Geochemical Aspects in the Palippothana Mortuary Complex

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Introduction

When consider the geochemical analysis for archaeological soil studies the general principles are based on a "life history" concept where a sediment has (1) a source, (2) a transport history, (3) an environment of deposition, and (4) undergoes post depositional alterations. A technique of that is increasing in its application in archaeological investigations is geochemical applications. This approach is advantageous of the ability of multi-element analyses to investigate anthropogenic geochemical signatures within archaeological soil systems (Wilson et al., 2008; Canti and Huisman, 2015). The relation between archaeology and soil chemistry can be described based on the enrichment or depletion in relation to Upper Continental Crustal (UCC) values of certain elements in the soil through the act of human occupation. Thus, the source and provenance signatures can be found. The archeological site based on the duration would have undergone a numerous amount of environmental changes. Environmental phenomena's such as floods, tsunamis, erosion, landslides etc., are some that could change the depositional environment of an archaeological site. The stratigraphy of the soil profile would thus explain the sequencing of deposition and the nature of the environment of that deposition. Grainsize, fossils, micropaleontology, heavy minerals are some of the disciplines that could further elaborate the status of the environment of each strata.

As for scholars, there are three major concerns about the archaeological application of geochemistry that can be identified. First, there is a general lack of analytical focus with respect to element selection and extraction. As an example, many procedure that involve extraction have attempted to study P in soils. However, there is still uncertainty about which soil phases are responsible for P retention in different archaeological settings and soil types. On the other hand, P has been proven to be an indicator that is unreliable in relation to human occupation (Entwistle et al., 1998, 2000a,b). The second is determination of the geochemical baseline comprising the natural soil composition. However, using soil composition to recognize the anthropogenic impact is often problematic (Matschullat et al., 2000). The occurrence of anomalous element concentrations in archaeological soils and the geochemical processes behind it is the third. These anomalous element concentrations are essential to mainly distinguish natural and anthropogenic influences, the elemental source tracking. However, these remain unexplored and unexplained.

One of the major drawback in geochemical investigations in archaeological soils is that the analysis is very tedious and expensive. Thus, the tendency of carrying out geochemical investigations for archaeological soils is very much less. However, in the recent past there is an interest in geochemists in investigating archaeological soils and the field of study is immerging with various geochemical aspects.

Aims and Objectives

To determine the historical events and technology that existed at a proto history burial site at Palippothana based on analysis of archaeological and geochemical context, using selected soil samples from three cores collected at a selected depth.

Sampling location

Palippothana is situated in the Northcentral Province in the Anuradhapura district at Kahatagasdigiliya – Ratmalgahawewa- Palippotāna around upper Ma Oya basin and upper Malwatu Oya basin. The excavation conducted under the code of RUSL/PP/EX1/2020, RUSL/PP/EX2/2020 and RUSL/PP/EX3/2020. The rectangular cist burial of EX1 location is 8.52254852, 80.6688265 and is a well preserved capstone. The location EX2 of 8.52245559, 80.66874884 is identified as vertically erected as parallel double orthostats without a capstone and the location of EX3 which recorded as 8.52256892, 80.66882895 is a square cist without a capstone.

The locations of the core sampling is as follows. The first core SLPPC-1 location is 488441.471 and 668273.088 and it was taken from the burial site. The second core SLPPC-2 location is 488592.396 and 668301.809 and was taken from where the settlement was found. The third core SLPP-C3 location is 488665.649 and 668376.357 and was taken from center of the village lake that fed the area.

Geochemical Analysis Methodology

First, exploration for the surrounding of the Palippothana area was done. A random survey method was carried out within the area. Archaeological data were collected through the field survey and excavations.

The archaeological excavation was carried out in Palippothana area which is a Megalithic burial site during the end of 2020 and after surveying the surrounding the burial site was identified. The burial site is extended to area of 5x4m selected for the archaeological excavation were identified on surface level. Horizontal excavation method used to excavate and context method used to remove the soil. One radiocarbon dates were taken, which was secured on human bone and it was detected by Beta Analytic, USA; (Beta – 20030256).

