On the Mongolian Steppe:

A Subsurface Investigation of Soyo, Northern Mongolia

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

Abstract

Soyo is an archaeological site located in a marginal environment in the Darkhad Depression of northern Mongolia, which is positioned to answer integral questions about the arrival of pastoralism. Situated on both taiga and steppe environments this site is core to the understanding of the transition from food foraging to pastoralism. This research has incorporated a geoarchaeological approach, utilising ground penetrating radar, radiocarbon dating, stratigraphic analysis, excavation, and sediment analysis.

Little research has been conducted on Neolithic sites in Mongolia, and even less that incorporate a geoarchaeological approach. This thesis has investigated the environmental history of the site from the Neolithic to the Bronze Age, and demonstrates how Soyo fits into occupation patterns within the wider region in the mid Holocene.

In the wider region, the optimum climate occurred between 6,500 and 2,500 BP, which chronologically ranges from the Epipaleolithic/Neolithic to the Bronze Age in Mongolia. The warmer climate at Soyo allowed for the development of soils and for plants to grow and thrive. The palaeoenvironmental data implies that from ~5,000 BP onwards the climate at Soyo was humid, with cold intervals. This is evidenced at Soyo with the upper palaeosols with a correlated date of ~1,200 BP. This thesis demonstrates that Soyo is a unique site and is also a strong example of the wider palaeoenvironmental region.

Though the Neolithic in Siberia and China have been chronometrically dated to 8,000 BP and 10,000 – 8,900 cal BP respectively, the Neolithic did not occur in Mongolia till ~5,500 BP. However, this does not mean that the Neolithic did not begin 8,000 BP in Mongolia as it did elsewhere. This can be attributed to reflect the lack of chronometric dating available to researches in Mongolia, and the restriction of foreign researches to conduct archaeological research in Mongolia whilst under Soviet control. Currently the oldest date for Soyo is 10,900 BP, and it is possible that this is an example of a Mesolithic/Neolithic (12,000 – 5,500 BP) (Hanks 2010) site in northern Mongolia. Whilst Soyo does not fit into occupation patterns within the wider region in the mid-Holocene, it does strongly support a pastoralist economy.

This thesis challenges the importance placed upon agriculture, and presents an important pastoralist archaeological site by using the palaeoenvironmental history to demonstrate its significance.

Declaration of Candidate

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed,

Anthea Vella

Date: 16/12/17

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1. Introduction

People have lived in extremely marginal environments and adapted to them since the emergence of anatomically modern humans in Africa over 200,000 years ago. Marginal environments have dictated the way in which people have created and used technology in order to survive. One such example is the introduction of pastoralism in extreme environments. For many parts of the world, the arrival of the Neolithic was brought about by agriculture, however pastoralism was key to the arrival of the Neolithic at the site of Soyo in northern Mongolia's Darkhad Depression.

This thesis is about the relationship between marginal environments and the people that lived within them. The subsurface sediments of Soyo detail how people were able to live in a marginal environment during the Neolithic. Through the use of geoarchaeological techniques, in particular archaeological geophysics, a clear image of the subsurface has been created which is not possible to accomplish without wide area deep excavations. Palaeosols are core to this investigation as it provides the recreation of the palaeoenvironment and past living/occupation surfaces. This thesis correlates environmental data with the known archaeological record in order to demonstrate that a flourishing pastoralist economy preceded any form of agriculture in a northern Mongolian setting. Soyo is a prime example of an occupied marginal environment during the Neolithic in Mongolia. This thesis directly demonstrates how archaeological data can be used to compliment existing environmental data. The adoption of pastoralism across Mongolia and the steppe environments has shaped the way in which people interacted with the environment.

Northern Mongolia is characterised by the steppe and taiga environments. The steppe is grasslands; the taiga is forests; and Soyo is at the intersection of these ecotone environments. Over the past 10,000 years, the steppe-taiga border may have shifted as a result of environmental changes and human induced impacts. These changes include varying precipitation and temperature, animal domestication and grazing, forest clearance, fire and woodcutting (Fitzhugh 2002:13). The environment dictated the mobility of people in times of changing climatic conditions. By investigating the environmental history, a broader understanding of the conditions that people experienced can be created, and this in turn provides insight into the way Soyo was occupied as a settlement. This includes insight into the seasonality of Soyo as a campsite; occupation and abandonment of the site; animals that were kept for herding; what animals were hunted or fished; and inferences about when people were more mobile in regards to specific climatic periods. This research is therefore well positioned to give new insight into Soyo as a Neolithic site, the environmental conditions, and the way in which people adapted to new technologies in northern Mongolia during this period.

Soyo is a Neolithic archaeological site located west of Khövsgöl Nuur, also known as Lake Hövsgöl, in the Darkhad Depression of northern Mongolia, Figure 1. Soyo is also a multicomponent site that spans from the Palaeolithic right through to modern activity, but has major cultural phases from the Neolithic to the Bronze Age. As mentioned above, the taiga and the steppe feature prominently at this site. People have used this site since the end of the Last Glacial Maximum (LGM), but Soyo has been seasonally inhabited at least for the past 7,000 years. The cold climate has preserved the aeolian, fluvial, and glacial depositions well at this site, as evidenced by the stratigraphy at the site. Soyo is one of the very few stratified sites in Mongolia.

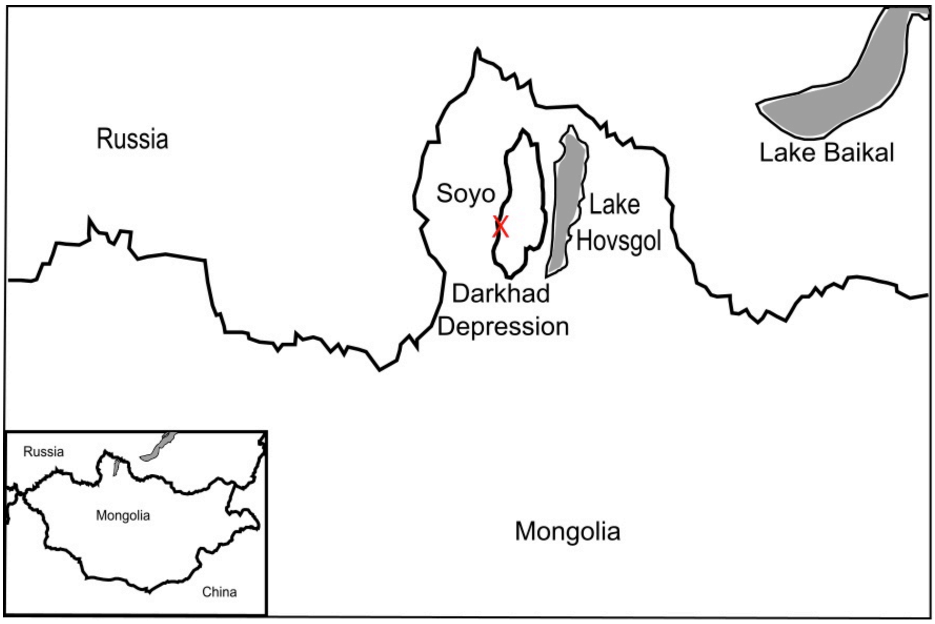


Figure 1. Location of Soyo, Darkhad Depression, northern Mongolia

The Neolithic is traditionally considered to be present at an archaeological site with evidence of agriculture. This is due to the extensive literature on the Neolithic, particularly in the Levant/the Near East (Bar-Yosef 1998; Childe 1936, 1950; Cole 1970; Simmons 2007). In northeast Asia, the Neolithic is characterized by the evidence of pottery, and this will be detailed further in chapter two. Pastoralism is an important way of life and still occurs in Mongolia (Honeychurch 2010; Marin 2008; Neupert 1999; Zhizhong and Wen 2008). In northern Mongolia, the adoption of pastoralism over agriculture was primarily due to the harsh environmental conditions, which still makes agriculture an unproductive subsistence system today (Clark 2014:6). For the majority of the year Soyo is cold and the ground is covered by snow. Although grasses do grow in this environment, the landscape is not conducive to agriculture, and this environment creates extremely difficult conditions. This presents an obvious need to be mobile in this environment, and to also have a supporting economy. Pastoralism is a well suited adaptive strategy for this, and Figure 2 demonstrates the dynamics of this. Pastoralism is defined as a form of subsistence that is reliant on herds of domestic stock and is also based around breeding and herding pasture animals (Cribb 1991:17; LaBianca 2004:116). Animals such as goats, sheep, cows, and horses are well suited to herding, and can adapt to colder climates, and in this instance are a more reliable food source than what crops would be.

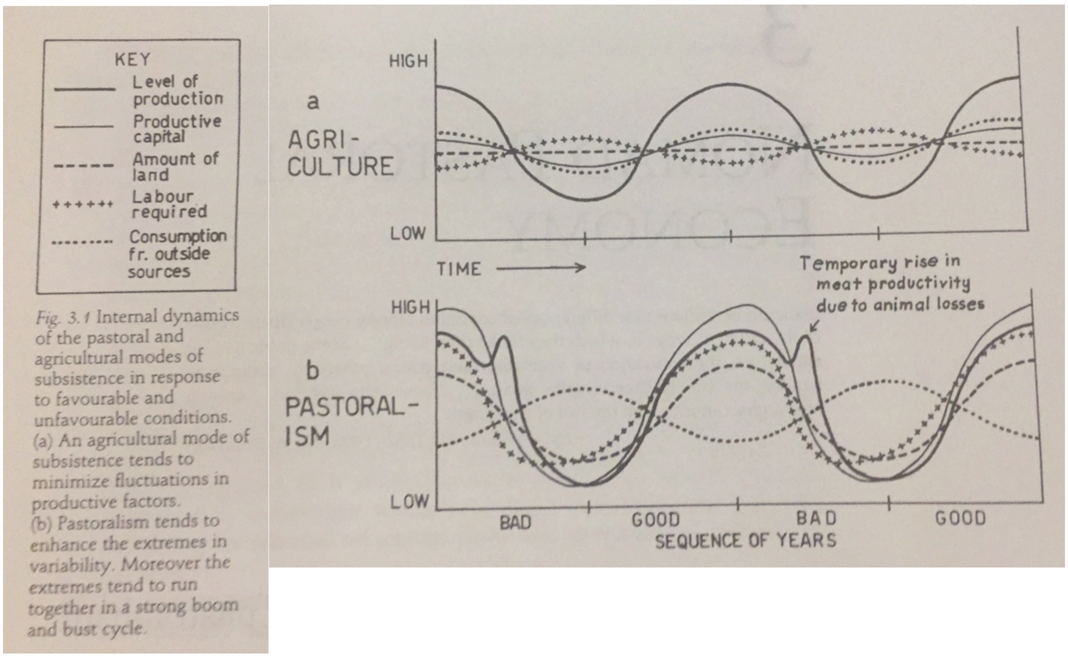


Figure 2. Dynamics of pastoralism and agriculture (Cribb 1991:24)

The primary aim for this thesis was to conduct a geoarchaeological investigation on the site of Soyo in order to establish a robust chronology and define the environmental history. A definitive site chronology for Soyo will place it in relation to other Neolithic sites across Eurasia, and within the existing chronology for Mongolia (Table 1). As demonstrated by the table below, the Neolithic is replaced in terminology by the Epipalaeolthic, which does not completely separate itself from the Palaeolithic, technology wise.

Table 1. Key periods in Mongolia (Clark 2014:18)

Period	Date Range
Upper Palaeolithic	7,000 BCE – 6,000 BCE
Epipalaeolthic	6,000 BCE – 3,400 BCE
Early Bronze Age	3,400 BCE – 1,600 BCE
Late Bronze Age	1,300 BCE – 700 BCE
Terminal Bronze Age- Early Iron Age	700 BCE – 150BCE
Iron Age	150 BCE – 300CE

This research has utilised a multidisciplinary approach incorporating archaeology, geophysics, and geology. Specific methodological applications from each of these distinctive fields have greatly aided this research. These applications included excavation, radiocarbon dating, GPR (ground penetrating radar), stratigraphic analysis, XRF (X-ray fluorescence), and 3D mapping of the palaeolandscape.

1.1 Research Question and Aims

Throughout this thesis the phrase, "the Neolithic is not well understood in Mongolia", is a common theme. This thesis aims to change that, primarily through an investigation of the environmental history in order to understand how people interacted with marginal environments during the Neolithic. This will be explored below in the research questions and aims.

<u>Research questions</u>

- What is the environmental history of the site of Soyo from the Neolithic to the Bronze Age?
- How does the site of Soyo fit into occupation patterns within the wider region in the mid Holocene?

<u>Aims</u>

- Examine the relationship between local environmental history and that of the wider region.
- Examine the sedimentary processes and local topographic context at Soyo to establish a taphonomic history of the site.

- Analyse the relationship between occupation deposits and the wider stratigraphy of the Soyo site.
- Establish a local site chronology.
- Provide recommendations for future geoarchaeological research at Soyo.

By utilising a geoarchaeological approach, the palaeolandscape and environmental history of Soyo will be reconstructed. This allows for the primary and secondary research questions to be investigated through several methods. In July 2016 GPR, aerial photography, static GPS, XRF, excavation data (including field notes and trench drawings), and samples for radiocarbon dating were collected. In 2017, radiocarbon dating was conducted in May. Similar techniques have been used by Bladon et al. (2011), Hassan (1978), Lowe et al. (2014), Urban et al. (2014), and Sadura et al. (2006).

1.2 Significance

The majority of archaeological research in Mongolia has been focussed on Bronze Age sites, as well as monuments known as Khirigsuur (Deer Stones) (Clark 2014; Hanks 2010). Khirigsuurs are also the location of large ritual sites, and are dated to the Bronze Age (Allard and Erdenebaatar 2005). The site of Soyo has been relatively un-researched, and there is limited literature on the archaeology of the region. Specific research gaps that are present include when, how, and why pastoralism began in northern Mongolia; and when the adoption of pottery in Mongolia began (Clark 2014:44; Gibbs and Jordan 2013). The investigations at Soyo form a small part of a larger study into the Neolithic in the region (Clark 2014). The spread of this human activity is an important aspect in understanding the interaction between hunting and herding. Here, Soyo will provide an example of the Neolithic transition from hunting to herding, and presents a unique example of the Neolithic transition in an extreme environment. Extreme and marginal environments are used interchangeably in this thesis. These terms are used to describe the harsh climatic conditions of the site, which will be detailed in chapter three.

Further to this, as mentioned above, is that very little is known of the Neolithic and Early Bronze Age in Mongolia, some of which is due to the impact of the Soviet period (Clark 2014:41; Hanks 2010:471; Houle 2010:4; Schneider et al. 2016:1; Sériadés 2004:139). Although archaeological research was conducted throughout this period by Mongolian and

Soviet researchers, access to this literature is limited. The archaeology of this region has not been investigated as extensively when compared to other regions in the world (Hanks 2010:470,480). Based on this, there is an opportunity to place this research within a global context regarding the spread of pastoralism through Eurasia during the Neolithic; of Neolithic practice adaptations across different regions; the way people adapted to new technologies in northern Mongolia during this period; and fits into the wider research question of when pastoralism spread into northern Mongolia.

Finally, although environmental research and excavations have been previously carried out in Mongolia, there has not been a specific geoarchaeological investigation on the site of Soyo itself, and the excavations were yet to be dated. There are very few documented sites in Mongolia that are as well preserved, or have an assumed 7,000 year uninterrupted occupation sequence as that of Soyo. This occupation sequence has been formed through a thick stratification of interbedded fluvial and glacial sediments.

