THE ECOLOGY AND ARCHAEOLOGY OF THE SERUWILA COPPER-MAGNETITE PROSPECT NORTHEAST SRI LANKA[1]

"The Director of mines, being conversant with the science of (metal) veins in the earth and metallurgy, the art of smelting and the art of colouring gems, or having the assistance of experts in these, and fully equipped with workmen skilled in the work and with implements, should inspect an old mine marks of dross, crucibles, coal and ashes, or a new mine, where there are ores in the earth in rocks or in liquid form, with excessive colour and heaviness and with a strong smell and taste" (*Kauṭilya Arthaśāstra* II.12.i.).

INTRODUCTION

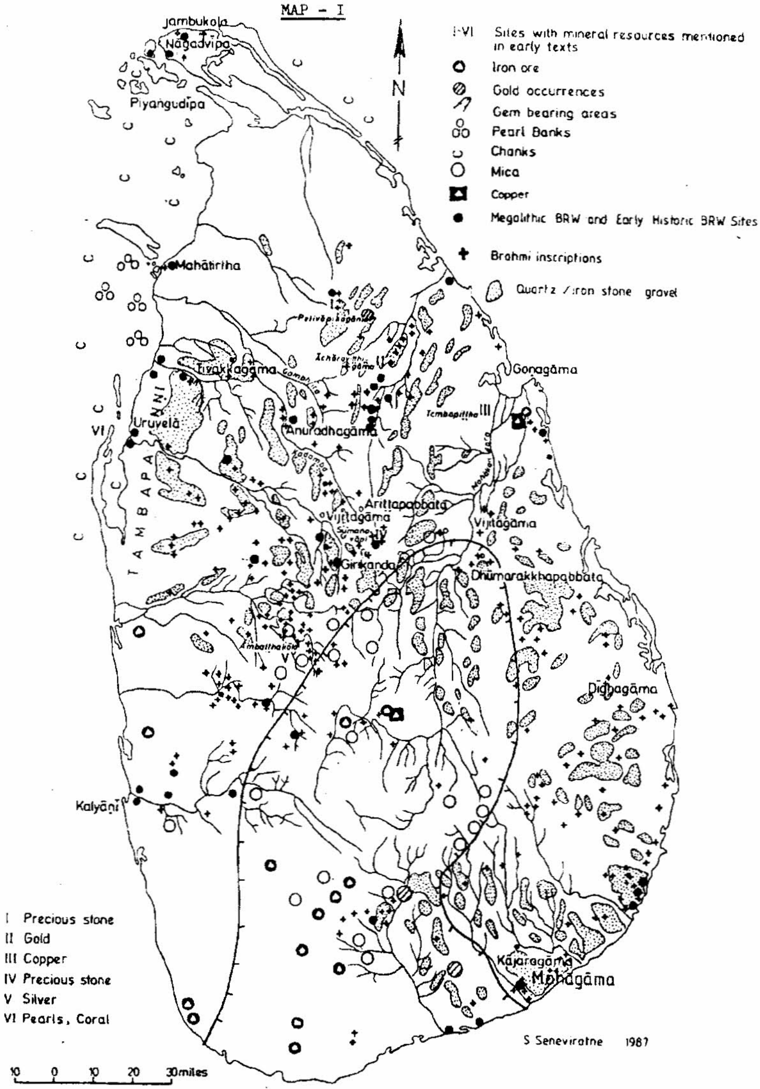
The ecological significance of resource zones sustaining pre-industrial metallurgical operations as a critical factor in the dialectics of social formation and technological change is seldom taken up for discussion in archaeometallurgical studies in south central Asia. The ecosystem of the Formative Proto and Early Historic Periods essentially functioned within an interacting process linking the resident community with the subsistence pattern, technology, resource use and settlement pattern. Consequently, this situation resulted in a coincidence between the technocultural zone and the physical zone during the Early Iron Age.

The momentum of technological processes associated with such societies largely depended upon certain pre conditions leading to a viable utilization of mineral resources, especially metallic ores. The utilization of a particular raw material in the production of a luxury, prestige, utilitarian or ritual item was conditioned by the variations in the demand based on factors such as the functional value of the item, the level of material development in society, direct or indirect access to strategic resources, the possession

---

1. A study of the preliminary investigations conducted at Seruwila was presented in a paper entitled "The Historical Archaeology of the Seruwila Copper-Magnetite Deposit" at the *Seminar on the Archaeometallurgy of Sri Lanka* (September 1987, Institute of Fundamental Studies, Kandy, Sri Lanka). A draft of the present paper was submitted to the *National Seminar on Indian Archaeometallurgy* (October 1991, BHU, Varanasi, India). This paper is to be published in *From Sumer to Meluhha* (Wisconsin Archaelogical Reports, Volume 3) ed. Mark Kenoyer (Wisconsin, Madison). The text remains unchanged, though some new references have been added to this article. The author gratefully acknowledges the invaluable assistance received from Mr. Dulip Jayawardena (former Director at the Geological Survey Department of Sri Lanka), Professor C.B. Dissanayake (Director, Institute of Fundamental Studies, Kandy) and Ms. Champa Fernando (Editor, Institute of Fundamental Studies). in the course of this research study.

MAP - I



I-VI Sites with mineral resources mentioned in early texts
Iron ore
Gold occurrences
Gem bearing areas
Pearl Banks
Chanks
Mica
Copper
Megalithic BRW and Early Historic BRW Sites
Brahmi inscriptions
Quartz / iron stone gravel
N
Jambukola
Nāgadvipa
Piyangudipa
Mahātirtha
Tivakkagāma
Uruvelā
VI
TAMBAPANNI
Anuradhagāma
Arittapabbata
Vijitagāma
Girikanda
Gonagāma
III
Vijitagāma
Dhūmarakkhapabbata
Dighagāma
Kalyāṇī
Kājaragāma
Mahāgāma
I Precious stone
II Gold
III Copper
IV Precious stone
V Silver
VI Pearls, Coral
10 0 10 20 30 miles
S Seneviratne 1987

of a suitable technology for resource extraction and production including the existence of an exchange mechanism facilitating the movement of raw material and finished products.[2]

Technological phases in Sri Lanka indicate the absence of intervening Neolithic and Chalcolithic Periods in the transition from the Mesolithic to the Early Iron Age. Both, in Sri Lanka and Peninsular India, the Proto Historic Culture is characterized by the Iron Age burials and the Black and Red Ware associated with such monuments and habitation sites of that period. The commencement of the Proto Historic Period at Anuradhapura, according to recent C-14 dates, is assignable to B.C. 750 ± 50.[3]. Investigations at Megalithic burial sites and Proto Historic habitations in Sri Lanka have revealed the occurrence of personal ornaments, weapons, and objects of domestic use made of iron and copper/bronze including industrial remains associated with metallurgical operations.[4]

Recent studies on the Early Historic Period also suggest that there was a relative increase in the level of utilizing metallic and other mineral ores between B.C. 300 and the Early Christian Period. The relative improvement in the production technology, a demographic expansion, an extension in the settlement zones, a better regularization of specialized craft production, an intensification of the exchange vortex, and the emergence of the pristine state may be listed as crucial factors contributing towards a wider use of metals and associated mineral resources during the Early Historic Period.[5]

The Iron Age communities, therefore had access to metallic ores (mainly iron and copper) located either within the micro-ecological zones or those obtainable through an interzonal exchange mechanism. On the basis of this assumption, a synthesised study of the Early Iron Age settlement archaeology and the distribution pattern of mineral resources (in varying macro and microregions) revealed a remarkable correlation between archaeological and textually recorded sites with resource zones (Map 1). The selection of the copper-magnetite deposit at Seruwila was a natural one to the Proto Historic resident communities of north Sri Lanka which had less access to the central montane region during that period. The central montane region, which is also the primary repository for mineral resources, came under intense exploitation only by the Early Historic Period and after. The significance of the Seruwila deposit is viewed

---

2. Seneviratne 1987: 132-133; 1988; 1990.

3. Deraniyagala 1990: 14.

4. *vide* Deraniyagala 1972; Parker 1884; Ragupathy 1987; Seneviratne 1984; 1987.

5. Seneviratne 1984; 1985; 1986; 1987; 1987a; 1988; 1990.

within the above context.

THE GEO-ENVIRONMENT SETTING (MAP 2)

The discovery of the mineralized zone at Seruwila in modern times was made in 1971 by the Geological Survey Department of Sri Lanka. However, in 1821 Davy made a reference to the existence of magnetic ore near Trincomalee[6] and following him Tennent records the occurrence of mercury in the same region.[7] Seruwila is located in north east Sri Lanka to the south of the Koddiyar Bay containing the large natural port of Trincomalee. The micro-region brought into focus in this study is situated between the Allai tank and the Ulakali lagoon. Its eastern limits are demarcated by the lagoon, beaches, and dunes. This whole region, along with the Koddiyar Bay, submerged during the Holocene transgression which was followed by the filling-in due to fluvial depositions. Sedimentation is extremely active to this day and the primary landscape is marked by alluvial plains and residual terrain. The Allai tank is situated within a vast natural depression, which is about 12 miles in circumference. The concentration of microearthquake epi-centres along the Mahaweli Basin is known[8] and it is suggested that such a seismic focus may have altered the course of the Mahaweli river in its lower reaches during the Middle or the Late Historic Periods.[9]

The geological formation had a direct bearing on the landscape evolution and the historical geography along the lower valley and deltaic Mahaweli. Seruwila has a matrix of high-grade metamorphic rocks belonging to the Pre-Cambrian Age represented by the Highland and the Vijayan Series. The Highland series, located to the north west, predominantly has charnockites and quartzites whereas the Vijayan Series in the southeast has granites, granitic gneisses, and hornblende-biotite gneisses as the major rock types. The rocks in the Seruwila area indicate parallel repetition of beds thereby showing isoclinal folding.[10]

The occurrence of the ore mineralization at the boundary of the Highland and the Vijayan Series is significant to our study. The highly crushed and altered nature of

---

6. 1821/1923: 13.

7. 1859.1: 29 note 3.

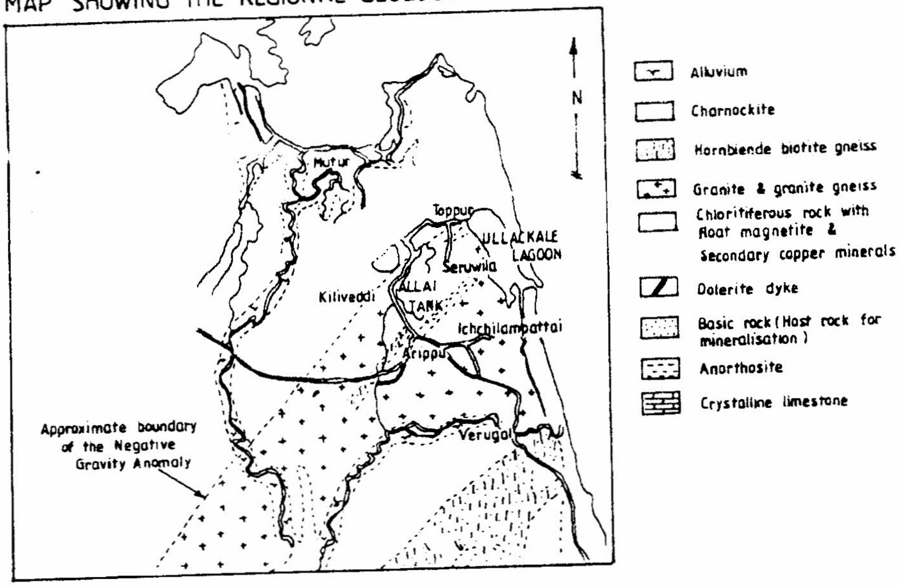
8. Fernando and Kulasinghe 1986.

