HYDROTHERMAL SYNTHETIC EMERALDS FROM AUSTRALIA: EMERALDS AND PINK BERYLS

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In the course of a study travel to Australia some members of the Swiss Gemmological Association SGG were able to see probably the most successful manufacturer of synthetic emeralds in the world. The firm Biron is producing synthetic emeralds and pink synthetic beryls, the former under the trade name "Kimberly Created Emeralds". Mr Artur Birkner, the manager of the company, welcomed our group to a tour around the firm and answered many of our questions.

THE PRODUCTION OF SYNTHETIC EMERALDS

Synthetic and imitation stones are artificial products which imitate a stone that occurs naturally. Whereas an imitation only resembles a natural stone by its outward appearance (e.g. green glass for emerald), a synthetic crystal is in many aspects identical to its natural counterpart. The chemical compostition, as well as the crystal structure, therefore all physical constants such as refractive indices, density, hardness, cause of colour etc., must correspond with the natural counterpart. Only under these conditions an artificially produced crystal may be called a synthetic.

1 Flux synthetic crystals

The production of the synthetic emeralds has been performed for a long time with variable success. In 1848 Ebelman was able to produce some of the first crystals. Before World War II Espig, from the IG Farbenindustrie AG in Germany, experimented with synthetic crystal growth and developed the fundamental technology for the production. The first commercially relevant results were scored by Carrol Chatham (USA) and Pierre