This research is significant as it utilises a geoarchaeological approach incorporating GPR, excavation, stratigraphic analysis, radiocarbon dating, and sediment analysis. This approach is rare in Mongolia, and as such this thesis aims to add to the regional and international literature on Neolithic settlements from northern Mongolia, and to fill the research gaps in the literature.

1.3 Background to Soyo

The joint Mongolian-American Deer Stone Project (Fitzhugh 2005) initially recorded Soyo, as an archaeological site, in 2003. Their particular research interests were focussed on Khirigsuur (Deer Stones), which are megalithic monuments. Artefacts such as lithics, ceramics, and bones were observed in sand dunes, and initial work was conducted at Soyo, which included some excavation and collection.

A gold deposit was discovered above the site not long after the initial site recording, and thus the area above Soyo has been mined up until 2012/2013, with Soyo being used as a camp. This activity delayed the progression of any archaeological fieldwork. Most recently, the research program Northern Mongolia Adventure and Discovery in Science (NOMAD Science), formerly known as the Northern Mongolia Archaeology Project (NMAP), have conducted a site assessment (2014), survey, and excavation (2015 – 2017).

Over the 2015 and 2016 field season at Soyo, 14 excavations were carried out in total, which comprised of 6 stratigraphic test pits and 8 archaeological excavation pits. GPR, aerial photography, stratigraphic and sediment analysis was also carried out.

The site of Soyo covers an area of 5 hectares, and is situated in between the Soyo Hill, Figure 3, and the Hog River. Taiga (Siberian larch forest) covers the hill, and the site itself is located on steppe, with sandy dunes. The site slopes down towards the banks of the river, and previous glacial activity is apparent on the surface of the site through the remaining granite boulders. The river has played a vital role to the formation of the landscape and the river itself can vary vastly, from a quiet stream to a gushing rapid river. The ford created by this environment provides easy access to both taiga and steppe landscapes; provided a diversity of environmental resources for exploitation, and may be a reason as to why people occupied this site.

Figure 3. The Soyo Hill and surface boulders

1.4 Thesis Outline

The format and structure for each chapter of this thesis is detailed below, and also includes this chapter.

This chapter has introduced the research area, research questions and aims, key terms and concepts, research significance, and the background to the site. This introductory chapter is key to the foundation of this thesis.

Chapter 2 will explore the literature relating to the Neolithic, the current archaeological chronology of Mongolia, and pastoralism. The key concepts in the literature will be explored further in chapter 5, in conjunction with an explanation of the results.

Chapter 3 details the regional palaeoenvironmental history, which includes the landscape, climate, geology, vegetation, fauna, and Lake Hövsgöl and Lake Baikal. The regional environmental history is a core component to the research questions and aims of this thesis.

Chapter 4 will present each of the methods utilised in this thesis. These methods include background to GPR; GPR survey and processing; positioning; aerial photography; orthophoto; stratigraphic excavation; sediment; background to radiocarbon dating; and preparation of samples for radiocarbon dating.

Chapter 5 provides the data gathered from chapter 4 in figures, tables, and graphs. Data will include GPR, radiocarbon dating, sediment analysis, and stratigraphic data. Additional data for this chapter will be included in the appendix.

Chapter 6 will discuss the results gathered and will address the research questions and literature cited from chapter 2. This discussion will centre on the correlation of data including GPR, radiocarbon dates; what this tells us about the site; how the local environmental data is similar or different to the wider regional data; and how this site is related to other Neolithic sites in Mongolia.

Chapter 7 will conclude the thesis by summarising the thesis, addressing the limitations or constraints of the methods, and focusing on how the results have addressed the research questions and aims. The limitations of the research project will be included in this chapter. Chapter 7 will also recapitulate the main research findings of the thesis and detail where future research should be focussed.

2. Literature Review

This chapter explores the literature, key concepts and themes central to this thesis, including the Neolithic, Mongolian archaeology, and pastoralism. Research gaps in the literature will be identified.

2.1 Neolithic

The Neolithic "revolution" is arguably the largest widespread cultural transition experienced by anatomically modern humans (Bar-Yosef 1998; Childe 1936; Cole 1970; McCarter 2012:1; Weisdorf 2005). The transition from the Palaeolithic to the Neolithic instigated a social change involving a move from hunting and gathering to agriculture and pastoralism, and developed independently in China (Table 2)(Cole 1970). Table 2 lists the oldest known Neolithic sites. The Fertile Crescent in the Near East, and the Middle Yangzi River in China are the oldest of these (Bar-Yosef 1998:142). Practices that are associated with the Neolithic generally include farming, pastoralism, an increase in population density, and a more sedentary lifestyle (Bendry 2011:4; Caldwell 1977; Lemmen et al. 2011; Simmons 2007; Wesidorf 2005). In east Asia, the term Neolithic denotes the arrival of pottery but not necessarily the introduction of domesticated animals and plants (Clark 2014:44; Gibbs and Jordan 2016; Wright 2006; Zhimin 1988:758). This thesis seeks to understand how people adapted to marginal environments, i.e. Soyo, by comparing the arrival of the Neolithic to neighbouring geographic areas of China and Siberia.

Table 2. Comparison of the earliest starting points of the 'Neolithic' in different regions

Region	Chronometric Date
Near East (Fertile Crescent)	10,500 BP (Olsson and Paik 2016:199)
Central Europe	7,700 BP (Rowley-Conwy 2011:432)
Siberia	8,000 BP (Lieverse et al. 2015:25)
China	9,000 BP (Cohen 2011:273)
Mongolia	5,500 BP (Hanks 2010:471)

2.1.1 Overview

The initial definition of the Neolithic was "new stone", where in northern Europe there was a difference between Palaeolithic flaked stone, and the new (Neolithic) polished stone (Renfrew 2006:396). The term "Neolithic revolution" was introduced by Gordon Childe, and was originally based around the notion that population increase was the defining factor for this social change (Table 3) (Childe 1950:4; Renfrew 2006:395). Note the inherent lack of reference to pastoralism in this table. Watkins (2010:621) cites the current perception of change being cultural and cognitive rather than economically based. The 'traditional' Neolithic model is centred on the adoption of agriculture and thus involves the domestication of plants, and animals, which have been argued to be a simultaneous development (Gibbs and Jordan 2016:27). There is evidence of early settlements during the Epipalaeolithic (13,000 BP) in the Near East by the Natufian culture (Bar-Yosef 1998:147; Watkins 2010:625), which suggests that the "traditional" Neolithic model did not happen instantaneously, but rather as a gradual process occurring over thousands of years (Bar-Yosef 1998:142; Belfer-Cohen and Goring-Morris 2011; Gibbs and Jordan 2016; Watkins 2010). Although the Neolithic occurred gradually, changes to diet and living conditions greatly impacted on the human body size and health (Bar-Yosef 1998:147; Cohen 1989; Durham 1990; Larsen et al. 2015; Radović and Stefanović 2014).

Table 3. Childe's definitive Neolithic traits (Gibbs and Jordan 2016:28)

Agricultural economy
Population growth
Food surplus storage
Sedentism
Trade Networks: non-essential items
Decentralised social organisation of collective activities
Religious promotion of fertility
Ground stone implements
Pottery
Weaving implements

There have been multiple attempts to explain why the Neolithic occurred when it did (Braidwood 1958; Gopher et al. 2001; Renfrew 2006), and these include social and environmental factors. One view is that humans were not socially prepared for an earlier change, i.e. population and demographic factors (Bar-Yosef 1998:151; Weisdorf 2005:566). Olsson and Paik (2016) argue that the start of farming within a region occurred through collectivist values, and eventually saw the migration of individual farmers to the margins of the region. Environmental determinism, also referred to as climatic determinism, is a theory that suggests that human cultural change is strongly shaped by environmental changes (Wright 1993). There has been debate on whether environmental determinism, specifically the cooling period of the Younger Dryas (~11,000 – 10,000 BP), was a factor in the arrival of the Neolithic (Coombes and Barber 2005; Erickson 1999; Lemmen and Wirtz 2012:2; Simmons 2007:36; Strauss and Goebel 2011; Weber et al. 2011). These debates suggest that the cold, dry effects of the Younger Dryas saw the rise of agriculture, particularly in the Near East (Rosen 2007).

2.1.2 Epipalaeolthic/Eneolithic

Across Asia and Siberia the term 'Neolithic' denotes the arrival of pottery but not necessarily the introduction of domesticated animals and plants (Clark 2014:44). It also incorporates the concept of social organization and complexity (Braithwaite 1984; Hodder 1990; Pearson and Underhill 1987).

In China, the use of the term Neolithic is used to describe the occurrence of ceramics, not the development of agriculture (Rhode et al. 2007:602). In terms of archaeology, the Epipalaeolthic in China is defined as Holocene dated artefacts with Palaeolithic features, and the interaction between foraging groups and emerging agricultural groups during the Epipalaeolthic, is what separates them from Upper Palaeolithic groups (Rhode et al. 2007:602). The Neolithic in China will be examined further below.

In Mongolian archaeological literature terms such as "Mesolithic" and "Epipalaeolthic" are used to relate to earlier chronological phases (~8,000 BP) rather than using the term "Neolithic" (Clark 2014:44). This is primarily due to the definition of the term, which relates better to the Near East and the origins of agriculture. Wright (2006:23-24), for example, bases the definition of the Neolithic on what chronologically comes after it; which includes the combination of subsistence, technology, and social complexity; and also expects that all aspects existed where one example is found.

Thus far, the terms used in the literature have not allowed for pastoralism to be given the same importance, or independence, that agriculture has. Therefore there is a need for a clarified term, which would allow for this.

For example, Wright (2006:10) discusses a model of agriculture based on the "ideological environment". Hunter-gatherer populations are able to pick from existing agricultural technologies and ideologies, and eventually reach a state where they are so dependant they do not return to the way it was before. Wright (2006:9) also argues for the notion that nomadic pastoralism is the equivalent to the agricultural production of food, just in another form. This notion of agriculture and nomadic pastoralism is not explored fully under the typical definition of the Neolithic. This further demonstrates the constrictions of using this term. Rhode et al. (2007:602) demonstrate that the transition between pre-determined periods,

"… might be best viewed as a dynamic set of interactions among people practicing various mixes of different economic strategies, rather than a unilateral shift of strategies or replacement of one population by another" .

This notion is one such way of changing pre-determined views of a complex and intriguing topic.

As little has been researched within a Mongolian Neolithic context, the following will examine the Neolithic in neighbouring Siberia and China, which will form the basis of a comparison.

2.1.3 Neolithic in Siberia

The Lake Baikal-Hokkaido Archaeology Project (BHAP) has worked extensively on Neolithic and Bronze Age archaeology establishing a defined chronology for the region (Hanks 2010; Shepard et al. 2016; Weber and Bettinger 2010; Weber et al. 2016; White and Bush 2011). In Siberia, the Neolithic has been dated to begin around 8,000 BP (Lieverse et al. 2015:25). Archaeological evidence of the Neolithic includes pottery, which was used early in this region at 11,000 cal BP, and lithics such as microblades (Tsydenova and Piezonka 2015:102,111). Siberia has a harsh climate, yet people have inhabited this region since the Upper Palaeolithic (Mooder et al. 2006:349). The Lokomotiv and Shamanka II cemeteries near Lake Baikal are important Neolithic sites in Siberia (Waters-Rist et al. 2011; Weber et al. 2016). The Lokomotiv cemetery has been dated to 7,200 – 6,000 BP (Bazaliiskiy and Savelyev 2003:28), and was occupied by the Kitoi (Mooder et al. 2006:350). Similarly, the Shamanka II cemetery has been dated to 7,500 –6,700 cal BP (Weber et al. 2016).

2.1.4 Neolithic in China

In China, the Early Neolithic has been dated to begin around 10,000 – 8,900 cal BP in four distinct areas: the Middle and Lower Yellow River, north China, and the central plains (Cohen 2011:274). The first sedentary villages in China were established between 12,500 – 9,000 cal BP (Cohen 2011:273). Towards the middle to late Neolithic in China, environmental records indicate that the optimum climate started between 8,900 – 7,500 BP, and ended around 4,300 – 2,500 BP (Jiao 2006: 618). Agriculture and plant domestication developed independently from the Near East (Liu et al. 2015).
Artefacts such as ground stone tools can be used to infer plant use, and possible diet reconstruction. Liu et al. (2010) concluded that ground stone tools were used in processing acorns. However, Tao et al. (2011) argued that groundstone tools were used to process both wild and domesticated plants through grain analysis (Tao et al. 2011).

Jiao et al. (2011) demonstrate that there is archaeological evidence of long distance trade routes in Neolithic China, through the study of stone adzes at the site of Tianluoshan, eastern China. There is evidence of trade journeys of up to 50 kilometers during 7,000 – 5,000 BP as evidenced by the fine grained volcanic rocks, which differed to the coarse grained volcanic rocks in the nearby Siming Mountains, for adzes (Jiao et al. 2011:1361).

2.1.5 Neolithic Comparison

Geographically speaking, Mongolia is adjacent to China and Siberia, so it would make sense that there would be some similarities in regards to specific technological advances, such as the Neolithic. Table 4 below summarises the key information in comparing Mongolia, China, and Siberia. China has pottery much earlier than Siberia or Mongolia, before the arrival of the Neolithic. In terms of environmental conditions, Siberia is a good comparison, as both Siberia and in particular northern Mongolia experience a harsh, cold climate, which was ameliorated during the Neolithic. Although Siberia and Mongolia both have a harsh climate, they have been inhabited since the Upper Palaeolithic. Soyo is located much closer to Siberia and Lake Baikal than to central Mongolia or China, Figure 4. Based on this, northern Mongolian archaeological sites could align closer to Siberian technological practices in regards to the adoption of another technology before agriculture.

Unlike China where agriculture developed independently, Mongolia developed pastoralism and also had pottery, and Siberia had pottery before agriculture, Table 4.

Table 4. Comparison of the Neolithic in Mongolia, China, and Siberia

Country	Earliest Date	Technology	Archaeological Example
Mongolia	5,500 BP (Hanks 2010:471)	Pastoralism	Horse transport 3,300 BP (Taylor et al. 2015)
China	9,000 BP (Cohen 2011:273)	Agriculture	Establishment of sedentary villages 12,500 – 9,000 cal BP (Cohen 2011:273)
Siberia	8,000 BP (Lieverse et al. 2015:25)	Pottery	Early pottery 11,000 cal BP (Tsydenova and Piezonka 2015:102,111)

2.2 Mongolian Archaeology: Chronology

Establishing the chronology of human occupation in Mongolia is difficult due to the lack of research, secure dates for the region, and lack of stratified sites (Hanks 2010). Most archaeological research has been focused on the Bronze Age; Turkic periods; pastoral nomadic lifestyle; and the Xiongnu and Mongolian Empire periods (Schenider et al. 2016:1). In particular, t his research has focused on mortuary or ceremonial sites, which are very useful in determining social status and spiritual beliefs. Excavation of occupation sites is essential to understanding the daily activities of people and is relevant to characterising the transition from one subsistence strategy to another (i.e. food foraging to herding). Table 5 demonstrates the chronology for these periods, and Figure 4 spatially displays Palaeolithic and Neolithic sites mentioned below. This focus on the Bronze Age has created a thorough account of how people used and interacted with the landscape in this period (Clark 2014; Hall et al. 1999; Hanks 2010:475; Honeychurch 2013;

Honeychurch et al. 2007; Houle 2016; Janz et al. 2017; Jonannesson 2015; Lee 2013; Schneider et al. 2016; Taylor et al. 2015).

