would then be called a ***twin axis***.
- Inversion through a point. The added center of symmetry would then be called a ***twin center***.

Twin Laws

Twin laws are expressed as either form symbols to define twin planes (i.e. {hkl}) or zone symbols to define the direction of twin axes (i.e. [hkl]).

The surface along which the lattice points are shared in twinned crystals is called a ***composition surface***.

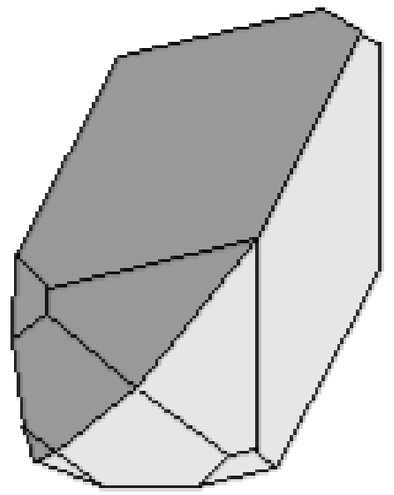
If the twin law can be defined by a simple planar composition surface, the twin plane is **always** parallel to a possible crystal face and **never** parallel to an existing plane of symmetry (remember that twinning adds symmetry).

If the twin law is a rotation axis, the composition surface will be irregular, the twin axis will be perpendicular to a lattice plane, but will never be an even-fold rotation axis of the existing symmetry. For example twinning cannot occur on a new 2 fold axis that is parallel to an existing 4-fold axis.

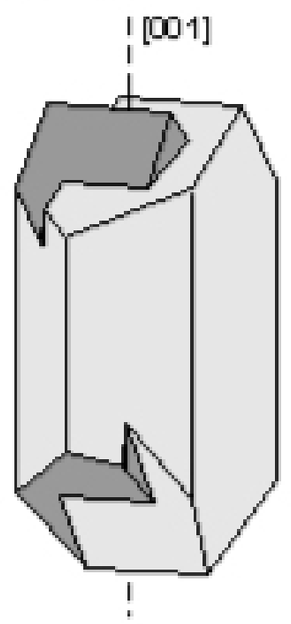
Types of Twinning

Another way of defining twinning breaks twins into two separate types.

1. ***Contact Twins*** - have a planar composition surface separating 2 individual crystals. These are usually defined by a twin law that expresses a twin plane (i.e. an added mirror plane). An example shown here is a crystal of orthoclase twinned on the Braveno Law, with {021} as the twin plane.

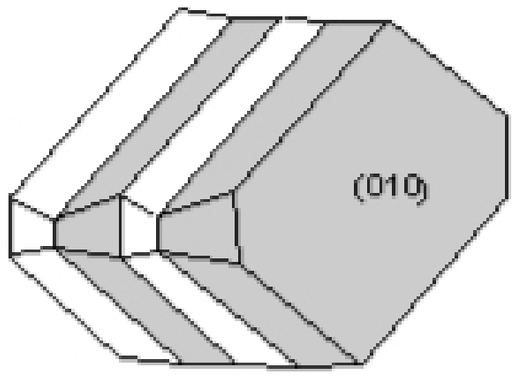


2. ***Penetration Twins*** - have an irregular composition surface separating 2 individual crystals. These are defined by a twin center or twin axis. Shown here is a twinned crystal of orthoclase twinned on the Carlsbad Law with [001] as the twin axis.

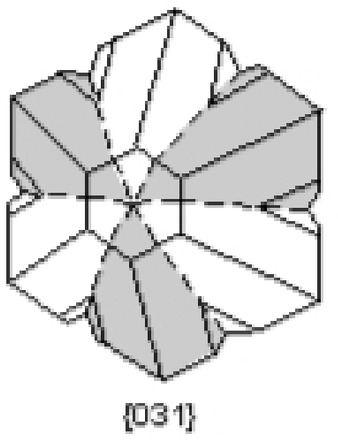


Contact twins can also occur as repeated or multiple twins.

- If the compositions surfaces are parallel to one another, they are called ***polysynthetic twins***. Plagioclase commonly shows this type of twinning, called the Albite Twin Law, with {010} as the twin plane. Such twinning is one of the most diagnostic features of plagioclase.



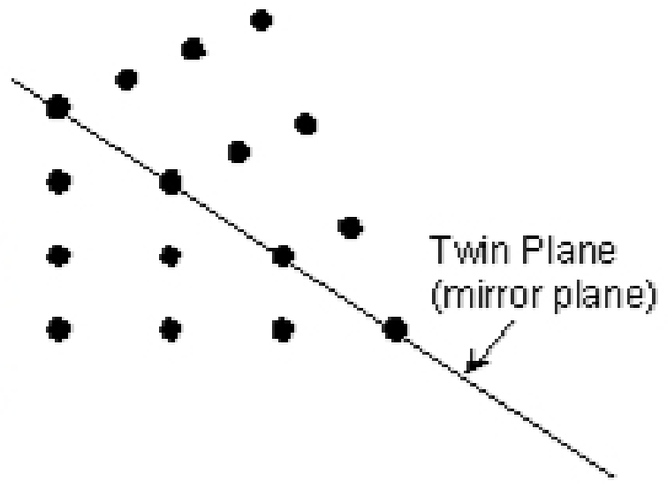
- If the composition surfaces are not parallel to one another, they are called ***cyclical twins***. Shown here is the cyclical twin that occurs in chrysoberyl along a {031} plane.



Origin of Twinning

Twinning can originate in 3 different ways, as growth twins, transformation twins, and glide or deformation twins.

1. Growth Twins - When accidents occur during crystal growth and a new crystal is added to the face of an already existing crystal, twinning can occur if the new crystal shares lattice points on the face of the existing crystal, but has an orientation different from the original crystal. Such growth twins can be contact twins, as illustrated here, or can be penetration twins. All of twins discussed so far are growth twins.



2. Transformation Twins - Transformation twinning occurs when a preexisting crystal undergoes a transformation due to a change in pressure or temperature. This commonly occurs in minerals that have different crystal structures and different symmetry at different temperatures or pressures. When the temperature or pressure is changed to that where a new crystal structure and symmetry is stable, different parts of the crystal become arranged in different symmetrical orientations, and thus form an intergrowth of one or more crystals. Dauphiné and Brazil twinning in quartz commonly forms this way during a decrease in temperature.

   Similarly the combination of albite twinning and pericline twinning in alkali feldspar results when high temperature sanidine (monoclinic) transforms to low temperature microcline (triclinic). This type of twinning is only observed using the polarizing microscope, and results in a "tartan" twinning pattern as shown in your text book on page 231, figure10.18. When this twinning pattern is observed with the microscope it is one of the most characteristic diagnostic properties for the identification of microcline.

3. Deformation Twins - During deformation atoms can be pushed out of place. If this happens to produce a symmetrical arrangement, it produces deformation twins. The mineral calcite can be easily twinned in this way, producing polysynthetic twins on $\{01\bar{1}2\}$.