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Cover Picture: Lepidocrocite inclusions in quartz.
Photography by Luella Dykhuis FGA DGA, Tucson, Arizona, U.S.A.

First Prize in the 2005 Photographic Competition (see p.490).

The Gemmological Association and Gem Testing Laboratory of Great Britain
Registered Office: Palladium House, 1-4 Argyll Street, London W1F 7LD

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A venture into the interior of natural diamond: genetic information and implications for the gem industry

Part I: The main types of internal growth structures

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Abstract: Natural diamonds are rarely homogeneous. Crystals contain evidence of complicated histories of growth, changes of habit, chemistry, stages of growth and resorption. To extract genetic information recorded during diamond formation they should be studied by modern methods of microanalysis in polished plates. The best way to polish diamond to reveal internal zonation is described and the interpretation of different types of internal morphology of diamonds from cathodoluminescence imagery is given. Knowledge of the internal structures of diamonds is not only useful for scientific observations, but also allows a better determination of their likely behaviour during the cutting and polishing processes. This gives an opportunity for more economic use of individual stones during gem production.

Keywords: cathodoluminescence, diamond, gem industry, internal structure, polished plates
As-grown, green synthetic diamonds

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Abstract: Green synthetic diamonds showing no evidence of irradiation or other laboratory treatment were examined to determine the nature of the coloration. The occurrence of distinct yellow and blue internal growth zones as well as absorption spectra indicating the presence of both isolated nitrogen and boron strongly suggest that the green colour is a result of the intergrowth of boron- and nitrogen-rich sectors. Variations in the boron/nitrogen concentration ratio during synthesis can produce as-grown diamond colours ranging from dark blue to green to yellow.

Keywords: boron, Chatham, colour origin, mixed growth, nitrogen, synthetic diamond
Iridescent colours of the abalone shell (Haliotis glabra)

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Abstract: Shells and pearls of some molluscs are popular ornaments primarily due to the beauty of their natural iridescent colours. Strong iridescent colours are very evident on the polished shell of the mollusc Haliotis glabra, commonly known as abalone. A scanning electron microscope (SEM) was used to determine the origin of these colours, and the surface of the abalone was found to have a fine-scale diffraction grating structure of 2 μm groove width. From the diffraction patterns that were obtained using He-Ne and Nd: YAG lasers illuminating the shell, the groove density of the grating structure was derived. Good agreement was found between the groove density derived by diffraction experiments and that measured directly using the SEM. The strong iridescent colours of the shell are caused by diffraction which is the result of high groove density on the surface. The crystalline structure of the nacreous layers of the shell was studied using Fourier transform infrared spectroscopy (FTIR), and peaks at 700 cm⁻¹, 713 cm⁻¹, 862 cm⁻¹ and 1083 cm⁻¹ confirmed that the crystalline structure of the nacre of the shell is basically aragonite.

Keywords: aragonite, FTIR, Haliotis glabra, iridescence, SEM, shell structure
Diffraction Enhanced Imaging: a new X-ray method for detecting internal pearl structures

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Abstract: The X-ray based Diffraction Enhanced Imaging method (DEI) has been applied to examination of pearls of different origin. DEI images – especially of large pearls – indicate internal growth features more clearly than the usual X-radiographs and show structures which could not be made visible with conventional methods. The DEI method furthermore offers a tool for the separation of larger tissue-nucleated cultured pearls from natural freshwater pearls if conventional X-ray methods fail.

Keywords: cultured pearl, diffraction, pearl structure, pearl testing, radiograph, X-ray
A microscopy-based screening system to identify natural and treated sapphires in the yellow to reddish-orange colour range

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Abstract: Features visible under a microscope of untreated, heat-treated and beryllium-diffusion-treated yellow, orange and reddish-orange sapphires, including padparadschas, are presented. A microscopy-based screening system for recognition and distinction of untreated, heat-treated and diffusion-treated sapphires combines structural features such as growth structures, colour zoning and inhomogeneous colour distribution patterns with the visual appearance of inclusions. Spectra and chemical compositions may be added to these microscopic characteristics and applied to an evaluation of samples of unknown origin and unknown treatment history. These properties combine to form a type of locality-specific data set, and are considered in the light of present knowledge about treatment techniques. The screening system allows the recognition of most untreated or heat-treated samples from Sri Lanka and Montana, U.S.A., and their distinction from beryllium-diffusion-treated samples from Sri Lanka, Montana, U.S.A., Ilakaka, Madagascar, and Songea, Tanzania.