9. Fernando 1971; Map 3.

10. *vide* Brohier 1935: III.39; Cooray 1967; Dissanayake and Navaratne 1981; Fernando 1971; 1982; Jayawardena 1982; Dissanayake 1985, for details on the geo-environmental setting.

Map-2

MAP SHOWING THE REGIONAL GEOLOGY AROUND SERUWILA AREA



Jayawardena 1982 : 141

the host rocks forming this boundary indicates that the mineralization is at a tectonic thrustplane. This is represented by an extensive mineralized belt, approximately 10 miles wide and 250 miles long, extending from Trincomalee to Ambalantota (Map 5). The ore mineralization at Seruwila may have taken place during the Upper Cretaceous Period and it is rich in magnetite ore and sulphides (mainly copper) including other minerals such as silver, bismuth, zinc, mica, and nickel (pentlandite rich in cobalt). The existence of serpentinite bodies in association with the prospect at Seruwila (and along the tectonic boundary of the Highland and Eastern Vijayan Groups) clearly points to a source of nickel and chromium.[11] Recent biogeochemical studies done at select zones along the mineralized belt revealed very specific types of vegetation associated with the gossanous outcrop at Kollan Kulam (near Seruwila) and serpentine-endemic vegitation between Uda Walawe and Welipatanwila in south Sri Lanka.[12] This is an indicator study worth extending to other areas in locating mineralized zones. Future discovery of gold is not ruled out as mica and gold occurrences have been reported from other localities having charnockitic gneisses in association with quartz formation in the Highland series.[13]

Ore bodies containing magnetite and copper sulphides in this prospect are lenticular in shape and concordant with the dip and strike of the host-rocks. The linear geophysical (negative) anomalies which have a high concentration of magnetite-sulphide ores, at least in the Arippu area, run in a NE-SW direction.[14] The magnetite-sulphide ore bodies vary in thickness from 3 to 30 ft. and are coarse-grained with magnetite, chalcopyrite, pyrrhotite and pyrite. It is estimated that the massive sulphide-magnetite ores are very rich in iron with values upto 99.5 percent. Investigations by the Geological Survey Department established the existence of nearly 7 million tonnes of magnetite ore extending nearly 200 ft. below the surface. The massive ore type carries a higher content of copper over the disseminated ores. The copper in the ore at Seruwila is around 1:3 and the amount of metallic copper in the Arippu area alone is quantified to be about 68,000 tonnes.

The general topography of Seruwila is relatively flat though the ultrabasic rocks , which is also the host rock for mineralization, and is highly weathered on the surface and survives as outcrops in the micro landscape. The magnetite outcrops vary in height

---

11. Dissanayake 1984; 1985.

12. For details see Brooks 1987; 277-279; Brooks et al. 1985: 223-235; Brooks and Johannes 1990: 60.

13. Jayawardena 1982; Dissanayake and Navaratne 1981; Karunaratne and Dissanayake 1990.

14. Jayawardena 1982.

from 3 to 45 ft. and some of these measure 3 to 15 ft. in length. Secondary copper minerals such as malachite and azurite, are exposed on the highly weathered surface of the rock.[15]

HISTORICAL GEOGRAPHY AND TOPOGRAPHY

Archaeological data and corroborative evidence derived from epigraphical (Brahmi inscriptions) and textual sources furnish us with information relating to the historical geography and topography of ancient Seruwila. In this connection, Pali texts of the Middle Historic Period, namely the *Dhātuwaṃsa* (*DV*) and to a lesser extent the *Mahāvaṃsa* (*MV*) carry useful references on the historical topography and mineral resources found in this region.

The antiquity of human activity in this region quite clearly extends to the Early Iron Age. Surface investigations at abandoned deep pits in the mineralized zone yielded scattered Megalithic - Black and Red Ware embedded in the soil. Interestingly enough, the *Dhātuvaṃsa* records at least three sites known as *ṭhitapāsāṇathūpa* located on the *sīmā* (boundary) of the *stūpa* premises at Seru (*DV* 68). This is clearly a reference to funerary monuments of upright stone or dolmenoid cists (Plan I).[16] The existence of a dolmenoid cist burial site at Kadiraveli, located only a few miles southeast of Seruwila, bears testimony to the prevalence of Proto Historic settlements in this region. Perhaps an echo of this Early Iron Age community movement to this region is found in the *Mahāvaṃsa* description on the founding of early settlements at Gokaṇṇa, a site located somewhere along the Koddiyar Bay.[17]

The Early Brahmi inscriptions found at Seruwila confirms the continued presence of a settled agricultural community in this region. Inscriptions from the adjacent region carry records of endowments made by merchants and chieftains of the Early Historic Period to the resident Buddhist clergy who depended on the agricultural surplus generated in this area.[18] The *Dhātuvaṃsa* description accounts for two *nagara* (city) and at least twelve *gāma* (village) settlements in addition to *khetta* (fields) and *vapi* (reservoirs) located in the area surrounding the *stūpa* during the chieftainship of Kavantissa, who ruled over the southeast quarter of Sri Lanka during the early 1st century B.C. (Plan I).

---

15. *vide* Jayawardena 1982; Herath 1975 for deetails.

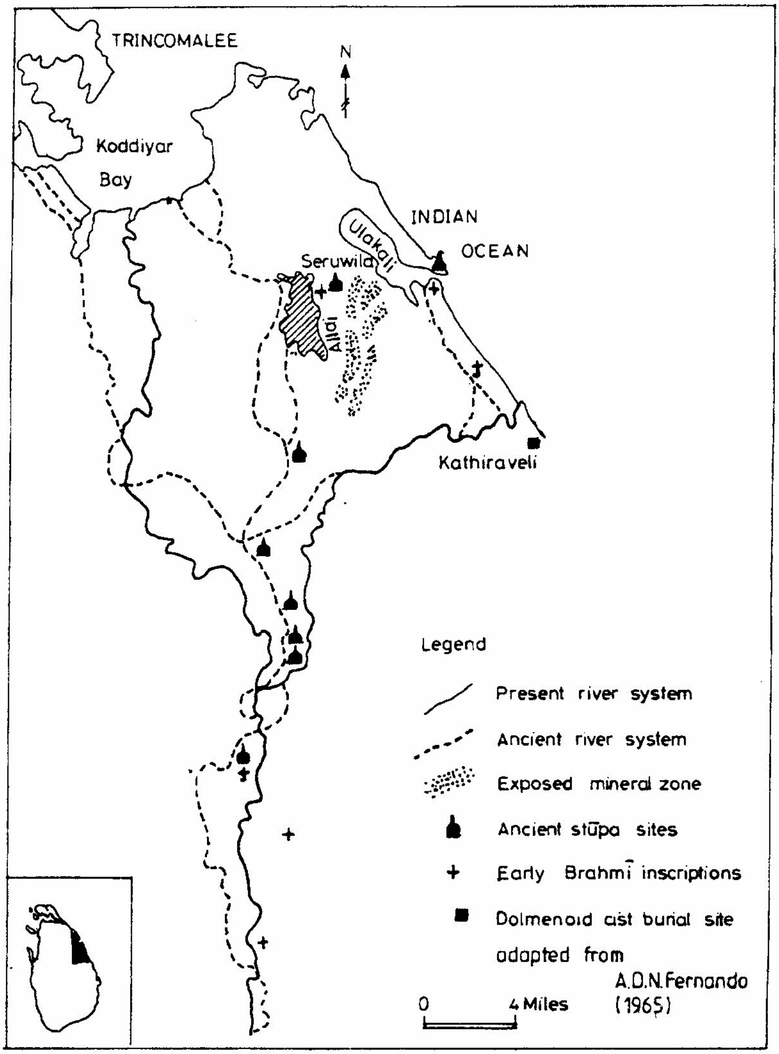
16. Seneviratne 1990a: 147.

17. *Mahāvaṃsa* VIII. 12-13; 24-25.

18. For inscriptions see Paranavitana 1970: Nos. 382-387; *Epigraphical Notes* 1974; XIII Nos. 5 - 6.

Map - 3

THE LOWER MAHAWELI SYSTEM AND ANCIENT STŪPA SITES



The microtopography at Seruwila indicates a gradual inclination from the southeast to the northwest, where the mineralized zone with its rocky outcrops marks the landscape in that sector. The location of the eastern sector as the primary habitation nucleus during the Early Iron Age was due to the natural selection based on the elevation of the microregion, the drainage pattern, and its proximity to the easily exploitable ore resources. Archaeological investigations have revealed an extensive habitation mound nearly 600 ft. to the east of the *stūpa*.[19] Textual description giving the location of habitations, reservoirs, and cultivated fields points in the same locational direction. It is interesting to note that the *nagara* of Seru is described as a city located in the midst of rocky outcrops or *pabbata*.[20] Similarly, the incorporation of the term *sela* (from *śaila* or stone) within the name of residential villages (e.g. Maccha-sela-gāma [*DV* 18, 68]), points to a particular topographic feature associated with such settlements (Map 6 and Plan I).

The Mahaweli River traversed the flat land situated immediately to the west of the resource zone prior to its change of course during the Historic Period due to seismic activity. The major branches of deltaic Mahaweli presently flow over 10 miles to the west and to the south of the *stūpa*. Aerial reconnaissance very clearly shows the dry bed of the Mahaweli running in a northward direction in close proximity to the western flank of the *stūpa* complex at Seruwila. The textual information on the landscape and human ecology of this riverine-deltaic region is explicit in its description. For instance, the *Dhātuvaṃsa* in no uncertain terms situates the *stūpa* and the monastery complex at the edge of a natural lake named Seru which in turn is located on the right bank of the Mahāvālukagaṅgā[21] Significantly, the *Sahassavatth-uppakarana*, another Middle Historic text identifies Seruwila as Mahāsarassa, which literally means the great Lake.[22] The text also describes a natural depression or *sobbha* to the west of the *stūpa*. It is significant that the Allai tank is located in a vast depression associated with the ancient drainage system of the Mahaweli River. Further to this, the text mentions at least three *tittha* (from *tīrtha* or river crossing, ford, landing) to the west and to the north of the *stūpa*. One such ford is very specifically mentioned as Uttarakoṭatittha (lit. 'the *tittha* of the northern end'). Most obviously these are references to river crossings of the ancient Mahaweli River, to the west of the *stūpa*.

---

19. Solheim and Deraniyagala 1972: 23-26.

20. *Dhātuvaṃsa* 68 - 69.

21. The Dhātuvaṃsa carries the following description "...tambapaṇṇi dīpe mahāvālukāgaṅgāye dakkhinabhāge serunāma dahassa ante varāha nāma soṇḍimatthake kākavaṇṇatisso nāma rājā patiṭṭhapessati cetiyaṁ saṅghārāma kārāpasseti". (*DV*. 24).

22. *Sahassa*. 183.