Table 5. Key periods in Mongolia (Clark 2014:18), with associated transitional periods (Fernández-Giménez et al. 2017:49,51; Hanks 2010:471)

Period	Date Range	Transitional Period	Date Range	Period	Date Rage
Upper Palaeolithic	7000 BCE - 6000 BCE			Mesolithic to Neolithic	12,000-5,500 BP (10,000-3,500 BCE)
Epipalaeolithic	6000 BCE - 3400 BCE				
Early Bronze Age	3400 BCE - 1600 BCE	Transition from Neolithic to Bronze Age	~5,500 BP (3500 BCE)	Bronze Age	5,500-3,300 BP (3,500-1,300 BCE)
Late Bronze Age	1300 BCE - 700 BCE	Transition from Bronze Age to Late Bronze Age	~3,300 BP (1300 BCE)	Late Bronze Age	3,300-2,800 BP (1,300-800 BCE)
Terminal Bronze Age-Early Iron Age	700 BCE - 150BCE	Transition from Late Bronze Age to Early Iron Age	~2,800 BP (800 BCE)	Early Iron Age	2,800-2,400 BP (800-400 BCE)
Iron Age	150 BCE - 300CE			Xiongnu	2,400-1,800 BP (400 BCE-200 CE)
		Emergence of the Mongol Empire	~800 BP (1200 CE)	Mongol Empire	1206-1690 CE

2.2.1 Early Upper Palaeolithic

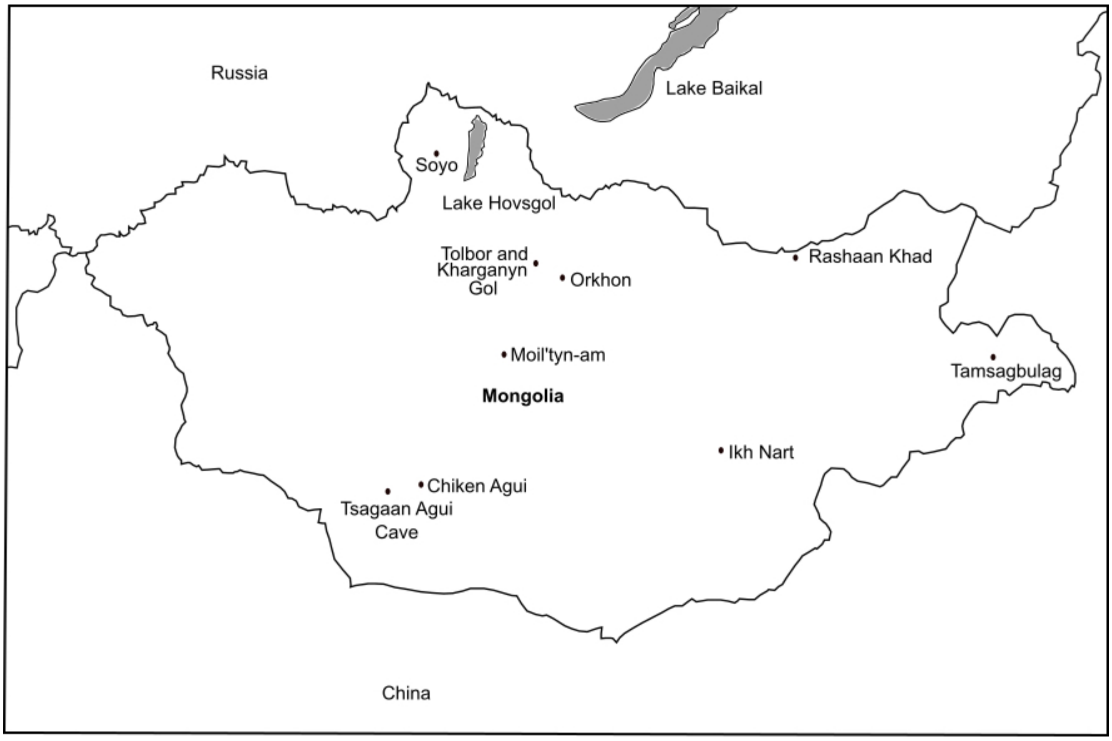


Figure 4. Palaeolithic and Neolithic sites in Mongolia

The Upper Palaeolithic is divided into several phases in Mongolia: Early Upper Palaeolithic, which is split into 1 and 2, Middle Upper Palaeolithic, and Late Upper Palaeolithic (Table 6) (Gladyshev et al. 2010; Rybin et al. 2016:71). Stone artefact typological and technological comparisons are the preface for these divisions.

Table 6. Upper Palaeolithic Periods in Mongolia (Rybin et al. 2016)

Period	Date/Date Range	Site/Region	Technological Example
Initial Upper Palaeolithic (IUP)	~44,000 BP	Northern and Central Mongolia	Choppers, and chopping tools, adzes, and flakes (Zwyns et al. 2014)
Early Upper Palaeolithic 1 (EUP-1)	39,000 – 38,000 BP	Tolbor and Orkhon rivers	Core technological change during the EUP is the development of pressure-flaking techniques for microcore reduction (Gladyshev et al. 2012)
Early Upper Palaeolithic 2 (EUP-2)	34,000 – 31,000 BP	Northern Mongolia (Tolbor 15), Central Mongolia (Orkhon river valley), Gobi Altai	
Middle Upper Palaeolithic (MUP)	30,000 – 19,000 BP	Chikhen Agui Cave Moil'tyn-am, Tsagaan Agui Cave	Partially retouched blanks (Rybon et al. 2016)

Period	Date/Date Range	Site/Region	Technological Example
Late Upper Palaeolithic 1 (LUP-1)	Poorly Dated	Kharganyn Gol, Tolbor, Rashaan Khad, Chikhen Agui	Flat-faced and subprismatic unidirectional and bidirectional parallel cores (Rybin et al. 2016)
Late Upper Palaeolithic-2 (LUP-2)	~18,000 –17,000 BP	Tolbor	Wedge shaped microcores (Rybin et al. 2016)
'Mesolithic'	~13,000 BP	Chikhen Agui	Microlithic industry

The Initial Upper Palaeolithic (IUP) began in northern and central Mongolia at a minimum of 44,000 BP (Rybin et al. 2016:74). These sites in particular, have been predominantly identified and recorded by the Joint Mongolian-Russian-American Expedition (JMRAE) during 2000 – 2007 (Zwyns et al. 2014:54), and these sites are important in understanding the dispersal of anatomically modern humans (AMH). Several radiocarbon dates have been gathered for the Tolbor Valley, with a date of 48,612 cal BP being the oldest (Zwyns et al. 2014:63). The Tolbor Valley features very prominently in the Early Upper Palaeolithic 1 and 2 (EUP-1 and EUP-2), 39/38,000 – 31/30,000 BP. Gladyshev et al. (2012) present data for the Tolbor-15 site in the Selenge River basin in northern Mongolia. Initial chronological data was provided for each archaeological layer via the comparison to archaeological assemblages in Mongolia and Siberia, specifically east of Lake Baikal, where dating was conducted (Gladyshev 2012:38).

The last glacial maximum (LGM) occurs at the end of the Middle Upper Palaeolithic (MUP), and demonstrates the impact of the LGM in relation to where people were able inhabit. For the sites mentioned above in Table 6, the ages are derived from associated geological deposits and are correlated with similar assemblages within dated sections of other sites (Rybin 2016:76). The Late Upper Palaeolithic 1 and 2 (LUP-1 and LUP-2) is poorly dated, but this period also correlates to the end of the LGM. For the site of Chikhen Agui in south western Mongolia, Derevianko et al. (2008:10) reported on geometric microlithis, which were correlated to the 'Mesolithic', ~13,000 BP (Rybin 2016:80).

2.2.2 Neolithic

The Neolithic period, and the timing to and from this transition to pastoralism are poorly understood in Mongolia. Hanks (2010) provides a comprehensive overview of current research within the Eurasian steppes, with a focus on Mongolia. The lack of research in this region has meant that there is a large gap in understanding the earliest date of anatomically modern humans in northern Eurasia within the central Eurasian steppe. This has been partly addressed by Rybin at al. (2016), but more detailed work is needed. Major Neolithic sites/regions in Mongolia include Tamsagbulag in eastern Mongolia (Figure 4)(Derevyanko and Dorj 1992; Séfériadés 2004), and the Gobi Desert (Janz 2012; Schneider et al. 2016). This is summarised in Table 7. This research presents the need for further work on Neolithic sites, and allows for a comparison on sites investigating how the Neolithic was adapted throughout Mongolia, and for the overall Neolithic chronology of Mongolia.

Table 7. Summary of Neolithic research in Mongolia

Author/s	Location	Research
Derevyanko and Dorj (1992)	Tamsagbulag, and Central Asia (Mongolia, Siberia, Kazakhstan)	Transition from Mesolithic to Neolithic
Janz (2012)	Gobi Desert	Landscape use and adaptation
Séfériadés (2004)	Tamsagbulag, Eastern Mongolia	Beginning of farming
Schneider et al. (2016)	Ikh Nart Nature Reserve, Gobi Desert	Landscape use, and resource availability

2.2.2.1 Tamsagbulag

The site of Tamsagbulag in eastern Mongolia presents an interesting comparison to Soyo. Tamsagbulag has evidence of both agriculture and settlement, which Janz (2012:88) cites as a similar pattern to that of sites in northeast China rather than Mongolia. The site was originally excavated in 1949 and 1967 by A.P. Okladnikov (Okladnikov and Derevianko 1970), but was later revisited by Derevyanko and Dorj (1992) and Sériadés (2004), who both researched the Mesolithic to Neolithic transition at the site. Derevyanko and Dorj (1992:169) state that in eastern Mongolia agriculture began independently through the practice of gathering food. Although there is leading evidence for this, more direct evidence, such as plant remains, residue, and bone, is needed to quantify this. Séfériadés (2004:142) dated one of the excavated sites to 6,400 cal BP, and the surrounding sites have been inferred to be of the same age (Janz 2012:89).

2.2.2.2 Gobi Desert

The Gobi Desert is vital to understanding how people adapted to marginal environments and how regional technological change was applied (Janz 2012). During the Holocene, palaeoenvironmental records indicate that the Gobi Desert experienced humid, warm and wet conditions (Janz 2006, 2012).
Similarly, Schneider et al. (2016) focused on the Neolithic transition to the Bronze Age, through a site within the Ikh Nart Nature Reserve, on the northern edge of the Gobi Desert. A date range of 4,422 BP – 4,284 BP was obtained through a geoarchaeological section with associated Neolithic materials including ground stone artefacts and milling stones (Schneider et al. 2016:6). The presence of agriculture in the archaeological record in eastern and southern Mongolia indicates a combination of subsistence strategies including hunting and fishing during the mid-Neolithic (Janz 2012:87).

Hunting equipment such as small blades, were found at the Chikhen Agui rockshelter. At this rockshelter in the Gobi Desert, artefact assemblages were dated to 13,400 – 6,400 cal BP, which places it within the early Holocene (Derevianko et al. 2008). It is significant as it was the first post-LGM site that has been dated chronometrically in the Gobi Desert (Janz 2012:96). Janz (2015:120) comments that local technological changes used to date sites within the Gobi Desert are based on stylistic comparisons with other local sites that have been dated, which can become problematic.

2.3 Pastoralism

As Mongolia adopted pastoralism as the primary technological and economic change in the Bronze Age, it is vital to explore the literature that prefaces it. This also provides a way in which to compare and contrast the arrival of pastoralism in Africa, to the arrival of pastoralism in Mongolia. Marginal environments play an important role in understanding the way in which these technologies are also adapted to.

2.3.1 Overview

Pastoralism is associated with raising and tending to livestock and is different from nomadic pastoralism, as this is based on the regular movement of both people and herds (Boschian 2017:650; Wright 2006:3). Lees and Bates (1974) proposed that nomadic pastoralism emerged as a specialised economy from a mixture of farming and localised herding. Animals such as horses, cows, and goats are commonly associated with this form of subsistence. Taylor et al. (2017) cite horses as being particularly advantageous in colder and more arid environments. These advantages include mobility, meat and milk, as well as other secondary products (Outram et al. 2009:1335). This has been referred to as the secondary products revolution (Gibbs and Jordan 2016:31; Gopher et al. 2001; Janz 2012; Shennan and Edinborough 2007; Sherratt 1981).

One such issue related to Neolithic studies is the emphasis placed upon agriculture in order to indicate a 'traditional Neolithic' site. This has subsequently hindered pastoralism research, as the focus has been on agriculture (Honeychurch and Makarewicz 2016; Makarewicz 2013). Wright (2006:11) argues that the adoption of pastoralism in northeast Asia is as important as the Neolithic transition to agriculture. Nevertheless, there has been research conducted on the initial domestication of animals, which includes horses (Honeychurch and Makarewicz 2016). Evidence for the earliest domestication of the horse is not well understood. Research by Warmuth et al. (2012) indicates that wild horses spread out of Eastern Eurasia at approximately 160,000 years ago, and that domestic horses later originated from western Eurasia. The Neolithic Botai culture in neighbouring Kazakhstan used pottery, made use of semi-sedentary structures, and had horses for domestic uses, which were domesticated prior to 3,000 BC (Outram et al. 2011:117,118). There is also evidence at this site for the use of horses for secondary products such as milk (Outram et al. 2009). Research by Taylor (2017) investigates the importance of horses in Bronze Age Mongolia, and the development of pastoral nomadism in the eastern steppe.

2.3.2 Pastoralism in Africa

The presence of pastoralism in Africa presents a way of comparing and understanding the arrival of the practice with Mongolia. By 7,000 – 4,000 cal BP, Holocene communities inhabited the Algerian highlands (Roubet and Amara 2016). This included the co-habitation of both hunter-gathers and pastoralists. Roubet and Amara (2016) have deemed this as an Initial Neolithic Pastoralism (INP) phase, and this is evident in the archaeological record through rock art.

In north Africa during the middle Holocene, people used pastoralism to survive a deteriorating climate, having previously utilized a hunter-gatherer-fishing mode of subsistence (Stojanowski and Carver 2011:89).

In south-eastern Africa, Robinson and Rowan (2017) demonstrate how vital regional aridity was to the spread of pastoralism. This aridity during the late Holocene meant that people had to travel from eastern Africa to reach grasslands in order to feed the herds (Robinson and Rowan 2017:66).

2.3.3 Pastoralism in Mongolia

Much like the transition to and from the Neolithic, the adoption and timing of pastoralism is also poorly understood in Mongolia (Cavalli-Sforza 1996; Clark 2014:19; Frachetti 2009; Taylor 2017). In nearby Sagan-Zaba, Lake Baikal, Siberia, there is faunal evidence of pastoralism at 2,300 cal BP (Nomokonova 2011). Pastoralism in the Eurasian Steppe has been dated to the 9th century CE (~800-900 BP)(Dalintai et al. 2012:52) however this has been widely criticised, and is thought to be much earlier (Christian 1998; Clark 2014:49; Houle 2010; Jacobson-Tepfer 2013). Janz (2012) comments that hunter gathers in Mongolia dominate the Epipaleolithic (6,000 BCE – 3,400 BCE), and Houle (2010) concludes that pastoralism is well developed by the Late Bronze Age. Clark therefore surmises that the arrival of pastoralism must be at least from the Early to Middle Bronze Age (Clark 2014:51). The management of domestic horses appears in the archaeological record at 3,500 BC (Taylor et al. 2015), and the earliest evidence of horse transport in western and central Mongolia at 1,300 BC. Taylor et al. (2015) developed a method of examining horse crania in order to substantiate if horses were being used for transport. The stress from the use of bridles was found to cause grooves to form on the skull, also known as nasal remodeling (Taylor et al. 2015:866). This is one such example of domestication in the archaeological record.