Keywords: absorption spectroscopy, beryllium diffusion, colour zoning, growth structures, heat-treatment, inclusions, padparadscha, sapphire, screening system, trace-element chemistry
Growth of hexagonal bipyramidal ruby crystals by the evaporation of molybdenum trioxide flux

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Abstract: Ruby crystals with hexagonal bipyramidal shape have been grown by the evaporation of MoO$_3$ flux isothermally. Red transparent crystals up to 1.8 mm in length and 1.7 mm in width were obtained, their sizes depending on the solute concentration and the holding temperature. Their form was a double six-sided pyramid bounded by twelve well-developed {1123} faces of isosceles triangle shape. The habit of ruby crystals grown by this isothermal method of MoO$_3$ flux evaporation is quite different from the habits of ruby crystals grown by slow-cooling or temperature-gradient.

Keywords: flux growth, hexagonal bipyramid, molybdenum trioxide, synthetic ruby
Sapphire diffusion treatment and the behaviour of iron and titanium

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Abstract: Using the parameters of thickness of diffusion layer and the conditions under which diffusion was carried out in a sample of blue sapphire from Thailand, the diffusion coefficients of iron ($D_{Fe}$) and titanium ($D_{Ti}$), the colouring ions, have been calculated. The results indicate that the diffusion coefficient of Ti$^{4+}$ is $6.57 \times 10^{-9}$ cm$^2$s$^{-1}$ and that of Fe$^{3+}$ is $1.62 \times 10^{-9}$ cm$^2$s$^{-1}$. The factors affecting $D_{Ti}$ and $D_{Fe}$ are discussed.

Keywords: diffusion coefficient, diffusion treatment, Fick's law of diffusion, sapphire
Two remarkable taaffeite crystals from Sri Lanka

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Abstract: Two slightly waterworn taaffeite crystals from Sri Lanka are described. A greyish violet crystal of 2.35 ct with bipyramidal habit exhibits two opposing basal pedions, three different hexagonal pyramids and one hexagonal prism as crystal forms. The morphology of a 0.73 ct chromium-bearing crystal with pyramidal habit is characterized by one pedion and one hexagonal pyramid. Gemmological, chemical and spectroscopic properties of the samples are in the range known for iron- and for iron- and chromium-bearing taaffeites from Sri Lanka.
Nephrite jade from Scortaseo, Switzerland

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Abstract: At Scortaseo in the eastern Swiss Alps, two lenses of nephrite jade occur within the central core of a talc orebody associated with metamorphosed dolomitic limestone of Triassic age. Although mining operations were initiated for exploitation of talc, several thousand tonnes of nephrite were also extracted as a by-product. Predominant colours of the nephrite jade are of uneven pale green and grey-green hue. Grain size ranges from fine- to medium-grained and subordinate constituents include calcite and talc. In addition to massive nephrite jade, a major part of the deposit includes a distinctive variety of mixed nephrite-calcite rock termed ‘Swiss jade’. It consists of pea-like spherules of nephrite set in a matrix of calcite. The nephrite jade is classified as para-nephrite in type and formed together with talc by intense hydrothermal alteration of dolomitic marble along shear zones. The quantity of nephrite jade available remains uncertain but appears substantial. Recent production involves recovery of material previously discarded during talc mining operations. The nephrite jade is fashioned into costume jewellery at a local workshop nearby at Poschiavo.

Keywords: bead, carving, nephrite, serpentine, spherule, Swiss jade, talc
Crossed filters revisited

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Abstract: The crossed filters technique, introduced to gemmologists by Basil Anderson, has not found extensive use due, in part, to the cumbersome excitation filter he used. The commercialisation of new solid state sources, and ready availability of a variety of coloured glasses now makes possible simple and inexpensive means for practice of this fluorescence method.

Keywords: crossed filters, chrome-bearing gems, fluorescence, gem testing

"These instruments and appliances to be of any practical value must be simple and substantial, as cheap as possible, and such that determinations made with their aid can be as well performed by the working jeweller as by a trained mineralogist."

Max Bauer (1904, p.561), writing about instruments for identification of gems.