Feature

Sapphires from Sri Lanka

A rural industry of small-scale mining, for sapphires and a host of other gemstones, is alive and thriving at Ratnapura in Sri Lanka. The minerals are extracted from alluvial gravels and colluvium, and most are then cut and polished locally for use in jewellery.

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The island nation of Sri Lanka, once known as Ceylon, has long been famous as a major source of gemstones. Sapphires are the most treasured of the country's resources, and their distribution in the shallow soil profiles means that small-scale mining with little mechanisation continues to be the best means of extraction. Furthermore, this mining causes no massive depletion of the resource, and the gemstones keep going as an important facet of the economy in various regions.

Sources of the gemstones

Except for some thin, Miocene coastal sediments, the whole of Sri Lanka is an impressive chunk of high-grade Archaean gneisses, a chunk of Gondwana that broke away from Madagascar and Australia which were once its neighbours. These strong rocks have been eroded into an impressive set of rounded and dissected highlands (the Hill Country that is famed for its massive tea estates), which is surrounded by lower hills and multiple peneplains dotted with inselbergs large and small.

Sri Lanka's Archaean gneisses are only broadly subdivided, partly because of the poor exposure across much of the extremely verdant terrain. Through the centre of the island, the Highland Complex lies along the source of an ancient plate convergence, and is the primary source of all the gemstones (Fig. 1). Most of the Highland rocks are garnet gneisses (Fig. 2) and sillimanite granulites, but the gemstones are all found in areas where there are also major units of cordierite gneisses. These relate in part to charnockite dykes that appear to be metamorphosed granitic materials. Sapphires may be a by-product of the early contact metamorphism that produced the cordierite, but can also originate from metasomatism; this created skarns in reaction with bands of marble, and also produced tourmaline, zircon and apatite in small pegmatitic intrusions. Records of the gem minerals within bedrock are sparse, so their true distribution and genesis remain open to some debate. The cordierite gneisses form a major proportion of the ground all around Ratnapura, which is the historical centre of the largest of Sri Lanka's gem fields.

What is clear is that the gemstones have been secondarily concentrated by weathering and erosion, so that they are now found in economic abundances within the cover soils beneath the valley floors. These soils are mostly sticky clays 2–15 m thick, with many quartz pebbles up to 50 mm in diameter. The gemstones are found in the layer known as the *illam*, normally only 50–600 mm thick and at the base of the soil profile. Some of the illam is alluvial sediment, so that it forms true placer deposits forming discon-

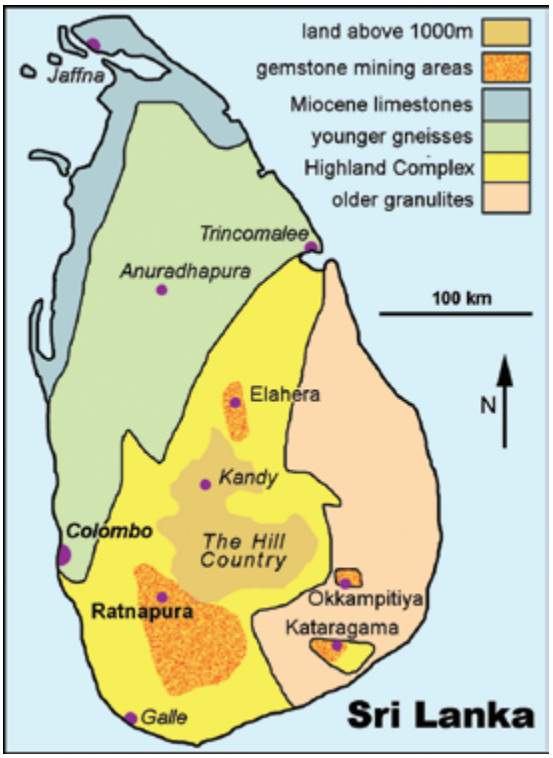

Fig. 1. Outline geology and the main gem areas of Sri Lanka.

Fig. 2. Garnet gneisses of the Highland Complex.

tinuous lenses along old stream channels; within this, the gemstones are generally well-rounded, stream-worn pebbles. But much of the illam is immature and poorly sorted colluvium and landslide debris that has not travelled far from source. There is every transition from colluvium to alluvium, and the former is distinguished by many of its gemstones surviving as angular, well-shaped crystals with sharp edges. Beneath the illam, weathered *in situ* bedrock, locally known as malawa, is mica-rich material a few metres thick; it does also contain gemstones but has not been widely mined as its yield is lower. Modern stream sediments contain another generation of reworked gemstones and have been dredged by hand, but only on a very small scale.