The topographic description in the *Dhātuvaṃsa* commences from the eastern sector and follows a full cycle before arriving at the same point. The final landmark in this description, the Loṇasāgara (lit. 'salt sea') located in the east, is a reference to the present Ulakali lagoon which also happens to be the nearest saltwater body. The text also refers to a city by the name Loṇanagara and a *paṭṭana* (port) named Madana, including a *stupa* that was located at the entrance to this port (*paṭṭanamukhadvāra*).[23] The archaeological site of Ilankaturai is situated at the estuary of Ulakali lagoon and this site has yielded the remains of an ancient *stūpa*, Early Historic Black and Red Ware, and early Brahmi inscriptions (Map 6 and Plan I).

ARCHAEOMETALLURGY OF THE SERUWILA PROSPECT

In view of the evidence at hand, it is clear that this resource zone was known, inhabited, and exploited during the Early Iron Age. It is important, therefore, to ascertain the functional value this particular resource zone had to the Early Iron Age community.

First, the very location of the Seruwila copper-magnetite prospect in proximity to the primary habitation zones in the north central plains is significant as it was within easy reach and easily accessible by land, river and sea routes. this is in contrast to the primary mineral deposits in the central montane region that had to be reached, identified extracted and transported through difficult terrain. Mineral stones and metallic ore in particular are 'weight-gaining' objects in relation to the distance factor.[24] It was not practical, therefore, to exploit distantly located sources during the Formative Period. A proper utilization of such resources became possible only with the evolution of Intermediary Transitional Ecosystems in the lower montane-subplain regions during the Early Historic Period[25]

Second, there is the question about the resource zone itself. the primary ore formation at Seruwila is represented by magnetite and sulphides, mainly copper. The functional as well as the utility value are critical factors in the preference shown in selecting a particular ore. In the first instance, it is unlikely that the Proto historic smelters of Sri Lanka had the technological capability of working the highly concentrated magnetite formation (99.5%) by reaching a temperature level of 1800°C to smelt the ore. Some of these concentrated magnetite formations are associated with sulphide ores such

---

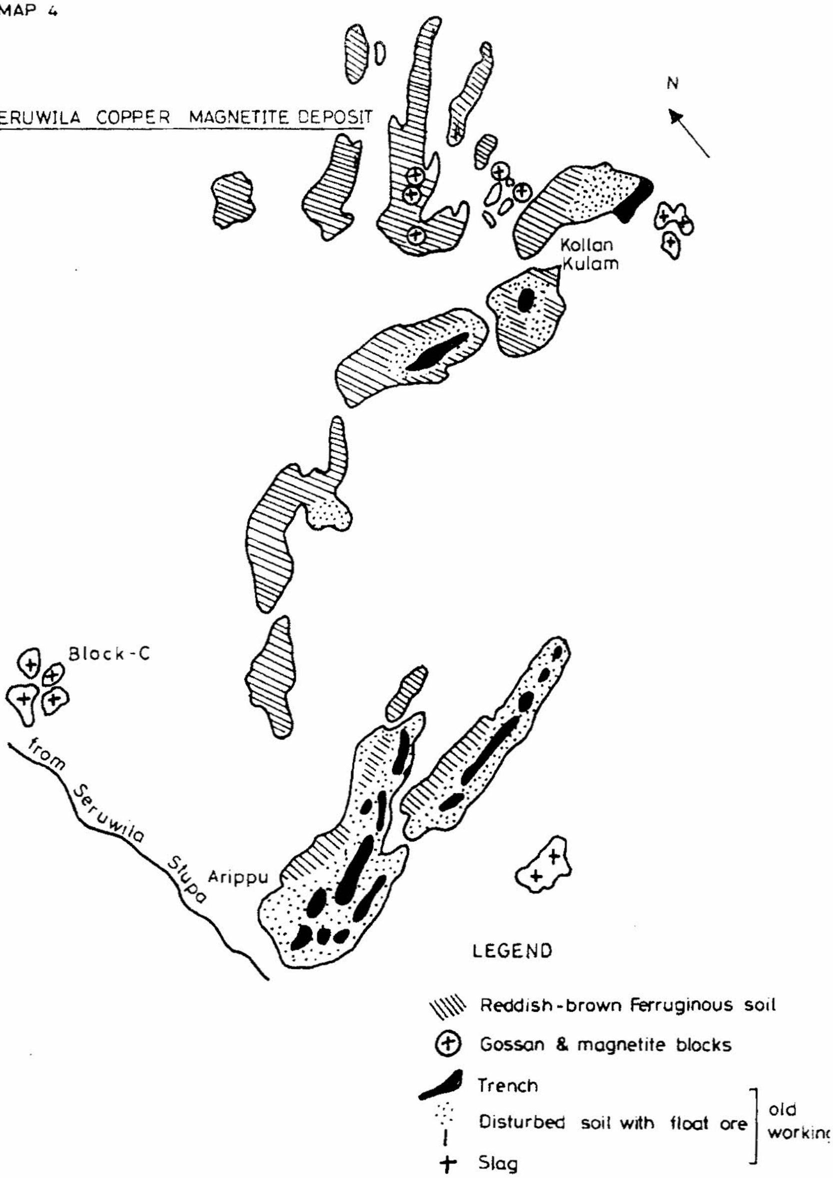
23. *Dhātuvaṃsa* 48.

24. Seneviratne 1987: 144; 1990: 128.

25. Seneviratne 1990.

MAP 4

SERUWILA COPPER MAGNETITE DEPOSIT



Sudharshan Seneviratne
1991

as pyrrhotite and pyrite/marcasite in the Seruwila prospect.[26] The existence of any sulphide in the ore tends to create a problem to the smelter as the metal becomes brittle due to the sulphur content and it consequently entails a difficulty in forging the metal.[27]

The alternate strategy for the Proto Historic ironsmith was to use haematite or limonite ore so commonly found in the northern plains or to work the disseminated ores found on the highly weathered outcrops at Seruwila. To take up the first, the 1969 excavation at the Citadel of Anuradhapura yielded iron stone nodules of haematite and limonite in direct association with iron slag within the Proto Historic levels.[28] Our studies on the settlement archaeology and resource zones also point to a high coincidence between areas with nodular gravel and Early Iron Age sites.[29] Haematite and limonite ores provided the Early Iron Age smelter with certain advantages over the highly concentrated magnetite. These are less compact ores, silicious by nature and relatively free from sulphur and phosphorus.[30] In the broad region, the method of roasting the ore was applied during the Early Iron Age to reduce the water content in the limonite ore,[31] a technique not unknown to the Pre-Modern metallurgist of Sri Lanka.[32] Similarly, archaeometallurgical studies from the broad region also confirmed that the Proto Historic smelters in Peninsular India reduced limonite and haematite at a temperature around 1200°C.[33] and that steel can be obtained by smelting ore containing 50 percent metal.[34]

The extraction of the disseminated ore at Seruwila for iron working operations poses an entirely different strategy of resource utilization. Contrary to the view we held

---

26. Jayawardena 1982: 131-132; Yapa 1982: 25.

27. Hodges 1965: 85.

28. Deraniyagala 1973: 152, 155.

29. Seneviratne 1985: 137-141.

30. Hodges 1965: 81.

31. See Hegde 1973: 403.

32. Coomaraswamy 1908/1956: 190.

33. Gogte 1983: 74.

34. Kularatnam 1979: 222.

previously[35] recent investigations conducted by us point to select utilization of less-compact magnetite ore during the Proto Historic Period. In this connection, an analysis of some iron objects unearthed from the Proto and Early Historic levels of Anuradhapura provided several revealing facts (Table 1; Str. 3A and 3B Proto Historic, 4A and 4B Early Historic).

In the first instance, at least five samples out of the eight tested have iron contents over 45 per cent and one sample (No. 7) indicating a high 86 percent. Iron contents of this intensity must either come from a rich source of iron or it reflects the ability of the metalsmith to extract the iron from the ore.[36] The second aspect is even more revealing about the source. All samples tested in this study established a consistent copper-nickel combination, pointing not only to a common source but also to a source particularly rich in copper.[37]

This poses a question about the source itself. One probable source to consider is the magnetite deposit at Panirandawa in southwest Sri Lanka which carried traces of copper.[38] The Panirandawa deposit, however, is inconveniently located in terms of its distance to the north central region. Further more, the magnetite ore is situated 70 to 120 ft. and at times runs to a depth of 500 ft. from the surface.[39] The Seruwila prospect holds the most complex mineral formation which is nearest to the metallic composition of the iron implements tested from Anuradhapura. Trace element studies of the Seruwila prospect showed that the magnetite ores are rich in iron (40 to 99.05 percent) and also the existence of cobalt, nickel, chromium and manganese in the ore. the selection of particular ore formations and their location are elaborated in a subsequent section in this study. The deliberate selection of the copper-magnetite ore at Seruwila by the Early Iron Age ironsmith apparently had a sound technological reasoning behind it. Metallic iron with high copper contents and nickel inclusions is known to be corrosion resistant. The metal objects that were analysed, especially sample No. 7, maintained a remarkable level of corrosion resistance[40]

Evidence derived from textual, epigraphical, and archaeometallurgical studies

---

35. Seneviratne 1987: 144.

36. Maliyasena and Seneviratne 1987.

37. *Ibid.*

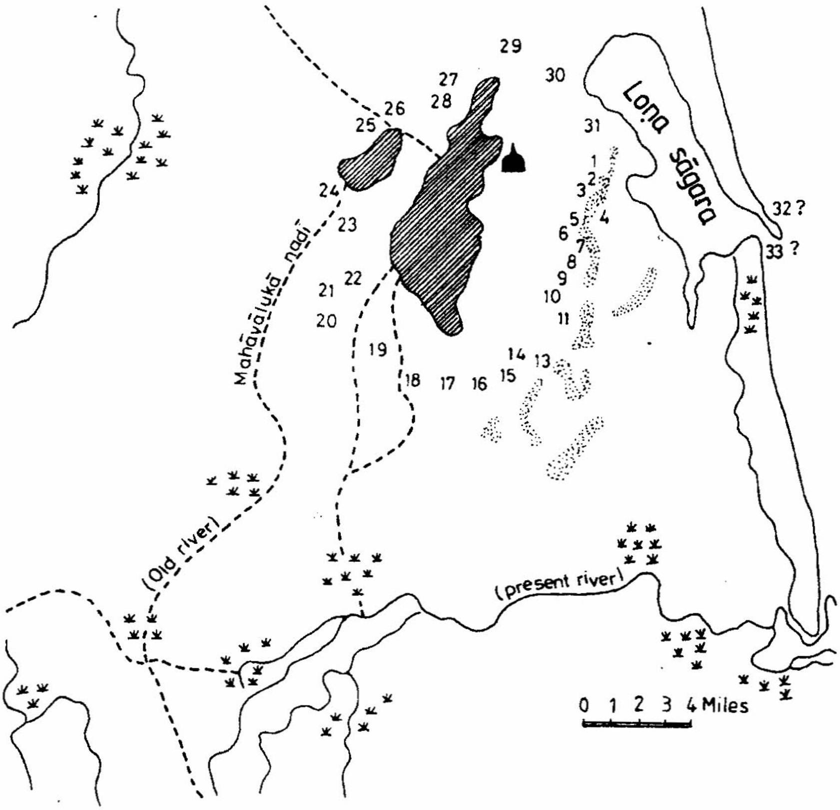
38. Pattiarachchi 1961.