Three core samples (n= 50 from each core) were collected from the site using a core sampler. The 1m core samples were cut into 2cm samples. They were collected into sealed polyethylene bags and stored in a cooling box at 4^0C. Approximately 50 g of each slag samples were oven-dried at 160 °C for 48 hours before crushing. All samples were crushed using an agate piston and mold for around 20 minutes. The crushed slag samples were compressed into briquettes, using a force of 200 kN for 60 seconds. The concentrations of 16 major and trace elements were then determined by X-ray Florescence spectrometry using the EDX method.

Results and Discussion

Dating results shows that the dating is 369 - 165 cal BC. Due to difficulties in analysis three samples each from the three core samples were initially analyzed. The Table 8-1 gives the data of the analysis.

Table 1: Elemental concentrations of major and trace elements of selected samples from core 1,2 and 3.

	Core 1				**Core 2**				**Core 3**			
Depth (cm)	**2-4 cm**	**54-56 cm**	**98-100 cm**	**Avg C1**	**0-2 cm**	**36-38 cm**	**92-94 cm**	**Avg C2**	**2-4 cm**	**44-46 cm**	**92-94 cm**	**Avg C3**
Major elements (wt %)												
SiO_2	37.33	38.71	39.88	38.64	48.70	39.10	51.04	46.28	47.78	48.83	49.42	48.68
TiO_2	1.39	1.24	1.19	1.27	1.84	1.49	0.97	1.43	1.24	1.29	1.44	1.32
Fe_2O_3	5.73	6.35	6.05	6.04	5.07	5.79	6.01	5.63	4.63	5.40	5.32	5.12
MnO	1.15	1.03	0.70	0.96	1.55	1.31	0.93	1.26	0.73	2.19	2.02	1.65
K_2O	1.96	1.78	1.79	1.84	2.85	2.29	1.62	2.26	2.42	2.50	2.68	2.53
CaO	0.71	0.64	0.59	0.65	1.16	1.06	0.59	0.94	0.75	0.73	0.82	0.77
Trace Elements (ppm)												
As	2	0	0	0.69	7	3	0	3.17	20	4	9	11.01
Zn	126	128	127	127.08	131	132	130	131.20	131	135	127	131.19
Cu	53	51	53	51.99	52	52	52	51.99	50	53	68	57.11
Ni	33	19	52	34.58	28	30	23	27.06	29	19	18	22.14
Cr	39	43	39	40.45	35	36	43	37.87	40	32	38	36.76
V	458	422	433	437.84	611	502	322	478.19	428	439	492	453.03
Y	13	14	14	13.62	13	13	12	12.73	15	13	13	13.66
Zr	1373	927	808	1035.92	1345	1397	774	1172.07	986	904	924	938.32
Nb	15	4	13	10.52	16	20	6	13.93	24	14	22	19.87
Th	21	26	18	21.85	2	0	5	2.35	1	1	3	1.90

Table 8-1 Elemental concentrations of major and trace elements of selected samples from core 1,2 and 3

Elemental variation in core 1, 2 and 3

The Chart 8-1 and Chart 8-2 shows the difference in each core for Major oxides and Trace elements respectively and Chart 8-3 shows the enrichment and depletion with Upper Continental Crustal (UCC) values.