Corundum, sapphire and more

Corundum is pure aluminium oxide, famed as the hardest natural mineral after diamond, and when it is of gem quality it is known as sapphire. Typical crystals are double-ended pyramids on hexagonal prisms (though the symmetry is trigonal), and these are commonly distinguished by their ribbed barrel shapes created by alternations of the prism and pyramid faces (Fig. 3). Some of the sapphire is colourless, while much is yellow due to its ferrous iron content. The more treasured stones are a lovely cornflower blue, due to ferric iron and titanium oxides as colloidal particles that also introduce lattice distortion. With chromium in it, sapphire can also be pink or red in colour; the latter is known as ruby, though this term is properly reserved for the blood-red stones and is little used in Sri Lanka, where it is generally kept for the stones from Mogok in Myanmar (Burma). A rare and highly valued salmon-pink variety from Sri Lanka is known as *padparadscha*, after its lotus flower colour.

Most Sri Lankan blue sapphires have only pale colour, but are changed to a deeper blue by heating.

Fig. 3. A box of crystals of blue sapphire fresh from the mines at Ratnapura; these were on offer for a starting price of £70 each.

This is regarded as perfectly acceptable in the trade, and unheated stones are now rare, though any style of staining to enrich the blue is very much not acceptable. Good, blue, heat-treated sapphires of 3–30 carats (0.6–6.0 g) form the core of the Sri Lankan gem trade. Smaller stones of all colours are also cut, while much larger blue stones are true rarities. Star sapphire has inclusions of parallel fibres and needles of rutile, which create the optical effect of radiating light rays in a stone cut and polished as a rounded cabochon.

Though famed for the blue sapphires, the Sri Lanka gem deposits yield a range of coloured stones like no others in the world. Very good spinels, of red, brown and blue colours, are notable, as are red, green, yellow and colourless zircons and red garnets. Beryl is mainly as the pale blue aquamarine, and there is also

Fig. 4. Rice paddies across the valley floor of the Kalu Ganga at Ratnapura; each small building or patch of brown soil is the site of an active or recent gem mining operation.

Fig. 5. Digging down to the gem-bearing illam in a small pit mine near Ratnapura.

the alexandrite variety of chrysoberyl that is green in natural light and red in artificial light. Colourless topaz does occur, but 'Ceylon topaz' is yellow quartz. Tourmaline is not common, but its name is often wrongly applied to various other coloured stones, and moonstone is the milky variety of feldspar. The trade may focus on the sapphires, but there is certainly no shortage of spectacular gemstones in the soils of Sri Lanka.

Mining at Ratnapura

For more than 2000 years, Ratnapura has been at the heart of Sri Lanka's gem industry; its name means City of Gems. Though the casual visitor may be forgiven for not noticing. The mining is all in small operations, without the extensive excavations of the alluvial ruby mining at Mogok in Myanmar. Most of the Ratnapura mines are hidden away in the forests, and in adjacent valleys, with very few out in the open paddy fields (Fig. 4). And each one is worked by just a handful of men. There is no real pattern to the mines, because the 'paystreaks' in the buried soils are all of only limited extent. Some palaeochannels in the alluvial illam can be recognised by lines of old mine dumps, and the miners have enough local knowledge to follow the richer ground. But finding the best gems in colluvial illam owes a lot to sheer luck, and there are still many new areas that await exploitation.

A Ratnapura gem mine is started when an entrepreneur rents a slice of land, puts up the capital to buy the necessary pumps, tools and shoring material, and offers a basic wage to a handful of miners. Most mines are then open pits that can reach down as much as 8 m to the gemiferous illam. A working pit is typically about 2 m by 5 m, dug straight down, entirely by hand, with the soil passed up to the surface in baskets (Fig. 5). Continuous pumping is generally essential, and the pit is shored with timber from rubber trees and betel palms. When the digging reaches the gem horizon, the illam is carefully saved ready for washing, but each pit is normally played out when it reaches down to the weathered bedrock. Then a new pit is started in adjacent ground, and the waste soil is used as backfill for its predecessor. The mining therefore progresses across the ground, hopefully following the richest material (Fig. 6).

If the barren soil cover is much over 6 m deep, a

Fig. 6. A small pit mine, under the nearer plastic awning, beyond the sites of its predecessors that were in the disturbed soil of the foreground.

Fig. 7. The first-stage washing box for illam that has been extracted from the small shaft mine under the blue awning up the hill.

Fig. 8 (left). Washing the clay out of the illam with a powerful jet of water.

Fig. 9 (left). A pile of gem-bearing gravel washed from the illam and awaiting the second stage of washing.

shaft is sunk to the gem horizon, and these can reach 15 m or so deep. From the shaft foot, horizontal galleries radiate within the gem-rich illam, but generally only extend 10 or 20 m. Again dug entirely by hand, they also require continuous pumping and shoring, and the illam is just dragged out in sacks before being winched to the surface in baskets.