39. Kumarapeli 1963. Also see Tantrigoda and Geekiyanage 1991.

40. Maliyasena and Seneviratne *op.cit.*

Map:- 6

Seruwila historical topography
(Suggested location pattern based on the Dhātuwaṃsa)



Sudharshan Seneviratne 1991

indicates that, the metal prospect at Seruwila had a grater utility value as a source of copper to the Early Iron Age community. Proto Historic burials and habitation levels in Sri Lanka point to a somewhat high occurrence of copper-bronze objects representing a range of personal ornaments and items of domestic use. The discovery of copper slag, copper inclusions from crucibles, and tuyeres within the Proto Historic context at the Citadel of Anuradhapura[41] establishes the working of copper during the Early Iron Age. Contrary to the view held so far, raw material in the form of copper and possibly tin was available to the Early Iron Age smelter from sources located within the island. Until the central montane region was effectively penetrated for its copper resources, the prospect at Seruwila may have been the primary source of copper and related minerals used in the industry. The Early Historic coppersmith is known as *tabakara* in the Brahmi inscriptions and as *tambakāra* in the Pali texts.

Spectrographic analysis of a copper object (probably an ornament), weighing 5.11 gms., unearthed from the Proto Historic level (Str. 3A) at the Citadel of Anuradhapura indicated the following.

Copper	94.10%
Silver	1.61%
Iron	0.84%
Nickel	0.13%
Lead	Trace
Zinc	0.41%

	97.01%[42]

It is interesting to note that the spectrographic analysis of the Seruwila ore revealed the same metallic composition. The high iron content (0.84 percent) in the metal of this particular object suggests that the copper was obtained by smelting an ore containing magnetite. The 1969 Anuradhapura Citadel excavations yielded copper slag having iron inclusions, which were probably secondary compounds of the ore. All this taken together with ore containing zinc, unearthed from the Proto Historic levels during the 1984/85 Citadel excavation, points to the Seruwila prospect as the source for the Early Iron Age copper industry at Anuradhapura.

In addition to its mineral content, convenient location, and easy access, the Seruwila prospect may have drawn the attention of the Early Iron Age metallurgist due to two other functional reasons. These may be listed as the natural setting of the ore formation and technological factors associated with production techniques, especially

41. Deraniyagala 1972: 145.

42. Maliyasena 1986.

working the copper ores.

It is significant that the ancient trenches overlapping the geophysical anomalies (in the Arippu area) revealed scattered remains of magnetite, chalcopyrite and to a greater extent secondary malachite and azurite or copper carbonates.[43] The magnetite at Seruwila is mainly associated with iron sulphide minerals (i.e., chalcopyrites) and to a lesser extent bornite. Sulphide ores such as bornite and chalcopyrites contain copper up to 55.5 percent and 34.6 percent respectively. There are problems related to extracting and working the sulphide ores and, consequently, these problems may have restricted the extensive exploitation of such ores during the Early Iron Age. An additional disadvantage in this connection is the existence of sulphide ores at relatively deep levels within the Seruwila prospect.

Conversely, the existence of some amount of iron pyrites in the slag heaps of Seruwila (or for that matter at any Pre Industrial foundry hearth) does not necessarily point to iron smelting. This may have very well been a result of copper extraction because iron and copper pyrites are known to occur together[44] The relatively high iron content (0.84%) in the spectrographically analysed Proto Historic copper object from Anuradhapura points to a specific technological advantage associated with the use of chalcopyrite magnetite ore at Seruwila. The presence of iron streaks is known to give additional strength to copper implements. The deliberate extraction of chalcopyrite ore by the Chalcolithic coppersmiths of Ahar (in India) may have been associated with this technological advantage.[45]

In view of the relatively large quantities of oxide ores scattered near trenches and pits, it is not altogether impossible that the Early Iron Age smelters may have been more attracted to the easily accessible secondary copper minerals such as malachite and azurite found on the highly weathered surface of the rocks. The existence of oxide ores at Seruwila is an interesting feature on several counts. For instance, the carbonates of this group such as malachite and azurite have colours (blues and greens) that may have been useful to the early smelters in locating their raw material with relative ease.[46] The very formation of the Seruwila prospect, representing small outcrops, provided additional advantages in the process of extracting the ore.

---

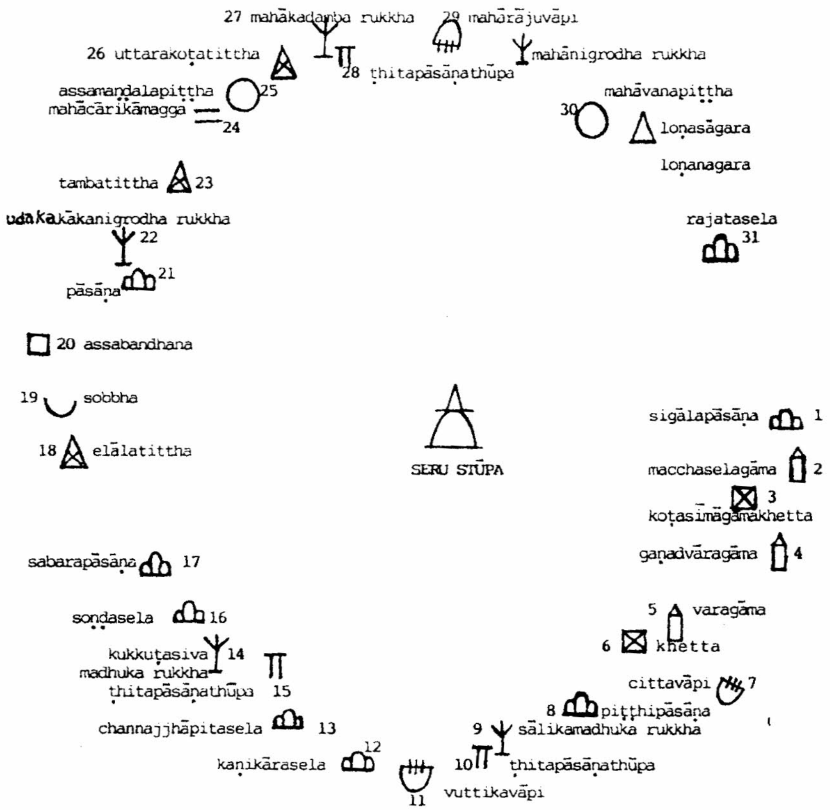
43. Jayawardena 1986.

44. Hodges 1965: 81; also see Bachmann 1982.

45. Hegde 1969.

46. Hodges 1965: 65; for similar features associated with malachite and azurite ores in the Aravalli hills, see Hegde and Ericson 1985: 63.

PLAN - I



SERUWILA HISTORICAL LANDSCAPE
A schematic presentation based on the Dhātuvaṃsa

Sudharshan Seneviratne 1991

In this connection, textual evidence may substantiate this suggestion. The *Mahāvaṃsa* narration describes the 'discovery' of copper in an area called Tambapiṭṭha, seven *yojana* east of Anuradhapura, during the reign of Duṭṭhagāmaṇī, C. 150 B.C.[47] Tambapiṭṭha is clearly a reference to the Seruwila area. The term *tamba* in Pali means copper and *piṭṭha* (piṭṭhena) means 'what stands out, along, over, beside, by way of'.[48] The *Dhātuvaṃsa* (68-69) in its topographical description, quite specifically mentions the rock or mineral outcrops (i.e., *piṭṭhipāsāṇa*) situated near the fields of the village Varagāma. In addition, the same text also records the existence of a series of other rock or mineral formations such as the Kaṇikārasela, channaįjhāpitasela, Soṇḍasela, and Sabarapāsāṇa located to the east of the *sobbha* or natural depression (Plan I). Of these, channaįjhāpitasela may mean the rock or mineral stone with shine, light or glitter, hinting perhaps at malachite and azurite copper ore formations. A second meaning may be derived as concealed or hidden (*channa*) burnt (*jhāpati*) rock (*sela*). *Sabarapāsāṇa* derives from *śvabhra-pāṣāṇa*, where *śvabhra* denotes mica. The *Dhātuvaṃsa* (69) also refers to a Rajatasela (Lit. silver-rock) located to the east of the *stūpa* (Plan I). Geo-mineralogical surveys in this region confirmed that the Seruwila prospect does carry minerals such as silver and mica.

The Early Iron Age metallurgist not only found oxide ores easy to locate but also convenient to extract and work within the existing technological framework. Surface ores may have been extracted by splitting the surface of the rock and by working narrow tunnels by the gad and hammer. The existence of numerous trenches also points to subsurface mining activity at this deposit in the past. The scattered remains of numerous magnetite minerals may reveal yet another feature related to the form of ore extraction. The highly concentrated magnetite may have been 'chipped-off' *en bloc*, thus separating it from the copper ore. For the Proto historic smelter, who was not technologically equipped to work the concentrated magnetite ore, the chipping-off process may have served as a convenient extracting method.

It is apparent that the working of sulphide ores in turn points to the ability of the Early Iron Age smelter in separating and refining the copper minerals. The disadvantage of working the sulphide ores, however, was the requirement of an additional in-put of time and labour due to the existence of unwanted matter such as gangue (silica) found in the ore. A second sample tested from Str. 4B (Citadel of Anuradhapura) showed that it is almost 100 per cent pure copper viz. copper 98.16 per cent, silver 1.95 per cent, iron 0.24 per cent, nickel 0.37 per cent.[49] It is possible that the ore was roasted to concentrate the copper. The practice of roasting was not unknown

---

47. *Mahavamsa* XXVIII. 16-17.

48. Rhys Davids and Stede 1959: 457.

49. Maliyasena 1986.

to the Chalcolithic smelters of Ahar in India,[50] and to the Pre-christian smelters of Thailand.[51]

The oxide ores on the other hand are considered to be the most simple and profitable type to be worked because the copper content of malachite and azurite is as high as 57.03 per cent and 55.01 per cent respectively. Surface investigations in the Arippu areas, where metallic copper is highly concentrated, quite significantly yielded beaten copper. Metallic copper found in this locality represents the type of native copper described as a raw material requiring '...neither smelting nor casting and could be worked into small articles by simply hammering...'.[52]

The ability to work copper and use alloys did not require great technological advancements to the metallurgist already familiar with the iron technology and the process of making steel.[53] For instance, if the raw material consisted of native copper, then the small objects could be hammered into shape. The ability to derive oxide ores with relative ease was an additional advantage. In working the ore, the early metallurgist had little trouble in smelting or melting copper ore as the minimum temperature required for that purpose is 400°C,[54] whereas reduction of carbonate/oxide ores can be performed at 1100°C.[55] In certain cases reduction can be done even at 700° - 800°C. and pure copper in fact melts at 1083°C.[56]

The existence of bronze implements within the Proto Historic context in Sri Lanka points to resource requirements beyond copper. It is, however, uncertain whether the bronze implements found within the Proto Historic context were imports or manufactured locally. Interestingly enough, two recorded instances of bronze objects from megalithic burials are reported from the western sector of the island, Pomparippu[57] and Pin-weva,[58] and it is not known whether this indicates the arrival

---

50. Hegde 1973: 401-402.

51. Bennette 1987.

52. Hodges 1965: 65.

53. *Vide* Seneviratne 1987.

