Alumosilicates: Andalusite, Kyanite, Sillimanite
鋁硅酸鹽：紅柱石、藍晶石、矽線石

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來自尼泊爾猶如藍寶石般的藍晶石，在市場上的出現，促使作者論述這種相當罕見的寶石及它的同質異像體（有相同化學成分，但不同晶格的礦物）--紅柱石和矽線石，包括它們形成的環境、寶石特徵和品種。

The appearance on the market of sapphire blue kyanite from Nepal has motivated me to report on this rather rare gemstone and its relationship to the other polymorphs with the same chemical composition, but different crystal lattice.

Al_2SiO_5 exists in three polymorph minerals, andalusite, kyanite and sillimanite (Deer et al., 1992). That means that the same chemical compound can crystallise with three different crystal lattices each with different symmetry. Which one of the three will be formed depends mainly on the prevailing pressure and temperature conditions of the parent rock, usually Al rich pegmatite or metamorphosed sedimantary rock. In the phase diagramme in Fig. 1, the stability fields of the different alumo silicates is shown. With a change of the p/T conditions crossing a phase boundary, the mineral will transform into the new phase. At lowering pressure and about 400°C kyanite would become andalusite. Alumosilicates are formed in aluminium-rich igneous and metamorphic rocks. All three polymorphs can co-exist around the so called triple point (see Fig. 1). The presence of one, two or three of the Al_2SiO_5 polymorphs in a rock provides valuable information to the geologist about the conditions of its formation.

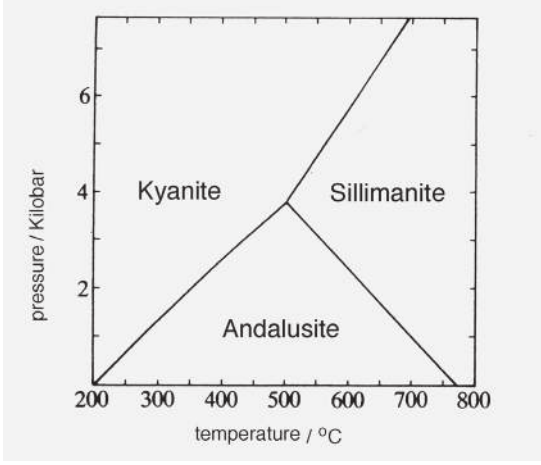

Fig. 1 A pressure/temperature diagramme (p/T) showing the stability fields of the alumosilicates andalusite, kyanite and sillimanite.

Well-crystallised alumosilicates can make pretty gemstones (Arem, 1987). Recently we have been seeing more blue kyanite in faceted, cabochon cut stones and bead necklaces than before; a welcome enrichment to the market place (Henn & Schollenbruch, 2012).

Andalusite (Fig. 2) crystallises in the orthorhombic system as a biaxial mineral. Its refractive indices vary slightly due to possible substitutions (e.g. Fe, Ti for Al) from nα = 1.629 - 1.640, nβ = 1.633 - 1.644, nγ = 1.638 - 1.650. Andalusite as a gemstone is brown to reddish and olive green in colour and strongly pleochroic. Viridine is a rare green variety of andalusite. Chiastolite, an ornamental stone, grey with a black X formed by inclusions of carbon rich minerals is quite common.

Kyanite (Fig. 3) crystallises in the triclinic system, as a biaxial mineral. Its refractive indices vary slightly due to

Fig. 2 Andalusite crystals and cut stones (oval 3 cts) from Brazil. Chiastolite from Australia.
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Fig. 3 Two Kyanite crystals from Kenya, next to cut kyanite from various deposits (the largest is 11 cts).
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possible substitutions (e.g. Fe, Ti , Mn, Cr for Al) from nα = 1.712 - 1.718, nβ = 1.720 - 1.725, nγ = 1.727 - 1.734. Kyanite as a gemstone is mostly blue, the colour caused by the chromophores Fe and Ti, as in blue sapphire (Krzemnicki, 2013). Should there be a small amount of chrome present, a colour change of the α-vibration is noted (Bosshart et al., 1982). Blue kyanite of gemstone quality is found in many places, as, e.g. Brazil, Madagascar, India, USA and Nepal. Light green material has also been seen from Brazil.

For some years now orange-yellow kyanite has also been found in N-Tanzania near Loliondo, which is already known for its spessartine garnets. Not surprisingly, the yellow colour in kyanite is also due to Mn.

Sillimanite (Fig. 4) crystallises in the orthorhombic system, as a biaxial mineral. Its colour is colourless to light greyish blue and brownish grey with nα = 1.653 - 1.661, nβ = 1.654 - 1.670, nγ = 1.669 - 1.684. Like Kyanite, sillimanite has strong cleavage and may be difficult to cut. Sillimanite is an indicator for high pressure/high temperature metamorphism in rocks and is often found where continents have collided. Faceted sillimanites come from Sri Lanka, India and Burma. Light yellow stones were first seen about 10 years ago. Like the attractive cat's eye sillimanites, these stem from India.

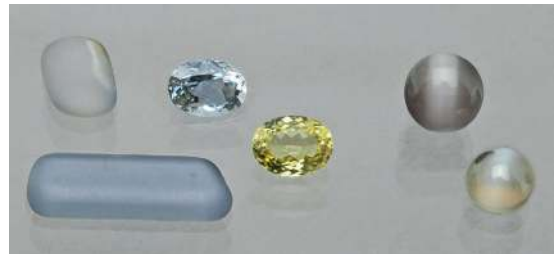

Fig. 4 Two rolled Sillimanite crystals. The faceted stones are from Sri Lanka (blue, 2.97 cts) and India (yellow, 3.31 cts). The cabochon cat's eye are also from India (Orissa).
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