Major Oxide concentrations

The Table 8-1 and Chart 8-1 shows that the SiO_2 values are very much below UCC, thus, the Si contents have not yet achieved maturity (Bhatia and Crook, 1986). There is a difference between values of SiO_2 in core 1, 2 and 3. The core 3 which was from the Lake, shows more content of SiO_2 than the others. Thus, out of the three cores, core number three shows the highest mature content. Core number three was taken from the lake and a lake goes through many physical changes over time. In Anuradapura or northcentral province the rainfall is confined mainly to three months of heavy rainfall and a severe drought period of almost three to five months where a lake would go completely dry. During the sampling period the lake was completely dry. Therefore, the maturity increase in the lake samples may be due to the geochemical and environmental changes. Silica is lower than 50 % or around may be indicative of re-solution silica. The TiO_2 content is more or less similar in values in all three cores. The highest Fe_2O_3 content is in the core 1 yet are close in values. The MnO values also are highest in the core 3 indicating high oxidizing conditions. The K_2O values are increasing from core 1 to core 3. The potassium content represents the illite clay mineral components. The CaO content is almost similar in all three cores with slight variations.

Trace Elements concentrations

The Table 8-1 and Chart 8-2 shows that the trace element values of Arsenic is very low though in the 2-4 cm sample the concentrations are very high specially in core 2 has 7 ppm and core 3 being 20 ppm. The UCC for Arsenic is 1.5 ppm as for (Taylor and McLennan 1985) and the core three shows almost 13 times higher than UCC. It is reported that anomalously high concentrations of Arsenic is reported in mining and smelting sites (Donati, 2007). The Iron Age has started from Anuradhapura and after two centuries has spread up to the middle Yan oya basin as for Deranaiyagala 1990. In the burial sites that were found in the Yan oya basin specially iron and Cu artifacts have been found (Mendis 2016). There are many evidence that smelting has been taking place in and around the northcentral area and thus, the high arsenic content could relate to smelting activities of the settlement of the ancient times.

The concentrations of Zn, Cu, Ni and Cr values are almost similar in all three cores with slight variations. The V concentrations of cores are somewhat similar with some amount of variations. However, when compare to UCC value of 60 for V the values in all the three core samples the V concentrations are very much high which almost 7 -10 times higher than UCC is. The Precambrian high-grade metamorphic rocks in Sri Lanka consisting of Calc-silicate rocks and also marbles may carry higher concentrations of V as also found in the other parts of the world (Suwa et al. 1996; Young et al 2013). Thus, the high V content may be derived from the Calc-silicate rocks and marbles which are found abundantly in the country.

The Y values are much similar in all three ores and Nb is much similar though in core 3 it is a bit higher. Th is much higher in the core 1 and the core 2 and 3 is similar in value. The Zr is very much higher than UCC being 4 – 7 times higher than UCC and also it is highest in core three. The highest Zr concentrations are found in the 2 – 4 cm samples of the three cores. Thus the high Zr and Ti could be signatures of high weathering conditions with these areas receiving heavy rains during the rainy season.

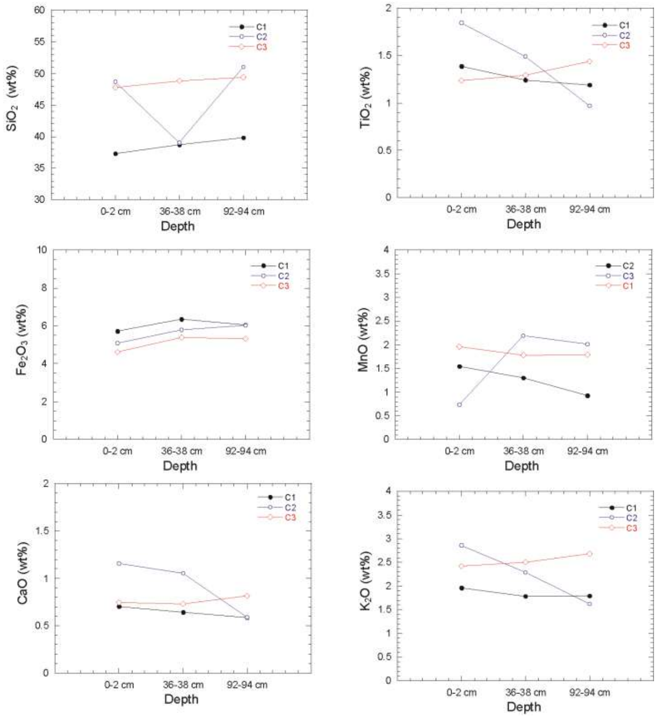

Chart 8-1 Major element concentrations of core 1, 2 and three for Palippothana archaeological burial site