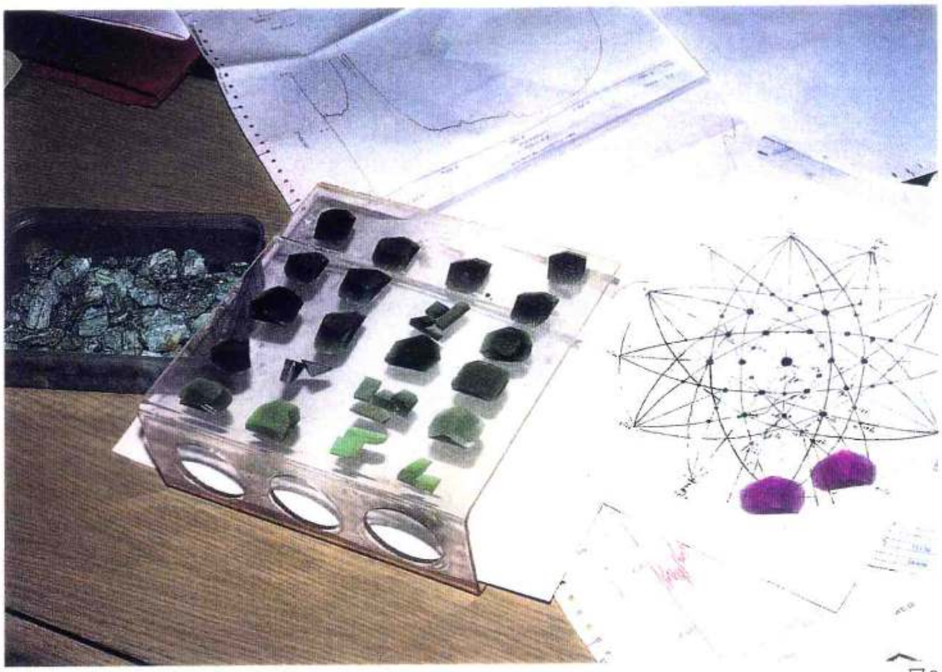

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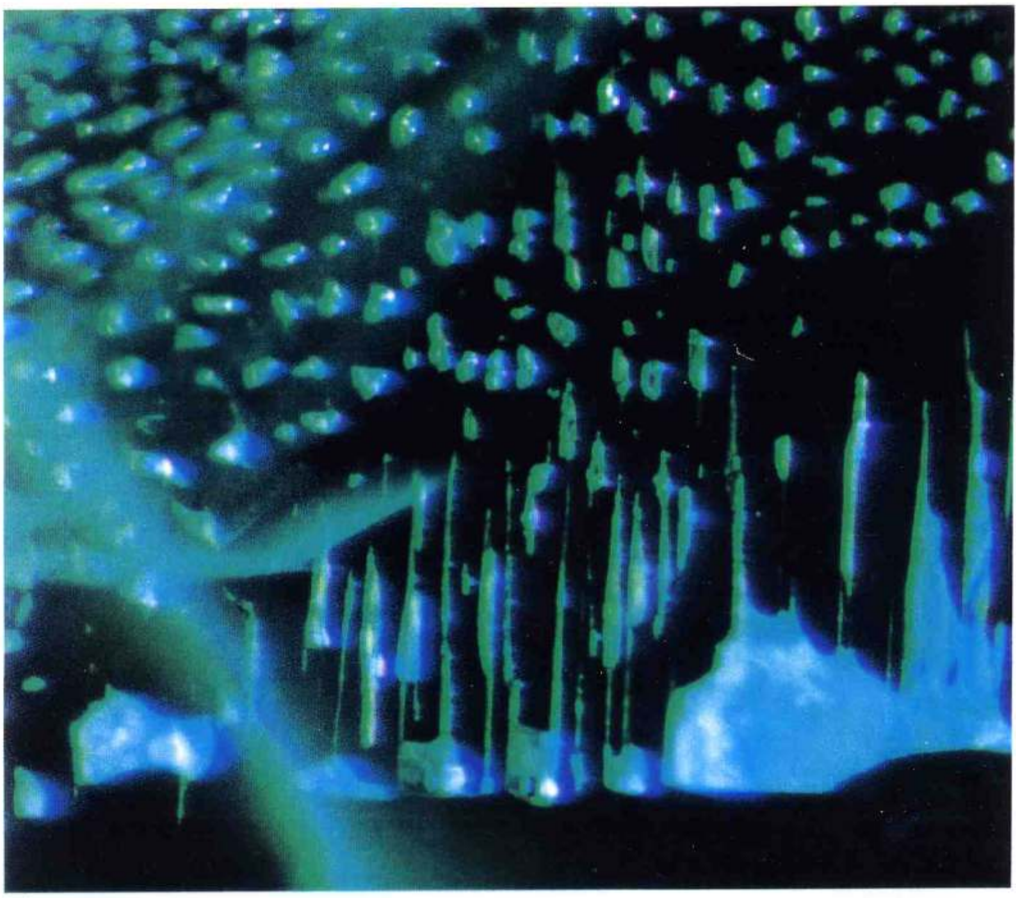
Fig 1: Hydrothermal synthetic beryl: synthetic emerald and pink beryl. Produced by Biron, Perth (Australia).

Fig 2: Artur Birkner, manager of Biron International Ltd., explaining the habit of his hydrothermal synthetic beryls.

Gilson (France) in the sixties. The crystal growth technology that they used was based on a melt of raw materials as oxydes to which chromium was added. Usually the melt is kept at a temperature of approx. 800°C under normal pressure in a crucible made of precious metal. As soon as the melt is over-saturated crystallisation may start with the formation of spontaneous nucleation. These germes go on growing until they are numerous enough to form crystal clusters. Thus, the reconsolidated material develops into a magnitude of small intergrown crystals. Spontaneous nucleation may be inhibited by installing a seed plate, i.e. a slice of beryl as a pattern for the growing crystal which continuously grows as long as the melt is over-saturated. Through this process all the dissolved material is attracted to the beryl plate and forms one single crystal. This is an optimal result for a crystal to be used as a gem.

The environment of the formation of these synthetics by the flux method differs sharply from the environment in which natural emerald is formed, notably by the lack of water. That is why such products (e.g. flux synthetic emeralds from Chatham, Gilson etc.) usually are rather easy to differenciate from natural emeralds. Gemmologists may recognice veil like residual flux droplets in tiny voids during a microscopical inspection. (Fig.3).

Nowadays flux synthetic emeralds are mainly produced in the USA (Chatham), Japan (Inamori) and Russia. The production of Gilson, formerly the most important producer in Europe, has moved to Far East due to the selling of the licence.



