Reconstructing Past Settlements through Soil Characterization: Vessagiriya, Sri Lanka

Attanayake, C.P.[1,3], Mapa, R.B.[1*], Seneviratne, S.[2] , Karunarathna, D.[4]

[1] Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka
[2] Department of Archeology, Faculty of Arts, University of Peradeniya, Sri Lanka
[3] Institute for Sustainability, Energy and Environment, University of Illinois, Urbana- Champaign, USA
[4] Esquimalt Municipal Archives and Centre for Asia-Pacific Initiatives, University of Victoria, Canada

*Corresponding Author Email: maparb1@gmail.com

Abstract

Information on soil layers deposited in different archaeological contexts can be used to explore past human settlements and activities. The objectives of this study were to characterize soils in the Vessagiriya archaeological site in Anuradhapura, Sri Lanka and to study the variation of soil properties within different cultural phases identified in excavations. The artifacts recovered from different strata at Vessagiriya were chronologically positioned from prehistoric to Late Historic times in Sri Lanka. Soil samples were collected from five main soil strata that suggested anthropogenic activities. Soil texture, fine and medium sand fractions, soil organic matter, soil's total and inorganic Phosphorus (P) proportions were determined for each layer. Relative proportions of inorganic P fractions significantly varied among the soil horizons. Specifically, stratum L5 showed a remarkably different relative proportion of inorganic P fractions indicating that it has been developed under different cultural phases. Fine sand/silt and medium sand/silt ratios at the Vessagiriya site were significantly different among soil layers indicating that the development of the soil profile had been impacted by external factors often associated with human activities.

ANCIENT LANKA

Ancient Lanka: Volume 4 (2025)

Background and Introduction

Archaeology is the scientific study of past human lifeways, where it is important to employ a multidisciplinary approach to offer the most appropriate interpretations. Besides artifacts and structures, information obtained from faunal remains, botanical remains, and the soil matrix could be integrated into the investigative and interpretive analyses. When humans occupy an environment, the characteristics of the natural habitats are changed. Eidt (1984) explains that when a particular land use system is practiced for a significant time span, it is responsible for producing a certain imprint of the given system in the soil by changing its natural characteristics. The result is human-made surface soil horizons known as plaggen epipedons (USDA, 1975). Such horizons can be identified by visible alterations including the presence of artifacts and marks left by implements. In addition, micro-level soil alterations that not visible to the naked eye are quite common in human habitats, where the enrichment of soils by the inclusion of organic matter derived from body excreta, burials and refuse from humans and animals occur (Blume & Leinwmber, 2004), while the exploration of past land use systems facilitates the incorporation of Indigenous knowledge, applicable to land use planning (Warkentin, 2006).

In the early 1930’s the relationship between human settlements and soil chemical enrichment was described by Arrhenius , who documented that the amount of phosphorus (P) in soil increased progressively as the habitation area was approached (Barba, 1994). During the 1960’s and 1970’s, European and American geographers used soil P analysis to find and delineate human settlements (Barba, 1994). By studying the present inhabited rural settlements and agricultural lands (Eidt, 1984; Barba, 1994), it was discovered that the distribution of chemical compounds in the ground is closely related to human activities performed on it.

In the Sri Lankan context, standard archaeological explanations are largely based on artifacts and other visible alterations. It is imperative to support these findings by evidence derived from micro alterations, to strengthen the interpretations. Located in the southern end of Anuradhapura, is considered as an important archaeological site, since one of the main entrances to ancient Anuradhapura city which was the capital of Sri Lanka in the 4th Century BCE, passed through Vessagiriya (Mendis, 2008; Seneviratne, 1984).

According to Sri Lankan historical textual sources, five hundred monks resided at Vessagiri monastery during King Devampiyatissa's reign (250-210 BCE) (*Mahāvaṃsa* Ch20 vv 15-16). Additionally, the Mahavamsa associates Vessagiri with the place where King Vattagamini Abhaya (104-76 BCE) took refuge during the Seven Tamil invasions (*Mahāvaṃsa* Ch33 vv 48-49) (Wickramasinghe, 1912, pp. 11-12). However, archaeological evidence, particularly epigraphical evidence from the current Vessagiri site, refers to this location as Issarasamana Vihara, indicating that it is a part of the ancient Isurumuni Vihara. Based on lithic evidence, Wickramasinghe (1912) confirms that the Vessagiri constructions most probably originated alongside the neighbouring rock temple, now known as Isurumuniya. As part of an extensive monastery, its proximity to Tissa Tank was doubtless, along with the Kasubgiri-vehera of Kassapa I" (Wickramasinghe, 1912, p. 31).

Figure 1. Vessagiriya site, Anuradhapura
Photo credit: Dulma Karunarathna

The most significant historic archaeological evidence is found on the drip-ledge cave sites at Vessagiri, which contain early Brahmi inscriptions dating to the 3rd century BCE. These drip-ledge caves were modified for habitation and donated through the collective patronage of chieftains of the early historic period, or the second phase of the early Iron Age of Sri Lanka (Wickramasinghe, 1912; Paranavitana, 1970; Seneviratne, 1984; 1992; Senanayake, 2007).

