The Belle Époque to 2000

Paris, the Belle Époque. This was a time when couturiers and jewellers extolled feminine beauty and gentlemanly elegance. It was also a time when Hrand Djevahirdjian, an Armenian lapidary, was manufacturing Geneva rubies in his workshop at 74 rue La Fayette. A time-consuming and demanding skill, it consisted of melting down scraps of natural ruby, then cooling and cutting them to obtain tiny button rubies.

Hrand Djevahirdjian was fascinated by the publication in 1902 of Professor Auguste Verneuil’s work on the creation of synthetic ruby. Verneuil had just invented a blowpipe using coal gas and oxygen, thereby opening up the way to industrial production. Hrand Djevahirdjian tried out the process, then improved on it by replacing the coal gas with hydrogen.

Villeurbanne, 1905. The overwhelming success of these synthetic stones forced Hrand Djevahirdjian to leave Paris and set up shop in Villeurbanne, where l’Oxyhydrique Française was able to supply him with hydrogen and oxygen.

Arudy, 1908. As orders kept pouring in, fresh investment and more plentiful energy sources were needed. This entailed leaving Villeurbanne and moving to Arudy in the Pyrénées, in south-western France.

Monthey, 1914 to today. Once again, there was insufficient gas and space! This time, Hrand Djevahirdjian’s search for new premises took him around much of Europe. In the small town of Monthey (Switzerland), the local chemical firm was able to supply him with the electricity and hydrogen he required. The town was located near the Paris-Milan railway line, and closer to his main clients. What is more, it was in the French-speaking part of Switzerland. The situation was ideal and Hrand Djevahirdjian immediately decided to move his business there.

The company became more self-sufficient during the First World War and began to produce ammonia, oxygen and hydrogen, thus becoming a chemical plant in its own right! The young manufacturer introduced new products: synthetic ruby for the watchmaking industry and sapphire for phonograph needles and meter bearings.
The company fell on hard times during the Depression of the 1930s. Badly in need of help, Hrand Djevahirdjian turned to his nephew Vahan, a chemical engineer, and persuaded him to leave Paris. Together, they reversed the situation and modernised the gas production installations.

Vahan took over on Hrand’s death in 1947. The age of post-war prosperity and technical development gave the company fresh impetus.

In 1960, Djeva supplied its first rubies for lasers to the United States. It then participated in the Telstar project, America’s first telecommunications satellite.

The plant had its own applications laboratory and, in 1974, added a laser boring workshop for watch rubies.

Two years later, perhaps the greatest dream of all came true when Djeva produced an excellent diamond substitute, the DJEVALITE®.

Katia Djevahirdjian, Vahan’s daughter and a chemical engineer herself, joined the board of directors in 1976 and has chaired the company since 1992, following her father’s death.

Granite strata in Monthey

When he moved for the third time in 1914, Hrand Djevahirdjian was determined to plan for the long term. He wanted no restrictions on expanding the company, and the 45,000 square metres of land he acquired at Monthey filled the bill perfectly.

There are currently 10,000 square metres of buildings, housing ten departments: the production of refractory clay muffles, water electrolysis, the purification of ammonia alum, the calcination of the alum, the production of synthetic stones, quality control, and heat treatment, as well as laser machining, an applied research laboratory and the company’s technical & administrative services.

Djeva has been a limited company since 1924 and currently employs over 100 people.

As well as manufacturing synthetic stones for both the jewellery and industrial sectors, Djeva offers a range of crystals to meet a wide variety of needs.

Its reputation has been built on its pioneering spirit, commitment and experience. Over the years, it has won the confidence of a large international clientele.
Tradition and progress

From Geneva rubies to popular coloured gemstones, from light-polarising rutile to the colourless sapphire used to protect watch dials and satellite solar cells, Djeva has always strived to keep pace with the requirements of state-of-the-art industry and to ensure that its synthetic stones are at the forefront of fashion. Needless to say, the company is always on the lookout for the earliest sign of a future trend. Its adaptability has put it in an enviable position, particularly in the scratch-resistant sapphire watch crystal market.

