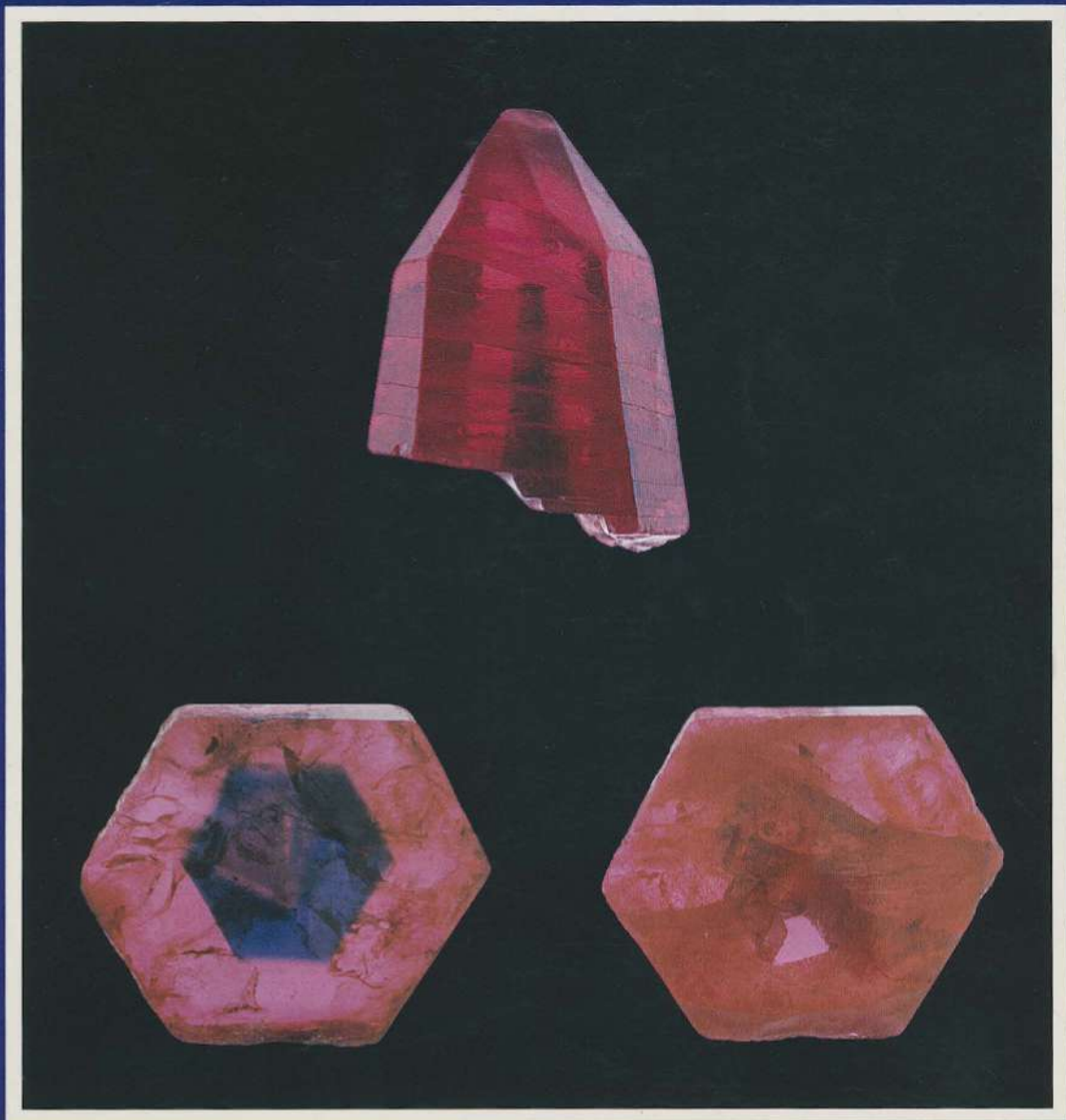




The Journal of Gemmology



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Cover Picture

Ruby crystals from Mong Hsu, Myanmar (Burma): the terminated crystal (9mm high) is not heat treated. The hexagonal blue zoning characteristic of natural (not heat treated) Mong Hsu ruby rough is prominently visible in this partly polished crystal fragment (7mm across) on the lower left, while the view on the lower right is the same crystal after heat treatment at 1350°C in an oxidizing atmosphere for seven hours (see 'Myanmar and its gems - an update' p.3)

Upper photo by Shane F. McClure and lower photos by John L. Emmett. Crystals courtesy of Robert E. Kane.

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Myanmar* and its gems - an update

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Fig. 1. The Kingdoms of Pagan in central Myanmar go back almost to the beginning of the Christian era, but the golden periods during the eleventh and twelfth centuries saw an extraordinary explosion of building which resulted in many hundreds of temples and pagodas (many now in ruins) squeezed into an area of only around 40 sq. km. *Photo by E.A. Jobbins*

Abstract

This paper up-dates and expands upon the information contained in Kane and Kammerling (1992) in relation to the gemstone production in the area of Mogok and goes further in that it relates the information gained on other important producing areas within Myanmar during several visits to the country by the majority of the authors. However, many of the areas referred to still remain unvisited by the non-Burmese and the information contained here is a compilation of published data and verbal information gained both within and without Myanmar.

Key words: Burma, gemstones, geology, Myanmar

*Myanmar - formerly Burma

Introduction

It is clear that over the past three years more information has become available about the current operations of the Myanma Gems Enterprise (MGE) and its joint-ventures. This follows a period that has lasted from the early 1960s in which little was revealed to the outside world about any gemstone production, prospecting, or any other related research that was being carried out in Myanmar [note: both Myanmar and Burma are used interchangeably throughout this paper depending upon historic preference]. One of the first indications of the increase in the availability of information was the paper published by Kane and Kammerling (1992) entitled *Status of ruby and sapphire mining in the Mogok Stone Tract*.

The situation in Myanmar is such that certain areas remain within the designation 'not recommended for travel', a warning that westerners would be most unwise to disregard. Certainly the country is rugged and there is a need for expert guides. The survey map (Figure 2) shows the positions of the diamond and jade deposits in the north, through the corundum deposits in the Mogok area (Figure 3) and the diamond deposits and pearl farms in the south.

Myanmar's gemstone wealth is set out in Table 1 in the form of 'Economically important gemstones', 'Economically less important gemstones' and 'Rare gemstones'. Table 1 reads like the index to a gemmological textbook, with very few stones missing, and this attests to the enormous gemstone wealth possessed by this country.

History

Myanmar (Burma) is regarded as one of the earliest sources of fine rubies, sapphires and spinels. Mining was first recorded in the sixth century (Chhibber, 1934). These gemstones continued to be mined through the centuries with the Monarchy taking control of the mines towards the end of the sixteenth century. A number of historically important stones may be dated back to this period. Indeed, Burmese rubies, sapphires and spinels have been set in royal regalia and aristocratic jewellery for many centuries and probably back to the sixth century.

Some of these important stones figure prominently in several of the treasures in the royal regalia of a number of countries, including England. Two of the authors have recently enjoyed the privilege of examining most of the historic English Royal Regalia which is housed in the Tower of London. Possibly the earliest stone is the Black Prince's Ruby (actually an orange-red spinel) which can, with a reasonable degree of certainty, be dated back to 1367. This large spinel is set in the front of the Imperial State Crown. From its properties and inclusions it would appear to be of Burmese origin. The Timur Ruby (also a spinel) in the British Royal collection would also appear to be of Burmese origin. Superb rubies with Burmese characteristics are liberally distributed in the various coronation rings and sceptres, and are prominent in the Imperial Crown of India.

'When Upper Burma was annexed to the Empire in 1886 negotiations were opened with commercial firms for the working of the ruby

mines near Mogok', so stated Gordon (1888) at a meeting of the Royal Geographical Society held on the evening of 27 February 1888. His report published in the proceedings of that meeting, goes on to state that a concession was granted to Messrs Streeter & Co. of London. He also reports that he was asked to survey and report on the mining district by the concessionaires. The map he produced at the time shows the Mogok area in great detail with even at that time a considerable amount of cultivated land.

Gordon's report for the period he spent surveying the ruby deposits is probably the most useful of its type for evaluating the differences that have occurred over the last 100 years. He describes not only the mines and mining methods in simple terms but also the inhabitants of the numerous villages in the area. He states that in this period the mines were of three types, the first, which was the least important at that time, consisted of

'working in fissure veins of soft material which are found embedded in the crevices of hard rock. ... The crevices in the older rocks give origin to cave mines, which are called "Loos" [also known as "loodwins"] where the soft earth is excavated in a primitive fashion and on a small scale. ... Pingu-toung, a steep hill overlooking Bama (spelt Panma in Figure 3), is rich in such mines.

'The second class of mine is called "Myaw" [also known as "Hmyawdwins"] or washing. The clay is cut into thin slices with a gardener's spade and washed from the funnel shaped excavations through the flumes or open timber channels, where the clay is dissolved away, or carefully examined for the stones.'

The third and most important at that time was the class of mines found in the flatter lands of the valleys. These were referred to as 'twinlons' (narrow circular pits) and their variants the 'lebins' (reinforced pits) which were normally only 60cm wide, the 'cobin' 1 to 1.5m deep and the 'imbye' 6 to 9m deep (Chikayama, 1987, 9, 4). At depths varying from 3 to 9 metres there is found a layer of corundum from a few centimetres to a few metres in thickness.

Messrs Streeter & Co. formed the Burma Ruby Mines Ltd. This company operated the mines from 1887 until 1925 with their operation centred around the area now known as the Mogok Stone Tract. Much modernization of mining methods took place during this period with the introduction of hydroelectric power to run the plant and



Fig. 2. Map of Myanmar showing gemstone and some mineral occurrences. See Table 1 for explanation of codes.
 Map compiled by G. Bosshart

Table 1: Gem minerals reported from Myanmar (Burma), including organic gem materials (compare with Figures 2 and 3) - Myanma names (in italics) after Chikayama (1988)

<i>Material</i>	<i>Description</i>	<i>Code</i>	<i>Locality</i>
1. Economically important gemstones			
Ruby (<i>Pa Ta Mya</i>)	red, purplish-red, also asteriated	R1	Mogok Stone Tract (MST) ¹
		R2	Momeik (Mongmit) ²
		R3, 4	Nawarat and Namhsa Stone Tract ²
		R5	Mong Hsu Stone Tract ²
		R6	Nanyaseik (Nanyazeik) ³
		R7	Sagyin Hills ¹
		R8	Belin Thandaung ⁵
		S1	Mogok Stone Tract ¹
Sapphire (<i>Ni La</i>)	blue, also asteriated	S2	Momeik ²
		S3	Mong Hkak ²
		S4	Twingire area ¹
		S	Mogok Stone Tract ¹
Fancy sapphire	pink, purple, violet, light yellow, colourless, green (rare)	S	Mogok Stone Tract ¹
Jadeite jade (<i>Kyauk sein</i>)	green, yellowish-green, white, purple to violet, brown, yellow and black	J1	Hpakant-Tawmaw Jade Tract (JT) ¹
		J2	Mawhan hills ²
		J3	Hkamti hills ⁴
		J4	Putao area ²
		J5	Laisai area ¹
		J6, 7	Mandawng and Shangaw ²
		J8	Maw-sit-sit ²
Maw-sit-sit Greenstone (nephritic)	yellowish-green and black (opaque) green, yellowish-green, brownish-green	J9	Langhko area ²
Peridot (olivine) (<i>Pyaunggaung sein</i>)	yellowish-green, green	PD	Pyaunggaung (Pyaung Gaung) ¹
Spinel (<i>Am nyant</i>)	red, pink, purple, orange-brown, red-brown, violet-blue, greyish-violet, greenish-blue	SP	Mogok Stone Tract ¹
Cultured pearl (<i>Pa le</i>)	white, golden, bluish (saltwater, beaded and tissue graft)	CP1	Sir Malcolm Island ⁴
		CP2	Mergui Peninsula ⁴
2. Economically less important gemstones			
Amber (<i>Pa yin</i>)	light yellow, reddish brown, orange-brown	AM1	Maingkwan hills ²
		AM2	Hukawng Valley ²
		AM3	Kalewa hills ⁴
Beryl	colourless Aquamarine (<i>Mya pya</i>) – light blue, greenish-blue	BE	Sakangyi (MST) ¹
		BE	Sakangyi (MST) ¹
Diamond (<i>Sein</i>)	yellowish to colourless (Cape series)	D1	Tenasserim/Taninthari River ⁴
		D2	Tavoy area ⁶
		D3	Toungoo area ⁶
		D4	Momeik area ²
		D5	Putao area ²
Feldspar (<i>Myaw nyo kyauk</i>)	Albite – colourless, white, yellow, also chatoyant Moonstone (<i>Myaw</i>) – white, light yellow, light brown, with bluish or white sheen (adularescent, also chatoyant)	FS	Kyaukpyatthand and Kyatpyin (MST) ¹

Material	Description	Code	Locality
Garnet (<i>U Daung</i>)	Almandine (<i>Zee</i>) – red-brown, dark red Spessartine (<i>Lein mau yi daung</i>) – yellowish-orange, brown-orange	GA	Kyatpyin (MST) ¹
Lapis lazuli (<i>Pa la dote Hta</i>)	blue, light blue (sodalite, lazurite)	LL1 LL2 LL3	Dattaw (MST) ¹ Kabaing (MST) ¹ Thapanbin (MST) ¹
Natural pearls	white, golden (marine)	NP1 NP2	Mergui archipelago ⁸ Bay of Bengal coast ²
Quartz (<i>Sa lin</i>)	Rock crystal - colourless Amethyst (<i>Sa lin swe</i>) – purple Smoky quartz (<i>Sa lin nyo</i>) – brownish Citrine (<i>Sa lin wa</i>) – light yellow Agate – various types Chrysoprase – green	QU1 QU2 QU3	Sakangyi (MST) ¹ Pagan hills ¹ Tagaung hills ¹
Scapolite (<i>Thu Yaung</i>)	colourless, pink, yellow, violet, also bluish, pink and white (chatoyant)	SC	Mogok Stone Tract ¹
Topaz (<i>Hatat ta ya</i>)	colourless, light yellowish-brown, light blue	TO	Sakangyi (MST) ¹
Tourmaline (<i>Pa ye u</i>)	yellow, orange-brown, brown, red, pink, black, green, greenish-brown, colourless	TM1 TM2	Mogok Stone Tract ¹ Monglong (Mainglon) ²
Zircon (<i>Gaw Meik</i>)	green, greyish-green, brownish-green, brownish-yellow, orange, orange-brown, red-brown	ZR	Mogok Stone Tract ¹
3. Rare gemstones			
Amblygonite	colourless, yellow	RM	Sakangyi (MST) ¹
Andalusite	red-brown, dull green, orange; chiasolite crosses	RM	Kyaukse hills ¹
Apatite	blue, green, also chatoyant, colourless, yellow	RM	Kyaukpyatthar (MST) ¹
Chrysoberyl	colourless, yellow Alexandrite (rare) – green	RM	Mogok Stone Tract ¹
Conch pearl	orange, flame structured (very rare)	RM	Mergui archipelago ⁸
Cordierite (iolite)	violet-blue	RM	Mogok Stone Tract ¹
Danburite	brownish-yellow, colourless, yellow-orange, pink, greenish-yellow, green	RM	Kyauksataung and Thapanbin (MST) ¹
Diopside	light greenish-yellow, green, also chatoyant	RM	Mogok Stone Tract ¹
Enstatite	greenish-brown, dark red-brown, light yellow-green	RM	Mogok Stone Tract ¹
Epidote	green (<i>tatamawite</i>)	RM	Tawmaw (JT) ³
Fluorite	purple, violet, green, yellow	RM	Mogok Stone Tract ¹
Kornerupine	yellow-brown, greenish-yellow, green, blue, also asteriated	RM	Mogok Stone Tract ¹
Kyanite (disthene)	light blue, blue	RM	Mogok Stone Tract ¹
Painite	dark red-brown (extremely rare)	RM	Ohngaing (MST) ¹
Phenakite	colourless	RM	Myanmar
Sillimanite (fibrolite)	violet-blue, green, grey-blue, also chatoyant	RM	Mogok Stone Tract ¹
Sinhalite	yellow-brown (very rare)	RM	Mogok Stone Tract ¹
Sphene (titanite)	orange-brown	RM	Mogok Stone Tract ¹
Spodumene	colourless	RM	Mogok Stone Tract ¹
Taaffeite	colourless, light violet (very rare)	RM	Mogok Stone Tract ¹
Tremolite	green chatoyant (amphibole)	RM	Myanmar
Vesuvianite (idocrase)	brown	RM	Myanmar

Note: All gem materials listed in Table 1 occur in the Mogok Stone Tract, with the following exceptions only: jade, andalusite*, epidote, phenakite, tremolite, vesuvianite, pearls and amber. (*Hughes, 1990, reports orange andalusite from MST, unconfirmed.)

Legend: 1 Mandalay District, 2 Shan State, 3 Kachin State, 4 Sagaing State, 5 Karen State, 6 Pegu State, 7 Arakan State, 8 Taninthari/Tenasserim State

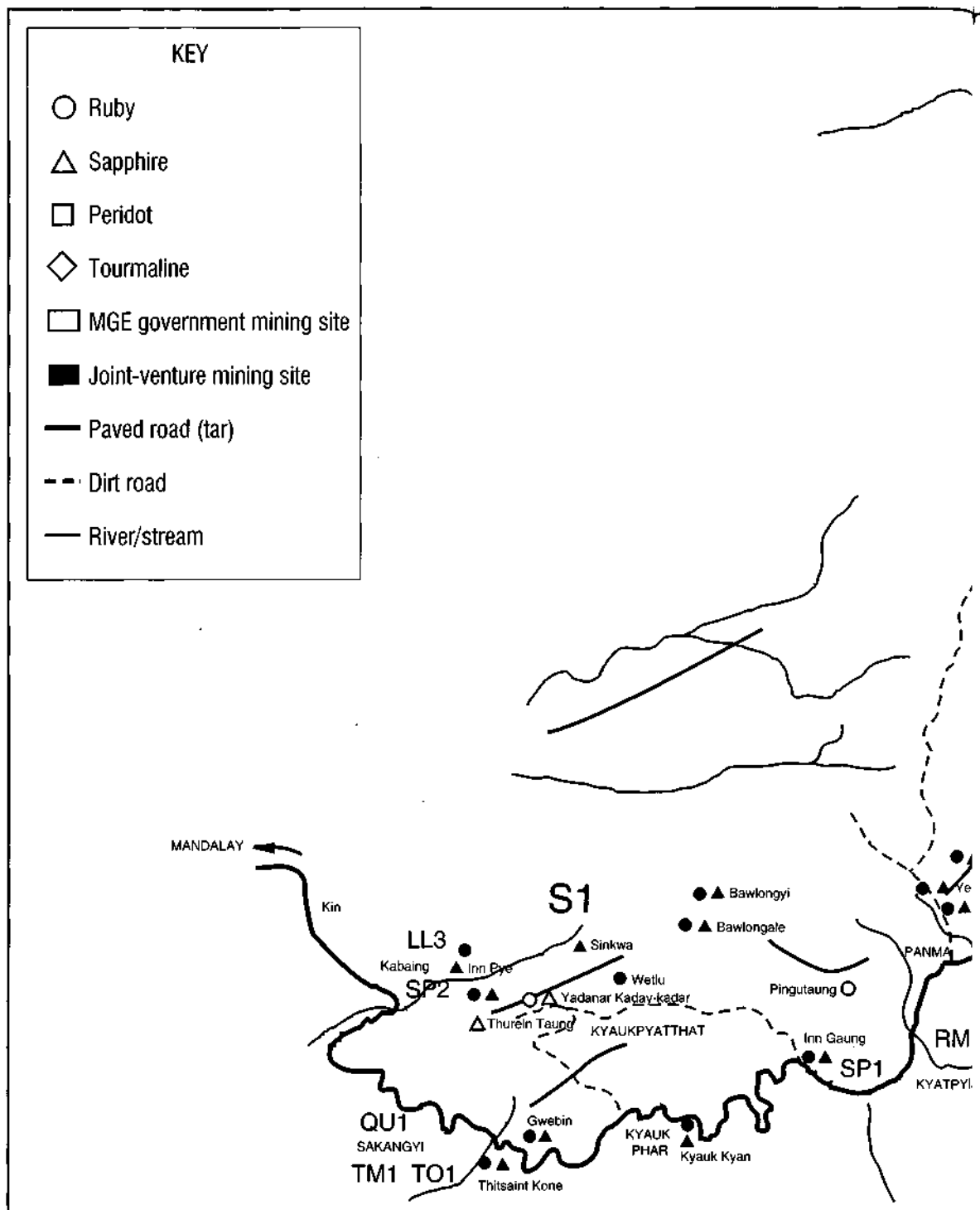


Fig. 3. Map showing gemstone workings in the Mogok Stone Tract. *Expanded and revised by G. Bosshart from Kane and Kammerling (1992) 'Status of ruby and sapphire mining in the Mogok Stone Tract', Gems & Gemology, 28, 3, 152-74, Fig. 4.*

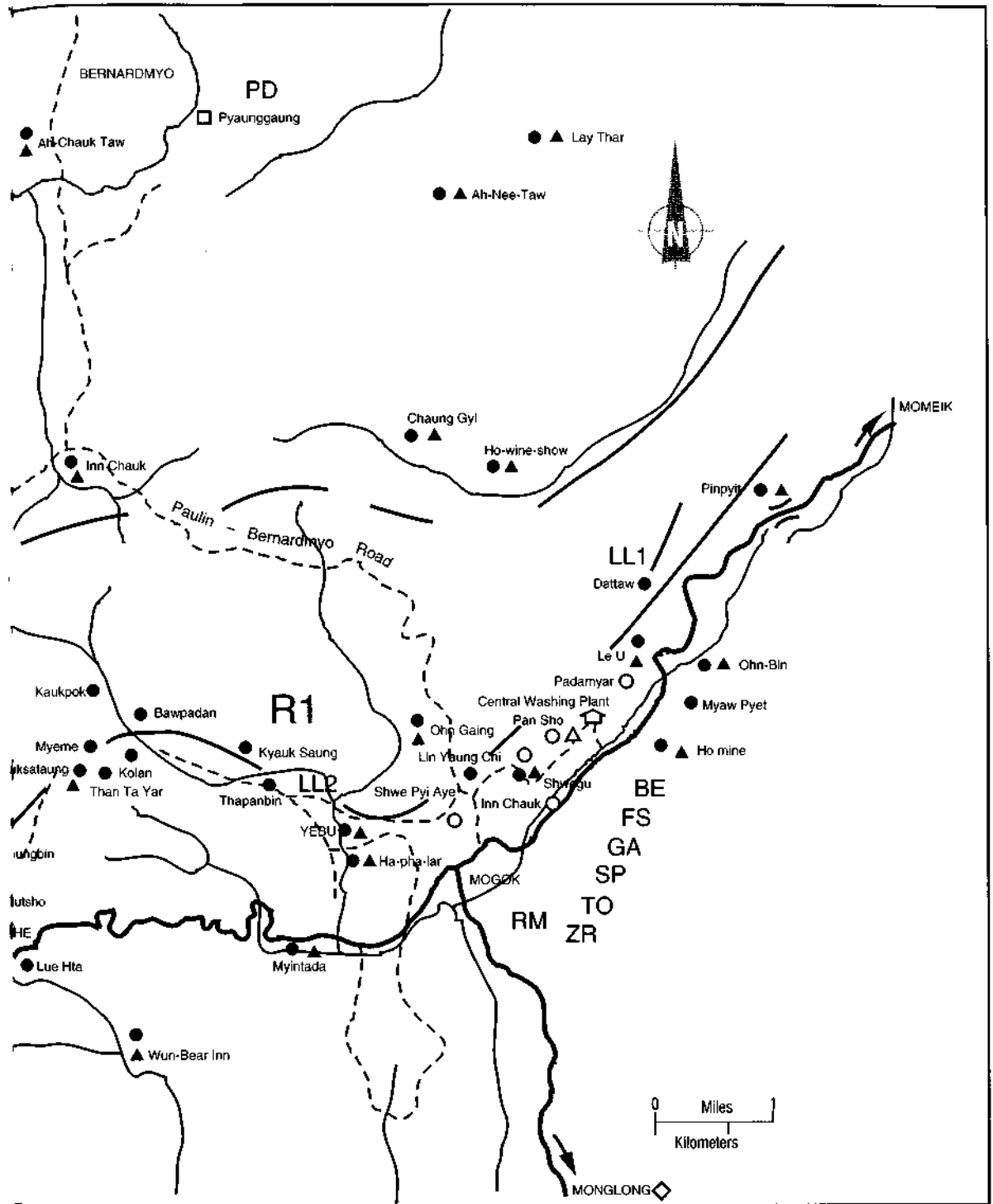




Fig. 4. This view of the town of Mogok shows part of the artificial lake in what was formerly an area worked by the Burma Ruby Mines Company. *Photo by R.C. Kammerling*

pump drainage water from the mine sites. The lake around which Mogok town is now built is witness to these former days for it is artificially produced from the former open cast workings of Burma Ruby Mines Ltd (Figure 4).