54. Bharadvaj 1973: 391-392.

55. Hodges 1965: 66.

56. *Ibid.*

57. *Arch. Surv. An. Rep.* 1957: 30-31.

of bronze implements to this region from South India. The metallic composition of bronzes from the urn burial site at Adichchanallur (Tirunelveli District) in Tamilnadu revealed the following:

Copper	75%
Tin	23%
Lead	0.2%
Iron	0.4% (Rea 1915: 3 note 3)

Significantly, with the exception of bronze objects obtained from the megalithic burials in northern Deccan, e.g. Takalghat and Mahurjhari[59] where the copper-iron contents at times are as high as 86.34 and 0.84 percent respectively, none of the Proto Historic sites in Peninsular India reveal a similar copper-iron combination in the bronzes. It is therefore pertinent to question whether the Proto Historic metalsmiths in the Tambapaṇṇi valley imported copper from Seruwila and obtained their tin requirements from internal sources such as Kadavur and Ururakkarad in central Tamilnadu in turning out their high quality bronzes.[60] These bronzes apparently carried high prestige value. For instance, at Adichchanallur the bronzes discovered were restricted to particulars objects, limited in number and were invariably deposited inside and very rarely found outside the urns.

By the Early Historic Period however, there is positive evidence for the existence of tinsmiths within the island. At Periyapuliyankulam, a site located near the Mamaduwa burial complex, an early Brahmi inscription records an endowment made by a *topaśa* or tinsmith.[61] Cassiterite is known to occur within the mineralized belt and in the Ratnapura area though its level and period of extraction are not known. The advantage of cassiterite is that it can be located with ease and also has a tin content as high as 75 to 78 per cent. Working cassiterite did not pose any problem either, as tin ore tends to melt at 232°C. It is not altogether impossible that some amount of tin may have been imported from external sources such as those located in central Tamilnadu. Resource movement of this nature may not have been unusual during the Early Iron Age as raw material such as carnelian was brought into Sri Lanka from the southern Deccan for the bead manufacturing industry during the Proto Historic Period.

---

58. Seneviratne 1984:248.

59. Deo 1982: 29; 1973: 77.

60. For such sources in Tamilnadu, see Chakrabarti 1979.

61. Paranavitana 1970: No. 370.

Alternatively, a second possible source for tin during the Early Iron Age especially the Early Historic Period may have been eastern India, which was linked up with Sri Lanka through the long-distance trade mechanism. The region known as Vanga in antiquity coincides with the tin-bearing western districts of Bengal. It is also significant that the personal name Tapussa, one of the earliest lay disciples of Buddha, may have derived from *trapu* or tin. Tapussa is said to have travelled from south Bihar touching north east Sri Lanka on his way to Suvarṇabhūmi (Burma). Southern Burma is a primary repository for copper and tin ores which were exported to eastern India at least during the Middle and Late Historic Periods.[62] (*vide* Schroeder 1981: Chapter 7). The possibility of copper technology reaching eastern India from South East Asia during the Proto Historic Period is not totally ruled out.[63]

It is also a fact that the metallurgy of iron has little in common with copper and bronze technology. However, a close proximity between these two industries in terms of their physical location was an advantage. The utilization of iron slag as flux in the native method of Indian as well as South East Asian copper smelting is a case in point.[64] Investigations at Early Iron Age habitation sites (e.g., Anuradhapura, Kantarodai, Tissamaharama) revealed that iron and copper workings were situated in the same locality and at times within the same premises. It is also recorded that as late as 1884, cassiterite-granules were smelted in iron furnaces in central India.[65]

Another aspect related to the utilization of mineral resources supplementing the technology of the craftsman was his ability to use antimony and arsenic, in order to give a hardening effect to antimonial and bronze implements. In addition to some sources yielding stibnite (antimony trisulphide) and mispickle (arsenical pyrites) located in the montane region and in south west Sri Lanka, it is quite likely that much of the antimony, mercury and arsenic requirements were obtained from the sulphur minerals found within the Seruwila prospect.[66] Terms such as *haritāla* (orpiment or arsenic trisulphide), *manosilā* (minium or red lead) and *hinguli* (cinnabar or mercuric sulphide) are found in the *Dhātuvaṃsa* and the *Mahāvaṃsa* descriptions. There may have been a relative appreciation of such minerals with improved levels of casting and alloying during the Early Historic Period. The microstructure of the spectrographically analysed copper object from the Early Historic levels at Anuradhapura indicated that it is free of voids

---

62. *Vide* Schroeder 1981: Chapter 7.

63. *Vide* Ray and Chakrabarti 1975.

64. For Thailand see Bennett 1987.

65. Chakrabarti 1979: 62.

66. Also see Tennent 1859.I: 29 note 3.

and was produced by casting.[67]

The rich mineral potential of the Seruwila deposit was quite well recognized by the 1st century B.C./A.C. Period. For instance, the dark blue transparent glass beads unearthed from Str, 4B at Anuradhapura and similar ones found at Kantarodai indicated that the colour had occurred due to cobalt.[68] The Seruwila deposit revealed cobalt-nickel mineralization[69] and the nickel found therein is described as pentlandite and has a melting point at 1455°C. Cobalt has to be extracted by converting the ore into oxide and reducing the latter with aluminium. It melts at 1480°C and is used in compounds to produce a blue colour in glass and in ceramics. As cobalt oxide is a very strong colourant, it is used in limited amounts as 1/2 to 1 percent.[70] The extraction of such sulphur ores become possible only with the ability of the smelter in generating high temperature levels under more controlled conditions by the Early Historic Period. The craftsmen of this period also mastered the art of obtaining colour variation on glazed tiles by using copper oxide[71] This is evident by the profuse occurrence of glazed tiles during the Early Middle Historic Period.[72] The crucial significance of the Seruwila deposit as the primary repository for strategic minerals was so well recognized during the Early Historic Period that, when the *Mahāvaṃsa* was documented in the 5th century A.D. its author did not hesitate to credit the reign of Duṭṭhagāmaṇī (C-150 B.C.), the hero-king in the chronicle, with the 'discovery' of this metallic source.

RESOURCE MOVEMENT AND PRODUCTION-DISTRIBUTION ZONES

The process of resource movement from Seruwila is central to this discussion. There was however an obvious difficulty involved in transporting large quantities of copper ore from Seruwila to centres of production and consumption. Copper, therefore may have moved out of the source area mainly in the form of a semi-product. The recovery of copper ingots from several Early Iron Age habitation sites in the north (e.g., Mantai, Kantarodai, Vallipuram) more or less points to the most convenient semi-product, facilitating resource movement associated with a weight-gaining object to

---

67. Maliyasena 1986; Deraniyagala 1986: 41.

68. Deraniyagala 1972: 138.

69. Jayawardena 1982: 138.

70. Hodges 1965: 45.

71. Pieris 1917: 23 note; Paranavitana 1936: 5.

72. Deraniyagala 1986: 42 dates the occurrence of glazed tiles at the Citadel to C. 200 A.D.

distantly located places. In all probability, *tambalohabīja* (lit. 'balls of metallic copper') presented to King Duṭṭhagāmaṇī by the residents of Tambapiṭṭha[73] may have well been such copper ingots. There is sufficient evidence from the Seruwila-Arippu region to conclude that extensive smelting activity was carried out in the source area in the past. Several field studies report the remains of large heaps of slag, especially in the Seruwila-Arippu area.[74] In some quarters the slag remains were in such large piles that they obstructed the construction of the Right Bank Canal of the Allai Scheme in 1957.

Textual, inscriptional, and archaeological sources carry evidence pertaining to this process of resource movement from the Seruwila region. Copper in the form of ore or ingots may have moved out of the source area through land and water courses. The topographic description in the *Dhātuvaṃsa* records the existence of several *tittha*, identifiable as ports/landings/fords associated with the Mahaweli River. One such *tittha*, located to the west of the *stūpa*, is called Tambatittha, literally 'copper-port', indicating perhaps its primary economic function related to copper (See Map 4 and Plan 1). Small boats carrying ore or ingots may have moved along the old river course of the Mahaweli connecting the internal resource areas with the Koddiyar Bay and the Ulakali lagoon, both ultimately opening out to the Bay of Bengal. As late as 1857 '... boats drawing a foot of water were able to come from Koddiyar Bay up the escape channel to within a few hundred yards of the (Allai) tank, a distance of six miles'.[75]

To note some land routes, it is significant that Pybus (the British emissary) travelled from Trincomalee to Kandy in 1762 along an existing route that commenced at the mouth of the Koddiyar river, moving south to Kiliveddi on the Allai tank and on to the ford at Kandakadu on the Mahaweli. Pybus also records the lake at Kiliveddi and the extensive plains in that region.[76] The *Dhātuvaṃsa* description also mentions a prominent highway known as Mahācārikā-magga, immediately after Tambatittha. This evidently refers to an important land route running westward from Seruwila to the north central region, directly to Anuradhapura thus connecting the source area with one of the major production-distribution centres.

Production-distribution may have been better regularized during the Historic Period as we have some information for the existence of organized corporate bodies of craft or commercial guilds. The *Dhātuvaṃsa* topographic description locates a village

---

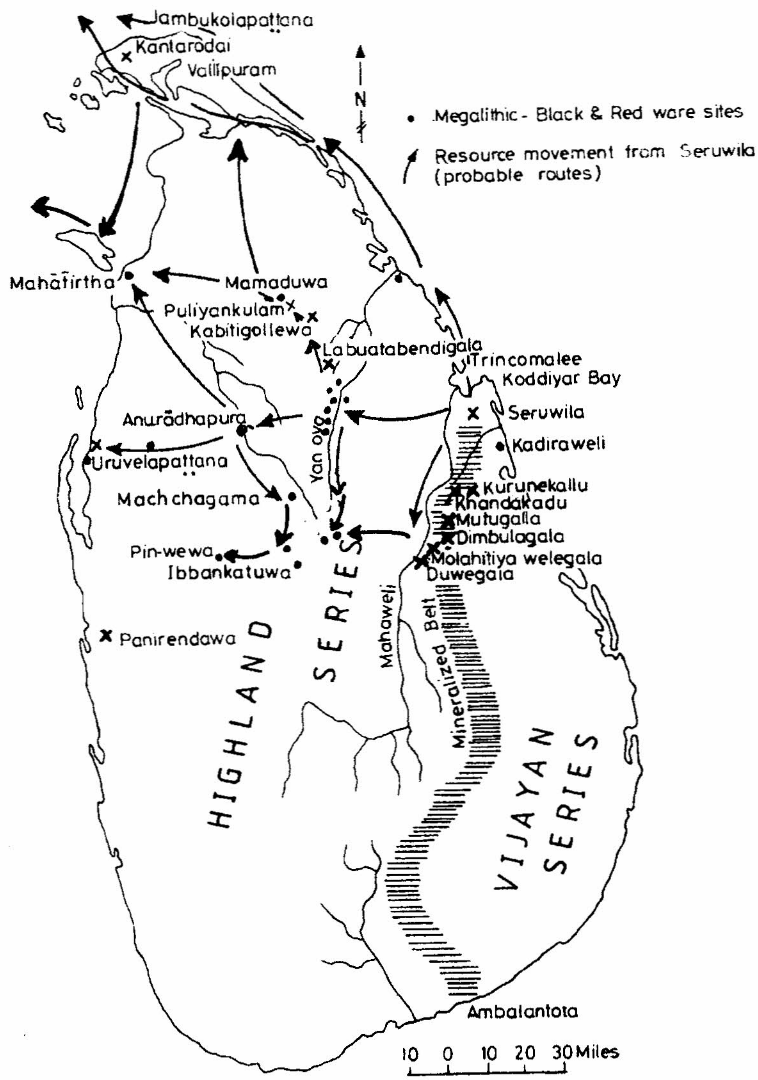
73. *Mahāvaṃsa* XXVIII. 17.