Djeva's production is based on three types of crystal:

- corundum is a rhombohedral-hexagonal single crystal. This aluminium oxide is usually produced in its colourless version and delivered in half or whole boules. The latter are annealed at a high temperature to eliminate internal stress. They can then be cut up in any direction without shattering at the slightest mechanical or thermal shock. Coloured stones are obtained by adding oxides such as chrome, titanium and iron, nickel, vanadium, cobalt, etc.

- spinel crystallises in the cubic system. This magnesia aluminate is colourless. Adding metal oxides produces stones of different colours, mostly used in jewellery.

- rutile is a tetragonal monocrystal. This titanium oxide is widely used in optics because its refractive index is higher than that of diamond. It can also be doped.
### Characteristics of Verneuil crystals

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Colourless corundum Al₂O₃ (synthetic sapphire)</th>
<th>Rutile TiO₂</th>
<th>Spinel MgO·3.5 Al₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline structure</td>
<td>rhombohedral-hexagonal single crystal</td>
<td>tetragonal single crystal</td>
<td>cubic single crystal</td>
</tr>
<tr>
<td>Composition</td>
<td>Al₂O₃</td>
<td>TiO₂</td>
<td>MgO·3.5 Al₂O₃</td>
</tr>
<tr>
<td>Main impurities</td>
<td>Na, Si, Ca, Fe, Ga, Mg, Ti, Mo, Pb, Cu, Zn, Ni, Cr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleavage</td>
<td>conchoidal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>3.98 - 3.99 g/cm³</td>
<td>4.25 g/cm³</td>
<td>3.41 g/cm³</td>
</tr>
<tr>
<td>Dislocation density</td>
<td>10⁹/m²</td>
<td>10⁹/m²</td>
<td>10⁸/m²</td>
</tr>
<tr>
<td>Thermal Properties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting point</td>
<td>2320 K</td>
<td>2100 K</td>
<td>2300 - 2330 K</td>
</tr>
<tr>
<td>Softening point</td>
<td>2070 K</td>
<td>2070 K</td>
<td>2300 - 2330 K</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific heat</td>
<td>7.5.10² J/kg.K at 300 K</td>
<td>10¹⁹ J/kg.K at 300 K</td>
<td>8.6.10² J/kg.K at 300 K</td>
</tr>
<tr>
<td>Thermal expansion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Properties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dielectric constant</td>
<td>10.6 electric field // C-axis at 300 K</td>
<td>170 electric field // C-axis at 300 K</td>
<td>8 - 9</td>
</tr>
<tr>
<td>Electrical resistivity</td>
<td>10⁵ Ω.cm at 300 K</td>
<td>10⁴ Ω.cm at 770 K</td>
<td></td>
</tr>
<tr>
<td>Optical Properties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractive index n, at 0.5893 µm</td>
<td>1.760 face // C-axis</td>
<td>2.903 face // C-axis</td>
<td>1.727</td>
</tr>
<tr>
<td>Chromatic dispersion (nF – nC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Visible light</td>
<td>1.760 face // C-axis</td>
<td>2.816 face // C-axis</td>
<td>1.055 face // C-axis</td>
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<tr>
<td>- Infrared</td>
<td>0.051 λ = 0.6861 μm</td>
<td>0.205 face // C-axis</td>
<td>0.012</td>
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<tr>
<td>- Ultraviolet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Disc thickness</td>
<td>1 mm</td>
<td>2.54 mm</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

For certain applications, a Verneuil crystal is chosen for its resistance to wear and to mechanical shocks. For others, the crystal needs to be resistant to contact with chemical agents, maintain its shape and withstand high temperatures. Then, there are applications that require specific electrical properties or a precise optical transmission in visible light, or in ultraviolet or infrared waves. Sometimes, it is just a question of a particular fire!
100-year-old technology

The process developed by Professor Auguste Verneuil and improved by Hrand Djevahirdjian has withstood the test of time. A combination of science and empiricism, it is still being used in the plant at Montheuil.

What is it exactly? Rest assured that there is no black magic!

The synthesis of stones involves fusing alumina - with or without the addition of metallic oxides - using an oxyhydrogen blowpipe and producing crystal drop by drop, much like a stalagmite, at a temperature greater than 2000 degrees centigrade.

