

CAN TRADITIONAL METHODS BE STILL USEFUL IN EXPLORATION AND MINING OF GEM DEPOSITS? - A REVIEW

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ABSTRACT

Gem mining in Sri Lanka can be traced back to more than 2500 years. The common gem minerals found in the country include corundum, kornepine, chrysoberyl, beryl, zircon, tourmaline, garnet, spinel, feldspar and quartz which occur mainly in the areas of Highland Complex of the high grade basement. The objective of the present study is to provide a summary review on application of traditional methods for gem exploration.

Identification of high gem potential areas is being carried out even today using the traditional knowledge and technology which is transferred over time in folklore and societal norms. For the gem exploration, information on the prevailing geological and geomorphological conditions such as surface topography, drainage network, modes of occurrences of ancient river beds and structural and weathering features of the bedrock are being used. Further, the characterisation of gem beds such as the shape, colour and thickness as well as morphology and the mineralogical composition of indicator minerals in gravels/sand fraction of the panned concentrate are being examined to discover high potential areas. Understanding the mode of occurrences of decomposed rock layer (*malawa*) is another tool in traditional exploration. Concentrations and types of indicative minerals in the panned extract and *malawa* are highly variable according to locations. Although the test pitting is the principal technique used in gem exploration, sounding rods are also used occasionally to trace the gem-bearing gravel layers. Although the traditional gem mining and investigating methods are not available in print, the knowledge is being transferred from generation to generation by word of mouth.

Despite the advent of modern technologies in mineral industry, traditional methods of gem exploration and mining in Sri Lanka still have a large potential as well as acceptance among the villagers.

Keywords: Gems, Traditional methods, Exploration, Mining, Sri Lanka

INTRODUCTION

Gem mining in Sri Lanka can be traced back to more than 2500 years into the time of building the Ruwanweli Stupa or earlier. According to literature, ancient people identified many localities of gemstone sources (see Figure 1). Sri Lanka is popular for many gem minerals such as corundum, chrysoberyl, beryl, garnet, tourmaline, zircon, spinel, andalusite, apatite, kornepine, cordierite, sillimanite (fibrolite), feldspar and quartz (Table 1). Traditional gem mining is concentrated mainly in Ratnapura, Pelmadulla, Balangoda, Eheliyagoda and Rakwana areas. However, modern techniques

have been proposed for Ratnapura area in the recent past. Gem mining activities have been extended recently to Elahera, Bakamuna, Kaluganga, Okkampitiya, Passara, Kanthale, Bibile, Horana, Waga and Kalahagala areas (Figure 2). Most of gem mining is being carried out on Quaternary sedimentary beds which occur in broad river-cut valleys (Appendix – Plate 1). Vein type deposits, pegmatites and lenses in rocks are also other sources for gems. The types of gem deposits are alluvial, eluvial with a residual component and in-situ type. The concentration of gemstones decreases from alluvial to residual types. In-situ gem deposits have been discovered accidentally and they are

referred as "Nidhanaya" (the Treasure). Geologically all the gem-bearing areas belong to Highland Complex (HC) of Sri Lanka and the potential areas were identified based on the available information and stream sediment analyses (Figure 3).