74. Solheim and Deraniyagala 1972: 4, 19; Jayawardena 1982: 129; Yapa 1983: 169.

75. Brohier 1935: III. 39.

76. Deraniyagala, P. 1958: 33-35.

Map-5



Sudharshan Seneviratne 1991

named Gaṇadvāragāma to the east of the *stūpa*. This locational direction coincides with the Arippu area where intensive metallic extraction was done in the past, and it also faces the ancient port, Madanapaṭṭana, situated to the east of the *stūpa* (Map 6 and Plan I). *Gaṇa* refers to a corporate body and *dvāra-gāma* implies a 'gateway village'. It is useful to note in this context that a 9th/10th century A.D. rock edict from Seruwila very specifically refers to a niyam-det.[77] The term *niyam-deṭ* derives from *nigama-jeṭṭha* > *niyam-jeṭ* which means guild-master. This also points to the commercial significance of this region as late as the 10th century A.D.

There seems to have been a series of such corporate bodies and even individuals located along the lower valley of the Mahaweli River facilitating the movement or processing metallic and minerals ores originating from Seruwila or from other points that were situated along the mineralized belt yielding metallic resources. For instance, an early Brahmi inscription from Kurunekallu mentions the *puki* (corporate body) of the Dipikuli[78]. At Kandakadu, not too far from Kurunekallu, a late Brahmi inscription (3rd. 4th century A.D.) mentions a *haba* of Cittanakara[79]. *Haba* derives from *sabhā* and in this context it refers to the city-guild of Cittanakara. Another early Brahmi inscription from Kurunekallu mentions an endowment of *parumaka* (lineage chieftain) Tabara Vēḷ[80]. The prefix *tabara* derives from *tambakāra* or coppersmith. This lineage chieftain may have been involved in the production of copper (as a master craftsman, leader of coppersmiths) or may have had wielded authority over an area yielding copper and even a route connected with the movement of metallic resources[81]. The socio-economic connection between this lineage chieftain and the corporate body called the Dipikuli, mentioned at the same site, is not clear. Mutugalla, which is another site located in this cluster, carries a reference to a *kabara* (ironsmith/metalsmith) in an early Brahmi inscription[82]. Another early Brahmi inscription at Mutugalla mentions a *toḍika* or ferryman of the village Banagama[83] This may point to the existence of an important ford or crossing associated with the Mahaweli River facilitating the movement of people

---

77. *Traimasika Sila Lipi Sangrahaya* Vol. I, 1979: 21. Department of Archaeology.

78. Paranavitana 1970: No. 320.

79. Paranavitana 1963: 79.

80. Paranavitana 1970: No. 319.

81. Seneviratne 1992.

82. Paranavitana 1970: No. 301.

83. Paranavitana 1970: No. 309.

and resources. Quite obviously the *toḍika* in this case was a person of some social standing as the same inscription addresses his son as a *gamika*.

All these sites are located on or in close proximity to the mineralized belt (Map 5). It is, therefore, not altogether impossible that the corporate bodies and the individuals mentioned may have been involved in the movement or extracting locally available mineral resources. The above-mentioned sites are situated within a distance less than 50 miles south of Seruwila and are easily accessible by boat and may have formed extended units of the same resource zone. For that reason this particular area may have been recognized as a very specific ecological zone by the Early Historic Period. An inscription datable to around A.D. 30, from Molahitiyawelegala (which is situated to the south of the above-mentioned region) mentions a place named Lodora or Lohadvāra[84]. The place named Lohadvāra is also mentioned in the *Cūḷavaṃsa* (XXXVII. 212) in association with Dhūmarakkhapabbata (Dimbulagala) which is not too far from Molahitiyawelegala. *Lohadvāra*, literally means 'door/entrance of metal'. *Loha* in general is metal though it specifically denotes 'copper, brass and bronze'[85]. Therefore, taken in the above context, Lohadvāra may have implied 'entrace to the land of metals or copper', reflecting the function of this particular region as an entry point to the resource zone associated with the Seruwila-Arippu area.

It is reasonable to assume that by the Early Historic Period, mainly copper and to a lesser extent iron and other minerals were beginning to move out of Seruwila into centres of production-distribution and consumption. Resource movement out of this region occurred through land-routes and coastal sea-routes. There may have been a quantitative expansion in the movement of resources or finished objects of metallic ware from the Proto Historic Period to the Early Historic Period. From Seruwila, resources may have moved into internal production-distribution centres where there was a further redistribution to other centres of consumption from the latter.

The middle Yan Oya valley could be identified as one of the most important production-distribution zones, since the Proto Historic Period. It possessed the geographical advantage of facing the Mamaduwa-Periyapuliyankulam area, the Anuradhpura area, the upper Kala Oya area and upper Yan Oya-Sigiri region. It was also strategically located centering three resource zones i.e. Seruwila, Kabitigollewa (Ācāraviṭṭhigāma in Map I) and the lower montane region. It is not a coincidence that the primary highway connecting Seruwila with Anuradhapura (i.e., Mahācārikāmagga) traversed the middle Yan Oya. The occurrence of pumice stone (found only in the littoral of the north east) at certain megalithic sites in the Yan Oya valley confirms the

---

84. Paranavitana 1983: 4 - 5.

85. Rhys Davids and Stede 1959: 589.

movement of resources through this region[86]. Our studies also indicate that the middle valley of the Yan Oya housed powerful *parumaka* or lineage chieftains controlling this vital junction region and its human resources since the Proto Historic Period[87].

By the Early Historic Period the existence of organized groups of specialists and the organization of labour in the middle Yan Oya valley is known to the sources. The *Mahāvaṃsa* (XXIII. 4-5) records the existence of a village of workers or *kammantagāma* in this region[88]. An early Brahmi inscription from Brahmanayāgama (middle Yan Oya valley) records the endowment of a *kabara* or metalsmith/ironsmith[89]. Another site in the vicinity, Nattukanda, carries a 1st Century A.D. inscription mentioning a reservoir associated with a *Kabaragama* or the village of ironsmiths/metalsmiths[90]. An inscription belonging to the same period at Kahatagasdigiliya in the middle Yan Oya valley mentions a *kabaravi*, literally 'the tank of the metalsmith'[91].

The organization of the Proto Historic residential villages of craftsmen into specialized units of production by the Early Historic Period suggests relatively intensive production based on metallic ore brought in from the Seruwila prospect. The most convincing evidence substantiating this hypothesis comes from a late Brahmi inscription (C. 350 A.D.) at Labuatabandigala, a site located between the middle Yan Oya and Kabitigollawa. This inscription very specifically mentions a *niyama* (*nigama*) or corporate body/guild known as the Mahatabaka, literally 'the great copper-working guild'[92]. The inscription situates this guild in the eastern quarter of the city '... *nakarahi pajinapasahi* ...' or the locational direction coinciding with the resource area (i.e., Seruwila) situated in the east. The inscription also hints that the guild functioned as a bank, pointing to its involvement in commercial transactions related to copper objects as well.

It may be suggested that the metallic ore, semiprocessed material, or finished objects moved across the middle Yan Oya valley and arrived at other primary

---

86. *vide* Cooray 1967: 193 for details on pumice; Seneviratne 1984: 251.

87. Seneviratne 1984: 248-154; 1987a; 1992.

88. Seneviratne 1985a: 390ff.; 1990n.

89. Paranavitana 1970: no. 161d.

90. Nicholas Vol. II 80 No. 6.

91. Uduwara 1991: 211.

92. For inscription see Paranavitana 1928-33: 247-253.

production-distribution zones. Immediately to the north west of the Yan Oya is the Mamaduwa-Periyapuliyankulam area, which has an antiquity going up to the Proto Historic Period[93]. The early Brahmi inscriptions at Periyapuliyankulam very specifically refer to *tabakara* (coppersmiths) and *topaśa* (tinsmiths) and several donations made by merchants. One such tinsmith is also called a *gahapati* or head of the household[94]. Our studies indicate that during the Early Historic Period a powerful *parumaka* lineage group apparently wielded hegemonic authority over this region and they contracted matrimonial alliances with the *parumaka* lineage group controlling the middle Yan Oya valley[95].

It appears that copper resources reached the Jaffna peninsular from Seruwila through sea and land routes, the latter running from the resource area through the middle Yan Oya and the Mamaduwa-Periyapuliyandulam area. Sites such as Kantarodai and Vallipiuram, which have an antiquity running to the Early Iron Age, yielded copper ingots, other copper products, industrial remains associated with copper related work and even lead.[96]. The *Sīhalavatthupakaraṇa* (*Svp.* 7) records the existence of a village called Mahāharitālagāma in Nagadvipa (Jaffna peninsular). *Haritāla* is orpiment or arsenic trisulphide, and this may point to the existence of a village where alloying was done with the use of orpiment. The *Mahāvaṃsa* carries several references to the port of Jambukolapaṭṭana, located in the northern littoral of the Jaffna peninsular and as a point of contact for the Coromandal coast in India.

Mahātīrtha (literally 'the great port') was another major production-distribution centre that developed during the Early Historic Period. This site, which is located in the north west littoral of Sri Lanka, has yielded large quantities of oxide copper ore, iron slag, iron ore, remains of crucibles, furnaces and associated tuyeres, large quantities of copper ingots and other finished metallic objects[97]. The source for the oxide and sulphide ores found at Mantai may be traced to Seruwila. The land route for such resources may have touched the Mamaduwa-Periyapuliyankulam area and the city of Anuradhapura as well. Considering the large quantity of metallic remains (both industrial and finished products) found at Mantai, it is quite possible that some amount of copper and other minerals may have reached this site from Seruwila along a coastal sea route. The existence of a port or ford called Tambatittha, to the north of the *stūpa*

---

93. Seneviratne 1984: 246-247.

94. Paranavitana 1970: Nos. 350, 351, 370.

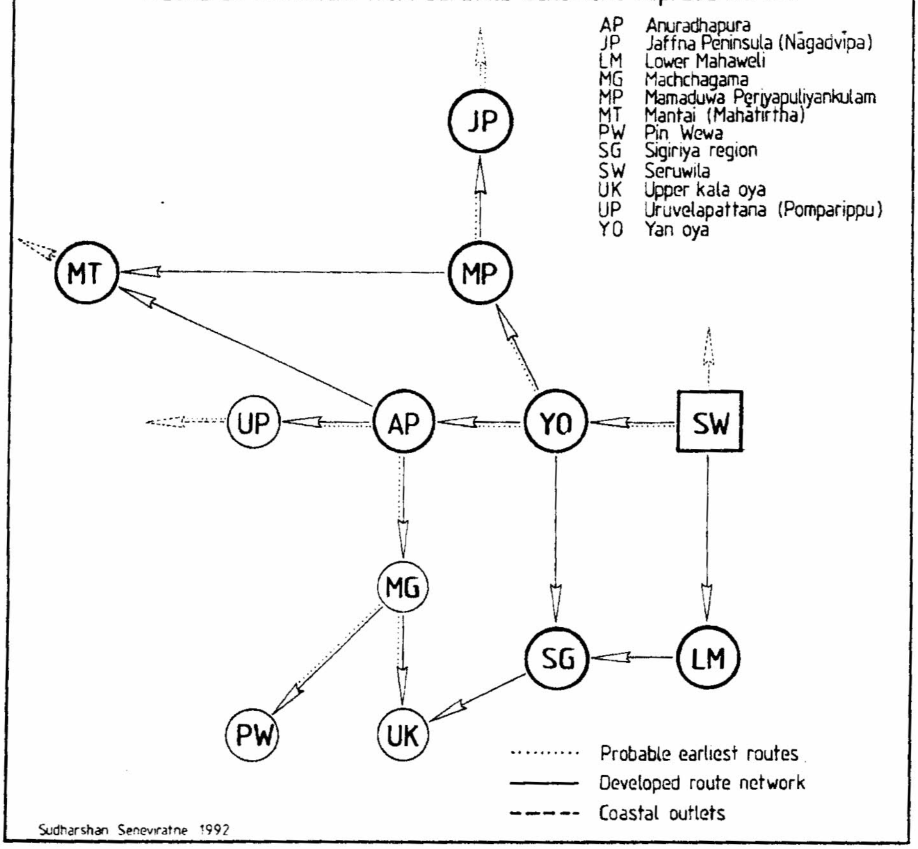
95. Seneviratne 1992.