A series of events during the early part of this century caused the eventual collapse of Burma Ruby Mines Ltd; the introduction of commercial synthetic ruby, the First World War and the Great Depression. The company surrendered its

Fig. 5. Two of the three known crystals of painite recovered at Ohngaing in the Mogok Stone Tract. The larger crystal weighs 1.477 grams.



leases to the Government in 1931 and mining reverted to the effective traditional indigenous methods. These methods continued to be used up until the early 1960s, when the mines were nationalized and the last reports, prior to the recent events, were available.

Returning to other exceptional gemstones, we should mention the [Pain] collection assembled by A.C.D. Pain during the period between the Second World War and 1963. Pain lived in Mogok and his interest in unusual stones was well known to the local miners who brought him 'difficult' stones for identification and possible purchase. His unique collection of rare and unusual stones was presented to the Natural History Museum, London, upon his death in 1971 and these Burmese stones were amalgamated with those of the former Geological Museum, London, in the 80s. Over the centuries Burma has produced almost every known gemstone. Of special note is the very rare mineral painite (only three crystals are known) which was named after A.C.D. Pain (Figure 5). Today, owing to the active participation of the Myanmar government, gemstone mining and exploration is once again mechanized and modern techniques

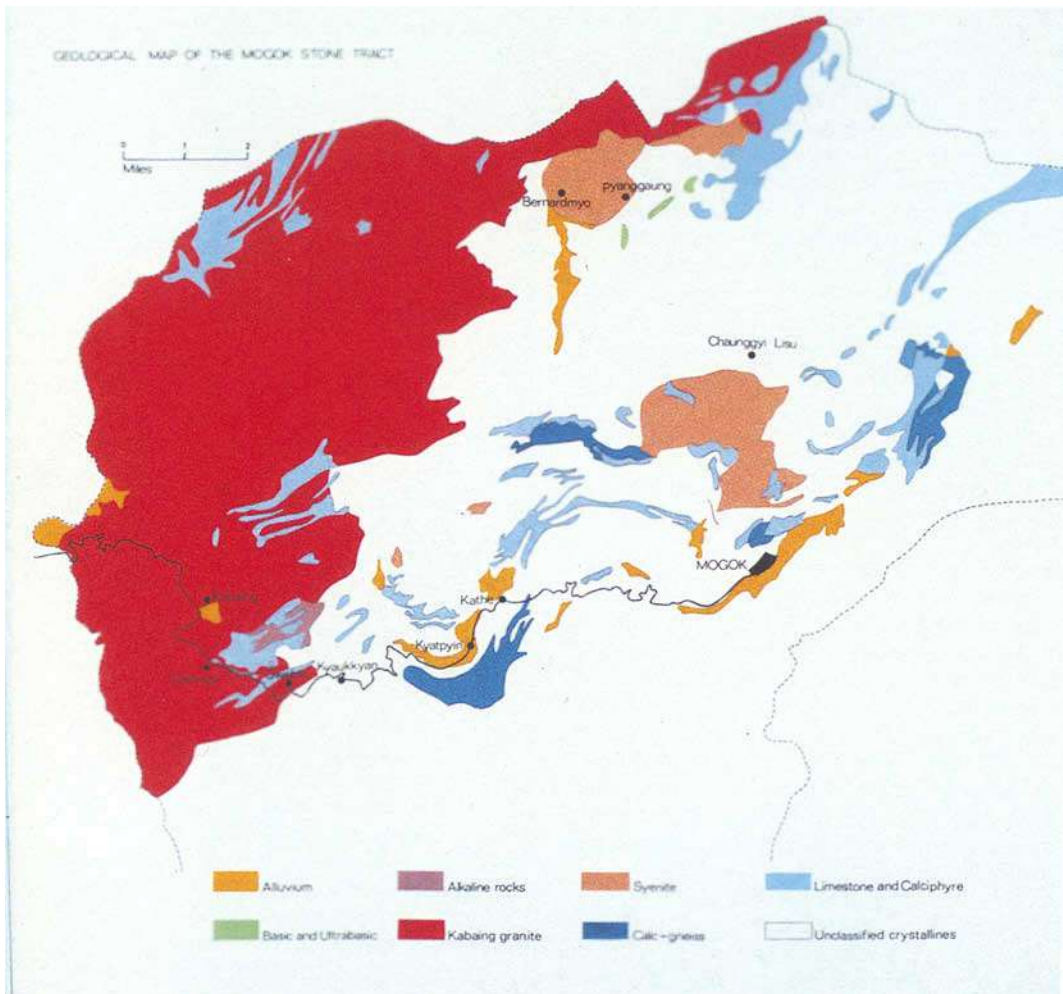


Fig. 6. Geological map of the Mogok Stone Tract, simplified after Iyer (1953)

are being employed. This has led to a marked increase in production.

General geological and tectonic survey

The country is traversed by roughly north/south trending mountains and hills belonging to the Eastern Himalayan orogenic system which sharply bends westwards just outside the country's northern-most tip. This morphology is the result of the Indian subcontinent drifting into the Asian continent, a mountain building process going on since early Tertiary times. This led to the juxtaposition of completely different rock types and to mineralizations having gem potential (e.g. the albite-jadeite dykes in Upper Burma, centred at

J1 in the survey map (Figure 2).

In Myanmar, the suture zone (an active seismic collision belt) defining where the Indian plate is subducted under the huge Asian continent is delineated by the arc-shaped margin between the Indoburman mountain ranges in the west, and the Chindwin, Minbu and Irrawaddy Delta Basins in the centre of the country (a subduction thrust accompanied by a stringer of serpentinite bodies). Other expressions of the general tectonic structure can be seen in the line up of volcanic and plutonic rocks along the well defined western edge of the Shan Highland Plateau (Thin, 1985) or even in the diamond occurrences lined up from the Tenasserim State in the south, all the way through to Northern Kachin State

(locations D1 to D5 in Figure 2). Additional detail on the tectonic history of Myanmar and Mogok is given by Bender (1983) and more recently by Mitchell (1993).

In general terms, it can be stated that western Myanmar is a high-pressure/low temperature area with ultrabasic rocks in the north-west and sediments, metamorphosed sediments and igneous rocks in the south-west (Chin and Arakan States). In contrast, the east of the country (Shan State) is a high-temperature zone composed of uplifted metasediments intruded by granites and diorites. The south is mostly made up of granites and Paleozoic rock types (Bender, 1983).

Mineral resources

Southern Myanmar (as well as the entire Malayan peninsula) is renowned for its productive tin (Sn) and tungsten (W) deposits. Going north, Sn and W ores are again found south-west of Bhamo. Inside the slightly curved western edge of the Shan Plateau, lead (Pb), zinc (Zn) and silver (Ag) ores are encountered. On a concentric line west of this ore belt (i.e. closer to the suture zone), nickel (Ni) and chromium (Cr) mineralizations have been detected in peridotites (south of the jade belt centre J1 - Figure 2). Antimony, bismuth, molybdenum, uranium and manganese ore as well as baryte, chromite, ilmenite, columbite, tantalite, monazite (rare earths), graphite, albite, gypsum and asbestos occurrences have also been reported.

Bawdwin near Namtu (east of the Mogok Stone Tract) is known for its Pb, Zn, Cu and Ni assemblage, boasting the most important silver deposit in Myanmar. Alluvial platinum (Pt) in small quantities is found north of Madaya/Mattaya (Mandalay district). To complete the picture, gold is exploited in a considerable number of mainly alluvial deposits, gold nuggets being extracted from the important Kawlin-Wuntho area placers. Production figures of present-day official and private (illicit) mining activities, however, are difficult to procure.

Following the south-central banks of the Irrawaddy river, oil fields are lined up, showing that the fossil energy deposits obey the same general tectonic pattern. Oil and natural gas are also drilled off-shore (Montgomery, 1993). Oil production is said to cover the domestic needs. Coal reserves are located near Kalewa and in the Hukawng Valley, in western and northern Myanmar.

How did the primary ruby deposits at Mogok form?

The origin of the primary ruby deposits at Mogok is still controversial. There are two reasonable alternative explanations: (1) contact metamorphism and (2) regional metamorphism. Proponents of both explanations agree on all the important facts, e.g. that the rubies occur in a coarse-grained marble (metamorphosed limestone); that associated minerals include spinel and numerous silicates (diopside, phlogopite, etc.); that the ruby-bearing marbles form more or less continuous bands and lenses interbedded with gneisses; and that there are many types of igneous intrusions (e.g. granites, pegmatites, syenites) in the area. All proponents also agree that for the corundum (Al_2O_3) varieties to form in either of the two metamorphic situations listed above, an unusually enhanced Al_2O_3 content must be present. This is in contrast to rocks of normal Al_2O_3 content, in which the Al_2O_3 is taken up by common aluminium silicates such as feldspar, garnet, clinozoisite and the Al_2SiO_5 minerals (andalusite, kyanite and sillimanite). Ideally, the best starting material for the formation of corundum would be one of the mineral forms of $\text{AlO}(\text{OH})$ (boehmite or diaspore) or $\text{Al}(\text{OH})_3$ (gibbsite), as the metamorphic conversion would merely involve the loss of OH (effectively, H_2O) at geologically reasonable temperatures (less than 600°C) and low pressures.

Contact metamorphism involves mineralogical and textural changes in rocks resulting from the heat of nearby igneous intrusions. In certain circumstances, hydrothermal fluids may be introduced and these will have a major effect on the types of minerals formed (e.g. skarn minerals); this type of contact metamorphism involving the introduction of new material is called 'metasomatism'. Pressure does not vary significantly in contact zones around intrusions. Temperature is the dominant factor. The width of zones of contact metamorphism varies greatly ranging from a few centimetres to several kilometres.

Iyer (1953), who spent three seasons mapping in the Mogok area, was convinced that the ruby deposits formed by the contact metasomatic reaction of late magmatic pegmatitic fluids with the limestones, which were subsequently metamorphosed to marbles. Eventually, an aluminium-rich, silica-depleted environment was created from which Al_2O_3 formed. The sequence of events summarized from Iyer (1953, p.36) apparently involve the removal of SiO_2 (desilication) and other constituents from the magmatic solutions by means of chemical reactions

with the limestones in stages: (1) diopside, forsterite (olivine) and certain other minerals formed due to contact metamorphism initially when CaO, MgO (originally from magnesium in the limestones) and SiO₂ were present in sufficient quantities; (2) when SiO₂ and CaO became depleted, MgO combined with Al₂O₃ to form spinel, and when MgO became exhausted the remaining Al₂O₃ in the magmatic fluids crystallized as corundum. This mechanism also explains the occurrence of spinel, which is significantly more abundant than corundum at Mogok. It should be noted, however, that many modern experts in metamorphic rocks would prefer a mechanism by which corundum and associated minerals were formed by desilication of the limestones (rocks) rather than by desilication of the fluids as was proposed by Iyer (1953).

Regional metamorphism occurs over a large area and is caused by deep burial of rocks or by tectonic (i.e. deformational) forces in the crust; moderate-high temperatures and low-high pressures may be involved. Keller (1990) advocates regional metamorphism (with high temperatures and low pressures) as the cause of the primary ruby deposits at Mogok, because the ruby-containing marbles are interbedded with gneisses of unquestionably regional metamorphic origin.

In order to explain the regional metamorphic origin of the rubies, it is necessary to invoke some set of circumstances by which Al₂O₃ contents became elevated in limestones before they were metamorphosed to marbles, at which time the rubies (corundum) would have been formed. One such mechanism can be envisaged by intense (lateritic) weathering of an impure limestone (containing clay minerals, for example), perhaps in a karst environment, leading to the formation of boehmite, diaspore or gibbsite. After the surface weathering, the rocks would have been overlain by a great thickness of other rocks (shales, etc.) and deeply buried. In response to regional metamorphism limestone would change to marble, shale to schist and gneiss, and the aluminum-rich limestone impurities (e.g. boehmite) to corundum (ruby). The equation for the formation of corundum would be:



This same mechanism was proposed for the formation of the ruby deposit in the Hunza Valley, Kashmir, Pakistan, which is very similar geologically to the deposits at Mogok (Okrusch *et al.*, 1976; Gübelin, 1982). Based on experimental data, Okrusch

et al. (1976) determined that the formation of the rubies at Hunza took place at about 600°C and the pressure was about 7kb (equivalent to about 23 km depth).

The important emery (corundum with admixed spinel, magnetite, etc.) deposits of Naxos, Greece, which have been mined for centuries, are explained by a similar regional metamorphic mechanism. With respect to these deposits, Dixon *et al.* (1987, p.515) observed:

'Most of the deposits form part of discontinuous horizons, which are more or less conformable with the surrounding marbles and can be followed laterally over several kilometers. Such horizons are the metamorphosed equivalents of fossil weathering crusts [e.g. laterites] in a tropical climate.'

From the above discussion it is clear that either of the two possible geological processes, i.e. contact or regional metamorphism, could explain the origin of the Mogok ruby deposits. In fact, it is possible that *both* contact and regional metamorphism could have affected the rocks containing the rubies at Mogok. Rubies could initially be formed by contact metamorphism in the zone around an igneous intrusion and these rubies could have survived subsequent regional metamorphism during which additional rubies, occurring over a much larger area, would be formed. It is also possible to envisage situations in which regional metamorphism would precede contact metamorphism and rubies would be formed by both processes. Detailed geological mapping, and gemmological and mineralogical studies, should be able to recognize the two metamorphic events. For example, groupings of rubies could be made on the basis of their mineral inclusions and trace elements and the physicochemical characteristics (e.g. temperature of their formation) of their fluid inclusions could be determined. The spatial distribution of the rubies with respect to the igneous and metamorphic bodies might enable a distinction to be made between the two processes. Interestingly, Hänni and Schmetzer (1991) reported that two different types of rubies, one of which also occurs in marbles, have been recognized from the Morogoro area, Tanzania, based on gemmological properties; one of the types has properties similar to those from Myanmar. No explanation for the difference was offered.

Finally, it must be emphasized that this discussion is not applicable to rubies and other corundum varieties that are found in certain other localities, such as Thailand and Australia, because these occur in basalts.

The gemstone deposits

Outline

Given that the Government of Myanmar do not recommend journeys into certain areas at the present time the following description of the various gem deposits is a compilation of personal visits to the sites by the authors and information gained from sources both inside and outside Myanmar, and the verification of earlier published references.

The reference maps consulted are those listed in the map reference section. The Mogok Stone Tract map of Kane and Kammerling (1992) has been revised and expanded. A simplified version of the geological map of Iyer (1953) is included here (despite its age) since it still gives a good idea of the local distribution of the various rock types - note especially the sinuous outcrops of limestone (marble) which traverse the area in a generally east-west alignment (see Figure 6). However, it should be noted that, as in many other countries in the area, names change with time or after political upheavals, or may vary due to different official and local spelling (Mong Mit of earlier times became Momeik; Mong Hsu in Shan dialect is Maing Su in official Myanmar language and Mai Suu is the Thai pronunciation in the gem exchange town of Mae Sai, northern Thailand; Hpakant, the name of the jade mining centre, can also be encountered as Hpakan and Phakant). Where not obviously wrong or outdated, two name or spelling versions are accepted with the more common one leading. For the Western hemisphere, rubies and sapphires still originate from Burma, not Myanmar (the country's official name since 1990), therefore, both names are used here equivalently. (NB. Myanmar is the correct adjectival form describing Myanmar.)

The following indications on the survey map (Figure 2) and MST map (Figure 3) are (1) approximate for R3-R4, R6, R8, S3, J3-J4, CP2, AM2, D1, D4, TM2, and/or (2) unconfirmed for S4, J5, -J7, AM3, D2, D5, LL2-LL3, NP2, QU2, QU3. Productive areas are: R1-R2, R5, S1-S2, J1, PD, SP, CP1-2; (D1), (LL1), (NP1), (RM). (See Table 1 for explanation of the codes and localities.)

Mines and mining in the Mogok Stone Tract

Access to the historic Mogok Stone Tract in upper Myanmar was severely restricted for approximately 30 years, beginning in the early

1960s. Taking a more pragmatic approach, the Myanmar government began to permit a limited number of foreign nationals to visit this important mining area at the beginning of this decade (Figure 3). Within the period February 1991 through February 1993, one or more of the authors took part in a total of four such visits, among the first by western gemmologists in recent years. The following information was gathered on these visits through personal observations and briefing documents provided by government officials and is presented for each of the mines seen. Also described is the Central Washing Plant, a facility that processes gem gravels recovered from several MGE-operated mines and the Zay Kyaung Buddhist Monastery, which displays several important gem-encrusted Buddhist images.

General Access

The famed Mogok Township is located about 100 air kilometres north-east of the city of Mandalay. On all of the authors' trips, Mogok was reached by road from Mandalay. In addition to the authors and their MGE hosts, the groups included an armed Myanmar security detachment. The drive, which takes approximately six hours in good weather, is on a 200km and somewhat sinuous poorly paved road that is less than two lanes wide. About half-way through the journey one comes across individuals 'panning' for gold and the occasional ruby in several streams along the road. As we drove through this land of farming villages and teak, bamboo and banana plantations, we passed many ox-driven carts, the main mode of transportation for many of the inhabitants. Approximately 26km north of Mandalay one passes close to the Sagyin hills where an important and still active marble quarry is located. Interestingly some gemstones - including rubies and sapphires - are recovered as a by-product of the marble recovery process (Bauer, 1937; Chikayama, 1987, 9, 5).

In all instances, four-wheel drive vehicles were used. Although it was not needed between Mandalay and Mogok, it would have been difficult, and in some cases impossible, to reach some of the mine sites without the four-wheel drive capability, especially during those visits when the access roads were quite muddy due to monsoon rains. While the drive is somewhat long and dusty, the scenery is very impressive so the time seems to pass fairly quickly.



Fig. 7. An enormous broken boulder of jade (with polished areas showing 'Imperial Jade') on display at the headquarters of the Myanmar Gems Enterprise, Yangon. Photo by E.A. Jobbins

The mining operations

From the nationalization of gem mining in 1963 until April 1990, all legal mining activity in the Mogok Stone Tract was conducted by the Myanmar government. The Myanmar Ministry of Mines still controls all legal mining and exploration in the Union of Myanmar. The Ministry founded the Myanmar Gems Corporation on 1 April 1976, to oversee the Mogok gems project, the Pharkant Jade Project of the Mineral Development Corporation, and the Trade Corporation No. 19 (Gems) of the Ministry of Trade. In 1989, the Myanmar Gems Corporation was renamed the Myanmar Gems Enterprise (Figure 7).

Today, in addition to MGE mining, there are also government-authorized joint ventures between the MGE and private individuals or groups, as well as illicit mining activities. Although both the MGE and joint-venture operations (and even some unauthorized concerns) now mine a small number of primary deposits, most of the mining by all parties at Mogok today continues to be in secondary (byon) deposits.

MGE Mogok Gems Mining Department

All government mining in the Mogok Stone Tract is handled by the MGE's subsidiary, the Mogok Gems Mining Department, which has several geologists and mining engineers on staff. Eight mines are currently being worked exclusively by the government: one for peridot and seven for ruby and/or sapphire. All are well organized, mechanized operations that use various methods of mining such as ground sluicing, open pit, and underground tunnels into the host rock, depending on the type and nature of a particular deposit. The number of MGE-operated mines is limited only by budgetary constraints - additional deposits have been identified (MGE officials, 1991).

Joint - Venture Mining Contracts

On 9 March 1990, in an attempt to drastically curtail illegal gem mining, the Myanmar government announced the availability to Myanmar nationals of joint-venture mining leases on both the ruby and sapphire districts and jadeite mining areas (*Working People's Daily*, 1990).

From this initial offering, the government

allowed 159 joint-venture projects to begin mining in June and July 1990. According to Yong (1990), the one acre plots were all located within a total of 230 acres in the areas of Mogok, Momeik, Mattaya and Thabeikkyin. Each approved operator reportedly paid at least 'a six figure' amount (in Myanma kyats).

All gems found at joint-venture mines have to be turned over to the MGE for quality grading and first quality stones have to be sold through the MGE at jewellery shops or the Gems, Jade and Pearls Emporium in Yangon (see below). Lesser quality stones are returned to the joint-venture operator after 10 per cent of the value is charged as a mineral tax, and 50 per cent of the value is paid to MGE (*Working People's Daily*, 1990). No gem mining joint-ventures between the MGE and non-Myanma nationals are presently in operation, but MGE officials have stated that they are being considered.

Independent (illicit) mining

In Mogok, citizens have found gems even while drilling water wells, leading to the mandate that anyone in the area who wants to dig in the earth must first seek approval from the government (*Working People's Daily*, 1990). Yong (1990) estimated that the government of Myanmar may have controlled as little as 5 per cent of the total gem production before the first joint ventures were established, with the rest being smuggled to Thailand and India. MGE officials believe that the many joint ventures now in operation have greatly reduced the amount of illegal mining. However, on a small scale simple washing of gem gravels with rattan baskets is still common in the streams and rivers in and around Mogok. Illicit miners also use age-old methods that are still practical today.

Mogok mines

Yadanar Kaday-kadar

This MGE-operated mine is located about 22 km south-west of Mogok township. It is a large, open-cast mine (Figure 8) whose importance is noted in its name, which roughly translates as 'billions of precious stones'. At the time of the authors' visits in 1991, 1992 and 1993, it was described by local officials as the most productive of the MGE-operated sapphire mines.

The site, at the base of Thurein Taung and Katheyaike hills, is a natural basin of about 180m diameter and with an area of about 29 800 sq.m forming the western end of an elongated lowland

that runs from north of Kyaukpyatthat village to Sinkwa (Yadanar Kaday-kadar Camp, 1991). A mass of limestone bands outcrop on the floor of the valley, forming the western rim of the lowland area. This rim serves as a structural barrier, trapping material that has washed down into the basin from surrounding high ground—including the two above-mentioned hills that are known to be sapphire-bearing. This basin had been worked by private miners until confiscation in the mid 60s, followed by a cooperative effort between local miners and military personnel. The current operation, under direct MGE supervision, began in May 1985 after geological surveying indicated the basin had very good potential.

It is interesting here to note that, although the current name of the mine has a positive connotation, an earlier designation tells of past difficulties in working the area. The local miners used to call this basin Lok Khet (meaning 'difficult to work') because of both the considerable overburden – averaging 18m deep – that had to be removed as well as the seasonal flooding. As the basin was not drained regularly, it eventually filled with water producing a small artificial lake. This problem with flooding was solved after the MGE took over the operation, by cutting a 270m long, 1.2m square drainage tunnel through the brecciated marble hillside, a project that took three years (MGE, 1992).

