

## FELDSPARS, EXOLUTION, ZONING, and TWINNING

The feldspar minerals are the most common minerals in the earth's crust. They are aluminosilicates of potassium, calcium, and sodium. The feldspars are divided into two groups, the alkali feldspars and the plagioclase feldspars. The plagioclase series is a solid solution series. The alkali feldspars are mainly potassium feldspar and albite. Albite and K-spar exhibit very limited solid solution at room temperature. If Na and K are both present in magma, the initial mineral will be a mixture of sodium and potassium but the resulting mineral will undergo **exsolution** as it cools. Two phases will be formed. Such mixtures are called **perthites** (albite or other sodic plagioclase in orthoclase) or **antiperthites** (microcline in plagioclase).

Feldspars are quite abundant in igneous rocks. The presence or absence of individual feldspar species is an important factor in igneous rock classification. Feldspars are also important constituents of many metamorphic rocks and are found in some sedimentary rocks, especially sandstones.

Some plagioclase feldspars will have one composition in the interior of the crystal, and a gradually or sharply changing composition toward the outer edge of the crystal. This is called **zoning**. There are several types of zoning. Continuous zoning occurs in minerals of a solid solution series, such as plagioclase, when the crystal grows under conditions of fairly uniform cooling of the magma, at a rate too fast to allow equilibrium to be maintained. Discontinuous zoning (example: calcic plagioclase with a narrow rim of sodic plagioclase) might occur when convection currents within magma carry a calcic crystal into a much more sodium-rich environment, or from a sudden change in physical conditions. Reverse zoning (calcic plagioclase surrounding the lower melting sodic plagioclase) is indicative of late reaction with foreign crystals with magma or possibly metamorphism. Oscillatory zoning (see Figure 1) is a large number of thin shells of different compositions. The cause is uncertain.

Feldspars are either monoclinic (sanidine, orthoclase) or triclinic. **Twinning**, a very common phenomenon in the feldspars, varies according to the composition and the crystal system. There are at least seven different twin laws for the feldspars. Of these, only three are common.

54. Compositional zoning in plagioclase is common. If the crystal is more sodic toward the rim, it is said to be normally zoned; if it is more calcic, it is reversely zoned. If the composition fluctuates back and forth, the plagioclase has oscillatory zoning, as seen in this phenocryst in an andesite from Mount St. Helens. Crossed polars, X20.

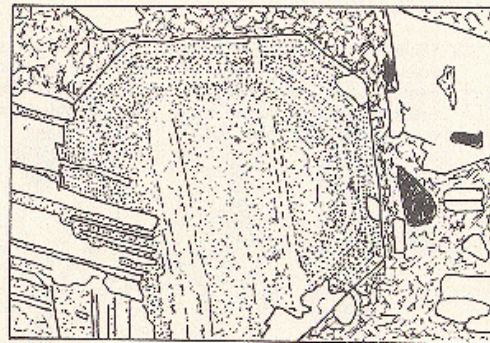


Figure 1

**Carlsbad:** Seen in either monoclinic or triclinic feldspars. Carlsbad twins are growth twins (that is, they form while the crystal is growing). They are seen as a pair of individual crystals, separated by a single line, in thin section (See Figure 2). Carlsbad twinning is a type of penetration twinning. Carlsbad twinning is common in igneous rocks, but very rare in metamorphic rocks.

**Albite:** Seen only in triclinic feldspars. Albite twins may be growth, deformation, or transformation (formed when the crystal is transformed from mono- to triclinic) twins. Albite twinning is polysynthetic contact twinning. It is seen as numerous individual twins, parallel to each other, in thin section (See figure 3). The twins may be wedge-shaped (thicker at one end) if the twinning results from deformation.

**Pericline:** Seen only in triclinic feldspars. Pericline twinning is quite similar to albite twinning. It may result from growth, deformation, or transformation. It is a polysynthetic contact type of twinning and shows a similar appearance to albite twinning, although with a different crystallographic orientation.

It is also possible for crystals to exhibit compound twinning in which two twin laws are expressed simultaneously.

**Albite-Carlsbad:** The two halves of the Carlsbad twin may show albite twinning. The albite twins are oriented parallel to the Carlsbad twins.

**Albite-pericline:** During transformation, both albite and pericline twins may form. The combination results in a "cross hatch" effect. Cross hatch twinning is particularly common in microcline because microcline often forms by transformation from orthoclase. Cross hatch twinning is often called "gridiron" twinning.

Twinning can be observed only under crossed-nicols.