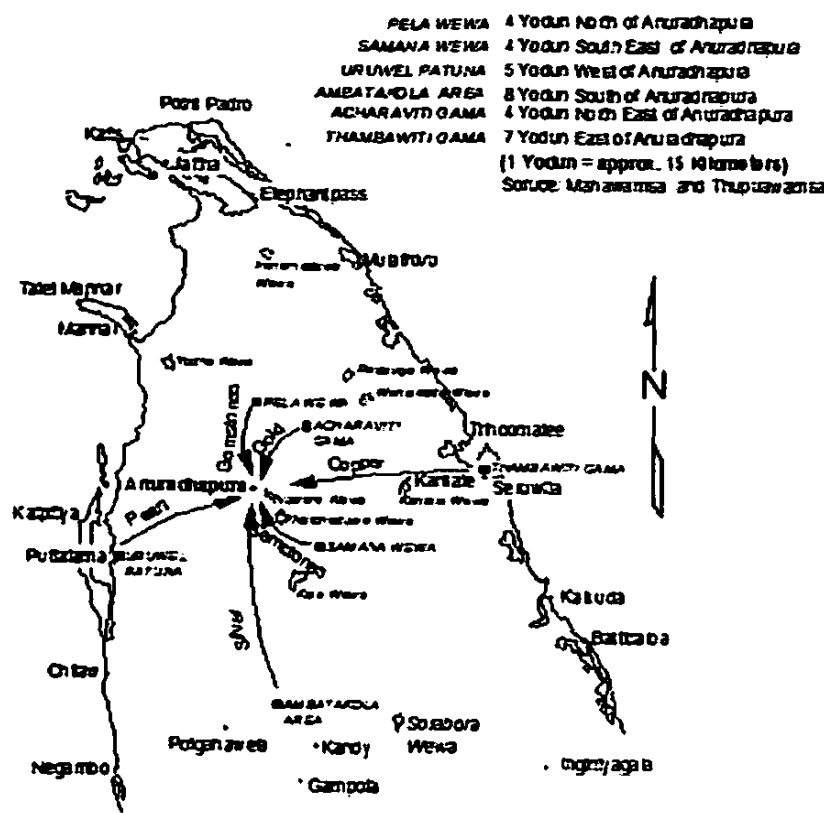


Fig. 1 Locations of ancient gem mining of Sri Lanka (Source: Mahawamsa and Thupawamsa).

Attempts have been made to introduce more systematic and new techniques to facilitate the existing methods of gem exploration.

In addition to gemstones, gold also is found mostly associated with gem bearing sediments (Coomaraswamy, 1904, 1905, Nawaratne and Wijeratne, 1995a, 1995b, Nawaratne, 1996). In certain areas, gold has been recovered in considerable quantities mainly from the gem-bearing river beds of Walawe Ganga, Kalu Ganga and Kelani Ganga.

METHODS OF STUDY

Literature survey on gem mining and explorations, geomorphological studies and field investigations in mining areas and assessment of traditional mining methods were carried out for a long period of time. Mineralogical composition of panned concentrates was studied in the field and selected samples were transported to the laboratory for further studies. Optical means such as binocular and polarizing

microscopes were used to further identify of heavy minerals.

TRADITIONAL KNOWLEDGE ON GEOLOGY AND MORPHOLOGY

The traditional gem miners gain knowledge on the characteristics and nature of gem deposits by participating in mining activities. Although written literature is not available, prospecting is done methodologically by identifying geological characteristics of gem bearing zones. They investigate old mining sites, topography of the area, colour and nature of the gem bearing layer, structures of the basement rocks, mode of