96. Pieris 1919: 60-61; *vide* Raghupathy 1987 for details.

97. Boake 1887: III; Carswell et Prickett 1984: L52, 65 Table 2; Prickett 1987.

Fig. I

Resource movement from Seruwila Schematic representation



at Seru may be noted here (Plan I). Such large quantities of metallic remains at Mantai also point to industrial production geared for export purposes. It is not altogether impossible that the high quality South Indian steel imported into the Roman Empire during the early Christian Era[98] may have originated from the manufacturing centres located at production-distribution zones such as Mahatirtha.

There is reason to believe that the primary habitation site associated with Anuradhapura may have functioned as a crucial production-distribution centre commencing from the Proto Historic Period. It is possible to suggest that the copper objects unearthed from the Proto Historic sites of Pomparippu (located near the ancient port of Uruvelapattana), Machchagama, Pin wewa (Galsohonkanatta), and even Ibbankatuva may have arrived in the form of finished products or as raw material from Anuradhapura. While the locational significance of Anuradhapura during the Early Iron Age was its strategic situation in relation to several mineral resource zones, the emergence of Anuradhapura as the primary political centre in the post 150 B.C. era, may have in turn enhanced its importance as a major production-distribution centre. It is therefore not surprising to find a concentration of metallurgical activity at Anuradhapura where advanced techniques may have been applied in the production technology. The 1984 Citadel excavation infact revealed a brick-built furnace from Str.6 (Middle Historic Period). This furnace was utilized for copper smelting and the structure was broken up to collect the solidified copper ingots[99]. The bricks used in the furnace were not vitrified indicating that the furnace was not subject to high temperature levels. The quartz component in the bricks require a minimum temperature of 1250°C for vitrification. Interestingly enough, kaoline was used as binding material in the furnace. Kaoline (which is the pure form of hydrated silicate) loses water on heating and has a high sinter and melting point, i.e. 1770°C[100]. It may be a useful exercise to study the metal industry and its technology at Anuradhapura in relation to the socio-political structure and the long-distance trade network of the Historic Period.

The development of the Sigiriya region during the Early Historic Period as the southern most production-distribution zone drawing on the mineral resources of the Seruwila prospect and the mineralized belt is significant. Recent investigations (by the Postgraduate Institute of Archaeology and the SAREC Project) in the vicinity of Sigiri revealed extensive remains of highly specialized iron-working sites having multiple furnaces for smelting purposes. Industrial operations, according to C-14 dates, seems to have commenced around the 1st century B.C./A.D. The metallurgist at this site had

98. Schoff 1915; Seneviratne 1987: 154.

99. Pers. Com. Deraniyagala; also see Deraniyagala 1986: 42-43.

100. Seneviratne 1987: 156.

used, both, the highly concentrated magnetite and magnetite having manganese as well[101]. Archaeological excavations at the Sigiri complex also yielded fragments of malachite copper[102].

Elsewhere we have suggested[103] the existence of a village of specialist blacksmiths in the vicinity of Sigiri. Pidurangala, the site adjacent to Sigiri, has an early Brahmi inscription carrying the term Kolagama[104], i.e. *kola* blacksmith/metalsmith and *gama* (*gāma*) i.e. village. In view of the type of iron ore found at the Sigiri smelting site, it is obvious that raw material moved into this region from Seruwila *via* the middle Yan Oya or from the eastern sector linking up with the mineralized belt in that region (see Map 5). This may hold true for the malachite copper unearthed from Sigiri though we have not ruled out the possibility of oxide copper moving down from the Bambaragala area (in the upper Mahaweli basin) along the exchange route traversing the Matale-Dambulla region[105]. The emergence of a major production-distribution zone in the upper Kala Oya region, which has been categorized by us as an Intermediary Transitional Eco-system, during the Early Historic Period witnessed the establishment of specialized units of production based on mineral resources[106]. We have already suggested a pattern for the movement of raw material or finished products to places of internal consumption and to coastal points for export purposes from the upper Kala Oya region[107].

In the final analysis we cannot underestimate the importance of Seruwila within the sub continental context. It remains as the largest copper-magnetite deposit south of the Bihar-Orissa region in South Asia. The interaction between the Seruwila region and external regions such as the Coromandal coast and even south east Asia requires closer attention. More specifically, the bearing this resource area had on the south Indian megalithic complex must be viewed within a new perspective related to resource movement and cross regional technological interaction. The movement of tin and lead in a southward direction along a coastal sea route associated with the Coromandal coast

101. Pers. comm. Senake Bandaranayake and Mats Mogren PGIAR/SAREC.

102. Bandaranayake 1984: 18, 185.

103. Seneviratne 1990: 127.

104. Paranavitana 1970: No. 873.

105. Seneviratne 1990.

106. Seneviratne 1990.

107. *Ibid.*

TABLE - I

Anuradhapura Citadel (Gedige) 1969 iron analysis

Sample No.	Layer	Weight	Fe %	Mn %	Ni %	Cu %	Cr %	Cu/Ni %
1	3A	0.0135	50.75	Nil	0.0247	0.0327	Nil	1.32
2	3A	0.0014	40.86	Nil	0.2381	0.42	Nil	1.76
3	3A	0.0135	50.75	Nil	0.0563	0.1589	Nil	2.82
10	3B	0.0113	47.09	Nil	0.0590	0.1431	Nil	2.43
4	4A	0.0049	40.72	Nil	0.0255	0.2101	Nil	8.24
5	4A	0.0346	53.83	Nil	0.5118	0.0425	Nil	0.08
7	4A	0.0017	86.07	Trace	0.4902	3.2871	0.4425	6.71
8	4A	0.0191	53.63	Nil	0.1309	0.0539	Nil	0.41

H.B. Maliyasena
20.8.1987

Maliyasena and Seneviratne 1987.

needs further probing. Similarly, a reference in the *Dhātuvaṃsa* (48) to the arrival of ships carrying silver and a fleet carrying gold, the latter arriving from Suvarṇabhūmi, at the port of Madanapaṭṭana near Seruwila is significant in the overall context. It is also not a coincidence that the early Brahmi inscriptions at Seruwila carry reference to endowments made by *dameḍa* (those arriving from the Tamil-speaking region) and *bata* individuals[108]. An early Brahmi inscription from Duvegala, (a site located south of Seruwila) mentions a *barata* individual and it also carries an engraving of a single-masted ship with a *nandipada* symbol at the helm[109]. Such ships were used along the Coromandal coast and the Sātavāhana bi-lingual coins in the same region carry representations of similar vessels of the double-masted type. We have also suggested elsewhere that the *bata-barata* group were members of the powerful and affluent south Indian Paratavar merchant group, who literally controlled the luxury trade in this region and were the most powerful middlemen in the Early Historic triangular trade vortex linking south India, Sri Lanka and the Roman trade[110].

Studies on the archaeometallurgy of south central Asia must necessarily take cognizance of regional concentration of resources and related regional patterns. Such investigations have to take note of intra-regional interactions with parallel studies on social and technological change for a better understanding of similarities and variations at the subcontinental level.

REFERENCES

Bachmann, Hans-Gert
1982 - *The Identification of Slags from Archaeological Sites*. London. Institute of Archaeology (Occasional Pub.No. 6).

Bandaranayake, Senake
1984 - *Sigiriya Project First Archaeological Excavation and Research Report*. Colombo. Central Cultural Fund.

Bennett, Anna
1987 - *Pre Historic Copper Smelting in Central Thailand*. Paper submitted to the Seminar on the Archaeometallurgy of Sri Lanka. September. Institute of Fundamental Studies. Kandy.

108. Paranavitana 1970: No. 382; *Epigraphical Notes* 1974: 13.4.

109. Paranavitana 1970: No. 270.

110. Seneviratne 1985.

Bharadvaj, H.C.
1973 - 'Aspect of Early Iron-technology in India'. *Radiocarbon and Indian Archaeology*. Bombay. TIFR. Eds. D.P. Agrawal and A. Ghosh. 391-399.

Boake, W,J,S
1887 - 'Tirukketisvaram, Mahatirtha, Matoddam, or Mantoddai'. *Journal. Royal Asiatic Society (Ceylon Branch)*. Vol. X No. 35: 107-114.

Brohier, R.L.
1935 - *Ancient Irrigation Works in Ceylon* Pt.III. Colombo Ceylon government Press.

Brooks, R.R.
1987 - *Serpentine and its Vegetation*. London. Croom Helm.

Brooks, R.R. et. al.
1985 - "Botanical and Geochemical Exploration Studies at the Seruwila Copper-magnetite Prospect in Sri Lanka". *Journal. Geochemical Exploration* 24: 223-235.

Brooks, R.R. and Dieter Johannes
1990 - *Phytoarchaeology*. Portland. Dioscorides Press.

Carswell, John and Martha Prickett
1984 - 'Mantai 1980: A Preliminary Investigation' *Ancient Ceylon*. No. 5: 3-30.

Chakrabarti, Dulip
1979 - 'The Problem of Tin in Early India - a Preliminary Survey'. *Man and Environment*. Vol. 3:61-74.

Coomaraswamy, Ananda
1908 - *Medieval Sinhalese Art*. New York. Pantheon (1956 reprint).

Cooray, P.G.
1967 - *An Introduction to the Geology of Ceylon*. Colombo. National Museum.

Culavamsa
1925 - Ed. Wilhelm Geiger. London. Pali text Society.

Davy, John

1821 - *An Account of the Interior of Ceylon.* Dehiwela. Tisara (1983).

Deraniyagala, P.E.P.

1958 - *The Pybus Embassy to Kandy.* Colombo. National Museum.

Deraniyagala, S.U.