Subsequently, King Vasamba (69-109 CE) supported the construction of the chapter house at Isurumuni temple (*Mahāvaṃsa,* ch 35 vv87-88). During King Voharikatissa's reign (214-236 CE), the temple was expanded with additional residential and service buildings (*Mahāvaṃsa* ch 36 v36). The zenith of its architecture and land revenues was attained during the reign of King Kassapa I (477-495 CE), after whom the temple was renamed as 'Boyaupulvana Kasupgiri Radhmahaveher,' in honour of him and his two daughters (*Cūḷavaṃsa,* ch 39 vv10-12). This name was widely inscribed in various subsequent Vessagiriya inscriptions, including slab inscriptions of the 10th century CE., during the reign of King Dappula V (940-52 CE) (Wickramasinghe, 1912, pp. 23-39; Paranavitana, 1934. p. 4; Senanayake, 2007).

The historical overview of Vessagiri Monastery shows that it was an active monastic site from the 3rd century BCE to the 10th century CE. During this timespan, the monastery underwent significant architectural and religious changes supported by both the community and royalty. The strategic location of Vessagiri at a key entrance point into Anuradhapura from its south, would have attracted the attention of political, religious, and social powers across cultural phases.

Archaeological evidence and historical textual sources from Sri Lanka clearly demonstrate the history of the Vessagiri archaeological site. Bell provides detailed reports on the state of the Vessagiri site as of 1906 and describes the early excavations carried out in 1907 between Rock A and B (Bell, 1911, pp. 1-7). The 2006 Vessagiri Archaeology Project, directed by the third author if this article, was a joint archaeological project associated with the Jetavana Project of the Central Cultural Fund, the National Department of Archaeology and the University of Peradeniya. The project aimed to explore and distinguish various cultural phases, including unidentified periods prior to the early historic era of Vessagiri, and to determine the site's connection to Isurumuniya. It also focused on studying the expansion and development of the Vessagiri monastery and settlement across different times and phases. The project thoughtfully incorporated interdisciplinary and multidisciplinary approaches to achieve these objectives. Archaeological explorations and excavations took place from 2006 to 2007 (Senanayake, 2007; Mendis, 2008). The soil analysis of the Vessagiri site played a crucial role in this multidisciplinarity. Several test pit excavations were conducted to meet the project's objectives. Soil samples were collected from the area adjacent to Rock B of Vessagiriya using the auger method, drilling into the soil to obtain samples.

For context on timelines, a summary of cultural phases at Vessagiriya is provided below (Mahāvaṃsa; Cūḷavaṃsa; Bell 1911; Wickramasinghe, 1912; Paranavitana, 1970; Deraniyagala, 1972, 1992; Seneviratne, 1984; 1987; 1990; 1996; Senanayake, 2007; Mendis, 2014; Mendis et.al., 2017):

Phase I Prehistoric - 3900 - 11th century BCE
Stone tools (microliths) of the "Mesolithic" period

Phase II Protohistoric (Megalithic) - 10th - 4th century BCE
BRW, small-scale irrigated cultivation in the first phase of Early Iron Age

Phase III Early Historic - 3rd century BCE - 4th century CE
(drip-ledge caves and Brahmi Inscriptions of the Second phase of Early Iron Age

Phase IV Late Historic - 5-10th century CE
Monastic Architecture, Painting, Inscriptions

Phase V Medieval - 13th - 18th century CE
Time of abandonment, a declining period

Phase VI Colonial - 19-20 th century CE
Intervention of Archaeological Survey of Ceylon in recording, exploration, excavation, and conservation

Phase VII Modern - 21st century CE onwards
Recent human activities

This paper includes a characterization of soils at the Vessagiriya site in relation to different cultural phases identified by prior excavations and archaeological evidence from the site. Two main cultural phases extending to 3900 BCE and complementary to the sequence at the Citadel at Anuradhapura have been identified from Vessagiriya (Deraniyagala, 1992; Seneviratne, 1984; Mendis, 2014; Mendis et. al., 2017). These phases encompass the prehistoric phase (ca. 3900 BCE). (Deraniyagala, 1972) and Early Iron Age (megalithic period) (ca. 950 – 400 BCE) (Deraniyagala, 1972, 1992; Seneviratne, 1984;1987; 1990; 1996). Since the identification of these phases was largely based on *in situ* artifacts, it was essential to have supportive evidence to substantiate these findings. Therefore, the objectives of this study were to characterize soils at the Vessagiriya site and relate the variation of soil properties to different cultural phases identified by prior excavations.