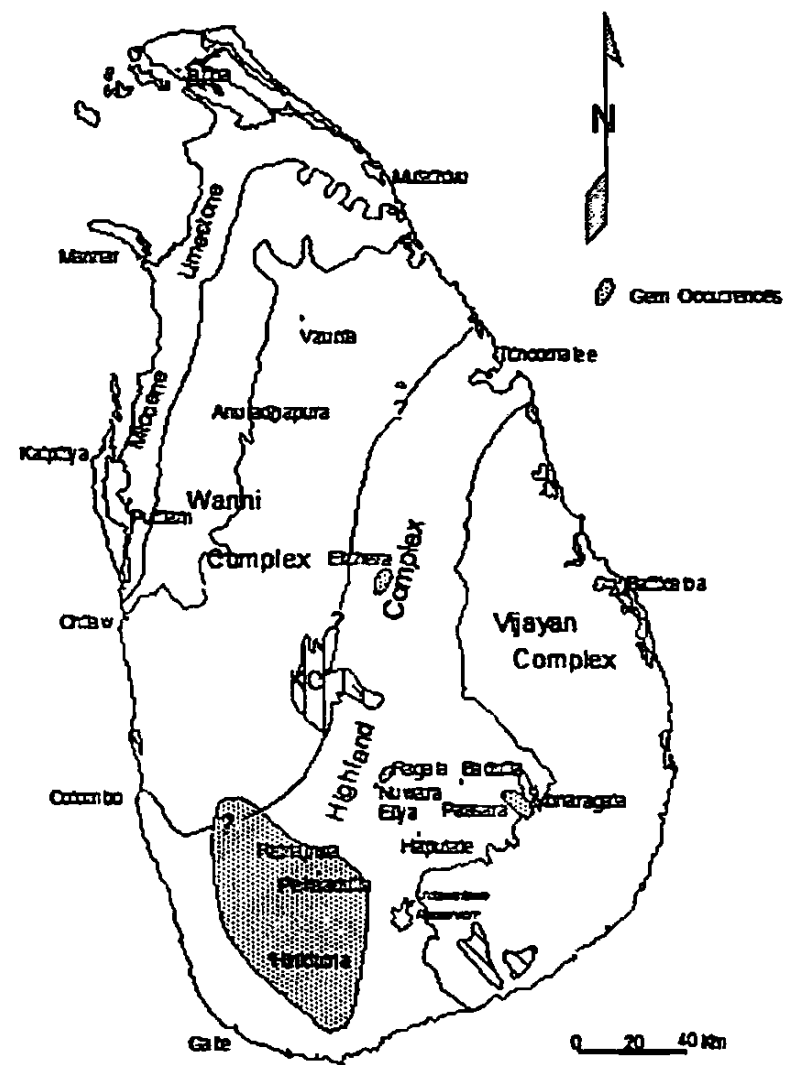


Fig. 2 Distribution of gem potential areas in Sri Lanka and major geological subdivisions of Sri Lanka (after Cooray, 1994).

occurrences of ancient river beds, characteristics of gem-bearing beds (*illama*) and the type of heavy minerals in the panned concentrate (indicator minerals in the *nambuwa*) and *malawa* (decomposed rock layer). In some instances, the miners use a "sounding rod" to determine gem bearing gravel beds by penetrating the rod even up to 6 meter depth.

For the continuation of mining activities in

known areas, investigations are being applied in old mining pits. Traditionally, gemstones are mined by open pit method if the deposits are occurred at shallow depths. However, well developed shafting and tunnelling methods are applied if the deposits are at deeper locations. Even though most of the selected gem deposits

next generation of prospective miners.

Even though the flat lands contain gemstones, special attention is paid on the valleys of the area where the highest concentration of gemstones are found. Initially, the miners investigate the bottom of the valleys and

Table 1 A summary of modes of occurrences of common gem minerals in Sri Lanka (Sed. Beds – sedimentary beds, In-situ Dep – In-situ deposits, Resi.Dep- residual deposits).

MINERAL NAME	GEMSTONE	OCCURRENCE
Corundum	Ruby	Sed.Beds, Resi. Dep
	Blue Sapphire	Sed. Beds, In-situ Dep., Resi. Dep.
	Star Sapphire	Sed. Beds, Resi. Dep
	Star Ruby	Sed. Beds, Resi. Dep
	Yellow Sapphire	Sed. Beds, Resi. Dep
	White Sapphire	Sed. Beds, Resi. Dep, In-situ Dep.
Chrysoberyl	Cat's eye	Sed. Beds
	Chrysoberyl	Sed. Beds
	Alexandrite	Sed. beds
Beryl	Aquamarine	Sed. Beds, In-situ Dep.
	White Beryl	Sed. beds
Spinel	Spinel (Blue, Yellowish, Yellow-Brown, Pink, Purple, Blue, Sinhalite)	Sed. Beds, Resi. Dep, In-situ Dep.
Topaz Garnet	Topaz (White, Yellow)	Sed. Beds, Resi. Dep.
	Almandine	Sed. Beds, In-situ Dep.
	Pyrope	Sed. Beds, In-situ Dep.
	Grossularite	Sed. Beds, In-situ Dep.
	Hessanite	Sed. Beds, In-situ Dep.
Zircon	Zircon (Green, Purple, Yellow, Brown, Colourless (Jargoon))	Sed. Beds, In-situ Dep.
Feldspar	Moonstone	Sed. Beds, In-situ Dep.
Quartz	Amazonstone	
	Smoky quartz	Sed. Beds, Resi. Dep, In-situ Dep.
	Citrine	Sed. Beds, In-situ Dep.
	White Quartz (Rock Crystal)	Sed. Beds, In-situ Dep.
	Amethysts	Sed. Beds, In-situ Dep.
Tourmaline	Quartz Cat's Eye	Sed. Beds
	Tourmaline (Brown, Green, Yellowish, Blue, Black)	Sed. Beds, In-situ Dep. Sed. Beds, In-situ Dep.
Olivine	Peridot	Sed. Beds,
Cordierite	Iolite	Sed. Beds, In-situ Dep.

