# A Study of the Ancient Environment at the Seruwila Copper Magnetic Deposit

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It was in the year 1971 that the Geological Survey Department of Sri Lanka discovered the mineralized zone at Seruwila. However, in the year 1821 Davy made reference to the existence of magnetic ore near Trincomalee, and Tennent (1859) records the occurrence of mercury in the same area. Seruwila is located in northeast Sri Lanka to the south of the Koddiyar Bay, containing the large natural port of Trincomalee. The microregion brought into focus in this study is situated between the Allaai Tank and the Ulakali Lagoon. This whole region submerged during the Holocene transgression and was followed by the filling in due to fluvial depositions. Sedimentation is extremely active to this day, and the landscape is marked by alluvial plains and residual terrain.

Seruwila has a matrix of high-grade metamorphic rocks belonging to the Pre-Cambrian Age represented by the Highland and the Vijayan Series, according to the recent geological studies. The Highland series, located to the northwest, predominantly has charnockites and quartzites, whereas the Vijayan Series in the southeast has granites, granitic gneisses, and hornblende-biotite as the major rock types. The rocks indicate parallel repetition of beds thereby showing isoclinal folding.

The ore mineralization at Seruwila may have taken place during the Upper Cretaceous Period. It is rich in magnetite ore and sulphides (mainly copper), including other minerals such as silver, bismuth, zinc, mica, and nickel. The serpentinite bodies in association with the prospect at Seruwila clearly point to a source of nickel and chromium (Dissanayake 1984; 1985). 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.

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 magnetite-sulphide ore bodies vary in thickness from 3 to 30 feet, and are coarse-grained with magnetite, chalcopyrite, pyrrhotite and pyrite. The massive sulphide-magnetiteores are estimated to be rich in iron with values up to 99.5 percent. Investigations by the Geological Survey Department established the existence of nearly 7 million tones of magnetite ore extending nearly 200 feet below the surface. The massive ore type carries a higher content of copper over the disseminated ores. At Seruwila, the copper in the ore is around 1:3 and the amount of metallic copper in the Arippu area alone is about 68,000 tones. The general topography of Seruwila is relatively flat. The ultrabasic host rock for mineralization survives as outcrops in the microlandscape. It is highly weathered. The magnetite outcrops vary in height from 3 to 45 feet. Some of these measure 3 to 15 feet in length. Secondary copper minerals such as malachite and azurite are exposed on the highly weathered surface of the rock (Jayawardena 1982).

## Historical Geography and Topography

Pali texts, namely the *Dhatuvamsa* and to a lesser extent *Mahavamsa* carry useful references on the historical topography and mineral resources found in this region. The antiquity of human activity in this region extends to the Proto-Historic or the Early Iron Age (Pre-4th Century B.C.). Surface investigations at abandoned deep pits yielded scattered Proto-Historic Megalithic-Black and Red Ware embedded in the soil. The existence of a dolmenoid cist burial site at Kadiraveli, a few miles southeast of Seruwila, bears testimony to the prevalence of Proto-Historic settlements in the region. The *Dhatuvamsa* records at least three sites known as *thitapasanathupa* on the boundary of the *stupa* premises at Seru. This refers to funerary monuments of upright stone or dolmenoid cists. The *Mahavamsa* description on the founding of the early settlements at Gokanna, near Koddiyar Bay, may perhaps be a reference to this Early Iron Age community movement to this region.

The early Brahmi inscriptions (B.C. 2nd Century) found at Seruwila confirms the continued presence of a settled agricultural community in this region. Inscription from the adjacent region bear evidence to the presence of Buddhist clergy in this area. The *Dhatuvamsa* accounts for two *nagara* (city) and at least twelve *gama* (village) settlements in addition to *khetta* (field) and *vapi* (reservoir) in the area surrounding the *stupa* during the early 1st Century B.C.

