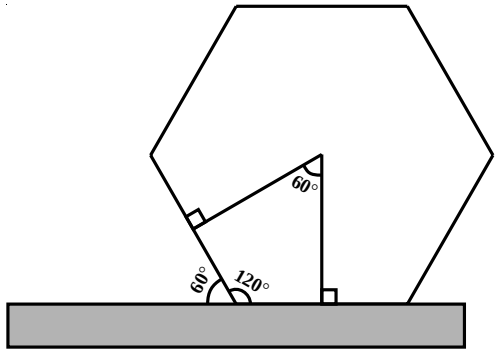
Lecture Notes - Mineralogy - Crystals are Patterns

- A mineral is a naturally occurring, inorganic crystal.

- **Interfacial angles** for good mineral crystals are measured perpendicular to the line of intersection of two crystal faces. The angle reported is always the acute angle. It is also the **acute** angle between the two normals to the crystal faces, measured in the plane defined by the two normals. Interfacial angles can be measured using a **contact goniometer** or more precisely using a **reflection goniometer**. See Klein & Hurlbut's figure 2.40.

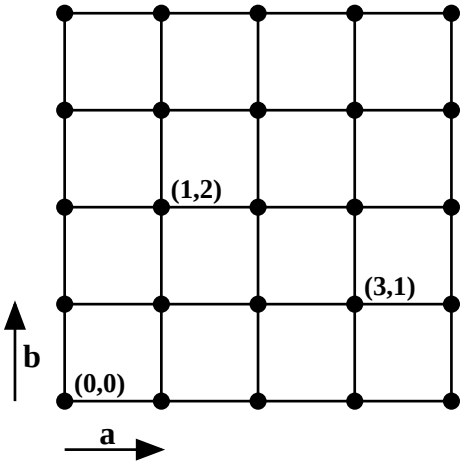


- The interfacial angle between two faces of a mineral crystal is identical for all crystals of the same mineral that exhibit the corresponding two faces. This is true regardless of the size or place of origin of the crystals! The observation of the **constancy of interfacial angles** was first reported by Nicolas Steno in 1669.

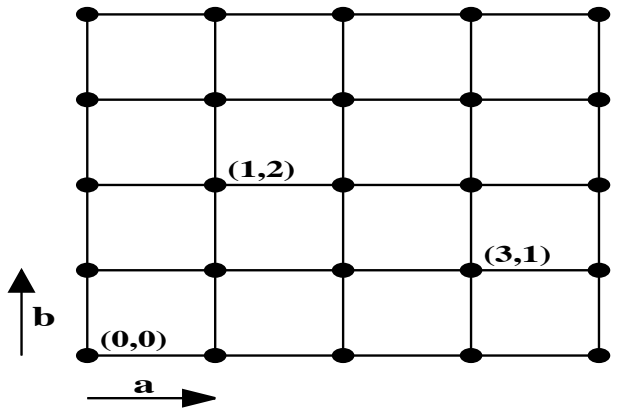
- The observation of the constancy of interfacial angles led to the suggestion that crystals are built according to a **pattern** from building blocks that are small relative to the size of any macroscopic crystal.

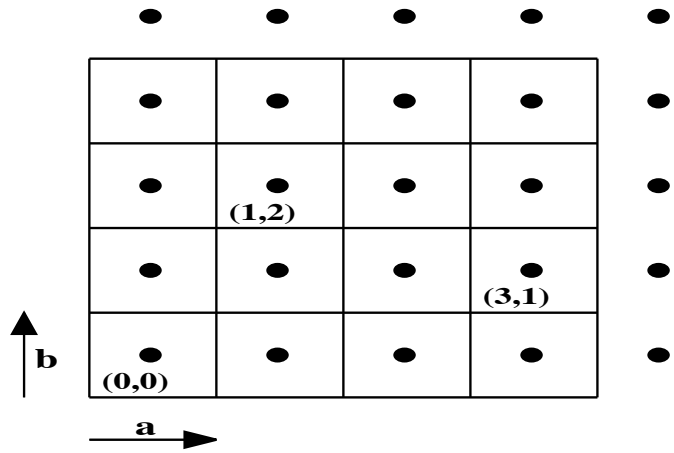
- Pattern recipes require a repeating unit or motif and instructions for how to perform the repeat. The recipe for a specific pattern may be discovered from the pattern by making some careful observations. (a) Identify points in the pattern that have identical surroundings, but which are offset from one another. The set of all such **translationally equivalent points** is called the **lattice** for the pattern. (b) Choose one lattice point to serve as an origin. (c) Connect the origin with adjacent lattice points (two for two-dimensional patterns, three for three-dimensional crystals) with lines (called **translations** or lattice vectors), making sure that the lines are not colinear or (for three-dimensions) coplanar. The parallelogram (or parallelepiped) defined by these two (or three) translations is called the **unit cell** for the pattern or crystal and contains within its boundaries the complete recipe for constructing the pattern.