The majority of the production at this mine, which may be both eluvial and alluvial, is blue sapphire (Figure 9), with lesser amounts of ruby, pink sapphire and other gems also being recovered. The mining observed by the authors is basically of the hmyawdwun type, with labourers using simple hand tools to cut trenches into the sides of the open pit. With water flowing rapidly from a pipe at the top of the trench, workers along its slope excavate gravels along its sides, pushing them into the stream of water.

The gravity-propelled water, mud and gravel mixture collects in a pit at the base of the trench, from which it is pumped upward to a wooden holding tank. At this stage in the operation larger rock fragments are removed by hand and the gravels washed with clean water. The gravels then travel through a series of sluices (Figure 8), with final hand-sorting taking place at the mine site.

Although not observed by the authors, some underground mining has also reportedly taken place at this site. These were reported in 1991 to

have included the following: a 27m main shaft that connects to the 180m drainage tunnel, a 17m cross-cut and a 12m minor shaft (Yadanar Kaday-kadar Camp, 1991).

Shwe Pyi Aye (meaning 'Golden land of peace')

This large open-cast mine is located within the township of Mogok. A secondary deposit, this site had been worked by military cooperatives from 1965 to 1987. Mining by the MGE began in December of 1987 and since then Shwe Pyi Aye has become known as a source of fine-quality rubies. Several years ago, a magnificent 5.56ct oval faceted ruby, known as the Crown of Mogok, was cut from a 10.95ct crystal recovered at Shwe Pyi Aye. Also recovered are pink sapphires, a significant amount of red spinels, minor amounts of blue sapphire, and other gem minerals.

Here, the gem-bearing gravel layer – typically 1.8 to 2.4m thick – is reached by removing the 12m to 24m deep overburden with a bulldozer of Japanese manufacture (Figure 10). The overburden itself consists of topsoil and 'red soil' (i.e. laterite). During a visit in March 1991, the exposed gravel was being removed through the use of labourers and simple hand tools, then pumped to an on-site processing centre that included the use of 2.5cm and 1.9cm screens and a series of sluices. At the time of these visits, on-site staff consisted of a mine manager, three engineers, a geologist and thirty-seven other personnel (Shwe Pyi Aye Camp, 1991).

When visited one year later, the exposed area of the mine had increased significantly, with much additional overburden having been removed. Mechanization now also included the use of an excavator to remove the gem-bearing gravels which were loaded onto a truck for transporting to the Central Washing Plant: on-site processing was no longer taking place. During the rainy season, when the Central Washing Plant apparently is not in operation, the gravels are accumulated at the mine site in a large, fenced-in holding area. At the time of this visit, the on-site work force had been reduced by ten men, a 'force reduction' due, no doubt, to the increase in mechanization (Shwe Pyi Aye Camp, 1992). The operation was essentially the same when visited in February 1993 (Shwe Pyi Aye Camp, 1993), but there was a significant enlargement of the excavated area compared with the previous year.

Pan Sho

Operated by the MGE, this open-pit mine is

located only 1.5km north-east from the centre of Mogok. Here, production from secondary sources includes rubies, pink and blue sapphires, and on a percentage basis significant amounts of other gem materials as well. During a visit in March 1991 a bulldozer was being used to remove the overburden, after which an excavator was employed to extract the gem gravels. These were loaded onto trucks for transport to the Central Washing Plant which is only about 0.5km away.

Than Ta Yar

Operated by the MGE until the latter part of 1991 when it became a joint-venture entity, Than Ta Yar is located about 5km to the north-west of Mogok and less than 1.5km from the Kyauk Saung mining area. At this locality hard-rock mining techniques are used to expose lodwines, chemically weathered cavities, fissures and even large cavernous areas in the host marble in which the more resistant heavy minerals such as corundum have concentrated. Pneumatic drilling and blasting were being used at the mine to widen openings in the marble so as to reach the often very rich gem deposits. Production at this site is predominantly ruby, with lesser amounts of other gem materials such as fine red spinels and moonstones. MGE officials stated that Than Ta Yar is one of the more important joint-venture operations at Mogok in terms of total carats of ruby rough produced.

Entrance to the Than Ta Yar mine is through a steep, downward sloping tunnel that intersects a deep (approximately 100m) vertical shaft. Near this point of intersection was a winch, used to extract larger waste rock from below. The bottom of the shaft was reached via wooden ladders and scaffolding. This lowest level of the mine contained roughly a metre of water, from which point workers placed waste rock and debris into a bucket which was winched by hand to the surface of the mine. This shaft was located about 2.5m higher than the bottom of and leading off from the main vertical shaft. The gem-bearing byon was pumped from the bottom of the mine to an on-site processing plant.

This recovery operation was located within a fenced-in compound no more than 50m from the mine's entrance. The gem-laden gravels and water being pumped from the mine showered out of a pipe like a fountain and onto an inclined trough (Figure 11), where workers with long-handled rakes manually pushed larger rock



Fig. 8. The large open-pit mine at Yadanar Kaday-kadar in October 1992. The 'byon' (gem gravel) is being washed down by the water jet (upper left); the gravel is concentrated in the sluices or 'hymadwin' (centre); the vertical drainage shaft is capped by the black 'tent' (bottom left); see text. *Photo by E.A. Jobbins*

fragments over the side. The remaining gem-bearing material collected in a heap on the ground at the opposite side of the trough, where it was loaded into small circular sieves. These, in turn, were placed in a small vibrator jig used to concentrate the heavy minerals on the bottoms of the sieves. Adjacent to the vibrator jig was a sorting table, onto which the sieves were quickly inverted. The final step was the hand removal of gemmy material, which was placed in a sealed

Fig. 9. Rough sapphire (some grading to ruby) from the Yadanar Kaday-kadar mine. *Photo by E.A. Jobbins*



container with a 'one-way' opening. At Than Ta Yar we also saw 'kanase' women pursuing their traditional function of working the discarded gravels from the mine, hoping to find rubies and other gems that may have been overlooked in the original recovery operation.

Thurein Taung ('Sun Mountain')

Operated directly by the MGE since December of 1987, this hard-rock mine produces sapphires almost exclusively. The site is reached by driving about 23km west from Mogok, followed by a brisk fifteen minute walk along 900m of a steep and narrow, often barely discernible footpath from the Yadanar Kaday-Kadar mine site. Here the geology consists of alkali-rich basic igneous rocks that have been intruded into the marble. The gems are recovered from this intruded igneous rock and biotite-bearing gneiss. Conventional tunnelling along the sapphire-bearing vein is accomplished through the use of pneumatic drilling and blasting with dynamite (Figure 12). Electricity to power the compressor as well as lighting within the mine is provided by an on-site generator. When first visited by one of the authors in March of 1991, the on-site staff



Fig. 10. Removing reddish-brown overburden (from 12-24m thick) to reach the gem gravels at Shwe Pyi Aye. *Photo by R.E. Kane*

Fig. 11. Gem-laden gravels from the Than Ta Yar mine are pumped to this on-site processing plant where they shower out of a pipe and on to an inclined trough. *Photo by R.C. Kammerling*



consisted of twenty-five employees: a site manager, an assistant manager, a geologist, two mining engineers and twenty other personnel (Thurein Taung Camp, 1991) (Figure 13).

Located a short distance from, and visible *en route* to, the MGE mine, is a similar operation that is operated as a joint venture. Both operations are within a few hundred metres of the spectacular Kyaukpyatthat Pagoda which sits atop a promontory that dominates the area.

Lin Yaung Chi

This MGE mine, surrounded by the Let Nye, Shwe Taing, and Yekan mountains, is located due north of Mogok on the east side of the Panlin Bernardmyo road. Lin Yaung Chi is known for its occasional production of exceptionally fine gem rubies, such as a piece of rough that was faceted into a 4.70ct stone that sold for US\$282,000 (\$60,000 per ct) in the February 1992 Emporium in Yangon. Accessory minerals, including spinel, garnet, apatite, green tourmaline and mica are also encountered while mining for ruby (Lin Yaung Chi Camp, 1992).

Prior to it coming under MGE control, this site was worked by local miners who recovered the gems by removing the topsoil to reach gem-bearing gravels that concentrated in weathered and fractured areas within the marble; these gem-rich gravels are known as 'let kya byon'. Rubies were found *in situ* in 1970 and MGE mining of this primary source began in April 1977 (Lin Yaung Chi Camp, 1991; 1992).

The current hard-rock mining cuts through brecciated marble associated with veins in a fault zone. The veins, which strike N64°E and dip at an angle of 30°, occur between a massive marble and a diopsidic marble (Lin Yaung Chi Camp, 1991; 1992). Tunnelling follows the fault zone between the two marble types, with sawn timbers used for shoring.

During all of our visits, rubies were being recovered from the main tunnel which at the time was roughly 150m long. A 30m-long secondary shaft, called lateral cut number 1, runs perpendicular to the main tunnel and is located about 50m down from its entrance; a second 50m long lateral cut (number 2) occurs a further 50m down the main tunnel. Both lateral cuts were made for the purposes of ventilation and water drainage, the latter accomplished through the use of generator-driven pumps; in addition, number 2 is also used to transport men and materials into and out of the mine.

As with all of the hard-rock mines visited by the authors, drilling and blasting were being used. At the time of our visits on-site staffing consisted of a mine manager, three assistant mining engineers and forty-four other personnel. Gem processing takes place on-site, just beneath the entrance to the main tunnel. Sorting begins with the use of large-mesh screens to remove larger rock fragments, followed by sluicing and then hand-removal of the gems from the gravels.

We were told by MGE officials that on the other side of the hill a secondary deposit was being worked (Shwegu, 'Golden cave'). By the description provided, the mining technique resembles a hmyawdwinn: using water gravity force (from a 135 000 litre reservoir), the gem-bearing gravel is forced down the hill into a sluice. This operation produces large sapphires of good habit, as well as the associated gem minerals of spinel, garnet, apatite, green tourmaline, and topaz (Lin Yaung Chi Camp, 1991; 1992). It is interesting to note that Lin Yaung Chi was in ancient times known as 'vulture hill'. According to a local legend vultures, who would rest on the hill when searching for food in the area, would mistake rubies lying on the ground for pieces of meat. It is possible, therefore, that the legend about vultures plucking rubies from a deep valley at Mogok traces to this very site.

Dattaw

A joint-venture mine, Dattaw is located approximately 5km to the north-east of Mogok. It is reached by driving along a narrow dirt road, followed by a rather steep climb by foot that takes approximately one hour. During the early stages of the climb we noted a number of areas where independent miners were working gravels along narrow streams.

The area where the Dattaw mine itself is located becomes apparent long before it is reached, as it reveals itself at a distance by its stark white marble tailings that flow down the side of the mountain. Some of this marble, still *in situ*, is also exposed on the face of the mountain where a number of tunnels have been excavated at various levels (Figure 14). The mine is entered through an excavated tunnel that leads into a natural limestone cave, the latter as high as 10m in some areas. Additional excavated tunnels lead off from this natural cavern. As with other hard-rock mining at Mogok, pneumatic drilling and blasting are used. Although we did not enter it, we were also shown the tunnel entrance that

leads to where the SLORC (State Law and Order Restoration Council) ruby had been uncovered. At the time of the March 1992 visit an area in front of this entrance was being used to prepare blasting charges.

Dattaw is known as a reliable source of some very large ruby crystals, as well as one of the more important producers in terms of total caratage, although some of the other mines typically produce higher quality stones. One of the large stones recovered at Dattaw was the Nawata ruby, later renamed the SLORC ruby. Found in early 1990, it weighed 504.5 carats and measured 43 mm x 37 mm x 33 mm before it was trimmed to 496.5 carats. Another large stone, reported to weigh 560 carats, was shown to two of the authors at the mine a few days after it was found in March 1992. In early 1993, the Dattaw mine produced yet another large specimen; this 1743ct crystal was examined by three of the authors during the February 1993 visit. Dattaw was also the source of a rare green danburite rough (58ct) which yielded a magnificent oval gemstone of 24.98ct (Figure 15).

Kyauk Saung

Located about 3km north-west of Mogok centre, this mining area hosts a number of separate joint-venture mines. Here primary mines are located along one side of the access road, stretching roughly 1.5km along a ruby-rich marble contact zone (Figure 16). The authors were told by MGE officials that underground water is diverted for working these mines. As elsewhere, drilling and blasting are used. MGE officials also indicated that the operations at Kyauk Saung were among the most productive joint ventures in terms of total caratage produced.

Although all the primary mining was concentrated on one side of the road, secondary mining was in progress on the other side. Here, within easy view of the joint-venture mining, some secondary mining, mostly of the 'lebin' type, was being carried out. In addition, there were many local people – mostly women – who were hammering on marble that had been discarded from the primary mines in hopes of recovering any rubies or spinels that may have been missed (Figure 17). This searching of the tailings by the 'kanase' women is an age-old custom.

Central Washing Plant

The Central Washing Plant is a facility constructed and operated by the MGE to process

gem-bearing gravels from government owned and operated mines that do not have such on-site facilities. It lies approximately 1.5km to the north-east of Mogok centre, very near the MGE operated Pan Sho mine. Construction of the plant began in May 1989 and was completed about six months later, with production starting during the last week of November. The plant has a capacity to process 100 tonnes of material a day (Central Washing Plant, 1991; 1992; 1993).

Gem-bearing earth removed from some of the MGE-operated mines is brought by trucks to this facility. The trucks back onto a concrete slab, dump their load onto a large metal grate and high-pressure water cannons are then directed onto the material (Figure 18). Larger rocks and debris are trapped by the sturdy grating and discarded by labourers, while the dirt and gem-bearing gravels are washed into a concrete pen that is at a somewhat lower level than the grate. From platforms on either side of the pen, additional water cannons are used to wash the gravels, causing the lighter soil to be washed away, this muddy waste water flowing down a chute. Simultaneously, the water cannons cause the gem-bearing gravels to travel into the first of a series of vibrating screens and concrete chutes. One of these screens separates out all stones larger than 1.9cm, which are then collected and hand-sorted on a table. A second screen separates out stones smaller than 1.9cm but larger than 0.6cm for similar hand-sorting. Finally, the smaller gravels continue down the system until they reach a large, concrete holding tank, near the bottom of which is a drain pipe of approximately 8cm diameter. Gravel removed through this pipe flows into shallow, circular metal pans that have bases fabricated from fine-mesh screening. Each filled pan is placed in a small vibrating jig for several minutes, the vibration causing the heavier minerals, including the corundum, spinels and zircons, to settle to the bottom centre of the pans. The pans are then taken to a sorting table where they are quickly overturned, thereby leaving the denser materials at the top centre of the piles. The gems are then picked out by sorters using stone tongs and placed in locked metal containers. Although all gem-quality materials were placed into the containers without sorting by type, the sorters showed the authors their expertise in separating ruby from red spinel on the basis of crystal morphology and slight differences in colour.

During the 1993 visit we were told that the



Fig. 12. Miner preparing for blasting in the 'hard-rock' mine at Thurein Taung. *Photo by R.E. Kane*



Fig. 13. Sorting sapphire at the primary tunnel mine at Thurein Taung. The blue sapphire is visible in matrix (bottom right) and in the concentrate (centre). *Photo by E.A. Jobbins*



Fig. 15. This very rare green danburite (24.98ct) was cut from rough (58 ct) found in a Dattaw mine. *Photo by E.A. Jobbins*

Fig. 14. In the primary mine at Dattaw, a worker uses a drill in the excavation of the marble. *Photo by R.C. Kammerling*



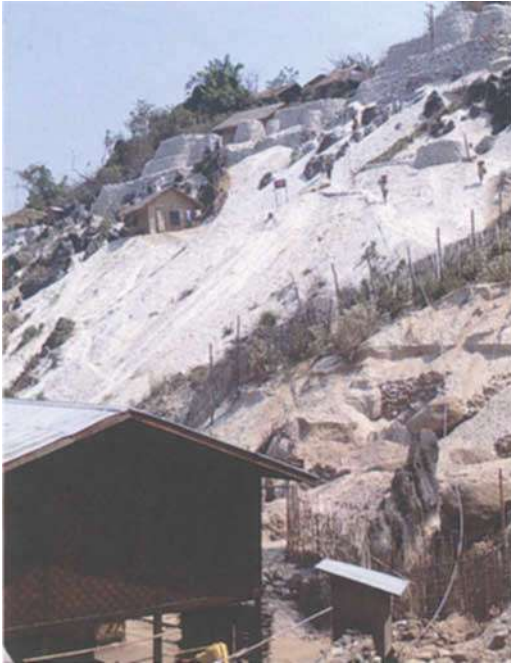


Fig. 16. At Mogok, the primary (*in situ*) occurrences of rubies is in a coarse-grained marble. Here at Kyauk Saung, white marble tailings cover a large portion of the hillside. *Photo by R.E. Kane*



Fig. 17. Here a 'kanase' woman hammers on marble discarded from the primary mines at Kyauk Saung in the Mogok Stone Tract in hopes of recovering any rubies or spinels that may have been missed. *Photo by R.C. Kammerling*

Fig. 18. Central Washing Plant. From platforms on either side of a pen, water cannons are used to wash the gravels brought to the facility for processing. *Photo by R.C. Kammerling*



Central Washing Plant was processing gem gravels from several mines, including Pan Sho, Shwe Pyi Aye, Padamyar and Pingu Taung. The considerable amounts of water required for the washing operation are pumped from a dirt reservoir located just below the washing plant. To increase the efficiency and capacity of the plant an additional, larger reservoir was being constructed of concrete during the 1993 visit. This new on-site source of water will be uphill and adjacent to where the trucks initially deposit the gravels.

Zay Kyaung Monastery

This Buddhist monastery (Figure 19) is of gemmological significance since it houses some important gem-set Buddhist icons. These are reported to have been produced with funds and gem materials donated by pious individuals. One such icon is a roughly 8cm tall image of the Buddha carved from what appears to be an opaque ruby. This is mounted on a 30cm high moulded plaster (?) dome that is completely covered with uncut, predominantly red stones which the authors believe to include both rubies and garnets (gemmological testing was not possible). Another such icon seen was also of Lord Buddha, this one fabricated of gold and ornately decorated with faceted gems, among them many that appeared to be rubies of very good colour. A smaller dome of unfashioned red gems was surmounted with another Buddha image approximately 7.5cm high (Figure 20), this one transparent and bluish-green in colour. We were told that this had been carved from an aquamarine crystal that was recovered locally. During our visit to the monastery in March 1992 we had an audience with the head monk, who granted us permission to photograph the icons.

Another point of interest in the Mogok area is Beedaw Hill, site of a Buddhist shrine (Figure 1). Our primary purpose in visiting this site, however, was for the spectacular view it provides of Mogok and the man-made lake below.

Mong Hsu

In July of 1992 the Government of Myanmar declared the Mong Hsu Gemstone Tract (R5 in Figure 2) and, in doing so, the country recognized yet another important source of gem quality ruby. 'Mong Hsu', as its spelling and pronunciation (Hsu = Soo) is becoming internationally recognized, may also be spelt and pronounced in a variety of other ways, including

'Mine Shu' as it was first spelt and pronounced to a number of the authors by Myanmar Gems Enterprise (MGE) staff in September of 1992.

The ruby mining area is near the Shan State town of Mong Hsu, an area of Myanmar which the government advise foreigners not to enter at this time. The authors, therefore, experienced some difficulty in obtaining first hand descriptions of the situation there. However, enough reliable and verifiable second-hand information was obtained through the MGE and dealers in Thailand for a reasonably accurate account of the situation to be recorded here.

The town of Mong Hsu is located approximately 250km east of Mandalay and the mining is said from information gained in November 1993 to take place at a site known as 'Sia laing'. Hlaing (1993) reports that this primary deposit occur between the peaks of Loi Hsawnshtoa (approximately 16km south-east of Mong Hsu) and Loi Paning, and secondary deposits are mined in the river terraces of Nam Hsu, just 5km south east of Mong Hsu. Hlaing also reports that primary Mong Hsu ruby occurs *in situ* in marbles and associated minerals include quartz, green tourmaline, red-brown garnet, staurolite, pyrite and acicular tremolite. He further states that the ruby-bearing gravels of the secondary alluvial deposit at the village of Loi Kham (about 8km south-west of Mong Hsu) are of a quartz-hematite-rock pebble type and that these lie below a yellowish-brown soil about 32-64m thick.

Whilst the alluvial Mong Hsu ruby tends to be water worn, the primary mining area yields euhedral crystals that are prismatic combined with series of dominant and subordinate bipyramidal faces and positive rhombohedral and/or small pinacoidal terminations (Smith and Surdez, 1993). Most Mong Hsu rubies contain distinct blue cores and/or zoning when mined (see cover picture) and these need to be removed by heat treatment. Whilst some heat treatment of this material is now taking place in Myanmar (as evidenced in the last two Emporiums), most stones are treated in Thailand. The Mong Hsu ruby is now one of the most common ruby 'varieties' available on the market and yet it has been conspicuously under represented at the Yangon Emporiums since its discovery. At the October 1993 Emporium only four small lots of stones identified as having come from this area and described as 'heat-treated cut ruby' in the Emporium catalogue were offered at auction.

Inclusions in Myanmar rubies and sapphires

It is well known in the gem world that for certain gemstones geographic origin – the provenance – can have a significant impact on its value. This is especially true with the most costly of coloured stones, among them ruby, sapphire and emerald. As rubies and sapphires from Myanmar have long been held in high esteem, their gemmological properties, in particular those that would help to separate them from natural stones from other localities, as well as their synthetic counterparts, have been studied in some detail.

Although more 'high-tech' methods – trace element analysis, optical absorption spectra, etc. – are being called upon increasingly in making such distinctions, internal features as noted through the microscope remain the most relied-upon characteristic to say whether a given stone is or is not of Burmese origin. Furthermore, this is the only diagnostic test available to the vast majority of gemmologists.

In the past it was not particularly difficult to recognize Myanmar rubies on account of their inclusions and to distinguish them with relative certainty from rubies originating from other localities. Commercially suitable rubies used to originate from Myanmar, Sri Lanka or Thailand, whereas other localities were more or less unimportant and their rubies did not appear on the market in sufficiently important quantities. The formation mechanisms and the geological conditions of the three most important ruby deposits are so completely different from each other that their rubies' growth features also differ quite conspicuously.

Exquisite rubies of the coveted pigeon blood red colour were very rare and hardly ever occurred in Thailand or Sri Lanka. Therefore, the colour already served as a certain indicator. However, the inclusions offered considerably more certainty. Although the individual mineral inclusions and their associations were characteristic for Myanmar (Mogok) rubies, it was the general appearance and *distribution* of the internal features which typified them. In order to gain a relative certainty, three internal features were necessary to coexist (Figure 21):

1. Relatively local concentrations, so-called *nests* or also zones, of short rutile needles

(silk), of which many would display the unusual *arrow twins* (Figure 22).

2. In addition, more or less well-shaped calcite crystals (Figure 23) which could usually be identified by their twinning lamellae or the rhombohedral cleavage planes. The calcite crystals are often accompanied by reddish-brown phlogopite or dark reddish-black prisms of rutile and sometimes by dolomite and spinel. However, no margarite has been observed as in rubies from the Hunza valley.
3. Further telltale features are the roiled structure of swirl-like treacle (Figure 25), resulting from inhomogeneities and optical distortions. Irregularly spaced polysynthetic twin lamellae may be present.

Fluid inclusions forming fingerprint feathers are relatively uncommon and certainly less frequent than in rubies from Sri Lanka. In contrast to the general appearance of the above-mentioned principal elements forming the inclusion scene in Myanmar rubies, Thai rubies reveal themselves by the so-called rosettes, which consist of a negative crystal or a crystal of apatite or garnet surrounded by the typical decrepitation halo.

