The Mineral Crystals

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In a crystal, the atoms are arranged in a definite and repetitive pattern. That means each piece of crystal consists of a definite number of atoms of the component elements arranged in a precise pattern. The result of this regular atomic arrangement is that crystals show definite external geometri¬cal shapes, bounded by plane faces. An example is the mineral quartz found in many parts of the world.

Most minerals occur in nature in crystalline form; thus their appearance and many of their properties largely depend upon the arrangement of the atoms within them. We call this their crystalline structure. It has already been mentioned that carbon can exist in the beautiful form of the diamond, but that it also occurs as graphite and soot. The fact is that one chemical substance can have two or three completely different appear¬ances; this does not apply only to the element carbon, but to many other substances.

In the graphite crystal, however, the atoms are arranged in flat, six-sided sheets, and these sheets are themselves only loosely linked with one another. This means that they can slide over each other. Thus, graphite is greasy to the touch and can be used as a lubricant when mixed with grease.

In nature, some gem minerals are found in the form of regular and sym¬metrical crystals with natural, lustrous plane faces. Some are indeed so per¬fect that they are used for native jewelry without being cut or polished. An example is the spinel crystal.

It must not, however, be assumed that a mineral can occur in any crystal shape. This is not so. To begin with, each mineral that occurs in crystalline form belongs to one of seven systems, and when the crystal system of a gem mineral in its natural form can be recognized, a great deal can be learned about that mineral's identity. For example, if some natural diamond crystals are examined, it is found that this mineral normally crystallizes in the shape of a double pyramid called an octahedron. Thus we know that a crystal of this shape can belong only to the so-called cubic crystal system, and therefore it can be deduced immediately that the mineral must belong to that system.

In order to define a crystal system, certain imaginary lines of reference must exist in order to describe the relative positions of the crystal faces. These imaginary lines are called crystal axes and there are usually three, or at the most four, such axes, which all intersect in the crystal's center. The impor¬tant thing to remember is that in each crystal system the crystal axes are arranged in one particular, fixed way that never varies, whatever form the crystal may take.

Perhaps the simplest of all crystal systems is the cubic one where the three crystal axes are all of an equal length, and intersect one another at right angles. Figure 5 illustrates the crystal shapes of the cube, the octahedron, and the dodecahedron, all of which belong to the cubic system and can there¬fore be described by the same three crystal axes (a). The diamond is usually found in the form of an octahedron and thus is described as being of octa¬hedral habit.

The gem stone zircon occurs in crystals of the tetragonal system. As Fig. 8 shows, these crystals look rather like building bricks. They have three crystal axes that intersect one another at right angles, but, unlike the cubic system, only two of these crystal axes (a) are of equal length, and the third vertical axis (c) is unequal.

In nature, crystals of the emerald occur like regular six-sided pillars (see Fig. 10), and these belong to what is known as the hexagonal crys¬tal system. This is one of two systems that have four crystal axes. Three of these axes (a) are of equal length and cross one another at angles of 60°, while the fourth axis (c) is unequal and stands at right angles to the plane formed by the other three.

Similarly, the remaining four crystal systems are described by their re¬spective crystal axes. The triclinic system (see Fig. 11) has three crystal axes, unequal in length and intersecting obliquely: c is the vertical axis; a is the shorter horizontal axis running from back to front, also known as "brachy-axis" (brachy in Greek means short); b is the longer horizontal axis running from right to left, also known as "macroaxis" {macro in Greek means long). The orthorhombic crystal system has three crystal axes {a, b, c), unequal in length and at right angles to each other (see Fig. 12). The monoclinic crystal system has three unequal crystal axes (a, b, c), one at right angles to the other two, which intersect obliquely.

One fascinating aspect of crystals is that they exhibit what are called direc¬tional properties. This rather grand-sounding phrase is best explained by some practical examples. A ruby crystal may, for instance, have a good red color if viewed from one direction, yet from another it will look brownish red. The explanation, of course, lies with the atomic patterns within the crystal itself, which allow certain colors to pass in one direction but not in another.

The diamond, despite its hardness, can be split easily in any plane parallel to a crystal face of the octahedron. This is comparable to a man chopping firewood. It is far more difficult to split a log across the grain of the wood fibers than it is to do so lengthwise in the direction of the fibers. The reason is that the wood fibers are extremely tough and difficult to cut across, whereas the individual fibers are only relatively loosely joined together. Similarly, there are certain directions in a diamond crystal where the atoms are linked more loosely, and in these directions it is possible to split a diamond with¬out great difficulty. In any other direction, the atoms hold tightly together and cannot be parted.

These directional properties must receive careful consideration when crys¬tals are chosen for gem stones, and the beauty of the final product will de¬pend upon the skill and knowledge of the lapidarist, or gem cutter whose job it is to cut and polish them.