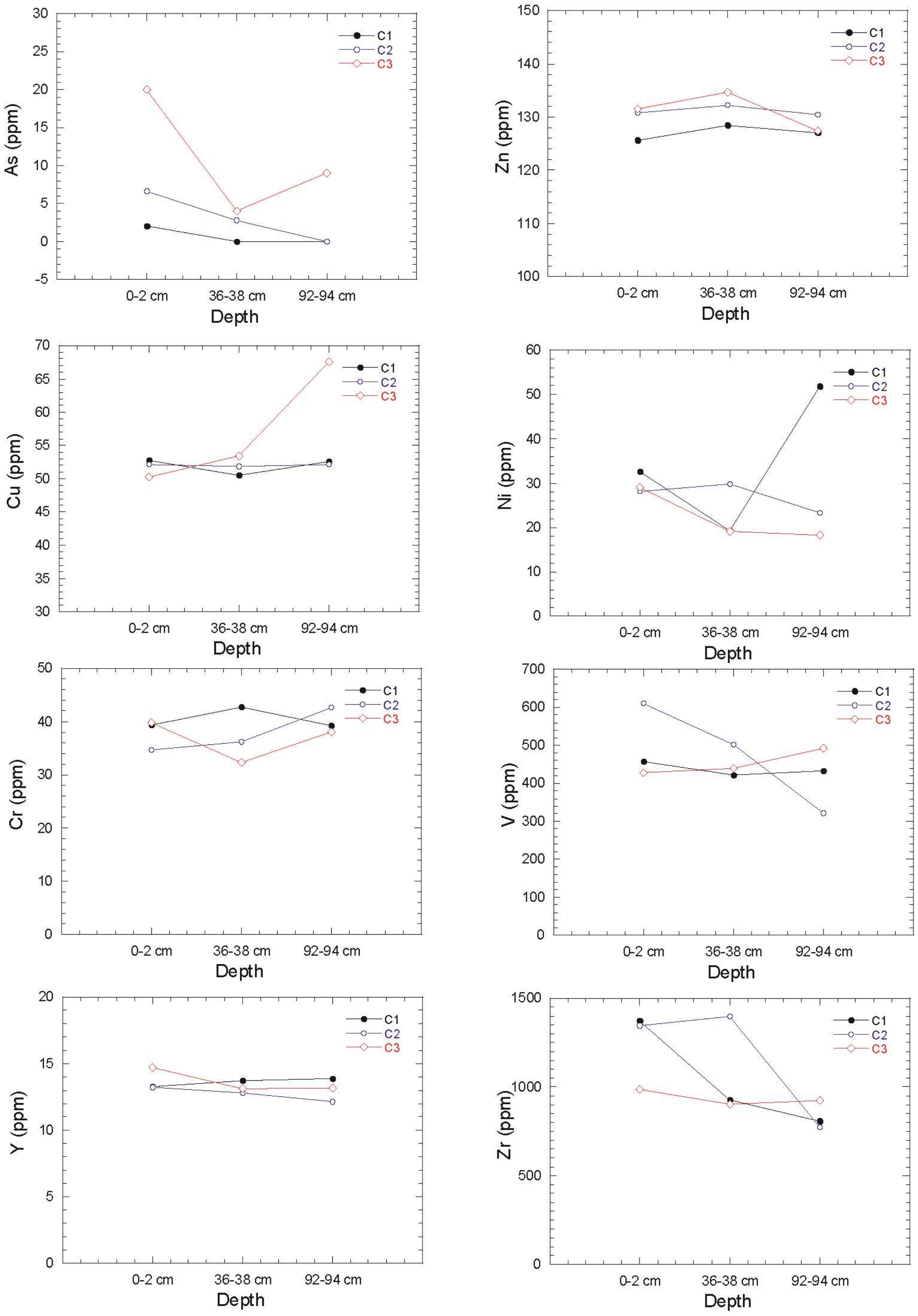

Chart 8-2 Trace element concentrations of core 1, 2 and three for Palippothana archaeological burial site