In the 1960s, rubies from East Africa (Longido, Umba Valley and Nganga, to name just the most important) started appearing on the market. However, due to their entirely different geological background and mode of formation, the internal features had nothing in common with Myanmar rubies.

When, however, more recently rubies originating from the Hunza Valley and deposits in Vietnam made their debut on the gem market, it was immediately obvious that it would be much more difficult to distinguish these from Myanmar rubies, for all three deposits are composed of very similar mother-rocks (dolomitic marble) with comparable geological histories. While a highly experienced gemmologist, who is accustomed to scrutinizing inclusion scenes and their individual elements, might be able to discern them, in most cases gemmologists have to take recourse to more elaborate methods. So far, experience teaches that rubies from the Hunza Valley in Pakistan and those from Vietnam contain a less diverse variety of mineral inclusions than the rubies from Myanmar, apart from other usually

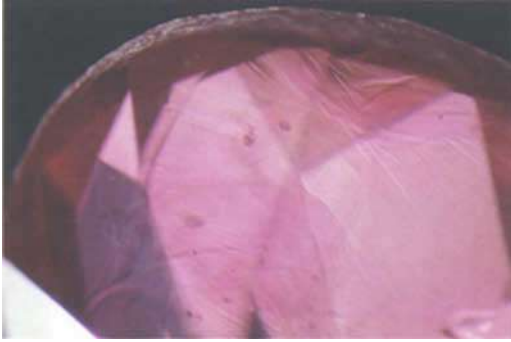


Fig. 21. Swirled 'treacle' or 'roiled' effect in a Mogok ruby. 15x. *Photomicrograph by J.I. Koivula*

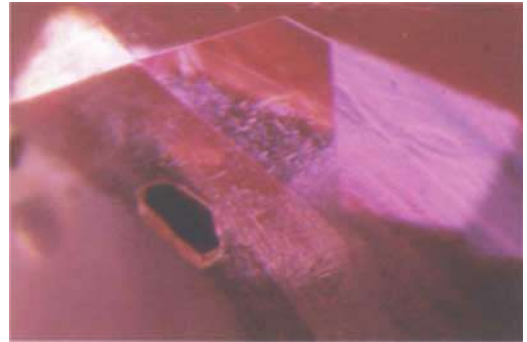


Fig. 22. A black crystal of graphite surrounded by short rutile needles and a 'roiled' or 'treacle' structure in a Mogok ruby. Graphite flakes also occur quite abundantly in the dolomitic marble mother-rock. 9x. *Photomicrograph by E.J. Gübelin*

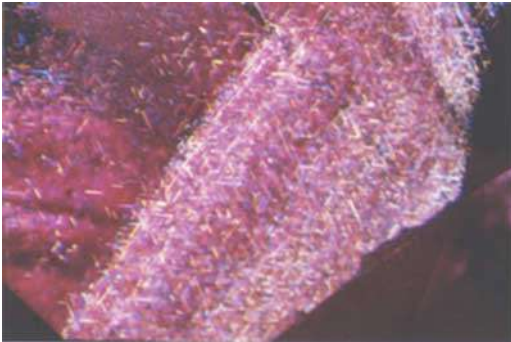


Fig. 23. Dense net of iridescent epigenetic rutile needles in a Mogok ruby. 60x. *Photomicrograph by J.I. Koivula*

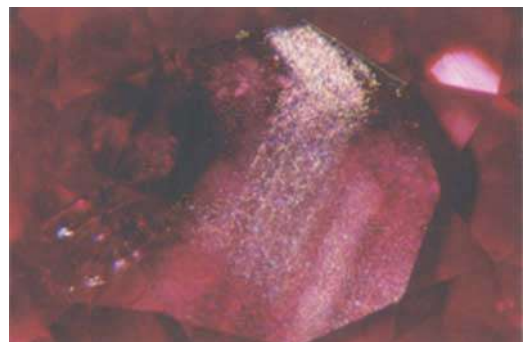


Fig. 24. Dense silk consisting of short rutile needles forming zones parallel to the prism faces in a Mogok ruby. They reflect the impinging light. 18x. *Photomicrograph by E.J. Gübelin*

Fig. 25. Strongly corroded calcite crystal displaying the typical rhombohedral pattern of twinning in a Mogok ruby. 64x. *Photomicrograph by E.J. Gübelin*

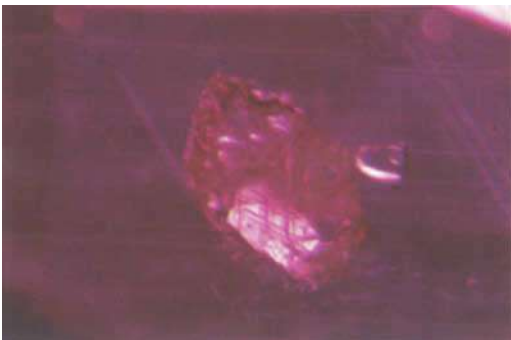
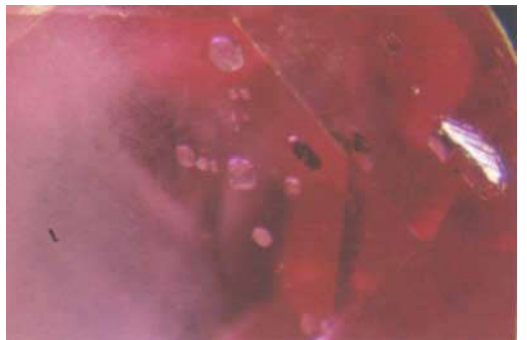


Fig. 26. Locally typical inclusion association, embracing a loose group of calcite crystals, as well as loosely woven silk (cloud) of rutile needles, and a black prism of rutile. 25x. *Photomicrograph by E.J. Gübelin*



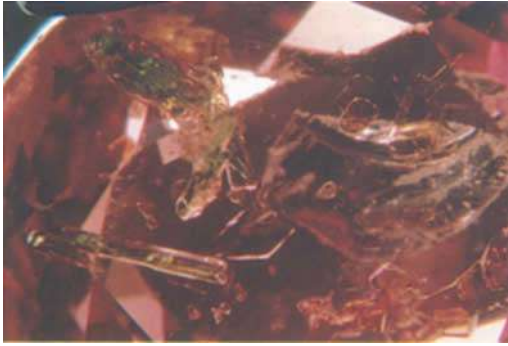


Fig. 27. New association of inclusions discovered: green pargasite crystals accompanied by strongly corroded brown spinel crystals. This association forms a particularly characteristic combination in Mogok rubies. 9x. *Photomicrograph by E.J. Gübelin*



Fig. 28. A recently identified slightly resorbed crystal of sphene displays typical striation as an individual peculiarity in a Mogok ruby. 8x. *Photomicrograph by E.J. Gübelin*

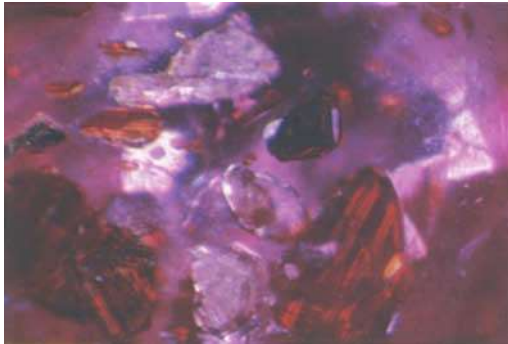


Fig. 29. Very dark brownish-red crystals of rutile, epigenetic rutile needles, and whitish and near-colourless calcite crystals in a Mogok ruby. 50x. *Photomicrograph by J.I. Koivula*

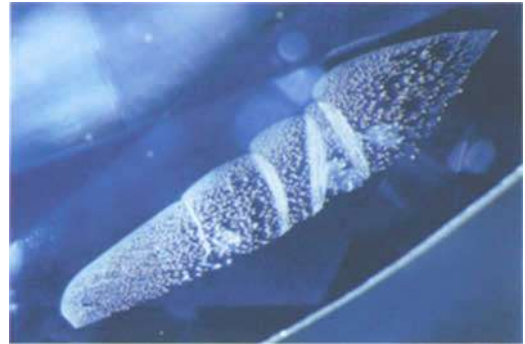


Fig. 30. A partially healed fracture system with some 'folding' in a Mogok sapphire. 25x. *Photomicrograph by J.I. Koivula*

Fig. 31. A white cloud of epigenetic rutile needles, some of which are iridescent, in a Mogok sapphire. 40x. *Photomicrograph by J.I. Koivula*



Fig. 32. Fine 'silk' of rutile needles and a corroded yellowish apatite in a Mogok ruby. 20x. *Photomicrograph by E.J. Gübelin*



trivial but, in certain cases, quite important differences.

During the two excursions to Myanmar (1992, 1993), in order to visit the gem mines around Mogok and to attend the Gem Emporium in Yangon two lots of rubies were purchased by one of the authors, containing 21 and 22 rubies respectively. Upon examination of these rubies, the fact that *all* 43 rubies displayed an absolutely characteristic inclusion scene containing the above and some additional features was met with reassuring satisfaction. (Figures 21 and 22 reliably attest to this fact.) Some of these rubies were surprising as they contained mineral inclusions which have never before been identified. By means of electron microprobe, energy dispersive X-ray fluorescence or X-ray diffraction they could be identified as being a yellowish, typically corroded apatite, a flake of graphite, a well-shaped scapolite crystal, a slightly resorbed sphen crystal and an emerald-green pargasite, as well as strongly corroded brown spinel (see Figures 25 to 28). So far it has been noticed that apatite in Myanmar rubies is normally resorbed to a rounded shape, whereas in Sri Lankan gemstones apatite usually displays euhedral, prismatic crystals. Some of these mineral inclusions have not yet been observed in either Hunza or Vietnam rubies.

Some of the inclusions seen in Myanmar rubies also occur in the sapphires. Fluid inclusions in the form of partially healed feathers often with a 'folded' or fingerprint-like appearance are not uncommon in Myanmar sapphires (Figure 30).

This relatively short report about the investigation of the above-mentioned 43 rubies, which took almost a whole year, reveals that a thorough study of the internal features of rubies from the various commercially important mines is always enlightening.

Very recent work has shown that inclusion patterns of Mong Hsu rubies differ markedly from those of Mogok rubies. Apart from occasional apatite or dolomite crystals, mineral inclusions are typically absent from Mong Hsu rubies. Instead they commonly display cloud and dust stringer patterns as well as prominent growth structures and colour zoning (see cover picture).

Furthermore, an examination of these stones by one of the authors revealed that the stones still exhibited their distinctive blue cores, in contrast to the Thai treated stones.

However, rubies from Mong Hsu are readily available in Mae Sai, the northernmost town in Thailand, just across the small Moei Kok River from the town of Tachileik, Myanmar. In Mae Sai, only a few hundred metres south of the border, rough, untreated rubies from Mong Hsu are openly traded in shops and at street-side tables along what has come to be known locally as 'Soi Tab Teem', or Ruby Lane (Figure 33). Here Thai dealers, mostly from the south-eastern city of Chanthaburi, purchase stones from Burmese who daily cross the bridge between Mae Sai and Tachileik. According to one such Thai dealer, the cost of setting up shop here is quite reasonable: roughly \$US 400 to rent a shop, \$80 for a table on the main soi (lane) and \$40 for a table on one of the smaller side lanes. While visiting this market in early November 1993, one of the authors was able to observe transactions taking place. Parcels may range from one or two small pieces to parcels weighing over 1kg (5000 ct). Stones are examined and, if agreement is reached, goods and money (in Thai baht) exchanged.

From discussions with individuals both in Myanmar and Thailand, the route from mine to market is as follows: the rubies are taken from the mine site to the town of Mong Hsu; they are then taken 275km (by road) to the city of Taunggyi where there is a government (i.e. legal) market at which, for a fee, dealers can trade their stones (interestingly, when one of the authors asked some Burmese dealers the source of their stones, some replied 'Taunggyi' rather than Mong Hsu). However, rather than then going to Yangon, the vast majority of the rough travels east to the town of Keng Tung and from there to Tachileik and across the border into Thailand. Typically the next stop is Chanthaburi where the stones are heat-treated to remove the blue colour core (see cover picture) and are then fashioned, after which they go to Bangkok for marketing throughout the world. In some cases it is reported that the blue cores become needle or flake-like inclusions on heating.

At the time of a visit by one of the authors to Mae Sai in late 1993, several individuals reported that the number of dealers had decreased significantly from a few months' previously. This was

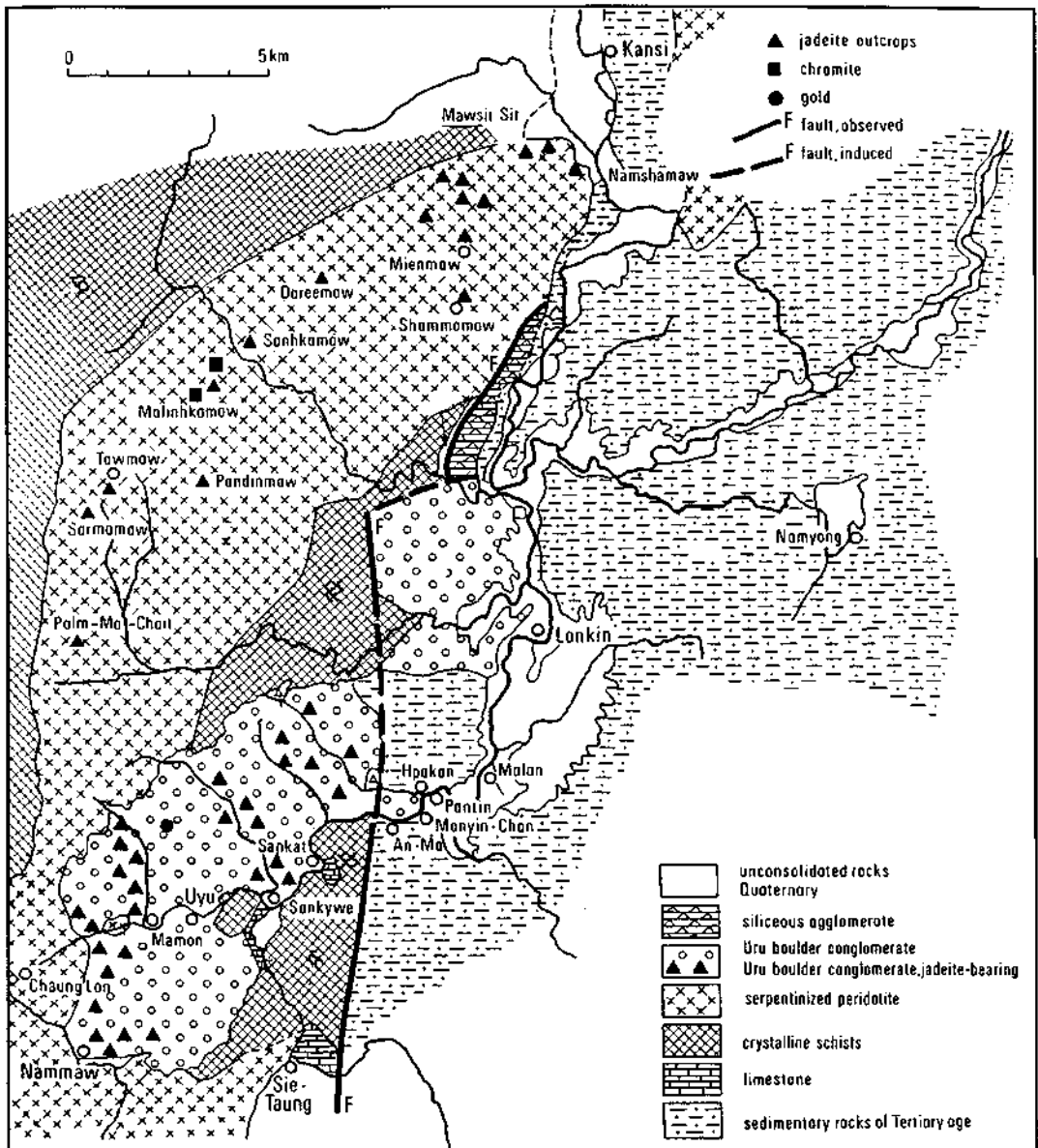


Fig. 34. Geological map showing jade occurrences. Modified after Chhiber (1934) and Bender (1983)

attributed to some controversy surrounding Mong Hsu rubies and a subsequent drop in price. Apparently fluid inclusions in the material result in some fracturing during heat treatment. The fractures in turn are invaded by the fire-coating substance(s) with which the stones are prepared before heat treatment, resulting in inclusions very reminiscent of secondary partial healing planes in some flux-grown synthetic rubies.

Unconfirmed reports in both Mae Sai and Bangkok suggest that some stones from Mong Hsu sent to Europe and the Far East were returned after being misidentified as flux-grown synthetics. It was further stated that, whereas heat treatment is generally an accepted – and expected – practice, the presence of such glassy, flux-like fillings deep in fractures was much less acceptable, especially in larger stones.

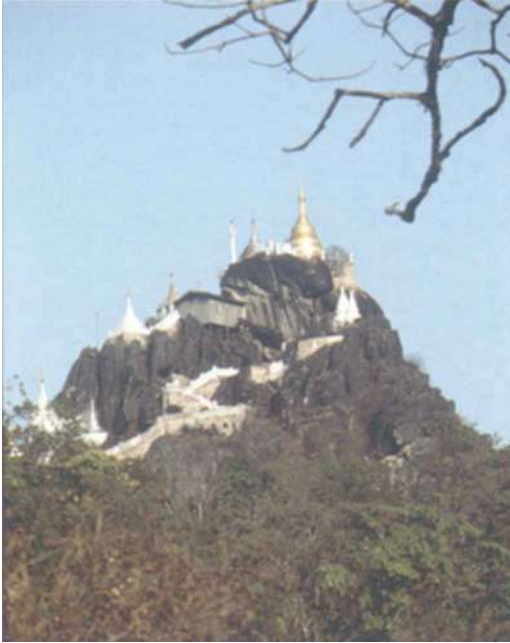


Fig. 19. The spectacular Kyaukpyatthat Pagoda sits atop a promontory only a short distance from the Thurein Taung mine near Mogok. *Photo by R.C. Kammerling*

Fig. 33. Gem dealers examine ruby rough from Mong Hsu in the gem market at Mae Sai, northern Thailand. *Photo by R.C. Kammerling*



Fig. 20. At Zay Kyaung Monastery, one of the important gem-set Buddhist icons. *Photo by R.C. Kammerling*

Jadeite

In 1893 Warry, who was an employee of the British Consulate, gave an account of the discovery of jadeite in Burma: a party of Chinese traders on their way back to China, were passing through what is now the northern part of the Kachin State sometime during the thirteenth century. They picked up some stones to help balance their baskets on the donkeys' backs. When they returned to China they found that the stones were top quality jadeite. Many Chinese went back to the area in search of the jadeite, but none was found. Another story, and one told by the local Kachin people recalls a girl doing her laundry in the Uru river. A passing group of Chinese traders, noticing the wonderful green hue of the rock she was using as her laundry board took it from her (Chikayama, 1988, 10, 1). Following a very hostile period that lasted up to 1784 a survey party from China located the occurrence of jade by the Uru River and from that time on jadeite was carried through the mountains and into Yunnan.

The so-called 'jade belt' of Upper Burma stretches from Hweka north of Indawgyi Lake to Singkaling Hkamti on the Chindwin river



Fig. 35. Sectioned boulder showing veins of 'Imperial jade' at the October 1992 Gem Emporium, Yangon. Photo by E.A. Jobbins



Fig. 36. Sectioned boulder of 'maw sit sit' jade at the October 1992 Gem Emporium, Yangon. Photo by E.A. Jobbins

(Figure 34). The main mining area being situated between Hpakan (about 105km or four hours by jeep from Mogaung Station) and Tawmaw near the Uru river (Lintner, 1989). Jade is also found in Mandawng and Shangaw east of the Nmai Hka river, as well as in the Kachin State. However, it is said that the deposits yield a jadeite of an inferior quality.

A broad area of serpentinized peridotite intrudes a country rock of crystalline schist to the north-west of Hpakan. In between this and the large expanse of Tertiary deposits to the east of the river Uru lies an area of conglomerate, the Uru Boulder Conglomerate, which is the source of most of the jadeite (Chikayama, 1988, 10, 3/4). In the Mamon jadeite mining area the Uru Boulder Conglomerate has a maximum width of 6.4km. The alluvial deposits along the river Uru are conjectured to exceed 300m in thickness, and it is said that from Mamon to Hpakan, the banks of the Uru are solid Boulder Conglomerate with jadeite sizes ranging from pebbles of 10cm to boulders of several metres width. Chikayama (1988, 10, 3/4) gives other occurrences of jadeite in this area as (a) outcrop/lode, (b) degradation gravel, (c) Tertiary conglomerate and (d) Uru riverbed deposits.

The government of Myanmar reportedly allows mining in only three places: Hpakan and the neighbouring villages of Waje Maw and Sanchyoi, the workers at these mines are government employees and they receive a monthly wage plus a 10 to 20 per cent commission on the value of any higher quality jade they may find (Frey and Lintner, 1991). Outside Myanmar this mining region is often referred to as 'Mogaung' after a town about 80km south-east of the mining

area on the major north-south Ledo Road. However, Hpakan is the jade capital of Myanmar's Kachin State and has been described as a 'mini Hong Kong' by many of its visitors with thousands of fortune seekers entering the area every year (Lintner, 1989).

Whilst in 1962 jadeite mining was put under government control, anti-government Kachin forces have prevented the full enforcement of this monopoly and much of the jadeite is smuggled out to Thailand through the border town of Mae Sai and on to the city of Chiang Mai. It is said that blocks are tied to rafts and taken down river to Hmalin. The jade then continues by steamer down the Chindwin, hidden in such places as paddy baskets, to the railhead at Monywa when the journey continues on to Mandalay and Taunggyi and on to the border with Thailand (Lintner, 1989). Whilst a small amount of this jadeite goes to India, the majority crosses into Thailand adding to the prosperity of Chiang Mai. There are also at least two jade-cutting factories in the town of Mai Sai of which the authors' are aware. In addition to fashioning jade other ornamental stones are cut in these facilities. There are three main qualities of jade (Chikayama, 1988, 10, 5):

- (1) Imperial jade (*Ah ye Kyauk sein*) (Figure 35) – the highest quality of chrome-green material. Used almost exclusively to produce small gemstones, e.g. cabochons, small pendant pieces.
- (2) Commercial jade (*Ah hte Kyauk*) – gem-quality material suitable for producing jewellery items such as bracelets and less valuable gemstones.
- (3) Utility jade (*Ah tha Kyauk*) – material typically

used for carving ornamental objects such as figurines and functional objects like bowls.

China appears to have become an important jade buyer again. The old jade route from the Kachin State to the former jade trading centres of Baoshan and Kunming in Yunnan is being revived. A significant portion of the Burmese jade still reportedly goes to Hong Kong but much is cut and carved in the areas of southern China neighbouring Hong Kong's Northern Territories. The Emporium sales of the major Burmese gem materials, including jade boulders by the MGE in Yangon, appear to be comparatively modest in terms of total dollar sales although they do typically represent a significant percentage of total Emporium sales. The great majority of the attendees for the jade portion of the Emporiums are ethnic Chinese. At the most recent Emporium these included, in addition to buyers from the People's Republic of China and Hong Kong, others from Taiwan, Thailand, Singapore, Indonesia and South Korea. It was remarked that the contingent from Taiwan was becoming increasingly important.

Maw-sit-sit (named after its locality) (J8 in Figure 2), which was at one time mistakenly sold all over Europe as chloromelanite (a form of jadeite of dark green to black colour), is a brilliant green rock often found with dark, almost black veins and spots (Figure 36). It was found, collected and studied by Dr Edward Gübelin in 1963. The black spots (chromite) are often surrounded by dark green kosmochlor (ureyite), a chrome-rich analogue of jadeite, with bright green jadeite and a chromian amphibole with minor albite (Anderson, 1990; Hänni, 1993).