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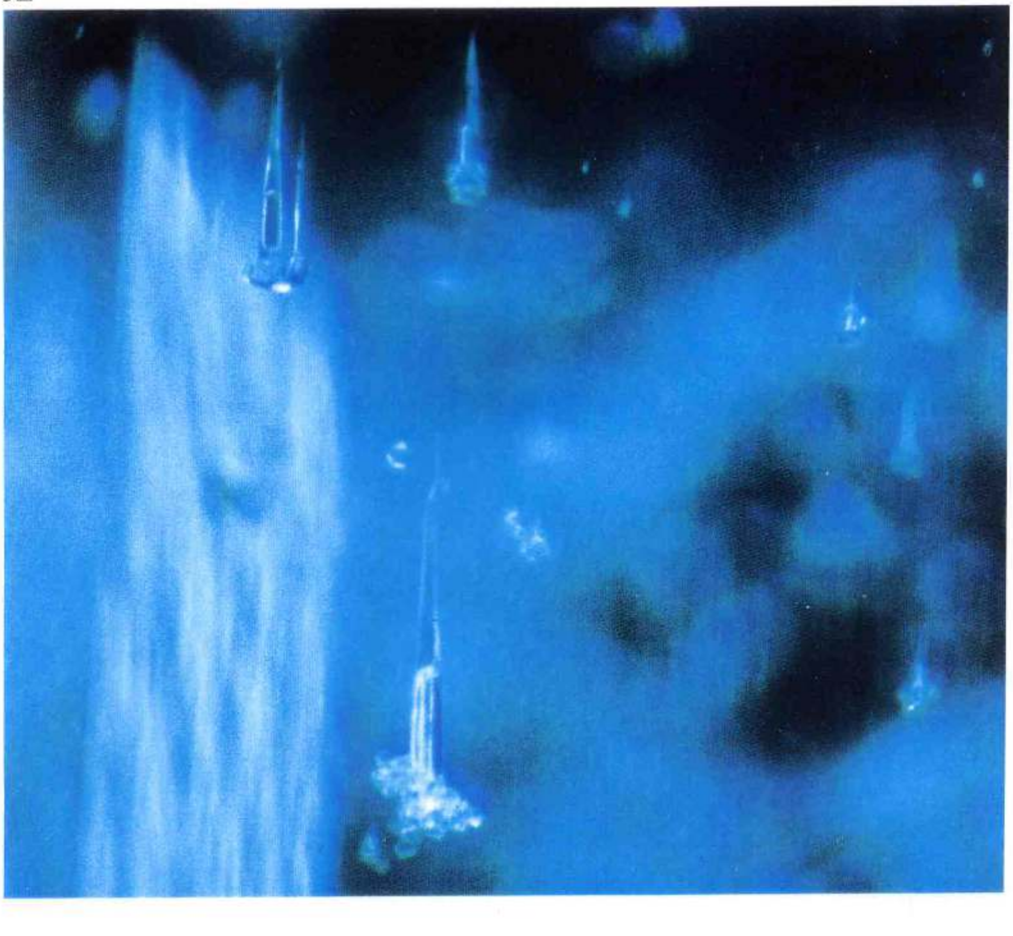
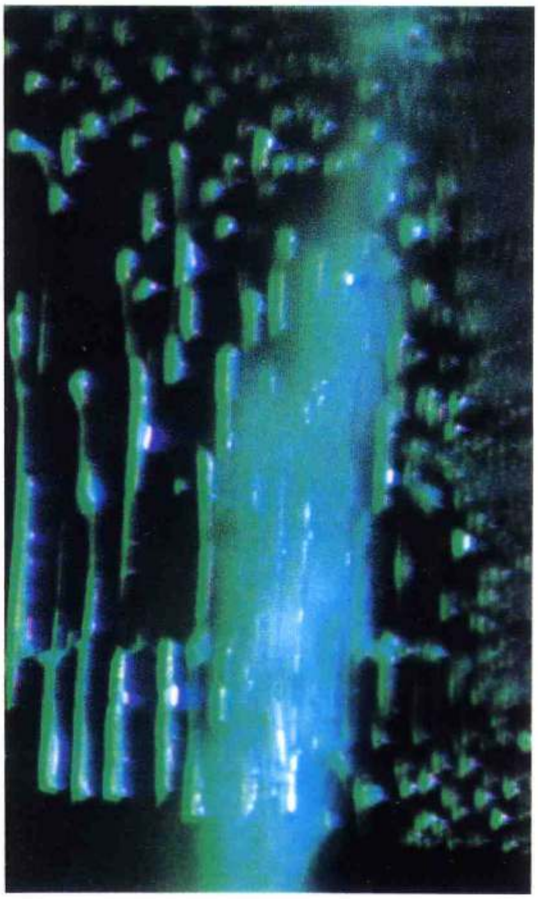


Fig 3: Fingerprint in a flux-synthetic emerald: The veil-like structures consists of tiny voids filled with residual flux. Occasionally a small bubble is visible.

Fig 4: Synthetic emerald produced by the hydrothermal method. Due to disturbances of the chemical equilibrium phenakite crystals have formed. Pointed voids were pulled behind those crystals. They usually contain a liquid and gas.