are mined by tunnelling, some fractions are left behind in between the tunnels and they may contain more gemstones than common eluvial gem deposits. These zones are called "nattirama" only the former miners would know their locations. In the Ratnapura area, such gem bearing beds lie within the paddy fields which are either old river beds or floodplains of Quaternary age (Daraniyagala, 1958). In general, the known information is passed to the

gradually move away towards the valley slopes.

The types of gem deposits found in such areas are alluvial, sub-alluvial to eluvial from the valley bottom towards the hill slope. The concentration of gem decreases from valley bottom to the slope area. In the Elahera-Bakamuna area, mining for gemstones is carried out in broad valley bottoms which are now mostly converted into paddy fields.

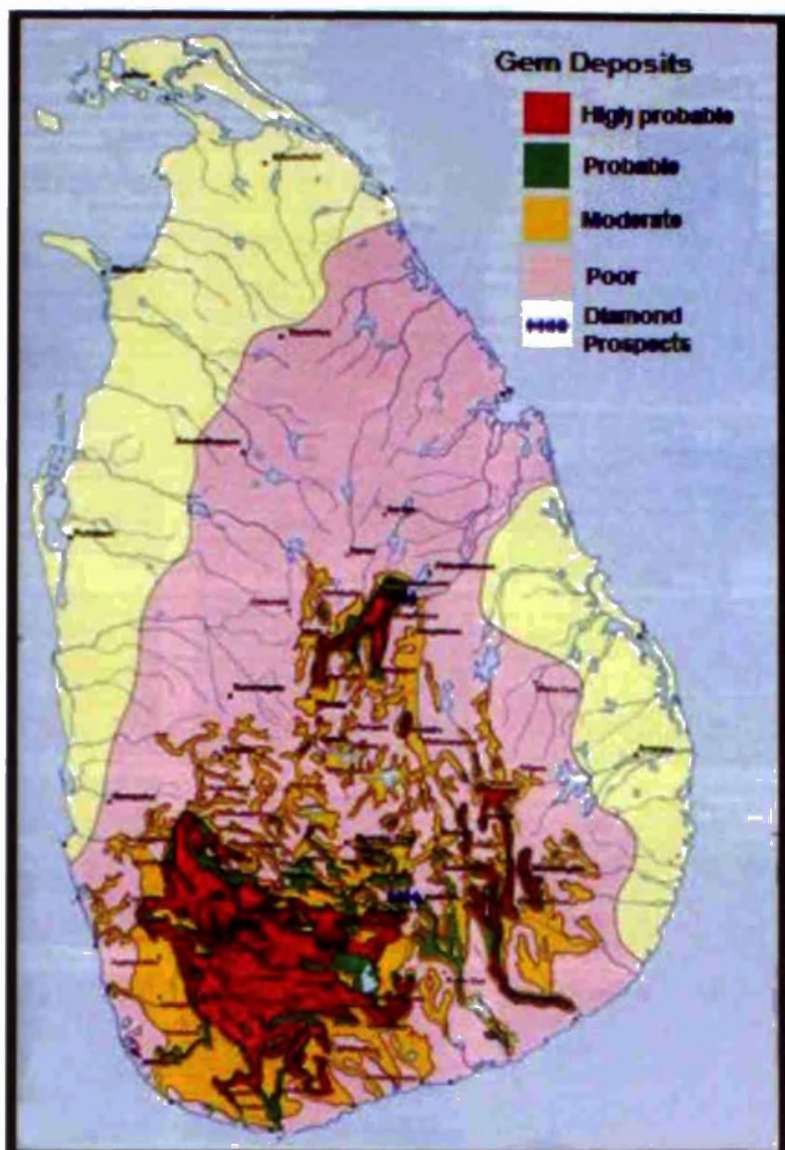


Fig. 3 Gem mineral prospective map of Sri Lanka (after Dissanayake and Rupasinghe, 1993).

In addition, most miners have knowledge on the structures of the surface of bedrocks or "malawa" since such features reveal highly concentrated areas. For example, thicker beds with higher concentrations of gems are found towards the dip of the surface (*baesma*). The depressions and potholes are also possible for occurrence of gemstones. By observing the old or active gem pits, the direction of the dip of the basement is visually evaluated.

Thorough knowledge on sedimentary sequences of gem bearing profiles is also essential since stratification of gem bearing areas is highly variable according to locations of the country. The sedimentary profiles of Ratnapura area contain many layers as shown in Figure 4(a). Interestingly, the sedimentary sequence is generally characterized by a single gem-bearing bed. Despite the Balangoda gem deposits being located near to Ratnapura, sedimentary sequences show slight differences (Figure 4(b)). In contrast, the sedimentary sequences of Elahera gem beds are significantly different due