Although there is possible archaeological evidence for the adoption of agriculture in sites such as Tamsagbulag in eastern Mongolia and sites in the Gobi Desert (Janz 2007, 2012), there is an inherent lack of agricultural remains and sites in northern Mongolia. Volkov (1995:320) has suggested that agriculture played little to no role in subsistence strategies in north and northwest Mongolia, with hunting and herding being the primary forms of subsistence (Allard and Erdenebaatar 2005:548). Furthermore, Allard and Erdenebaatar (2005:548) conclude that in north and northwest Mongolia, there is currently no archaeological evidence that agriculture was present before pastoral nomadism. Eng (2016) conducted a study on skeletal remains dated to the Bronze Age and Iron Age from northern China and Mongolia in order to infer activities associated with pastoralism. With increased regional aridity around 4000 BP, Eng (2016:173) suggests that the changes to the archaeological record at this time indicate a decline in agriculture. In this instance pastoralism was used as an adaptive strategy in relation to the changing environment.

However, Janz (2007) presents a case for ideological resistance to the adoption of agriculture in Mongolia. The steppes covering the majority of Mongolia are more or less much too arid and the soils are very undeveloped which would not do well to support agriculture. Janz later cites areas such as northern Mongolia and southern Siberia as having more evidence for agriculture. Here the transitional areas of the forest-steppe would have better-developed soils due to the increased supply of water. This presents an interesting situation for Soyo, as there is no archaeological evidence for agriculture. So although the environment may have been suitable for some parts of the year, it appears that people consciously chose to avoid agriculture.

2.4 Conclusion

In conclusion, the main research gap present in the literature is the lack of research on Neolithic sites in Mongolia. This chapter has demonstrated the links between the Neolithic, pastoralism, and the current chronological archaeological data for Mongolia.

3. Regional Palaeoenvironmental History

This chapter explores the history of the regional palaeoenvironmental records. The palaeoenvironmental records from the Darkhad Depression and from Lake Hövsgöl are an extensive record of a changing climate. They provide valuable insight into past climatic conditions, and in this thesis will be used as a basis for the local environmental data to be compared and contrasted to. The wider palaeoenvironmental region also incorporates Lake Baikal, Siberia. This chapter will investigate the landscape, climate, geology, vegetation, and fauna of the region; and will also investigate the climate records for both Lake Hövsgöl and Lake Baikal. The chapter will conclude with the regional palaeoenvironmental curve.

3.1 Landscape

Soyo, the Darkhad Depression and Lake Hövsgöl (also Khövsgöl or Khubsugal) are all located within the central Asian, Eurasian Steppe. The Steppe is an expansive region, which stretches from Hungary and Ukraine in the west to Manchuria (northeast China) in the east. Kazakhstan, Russia and Mongolia form to combine the middle section of the Steppe. A steppe is typically characterised by grasslands, but the Eurasian Steppe also incorporates arid zones and forests (Hanks 2010:471). Each environmental zone varies in climate and topography, of which altitude is also a factor. The region in which Soyo is located is predominantly characterised by long, cold winters and during these periods many resources are limited or completely absent (Clark 2014:55).

Overall, the Darkhad Depression lies at an altitude of approximately 1,538 meters above sea level (Batbaatar and Gillespie 2008:170; Krivonogov et al. 2012:143). Mountain ranges such as the Horidol Saridag and Bayanzurh in the east and the Ulaan Taiga in the west surround the depression. These range up to 3,300 metres above sea level (Krivonogov et al. 2012:143). To the north of the Darkhad Depression lies the Great Sayan and Munku-Sardyk mountain ranges which are higher again, at 3,500 metres above sea level (Krivonogov et al. 2012:143). Within the depression, there is a larger lake, named the Dood Tsagaan Nuur. This lake consists of three smaller lakes, Targan, Dund Tsagaan Nuur, and Kharmai (Krivonogov 2012:145). There are numerous smaller lakes located in the Darkhad Depression. The Shishged Gol is the largest river in the region, and drains northwest into the Yenisei River and the Minusinsk Basin, in southern Siberia. Other rivers located within the depression include the Shargyn Gol, Tengissiin Gol, and the Hoggin Gol.

3.2 Climate

The current (1973 – 1990) climate of the Darkhad Depression includes long, cold periods, and the mean annual temperature is -7.8° C, with a high of 12.6° C in July and a low of -32.4° C in January (Clark 2014:56).

Table 8. Progression of the Darkhad Depression from the Late Pleistocene to the mid-Holocene (Batbaatar and Gillespie 2016; Narantsetseg et al. 2013)

Period	Details of Lake
20,000 cal. BP – 14,000 cal. BP	Deep lake
14,000 – 9,500 cal. BP	No lake
9,500 – 8,500 cal. BP	Low lake levels from increased precipitation and melting permafrost
8,500 – 7,500 cal. BP	Cold dry climate kept lake bioproduction low
7,800 – 5,800 cal. BP	Humid and warm climatic period creates instability in lake environment
~5,800 cal. BP to present	Wetter conditions brought lake to current level in mid-Holocene

During the LGM (~20,000), a deep lake was present in the Darkhad Depression, and this lake was present intermittently until ~14,000 (Batbaatar and Gillespie 2016:1). As shown in Table 8, the climate in the Darkhad Depression varied greatly, and the Eurasian Steppe experienced major climatic phases throughout the Holocene (Frachetti 2009:79; Kremenetski 2003). The mid-Holocene also included low lake levels within the Darkhad ~ 6,500 to 5,400 (An et al. 2008:287). Beryllium (^{10}Be) dating shows that at ~12,000, 10,000, and 1,500 BP MIS2 glaciers from the surrounding mountains advanced (Batbaatar and Gillespie 2016), and this also changed the form of the landscape. Glacial moraines as well as surface boulders are present at Soyo, as shown in Figure 5.

Figure 5. The Hog River, surface boulders, and across the river a glacial moraine

3.3 Geology

During the Soviet period in Mongolia the Soviet Union produced mineralogical maps. These maps demonstrate that there are significant deposits of gold, copper, iron, phosphorite and deposits of jade within the Darkhad Depression (Akademija Nauk S.S.S.R. 1989 in Clark 2014:55). A borehole located on the bank of the Sharga River in the Darkhad Depression was drilled in 2005. It revealed that blue grey lacustrine silt was situated from 0 to 5.2 metres below the surface, and from 3.5 to 5.2 metres the silt had an ice content of 30-45% (Global Terrestrial Network for Permafrost 2005). The Depression is also situated on early Cambrian carbonate, as well composite Precambrian terrane, and Archaean and Proterozic crystalline (Macdonald and Jones 2011:339). Volcanic and clastic rocks are also present, resting above the Precambrian layer (Macdonald and Jones 2011:340).

The Lake Hövsgöl basin is situated on limestone with deposits of phosphorite along the south and southwest. To the north, a mixture of Precambrian rocks and Paleozoic granitic rock are covered by alluvium, which dates to the Pleistocene (Goulden et al. 2000:136).

3.4 Vegetation

The Darkhad Depression is an isolated basin, approximately 140 kilometres long, by 40 kilometres wide. The Sayan Mountains surround the Depression with an altitude ranging from 1,500 to 3,200 meters above sea level. Coniferous forests extensively cover these mountains and contain edible mushrooms and berries (Clark 2014:54). This thick taiga zone is continued to the north of the Depression. Taiga forests are predominately comprised of larch (*Larix siberica*) (Goulden et al. 2000:138). Within the centre of the Darkhad is the steppe zone, which during the summer contains meadows filled with a range of wildflowers and grasses (Clark 2014:55). The northern steppe zones flower more consistently than the semi-arid steppes (Frachetti 2009:76).

3.5 Fauna

The Darkhad Depression is home to a diverse range of fauna. Fish species include Baikal omul, sharp-snouted lenok, Arctic grayling, Siberian roach, minnows, Siberian spined loach, European perch, and burbot (Akademija Nauk S.S. S. R. 1989:86-87 in Clark 2014: 53).

Bird species include hawks, kites and eagles, larks, kingfishers, ducks, geese and swans, swifts, bitterns, herons, and egrets (Akademija Nauk S.S. S. R.
1989:86-87; Kozlova 1932a, 1932b, 1932c, 1933a, 1933b in Clark 2014: 54). Game animals include wolf, carsac fox, brown bear, sort-tailed weasel, Siberian weasel, steppe polecat, lynx, Eurasian badger, wild boar, mountain hare, Siberian chipmunk, and Eurasian otters (Akademija Nauk S.S.S.R.
1989:92-93 in Clark 2014:55).

Livestock such as horses, cows, yaks, sheep, goats, and camels also frequent the region (Goulden 2000:137).

3.6 Lake Hövsgöl

Previous research has included detailed palaeoenvironmental records of Lake Hövsgöl (Choi et al. 2014; Gillespie et al. 2008; Karabanov et al. 2004; Matsumoto et al. 2012; Murkami et al. 2010; Nara et al. 2010; Prokopenko et al. 2007). Lake Hövsgöl is Mongolia’s largest and deepest lake (Prokopenko et al. 2007), and palaeoenvironmental records from the past 27,000 years demonstrate the regional climatic variation (Matsumoto et al. 2012; Murakami et al. 2010). Lake Hövsgöl lies within the Baikal Rift zone (An et al. 2008; Karabanov et al. 2004), which developed during the late Miocene (Orkhonselenge et al. 2014:46). It is second to Lake Baikal in regards to size in the region. During the Pleistocene (~32,000 – 29,000 BP), there was a transition to a glacial climate and environment (Rybin et al. 2016:73).

Karabanov et al. (2004) and Prokopenko et al. (2003) determine that during the warming of the Bølling-Allerød period (~12,000 – 14,000), the water level of Lake Hövsgöl rose (Karabanov et al. 2004:238). However, Murkami et al. (2010:381) conclude that although the volume of Lake Hövsgöl increased gradually, it did not immediately respond to abrupt climate shifts such as the Bølling-Allerød and Younger Dryas events. It is more likely that Lake Hövsgöl remained relatively stable during this period. Choi et al. (2014:1148) also comment that during the Younger Dryas (~12,700), for a short time, Lake Hövsgöl became colder and drier. This is evidenced through ^{10}Be dating, which shows that there was also less precipitation (Choi et al. 2014:1148).

Table 9. Holocene climate progression of Lake Hövsgöl (Prokopenko et al. 2005, 2007)

Period	**Climate Conditions**	**Period**	**Climate Conditions**
~9,000 – 7,500 BP	Relatively cooler summer with precipitation higher than today	~11,000 – 7,000 BP	Higher precipitation
~7,000 – 5,500 BP	Regional cooling	~6,000 – 3,500 BP	Warmer period and reduced forest vegetation
~5,500 – 4,000 BP	Increase in steppe vegetation and pronounced warming and aridification in the region		
After ~3,500 BP	Late Holocene forest expansion		

Table 9 demonstrates the variation in climate during the Holocene for Lake Hövsgöl. During ~5,500 – 4,000 the warmer summers meant that the soils had a higher temperature and lower moisture content (Prokopenko et al. 2007:2). Lake Hövsgöl experienced the Holocene summer maximum temperatures between 6,500 and 2,500 (Prokopenko et al. 2007:15). An increase in steppe vegetation during this period would have made it easier for people to move through the landscape.

3.7 Lake Baikal

Located in Siberia, Lake Baikal (455 meters above sea level) is the world's largest and deepest freshwater lake (Tarasov et al. 2007). It holds ~20% of the Earths freshwater (Seal and Shanks 1998), and formed over 25 million years ago during the Miocene. Lake Baikal has never completely glaciated, which means that palaeoenvironmental records of past glacial and interglacial periods can be investigated (Morley et al. 2005:222). Much like Lake Hövsgöl in Mongolia, extensive research has been carried out at Lake Baikal (summarised by Shichi et al. 2013). Radiocarbon dating of moraines along the eastern shore of Lake Baikal have been dated to 50,000 BP, 40,000 – 35,000 BP, and 26,000 – 13,000 BP (Krivonogov et al. 2004: 749). Table 10 below demonstrates the change in vegetation around Lake Baikal through pollen records. The climatic optimum for Lake Baikal occurred during ~9,000 – 7,000 cal. years BP (Tarasov 2007:454), and Table 11 evidences this through the changing climate at Lake Baikal.

Table 10. Pollen records for Lake Baikal (Tarasov 2007:447,449)

Period	Vegetation Change
15,000 – 13,300 cal. BP	Open landscape: shrub tundra and steppe plants
13,300 – 10,400 cal. BP	Spread of boreal conifer and deciduous trees. Warm and wet climate conditions.
10,400 – 7,800 cal. BP	Spread of fir and Scots pine and degradation of the permafrost layer

Table 11. Climatic conditions for Lake Baikal (Shimaraev and Mizandrontsev 2006:260-261)

Period	Climate Variation
14,000 – 11,300 BP	Increase in water input
13,000 – 12,500 BP	Increase in weather intensity due to rise in CO_2
11,200 – 10,900 BP	Decrease in weathering rate
10,800 – 8,800 BP	Warming
6,000 BP – present	Gradual cooling to current climate

3.8 Regional Palaeoenvironmental Curve

Table 12 demonstrates the changes in climate at Lake Hövsgöl over the past 10,000 years. This collated information allows us to compare the radiocarbon dates of Soyo to the environmental record of nearby Lake Hövsgöl in order to establish the climate during the development of the landscape. From 11,000 – 7,000 BP the climate was wet, and the level of Lake Hövsgöl began to rise around 12,000 BP (^{14}C) (Karabanov 2004:238). At 8,500 years (^{14}C) present day elevation and stabilisation of Lake Hövsgöl was reached (Karabanov 2004:238), and by 7,000 BP the climate in the region had begun to cool and this lasted till 5,500 BP. However, it was also arid by 7,000 BP (Prokopenko et al. 2007). As the region cooled there was also a simultaneous warm period, which lasted at Lake Hövsgöl from 6,000 BP – ~3,500 BP. From 6,500 BP – 5,400 BP Lake Hövsgöl returned to low lake levels in a dry interval (An et al. 2008:287). There was also an increase in steppe vegetation, and a subsequent decrease in forest vegetation. This began at 7,000 BP and this increase lasted until 4,000 BP, with the forest vegetation continuing to decrease until 3,500 BP. However, there are some inconsistencies with this table. In particular, the overlap of the cool and warm periods, 7,000 – 5,500 for cool, and 6,000 – 3,500 for warm. Prokopenko et al. (2005, 2007) present both datasets. The warm period fits well with the increase in steppe vegetation, and decrease in forest vegetation, which occurs during 7,000 to 4,000. It is possible that during this period in the Holocene the climate was fluctuating frequently enough that both types of climates occurred.

Orkhonselenge et al. (2013:107) establish that whenever there were high lake levels, there was a dry period, and low lake levels correlated with wet climatic conditions. Lake Hövsgöl reached +6 meters above present levels, which is the highest the lake reached during the Holocene, and this can be attributed to the termination of glaciers (Orkhonselenge et al. 2013:105). Similarly, during the early-mid to late Holocene, the level of Lake Hövsgöl dropped at 7,400 – 7,100; 4,800 – 4,500; and 1,000 – 900 cal BP (Orkhonselenge et al. 2013:105); and also drops 2,100 – 500 BP (Orkhonselenge et al. 2014:52).

The climatic optimum for Lake Hövsgöl occurred between 6,500 and 2,500 BP (Prokopenko et al. 2007:15), and this warmer period meant that soils would have a higher temperature and lower moisture content (Prokopenko et al. 2007:2). The warmer climate would have allowed for the development of soils and plants to grow and thrive. This is evidenced at Soyo through the palaeosols, which are visible on the surface. In this case, Soyo is typical of the wider regional environment. In the Late Holocene this region experienced fairly frequent periods of climatic stability, evidenced by the palaeosols.