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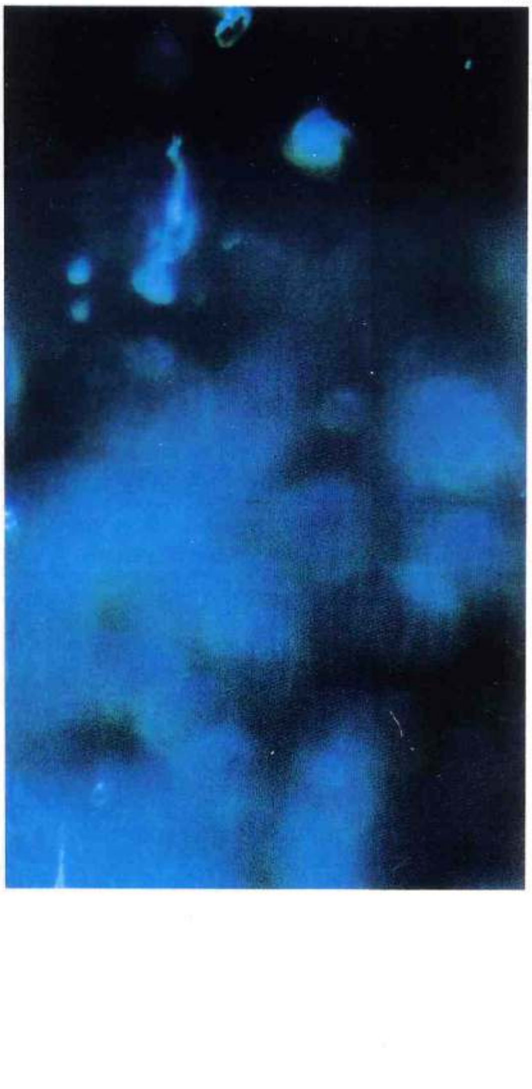

2 Hydrothermal synthetic emeralds

The first steps to produce synthetic emeralds by the hydrothermal method were made at the beginning of the sixties. In the case of the hydrothermal process the crystals do not grow in a melt, but in over-heated water. The raw materials, oxydes or beryl, together with additional chromium (e.g. chromiumchloride) are dissolved in an autoclave. An autoclave is comparable to a pressure cooker. In order to rise the solubility of the raw material the acting aqueous solution has to be extremely acid (e.g. pH 0.1). Under the influence of heat (e.g. 550°C), pressure (e.g. 1000 bar) and steam the primary materials are dissolved. So that the autoclave itself does not start to dissolve, a lining made of precious metal (e.g. silver, gold and platinum) is required. Furthermore it is important that within the autoclave there is a temperature gradient, a difference in temperature of about 60°C. In the hotter zone (under-saturation) the substances are dissolved, in the cooler zone (over-saturation) the chemical elements are deposited on the exposed seed plate. By means of the vapour, the chemical components move atom per atom to the seed plate which grows. Synthetic emeralds are formed through this procedure.

Johann Lechleitner was the first who succeeded in growing synthetic emerald on facetted colourless beryl. Later on, Linde (USA) produced larger synthetic emeralds by the hydrothermal method, those contained a seed plate of natural colourless beryl. Hydrothermal synthetic emeralds which have been produced since the sixties have considerably increased in quality. Originally only a growth rate of a few millimeters was possible during each run of hydrothermal growth, or per autoclave filling. Thus, the crystal or seed plate had to be covered many times until the coating was sufficiently thick. The first multilayer synthetic emeralds were called "sandwiches". Samples from this older type of hydrothermal emeralds usually exhibited a multitude of inclusions, most of them consisting of tiny phenakite clusters and acicular voids with a liquid and gas filling. Hydrothermal synthetic emeralds are today produced by Regency (former Linde, USA), Vasar (Russia), Kimberley (Biron, Australia).

3 Kimberley hydrothermal synthetic emeralds

Mr Artur Birkner, the producer of Biron hydrothermal synthetic emeralds, was expecting our group in front of his small and modern factory in Perth. We were invited to a tour around the firm. Geological maps, mineral samples, book shelves and a desk covered with analytical printouts, notes and diagrams filled the office of this successful producer. He was prepared to tell us about the eight years of costly development of which the final result were these most impressing crystals that are the horror for many a gemmologist. Mr Birkner told us that his aim was not to fake real emeralds. What he really wanted was to produce stones which come as close as possible to the natural counterparts. Thus, people who are fascinated by emeralds are now able to afford a piece of jewellery, of which the stones may be even more beautyful and durable than natural emeralds for a reasonable price. It seems that the market of synthetic emeralds is nearly detached from the market of natural ones.