to (a) presence of layers rich in ferruginous materials and (b) their occurrences at shallow depths.

The "malawa" (decomposed rock layer) which underlies the lowest gem-gravel bed also gives information about the richness of the deposit. Its composition varies with respect to the type of deposit and the location. The composition of gem layers depends on the colour of the "malawa". It is categorized into several types according to their colour and mineralogical composition. They are (i) black "malawa" rich in organic materials, (ii) mica "malawa" containing higher concentrations of greenish colour mica flakes (altered biotite), (iii) Kaoline "malawa" rich in clay and (iv) "Malawa" of negligible thickness on the bed rock.

Panned concentrate, *Nambuwa*, is rich in fine grained heavy minerals. It is categorized according the mineralogical composition. The different panned concentrates found in Sri Lanka are:

1. Black tourmaline with opaque zircon, ilmenite, corundum, black spinel and garnet (*Kattanambuwa*).
2. Concentrate rich in light coloured minerals such as spinel, corundum, tourmaline and garnet (*Dalan nambuwa*).
3. Ilmenite rich concentrates (*Wedibehethnambuwa*).
4. Garnet rich extract (*Rabaha nambuwa*).
5. Fine ferruginous gravel (*Thelboralu nambuwa*). These are commonly found in Elahera and, Bakamuna areas, and
6. Concentrates devoid of heavy minerals.

The presence of *Dalan nambuwa* and *Katta nambuwa* indicates for high potential for gem minerals. In contrast, *Thelboralu nambuwa* and *Nambuwa* lacking in heavy minerals imply low gem potential. In general, *Wedibehethnambuwa* represents low gem potential areas.

CHARACTERISTICS OF THE GEM BEARING LAYERS (ILLAMA)

The *illama* is characterized by variable size of particles from boulders to fine clay. Most of the