Hauled out from either pit or shaft, the gem bearing illam is dumped into large wooden boxes where it is blasted with a jet of water from a powerful hose (Fig. 7). This breaks up the clay, which is washed out through a fine screen that forms one wall of the tank (Fig. 8). Rocks and cobbles are picked out by hand, and the remaining sand and gravel is stockpiled (Fig. 9). Then the digging work stops for a time, and the mine is temporarily allowed to fill with water while the gravel is washed. This is done in deep rattan baskets (Fig. 10). The miner stands waist-deep in water holding the basket almost submerged. Gravel is shovelled into it, then washed around. Every so often barren soil is scooped off the top and dumped while more fresh gravel is tipped in. Within the sludge, gravity takes over as the gem minerals sink to the bottom of the basket; sapphire has a density of around 4.0 g/ml, and everything of value is denser than the clay and quartz sand. This hand washing is a variation on gold panning, except that the lighter minerals are not simply washed over the rim of the pan. Basket washing can handle much more material than panning, and after a fair amount of gravel has been tipped in and skimmed off, the basket is turned out to where the gemstones are simply picked off from what had been the very bottom of the agitated gravel. The large stones go to the mine owner, who also pays a small bonus to the miners that found them, while the smallest stones are left for the miners to sell themselves for whatever they can get.

Fig. 10 (right). Rattan baskets that are used for the critical second stage of washing the gemstones from the gravel.

Even the gem markets are barely conspicuous to

Fig. 11. Traders at the morning gem market in Ratnapura.

Fig. 12. A paper folder of rough yellow and blue sapphires, with a single pink sapphire, on first offer at 10 US dollars each (about £7) in the Ratnapura morning market.

the passing visitor. There are no stalls or stones on display. Instead a crowd of men gather each morning in the clock-tower square in the middle of Ratnapura (Fig. 11). Each man has a pocket, or a purse, or a small bag, containing folds of paper that hold various collections of rough stones (Fig. 12), and anyone who comes as a buyer is soon surrounded by sellers who offer their wares. Gemstones pass from hand to hand in an atmosphere of complete trust, and instant sales (after serious haggling of course) transfer the rough stones to the cutters. There is a huge cottage industry of cutting and polishing the gemstones in the same area as their source mines; originally worked on lathes hand-driven with a cord-bow, electric-powered discs are now the main tool. It is estimated that miners, cutters and traders account for up to 50 000 people in and around Ratnapura.

Sapphires then and now

Coloured stones washed from the soil have been known in Sri Lanka since time immemorial, but it was the Buddhist incomers from India around 500 BC who first really appreciated their value and started extracting the gemstones to use as jewellery. In 1292, Marco Polo passed by and commented on the riches of the island's gems, and the industry continues to thrive today. Half of the world's sapphires weighing more than 100 carats have come from Sri Lanka, nearly all from the Ratnapura district. And these are where the greatest value lies. The Queen Marie of Romania sapphire, known after an earlier owner, weighs in at 478 ct, and changed hands at auction in 2003 for just over a million pounds sterling.

Fig. 13. A handful of small stones on offer direct from a Ratnapura miner; the very pale yellow and the pale blue are sapphires, the clear is a topaz, the green is a zircon, and the various reds are spinels.

The world's big producers of sapphires are today Madagascar and eastern Australia. Kashmir has long been famed for its blue sapphires, but its yield has declined as some mines have become exhausted and others lie in disputed border regions. Thailand, Cambodia and Myanmar are still significant producers, beside Myanmar being justifiably famous for its red rubies. There is also a huge world-wide production of synthetic corundum. Gem quality material of the right colour is relatively easy to manufacture, and is fed into the jewellery trade; natural sapphires and rubies do still command much higher values, even though they are almost indistinguishable from the synthetic. Most of the synthetic corundum ends up as abrasive powders, while cleaner material is used to make industrial windows, LED substrates and watch bearings.

Currently Sri Lanka produces around 3M carats of gemstones per year, of which a quarter are sapphires, and these account for 7 per cent of the nation's exports (mostly as cut sapphires). But Ratnapura is no longer the only centre of production. Further north, the Elahera district (Fig. 1) rose to prominence after 1960 and now produces about a third of the nation's raw gemstones. Many of its workings are larger operations where machinery is used to remove the overburden. Further east, the Okkampitiya field is also significant. Many of its pits are worked in the dry on a seasonal basis, by men who return to the rice fields in the wet season. Both these areas are also well known for the quality of their red garnets. But Ratnapura remains the big centre, and its extensive resources look like keeping the Sri Lankan tradition of producing fine gemstones alive for many years to come.

Suggestions for further reading

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