Peridot

The mines in the Pyaunggaung mountains

The mining for peridot takes place on the northern slopes of Kyaukpon mountain (Webster, 1983) near Pyaunggaung in an area approximately 19.5km north-north-west of the town of Mogok. The peridot is found in association with ultrabasic rock in talc/olivine veins, and also in actinolite, phlogopite, talc, olivine and chrysotile pockets. The area was a significant producer of peridot after the Second World War. It is probable that the ancient kingdom of Pegu supplied gems from these mines to the outside world and that they were among those that were so appreciated before the Renaissance (Bariand and Poirot, 1985).

Travelling to the mining area from Mogok entails a four-wheel-drive journey of one or two hours, depending upon the weather conditions, along the unpaved Panlin-Bernardmyo road that in places is no more than a mule track. The route winds through the mountains from an elevation of 1500m in Mogok to approximately 2150-2250 m at the mine sites. It is a route extensively used by mule trains which take farm produce from the mountain villages down to be sold in Mogok, and other goods on the return journeys. Onions and rice appear to be the main items transported on the downward journey.

During the early stages of the journey several instances of what appeared to be unauthorized ruby mining were observed, but this became less evident as the elevation increased. The MGE operated peridot mine sits on Kyaukpon mountain and overlooks the town of Bernardmyo (originally a sanatorium named after the first Chief Commissioner of the province following annexation to the British Empire in 1886 (Gordon, 1888)). It is approached by turning off the main two-vehicle-wide track on to a smaller single-vehicle track and through a small onion farming village and terraced rice fields. It is interesting to note that there are a number of villages of ethnic Nepalese in the area. Once through this area the large open pit mine with associated buildings comes into view (Figure 37), here drilling and blasting are used in the recovery operation. The mine area is also used as a military post situated above the mine buildings. A ten minute hike from this mine brings one to a joint-venture mine, a primary deposit worked as an open pit. Local miners used simple hand tools and blasting to break away the host rock in search of peridot. More joint-venture operated peridot mines, involving a further one-hour journey by foot, were visited by two of the authors in March 1992. These were two separate but closely spaced tunneling operations being worked with hand tools and explosives.

The largest peridot produced as of October 1992 is a cabochon cut stone of 319ct that was on display at the second Emporium of the same year. In the authors' experience, the vast majority of very large (50ct plus) peridots seen in the market-place today originate in Myanmar (Webb, 1993) and one is, therefore, not surprised to come across cut stones in the 100ct range at the Emporium (Figure 38). The two largest peridots offered at the Mid Year Emporium in late 1993 were a 147.50ct faceted free form and a 101.55ct faceted oval.

Spinel

Spinel in assorted colours and perfect to distorted octahedra is widely found in certain marble bands throughout the Mogok belt. It occurs in large quantities and outnumbers ruby in places. Kabaing is known for 'hot pink' spinels and Kyatpyin for the finest red spinels.

Diamond production

On 9 June 1971 the *Financial Times* Correspondent in Rangoon reported to his newspaper that diamond finds in Mongmit township of northern Shan State had prompted the Mineral Development Corporation, the State mining concern, to send a seventeen-man exploration team to the area. The finds were taken seriously in view of a report made by an official geological survey team in 1958 about the presence of kimberlite in this area. Mongmit lies in the region noted for rubies and sapphires but since about the middle of 1992 there have been reports of some diamonds being picked up by some villagers there (as reported in Chikayama, 1987, 9, 6).

At the October 1992 Mid Year Emporium 27 cut Myanmar diamond lots totaling 101 stones were offered for sale. Eleven lots were sold with the largest stone, which was 3.56ct, reaching US\$10470 (US\$2941 per carat). Similar prices were reached for a few other lots, but many stones were of a lesser quality with prices in the region of US\$500 per carat. Whilst this may not indicate a large production of diamond from Myanmar (and indeed there was some question at the Mid Year 1993 Emporium about whether all of the diamonds offered actually originated in Myanmar), Emporium sales are not necessarily a good indicator of the country's total production. Indeed, in view of its tectonic position, athwart major suture zones there would appear to be some doubt as to whether Myanmar might become a really major source of diamonds.

Diamonds are found in three regions (Hlaing, 1990), in the areas of Mong Mit in the northern Shan State and Toungoo in central Myanmar, and to the east of Mergui (D1, D3 and D4 in Figure 2). The diamond crystals are found in octahedral, trisoctahedral, and hexoctahedral forms, some being distorted. The deposits are all secondary and of the river terrace type, the diamonds being found in the gravels and in association with rubies and sapphires in Mong Mit and with gold and other heavy minerals in

the other two areas (Figure 39).

Diamond production is a small scale side-line of the alluvial tin mining in Tenasserim State (east of Mergui) and is in its infancy still. The MGE hopes to locate the primary diamond sources in the mainly forested areas by applying geophysical prospecting methods. The stones recovered in Myanmar are all faceted (as round brilliants) at a facility within the MGE Headquarters in Yangon. The finished stones reportedly average 0.30-1.00ct, with the largest to date being about 10ct (Koivula *et al.*, 1992).

Pearl production

Up until the late '70s Myanmar produced fine quality large cultured pearls in crops varying from 6000 to 8000 mommes. However, in more recent years both the quality and production have decreased to such a level that it has reportedly discouraged pearl buyers from attending the Emporiums. Of the 180 lots offered at the October 1992 Emporium very few were of a quality that would interest the discerning buyer (Figure 40). The sizes were not large, colours generally poor, and surfaces spotted and cracked. A similar situation was true of the following Emporium in February 1993, pearls were then undersized, and poor in colour and shape ('Burma: pearling hits rock bottom', 1993).

Whilst it is stated that the situation should improve with the implementation of a new joint venture scheme with a Japanese company, it is reported that few dealers have confidence that this might become a reality ('Burma: pearling hits rock bottom', 1993). This situation is somewhat disappointing given the enthusiasm which started the project with the 'Burma Pearl Fishing and Culturing Syndicate' in 1954. It was a few years prior to this that a customs official living in Mergui began to realize the potential of the shell harvest in the area (Mynt, 1992). The shell harvesting led to the production of cultured blister pearls off Malcolm Island (an island among 800 others in the Mergui Archipelago, the group stretch for some 530km through the Andaman Sea) and later also off Owen Island. Whole cultured pearl production began shortly after with the marketing of the results in 1958 (CP1 in Figure 2). In 1964 the farms were nationalized.

Today, in addition to the cultured blister pearls and the whole and beaded cultured pearls, many non-nucleated (tissue grafted) cultured pearls are produced and offered for sale at the Emporiums.



Fig. 37. A peridot quarry in fragmentary ultrabasic rocks at Pyaunggaung. *Photo by E.A. Jobbins*

Fig. 38. Exceptional gemstones in the collection of the Myanmar Gems Enterprise: red spinel (20.60ct), 'sleepy' green peridot (143ct), pale brownish-pink topaz (123ct), pale green diopside (29.22ct), orange spessartine (14.20ct), aquamarine (27.40ct), pale yellow danburite (19.50ct) and a purplish-blue fluorite (25.55ct). *Photo by E.A. Jobbins*

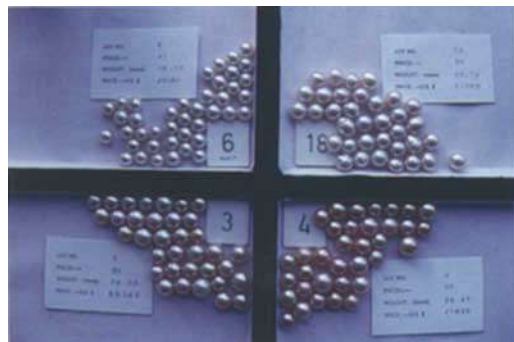




Fig. 39. Twenty diamond crystals recovered from alluvial deposits in Myanmar, ranging in weight from 3.50 to 10.13ct. Photo by R.E. Kane

Malcolm Island is still the centre of the Burmese pearl fishing area. More than 300 people are employed in the cultivation industry. As there is no mollusc cultivation programme, the molluscs at approximately three years of age are collected wild by divers known locally as 'Salons' (sea gypsies). About ten locally-produced nuclei are implanted in one mollusc (*Pinctada maxima*) and it takes about three years to produce one pearl. Harvesting takes place four times a year and one mollusc may be re-implanted up to three times. Rather than following the practices of other farms the molluscs are not suspended from a raft, but the baskets are left 10m down on the sea bed (Chikayama, 1988, 10, 3). New pearling stations exist along the Mergui Peninsula and are planned to increase up to fifteen farms. Natural pearls may also be fished in the area of Mergui and in 1960 a 200mm orange conch pearl was discovered in a muddy bottom in the same area (Scarratt *et al.*, 1994).

Fig. 40. Four of the best lots of cultured pearls offered at the October 1992 Gem Emporium, Yangon. Photo by E.A. Jobbins



Amber

Burmese amber (burmite) has been mined for centuries, not only as a gemstone but also as a medicine. It is said to be more durable than other amber and to contain only one quarter to one half the amount of acid that Baltic amber (succinite) does (Chikayama, 1987, 9, 7).

Amber is found in Myanmar's northern-most areas in a straight line from the border with Assam (India) in the west to Myitkyina and the Yunnan (Chinese) border. The Hukawng Valley in Myitkyina District was, at least in the past, a major source (Ehrmann, 1957). The mines are located in the Chindwin district and at Maingkwang (just north of the jade deposits near Hpakan, AM1 in Figure 2) (Fraquet, 1987; Lintner, 1989). One other specific Hukawng Valley locality mentioned in the literature is Nango-tai-maw hill, 5km south-west of Maingkwang (Bauer, 1937). The material occurs typically in lenticular, fist-size pieces within Tertiary blue shale and sandstone, experience showing that thin seams of coal were indicators of good amber (Ehrmann, 1957). Fraquet (1987), describing a typical working, states that the pits were 'only about 1/3 metre square', and that after working through 4 to 6 metres of dry clay containing small pieces of lignite, there appeared a grey, slaty clay, and imperfectly formed lignite. At this layer the amber occurred in irregular pockets. At Khanjamaw ('maw' means mine) the amber level is at 13-15m, at Ladammaw it lies at 10m and at Lajamaw a mere 30cm below the surface (Chikayama, 1987, 9, 7).

At some earlier Emporiums, Burmese amber from the banks of the upper Chindwin River was

Fig. 41. A 5.7cm diameter orb showing typical swirl structure, alongside a lenticular rough fragment (7.1cm wide); both of reddish-brown Burmese amber (see text). Photo by E.A. Jobbins



offered for sale (Gübelin, 1974). Most recently – at the 1993 Mid Year Emporium – one minor lot of predominantly dark, rather small pieces was offered. Ehrmann (1957) reported that larger blocks of material were traditionally purchased by Chinese for fashioning. Unfortunately, in recent years large ‘carvings’ composed of dark reddish-brown plastic and believed to originate in China or Hong Kong have been offered for sale as ‘Burmese amber’.

Burmese amber is often referred to as ‘burmite’; Baltic amber that has been imported into Myanmar was in the past labelled ‘Indian amber’ (Bauer, 1937). According to Vavra (1982), burmite from various sources includes resins of different geological ages, from Cretaceous to post-Eocene. This same author states that included material has been identified as copal. Fraquet (1987), however, states that burmite is of Eocene age, i.e. from 38 to 54 million years old.

Burmite is generally from a dark rich brown to a pale sherry colour and is never of the yellow shades seen in the amber from the Baltic region. However, the most sought-after colour for Burmite is a rich cherry red, a colour that does occur naturally but is more often produced by the plastic imitations mentioned above that are so often misrepresented as burmite.

Two historically important pieces of Burmese amber are described by Fraquet (1987), the latter of which was examined by two of the authors in 1992. Both pieces are said to have been originally part of the Burmese Royal Regalia dating back to the Dynasty prior to Kings Mindon Min and Theebaw (who reigned from 1853-1878 and 1878-1885 respectively). The first piece is described as carved in the duck-like symbol of Burma, the ‘hinta’, measuring 28cm in length and 15cm wide it is today on display at the National Museum in Yangon. There are now only faint traces of the gold leaf design, and the eye sockets, which it is assumed once contained rubies, are now empty. This is a good example of what can be done with opaque Burmese amber. The second piece which is much less well known is an orb of clear reddish brown amber (some 6cm in diameter - described by Fraquet (1987) as 10cm in diameter) which is presently held in private hands and might have formed part of the ‘Burmese Royal Regalia’. The orb was given to an Englishman by the King ‘following the death of the King’s wife’ and still remains within that family. The orb was said to sit in a carved hand within the Regalia and was

presented to the King to signify the birth of a male child (Figure 41).

Marketing

The primary official outlets for Myanmar’s gem wealth are the Gems, Jade and Pearl Emporiums held in Yangon. The first was held in December 1964 and they became annual events occurring in late January to mid-February. In 1992 a second ‘Mid Year’ Emporium was instituted for the autumn. Sales at these MGE-organized events, which were held up until late 1993 at the Inya Lake Hotel, total in the millions of US dollars. At the February 1991 Emporium sales totalled slightly over US\$11 030 000: approximately \$6.9 million in jade, \$2.8 million in pearls and \$1.3 million in ‘gems’. This latter category, although primarily consisting of corundum, also includes peridot, zircon, aquamarine, garnet, amethyst and even some diamonds. Sales at the February 1992 Emporium totalled about US\$8 million, including \$4.5 million in jade, \$0.8 million in pearls and \$2.7 for gems (Clark, 1992). The October 1992 Emporium produced over \$8.9 million in sales, including about \$6.37 million in jade, \$0.47 million in pearls, \$1.76 million in gems and \$0.3 million for jewellery and jade carvings. Sales at the February 1993 Emporium registered a significant increase over those of February 1992, totalling \$14.66 million. This included \$11.47 million in jadeite, \$1 million in gemstones, \$0.64 million in pearls, \$0.48 million for jewellery and \$0.12 in jade carvings. There was also a special sale of utility jadeite which brought in an additional \$0.62 million (‘Sales at emporium rise 153%’, 1993).

In 1993 the Mid Year Emporium was held over a nine day period in late October and early November. A description of this event follows, as it most probably represents the venue and format for Emporiums in the immediate future and also provides a more detailed look at the types of goods offered.

The first two days of this most recent event were allotted for the viewing of goods, followed by seven days of competitive bidding (four days for jade, one day for pearls and two days of gems). There were 614 lots of jade, 198 pearl lots and 318 lots of gems offered. However, the 1993 Mid Year Emporium was notable historically in that it was held for the first time in the new MGE exhibition hall, built adjacent to the MGE headquarters and solely for these bi-annual sales. On the ground floor of the new facility, consisting

primarily of a large open room known as the jade display room, lots of rough jade were shown on small tables while fashioned items (carvings, cabochons and 'semi-fashioned' pieces) were in display cases. Also offered were fashioned items at fixed prices. These included all jade-related items priced under \$US 3000, the lowest reserve price for jade at the auction. In addition to the material presented inside the building there were jade lots along the sides and back of the exhibition hall. These included the largest jadeite boulders and large lots (some weighing over 1500 kg) of 'utility jade', i.e. lower quality carving material.

The second storey of the new exhibition hall is where the auction takes place. Here bidders sit at tables in a large room reminiscent of a banquet hall. The auctioning is conducted by five MGE officials from a raised dais at the front of the hall. As each lot was presented for bidding, the pertinent information - lot number, category of material (e.g. utility jade) and reserve price - was projected on to a large screen. Simultaneously, a previously recorded short videotape, showing the actual lot being offered, is shown on the right side of the screen. When a winning bid is announced, the price paid and name of the purchasing firm is also projected. Actual bidding takes place by registered buyers who fill out bid forms (for the jade auction these are on green paper). The bidder then signals to one of several Burmese bid collectors who briefly check the form and then place it into one of two silver bowls sitting on pedestals to either side of the raised dais. When the auctioneer has determined that no more bids will be made, the two silver bowls are brought up to the dais and their contents emptied on to the tables. The bids are then inspected and the winning bid (assumingly the largest offer) announced and projected.

Gems, pearls and jewellery were displayed in cases on a balcony above the second storey. As with jade, items below a certain reserve price (approximately \$3000 for gems and \$1500 for pearls at the Mid Year 1993 Emporium) were sold at fixed prices; all of the jewellery was sold at fixed prices. The latter included various types of jewellery items being sold on consignment to the MGE as well as gem-set gold rings produced and marketed by the Myanmar VES Joint Venture Company Ltd. The joint-venture firm sold its products at its own booth on this balcony level. This was the third Emporium at which they have offered their goods.

Although rubies and sapphires were the most abundant coloured stones being offered, as at past Emporiums, other gems were also available either through competitive bidding or fixed price. These included amethyst, citrine, kyanite, danburite, spinel, topaz, zircon, diopside, scapolite, apatite, aquamarine and peridot. There was also one small boulder with a yellowish-brown weathered surface and one exposed area of dark blue that was labelled 'lapis lazuli'.

Total sales of approximately \$15.53 million were reported for this most recent Emporium, with 506 lots having been sold. This figure includes both items sold through competitive bidding (jade - 264 lots/\$5.49 million; pearls - 75 lots/\$0.67 million; gems - 77 lots/\$1.43 million); additional sales of roughly \$0.70 million in jewellery; \$69 000 in jade carvings; \$9000 in fixed price jade; \$5.95 million in fixed price gems; \$0.15 million for special sale jade; \$61 000 for special sale gems. It is important to note that the disproportionately large figure for fixed price gems includes \$5.86 million paid for a 38.12ct ruby for which bids were accepted from a select group of invitees.

There are additional legal outlets for Myanmar's gems. According to a report in *JewelSiam* ('Neighborly Burma', 1990), other sanctioned sales have been made through special arrangement with the Myanmar government. The MGE also accepts inventory from the private sector and sells it on a consignment basis, both at the Emporiums and in its retail shops (Montgomery, 1993a). In addition, in August 1992 the MGE entered into a joint venture with Thailand's VES Group of companies to produce and market jewellery. This operation, which moved into its new factory in January 1993, has been set up to cut and polish the gems as well as produce the jewellery in which they will be set. While initial production has been of inexpensive items for the tourist (and perhaps local Myanmar) trade, the ultimate goal is to offer higher-quality goods on the international market in the near future. Two hundred fifty pieces of the joint venture's early production were offered at the Emporium in October 1992 ('Burma signs joint ventures for pearls, jewelry', 1993; 'Thai-Myanmar Joint Venture', 1993; 'Thai-Burma factory opens in Rangoon', 1993). Sales increased at the February 1993 event and more than doubled (in both total value and number of pieces) at the October/November 1993 Emporium (Montgomery, 1993b).

Yet in spite of on-going efforts of the Myanmar government to increase their control over the mining and marketing of their nation's wealth, significant quantities of gemstones are believed to still leave the country through extra-legal avenues. It is widely reported in Bangkok that the cross-border trade continues at a steady pace, with major transit points occurring in the areas near the Thai towns of Mae Sai (see above) and, to a lesser extent, Mae Sot. This illicit trade appears to have increased in the Mae Sai region in the past year or two with the discovery of the significant new ruby source at Mong Hsu. In the early part of 1993, several of the authors were queried by members of the jewellery industry about a reportedly new south-east Asian ruby source described as 'Mae Sai' or 'Mae Sar'. It is believed these references were to Mae Sai in northern Thailand, a town later confirmed as being a centre for the trade in rubies from this new Myanmar source (see Mong Hsu above). Goods are also reported to enter India and China through illicit channels.

Chikayama reported to the 24th International Gemmological Conference (1993) that there was in fact a new route for Myanmar's gemstone production entering China. He stated that this was through a 'Free Trade Area' at Rui Li, north-west of Mandalay.

It is also interesting to note in this regard that in 1993 a Thai firm based in Mae Hong Son had received approval from the Myanmar government to build and operate a road linking Chaing Rai in Thailand with eastern Myanmar ('Northern Thailand set for Burma route', 1993). This road could easily help to increase the cross-border traffic in goods, both legal and otherwise.

Regardless of how it is marketed, all indications are that the gem wealth of Myanmar will almost certainly continue to be in great demand, bringing exceptional prices in the international market. As one example, the third highest price paid for a lot at a Sotheby's, Geneva, auction in May 1993 was for a ring set with a 16.51ct Myanmar ruby. This single item, lot 537, went for US\$ 3.03 million ('53 carat diamond—\$3.7m; 11 carat blue—\$3.6m', 1993). Another relevant example is the 38.12ct ruby that fetched over \$5 million at the most recent Emporium (see above).

Summary

The occurrences of jadeite in Kachin State still have no competitors anywhere in the world, both in terms of the quantity and quality of the jadeite mined. The deposits appear to be far from

exhaustion. Myanmar deposits of rubies, sapphires and many other gemstones are at their richest and most concentrated in the Mogok Stone Tract (MST) which is situated at the western border of the Shan State and is generally understood to include the alluvial deposits in the wider vicinity of Mongmit, north of Mogok, as well. There seems to be no sign of exhaustion in the MST for any of the gem species mined. Recent and very productive additions are the important Mong Hsu ruby fields and the even more recently discovered Mong Hkak sapphire deposit which is also situated in the eastern Shan State. Several diamond placers in Myanmar are known today but no primary diamond pipes or sills. Production is very modest but might increase.

Pearl fishing and culturing is centred in the Mergui Archipelago (Tenasserim (Taninthari) State). Sea water pollution has not been mentioned as one of the factors having possibly impaired the quality of the Burmese cultured pearl.

Considering Burma's amazing wealth in many different types of mineral resources and considering the presence of a long collision belt reminiscent of the one forming the north-west bend of the Himalayas in Pakistan, the pertinent question might be asked, 'Where do Burma's hidden emeralds lie?' As postulated by Kazmi and Snee (1989), the contact of chromium-bearing oceanic rocks (ophiolites, etc.) and beryllium-bearing continental rocks (granitic intrusions, pegmatites) in the Himalayan suture zone generated 'the essential combination of elements needed' for emeralds to form in Pakistan. In Myanmar, rocks of both ultramafic and acid types are present as well, possibly even in the proximity required for emerald growth. The find of these green wonders would complete the colour spectrum of Burmese gemstones.

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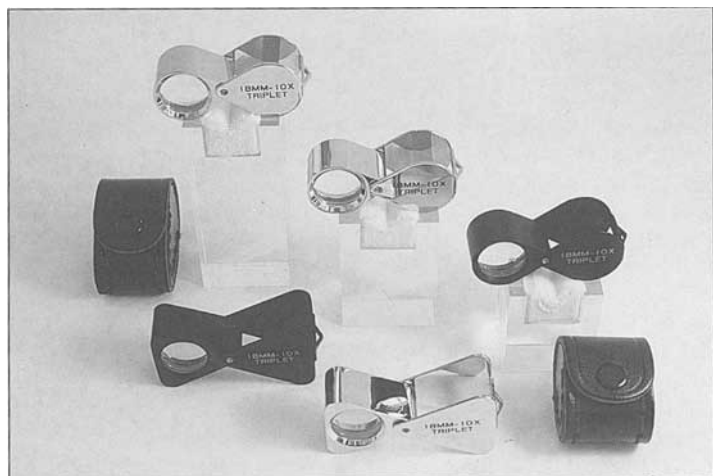
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Notes from the Gem and Pearl Testing Laboratory Bahrain – 3

Ahmed Bubshait, B.Sc., FGA, and Nick Sturman, FGA, DGA

Abstract

Our third contribution deals with 'filled' natural and synthetic rubies and with natural and cultured pearls.

Natural rubies with 'filled' fissures

In our last notes from the Laboratory - 2 (J. Gemm., 1993, 23, 7) we reported on some filled natural rubies mounted in a necklace. Since then we have examined a number of new rubies submitted for routine testing and, of these, one group of stones also revealed glass fillings of the type that laboratories often encounter these days. Three faceted stones in this group (weighing 1.79 ct, 1.98 ct and 2.04 ct) contained filled surface-reaching fissures (Figure 1).