The microtopography indicates a gradual inclination from the southeast to the northwest, where the m ineralized zone with its rocky outcrops marks the landscape. The human habitation was in the eastern sector. This is confirmed by both archaeological investigations and textural descriptions. The Mahaweli River traversed the flat land situated immediately to the west of the resource zone prior to its change of course possibly during the Middle Historic period due to seismic activity. The *Dhatuvamsa* situates the *stupa* and the monastery complex at the edge of a natural lake named *Seru* which is located on the right bank of the Mahaweli River. The present Allaai Tank is located in a vast depression associated with the ancient drainage system of the Mahaweli River.

## Archaeometallurgy of the Seruwila Prospect

It is evident that this resource zone was known, inhabited and exploited during the Early Iron Age. The Seruwila copper-magnetite prospect was within easy reach and was easily accessible by land, rive rand sea routes. it was practically impossible to exploit distantly located 'weight-gaining' minerals during the Formative Period. The primary ore formation at Seruwila is magnetite and sulphides, mainly copper. The functional and utility values are important factors in the preference given in selecting a particular ore. 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 $1800^0$C to smelt the ore. The existence of sulphide ores such as pyrrhotite and pyrite/marcasite in the Seruwila prospect would have created a problem to the smelter as the metal becomes brittle due to the sulphur content and entails a difficulty in forging the metal.

The alternate strategy for the Proto-Historic ironsmith was to use haematite or limonite ore commonly found in the northern plains or to work the disseminated ores found at Seruwila. Excavations at the Citadel of Anuradhapura and our own studies on resource zones showed that 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 phosphorous.

The Seruwila prospect holds the most complex mineral formation which is nearest to the metallic composition of the iron implements tested from the Early iron Age levels at Anuradhapura. Trace element studies showed that the magnetite ores at Seruwila are rich in iron (40 to 99.05 percent) and also the existence of cobalt, nickel, chromium and manganese in the ore. The deliberate selection of 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. Evidence derived from textual, epigraphical and archaeometallurgical studies indicates that the metal prospect however had a greater utility value as a source of copper to the Early Iron Age Community. 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.

It is interesting to note that the spectrographic analysis of the Seruwila ore revealed the same metallic composition as found in similar studies on a copper object unearthed at the Citadel of Anuradhapura. It could be pointed out that Seruwila prospect was 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 the natural setting of the ore formation and technological factors associated with production techniques. The *Mahavamsa* identifies this region as Tambatittha, located to the east of Anuradhapura. The ancient coppersmith is known to the text as *tambakara*.

The existence of some amount of iron pyrites in the slag heaps of Seruwila does not necessarily point to iron smelting. This may have been a result of copper extraction, because iron and copper pyrites are known to occur together. The relatively high iron content (0.84%) in the Proto-Historic copper object from Anuradhapura points to a specific technological advantage in the use of chalcopyrite magnetite ore at Seruwila. The presence of iron streaks is known to give additional strength to copper implements.

In view of the relatively large quantities of oxide ores scattered near ancient trenches and pits, it is possible 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. Their colour (blue and green) may have been useful in locating the raw material with relative ease. The very formation of this group in small outcrops made the extraction of the ore an easy process. The *Mahavamsa* and *Dhatuvamsa* mention about the presence of copper and other mineral formations in this area. Geo-mineralogical surveys confirm that the Seruwila prospect does carry minerals such as silver and mica too.

The surface oxide ores may have been extracted by splitting the surface of the rock and by working narrow tunnels by the gad and hammer. The presence of wooden shafts also points out to sub surface mining. The highly concentrated magnetite may have been chipped off *en bloc*, thus separating it from the copper ore. The oxide ores are further 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 and 55.01 percent respectively. In addition, the type of metallic (or native) copper found in this locality required '...neither smelting nor casting, and could be worked into small articles by simply hammering.' The disadvantage of working the sulphide ores, on the other hand, was the requirement of an additional input of time and labour due to the existence of unwanted matter. The ore had to be roasted too to concentrate the copper.