Materials and Methods

This study was conducted at the Vessagiriya archaeological site in Sri Lanka in 2007. The location of the sampling site was at $8^0$06.32'N and $80^0$28.21'E, where artifacts belonging to prehistoric and Early Ion Age (EIA) were found (Mendis, 2008; 2014; Mendis et. al., 2014). The soil profile consisted of five major soil layers at the depths of 0-25 cm (L1), 25-37 cm (L2), 37-55 cm (L3), 55-89 cm (L4) and 89-168 cm (L5). Since the soil profile has been exposed to the external environment for a considerable time span, samples were obtained by auguring near the profile. Soil samples were air dried and fraction < 2 mm was separated, passing through a 2 mm round hole sieve for subsequent analysis. Three replicates were analyzed for each parameter in all five layers. Means were computed by performing One Way ANOVAs using SAS software (Elliott, 1995).

Determination of soil texture and sand fractions

Forty grams of soil was treated with drops of 30% H_2O_2 until no more frothing was observed which ensured that all the organic matter in the sample was oxidized. Ten milliliters of 5% sodium hexa-metaphosphate and 100 ml of distilled water was added and kept overnight to facilitate chemical dispersion of soil particles. Then the soils were stirred for 10 minutes to ensure proper dispersion. After these pre-treatments, the relative proportions of silt and clay were determined by the pipette method as described by Gee et al. (2002). The sand fraction was oven-dried and segregated into five groups according to the size of the particles using a nest of sieves. The particle sizes of the five groups were 1-2 mm (very coarse sand), 0.5-1 mm (coarse sand), 0.5-0.3 mm (medium sand), 0.3-0.1 mm (fine sand) and 0.1-0.05 mm (very fine sand). Using the relative weights of these sand fractions, fine sand/silt and medium sand/silt ratios were derived for each layer.

Determination of soil organic matter

Soil organic matter contents in each layer were determined by the Walkley and Black method (Nelson et al., 1996) in which the amount of $Cr_2O_7^{-2}$ reacting with organic C was determined using the titrimetric method. Organic C was converted into organic matter content by assuming that soil organic matter contains 58% of organic carbon.

The determination of total P and inorganic P fractions

The digestion of 0.3 g of the soil sample was done using 1 ml of aqua regia (1 ml of 36% HCl and 3 ml of 70% HNO_3) and 1 ml of 48% HF acid as described by Hossner (1996). Insoluble metal fluorides appeared as white residue, which remained after the digestion was dissolved using 100 ml of saturated H_3BO_3 acid solution. The resulting solution was tested for their P contents using the ascorbic acid method (Kuo, 1996).

Inorganic P fractionation

Inorganic P was fractionated into three categories. They were:

Fraction 1: Easily extractable P containing loosely bound Al-P, Fe-P and resorbed by $CaCO_3$ and P in solution

Fraction 2: Tightly bound P incorporated with Al, Fe oxides and hydrous oxide

Fraction 3: Calcium Phosphate

The fractionation scheme proposed by Kuo (1996) for calcareous soils was used to extract the above three P fractions in each layer. The extraction of the P fractions in 1.0 g of soil was done using 50 ml of 0.1 M NaOH and 1 M NaCl (Fraction 1), 40 ml of 0.3 M $Na_3C_6H_5O_7$ and 5 ml $NaHCO_3$ (Fraction 2) and 50 ml of 0.5 M HCl (Fraction 3). Phosphorous contents in the extractions were determined by the ascorbic acid method (Kuo, 1996).

The total inorganic P in each soil layer was determined by the summation of the above three fractions. Percentage contribution of each fraction to the total inorganic fraction was taken as a parameter for the interpretation. The relative proportions of P fractions can be effectively used to demarcate different land use systems, and thus different cultural phases in archaeological sites (Eidt, 1984). The existence of similar inorganic P proportions in different soil layers aids the conclusions that respective layers were developed under the same cultural phase whereas different inorganic P fractions implies that they were formed under the influence of activities during different cultural phases.

Results and Discussion

The soil data obtained for each layer at the Vessagiriya site were interpreted based on the identification of different cultural phases established in prior excavations. Figure 1 expresses the suppositions indicated by the associated artifacts. The deepest layer (L5), yielded microliths made out of chert and quartz and was recognized as the depositions that occurred during the Prehistoric phase (Phase I) dating to approximately 5000 BCE. During this period advanced stone tool technology existed and implements such as hand axes, scrapers and chisels were made using chert and quartz (Deraniyagala 1972; 1992; Mendis et.al. 2017).

Layers named as L3 and L4 were speculated as the depositions that occurred during the Early Iron Age (EIA) dated to 900-500 BCE (Mendis, 2014; Mendis et al., 2017), based on the observed artifacts from excavation VGHL EX2 (Figure 2). This observation is complementary to the results obtained by the excavations at the Citadel of Anuradhapura where the existence of a society approaching complexity during the period of 800 - 300 BCE was identified (Deraniyagala, 1992), when human habitations are characterized by the establishment of settled agriculture and the introduction of irrigation techniques. The introduction of iron technology, the manufacture of Black and Red Ware (BRW pottery), and the development of organized burial centers are the other features of the EIA. With this background at hand, the soil properties in each layer were interpreted.