Whether fillings such as these are the accidental result of the heat treatment process or are the result of a fraudulent attempt to improve the appearance and weight of the stones, the fact is that the fillings are not produced by nature and are a result of man's interference. Therefore, our policy is to inform customers about this and any other enhancements/treatments that we observe, so that they in turn are able to pass the information on to their customers. In this way all our customers can be better 'prepared' for the future.

Fig. 1. Glass filling in one of the three natural rubies tested.



Distinguishing a natural inclusion from a filling in a natural ruby

When examining any ruby for evidence of 'fillings', all gemmologists have to be careful not to mistake a natural inclusion (such as a crystal that has been exposed at the surface during cutting) for an artificial filling. Recently, we had the chance to examine a cabochon-cut stone weighing 7.32 ct with such an inclusion. The inclusion (Figure 2) occupied a considerable area at the base of the stone, was visible to the naked eye and, unlike the artificial fillings, showed a distinct white cast.

We pursued our investigation further to try and identify the inclusion and rule out the possibility that it may be another type of unusual filling not previously encountered in natural rubies. A distant vision reading of the RI of the area gave a value in the region of 1.6 and microscopic examination revealed some small crystals and feathers, as well as at least one distinct cleavage direction. With this information we considered which natural mineral it might be. Our conclusion was that calcite was the most likely contender and so we tested this idea by placing a small amount of dilute hydrochloric acid on a small area and noted its strong effer-

Fig. 2. The probable calcite inclusion seen in the 7.32 ct. natural ruby, as seen in overhead fluorescent lighting.



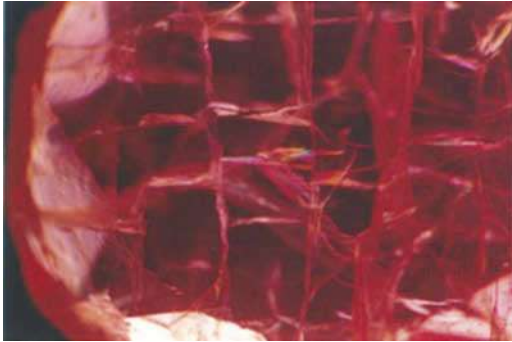


Fig. 3. Some unusual flashes of colour within the induced fractures of this cracked Verneuil synthetic ruby.

vescent reaction. Additionally, we placed the stone under UV radiation to see if any fluorescence could be observed in the area of the inclusion. A moderate orange fluorescence was noted in the red background fluorescence of the ruby, which is also consistent with the behaviour of calcite.

Filled synthetic rubies

One of our regular customers recently asked us to check a few assorted stones on a verbal assessment basis. Amongst them were some red stones that on preliminary testing gave results expected for rubies. We then turned to the microscope and it was quickly evident that a majority of the stones showed features characteristic of cracked synthetic Verneuil ruby. However, some of the fractures, induced by heating and then rapid cooling of the stones (Hughes, 1990), were the source of uncharacteristic flashes of a variety of colours (Figure 3). This prompted us to examine the fractures in more detail, with the result that

Fig. 6. Some of the small 'demi-like' pearls that were selected from the largest group of pearls.

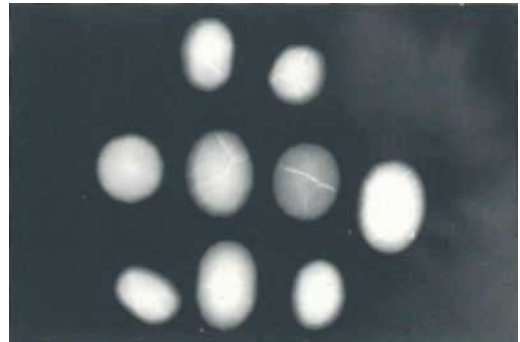
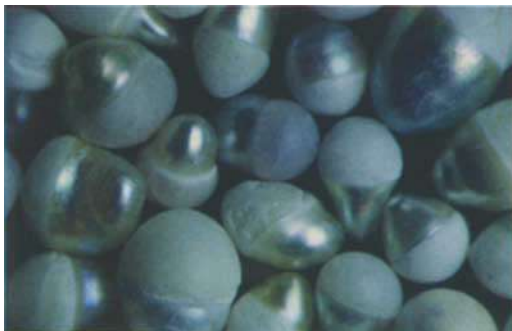


Fig. 4. The radio-opaque filler is clearly visible in the induced fractures in these cracked Verneuil synthetic rubies.



Fig. 5. The pearls submitted by Custom officers, shown with a loupe for scale.

we recognized a similarity with the filled fractures seen in resin-treated emeralds and glass-filled feathers in diamonds. As in many filled diamonds and emeralds, the filler is very difficult to detect at the surface (unlike most rubies where the difference in surface lustre is more apparent). The colours seen within the

Fig. 7. One of the 'demi-like' pearls shown in Figure 5. The fibrous structure of the broken non-nacreous half of the pearl is shown.



induced fractures are similar to those seen in resin-filled emeralds, but not as distinct as those seen in filled diamonds. A weak blue 'flash', similar to the effect sometimes seen in filled emeralds, could be seen in some of the stones when observing the fractures at the right angle.

Diamond can tolerate fairly high temperatures and it is known that the material used to fill fractures is often a lead- or bismuth-based glass (Koivula *et al.*, 1989). So because corundum is also known to tolerate high temperatures, we reasoned that a similar radio-opaque material may have been used to fill the fractures and hence might show up as opaque areas on the X-ray film. The series of opaque white lines running throughout some of the stones on the radiograph (Figure 4) confirmed our reasoning. In order to determine that this result was not the 'norm' for crackled synthetic rubies, two stones without unusual flashes of colour within their fractures were obtained and radiographed. Both stones showed no evidence of material opaque to X-rays within the fractures.

An unusual lot of pearls

Many of the pearls examined by the laboratory are submitted by Customs and Ports Directorate, since Bahraini law requires that all pearls coming into the state have to be checked to eliminate any cultured pearls that may be amongst them.

The pearls shown in Figure 5 are typical of the consignments received from Customs. The pearls were split into two groups, the larger weighing 5000 ct and consisting of mostly small rounded pearls and the smaller group weighing just under 2500 ct, consisting mainly of larger irregularly-shaped pearls. When radiographed the latter group showed that a majority of the pearls had non-nucleated cultured pearl structures, whilst a minority had natural pearl structures. The larger group consisted of a mixture of natural and non-nucleated cultured pearls and both groups had a few nucleated cultured pearls. In addition to natural pearls, non-nucleated and nucleated cultured pearls, a small number of 'demi-like' pearls, which are half nacreous and half non-nacreous (Hurwit, 1989 and 1991), and some completely non-nacreous pearls were also observed amongst the larger group. Some of the 'demi-pearls' (Figure 6), and one in particular, showed damaged non-nacreous areas that clearly revealed a fibrous, more columnar structure (Figure 7), typical of some freshwater pearls (Scarratt, 1987). However, they did not produce

the fluorescence in X-rays typical of freshwater pearls.

The fluorescence of some of the remaining pearls did match the sample test results that we obtained. For instance, some pearls that we determined had fairly convincing non-nucleated cultured pearl structures and emitted a very strong fluorescence and phosphorescence when exposed to X-rays (typical of freshwater cultured pearls such as those from Lake Biwa), whilst others that had good natural structure were inert under X-rays.

In normal circumstances, these pearls would have been returned to Customs' officers who would have then returned them to the original supplier, in this case a company in Pakistan. This, however, was not a normal circumstance, as the importer informed us that these pearls were not destined for the jewellery trade (the area covered by the cultured pearl law in Bahrain) but for medicinal purposes. Like many Asian countries and some Middle Eastern countries, Bahrain has an active alternative medicine trade that, amongst other things, uses pearls, lapis lazuli, orpiment and sulphur to treat a variety of ailments.

Given this explanation about the destiny of these particular pearls and after consultation with various authorities including Customs' officers, two members of the laboratory staff visited the premises of the importer and witnessed him crush all the pearls shown in Figure 5. Needless to say, the pearls described in this last section are no longer in the form they arrived in, but we hope that their medicinal properties help cure eye problems and cases of cystitis and impotency which, we were informed, are the most common problems for which pearls in their powdered form are prescribed.

Acknowledgements

The assistance offered by staff from both the Bahrain and London Laboratories is acknowledged with thanks.

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1993 Annual Conference

Mary Burland

The 1993 GAGTL Annual Conference was held on 24 October at the Great Western Royal Hotel, Paddington, London, followed by an Open Day at the GAGTL Gem Tutorial Centre in Greville Street on 25 October. Once again, there were many delegates from overseas including representatives from Australia, Bahrain, Canada, Malaysia, Sri Lanka, Taiwan and the USA as well as from many European countries. Delegates were able to view the displays and examine, with the expert assistance of laboratory staff, some of the stones discussed during lectures.

The theme of the conference was 'Inclusions' and the Conference opened with the keynote lecture by Dr E. Gübelin entitled 'New gem inclusions'.

New gem inclusions

With the aid of many magnificent slides, a selection of which is shown on p.46 Dr Gübelin discussed some of the new inclusions he had found since the publication of the *Photoatlas*

(Gübelin and Koivula, 1986). The 'portraits' of the inclusions were accompanied by chemical analyses shown simultaneously on a second screen. The methods used for the identification of each inclusion (for example energy dispersive X-ray fluorescence, electron microscopy or Raman laser spectroscopy) were explained in detail.

Gemstones illustrated included kyanite, euclase, demantoid and pyrope garnet, moonstone, peridot, rock crystal, sapphirine, ruby, sapphire, taaffeite, spinel and natural and artificial glass.

Dr Gübelin explained how it was possible to speculate on the place of origin of gemstones by identification of the inclusions. Not only are particular mineral inclusions typical of certain areas, but also the shape of the crystal inclusion can provide clues as to the host's origin.

In conclusion, Dr Gübelin referred to the 'nostalgic' and traditional method of identifying inclusions that had been used before the sophisticated instruments, such as those he had been

Fig. 1. Keynote speaker Dr E. Gübelin with Miss Pat Lapworth who has been responsible for the English translation of his books.



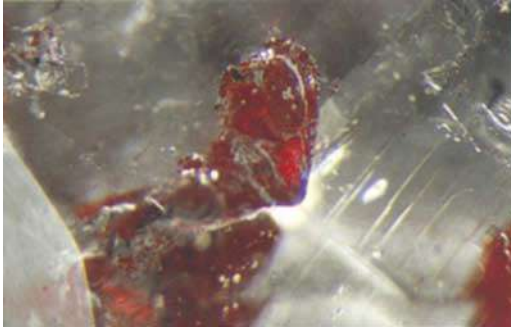


Fig. 2. Colourless faceted baryte from Chauwai, Kirghisia. Red, more or less corroded crystals of cinnabar, HgS , ornate the interior of this rare collector's gemstone. 9x



Fig. 3. Goshenite (colourless beryl), Minas Gerais, Brazil. A beautifully shaped, euhedral crystal of yellowish brown spessartine, $\text{Mn}_3\text{Al}_2(\text{SiO}_4)_3$, presents itself in correct position to the beholder. 20x



Fig. 4. Colourless beryl from Hagendorf, Bavaria, Germany. A group of intergrown slightly resorbed crystals of zwieselite, $(\text{Fe}^{2+}, \text{Mn}^{2+}, \text{Mg}, \text{Ca})_2(\text{PO}_4)(\text{F}, \text{OH})$, accompany their host for its lifetime. 8x

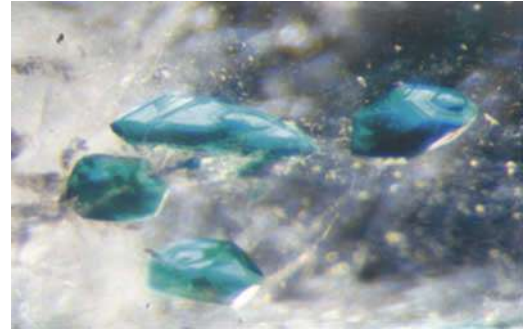


Fig. 5. Calcite, Congo, Africa. A small loose group of well-shaped diopside, $\text{CuSiO}_2(\text{OH})_2$, crystals aligned parallel to the host crystal's direction have found a permanent resting place. 20x

Fig. 6. Rock crystal from Sri Lanka. Distinctly shaped tabular crystals of muscovite mica, $\text{KA}_2(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH}, \text{F})_2$, strung on rutile fibres (TiO_2) shine with kaleidoscopic colours between crossed polars. 30x

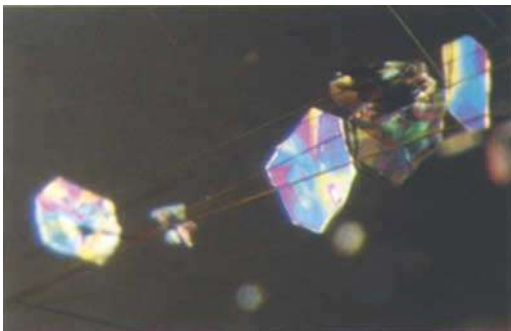
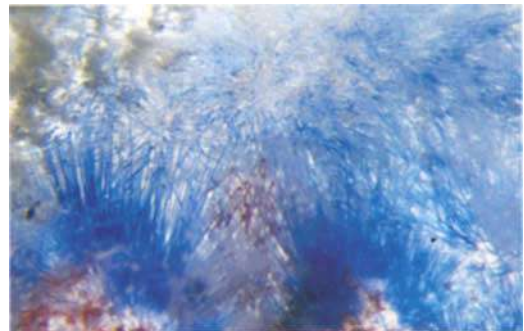


Fig. 7. Rock crystal from Ajo, Arizona, USA. A divergent radial arrangement of fibrous papagoite, $\text{CaCuAlSi}_2\text{O}_6(\text{OH})_3$, and ajoite crystals, $(\text{K}, \text{Na})\text{Cu}_7\text{AlSi}_9\text{O}_{24}(\text{OH})_6 \cdot 3\text{H}_2\text{O}$, impart delightful coloration to an otherwise colourless quartz. 15x



discussing, were invented. Gemmologists had to identify inclusions 'using visual methods,' he explained, 'by their colour, appearance and characteristic habit, and some knowledge of the genetical conditions of the host gem itself'. A pink sapphire from Sri Lanka was illustrated, showing an inclusion of a diaspore crystal on a graphite flake which, under magnification, Dr Gübelin had been able to identify from the individual faces and shape of the crystal.

Burmese and Vietnamese gem inclusions

The second lecture of the day was by Alan Jobbins who spoke about his visits earlier in the year to Burma and Vietnam. He described in detail the geology and topography of the areas, and illustrated a number of the mines visited. The methods by which the rubies and sapphires are extracted, sorted and marketed were also discussed.

Rubies from Burma and Vietnam were compared, showing many similarities. As well as discussing the inclusions to be found in the rubies, Alan also described colours typical of stones from the areas visited, zoning and other characteristics that could indicate the origin of the stones.

Fillings in diamonds and coloured gemstones

Following lunch, Dr Gübelin gave a second lecture, this time on the filling of diamonds and other gemstones.

He discussed and illustrated laser drilled diamonds in which the laser canals which had been filled, as well as diamonds in which cracks that reached the surface of the stone had been filled.

Illustrations of stones before and after treatment indicated the degree of invisibility that could be achieved when flaws were filled. Dr Gübelin went on to describe ways in which such fillings could be identified.

In addition to diamond, the filling of coloured gemstones such as emerald, aquamarine, tourmaline and corundum (including diffusion treated sapphire) was discussed and methods of identification suggested.

Montana sapphires

Michael O'Donoghue spoke on the sapphires of Montana, giving a general history of the mining in the area. It is unique in that it is the only place in which you can find corundums in situ as well as gravel type deposits. He described



Fig. 8. Michael O'Donoghue who spoke on Montana sapphires.

the methods of mining at the Yogo mine and various deposits along the Missouri River. The sapphires are generally small and the colour pale blue, green or yellow – bluish-green stones with an orange spot inside are particularly typical of the area. All stones, with the possible exception of those from Yogo, are heat treated.

Michael illustrated a number of stones including a mauve star sapphire (star stones are not usually found in the area) and a stone reputed to have been mined as a colourless sapphire in the 1920s which had only recently been heated to an attractive yellow colour.

Unusual gems in forensic science

Philip Sadler gave us an insight into the work of the forensic laboratory of the Metropolitan Police.

A number of items associated with the gem and jewellery trade passed through the laboratory. Philip described a number of these and their case histories, as well as the techniques used to identify a range of substances.

Pearls in the Arabian Gulf

In the final lecture of the day, Stephen Kennedy of the Association's Laboratory commenced with a summary of the history of the pearls in the Gulf, dating back to c. 2000 BC.

In 1988 Stephen went to Bahrain to assist the



Fig. 9. Stephen Kennedy who spoke on the Gulf pearls.

Ministry of Commerce and Agriculture in setting up their own pearl and gem testing laboratory to monitor their large and expanding pearl trade. Stephen discussed the past and present pearl trade in Bahrain and illustrated examples of

modern jewellery now sold in the Gulf.

In London, the Laboratory recently had the opportunity to examine two exceptional pearls. These were the Pearl of Asia and the Hope Pearl. With a number of illustrations of the pearls and their mounts, he outlined their histories and then described them in detail, explaining methods used to test them and displaying the results.

OPEN DAY

On Monday 25 October an Open Day was held at the GAGTL Gem Tutorial Centre in Greville Street, London. Members of the laboratory staff were available to discuss any problems with delegates. One subject that concerned delegates was the issuing of origin reports on gemstones. It was explained that, as a service to Laboratory Members and only in cases where there was no reasonable doubt of the origin of a gemstone, a letter giving an opinion of origin could be issued to accompany an Identity Report.

A number of delegates asked about the colour grading of coloured gemstones (excluding diamonds). Although there are systems available for colour grading, no one system has outstanding advantages over any other or has been considered sufficiently satisfactory for use by this Laboratory.

Fig. 10. Ali Safar and Ahmed Bubshait from the Gem and Pearl Testing Laboratory, Bahrain.



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DISPLAYS

Specimens under the microscope

Delegates had the opportunity to examine, with the expert assistance of laboratory staff, a

number of specimens discussed during lectures. These included untreated Burma rubies, referred to by both Dr Gübelin and Alan Jobbins during the morning lectures, showing typical inclusions for the older stones, but delegates were advised that the newer rubies coming from the area showed very different inclusions as a result, among other

things, of heat-treatment. Also exhibited were diamonds showing inclusions such as crystals, clouds, feathers and indented naturals, and it was explained how these related to clarity grading.

Following the talk by Michael O'Donoghue, a selection of Montana sapphires was on

display as well as a book of memorabilia from the mines, and delegates were able to compare heat-treated and untreated specimens from

Rock Creek under the microscope.



Fig. 11. Joris C. Höfelt, Utrecht, The Netherlands, examining a Burma ruby with Riitta Spencer, Clive Burch in background.

Replicas

Replicas of famous diamonds were exhibited by Richard Willmott. As well as replicas of the cut stones, in some cases there were also models of the rough crystals before cutting. (For further information on Richard Willmott's replicas see Willmott, 1993.)

Glass filling of diamonds

There was also a display by Dr Jamie Nelson of the production of colours which appear as dispersion staining colours in glass infilled diamonds (see Nelson, 1993). This was in the form of a practical hands-on demonstration of spectra.

Gem identification

Delegates were able to microscopically examine rough and cut samples of the two types of synthetic emerald most likely to be encountered in the trade today. The first was a hydrothermal synthetic emerald from Russia showing typical inclusions and marked zoning. This type of synthetic is particularly difficult to distinguish from the natural because it often contains two-phase and sometimes three-phase inclusions. The second was a Chatham synthetic emerald grown by the flux method.

Diamond

The methodology of diamond grading was explained and demonstrated.

Delegates were able also to examine diamonds that had been fracture-filled and laser drilled, as discussed by Dr Gübelin during his second lecture. Filled diamonds are now circulating and it is vital that members of the trade can recognise such treatment.

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XXIV International Gemmological Conference Paris 1993

E. Alan Jobbins

At this conference, which was admirably organized by Jean-Paul Poirot and his helpers, the excursions (1-9 October) preceded the scientific sessions. Delegates visited Lyons, the Chessy St-Bel copper mines, and synthetic corundum and jewellery factories near Grenoble. In the Auvergne they visited classic areas of volcanicity, sapphire and tourmaline localities. At Bourges Cathedral they studied architectural and decorative building stones. The scientific sessions (11-15 October) were held in Paris under the auspices of the Paris Chamber of Commerce and Industry. The papers presented are listed below:

- G. Bosshart 'Cut diamonds of natural green coloration.'
- E. Fritsch 'New and useful criteria for the separation of natural and treated colour green to blue diamonds.'
- C. Sapalski and L. Sarmiento 'Relationship between colour grade, N3 absorption and response to ultra-violet light in diamonds.'
- H. Tillander 'The revised history of

- diamond cuts.'
- H.O. Meyer 'Diamonds in North America.'
- A.A. Levinson 'Diamond exploration in Canada; current status.'
- N.L.E. Haralyi 'Big sized diamonds in Brazil.'
- J.M. Saul and A. Mercier 'Thermobarometry applied to deposits of crystalline coloured gemstones.'
- D. Schwarz 'Some news on emeralds and their occurrences.'
- J. Kanis 'Zimbabwe revisited - Orissa gems updated.'
- A. Chikayama 'About a new route for Myanma gemstones.'
- R.E. Kane 'Selected Burmese gems.'
- R.R. Harding and N. Barot 'Pink corundum from Kitui (Kenya).'
- H.A. Hänni and K. Schmetzer 'First results on a new flux-grown synthetic ruby (Douros) produced in Greece.'
- K. Schmetzer 'Growth structures as means for the characterization of new types of high quality

Attending a reception at the Pierre and Marie Curie University in honour of delegates to the XXIV International Gemmological Conference are Jean-Paul Poirot, the organizer (far left), Pascal Entremont (third from left), Pierre Bariand (arms folded) and, addressing the gathering, the Vice President of the University, M. Lemerle.