The normalization with UCC is given in Chart 8-3 and shows that TiO_2, MnO, As for core 2 and 3, Zn, Cu, Ni for core one, V, Zr, and Th in ore one are enriched. The elements SiO_2, Fe_2O_3, K_2O CaO, Arsenic for core 1, Ni for Core 3, Cr, Y, Nb and Th for core 2 and three are depleted.

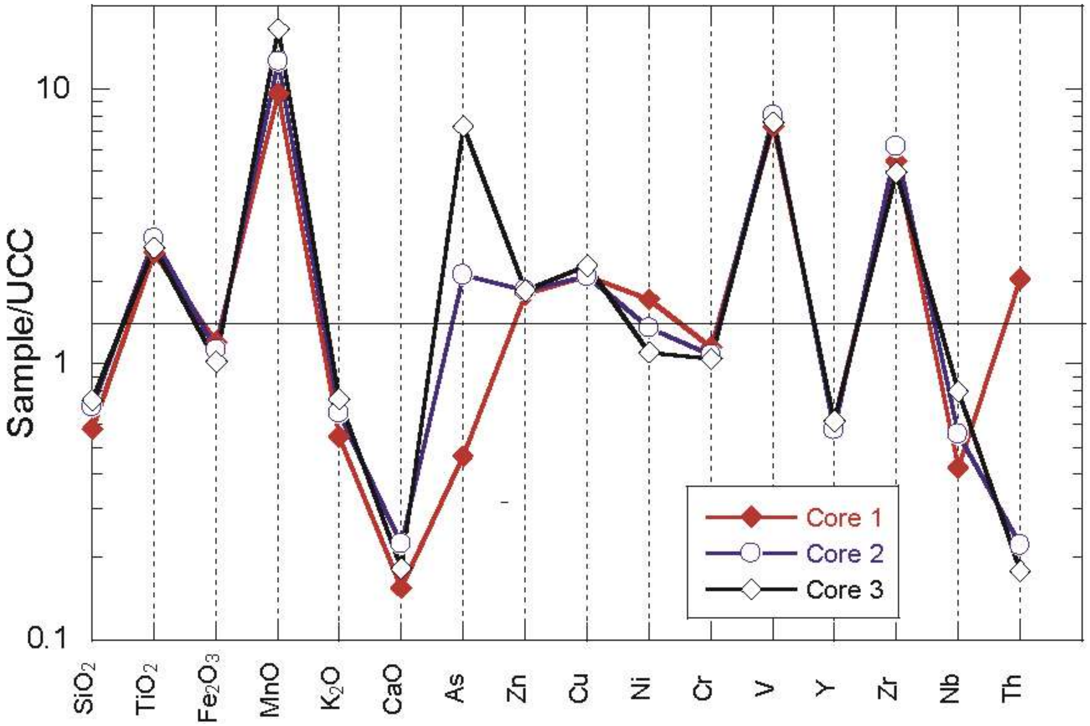

Chart 8-3 The normalization with UCC for the core 1,core 2 and core 3 soil samples

Conclusion

High Ti and Zr show strong weathering, while high concentrations of Mn represents high oxidation conditions. Silica is lower than 50 % or around may be indicative of re-solution of silica and also low maturity of silica. K are related to clay minerals such as illite. The high V content may be derived from the Calc-silicate rocks and marbles which are found abundantly in the country. The high arsenic content could relate to smelting activities of the settlement of the ancient times.

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