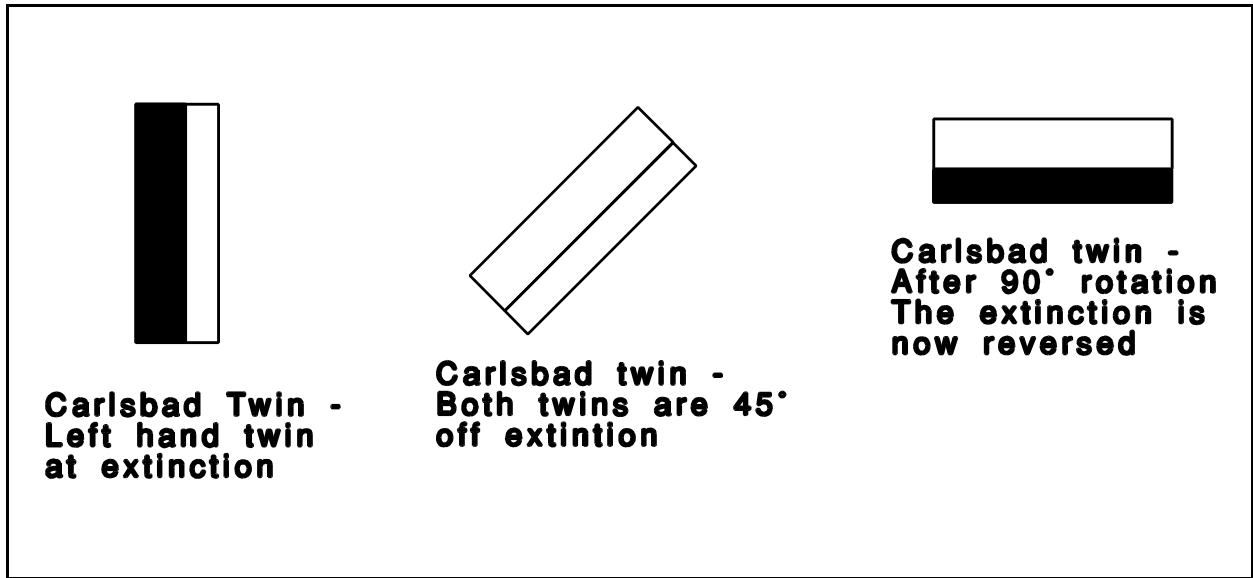


Figure 2

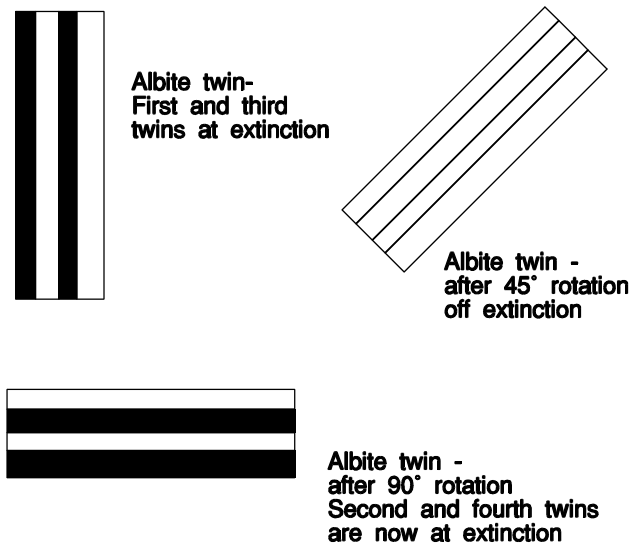


Figure 3

**ASSIGNMENT:** Examine each of the following feldspar thin sections. Use the guidelines from lab 10 in preparing this and all future assignments for this course. Make a sketch of a mineral showing each of the following:

1. Carlsbad twinning
2. Albite twinning
3. Albite-Carlsbad twinning
4. Gridiron twinning
5. Ex-solution
6. Zoning

You may sketch one mineral showing two or more features, if you can find a good example. You are responsible for looking at all sections, whether sketched or not.

The thin sections are from the feldspar set (red labels), the mixed mineral set (white labels), and the North American rock set (NARS - red numbers on a white background).

2 (red) Albite - shows albite twinning

23 (white) Oligoclase - many are oligoclase peristerites ( a form of exsolution)

5 (red) Andesine - Albite and Carlsbad twinning

8 (red) Labradorite - Large crystals showing albite and Carlsbad twinning

12 (red) Bytownite - Missing (slide broken)

9 (red) Anorthite (with pyroxene) - pyroxene is green in pp, often showing bright interference colors in crossed nicols

26 (white) Orthoclase - may contain some microcline showing gridiron twinning

2 (red numbers) - Muscovite-Biotite Granite - some zoning

3 (red numbers) - Biotite-Hornblende Granite - good zoning

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