



What gives a crystal shape? Symmetry, periodicity and... twins

During the 19th century, the notions of frequency (periodic repetition) and atomic order became important in the study of form and symmetry in crystals.

Bravais' idea was as follows: the stronger the bonds between molecules in the plane of a crystalline face, the more the face develops. The planes which are more likely to appear are those with higher molecular density.

Combining symmetry and lattice systems

At the end of the 19th century, the hypothetical molecules are replaced by more complex wallpaper-like patterns containing atoms and potential new symmetries.

These symmetry patterns were hypothesised by Sohncke and then recorded by Schoenflies and Fedorov. This albeit abstract theory was to be confirmed in 1912, together with the periodicity of the crystals, by the first X-ray diffraction experiments.

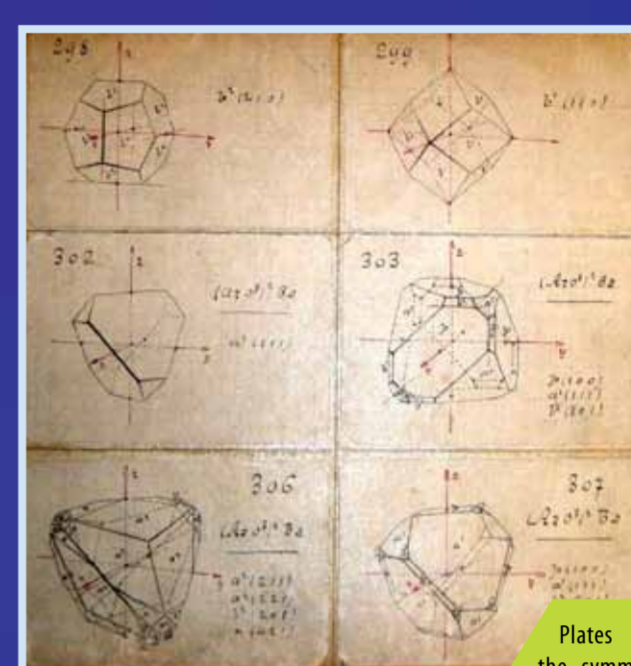
Linking the form of the crystals to their atomic structure

Georges Friedel carried on from Bravais and observed a large number of natural crystals. He was able to prove that the frequency of appearance of a face is linked to the density of the points of the lattice, and, therefore, to the crystal's intimate structure. This is the Bravais-Friedel law.

We can see that by the beginning of the 20th century, before being able to "see inside" crystals, crystallographers had already established a body of experimental and theoretical knowledge of them.



Auguste Bravais



Plates showing the symmetries used by Georges Friedel in his courses at the Ecole des Mines de St Etienne

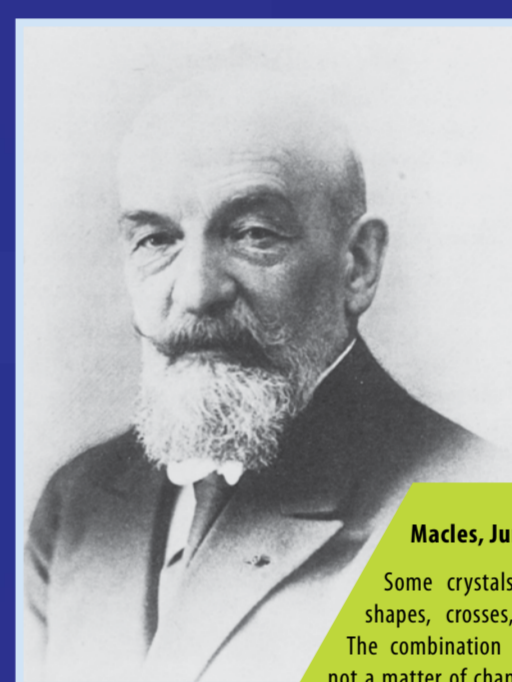
Source : Coll. Ecole des mines de St Etienne



Twinned crystals («macles») and wooden models

Crystals can be very complex in form with «sunken» angles; they are known as twinned crystals or «macles». A twinned crystal is the result of two crystals grouping together geometrically following a strict crystalline symmetry rule (mirror, rotation) not proper to one of the crystal. Every twinned crystal is associated with a pseudo-symmetry in the crystal:

- **Staurolite**, Coray, Bretagne. Collection des Minéraux, ©UPMC-Paris «St Andrew's cross» twin
- **Pyrite**, Logrono, Espagne. © Coll. Muséum de Grenoble «cube» twin
- **Gypse**, Sicile. © Coll. Muséum de Grenoble «lance-head» twin
- **Quartz**, La Gardette Isère ©Muséum Grenoble «Japan» or «Gardette» twin.



Macles, Jumeaux, Twins, ...

Some crystals form groups with astonishing shapes, crosses, arrows, stars, butterfly wings... The combination of crystals forming these groups is not a matter of chance. In 1751 Gauthier de Robien was the first to provide a description of «macles» in his «new ideas on the formation of fossils». This was followed up in the 18th and 19th centuries by a number of different observations and studies. Theoretical works on the grouping of crystals flourished in the 20th century, with the work of Georges Friedel in particular. Friedel established a theory of twinned crystals called «macles», based on the existence of a twin lattice which could extend throughout the lattice of the crystal itself.

Source: Romé de l'Isle 1772, *Essai de Cristallographie*
Georges Friedel 1904, *Etudes sur les groupements cristallins*
Georges Friedel 1926, *Leçons de Cristallographie*
J.Claude Boulliard 2010, *Le cristal et ses doubles*