G. Brown	natural and synthetic rubies. 'Australian synthetic periclase.'	A. Bouquillon, J.P. Poirot and G. Querré	'Natural stones and man-made materials used in Egyptian jewellery: example of three pectorals of the Louvre Museum.'
V.S. Balitsky, I Makhina V. Prygov and A. Mar'in G.V. Bukin	'Siberian synthetic gemstones.'	G. Graziani, P. Evangelista and M. Martini	'A gem collection never before published: the dactylolytheca of Pope Leo the XIIIth.'
U. Henn and H. Bank	'An update on synthetic stones manufactured in Russia; properties and distinguishing features.'	J. Koivula E. Gübelin G. Tombs and M. Ducan G. Brown, J. Townsend and K. Endor	'Inclusion research update.' 'New inclusions observed.' 'Opal. Safe or unsafe. A guide to recognition.' 'Lambina opal field.'
H.S. Pienaar and D. Glenister G.F. Becker C. Arps	'Studies on gem zircon.' 'Utah red beryl.' 'Museum specimens and nomenclature.'	M. Sevdernisch	'Three lapidaries: skill versus technology.'
C. Sapalski and J. Saadi	'Geologic monument of unique diatremes bearing stactitic formations of rhodochrosite (Capillita Mine, Catamarca, Rep. Argentina).'	V.S. Balitsky	'Current situation and new gemmological tendencies in contemporary Russia.'
F. Payette	'Rare gem-quality minerals from Mont Saint-Hilaire, Province of Quebec, Canada.'	G. Zoysa	'New developments in Geuda corundum and its technology.'
H. Bank I.Z. Eliezri	'Gemmological news.' 'New spessartite garnet occurrence in Namibia.'	N.L.E. Haralyi	'Comments on the magnetic properties of gemstones.'
E. Buhtiarova and T. Bublikova	'Main gemmological characteristics of charoite from eastern Siberia.'	J.M. Dereppe and C. Moreaux	'Application of Nuclear Magnetic Resonance to the study of gemstones.'
F.H. Pough R. Segnit	'Phenomenal obsidians.' 'A colour change sapphire from Queensland (Australia).'	T. Tay (to be read by G. Zoysa) M.L. Delé, J.M. Dereppe, P. Dhamelincourt, P. Sombret and J.P. Poirot	'A study of natural and synthetic rubies by PIXE.' 'Use of spectroscopic techniques for the study of natural and synthetic gems; application to rubies.'
J. Ponahlo	'Cathodoluminescence of some rare and of colourless gemstones.'	P. Zecchini, K. Yamni and C. Aurisicchio	'Determination of the composition of natural garnets by using infrared reflectance spectroscopy and multivariate calibration.'
H.J. Schubnel	'Historical synthetic stones of corundum, beryl, chrysoberyl, phenacite in the collection of synthetic minerals in the Museum d'Histoire Naturelle (1824-1900).'	J.M. Nogués-Carulla and N. Ferrer B. Lasnier	'Characterization of cut diamonds by FTIR analysis: possibilities and limitations.' 'A new Raman probe specially adapted for gemmological laboratories.'
E.A. Jobbins	'Sapphires and rubies in Vietnam - an update.'	J. Shida	'Observation of rubies by LASER tomograph; effects of heating.'
K. Scarratt	'The pearls of the Melo volutes.'	H. Merigoux, B. Astric and P. Zecchini	'Variation of the appearance of a faceted stone according to its refractive index.'
R. Cusi	'Conch pearls: a review on the Strombus gigas production and its use.'		
M. Superchi	'Conch pearls: a technical note on the Strombus gigas production.'		



Members having gained their Diploma in Gemmology or the Gem Diamond Diploma (FGA or DGA) may now apply for use of the Coat of Arms on their stationery or within advertisements.

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Book Reviews

HENIG, M., 1990. *The Content cameos*. Derek J. Content Inc. in association with the Ashmolean Museum, Oxford. Hardbound with dust wrapper, 200 pp, 228 monochrome and 93 colour illustrations, bibl., indexes. £52.00.

The Content Family Collection contains what appears to be the largest assemblage of Ancient Cameos outside the major European museums. Now on display in the Ashmolean Museum, Oxford. Every stone in a holding of over two hundred is discussed and its significance assessed: in addition all the gems have been illustrated in monochrome and many of them in colour as well. N.B.I.

HENIG, M., VICKERS, M. (eds), 1993. *Cameos in context*. Derek J. Content Inc. in association with the Ashmolean Museum, Oxford. 102 pp. Hardbound with dust wrapper. £27.50.

The record of six lectures given at the Ashmolean Museum, Oxford in the Summer of 1990 to celebrate the arrival of Ruben's painting of the Grand Camée de France (the 'Cameo of Tiberius') bequeathed by Christopher Norris, and the deposit on loan of the Content Family Collection of Ancient and Later Cameos. The lectures were sponsored by Benjamin Zucker.

Six chapters, each on a different aspect of cameos by renowned experts on their fields.

'The Portland Vase: an aspect of Roman cameo cutting' by David Whitehouse (Director, Corning Museum of Glass, USA) and Kenneth Painter (Formerly Deputy Keeper, Greek and Roman Department, British Museum).

'Ancient cameos in the Content Family Collection' by Martin Henig (Research Associate, Institute of Archaeology, University of Oxford).

'Late antique cameos c. AD 250-600' by Jeffrey Spier (Research Associate, University College, London).

'Cameos in Byzantium' by Cyril Mango (Bywater and Sotheby Professor of Byzantine and Modern Greek, University of Oxford) and Marlia Mundell Mango (Research Associate, Institute of Archaeology, University of Oxford).

'Rubens and the Cameo of Tiberius' by Christopher White (Director, Ashmolean

Museum, University of Oxford).

'Portrait cameos: aspects of their history and function' by Gertrud Seidmann (Research Associate, Institute of Archaeology, University of Oxford).

Each chapter has an extensive bibliography. A beautifully produced, well illustrated book.

N.B.I.

KARLIN, E.Z., 1993. *Jewelry and metalwork in the arts and crafts tradition*. Schiffer Publishing, Atglen, PA. pp 272, illus. in colour. £69.95.

This is an excellent survey of Arts and Crafts jewellery which is enjoying a well-deserved popularity at the time of writing. It is colourful and imaginative; both these qualities are brought out by this not-unreasonably-expensive book which is well illustrated in colour. The text opens with a survey of work done in England: this is followed by accounts of Scottish and Irish work. The effects of British training of Australian craftsmen are described next before the European arts and crafts interpretation is examined. American work comes last. After these regional descriptions modern studio jewellery is spotlighted. There is a glossary, hallmarks table, lists of dealers and auction houses, notes on major museums, bibliography and notes on values. The text is easy to read and the whole makes an attractive and useful book. M.O'D.

PECKETT, A., 1992. *The colours of opaque minerals*. Wiley, Chichester. pp. xxxviii, 471, illus. in black-and-white and in colour. £95.00.

Though the main purpose of this book is to aid the microscopist in the identification of ore minerals on the basis of their colour, there is a great deal of interest to anyone dealing with natural specimens with a rigorous treatment on the nature of light and of colour with notes on the operation of the eye. Several of the various colour evaluation systems are fully described and the inevitably mathematical treatment is at least explained in an appendix which pays particular attention to complex numbers and matrix algebra.

The book is divided almost into two halves; the first part deals with the theoretical aspect of opaque

mineral colour description, the second with the minerals themselves. In the latter each mineral is described as seen in polished mounts with the reflected light microscope in plane polarized light and between crossed polars. The colours seen depend upon the crystal structure and the electronic structure of the minerals. Each mineral description includes name and composition, crystal structure and optical properties, quantitative colour description, IMA approved name, X-ray diffraction data and atomic co-ordinates, with much other useful material and latest abstract in *Mineralogical Abstracts* where available. M.O'D.

PINET, M., SMITH, D.C., LASNIER, B., 1992. La Microsonde Raman en Gemmologie. *Revue de Gemmologie a.f.g.* numero hors series. pp. 60, 50 figs. FF200.

A special volume illustrating the Raman spectra (and other data) of a selected series of gemstones. E.A.J.

SURY, E., 1991. *Mineralien richtig reinigen*. 2 Auflage Sektion Basel SVSM, Basel. pp 68. DM18.00.

A useful ring-backed guide to the cleaning and conservation of minerals including some gem species. Various liquids are suggested for the cleaning process. M.O'D.

WARD, F., 1993. *Emeralds*. Gem Book Publishers, Bethesda MD. pp. 64, illus. in colour. US\$ 14.95.

The second of the Fred Ward Gem Book Series (the first was *Ruby and sapphire*) is equally well-produced and succeeds in giving a great deal of information in a very small compass. Depending for its initial impact on the number and quality of the coloured photographs, the book covers emerald in history, present-day mining and commerce, oiling and treatment, synthesis and imitation, with details of emerald mining in the main producing countries. I recommend the book for all interested in this beautiful stone. M.O'D.

WEBER, I.S., 1992. *Kostbare Steine: die Gemmensammlung des Kurfürsten Johann Wilhelm von der Pfalz*. Deutscher Kunstverlag, Munich. pp. 287, illus. in black-and-white and in colour. DM 148.00.

More than 400 engraved gems from the classical period (two examples) up to the end of the eighteenth century form part of the collection of Johann Wilhelm von der Pfalz, housed in the Staatlichen Münzsammlung in Munich. This scholarly book is

a catalogue of the collection, entries giving place of manufacture, date, subject, physical description, dimensions, inventory numbers, references to the literature and notes on provenance. A section of eleven colour plates illustrates a cross-section of the collection while a twelfth plate depicts the special cabinets which contain it. The standard of reproduction in black-and-white is particularly high while the colour plates are excellent. There is a very useful bibliography and tables in which items are listed by inventory number and catalogue number successively, one table forming a concordance to the other. Provenance is given in both tables. M.O'D.

M.O'D.

WEISE, C., 1993. *Jade, Juwel des Himmels*. Christian Weise Verlag, Munich. Unpaginated, illus. in colour. DM16.00.

Ninety-one jade artefacts from the Chinese Xing [1644-1911] dynasty are described and some of them illustrated in this catalogue of an exhibition held at the publisher's gallery in Munich during 1993. Short notes on jade and its importance to the Chinese are given and in the catalogue entries the purpose, size and colour of the artefacts are provided. The colour reproduction is good for so inexpensive a work. M.O'D.

M.O'D.

WIGHT, Q., 1993. *The complete book of micromounting*. The Mineralogical Record, Tucson. pp. 283, illus. in black-and-white and in colour. Price on application.

It is some years since a book on micromounting was published in English and there has never been a history of this particular way of studying minerals. Micromounting has always been a North American preoccupation and the text reflects this geographical bias. After an interesting account of the earliest micromounters the text goes on to give a step-by-step description of the techniques involved. A hall of fame gives biographies of figures of recent years and the book concludes with a photo album in which 165 coloured photographs of fine-quality micromounts are arranged alphabetically. Since many rare species are found only in small sizes this is one of the only ways in which many can be shown. There is a useful bibliography and appendices in which various micromounting activities are described.

The author has, in fact, completed the text prepared by the late Neal Yedlin and Paul Desautels: the former often said 'buy and use a good mineral book' - this is one. M.O'D.

M.O'D.

Proceedings of the Gemmological Association and Gem Testing Laboratory of Great Britain

PHOTO COMPETITION

The GAGTL are pleased to announce their first ever Photographic Competition.

The theme for the competition is 'The ins and outs of gemstones'. The photographs, which must be of gemmological interest and visually attractive, can be of any form of gem material, rough or cut, and can be of the exterior or interior of the subject. Entry is free to members of GAGTL and there will be two categories - Macro and Micro - with a prize for each category to the value of £100.00.

The closing date for the competition will be 30 April 1994. Selected entries will be exhibited at the GAGTL Annual General Meeting to be held on 13 June 1994 in London.

For rules of entry and an entry form contact Doug Garrod in the Education Department at GAGTL on 071 404-3334.

GIFTS TO THE GAGTL

The Association is most grateful for gifts of gems and gem materials for research and teaching purposes from the following:

D.H. Ariyaratna, London, for his book *Gems of Sri Lanka* published by the author.

Clive R. Burch, B.Sc., Cleadon, Tyne and Wear, for an exhibition collection of pictures of inclusions in gemstones, captioned and framed. The collection will be on display at 27 Greville Street, London.

Rui Galopim de Carvalho of Lisbon, Portugal, for the book *Royal treasures of the Portuguese Crown* by Isabel Silveira Godinho, Ana Maria Batalha Reis. Trans. Peter Ingham. Clube do Coleccionador dos Correios, 1993.

Garrard & Co., Regent Street, London, for a green composite stone from the 1920s imitating emerald.

J.A. Kessler Ltd, London, for six natural emeralds.

Tonny S. Lee, Taipei Co., Taiwan, for two actinolite cat's-eyes from Taiwan.

Harry Levy of Levy Gems for a collection of glass cabochons imitating cat's-eyes of various colours.

Pauline Matthews for an emerald in pegmatite and mica schist from the Menzies Mine, Western Australia.

K. Narayanamurthy, Kuala Lumpur, Malaysia, for rough topaz from Malaysia.

Professor David C. Smith of the Museum National d'Histoire Naturelle, Paris, France, for books on gems and Raman spectroscopy for the library.

M.H.M. Suhaib, B.Sc., Akurana, Sri Lanka for a range of untreated, treated and cut and polished geuda sapphires from Sri Lanka. The GAGTL also wishes to thank the Sri Lankan Government and the State Gem Corporation of Sri Lanka for kindly permitting the export of geuda gem samples.

NEWS OF FELLOWS

Alan Jobbins will resign from the Editorship of the *Journal of Gemmology* with the publication of this number. He wishes to thank all the authors and others who have helped him over the years; he owes a particular debt to Mary Burland for her unstinting editorial assistance and wise counsel.

He resigned from the Council of Management in September 1993.

Peter Read was invited to speak at the Canadian Institute of Gemmology's Gem Forum 1993 held in Vancouver over the weekend of 22-24 October. He gave two talks entitled 'GEMDATA Update 5' and 'The Brewster-angle refractometer'. These talks were followed by a slide presentation 'Gemscapes' at the Gala Dinner.

Whilst in Vancouver, Peter Read also ran an examination preparation course, in conjunction with **Geoffrey Dominy**, for the Canadian Institute of Gemmology students taking the GAGTL examinations.

MEMBERS' MEETINGS

London

The following meetings were held at the GAGTL's Gem Tutorial Centre at 27 Greville Street, London EC1N 8SU:

On 20 September 1993 Frank Greenaway gave a lecture on photographing minerals and gems.

On 6 October Eric Emms gave an illustrated lecture entitled 'Diamonds in the Laboratory'.

On 8 November Amanda Good and Martin Issacharoff spoke on the gemstones of Thailand.

On 22 November Harry Levy gave a lecture entitled 'CIBJO matters - the gem trade in Europe'.

On 7 December Stephen Kennedy and Ana I. Castro gave an illustrated lecture entitled 'Pearls in the Laboratory'.

Midlands Branch

On 24 September 1993 at Dr Johnson House, Bull Street, Birmingham, Dr Jeff Harris gave an illustrated lecture entitled 'Deep diamonds'.

On 29 October at Dr Johnson House, David Wilkins gave an illustrated lecture entitled 'Rescued from the scrap box'.

On 26 November at Dr Johnson House, Dr Jamie Nelson demonstrated three new gemmological teaching aids. The 'hands-on' exhibits were a two-spectra comparison spectroscope, two optical light-path units and a teaching apparatus embodying elementary 'first-principles' gemstone physics.

The Branch's 41st Anniversary Dinner was held on 11 December.

North West Branch

On 15 September at Church House, Hanover Street, Liverpool 1, a talk was given by Jonathan Condrup from Sotheby's, London.

On 20 October at Church House, Tony Hammond gave an illustrated lecture entitled 'Minerals of the Bronze Age'.

On 17 November at Church House the Annual General Meeting of the Branch was held, at which Irene Knight and Joe Azzopardi were re-elected Chairman and Secretary respectively.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 8 September 1993 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership and Fellowship

Ferguson, Neil Fleming, Balloch, Dunbartonshire. 1990/1993
Godfrey, Irmfried Adelheid, Milngavie, Glasgow. 1993

Fellowship

Balducci, Annette, Neston, S. Wirral. 1993
Bortorelli, Andrea Elsbeth Louisa, London. 1993
Bombeke, Sonja, Zoeterwoude Rijndijk, The Netherlands. 1993
Cavelti, Christian G., Vancouver, Canada. 1993
Chan, Seung Yuen, Samuel, Quarry Bay, Hong Kong. 1993
Chow, Wing Yuen, William, Shatin, N.T., Hong Kong. 1993
Chown, Philip John, Sevenoaks. 1993
Earnshaw, Alison, Tonbridge. 1993
Graham, Jennifer J., Glasgow. 1993
Green, Janette Frances, Leamington Spa. 1993
Hamp-Gopsill, David, Burton-on-Trent. 1993
Hanna, Margaret, Grayshott. 1993
Hawes, Rona M., Redhill. 1993
Jegge, Erich Peter, Zurich, Switzerland. 1993
Jones, Amanda Melanie, Stourbridge. 1993
Kennedy, Lisa, Bexley. 1993
Lai, Yi Oi, Kowloon, Hong Kong. 1993
Lee, Fung Kiu, Kowloon, Hong Kong. 1993
Linde, Pamela Ann, Crewe. 1993
McLean, Grace, Dundee. 1993
Martin, Jennifer Frances, Hanham. 1993
Mathiopoulou, Regina M., Athens, Greece. 1993
Morris, Patricia E.J., Crewe. 1993
Nicholson, Charles James Rupert, Hackney, London. 1993
Nicoll, Douglas John, Haddington, East Lothian. 1993
Roberts, Keri Jane, Radstock, Nr Bath, Avon. 1993
Roskin, Gary A., Los Angeles, Calif., USA. 1993
Sagir, Yoram, Ramat-Hasharon, Israel. 1993
Schuivens, Chantalle Martine Ernestine Wilhelmine, Geleen, The Netherlands. 1993
Spencer-Haddock, Brendan, Edinburgh. 1993
Welsh, Alexis, L., Bangkok, Thailand. 1993
White, Isabel Howard, Tunbridge Wells. 1993
Williams, Jason F., West Byfleet. 1993
Wong, Chi-Wing, Kowloon, Hong Kong. 1993
Wong, Man Yee, Bess, Hong Kong. 1993
Yu, Peter K.N., Kowloon, Hong Kong. 1993

Transfers from Ordinary Membership to Fellowship

Berruex, Cedric, La Chaux-de-Fonds, Switzerland. 1993

- Chedta-Thaiyawong, Kanitha, Bangkok, Thailand. 1993
 Dansereau, Eva M., Winnipeg, Canada. 1993
 De Granville, Francesca, Oklahoma City, Okla., USA. 1993
 Duigan, Ingeborg, Hong Kong. 1993
 Farrimond, Thomas, Cambridge, New Zealand. 1993
 Harada, Kayoko, Kanagawa Pref., Japan. 1993
 Kang, Joo-Youn, Seoul, Korea. 1993
 Kiji, Michio, Osaka, Japan. 1993
 Kinda, Yumiko, Osaka, Japan. 1993
 Kitawaki, Hitoshi, Saitama Pref, Japan. 1993
 Kitawaki, Jyunko, Osaka, Japan. 1993
 Luke, Ting Cho Lin, Arlene, Hong Kong. 1993
 Ma, Siu Lam, Hong Kong. 1993
 Odawara, Hiroko, Osaka, Japan. 1993
 Okuta, Etsuko, Osaka, Japan. 1993
 Shibata, Hitoshi, Osaka, Japan. 1993
 Tanaka, Kazuhide, Osaka, Japan. 1993
 Tonn, Heleen Antoinette, Rotterdam, The Netherlands. 1993
 Van Opstal, Wilma, Tilburg, The Netherlands. 1993
 Yamasuga, Ryoji, Hyogo Pref, Japan. 1993
 Yasuda, Kiyotaka, Osaka, Japan. 1993
 Yokote, Hideki, Fukuoka Pref, Japan. 1993
 Zanettin-Barbin, Fabrizia, Geneva, Switzerland. 1993
 Zhang, Beili, Wuhan, P.R. China. 1993

Ordinary Membership

- Ahamed, Omar Faiz, Gillingham
 Anderson-Slight, Jamie Gordon, Horsham
 Bruguera de la Pena, Jorge, Barcelona, Spain
 Butcher, Anna, London
 Edwards, Kenneth Frank, Luton
 Fraser-Harris, Malcolm, Lewes
 Gunn, Sapphire, Harrow Weald
 Hultberg, Stefan, Copenhagen, Denmark
 Jackson, Stephen, Redruth
 Jones, Stephen David, Hong Kong
 King, Carolyn Jane, Richmond
 Kumar, Visuvalingham Krishna, Morden
 Ma, Hon Kit, Jonathan, Hong Kong
 Marshall, Michael Robert, Solihull
 Ooka, Yoshiyuki, Kraainem, Belgium
 Randall, Gary Marshall, Lowestoft
 Saaf, Judith Heselton, Groisy, France
 Seegobin, Wendy, Walthamstow
 Sutton, Daniella Nicola, Cheltenham
 Wren, Amanda, Edinburgh

GAGTL GEM TUTORIAL CENTRE

27 Greville Street, London EC1N 8SU

Identification of Beads & Necklaces
 15 February

How often do you need to identify a gemstone with a curved surface or an opaque substance that you cannot place on the refractometer?

This is the course for you. Spend a day studying a variety of beads and other items.

Price £35.25 (including sandwich lunch)

Weekend Diamond Grading Course
 5-6 March

This successful course concentrates on the practical aspects of clarity and colour grading of polished diamonds, using 10x lens, microscope and colour comparison stones. Mounted stones, simulants and clarity enhanced stones will be seen. Of great value to all involved in diamond trading and appraisal, the course is taught by Laboratory staff.

Price £246.75

Preliminary Workshop

6 April

A day of practical tuition for Preliminary students and anyone who needs a start with instruments, stones and crystals.

Price £44.65; GAGTL students £31.73 (including sandwich lunch)

Synthetics & Enhancements Today

19-20 April

How aware are you of the various treated and synthetic materials that are likely to be masquerading alongside the gemstones you are buying and selling? Whether you are valuing, repairing or dealing, can you afford to miss these two days of investigation into the Laboratory's important collection?

Price £223.35 (including sandwich lunch)

ALL PRICES INCLUSIVE OF VAT AT 17.5%

At a meeting of the Council of Management held on 20 October 1993 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership

Turner, Gaynor Jane, Edinburgh. 1993

Diamond Membership and Fellowship

Turner, Stephen Jeffrey, Edinburgh. 1993

Fellowship

Chan, Mei Wah, Carol, Hong Kong. 1993
 Chenevix-Trench, Susannah, Hong Kong. 1993
 Cheung, Shuk Mei, Hong Kong. 1993
 Crabbe, Jeremy Paul, Hong Kong. 1993
 De Chameralat, Marie, Paris, France. 1993
 Donkin, Jeffrey John, Surbiton. 1993
 Ettila, Annamari, Helsinki, Finland. 1993
 Forrest, Jacqueline, Charing Cross, Glasgow. 1993
 Fowle, Michael John, Nairobi, Kenya. 1993
 Fung, Lai Yi, Kowloon, Hong Kong. 1993
 Gibson, William Michael, Highland, Md., USA. 1993
 Gisbert, Ana Maria, Madrid, Spain. 1993
 Hung, Ching Ting Cara, Quarry Bay, Hong Kong. 1993
 Hung, Suet Fung Josephine, Hong Kong. 1993
 Indiano, Natividad, Madrid, Spain. 1993
 Keating, Martina, Waterford, Ireland. 1993
 Kelloniemi, Katri Irene, Helsinki, Finland. 1993
 Kim, Jee-Eun, New Malden. 1993
 Kruiise, Berendina Jantje, Zwolle, The Netherlands. 1993
 Lasry, Veronique, Madrid, Spain. 1993
 Lau, Paul, Kowloon, Hong Kong. 1993
 Lee, Choi Kan Franky, Kwun Tong, Hong Kong. 1993
 Lee, Jin-Young, Potters Bar. 1993
 Leong, Margaret, Gadong, Brunei. 1993
 Mani, Heida, Ontario, Canada. 1993
 Nam, Song-Ja, Daejon, Korea. 1993.
 Paakkari, Petri William, Lahti, Finland. 1993
 So, Chak Tong Anthony, Hong Kong. 1993
 Stahl, Elone, Tygelsjo, Sweden. 1993
 Thompson, Jane Devereux, Woodbridge. 1993
 Turner, David Barry, Newcastle-upon-Tyne. 1993
 Wong, Lai Fun Alice, Hong Kong. 1993

Ordinary Membership

Aarden-Kilger, Flavia L.M., Bommel, The Netherlands
 Carr, Simon Damian Peter, Garstang
 Chong, Seok-Ran, Busan, Korea

Damiao, Luisa Isabel Gomes, Mitcham
 Doumbouya, Mohamed, St John's Wood
 Frey, Robert, London
 Gordon, Tanya, London
 Green, Nicholas Philip, London
 Hare, Judy, Finchley
 Hill, Letitia, Birmingham
 Hill, Lisa Juliet, Queens Park
 Jack, Johanne C., Khon Kaen Thailand
 Kilby, Linda Elaine, Great Harwood
 Lam, Siu-Wing, Hong Kong.
 Lubowa, Ngoy, Forest Gate
 Pomicter, Leonard John, Santa Monica, Calif., USA
 Purkiss, Karen Ann, Colchester
 Quintner, Flora, Grays
 Raphael, Menachem, Alwoodley
 Sotolongo, Sachiko, London
 Tanaka, Keiko, East Finchley
 Tinnyunt, Emma Judy, Torquay
 Von Manussis, Veronica, London
 Yip, Ngai, Kowloon, Hong Kong

At a meeting of the Council of Management held on 17 November 1993 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership

Cooke, Eva-Maria, North Cheam. 1993

Fellowship

Chellew, Ross Jasper, London. 1993
 Fung, Kam Man, Hong Kong. 1989
 Gillies, Bronwyn Joy, Wanaka, New Zealand. 1993
 Leinonen, Ossi Antero, Viantie, Finland. 1993
 Margolis, Paul Howard, Vancouver, B.C., Canada. 1993
 Park, Kyong Ok, Seoul, Korea. 1992
 Roubin, Ernest, Athens, Greece. 1993
 Wilcox, Kimberly Anne, Delmar, NY, USA. 1993
 Wong, Ming Kin, Hong Kong. 1993
 Yang, Hye Kyeong, Houston, Tex., USA. 1993

Ordinary Membership

Ashton, David, Homerton
 Baker, David M., Dublin, Ohio, USA
 Dapper, Sylvia, Catford
 Davis, Shelagh Mary, Andover, Hants.
 Dyer, Elaine, Compton Dundon
 Fields, Catherine, London
 Hatiris, Michael, Athens, Greece
 Hatzimihael, Michael, Athens, Greece
 Hoi, Tyng Siew, Kuala Lumpur, Malaysia

Kaskara, Tatiana, Pimlico
Kimani, Marjory Nyakiago, Nairobi, Kenya
Maulud, Mat Ruzlin Bin, Leicester
Maxwell, Gary, London
Nakane, Chie, Hyogo Pref., Japan
Pearce, Nigel Robert Williams, St. Helier, Jersey
Schieser, Andrea Louise, Austin, Tex., USA
Sinton, Sarah Kristine, Wandsworth
White, Malcolm John, Kingston-upon-Thames

PRESENTATION OF AWARDS

The Presentation of Awards gained in the 1993 examinations was held on 25 October at Goldsmiths' Hall, London. Mr Ian Thomson presided and congratulated the successful candidates. Among those present were award winners from Finland, France, Greece, Hong Kong, Japan, The Netherlands and Switzerland, as well as those from the UK.