Soil texture

Soil texture refers to the relative proportions of different mineral fractions found in soil. Soils in all layers were sandy in texture containing more than 50% of sand. The layers contained comparatively low silt and clay proportions, which represent a particle size of less than 0.05 mm in diameter according to the USDA classification (Gee et al., 2002). According to George and Christopher (1998), relationships of the ratios between coarse and fine particles are used to differentiate sedimentary facies: the portions of a rock unit with a distinctive group of characteristics that differs from other parts of the same rock unit. Therefore, a soil profile that is not disturbed by an external factor shows similar ratios of different textural fractions in all soil layers, although the individual proportions of different textural fractions may be different among the layers. As indicated in Table 1, the ratios of different mineral fractions vary among the soil layers. It expresses that the soil profile development was disturbed by external factors. Since early civilizations were mostly associated with the availability of water resources, there is a higher probability of disturbing the soil profile development by sedimentation processes.

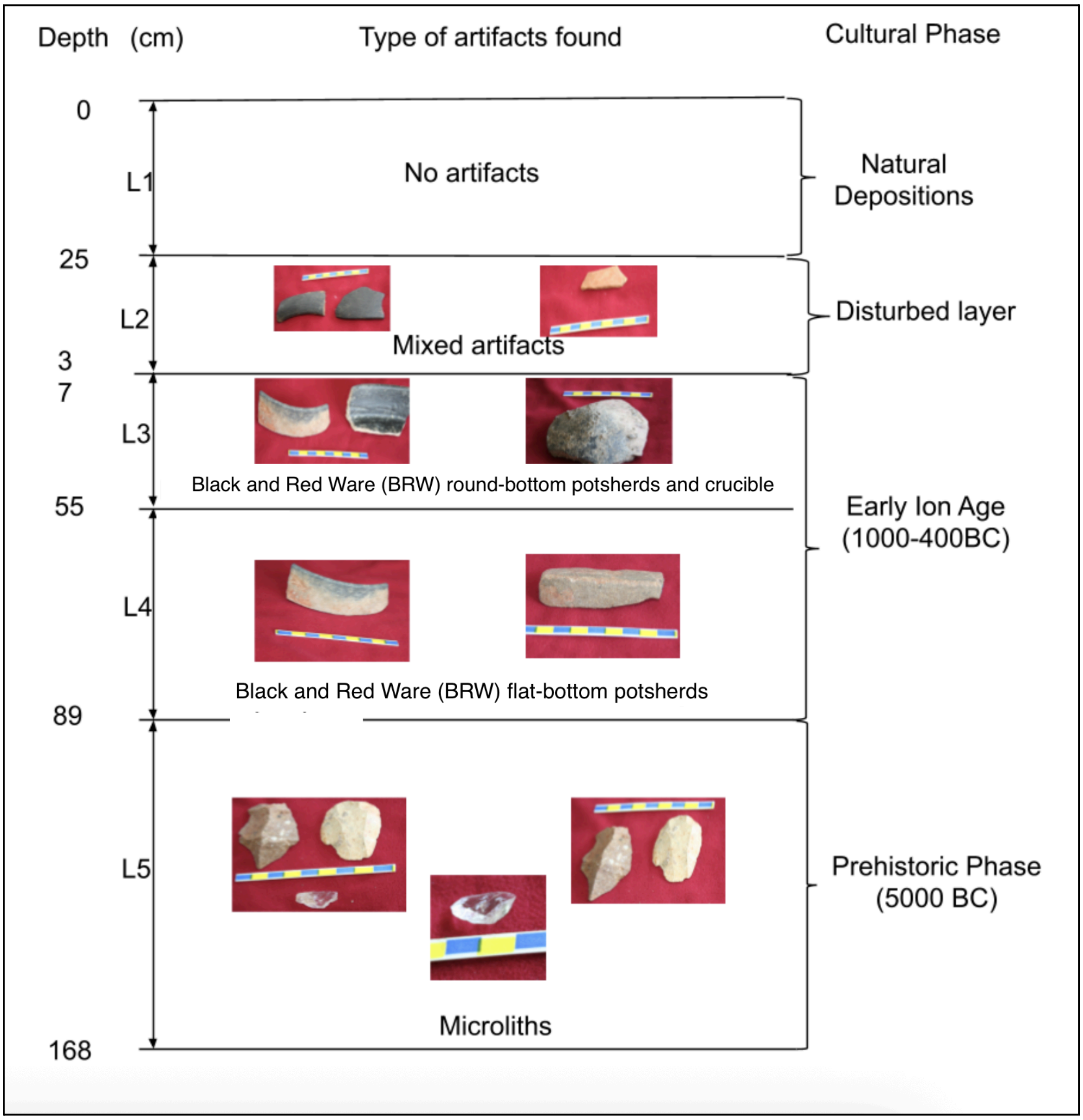

Figure 2. Sketch of a soil profile including associated artifacts within the cultural phases presumed in each horizon at the Vessagiriya site. (Scale: 1 cm divisions)

The sandy texture of soils in all five layers and low organic matter content indicate that the soil profile development had not been affected by sedimentation, which is a process that increases silt and clay contents in respective locations. The influence of anthropogenic activities could be another factor that was responsible for the disturbance of the natural soil development process.