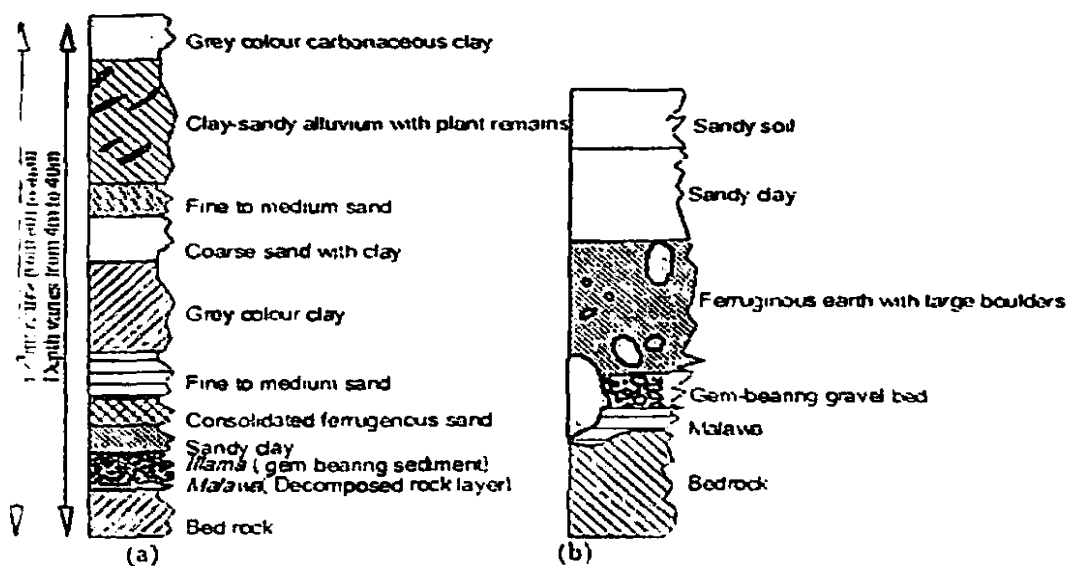


Fig. 4 Generalized stratigraphic sections of gem mining areas (a) Ratnapura beds (b) Balangoda beds.

larger particles are quartz with minor rock fragments and other weathering resistant minerals. The roundness of the grains in *illama* shows the maturity of the gem bearing bed (Appendix – Plate 3). Mature gem bearing beds normally have higher concentrations of gemstones. Generally the roundness decrease from alluvial beds to eluvial ones. The size of the particles in the *illama* is indicative of the maturity of the gem-bearing gravel layer.

Traditional miners categorize the *illama* into many groups according to mineralogical composition and physical characteristics. Yellow coloured gem-bearing beds (*Kahaillama*) are characterized by rounded to sub-rounded grains with slightly brownish yellow coloured matrix materials. The colour of such deposits may be due to the presence of low iron concentrations. Presence of higher contents of organic matter gives black coloured (Appendix – Plate 4) gem-bearing beds (*Kaluillama*). Occasionally such deposits contain pieces of rotten wood. Generally these deposits are rich in gem minerals. *Illama* containing sand size gems are called *Weliillama* which has rounded or sub-rounded pebbles and sand grains. The beds rich in pebbles with highly variable sizes are called *Ketaillama*. *Kuruluketaillama* is characterized by relatively smaller pebbles and has a potential for gems. Ferruginous gem-bearing beds (*Yamala illama*) contain particles sizes from boulders to fine sand

size particles with iron oxide matrix and they are mostly dark brown to black coloured layers.

The chemical characteristics of the gem bearing sediments were shown to be important in gem exploration (Dissanayake et al, 1993). For chemical analyses, sampling of the *illama* layer has to be done with a soil auger. This is problematic when the deposits are deep and power augers have to be used. Power augers can be used to depths of about 30 meters and if the deposits are shallow hand operated augers can be used. For shallow deposits, test pitting can be done more conveniently. Collecting samples of “*illama*” with an auger will be difficult when it is composed of boulders and larger pebbles.

TRADITIONAL EXPLORATION USING RODS AND TEST PITS

Sounding rods of different diameters are used in finding gem-bearing gravel beds. These rods can penetrate into the gem beds and their length can be from 0.5m to 7m. The lengths of normal steel rods, casting rods and thin long rods are in the range of 0.5m, 1.5m, and 2.5m and up to 7m respectively. Test pits of various sizes are also used to find out gem potential areas. The depths of some test pits can be higher than that of actual gem pits.