1972 - 'The Citadel of Anuradhapura 1969: Excavation in the Gedige Area'. *Ancient Ceylon* No. 2: 48-169.

1986 - 'Excavations in the Citadel of Anuradhapura: Gedige 1984, a Preliminary Report'. *Ancient Ceylon* No. 6: 39-48.

1990 - 'The Prehistoric Chronology of Sri Lanka: Appendix - I List of Radio-carbon Dates from Proto and Early Historic Periods'. *Perspectives in Archaeology: Leelananda Prematilleke Fetschrift 1990.* Eds. Sudharshan Seneviratne, Moira Tampoe et al. University of Peradeniya. Department of Archaeology. 1-24.

Dhatuvamsa

1984 - Ed. Kamburupitiya Nandaratana. Colombo. The Cultural Publications.

Dissanayake, C.B.

1984 - *Serpentinite Deposits of Sri Lanka.* Seminar on Mineral resources of Sri Lanka. (Unpublished). Colombo. SLAAS Proceedings.

1985 - "The Application of Plate Tectonics to Mineral Exploration. Discovery of a Mineralized Belt in Sri Lanka". *Recent Advances in the Geology of Sri Lanka.* Eds. C.B. Dissanayake et P.G. Cooray. (Occasional Publication: No. 6). Paris. International Centre for Training and Exchange in Geoscience.

Dissanayake, C.B. and S.W. Navaratne

1981 - 'The Occurrence of Gold in Gem Beds of Sri Lanka'. *Economic Geology* Vol. 76 No. 3: 733-738.

Fernando, A.D.N

1971 - 'Aerial Survey and Archaeology with special reference to the Old Course of the Mahaweli'. *Ancient Ceylon* No. 1: 193-195.

1982 - *The Ancient Hydraulic Civilization of Sri Lanka in Relation to its Natural Resources*. Special Number of the Sri Lanka Branch of the Royal Asiatic Sociey. New Series. Vol. XXVII.

Fernando, M.J. and A.N.S. Kulasinghe

1986 - 'Seismicity of Sri Lanka'. *Physics of the Earth and Planetary Interiors*. 44: 99-106 (Amsterdam).

Gogte, V.D.

1983 - 'Iron and Copper in Mahurjhari Megaliths: Chemical Metalographic Analysis'. Bulletin. *Deccan College Research Institute*. Vol. 42: 74-77.

Hegde, K.T.M.

1969 - 'Technical Studies in Copper Artefacts excavated from Ahar'. *Excavation at Ahar* Ed. H.D. Sankalia et.al. Poona. Deccan College. 225-228.

1973 - 'Early Stages of Metallurgy in India'. *Radio-carbon and Indian Archaeology*. Bombay. TIFR. Eds. D.P.Agrawal and A. Ghosh. 401-405.

Hegde, K.T.M. and J.E. Ericson

1985 - 'Ancient Indian Copper Furnaces'. *Furnaces and Smelting Technology in Antiquity*. Ed. P.T. Craddock. British Museum Occasional Papaer No. 48: 59-69.

Herath, J.W.

1975 - *Mineral Resources of Sri Lanka*. Colombo. Geological Survey Department.

Hodges, Henry

1965 - *Artefacts*. London. John Baker.

Jayawardena, D.E. de S.

1982 - 'The Geology and Tectonic Setting of the Copper-iron Ore Prospect at Seruwila. North east Sri Lanka. *Journal. National Science Council of Sri Lanka*. 10 (i): 129-142.

1986 - *Records of Ancient Steel Making and Copper Refining in Sri Lanka*. Paper presented at the 1st National Archaeological Congress. Colombo. SLFI. (November).

Kangle, R.P. (Tr.)
1972 - *Kautilya Arthasastra*. Vol. II Bombay. University of Bombay.

Karunaratne, W.M.A.A. and C.B. Dissanayake
1990 - 'Metal Mining Sites in Ancient Sri Lanka'. *Perspectives in Archaeology: Leelananda Prematilleke Fetschrift 1990*. Eds. Sudharshan Seneviratne, Moira Tampoe et.al. University of Peradeniya, Department of Archaeology. 71-78.

Kularatnam, K.
1979 - 'Ceylon Building Stones'. *Ancient Ceylon* No. 3: 211-223.

Kumarapeli, P.S.
1963 - *A Preliminary Report on the Iron Ore Investigations in Chilaw District*. Colombo. Geological Survey Department (Unpublished report).

Mahāvaṃsa
1958 - Ed. Wilhelm Geiger. London. Pali Text society.

Maliyasena, H.B.
1986 - *Metallurgical Studies of Sri Lankan Artefacts*. Paper presented at the 1st National Archaeological Congress Colombo. SLFI. (November).

Maliyasena, H.B. and Sudharshan Seneviratne
1987 - *Metallurgical and Archaeological Studies of some Iron Objects from the 1969 Anuradhapura Citadel (Gedige Area)*. Paper presented at the Seminar on the Archaeometallurgy of Sri Lanka. September. Institute of Fundametnal Studies. Kandy.

Nicholas, C.W.
(Undated) *Brahmi Inscriptions* (Handwritten mss.), University of Perdeniya, Central Library.

Paranavitana, S.
1936 - *The Excavations in the Citadel of Anuradhapura*. Memoirs of the Archaeological Survey of Ceylon. Colombo.

1928-33 - 'Two Rock-inscriptions from Labuatabandigala'. *Epigraphia Zeylanica*. Vol. III: 247-253.

1963 - 'Kandakadu Rock Inscription of Upatissa II'. *Epigraphia Zeylanica*. Vol. V(i): 71-80.

1970 - *Inscriptions of Ceylon*. Vol. I. Colombo. Archaeological Survey of Ceylon.

1983 - *Inscriptions of Ceylon*. Vol. II. Colombo, Archaeological Survey of Ceylon.

Parker, Henry

1884 - 'Report on Archaeological Discoveries at Tissamaharama in the Southern Province of Ceylon'. *Journal. Royal Asiatic Society (Ceylon Branch)*. Vol. VII No. 27: 95-192.

Pattiarachchi, D.B.

1961 - *Some Aspects of Genesis of the Iron-ores of Ceylon*. Paper presented at the CAAS sessions. Colombo. (Unpublished).

Peiris, P.E.

1917 - 'Nagadipa and Buddhist Remains in Jaffna'. Pt. II. *Journal. Royal Asiatic Society (Ceylon Branch)*. Vol. 26 No. 70: 11-30.

1919 - 'Nagadipa and Buddhist Remains in Jaffna. Pt. II. *Journal. Royal Asiatic Society (Ceylon Branch)*. Vol. 28 No. 72: 40-65.

Prickett, Martha

1987 - *The metal Objects from Màntai*. Paper presented at the Seminar on the Archaeometallurgy of Sri Lanka. September. Institute of Fundamental Studies, Kandy.

Raghupathy, Ponnampalam

1987 - *Early Settlements in Jaffna: An Archaeological Survey*. Madras. T. Raghupathy.

Ray Amita and Dulip Chakrabarti

1975 - 'Studies in Ancient Indian Technology and Production: a Review, *Journal. Economic and Social History of the Orient*. Vol. XVIII Pt. ii: 219-232.

Rea, A.

1902-03 - 'Pre-Historic Antiquities in Tinnevelly'. *Annual Report of the Archaeological Survey of India*. 111-140.

1915 - *Catalogue of the Prehistoric Antiquities from Adichchanallur and Perumbair*. Madras. Government Press.

Rhys Davids, T.W. and W. Stede

1959 - *The Pali Text Society's Pali-English Dictionary*. London. Luzac and Co.

Sahassavatthuppakaraṇa

1959 - Ed. A.P. Buddhadatta. Colombo. Anula.

Schoff, Wilfred H

1915 - 'The Eastern Iron Trade of the Roman Empire'. *Journal. American Oriental Society*. Vol. 35: 224-1239.

Schroeder, Ulrich Von

1981 - *Indo-Tibetan Bronzes*. Hongkong. Visual Dharma Publications.

Seneviratne, Sudharshan

1984 - 'The Archaeology of the Megalithic Black and Red Ware Complex in Sri Lanka'. *Ancient Ceylon* No. 5: 237-307.

1985 - 'The Baratas: A Case of Community Integration in Early Historic Sri Lanka'. *Fetschrift 1985 James Rutnam*. eds. A.R.B. Amarasinghe and Sumanasekare Banda. Colombo. UNESCO. 49-56.

1985a - *Social Base of Early Buddhism in South East India and Sri Lanka, c. 3rd Century B.C. - 3rd Century A.D.* Ph.D. Dissertation. Jawaharlal Nehru University. New Delhi.

1986 - *Metal Research: Progress and Possibilities*. Working paper presented at the Prelimianry seminar on possible avenues of investigation into plasters and metals. Colombo. IFS (March).

1987 - 'Iron Technology in Sri Lanka: a Preliminary Study of Resource Use and Production Techniques during the Early Iron Age'. *The Sri Lanka Journal of the Humanities*. Vol. XI (nos.i & ii) 129-178 (for 1985).

1987a - *Proto and Early Historic investigations along the Yan Oya Yalley, North Central Sri Lanka.* Paper presented at the Second South Asian Archaeological Congress. Colombo/Kandy (December).

1988 - 'Mica Zones and Early Iron Age Sites in Sri Lanka: an exploratory study'. *The Sri Lanka Journal of the Humanities.* Vol. XII (i & ii): 121-132 (for 1986).

1990 - 'The Locational Significance of Early Iron Age Sites in Intermediary Transitional Eco-Systems: a case study of the Upper Kala Oya Region. North Central Sri Lanka'. *The Settlement Archaeology of the Sigiriya-Dambulla Region.* eds. Senake Bandaranayake et. al. Postgraduate Institute of Archaeology. University of Kelanaiya. 121-140.

1990a - 'A Life after Death: Continuity and Change in the Religious Symbolism of the Early Iron Age'. *Perspectives in Archaeology: Leelananda Prematilleke Fetschrift 1990.* eds. Sudharshan Seneviratne, Moira Tampoe et al. University of Peradeniya. Department of Archaeology. 145-152.

1992 - 'Pre-state Chieftains and Servants of the State: a Case Study of Parumaka'. *The Sri Lanka Journal of the Humanities.* Vol. XV (nos. 1 and 2): 99-131.

Sīhalavatthupakaraṇa
1959 - Ed. A.P. Buddhadatta. Colombo. Anula.

Solheim, W.G. and S. Deraniyagala
1972 - 'Archaeological Study to Investigate South East Asian Prehistoric Presence in Ceylon'. *Ancient Ceylon* (Occasional Paper No. 1).

Tantrigoda D.A. and P. Geekiyanage
1991 - 'Interpretation of Magnetic Anomalies over the Panirendawa Magnetite Deposit'. *Journal of the Geological Society of Sri Lanka.* Vol.3. p. 21-25.

Tennent, James Emerson
1859 - *Ceylon.* Vol.I. London. Longman. (3rd and Revised Edition).

Uduwara, Jayantha
1991 - "Kahatagasdigiliya Rock Inscription'. *Epigraphia Zeylanica*. Vol. VI. (Pt.2): 211-214.

Yapa, S.W.
1982 - 'Froth Flotation of Seruwila chalcopyrite'. *Transactions. Institute of Engineers*. Sri Lanka 21-28.

SUDHARSHAN SENEVIRATNE