Table 1. Means of fine sand/silt and medium sand/silt ratios in each soil horizon at the Vessagiriya excavation site.

Horizon Depths (cm)	Fine sand / Silt	Medium sand / Silt
0-25 (L1)	0.52* b	0.43* c
25-37 (L2)	0.53 b	0.57 b
37-55 (L3)	0.56* b	0.40* c
55-89 (L4)	0.91 a	0.95 a
89-168 (L5)	0.94 a	0.94 a

(Values followed by the same letter are not significantly different at the 0.05 probability level. The diameter range of the fractions considered as fine sand, medium sand and silt were 0.1-0.3 mm, 0.3-0.5 mm, 0.002-0.05 mm respectively)*

Soil organic matter content

The highest organic matter content found among the soil layers was 1.2%. The gradual decreasing of soil organic matter content was noticed along the soil profile, as in the case of a well aerated soil. The consequence of accumulation of water on the soil surface over a sufficient time span causes the development of an anaerobic condition, resulting in the accumulation of soil organic matter within the soil profile. Since remarkably higher organic matter content was not observed among soil layers, this land was probably not under submerged conditions. This observation indicates that the chance of sedimentation during the profile development was very slight, complementary to the explanation derived from the soil texture analysis. These facts prove that the soil profile development was disturbed by anthropogenic activities but not by sedimentation. The presence of primary artifacts in L3, L4 and L5 layers strengthen the point that the soil was developed under the influence of human activities.

Total P content

The deposition of chemicals, mainly heavy metals and Phosphorus (P), is a major consideration for archaeological sites (Aston et al., 1998; George et al., 1998; Barba 1994; Moore et al., 1988; Eidt, 1984). Among these chemical deposits, P is considered as the widely used element to investigate past settlement patterns, because it largely contributes to the enrichment of soils in dwelling areas (Aston et al., 1998; Eidt, 1984). In addition, the loss factor of soil P is very low. When soluble P is released to a soil solution it is fixed in Fe, Al oxides and hydrous oxides, and accounts for the soil solid phase. With regard to long term reaction products, no indicative studies exist showing an increase or decrease in the amount of P in solid phases in a soil, upon addition or removal of soil P (Sims et al., 2005).

The variation of total soil P among the layers is indicated in Figure 3. The top two layers marked as L1 and L2 recorded the highest P concentration compared to the other layers. It was approximately five times higher than the minimum P concentration found in layer L4 . As Aston et al. (1998) described, in past settled areas the ratio shown by the P content in a location to the lowest P content in a nearby area is a measure of the degree of relative disturbance resulting from human activities. Accordingly, the relative degree of disturbance in L1 and L2 layers was almost five times higher than that of L4 layer. Similarly, the L3 and L5 layers, which contained statistically similar total P concentrations, indicate relative disturbance that is twice as high as in the L4 layer.

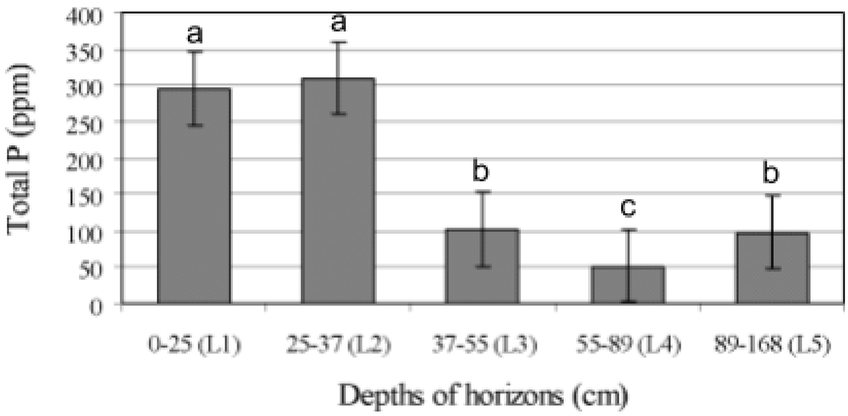

Figure 3. Total P concentration in each soil layer at Vessagiriya excavation site. *(Values followed by the same letter are not significantly different at the 0.05 probability level)*

Since the soil profile was developed under human influence, the significant relative variation of soil P contents is a consequence of the existence of 1) different land use systems, 2) a continuation of the same land use system in different intensities, and 3) the persistence of the same land use system within different time durations.