The rich mineral potential of the Seruwila deposit was known by the first century B.C./A.C. period. For instance, the dark blue transparent glass beads unearthed from Anuradhapura indicated that the colour had occurred due to cobalt. The Seruwila deposit revealed cobalt-nickel mineralization, and the nickel found therein is described as pentlandite and has a melting point at $1455^0$C. Cobalt has to be extracted by converting the ore into oxide and reducing the latter with aluminium. The crucial significance of the Seruwila deposit as the primary repository for strategic minerals was so well known during the Early Historic period that the *Mahavamsa*, documented in the $5^{th}$ century A.D., credits the period of king Dutugemunu with the discovery of this metallic source.

## Resource Movement and Production-distribution Zones

There were obviously some difficulties in transporting large quantities of copper ore from Seruwila to centres of production and consumption. It may have moved out of the source area mainly in the form of a semi-product or as copper ingots, known as *tambalohabija* in the *Mahavamsa*. Such copper ingots were discovered from Early Iron Age habitation sites in the orth (e.g., Mantai, Kantarodai, Vallipuram). There is evidence from Seruwila-Arippu area to conclude that extensive smelting activity was carried out in the source area. The remains of large heaps of slag in this area, and in some quarters large piles of slag remains obstructed the construction of the Right Bank Canal of the Allaai Scheme in 1957. Textual, inscriptional and archaeological sources carry evidence to the process of resource movement from the Seruwila region. Copper ore or ingots may have moved out through land and along the river cource of Mahaweli. The Dhatuvamsa records the existence of Tambatittha (copper port) near Seruwila on the Mahaweli River. There was a land route to Anuradhapura and the river course destinations were Koddiyar Bay and Ulakali Lagoon, ultimately opening out to the Bay of Bengal.

There may have existed organized corporate bodies of the craft or commercial guilds to regularize production distribution. *Dhatuwamsa* locates a village named *Ganadvaragama* to the east of the *stupa*. *Gana* infers corporate body and *dvaragama* implies gateway village. A 9$^{th}$/10$^{th}$ century A.D. rock edict from Seruwila very specifically refers to a *niyam-det*, meaning guild master. Early Brahmi inscriptions from Kurunekallu and Kandakadu mention *puki* (corporate body) and *haba* (city-guild) respectively. Inscriptions also refer to lineage chieftains, coppersmiths, ironsmiths/metalsmiths, ferrymen and village headmen. All these sites, guilds and individuals mentioned in close proximity to the mineralized belt stand for a very specific ecological zone by the Early Historic Period. An inscription from Molahitiyawelegala (south of this region) mentions a place named *Lohadvara* meaning door/entrance of metal. This implies entrance to the land of metal or copper.

It could be reasonably assumed that by the Early Historic period, mainly copper and to a lesser extent iron and other minerals were beginning to spread into centres of production-distribution and consumption through land-routes, internal waterways and coastal sea-routes. The middle Yan Oya valley possessed the geographical advantage of connecting Seruwila with the Anuradhapura area, the upper Kala Oya area and upper Yan-Oya-Sigiri region. The *Mahavamsa* and several early inscriptions bear testimony to the existence of metalsmiths and ironsmiths and their guilds in this strategically located middle Yan Oya valley.

Copper resources reached the Jaffna Peninsula from middle Yan Oya through land routes. From Seruwila the resources had their way through the Mahaweli River and then by sea. As production-distribution centres *Jambukolapattana* and *Mahatirtha* had their access to Seruwila oxide ores. It is possible that the high quality South Indian steel exported to the Roman empire during the early Christian Era may have originated from the manufacturing centres located at centres like *Mahatirtha*.

Seruwila prospect remains as the largest copper-magnetite deposit south of the Bihar-Orissa region in South Asia. Hence, the interaction between the Seruwila region and external regions such as the Coromandal coast and even Southeast Asia requires closer attention in terms of references made in the Dhatuwamsa and in early Brahmi inscriptions from sites located south of Seruwila.