During our walk through the firm we followed the numerous steps which are necessary for the successful production of synthetic stones.To start with we were shown beryl mine scrap from Brazil which are used as raw material. A worker was chopping the bits and selecting the usable parts which are used as charge for the autoclave. Thus, natural beryl is used to produce synthetic emerald. Another worker was busy making cylindric capsules out of gold plate. They are to furnish the inner lining of the reaction volume in the autoclave, offering a space of approximately 4 cm in diameter and 30 cm in length. The electric furnace is equipped with special ceramic parts which they also produce in a neighboring workshop. In another room, the seed plates are cut out of the finished synthetic emerald crystals. They are cut flat and used again in a forthcoming process. These seed plates consist of slides of beryl crystal, cut approximately 30° obliquely to the c-axis. On this surface, the crystal growth proceeds the most rapidly. At any one time six seed plates go into one gold capsule, where they are suspended on platinum wire. The composition of the hydrothermal brine and the combination of the added colouring trace elements like chromium, vanadium, iron remain manufacturers secret. Finally we visited an explosion secured room with at least 100 furnaces which heat the autoclaves. Important steel rods were ready to hold and withstand the extreme pressure in the autoclave during the synthesis. Heat and pressure are controlled by computers. It was obvious how capital intensive the production of high quality synthetic emeralds is. In the last stage of our tour we saw how carefully the finished stones were cut. They are on stock in different shades, shapes and cutting styles.

Biron synthetic pink beryl

We were very surprised when Mr Birkner showed us his new synthetic beryls which he grew the same hydrothermal way as the Kimberley synthetic emeralds, Natural pink beryl is usually named morganite. It owes its rose colour to traces of manganese. The crystal lattice of beryl allows manganese in two different valence states. The trivalent ion has a strong colouring effect. A well known example are the red beryls from Wah Wah Mountains (Utah, USA). The bivalent ion has a weaker effect of manganese, so morganites with Mn2 + mostly exhibit a pink coloration. On the other hand it is surprising that the new synthetic pink beryls of Biron do not show any traces of manganese, but have remarkable traces of titanium which seems to cause the pink colour. This type of colenring is not known among the natural pink beryls. Since the synthetic pink beryls are produced following the same process as the synthetic emeralds, they exhibit the same inclusions and growth characteristics, as explained in Figs 5 and 6.

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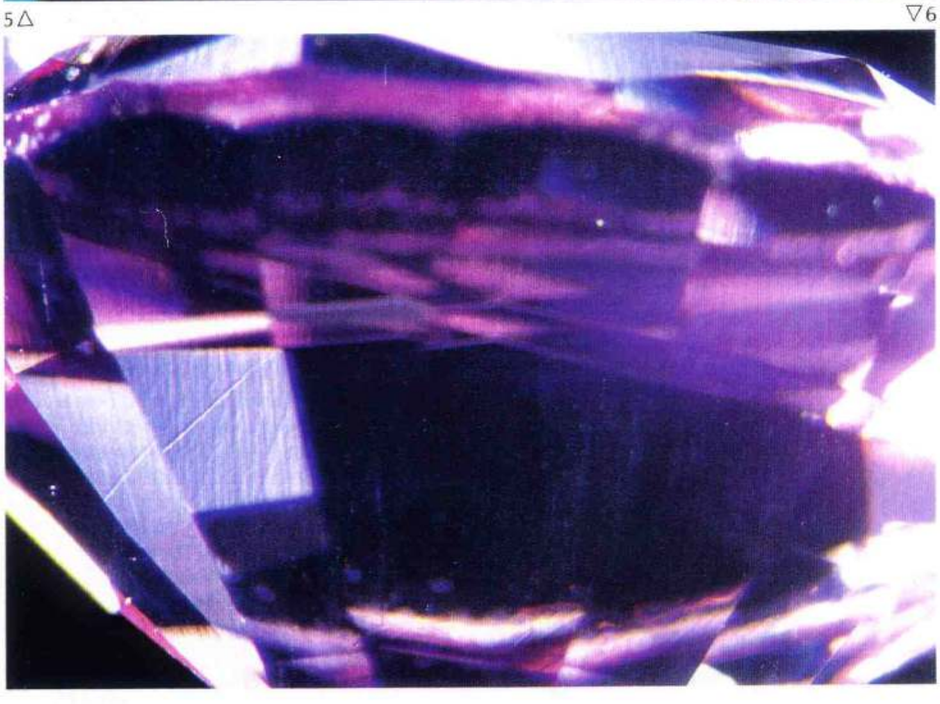

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Fig 5: Structural characteristics in hydrothermal emerald of Biron. The typical chevron pattern and spindle like to swirly structures are common and easily visible in dark field illumination.

Fig 6: Swirly structures and kind of a rain of tiny inclusions in hydrothermal synthetic pink beryl by Biron.

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