Table 12. Regional palaeoenvironmental data

Time Period BP	Holocene (An et al. 2008)	Wet	Dry	Warm	Cool	Lake Level	Vegetation
0 – 1000	**Late** Humid with Cold Intervals					500 – 2,100 BP drop in lake level (Orkhonselenge et al. 2014).	
1000 – 2000							Moderate forest expansion 3,500 – 1,100 ka (Prokopenko et al. 2007:9)
2000 – 3000							
3000 – 4000			**Dry** 3,500 – 6,000	**Warm** 3,500 – 6,000			Decrease in forest vegetation 3,500
4000 – 5000						Low lake level, dry interval 6,500 – 5,400 (An et al. 2008:287)	Increase in steppe vegetation, and decrease in forest vegetation 7,000 – 4,000
5000 – 6000	**Mid** Arid				**Cool** 7,000-5,000		
6000 – 7000	**Early-Mid** Highly Humid		**Arid** 7,000				
7000 – 8000	**Early** Warm and Humid	**Wet** 11,000 – 7,000				7,100 – 7,400 BP drop in lake level (Orkhonselenge et al. 2013:105). 8,500 (^{14}C) present day elevation and stabilisation (Karabanov 2004:238)	
8000 – 9000							
9000 – 10000						12,000 (^{14}C) lake level rise (Karabanov 2004:238)	

4. Methods

This chapter details the methods and equipment used to gather the data for this thesis. The methods chapter covers an overview to GPR; GPR field survey and data processing methods; positioning; aerial photography; orthophoto; DEM; depth to surface maps; stratigraphic excavation; sediment analysis; and radiocarbon dating using the ultrafiltration method. Stratigraphic photos, drawings, the master stratigraphy table, and the overall site map can be found in Appendices A to D respectively.

4.1 Ground Penetrating Radar

Ground penetrating radar (GPR) is a non-invasive geophysical technique designed for subsurface investigation (Bristow and Jol 2003:4; Conyers 2004, 2007, 2012, 2016; Robinson et al. 2013). It transmits high frequency electromagnetic (EM) waves from a surface antenna into the subsurface (Conyers 2004:1), and as this is propagated out, the velocity of the wave changes as it passes different electrical properties (Robinson et al. 2013). These changes demonstrate different soil properties, or buried objects within the subsurface. As the transmitted energy is reflected off buried objects, it returns back to the antenna, where it is received (Conyers and Cameron 1998:419). This makes GPR an active process (Kvamme 2003:439).

A higher frequency antenna (400 to 1000 MHz) has shorter wavelengths, higher resolution, but a low depth penetration. Low frequency antennas (10 – 50 MHz) are the opposite of this (Conyers 2007:333; Goodman and Piro 2013:42; Jol and Bristow 2003:10). The choice of frequency is entirely dependent on the site and the soil (moisture retention and composition), and a balance needs to be reached between depth and resolution to ensure the best results.
Surveys are generally set up in a grid, with spacing ranging from 20cm upwards, see Jol and Bristow 2003 for an overview on surveys (Conyers 2004:11, 2007:333; Kvamme 2003:440,442). By using a closer set of spacing, a denser set of data coverage is ensured (Jol and Bristow 2003).

4.1.1 GPR: Processing

The processing of raw GPR data is a necessary step before the data can be interpreted. Processing steps clean up and enhance the data. Robinson et al. (2013) and Jol and Bristow (2003) provide an overview of GPR processing and interpretation. Basic processing steps include time-zero correction, dewow filtering, gain, filtering, background subtraction, and topographic correction (Robinson et al. 2013:10-11). Time zero removes the airwave, and repositions it to the first negative peak of the trace (Robinson et al. 2013:9). Dewow removes very low frequencies (Annan 2005), and gain, such as auto-gain control (AGC) or exponential gain compensation (SEC), enhances the data. This can either be by equalising down the trace (AGC) or by emulating the variation in signal amplitude (Robinson et al. 2013:10). Filtering removes noise, enhances the visual quality, and further removes high or low frequencies (Cassidy 2009; Robinson et al. 2013:10). Background removal enhances more subtle signals, and a topographic correction corrects for the terrain. With a topographic correction, the spatial context for stratigraphic layers will change.

4.1.2 GPR: Sediment/Stratigraphic Identification

Sediment analysis and stratigraphic identification is vital to archaeological research. Sediment analysis can aid in the reconstruction of palaeoenvironments and site history; the interpretation of past relationships with the landscape (Hassan 1978:197); and gives cultural features context within the environment (Conyers 2012:57). GPR allows for this identification without disturbing the subsurface, however it is beneficial to correlate radar data with sedimentary information, via cores or trenches. Table 13 demonstrates how soil horizons can be identified, with horizon A being the top layer and horizon C the lowest. The identification of paleosols, or old soils, can greatly aid in reconstructing the palaeoenvironment, and the duration of time it represents (Birkeland 1990:219). The thickness of stratigraphic layers can aid in this reconstruction and can also be correlated with other data. Jol and Bristow present three approaches to be used for interpreting stratigraphy from radar data (2003:23). These include identification of buried objects; stratigraphy; and sediments. By focusing on the stratigraphy, a relative chronology can be established from the overlayed layers and cross-cutting features (Jol and Bristow 2003:23).

One major limitation to GPR is that radar propagation and reflection are primarily affected by electrical conductivity and magnetic permeability. Further to this is the depth that the radar can penetrate is also dependent on the soil type, clay content, ground moisture, surface topography and vegetation (Conyers 2004:14,45). The differing physical and chemical properties of the subsurface also alter radar propagation. Velocity calculations can be used if the soil types are known previously to establish the success of the survey (Robinson et al. 2013).

Table 8. Soil horizons (Conyers 2016:62)

Horizon A	Accumulation of organic matter
Horizon B	Accumulation of clay, iron oxides, and carbonate and by the weathering of the parent material. Moves downward over time
Horizon C	Partially weathered parent material

4.1.3 GPR: Case Studies

In (palaeo)environmental studies, GPR has been used to successfully map the stratigraphy of aeolian dunes (Botha et al. 2003; Bristow et al. 1996; Bristow et al. 2005; Dickson et al. 2009;); identify washover periods (Gouramanis et al. 2015; Switzer et al. 2006); and map soil stratigraphy (Davis and Annan 1989; Jol and Bristow 2003). GPR has been used similarly for archaeological research (Bevan and Kenyon 1975; Bladon et al. 2011; Conyers 2012; Conyers et al. 2013; Herrmann 2013; Himi et al. 2016; Urban et al. 2014; Zhao et al. 2013). The ability of GPR to map such a variety of materials enables environmental and archaeological analysis to be conducted simultaneously. The identification of the internal structure of aeolian dunes allows for the migration of the dune to be studied (Bristow et al. 2005; Dickson et al. 2009). Furthermore, this also aids in understanding how past fluvial systems have deposited sediment, and how these systems have cut into the landscape and changed over time (Conyers 2016).

4.2 GPR Survey

During fieldwork of July 2016, a GPR survey was carried out over an area of 5 hectares. A 500 megahertz antenna was used with a Mala X3M, and the overall survey used a line spacing of half a meter, with lines collected in alternate directions. The frequency of the sampling was set at 13688 megahertz, and a total of 1024 samples were collected. The time window was set at 75 nanoseconds, and the trace interval was set at 0.019 meters. Finally, the antenna separation was set at 0.180 meters. This data was then post-processed using the program ReflexW, version 8.5 (Sandmeier 2017). A 100 meter section of the site was chosen for processing. As discussed in detail below, the overall processing steps included time zero correction, dewow, energy decay, bandpass butterworth, background removal, running average, fk migration, and a topographic correction (see Conyers 2012; Jol and Bristow 2003; Robinson et al. 2013:10-11).

4.2.1 Processing Steps

Time zero correction was set at -4ns, which removes the time taken to reach the subsurface, and adjusts time zero to begin below the ground surface (Robinson et al. 2013:9). Dewow filters out the lower frequencies acquired by the GPR, and also reduces the data to a mean zero level (Annan 2005). The dewow was set at 10ns. Low amplitude reflections are enhanced through the gain step. Energy decay is one such process where the curve of the decay is applied as an inverse function to the data (Robinson et al. 2013:10). Here it was scaled to 0.8. Band pass filtering revolves around eliminating frequencies that are higher or lower than the specified megahertz of the GPR (Cassidy 2009). What is then displayed from this processing step is an average of the traces recorded. Bandpass butterworth was the specified filter used for this step, with a lower cut off of 201 MHZ, and an upper cut off of 1972 MHz. Background removal removes the noise and creates a clearer image (Robinson et al. 2013:10). For this processing step, the start time was set at 71.30207 and the end time at 51.39483. Further to this is the migration process, which aims to pin point the source of each hyperbola, by calculating the velocity from the ground (Zhao et al. 2013:114). This velocity calculation aids in locating the hyperbolas to a more accurate location (Conyers 2016:18). A fk migration (stolt) was used on this data, which tidied up the data and allowed for a clearer image to be analysed. A scaling factor of 0.8 was used, with a start time of 0 and an end time of 0.03436. Running average selects a specified number of traces and conducts an average over these traces (Cassidy 2009:154). This then smooths out certain parts of the data. The average traces were set to 2, with a start time of 71.30207, and an end time of 74.73567. Time cut was the final processing step that cuts the data off at a specified time. Further data processing involved the TraceHeader and TraceHeader Tabella. The Traceheader was updated to display coordinates, and from this the TraceHeader Tabella was then reconfigured. The topography data was imported into the TraceHeader Tabella, which gave the GPR line the correct elevation, and 3D topography.

4.3 Positioning

Positioning for the GPR survey was provided by a CHCX90+ Static GPS, and was then post-processed by AUSPOS. AUSPOS is a free online service provided by Geoscience Australia. It processes GPS data using the Bernese Software System, and the International GPS Service (IGS) which both provide highly precise information regarding orbit parameters (Geoscience Australia 2017). Essentially this meant that there was centimetre accurate positioning for each grid corner. The GPS RINEX (Receiver Independent Exchange) data, antenna type and height were sent to AUSPOS for processing. An odometer and measuring tapes were used to position individual lines.

4.4 Aerial Photography

Aerial photography was taken with an Into the Wind UltraFoil 15 with a Canon S100 camera. By using a CHDK script, photos were programmed to be taken at 3 second intervals. Agisoft Photoscan Professional, version 1.3.3 (Agisoft 2017) was used in the lab to process the photos and produce a model of the site. Dubbini et al. (2016:125), and Thomas and Kennedy (2016:888) have provided a processing methodology. The processing steps used included: adding and aligning the photos; building a dense point cloud; building the mesh; generating the texture; building an orthomosaic; and finally building a digital elevation model.

4.5 Orthophoto

The creation of the orthophoto was made through a combination of the aerial photography, which was tied together in Agisoft Photoscan Professional (Agisoft 2017) and the GPS points. It aided in identifying several of the key stratigraphic features, such as moraines, which are more obvious on a high resolution image. For the parts of the site that currently have not been excavated archaeologically or stratigraphically, this provides further information to interpret the GPR in these areas.

4.6 DEM

From the creation of the model for the site and the orthophoto in Photoscan Professional (Agisoft 2017), a digital elevation model (DEM) was also created. Much like the orthophoto, the DEM provides a 3D model of the landscape, which aids in the identification of key stratigraphic features. The DEM also formed the base map for the depth to surface maps detailed in the section below. The overall site map produced from the DEM can be found in Appendix D.

4.7 Depth to Surface and Isopach Maps

ArcGIS ArcMap version 10.4.1 (ESRI 2017) was used to create maps to display the depth to surface for the GPR data. Using the projected coordinate system WGS84, Zone 47N was used for map creation for Soyo. In total, four maps were created. Data from the GPR lines were imported into an Excel spreadsheet, and were split into individual pick codes (i.e. 1, 2, 3, 4). Each individual pick code was saved into a new csv file. ArcMap was opened as a blank page, and each data file for the individual pick codes were imported as XY data. Pick code 1 and 4 were plotted over the site and can be found in Figures 14 and 15.

Once the XY data was imported the spatial analyst inverse distance weighted (IDW) interpolation was used on each file to create the depth to surface raster files. Next, the DEM was imported into ArcMap, and used as a base map for each of the depth to surface maps.

The 3D Analyst Tool minus was then used to subtract the IDW maps from the DEM. This created an Isopach map for each layer. Values were then classed into classes, and assigned a colour scale. A scale, north arrow, and title were also added to each map.

4.8 Stratigraphic Excavation

Six stratigraphic test pits were excavated along the GPR 13 meter line, and one archaeological pit was excavated. These excavations were spaced out every 10 meters along the GPR profile. Beginning from the Soyo Hill was test pit 1.7, and test pit 1.2 was placed adjacent to the Hog River. Excavation pit 6 was placed in between test pit 1.4 and 1.3 towards the river. Stratigraphic drawings were made of each pit, and these were later redrawn using the program Inkscape. Stratigraphic photographs and drawings of these excavations are shown in Appendix A and B. Spits were used to excavate the archaeological pit.

4.9 Sediment Analysis

During the 2016 fieldwork, soil analysis was carried out in conjunction with the stratigraphic excavations. A hand lens, Munsell colour chart, and a grain size chart were used in the field to describe the samples. Back in the lab, field notes were transferred into a master stratigraphy spreadsheet to combine this data. Details listed in this spreadsheet included individual soil identification labels, grain size, sorting and mineralogy; Munsell code and colour; whether modern roots, sedimentary structures, or organic structures were present; whether bioturbation, cryoturbation, or mottling had occurred; if a palaeosol was present; an other category; and finally a description was included. These attributes either had a yes or no, or a further comment aspect to it. Geographical details such as the easting, northing, and elevation for each stratigraphic unit were also recorded. The depth to top in the southwest corner (in meters), the depth to the base in the southwest corner (in meters), the elevation to the top and the base was recorded in the spreadsheet as well. Finally, the overall stratigraphic unit details for Soyo were included. The master stratigraphic spreadsheet is attached in Appendix C.

4.10 Radiocarbon Dating

Radiocarbon dating for 15 bone samples began in May 2017 at the Australian Nuclear Science and Technology Organization (ANSTO), Lucas Heights. This was made possible through an ANSTO grant (Project #10692). The ultrafiltration method was initially devised by Brown et al. (1988), which built on from work by Longin (1971). More accurate radiocarbon dates can be achieved through the use of ultrafiltration (Minami et al. 2013). This protocol has been a successful method as demonstrated by Brock et al. (2007), Higham et al. (2006), Jacobi et al. (2006), and Minami et al. (2013), and was the method used on these samples. A whale bone was used as a standard (VIRI).

4.10.1 Ultrafiltration Bone Pretreatment Method

4.10.1.1 Physical Pretreatment:

1. Each sample labeled according to the ANSTO system.
2. Bone samples were cleaned using a Dremel Flexible Shaft model 225 drill in a Dynaflow Dynasafe control system MK5 fume cupboard, Figure 6.