Professionally, structural geological maps can be used as a guide in the exploration for gem deposits, since they are related closely to geological structures such as anticlines. Although study of maps is not conventionally done, traditional miner will look for valley bottoms for rich gem deposits. This morphological feature has been formed by destruction of structures such as anticlines during weathering. They also follow hillslopes for eluvial deposits. In the Ratnapura area, the structural pattern has produced ridge and valley topography which is composed of a set of sub parallel ridges and valleys representing remnants of ancient anticlines and synclines. In the anticlinal zones, the heavy erosion has developed valleys in between scarp slopes

which may produce a high concentration of gemstones in the sediments that have been released from gem-bearing country rocks. The valuable gemstones such as blue, yellow and star sapphires, tourmaline, spinel and garnet are found in abundance in Bogawantalawa area which lies in a major anticlinal zone (Dissanayake et. al. 1993). Even though the areas of sedimentary beds of gem mineralization are known in the regional scale, it is difficult to pinpoint a location that may contain actual gemstones. It is always a trial and error exercise.

MINING

Both surface and underground mining are being

prevented using specific plant called *kekilla*. Shallow gem mining now has been mechanized and extended to depths of about 4m when ground is fairly stable. Mechanised gem mining using power shovels is generally much faster than normal manual operations, but it is applicable only to safe and stable grounds (Appendix – Plate 5). Deep mining is still carried out using traditional methods, with rectangular pits of 4'x8', 6'x12' or sometimes 6'x6'. The pits are reinforced by timber (mostly rubber wood) and planks from arecanut trees using ferns. Figure 5 shows some reinforcement of gem pits of the Ratnapura and Pelmadulla areas. Two cross beams are fixed adjacent to the