Following the presentation of awards for the Gem Diamond and Gemmology examinations, a Research Diploma was awarded to Dr Jamie Nelson for his thesis entitled 'The glass filling of diamonds'. A certificate was presented to Eric Bruton, who had been elected as Vice President of the GAGTL at the Annual General Meeting held on 14 June 1993.

The awards were presented by Lord Ian Balfour. In his address Lord Balfour referred to his career in the diamond trade. He started as a

Fig. 1. Lord Balfour.

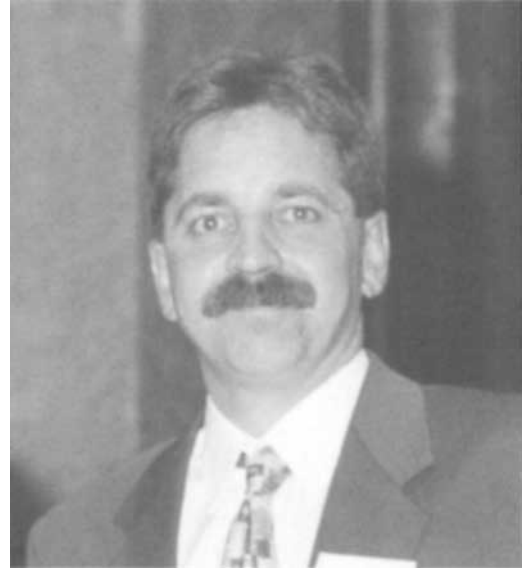
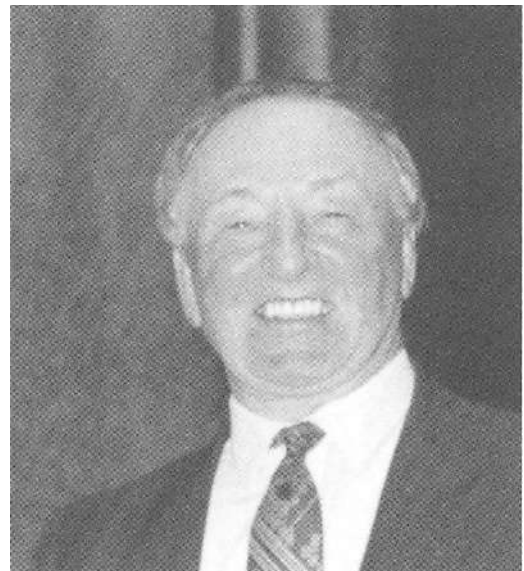


Fig. 2. Anderson Bank Prize winner Pierre Vuillet à Ciles of Villards d'Heria, France.

diamond sorter, which was very good experience, and very early in his career he was shown a pamphlet on famous diamonds. This was the beginning of his interest in the subject which led eventually to the publication of his book *Famous Diamonds of the World*. A second edition of the book was published in 1992 and a third is in prospect.

Fig. 3. Dr Jamie Nelson awarded the Research Diploma.



'Diamonds', said Lord Balfour, 'are only one facet of gemmology.' He stressed that knowledge does not stand still and those that had qualified should consider the Diploma as a major step on their quest for excellence in gemmology.

The vote of thanks was given by Christopher Cavey.

In conclusion Ian Thomson thanked the Goldsmiths' Company for allowing the GAGTL to hold the presentation ceremony at the Hall. He also thanked the Examiners and the education team for their work during the year.

Awards ceremony in China

During a visit to Hong Kong and China, Eric C. Emms was guest of honour at the awards ceremony at the annual Gemmological Conference of the China University of Geosciences in Wuhan. The University is an Allied Teaching Centre (ATC) of the GAGTL and has taught the Diploma course in gemmology leading to the FGA status for many years. Vice Minister of Geology, Mr Zhang Wenye, presented successful candidates in the Diploma examinations with their Diplomas and Eric Emms presented the three awards. The Tully Medal and the Anderson Prize were presented to Ms Guo Tao. The Diploma Trade Prize was presented to Mr Guo Xiaoming.



Fig. 4. Vice-President Eric Bruton.

In his speech following the presentation, Mr Emms described GAGTL plans to teach the Gem Diamond Diploma course leading to DGA status in China and other ATCs in East Asia. A report on the launch of the Gem Diamond Diploma course in China will appear in the next issue of the Journal.

Letters to the Editor

From Dr A. Peretti and Christopher P. Smith

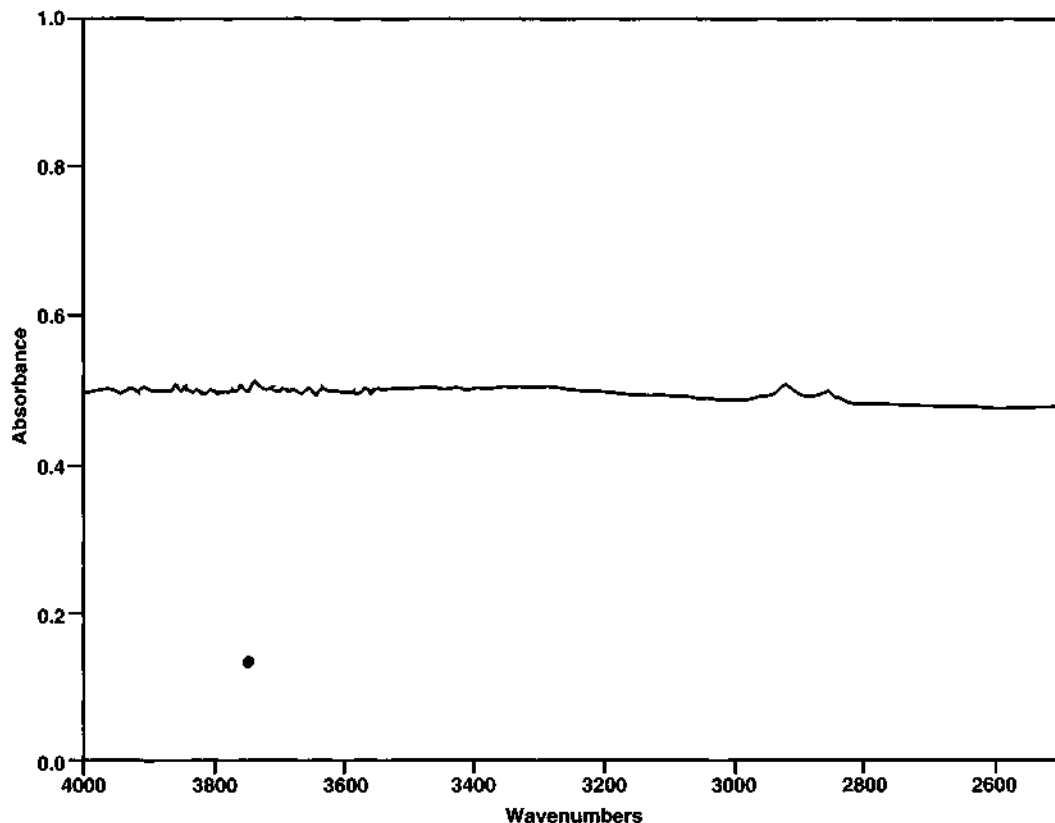
Dear Sir,

Concerning new synthetic rubies in Russia and the recent article of Dr Henn and Professor Bank in the *Journal of Gemmology*.

We feel it is necessary to clarify certain statements made by Dr Henn and Prof. Bank in the July 1993 issue of the *Journal of Gemmology* (23, 7) in their article on new synthetic rubies from

Russia. According to their introduction, the reader may be led into thinking that the material which we have described as being of hydrothermal origin, is the same material which Dr Henn and Prof. Bank have described in their paper. Therefore, we would like to clear up any possible misconceptions by supplying proof of the hydrothermal origin of the synthetic rubies we

Fig. 1. Infrared absorption spectrum in the region of 2500 to 4000 wavenumbers, of a flux-grown synthetic ruby produced by the Academy of Sciences in Novosibirsk, displaying the relatively featureless IR spectrum of a synthetic ruby grown by a flux process. Path length approx. 4mm



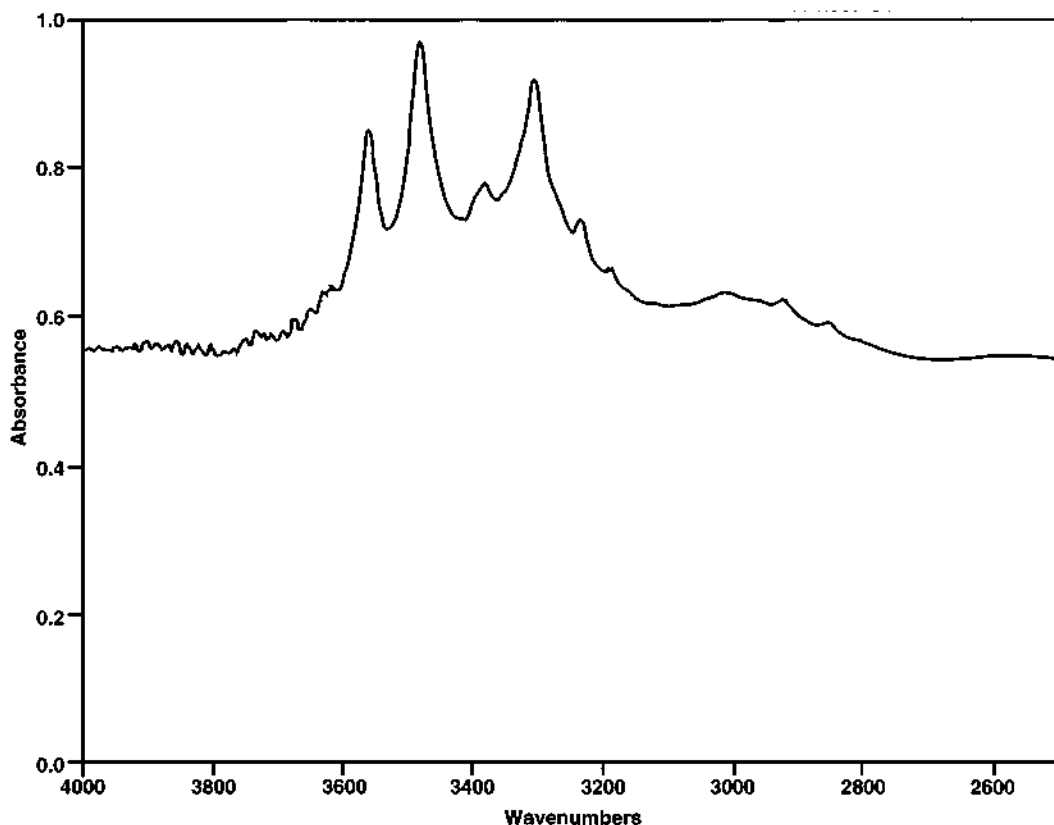


Fig. 2. Infrared absorption spectrum in the region of 2500 to 4000 wavenumbers, of a hydrothermally-grown synthetic ruby produced by the Institute of Geology and Geophysics in Novosibirsk. Exhibiting the typical series of sharp absorption peaks located at 3561, 3483, 3382, 3305, 3235 and 3191 wavenumbers, related to structural OH groups. Path length approx. 4 mm

have investigated, through infrared spectroscopy and scanning electron microscopy.

To begin with, we have also examined the material which Dr Henn and Prof. Bank detailed in their paper. The samples were given to Dr Dietmar Schwartz, of the Gübelin Gemmological Laboratory, directly by Dr Bukin, of the Academy of Sciences in Novosibirsk. This included rough crystals with the identical morphology as those pictured in the *Journal of Gemmology* article, p. 394. Dr Henn and Prof. Bank are indeed correct in reporting that this material is grown by a flux-melt process. However, this is not the material which we have presented in ICA Laboratory Alert No. 66 or the article published in the *Australian Gemmologist* (18, 5, 149-56), describing hydrothermally-grown synthetic rubies. The material we have reported

on, is produced by the Institute of Geology and Geophysics, another of the several research laboratories under the Academy of Sciences in Novosibirsk and marketed by the Tairus joint-venture through Pinky Trading Co. Ltd in Bangkok (Thailand) directed by Mr W. Barshai (a competitor of Dr Bukin). There is more than one research facility producing synthetic rubies in Russia for various techniques including pulled (Czocharalski), flux-grown, floating-zone as well as hydrothermal. As we have been informed, the Tairus joint-venture is only marketing floating-zone and hydrothermally-grown synthetic rubies.

For comparison purposes, we have enclosed infrared spectra for both types of synthetic ruby under discussion. Typical of flux-grown synthetic rubies, the material from Dr Bukin is free of

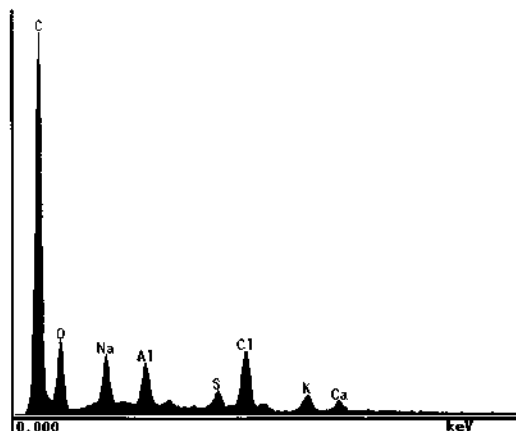


Fig. 3. SEM-EDX analyses of the whitish crusts found on rough rubies reportedly produced by the hydrothermal process in Novosibirsk (Russia). Note the presence of Ca, K, and Na and C evidencing the presence of alkali carbonates in the whitish crusts. Such materials are used as nutrients for complexing alumina in hydrothermal ruby productions. Note no signatures for transition or heavy metal elements.

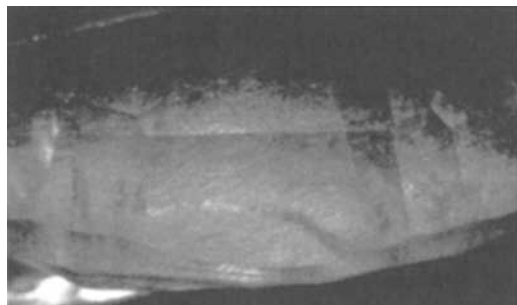


Fig. 4. The most distinctive inclusion feature of the hydrothermal synthetic rubies described to date, consists of heavily disturbed growth characteristics. 35x

significant absorption features in the region of 2500 to 4000 wavenumbers (Figure 1). In contrast, the hydrothermally-grown synthetic rubies display a series of absorption peaks, within the same region of 2500 to 4000 wavenumbers, which are related to structural OH groups (Figure 2). These spectral characteristics are consistent with what has been reported for experimentally-grown hydrothermal synthetic rubies, by Russian and American researchers. About this

topic we will soon report in detail.

In addition, we have analysed by scanning electron microscopy, metallic inclusions as well as whitish crusts which were coating some of the rough crystal fragments of the material we have described as hydrothermal rubies. The metallic inclusions were identified as two different types of copper alloys, it is important to note that copper is not used in the flux-growth process because it is not resistant enough to the high temperatures necessary for this process. The whitish crusts were identified as alkali and potassium carbonates (Figure 3). These materials have been described as nutrients in the literature for the production of hydrothermal rubies. No platinum or tungsten was detected in the metallic alloys and no lithium or tungsten was detected in the whitish crusts. Such elements would have been expected if we were analysing the same material as described by Dr Henn and Prof. Bank.

Lastly, we've included a photo-micrograph of the most distinctive and identifiable inclusion feature observed in the hydrothermal synthetic rubies we have reported on to date. This consists of heavily disturbed growth characteristics (Figure 4), which are very reminiscent of the growth characteristics seen in the hydrothermal synthetic emeralds produced in Russia (see e.g. Schmetzer, 1988; Characterization of Russian hydrothermally-grown synthetic emeralds, *Journal of Gemmology*, 21, 145-64). They are not present in the material described by Dr Henn and Prof. Bank.

We hope this will prevent any possible misconceptions between these two materials. Continued research of the hydrothermally-grown synthetic rubies has provided more interesting results, which will be forthcoming in the gemmological literature.

Yours etc.

Adolf Peretti and Christopher P. Smith

1. Peretti Gemlab, Adligenswil, Switzerland
2. Gübelin Gemmological Laboratory, Lucerne, Switzerland

Reference

- Peretti, A., Smith, C.P., 1993. 'A new type of synthetic ruby on the market: offered as hydrothermal rubies from Novosibirsk.' *The Australian Gemmologist*, 18, 5, 149-57

From Patricia B. Lapworth

Dear Sir

It seems a pity that the Japanese have chosen to call their new *imitation* opal by the name 'Opalite' (see Scarratt et al. 'Opalite triplets - new imitations of opal', *Journal of Gemmology*, 1993, 23, 8, 473-80), which has been used for over 25 years at least in Australia, to my knowledge, for decorative *natural* common opal (usually yellow with black dendrites) much used by lapidaries. It appears in a number of authoritative Australian texts on ornamental, etc., stones and appears in Peter Read's *Dictionary of gemmology*.

Surely there are already enough examples of confusion in gemstone nomenclature already without inventing new ones!

Yours etc.,

Patricia Lapworth
Guildford GU1 3RR
23 November 1993

Corrigenda

In *J. Gemm.*, 1993, 23, 8, p. 465, Table 1, fifth column heading for ' λ ' read ' λ_0 '

On p. 466, Figure 8, formula at top left, for '38 670' read '30 730'

On p. 467, left hand caption on each of the three photomicrographs, for ' n_D^{25} ' read ' n_D^{20} '

On p. 468, second column, line 14, for '495' read '495'

On p. 470, Figure 11, formula at top left, for '38 670' read '27 830'



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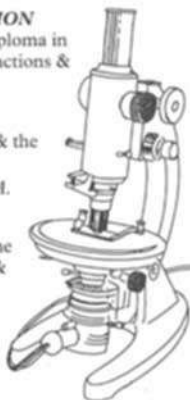
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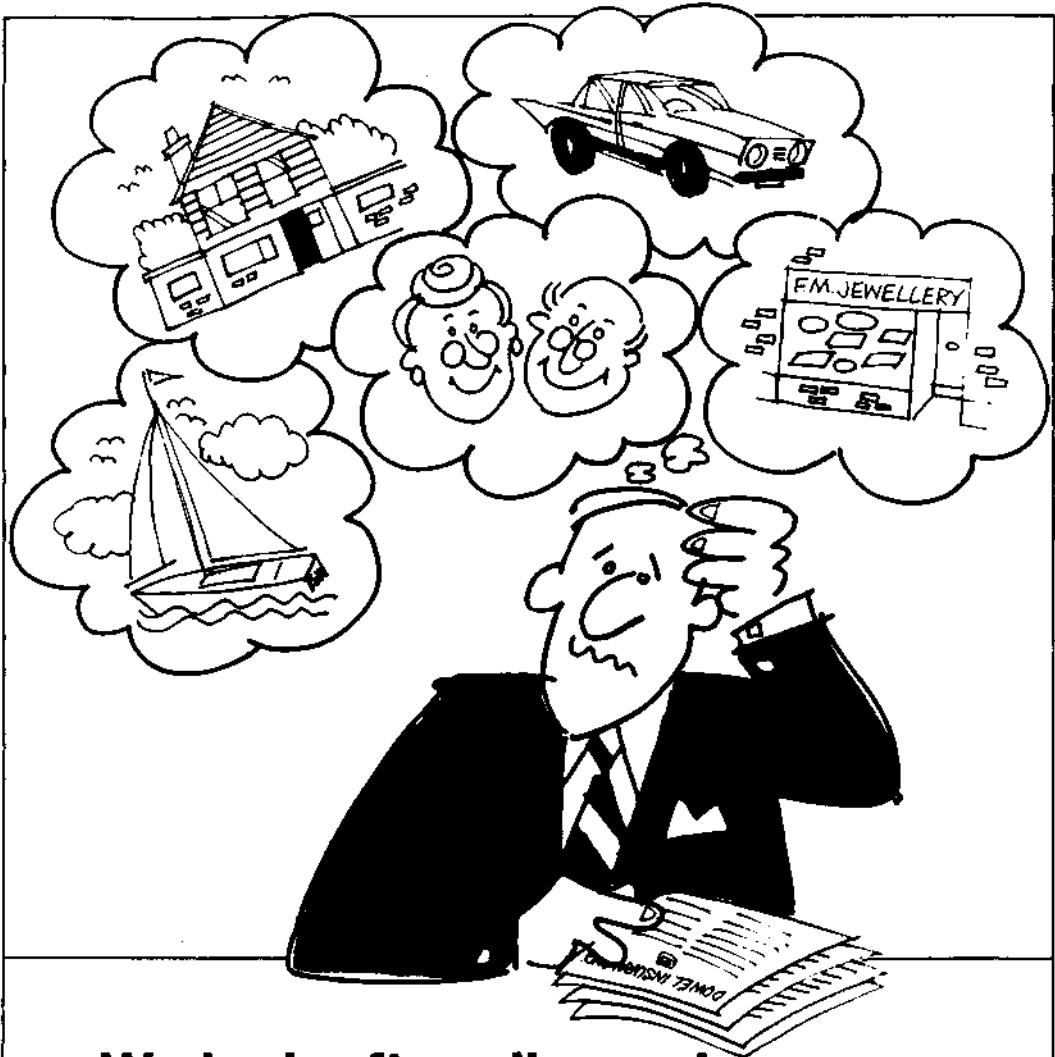
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