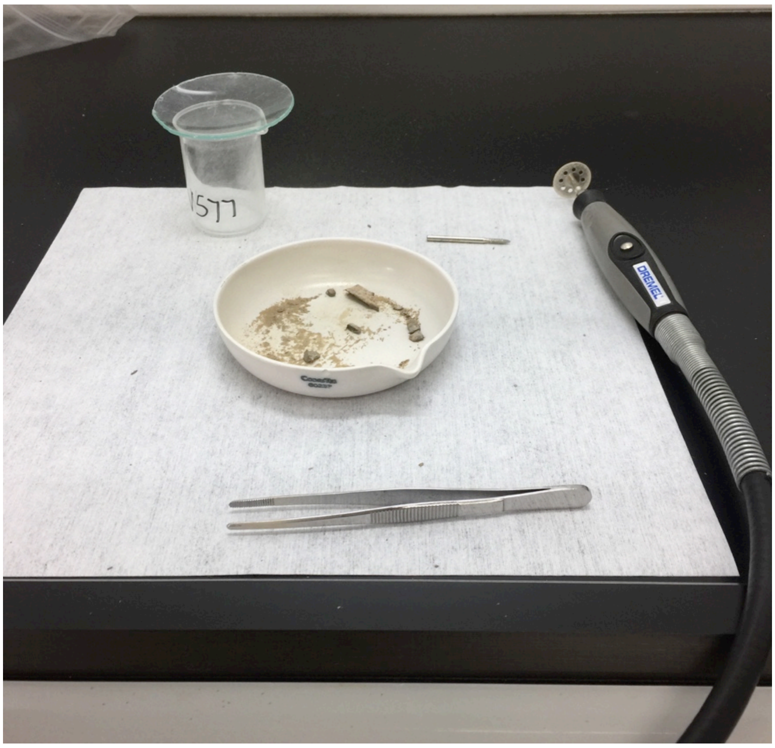


Figure 6. Surface of bone sample OZV 577 being cleaned with the drill

3. Samples were placed in a small labeled beaker, weighed using a Mettler AE 260 DeltaRange balance, and recorded.
4. Beaker samples were placed into a Soniclean bath to be ultrasonicated in DIW (MilliQ water) for 5 minutes.
5. Samples were then placed in a freezer for 1-2 hours.
6. The samples were then placed in a LABCONO FreeZone1 overnight to freeze dry the bone, Figure 7.

Figure 7. Samples being freeze dried

7. The samples were then ground down using a mortar and pestle into smaller chunks, Figure 8, or a powder if possible in the Dynaflow Dynasafe MK5 fume cupboard.
8. Pre-cleaned centrifuge tubes were weighed and tared, and approximately 600mg of each sample was weighed out and placed into the tubes.

Figure 8. Bone samples ground down in mortar and pestle

4.10.1.2 Chemical Pretreatment

1. Each sample was demineralized with 30-40ml of 0.5M HCl in the plastic centrifuge tubes for 1-2 hours at room temperature, with the lids slightly loose, Figure 9.

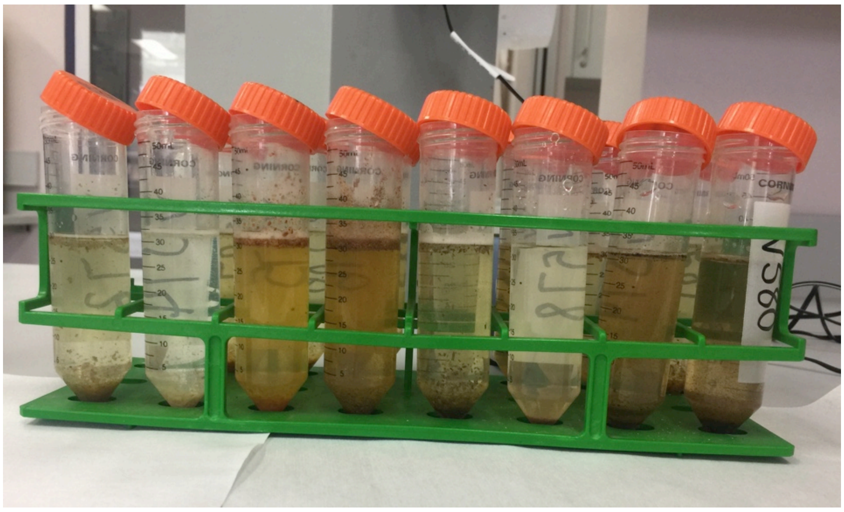


Figure 9. Samples being demineralized

2. Tubes were gently shaken at regular intervals in the 1-2 hours
3. Each sample was then topped up with MilliQ water (to the 50ml mark on the tubes) and centrifuged in an Eppendorf centrifuge 5702 at 3000rpm for 5 minutes.
4. The above two steps were repeated twice.

5. Once the CO_2 had ceased to evolve, the centrifuge tubes were then filled with MilliQ water and centrifuged at 3000rpm for 5 minutes, Figure 10, and the liquid was then drained off. This step was repeated three times.

Figure 10. Samples in the centrifuge

6. Each sample was then covered with 20ml of 0.1M NaOH for 20 minutes at room temperature, which removed humic acids.
7. The sample were then rinsed with MilliQ water, centrifuged for 5 minutes at 3000rpm, and drained off. This was repeated three times.
8. Each sample was then covered with 20ml of 0.5M HCl for 15 minutes at room temperature to remove the dissolved CO_2.
9. The samples were then rinsed, centrifuged for 5 minutes at 3000rpm, and drained. This was repeated three times.

4.10.1.3 Gelatinisation

1. Samples were transferred from the plastic centrifuge tubes into glass tubes using MilliQ water.
2. Samples were placed into 10ml of pH3 water in glass tubes with small beakers on top, Figure 11.

Figure 11. Samples in glass tubes with pH3 water and small beakers

3. The samples were placed in a LABEC oven at 75°C for ~20 hours.
4. The plastic centrifuge tubes were rinsed with MilliQ water and placed in the oven with the lids slightly ajar to dry.

4.10.1.4 Ultrafiltration Cleaning

1. Millipore 'Ultrafree-15' filters with 30KD filters were rinsed inside and out, and were individually placed into clean plastic centrifuge tubes.
2. MilliQ water was added to the Ultrafilters to the 50ml mark on the centrifuge tubes.
3. The Ultrafilter lid was closed and then centrifuged for 15 minutes at 2500-3000rpm.
4. Each filter was then flicked briskly to remove any remaining water in the filter, and was centrifuged and flicked for a second time.
5. A large beaked was filled with MiliQ water and the Ultrafilters were submerged in this.
6. The beaker was then placed in the Soniclean for 1 hour.
7. Each ultrafilter was then flicked and rinsed inside and out, and any liquid in the bottom of the centrifuge tube was drained off.

8. MilliQ water was used to fill the ultrafilters up to the 50ml mark on the tubes and centrifuged. This process was repeated three times. On the final centrifuge, the remaining liquid at the bottom of the centrifuge was kept.
9. Eeze-filters were placed into a large beaker filled with MilliQ water.
10. The beaker was then placed in the Soniclean for ultrasonication for 20 minutes.
11. Each filter was then rinsed inside and out using MilliQ water.
12. The samples were taken out of the oven after ~20 hours in order to cool.
13. When the samples were cool enough to be used, a clean glass tube was filled halfway with MilliQ water, and each eeze-filter was pushed through, immediately before being pushed through the samples, Figure 12.

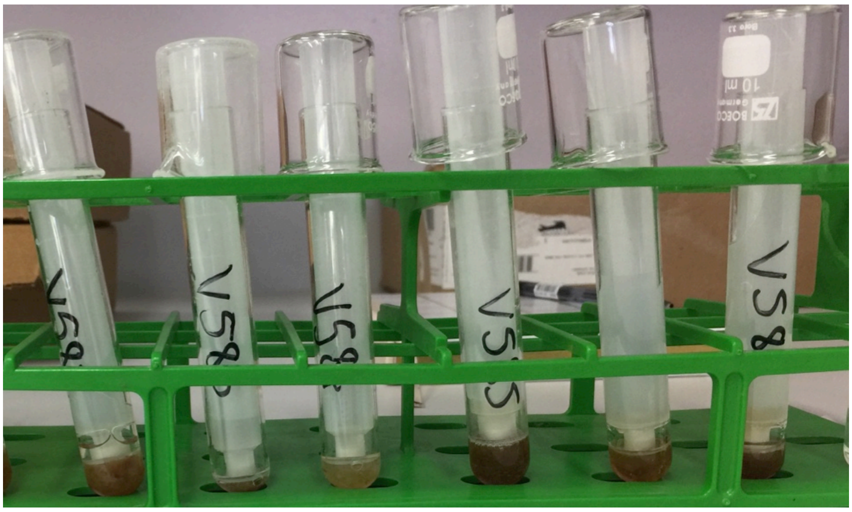


Figure 12. Eeze-filters in glass tubes

14. The eeze-filter was pushed to the bottom of the vial, and the solution in the ezee-filters was then transferred over to the ultrafilters.

4.10.1.5 Ultra-filtration

1. Each gelatinized sample in the Ultrafilters was then centrifuged at 3000rpm for 30 minutes.
2. Glass pipettes were cleaned with MilliQ water.
3. Any remaining solution from the ezee-filters was added to the Ultrafilters and centrifuged again at 3000rpm for 30 minutes.
4. Glass centrifuge tubes were then labeled accordingly for each sample.

5. The clean glass pipettes were used to pipette out the >30KD solution around the filter into the clean glass centrifuge tubes.
6. If there was any solution remaining, MilliQ water was used to pipette out any of this into the glass centrifuge tubes.
7. If any samples had been completely filtered through, they were labeled with U2.
8. Laboratory Parafilm was used to cover each glass centrifuged tube, before being placed in the freezer >1hour to overnight.
9. The samples were taken out of the freezer and the parafilm was pierced several times, and placed into the LABCONO FreeZone1 to freezedry the solution for 24 hours, Figure 13.

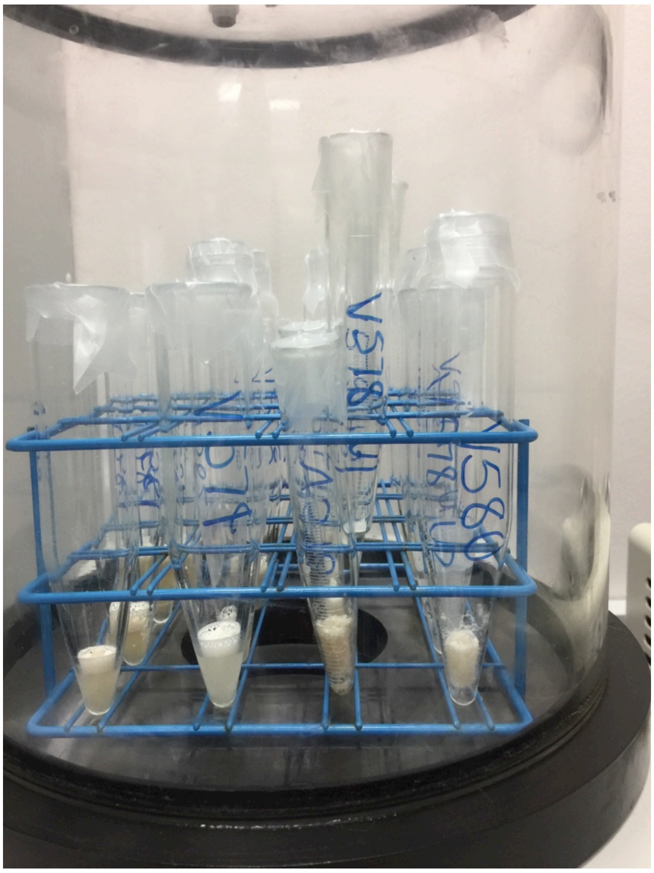


Figure 13. Samples with pierced parafilm in the freeze dry

4.10.1.6 Combustion, Quality Tests and Storage

1. Small glass vials were labeled with the OZ code and a ‘p’ indicating pretreatment.
2. The samples were taken out of the freezedry.

3. Each labeled glass vial was weighed, tared, and had the corresponding sample transferred over with a clean metal spatula.
4. The samples were then weighted and recorded
5. Small samples were then placed inside tin capsules, and were weighed using a Mettler Toledo.
6. Several samples were weighed out for collagen, and 65-88ug was required for 13C; for the C:N ratio 250-320ug was required; and for extremely small samples a measurement of 250-320ug was required.
7. Once the desired weight was recorded, the tin was folded into a ball and placed into a corresponding row.
8. From here, the staff at ANSTO took over the process to include combustion, and graphitization.

5. Results

The results from the GPR, radiocarbon dating, sediment analysis, and stratigraphic data will be presented in this chapter. Each method produced a rich source of data, and the correlation of these methods is vital to interpreting the palaeoenvironmental history. This will provide an environmental lens through which to view the archaeological data. Interpretation of the results will be conducted in chapter 6.

5.1 GPR

Several features were identified in the post-processed GPR data and picked in the analysis. Based on the site data from the stratigraphy from the excavations, some of the surfaces have been interpreted to be palaeosols, moraines, and boulders. Hyperbolas and stratigraphic surfaces have been also been observed in the data. In processing and interpreting the GPR data, features such as boulders, moraines, hyperbolas, and the palaeosols were assigned a specific code, picked, and interpreted. Each feature was defined according to the attributes present in the data. Four pick codes were used to distinguish between the features, and are detailed in Table 14 below. Pick code one was drawn onto the data using a manual pick, and pick codes two to four were drawn onto the data using a continuous line. A description for each feature was developed in order to correctly identify each feature in each line. Pick code one was assigned to hyperbolas; pick code two to palaeosols; pick code three to moraines; and pick code four to boulders. For pick code one, hyperbolas were identified by individual hyperbolas with a weak to moderate amplitude. Palaeosols were determined to be unbroken, banded lines that had a strong amplitude. Pick code three features, moraines, were recognized by high amplitude hyperbolas with a strong reflectance. Finally, pick code four, boulders, were described as being closely banded small-mid sized hyperbolas, generally occurring in a high frequency, with a weak to mid reflectance. The outline of the palaeosols and moraines was drawn into Reflex; the hyperbolas were picked, and the boulders had a line drawn horizontally though them. The distribution of pick code one and four, can be found in below in Figures 14 and 15.