Soil inorganic P fractionation

The distribution of inorganic P within the three fractions mentioned in the materials and methods section above, behave as a ‘signature’ or ‘print’ for a specific land use system (Moore et al., 1988; Eidt, 1984). This hypothesis can be applied to differentiate land use systems or cultural phases in an archaeological site. Fraction 1 represents the easily available portion of soil inorganic P whereas fraction 2 and fraction 3 include the fixed P and calcium phosphate respectively. According to Table 2, the deepest layer, L5, showed different proportions of soil P fractions when compared to others. It relates to a completely different land use system adapted by human settlements during the formation of the L5 layer. Layers marked as L3 and L4 demonstrated similar signatures in inorganic P fractions indicating the existence of similar land use systems during their formation. As represented in Figure 3, the total P concentrations of L3 and L4 layers were dissimilar. Such observations are possible when the same land use system existed in different intensities or in different durations. With the help of prior excavations, L3 and L4 layers were predicted as the developments that occurred during the Early Ion Age (Figure 2).

Table 2. Three different inorganic P fractions as a percentage of total inorganic P in each soil layer at Vessagiriya site.

Horizon Depths (cm)	Fraction* 1%	Fraction* * 2 %	Fraction* * * 3 %
0-25 (L1)	2.1	74.8	24.3
25-37 (L2)	2.3	74.5	24.6
37-55 (L3)	7.2	24.1	69.0
55-89 (L4)	9.5	22.7	69.4
89 -168 (L5)	4.5	83.3	13.7

*(*Easily extractable P containing loosely bound Al-P, Fe-P, resorbed by $CaCO_3$ and P in solution. ** tightly bound P incorporated with Al, Fe oxides and hydrous oxides. *** Calcium Phosphate)*

It is documented that the transformation of the Prehistoric phase to Early Iron Age in Sri Lanka had taken place swiftly, whereas in many other Eurasian settings, a gradual change has been witnessed (Seneviratne, 1984). In many locales in Sri Lanka, the Protohistoric or Megalithic cultural phase (Phase II) follows the enduring microlithic techno-period of the Prehistoric Phase. Sri Lanka began to show this rapid transition around the 10th century BCE, influenced by the Megalithic culture of peninsular South Asia. This phase is characterized by small-scale farming, the domestication of plants and animals, small village tanks, small rainwater-harvesting projects, the use of Black and Red Ware (BRW) pottery for storage and daily use, small-scale settlements, the use of iron tools, and megalithic burial traditions. Additionally, this period shows noticeable population growth and the expansion of land used for settlements, farming, and irrigation (Seneviratne, 1984; 1987; 1990).

The strong agricultural potential with abundant supply of water, the presence of dense equatorial rainforest and deep soils with iron ore that could be used for iron implements, are considered as major factors that attracted people who intruded on the existing cultures of the Prehistoric Phase (Seneviratne 1984; 1987; 1990). The drastic variation in the proportions of soil inorganic P fractions from L5 to L4 also support the fact that cultural activities shifted extensively.

Similarly, L1 and L2 layers showed the same inorganic P fractionation signature, indicating the existence of the same land use system which was different from the other two cultural phases discussed above. As stated earlier, artifacts were not discovered from the L1 layer but it does not convey the idea of an absence of human settlements during its formation. Aston et al. (1998) identified sites having few archaeological remains as human occupied areas by analyzing soil properties. Artifacts belonging to several cultural phases were revealed from the L2 layer, suggesting the disturbance of archaeological evidence in this layer.

In addition to identifying differentiation in land use systems, the relative age of soil could be derived from the inorganic P fractionation procedure (Eidt, 1984; Moore et al., 1988). As shown in Figure 4, the fixed P, which was named as fraction 2 in the P fractionation procedure, increased with the time of soil development, while other two fractions declined. This phenomenon facilitates the determination of relative age of the soil. The relative proportion of fraction 2 is highest in the L5 layer (Table 2), indicating that the L5 layer possesses the most mature soil within the soil profile. Soils in L3 and L4 were less mature than the soil in the L5 layer. Therefore, it is possible to claim that the cultural phase responsible for the development of the L5 layer is older than the cultural phases that occurred during the formation of L3 and L4 layers; a fact corroborated by the artifacts from those layers.

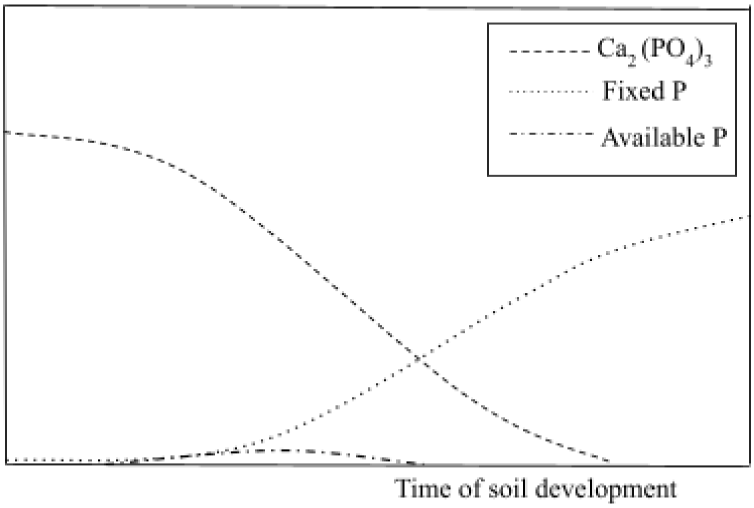

Figure 4. Relative distribution of major forms of soil inorganic P as related to time of soil development (Sims et al., 2005)