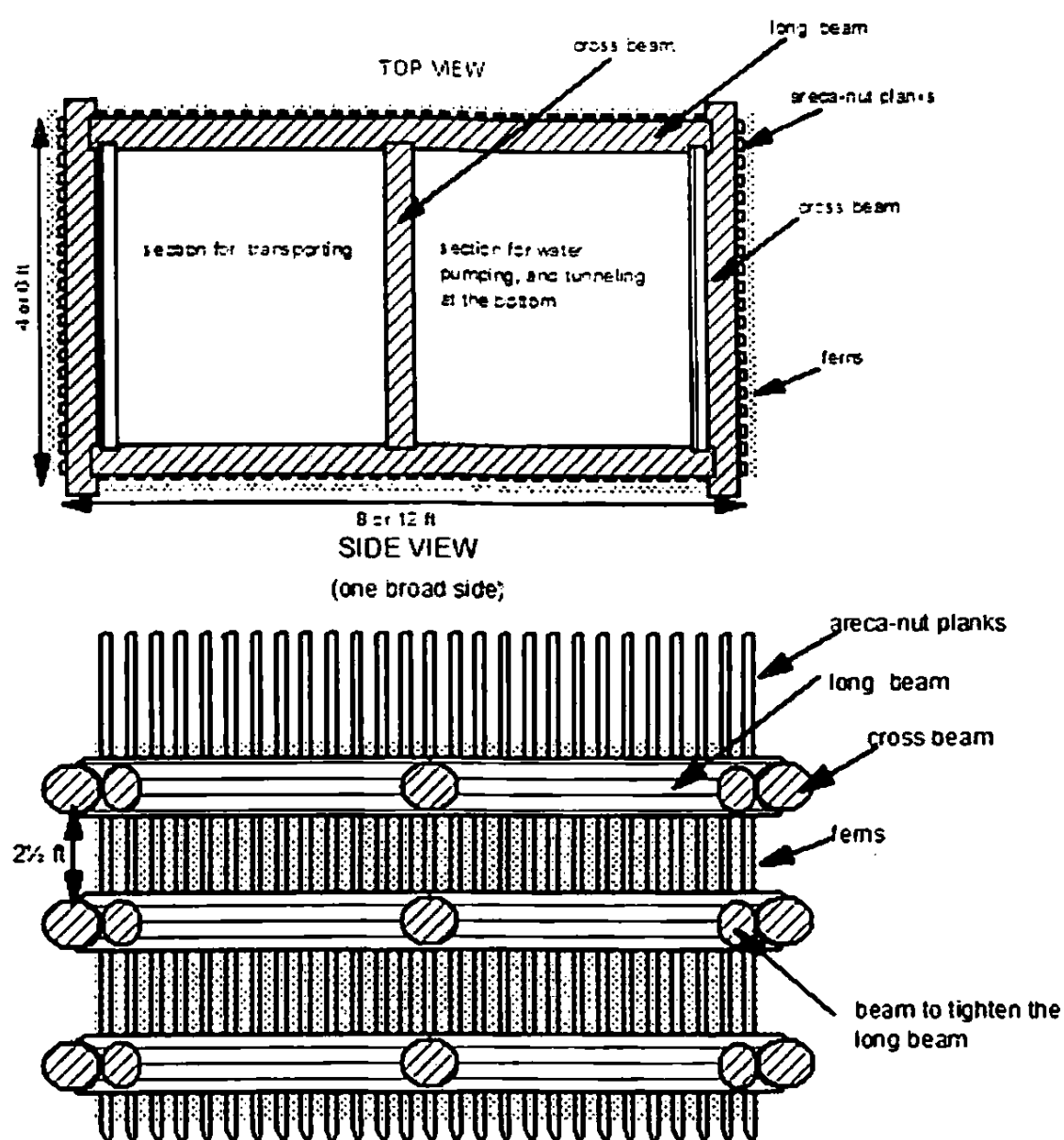


Fig.5 One of the wide walls of a gem pit (upper) and layout of timber and planks of areca-nut trees to reinforce the mine (lower).

carried out for the exploitation of gems. The traditional mining methods include pits of about 5m with or without reinforced walls. When the mining is carried out in the dry ground, walls of the pit are not normally supported. However, for soft and wet grounds, walls are supported with timber and planks made from arecanut trees (Appendix – Plate D). Infiltration of fine mud is

narrow wall by making two holes in the broad wall. Two long beams are fixed to those two cross beams using curved notches at the ends of the long beams. Then two thinner cross beams are fixed near the short walls to stabilize the two long beams. In the middle of the long beams another cross beam is fixed by curved notches to tighten the long beams. Arecanut tree planks are

set as shown in the diagram (Figure 5) behind the long and cross beams to hold the fern that would prevent the inflow of materials from the walls. Tunnelling also has similar reinforcement but on a smaller scale.

REMARKS

The traditional methods of exploration for gem-bearing deposits can still be used as they use essential geological information. The geological information is obtained from existing pits and past experiences in mining. Paddy fields which contain buried river beds and flood plains are commonly selected for gem mining. The maturity of the gem-bearing sediments is identified by considering the size and shape of mineral grains. The panned concentrate of heavies provides information about the heavy minerals including gemstones.

In the past years, chemical analysis of gem-bearing sediments has been carried out in an attempt to obtain additional information of gem-bearing deposits. However, the sampling has to be done from existing gem pits and it is not normally practised in gem exploration. No other methods like auguring using power augers have been developed up to now. However, sampling of the gem-bearing layer with an auger will be difficult due to the presence of large pebbles and boulders. The modern techniques such as resistivity sounding and seismic exploration may

be useful in identifying gravel beds if the beds are continuous and extended to large areas. These methods may not be very useful to evaluate the remaining portions of the beds in mined-out areas like Ratnapura and Pelmadulla.

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APPENDIX



Plate 1 Shed built using bamboo trees, arecanut trees, and coconut leaves to protect the gem mine from rain, Braod valley at Pelmadulla



Plate 2 A part of a deep gem mine showing reinforcement with timber, mainly rubber wood. This reinforcement is done at about 3-4 ft intervals



Plate 3 Rounded pebbles found in the gem-bearing layer, "illama" which indicates the maturity of the sediments



Plate 4 An example of black illama recovered from the nearby gem pit



Plate 5 Mechanised gem mining done specially for somewhat shallower deposits

Photographs by Tilak Hewawasam