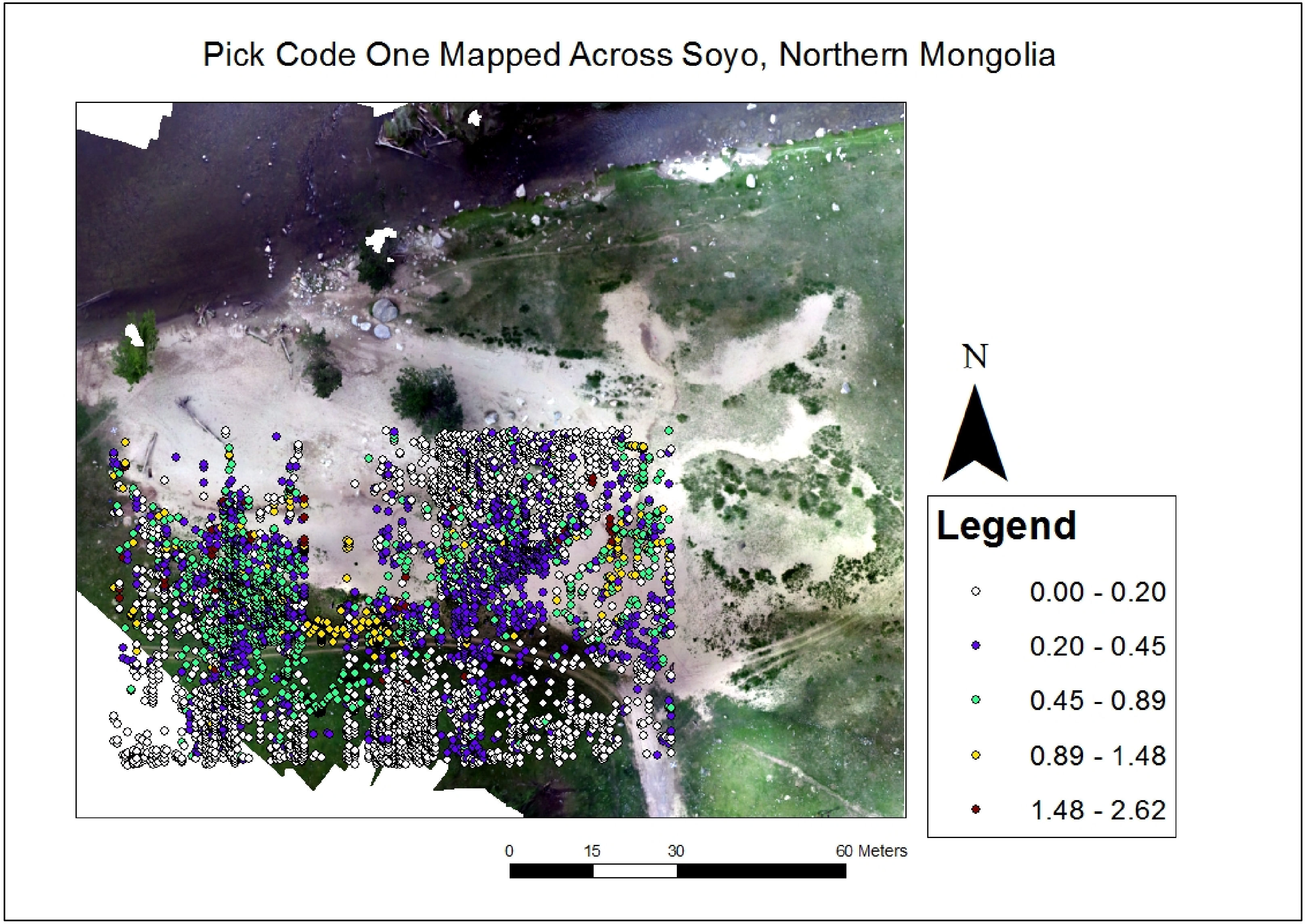


Figure 14. Mapping of Pick Code One Across Soyo

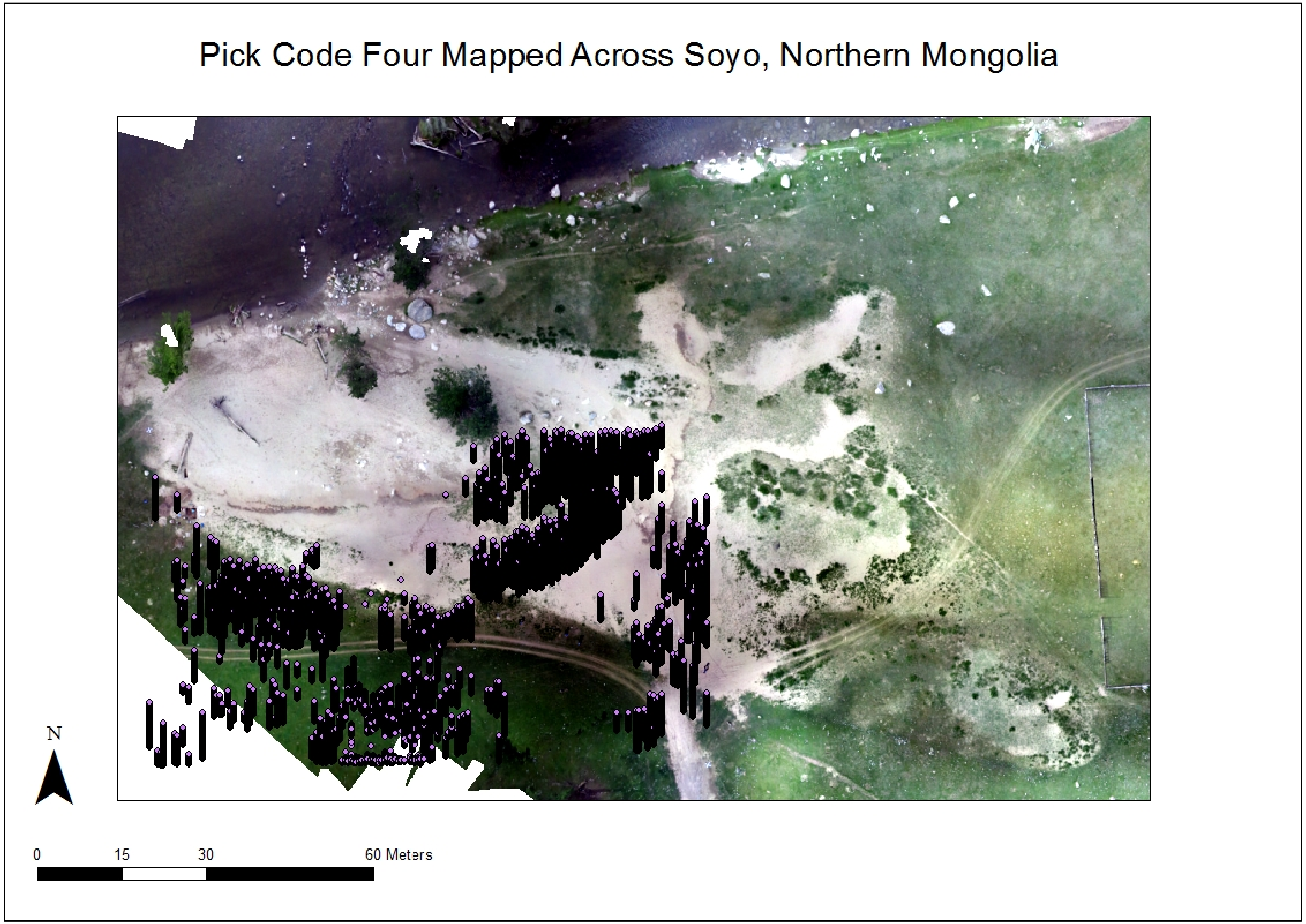


Figure 15. Mapping of Pick Code Four Across Soyo

Five classes were used to classify the hyperbolas across the site. Overall 56.55% were in 0.00 – 0.20 meters, 29.6% were in 0.20 – 0.45 meters, 11.35% were in 0.45 – 0.89 meters, 1.4% were in 0.89 – 1.48 meters, and 1.1% were in 1.48 – 2.62 meters.

The depth and the length of the identified palaeosols and moraines were also noted and used to construct the depth to surface maps. Figure 16 is an example of picked hyperbolas, boulders, moraines, and palaeosols.

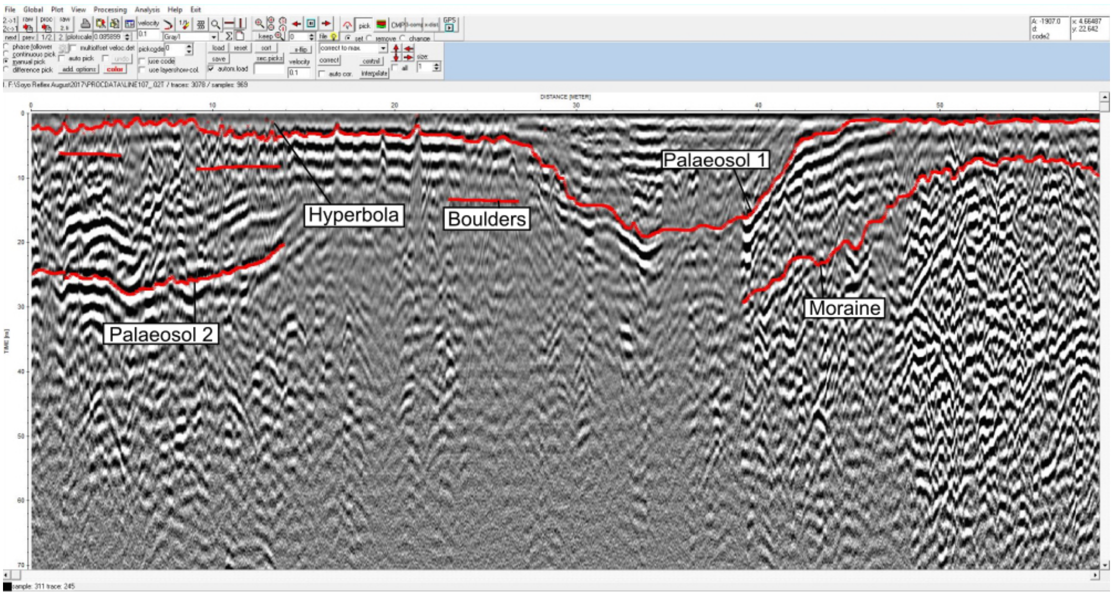


Figure 16. Picked hyperbolas, boulders, moraines, palaeosol 1 and palaeosol 2

The palaeosols have high reflectance values, which show up extremely clearly in the GPR data. The palaeosols were subdivided into palaeosol one (upper), and palaeosol two (lower). 78% of the total GPR lines interpreted included all four pick codes (boulders, upper palaeosol, lower palaeosol, and moraines). 21.5% of the GPR lines had three pick codes identified, and this was split into 19%, with boulders, upper palaeosol, and moraines identified, and 2.5% with the upper palaeosol, lower palaeosol, and moraines identified. Finally, 0.5% of the interpreted GPR lines had two pick codes identified, palaeosol upper, and moraines. Of the four pick codes identified both palaeosol upper and moraine were identified most frequently, and were identified in 100% of the GPR lines. Boulders, identified in 97% of the GPR lines, followed this and the lower palaeosol was identified in 80.5% of the interpreted GPR lines. The coverage of the GPR lines over the site can be found in Figure 17 below.

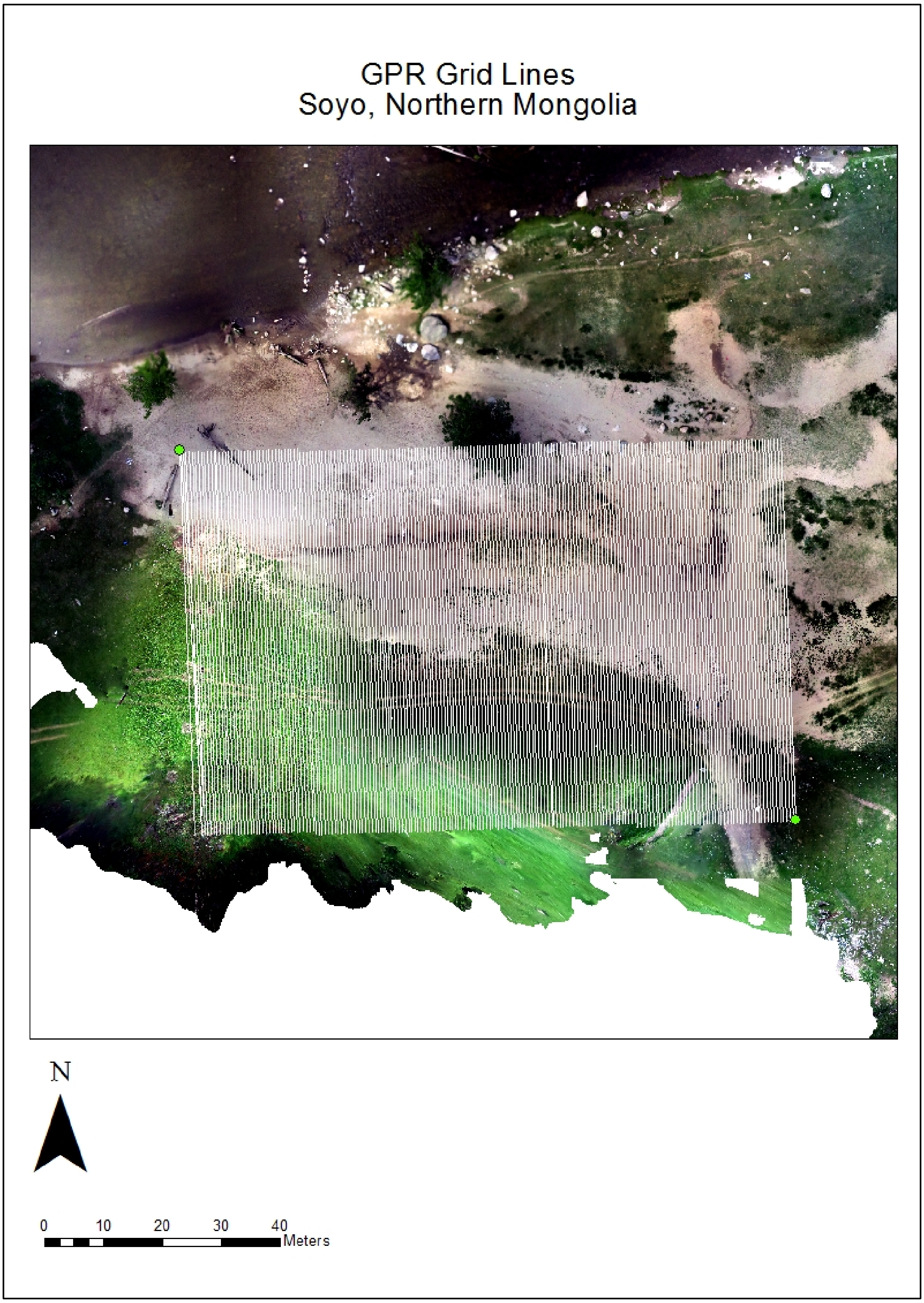


Figure 17. Coverage of GPR lines over Soyo

Table 9. Pick code and feature correlation

Pick Code	Category
Pick code 1	Hyperbolas
Pick code 2	Palaeosols
Pick code 3	Moraines
Pick code 4	Boulders

5.2 Radiocarbon Dating

Twelve bone samples were selected from one excavation unit and were sent to ANSTO to be radiocarbon dated. The bone samples underwent quality tests, detailed below, in order to establish the presence of contamination, and collagen levels. Samples were taken from Excavation Unit 6. Three samples from Excavation Unit 6 did not have substantial amounts of collagen and thus failed to be radiocarbon dated. This data is displayed in Table 15, and the oldest date for Excavation Unit 6 is 10,900 +/- 40 BP, and the youngest date is 85 +/- 25 BP. Samples OZV573 and OZV574 were dated to be modern in age.

Excavation Unit 6 includes chronological cultural periods of the transition from the Mesolithic to Neolithic (12,000 – 5,500 BP); the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP); and a modern period. The Mesolithic to Neolithic period is represented by 11.11%; the transition from the Iron Age to the emergence of the Mongol Empire is represented by 33.33%; the period between 265 to 85 BP is represented by 33.33%; and the modern period is represented by 22.2%
The distribution of these dates across Excavation Unit 6 are displayed in Figure 18, and Figure 19 maps the stratigraphic level for the samples.