The two top soil layers identified as L1 and L2 exhibited higher proportions of inorganic P fraction 2 compared to the two layers deposited below, named as L3 and L4. This is a problematic observation that needs further investigation using geological evidence about the soil formation and site evolution processes. However, the extrapolation of soil forming process with soil inorganic P fractionation data needs careful investigation combined with the awareness of complexities in soil forming process and the concept of divergent evolution in soils. As pointed out by Moore et al. (1988) loading a site by anthropogenic deposits stimulates plant growth, nutrient cycling and the change in the type of vegetation. This can lead to retaining P primarily within the organic fraction. Therefore, further studies are required to establish clear relationships of soil forming process and the behaviour of P in soils.

Conclusion

Based on archaeological and historical textual sources, the Vessagiri micro and macro-regions exhibit several distinct cultural stages: the microlithic phase of the Prehistoric period, the Black and Red Ware culture of the Protohistoric period, the Early Historic period, and the Late Historic period, before the site was abandoned during the medieval period and finally, when the Archaeological Survey of Ceylon intervened for study and conservation during the colonial period. Different fine sand/silt and medium sand/silt ratios, sandy soil texture and low soil organic matter content among the soil layers proves that soils at the Vessagiriya archaeological site developed under human influences. The relative proportions of soil inorganic P fractions significantly varied among the cultural phases identified by prior excavations. Therefore, analyzing the distribution of inorganic soil P across different fractions can serve as a method to distinguish various cultural phases, especially from the prehistoric to the historic periods.

The soil layers can be assigned to different cultural phases based on the relative dating system, derived from the material culture discovered within each respective layer. However, this study recommends that additional scientific research be conducted at the site, particularly involving the collection of soil samples from various locations within the micro and macro regions of Vessagiri, followed by the application of absolute dating techniques to establish a chronological framework to obtain a precise timeline for Vessagiri.

Acknowledgements

This was a joint project led by Prof. Sudarshan Seneviratne and conducted by the Department of Soil Science, Faculty of Agriculture, Department of Archeology, Faculty of Arts, University of Peradeniya, Sri Lanka, Central Cultural Fund and Government Department of Archaeology. The authors would like to acknowledge the support given by Prof. Thusitha D. Mendis at the Vessagiriya excavation site, Dr. D.K. Jayarathne and Ms. D. K. Ellepola, Department of Archeology, Faculty of Arts, University of Peradeniya. The editorial work undertaken by the *Ancient Lanka* team is appreciated.

References

Aston, M. A., Martin, M. H. & Jackson, A. W. (1998). The potential for heavy metal soil analysis on low status archaeological sites at Shapwick, Somerset. *Antiquity, 72(278),* 838-847. https://doi.org/10.1017/S0003598X00087445

Barba, L. (1994). The old soil as a source of new archaeological information. In *Commission V: Symposia* (vol. 6, pp. 321–329). International Society of Soil Science.

Bell, H.C.P. (1911) Archaeological Survey of Ceylon Annual Report 1907, Colomo: Government Printer Ceylon.

Blume, H & Leinweber, P. (2004), Plaggen Soils: landscape history, properties, and classification. Journal of Plant Nutrients and Soil Science. 167(3):319-327. DOI: 10.1002/jpln.200420905

Deraniyagala, S. U. (1992). *The Prehistory of Sri Lanka, Part I & II: an ecological perspective (*2nd ed.). Department of Archaeology Survey.

Deraniyagala, S. U. (1986). Excavations in the Citadel of Anuradhapura: Gedige 1984, a preliminary report. *Ancient Ceylon*, *6*, 39-47.

Deraniyagala, S. U. (1972). The Citadel of Anuradhapura 1969: Excavations in the Gedige area.*Ancient Ceylon*, *2*, 48-169.

Deraniyagala, S.U (1971). Prehistoric Ceylon - a summary in 1968. *Ancient Ceylon, 1,* 3-46.

Deraniyagala, S. U. (1992). *Pre-history of Sri Lanka: An ecological perspective*. (Vol. 2). Department of Archaeology Survey, Government of Sri Lanka.

Geiger, W. (1929). *Culavamsa: Part I* (Mabel Rickmers English translation). Pali Text Society.

Geiger, W. (1912). *The Mahavamsa or the great chronicle of Ceylon*. Pali Text Society.