The real art of synthesis behind this deceptively straightforward operation resides in the accuracy of the various settings while the crystal is growing, a process that can last for several hours or even days. Fusion has to be conducted continuously in the same area of the downwardly-applied flame so that the crystal can be built up by the superposition of very fine layers of molten material.

Due to advances in industrial techniques, however, components are now available that not only meet our exacting demands but also open up interesting possibilities for automating the process.
A craft and a science

Alumina or aluminium oxide, the raw material for corundum, is extracted from bauxite. Most of this comes from Australia and is converted into ammonia alum in Germany and France. Partially refined, it is then delivered to Djeva.

Before the crystal makes its almost magical appearance, several preliminary operations have to be completed in various sections of the plant:

- the purification of ammonia alum through recrystallisation after hot-water dissolution, then filtration. This process eliminates impurities which are likely to affect the quality of the stones.
- the calcination of alum in the furnaces at temperatures over 1100° C. Purified alum, sometimes mixed with colouring agents, is distributed into quartz crucibles to undergo thermal decomposition. This operation is performed day and night. The alum is transformed into a sort of fragile meringue, which is then sieved to obtain a fine alumina powder of microscopic crystals.
- the manufacture of refractory clay muffles through pressing. Varying in diameter, these protect the crystal during its growth and its cooling.
- the production of hydrogen and oxygen through electrolysis. These gases feed the blowpipes.

What nature takes millions of years to create, Djeva can reproduce in a few hours!

Within the production area, more than 2000 blowpipes are arranged in several units. The flames are fed with a meticulously controlled supply of hydrogen and oxygen, whilst hammers, like little tapdancers, strike the powder drums to ensure a smooth flow of small quantities of alumina powder. This melts and progressively builds up on to the seed crystal, giving the stone its crystalline direction. All that remains is to monitor the growth of the stone through an opening in the fire-proof oven and to carefully regulate the operation, which ends when the flames are extinguished.

The quality control of the crystals requires the skill of specialists, who sort the stones into various types according to shape, inclusions, cracks and intensity of colour.

Djeva's production equipment comprises unique, custom-built machinery and instruments, which the workforce itself helped to design. This dynamic encourages constant dialogue amongst members of the technical staff.
Water, the vital ingredient

Hydrogen and oxygen, which feed the insatiable flames of the blowpipes, are for the most part produced by water electrolysis within the company itself. But Djeva maintains close links with outside suppliers to supplement its stock.

On days of peak production, daily consumption of these gases amounts to as much as 30 000 cubic metres. This varies, of course, between day and night, and sometimes from one hour to the next. Enjoying the benefits of modern technology, the plant is presently equipped with enormous pressurised buffer tanks for storing the equivalent of approximately 20 000 cubic metres of hydrogen and oxygen. These reserves provide the necessary flexibility for production and consumption.

Djeva consumes around 40 million kilowatt-hours of electricity a year, comparable to the needs of a village of 7500 inhabitants! This energy is mainly produced by hydroelectric plants and supplied by a nearby company.

Mindful of its environmental responsibilities, Djeva possesses a range of high-performance equipment for processing the gases produced by the decomposition of alum and for water treatment. The company, therefore, complies in full with current legal requirements.
Jewellery and industrial stones

Essentially, Djeva supplies the rough crystal. This is then cut and machined in different places around the world for use in either the simplest or most complex applications in the fields of jewelry, communications, new technologies and medicine.

The jewellery sector finds inspiration in Djeva crystals, with their wide range of tints and nuances, more than 60 in all. There are rubies from light to deep red, sapphires from Cashmere blue to Burmese blue, from yellow to orange, and a rainbow of corundum shades, including purple, alexandrite, oriental emerald and alexite.

When cut into cabochons, some synthetic stones are more subtle and vie with the finest natural specimens for beauty. Under a spotlight, their rutile inclusions reveal a six-pointed star at the curve of their periwinkle blue, pink or lilac dome. As for the spinels, their delicate colours evoke aquamarine, pink beryl, green tourmaline and yellow zircon.