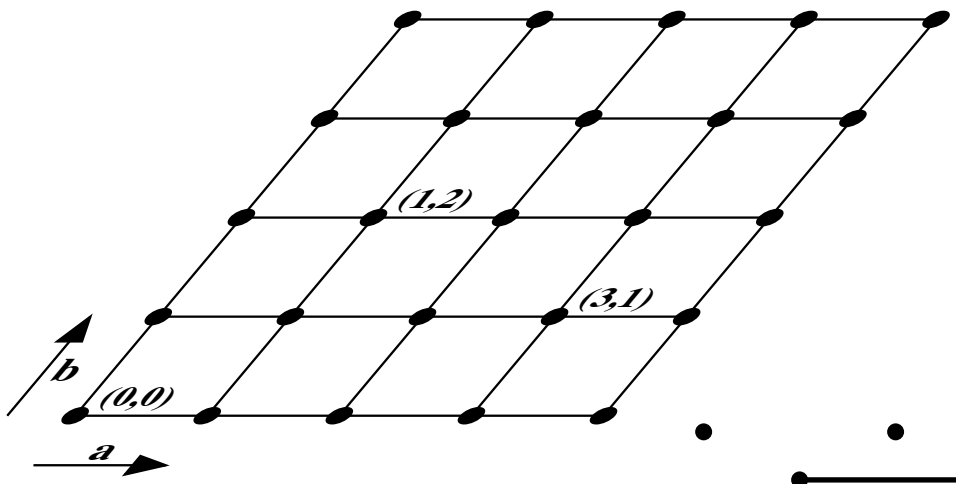
- Unit cell translations may be used to define a coordinate system for a crystal. Points are located in **crystallographic coordinate systems** by measuring parallel to the unit cell translations. In practice, this is like using graph paper that has been stretched, so that the squares become rectangles, or sheared, so that the squares become parallelograms.

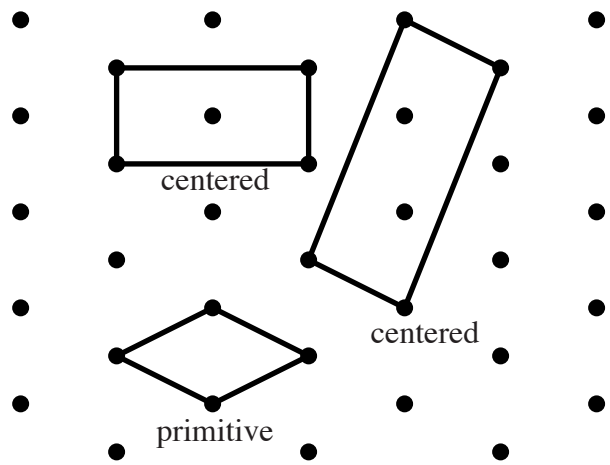


- Unit cell translations are labeled **a**, **b**, **c**. Their positive directions are selected to define a **right-handed coordinate system**: if the index finger on your right hand points from positive **a** to positive **b**, then your thumb points in the direction of positive **c**. The angles between unit cell translations are identified by the Greek letter corresponding to the name of the opposite translation. For example, γ is the angle opposite **c** (*i.e.* the angle between positive **a** and positive **b**). Similarly, the angles opposite **a** and **b** are α and β, respectively.









- For any given lattice, there are many possible choices of unit cell. Normally, the unit cell translations are selected so that there is one unit cell for each lattice point. Any such unit cell would be a primitive unit cell. All primitive unit cells have the same area (or volume). In some instances, however, it is convenient to choose a larger unit cell such that there is one unit cell for every two (or more) lattice points. These are called centered unit cells. **Centered unit cells** are generally choosen to have a rectangular geometry.