Eidt, R. C. (1984). *Advances in abandoned settlement analysis: Application to prehistoric anthrosols in Colombia, South America.* University of Wisconsin: Milwaukee.

Rapp, R. J., Hill, C. L. (1998). *Geoarchaeology: The earth science approach to archaeological interpretation.* Yale University Press.

Gee, W. G. & Or, D. (2002). Particle size analysis. In J. H. Dane & G. C. Topp (Eds.). *Methods of soil analysis, part 4 physical methods (*pp. 151–184).Soil Science Society of America. https://doi.org/10.2136/sssabookser5.4.c12

Hossner, L. R. (1996). Dissolution of total elemental analysis. *In* Sparks, D. L. Sparks, A. L. Page, P. A. Helmke, R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston & M. E. Sumner (Eds.). *Methods of soil analysis, part 3: Chemical methods* (pp. 49–64).Soil Science Society of America. https://doi.org/10.2136/sssabookser5.3.c3

Kuo, S. (1996). Phosphorous. In D. L. Sparks, A. L. Page, P. A. Helmke, R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston & M. E. Sumner (Eds.).*Methods of soil analysis, part 3: Chemical methods* (pp. 869–919). Soil Science Society of America. https://doi.org/10.2136/sssabookser5.3.c32

Mendis, T. (2008). A New Cultural Road Map to Anuradhapura A Material cultural at Vessagiriya. In Heritage Achievement, Colombo, Sri Lanka: Central Cultural Fund

Mendis, T. (2014). An Archaeological Analysis on Proto and Early Historic Landscape in Anuradhapura Citadel, Jethavanarama and Vessagiriya micro sites. Samodhana: Journal of Faculty of Social Sciences and Humanities 3(1): p.1–6.

Mendis DT, Abeywardana N, Withanachchi CR (2017) An archeological study to identify the ancient settlement pattern of Anuradhapura with special reference to the “Deegapasana” rock outcrop in Sri Lanka. Heritage 6(3):21–48

Moore, T. R. & Denton, D. (1988). The role of soils in the interpretation of archaeological sites in Northern Quebec. In J. L. Bintliff, D. A. Davidson & E. G. Grant (Eds.). *Conceptual issues in environmental archaeology* (pp. 26–24). Edinburgh University Press.

Nelson, D. W. & Sommers, L. E. (1996). Total carbon, organic carbon and organic matter. In D. L. Sparks,A. L. Page, P. A. Helmke,R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston & M. E. Sumner (Eds.). *Methods of soil analysis by Sparks* (pp. 961–1010). Soil Science Society of America. https://doi.org/10.2136/sssabookser5.3.c34

Paranavitana, S. (1970). Inscriptions of Ceylon, Vol. I, Part I, 1970, Department of Archaeology.

Senanayake, A. M. P. (2007). Vessagiriya: Epigraphy & Paleography, Proceedings of the Peradeniya University Research Sessions, Sri Lanka, Vol. 12, Part II, P.336

Seneviratne, S. (1996). Peripheral Regions and Marginal Communities: Towards an Alternative Explanation of Early Iron Age Material and Social Formations in Sri Lanka. Tradition, Dissent and Ideology: Essays in Honour of Romila Thapar: p.364–410.

Seneviratne, S. (1992). Pre-state chieftains and servants of the state: A case study of Parumaka. Sri Lanka Journal of the Humanities, 15(1-2), 99–131.

Seneviratne, S. (1990). The locational significance of early Iron Age sites in intermediary transitional eco-systems: A preliminary investigation of the upper Kala Oya system. In S. Bandaranayake, M. Mogren, & S. Epitawatte (Eds.), The settlement archaeology of the Sigiriya-Dambulla Region (pp. 121–152). Postgraduate Institute of Archaeology.

Seneviratne, S. (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,* 11, (121-132).

Seneviratne, S. & Senanayake, A. M. P. (1987). A preliminary study of a road trace from Uruwela to Ambattbakola during the early historic period. In Proceedings of the 2nd National Archaeological Congress. Colombo, Sri Lanka, Foundation Institute.

Seneviratne, S. (1984). The archaeology of the megalithic-black and red ware complex in Sri Lanka. *Ancient Ceylon 5*, 237–307. Department of Archaeology. Colombo

Sims, J. T. & Pierzynski, G. M. (2005). Chemistry of phosphorus in soils. In M. A. Tabatabai & D. L. Sparks (Eds.). *Chemical processes in soils* (Vol. 8, pp. 151–184). Soil Science Society of America. https://doi.org/10.2136/sssabookser8.c2

USDA. (1975). *Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys*. United States Department of Agriculture: Soil conservation service

Warkentin, B. P. (2006). Footprints in the soil: People and ideas in soil history. Elsevier.

Wickremasinghe, D. M. D. Z. (ed) (1912). *Epigraphia Zelanica*, London: Government of Ceylon.