The genius of man, the metamorphosis of material... Guided by knowledge, the hand of the master craftsman can transform a piece of rough, lifeless material into a beautiful and bewitching gem.

The watch industry consumes a large quantity of corundum. Over the centuries, watches have been embellished with precious metals, engravings and high-quality enamels. Likewise, for 30 years or so, sapphire has brought its own personal touch to the watchmaker’s art. Restricted initially to jewellery watches, scratch-resistant sapphire crystal has fulfilled the expectations of its creators and is now used in a whole range of increasingly sophisticated products.

The watch industry also uses ruby to make bearings, endstones, pallets and impulse pins. The hardness of this corundum guarantees its longevity, while its homogeneity helps to achieve precision when boring, cutting and polishing.
Djeva's laser boring is backed by a quarter of a century of experience in high-precision machining of ruby and sapphire bearings. Its perfection and speed have made it a highly-valued specialist in drilling holes with diameters varying from one to ten hundredths of a millimetre. Laser technology has revolutionised the technique handed down by the Swiss optician Nicolas Fatio de Duillier. The age of the high-speed drill belongs to history!

Industry uses synthetic crystals for a multiplicity of purposes. It is hardly surprising, therefore, that the range of industrial applications is constantly expanding.

In micromechanics, there are countless applications for ruby and sapphire. In the following examples, the hardness and non-porosity of the crystals are crucial in limiting wear on components:

- microbearings for electricity meters and water meters
- balls for metrology probes
- engraving blades
- pin-guides for printer heads
- magnetic tape guides and cleaners
- thread guides for the textile industry
- conical pivots for compasses
- injection nozzles for oil-fired furnaces
- pistons, pipes, injectors, carburettor choke tubes, etc.

Chemical engineering uses synthetic sapphire, amongst other materials, for its:

- observation windows in furnaces and chemical reactors
- detector cell windows (chemical analysis and chromatography).
The world of optics uses the transmission capabilities of corundum and rutile in visible light, and in infrared and ultraviolet waves. These crystals are used as:
- lenses and windows for infrared detectors
- prisms for refractometers.

The revolution set off in the early 1960s by the work of a few scientists on the amplification of light resulted in Djeva’s close involvement with the development of laser technology, especially in industry and medicine.

During the same period, the Plouzané-Bodou telecommunications centre in Brittany was the first to use a ruby laser immersed in a liquid helium bath to amplify signals from Telstar-type satellites and to transmit television images from the United States to Europe. These sorts of developments have opened up fresh opportunities for synthetic ruby.

Rutile provides a higher refractive index than diamond, its field of application is limited, however, because it is scarcely any harder than glass.

The electronics sector also uses sapphire as it is an excellent electrical and highly constant, low-loss dielectric insulator. It is appreciated for its heat transmission and heat dissipation capacity, particularly in low-temperature applications.

Medicine imposes strict criteria on the choice of materials: a very high level of purity with zero risk of contamination, absence of porosity making the sterilization easier, biocompatibility, excellent surface finish, wear resistance, resistance to chemicals, and optical transparency. These criteria are best met by synthetic ruby and sapphire, primarily used as:
- components for micropumps
- miniature valves
- lenses and protection windows for endoscopes
- scalpels for ophthalmology
- high-pressure pump pistons and valves for laboratories and analysis.
Communication, confidence, flexibility

It is not enough to be creative. One also has to offer quality. Djeva has always meticulously applied this philosophy, which it inherited from its founders.
But what is quality? It is the secret of a closely-knit team, one that cultivates a sense of responsibility at all levels, right to the final phase of product control.
The quality and type of product are specified in the first place by the client. Requirements are so varied, however, that the company makes every effort to provide personalised service.
So, whether it be a question of colours, orientation inspections or annealing operations, it always meets the challenge.
Flexibility and versatility have been the watchwords of this family business for almost 100 years. With advances in know-how combined with ongoing scientific and technical research, Djeva is ideally positioned to play a dynamic role in the future of the synthetic stone sector, both in the most sophisticated industrial fields and in the world of artistic creation.

For any further information, please contact

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