Table 10. Radiocarbon results for 12 bone samples, conducted at ANSTO, Lucas Heights, NSW, Australia

ANSTO code	Sample Type	Submitter ID	$\delta(^{13}C)$ per mil	percent Modern Carbon	Conventional Radiocarbon age
				pMC 1σ error	yrs BP 1σ error
OZV573	Bone	147	-21.5 +/- 0.1	109.87 +/- 0.25	Modern
OZV574	Bone	151	-20.5 +/- 0.1	130.30 +/- 0.27	Modern
OZV575	Bone	185	-20.3 +/- 0.1	96.76 +/- 0.25	265 +/- 20
OZV576	Bone	186	-19.8 +/- 0.1	98.92 +/- 0.27	85 +/- 25
OZV577	Bone	191	-20.1 +/- 0.1	25.75 +/- 0.11	10,900 +/- 40
OZV580	Bone	200	-20.4 +/- 0.1	86.08 +/- 0.23	1,205 +/- 25
OZV581	Bone	201	-19.2 +/- 0.3	89.34 +/- 0.24	905 +/- 25
OZV582	Bone	202	-19.0 +/- 0.1	98.56 +/- 0.23	115 +/- 20
OZV584	Bone	213	-19.9 +/- 0.1	86.13 +/- 0.24	1,200 +/- 25

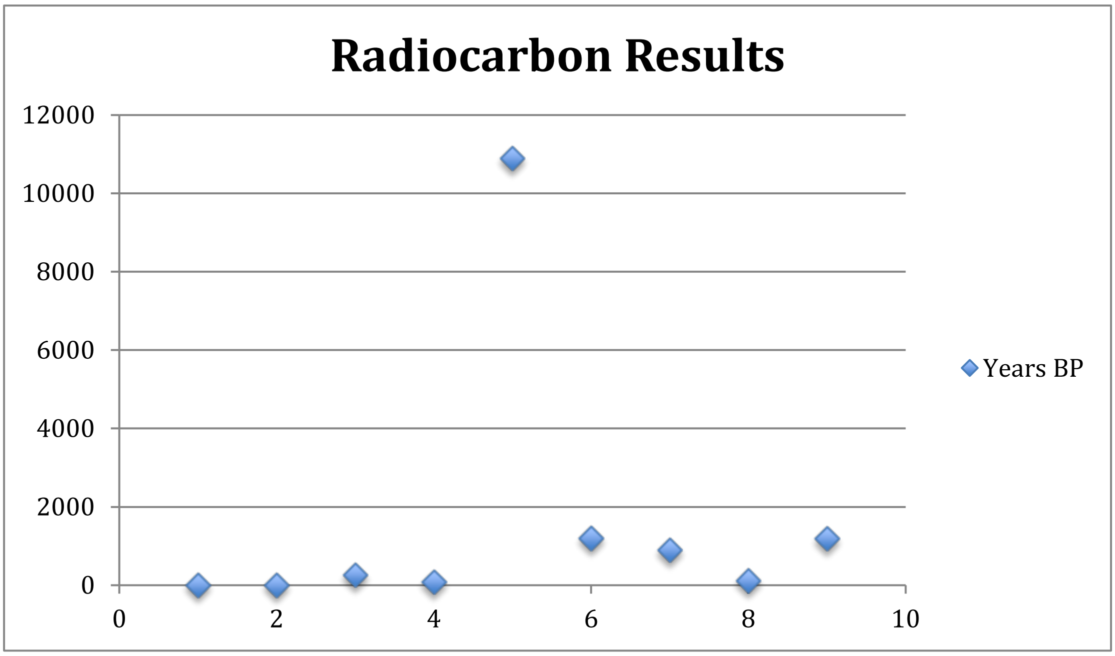


Figure 18. Distribution of radiocarbon dates

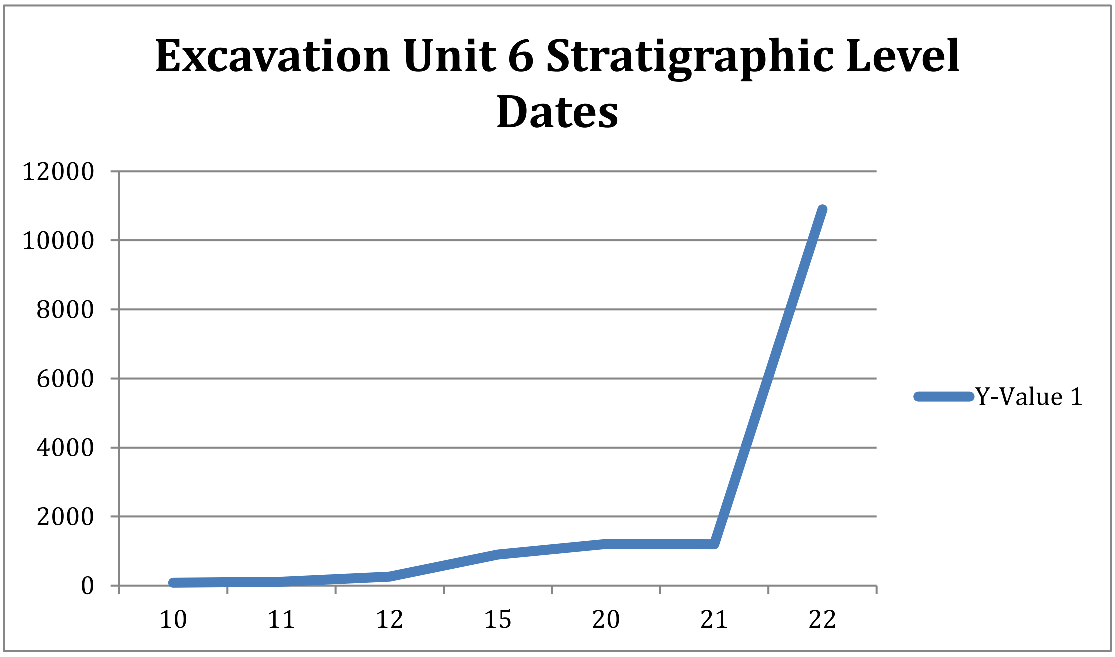


Figure 19. Stratigraphic levels of radiocarbon dates

Table 11. Summary of bone collagen results

OZ Code	Customer Code	Collagen %	Atomic C/N ratio	$\delta^{13}C$
OZV573	147	4.6	3.2	-22.0
OZV574	151	8.9	3.2	-20.9
OZV575	185	4.7	3.3	-20.6
OZV576	186	1.8	3.4	-20.2
OZV577	191	3.6	3.3	-20.4
OZV578	192	0	n/a	n/a
OZV579	197	0	n/a	n/a
OZV580	200	1.0	3.4	-20.4
OZV581	201	4.4	3.3	-19.5
OZV582	202	3.7	3.2	-19.6
OZV583	206	0	n/a	n/a
OZV584	213	6.4	3.2	-20.3

Table 16 is a result of the quality tests that each sample went through. These test determine how suitable the extracted collagen is in each bone sample. Three samples (OZV578, OZV579, and OZV583) did not produce any collagen.

The percentage of collagen determines the quality of the bone for dating. Bone samples that are highly degraded have a cut off of 1% weight collagen (Higham et. al. 2006). Likewise, the C:N ratio is used to detect contamination of collagen in the sample. The ANSTO lab accepts values between 2.9 – 3.5. These ratios demonstrate that any contaminants had been removed in the pretreatment process, and that the level of collagen preserved was adequate for radiocarbon dating. The final test determines whether there is any presence of external contamination. Values of -19% to -22% are acceptable, and also indicate a diet of terrestrial C3 plants. External contamination values would have higher negative values.

Table 17 details the stratigraphic location of the bone samples in Excavation Unit 6, and the assigned radiocarbon date.

Table 12. Correlation of radiocarbon date and bone sample location

Sample ID	OZ Code	Unit	Level	Stratigraphy	Radiocarbon Date
147	OZV573	6	6	B	Modern
151	OZV574	6	8	B	Modern
186	OZV576	6	10	C	85 +/- 25
202	OZV582	6	11	B	115 +/- 20
185	OZV575	6	12	C	265 +/- 20
192	OZV578	6	14	D	N/A
201	OZV581	6	15	D	905 +/- 25
206	OZV583	6	16	O	N/A
197	OZV579	6	18	F	N/A
200	OZV580	6	20	G	1,205 +/- 25
213	OZV584	6	21	G	1,200 +/- 25
191	OZV577	6	22	G	10,900 +/- 40

5.3 Maps

Two depth to surface maps for pick code two, the palaeosol, and pick code three, the moraine, were created for analysis. These can be found in Figures 20 and 21. The palaeosol ranged in depth from 0.008 meters to 1.726 meters. The moraine layer ranged in depth from 0.015 meters to 1.85 meters. An isopach map was created for the palaeosol layer, and can be found in Figure 22. The palaeosol, which was visible on the surface, can be identified in the map through the orange/red colours across the isopach map. For this map, the palaeosol has a high of 1634.47, and a low of 1619.21. Elevation maps were also created for the palaeosol and moraine layers, which can also be found in Figure 23. The palaeosol layer has a high of 6.13843 and a low of -6.10962. The moraine layer has a high of 1.11609, and a low of -1.80798. The palaeosol layer mapped in Figures 20 to 23 has data missing from maps, due to an error in Reflex.

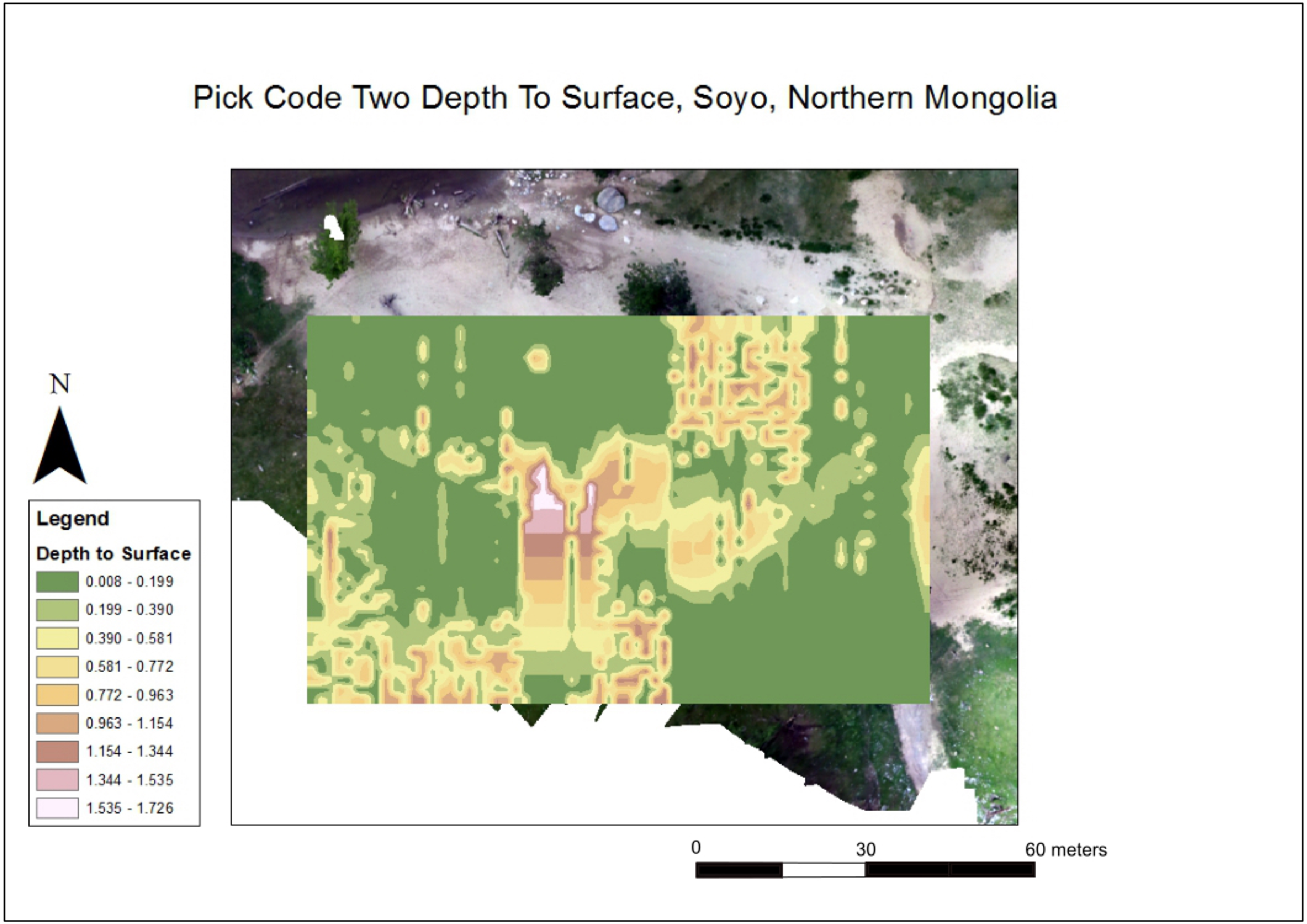


Figure 20. Depth to Surface Map: Pick Code Two

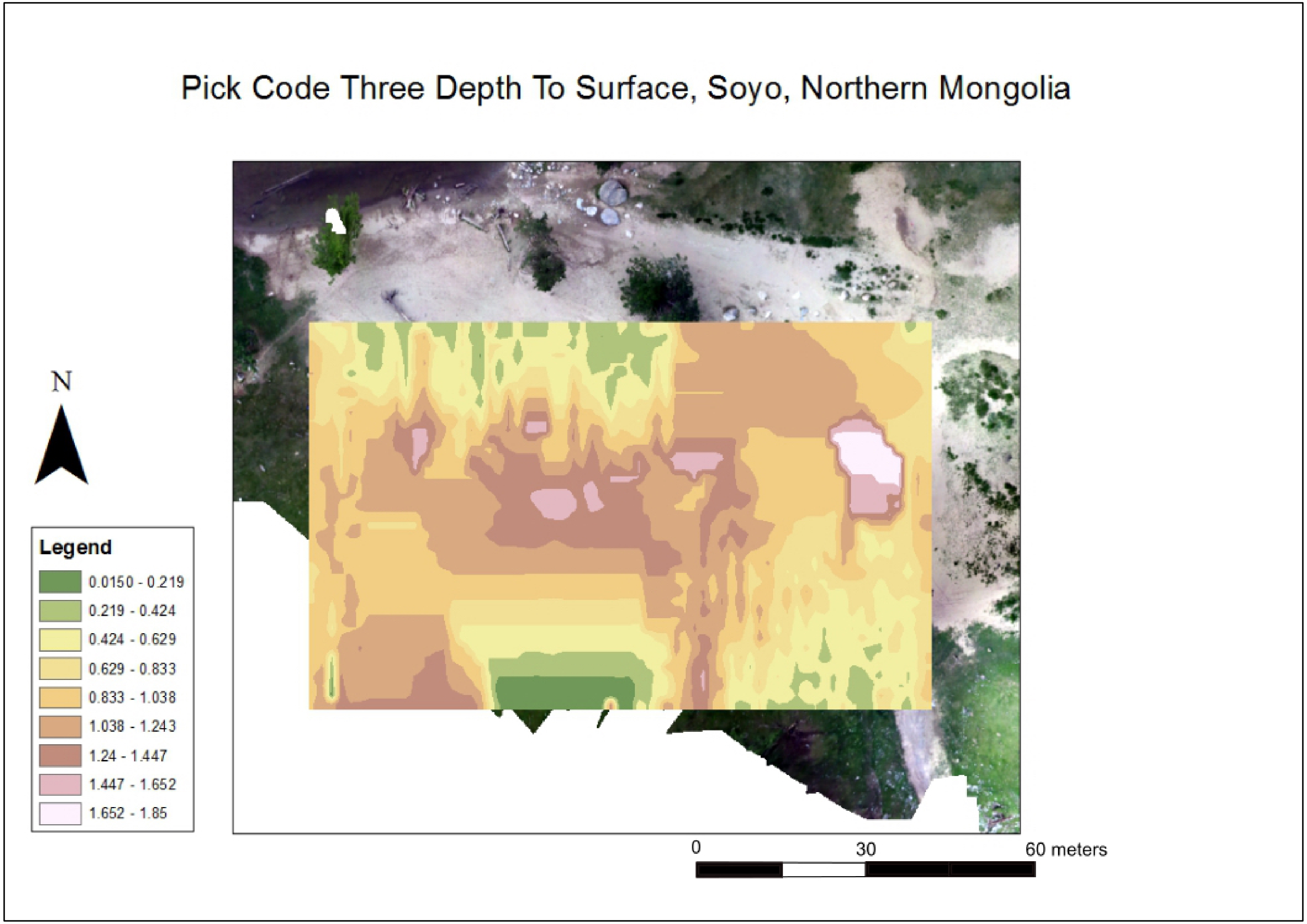


Figure 21. Depth to Surface Map: Pick Code Three

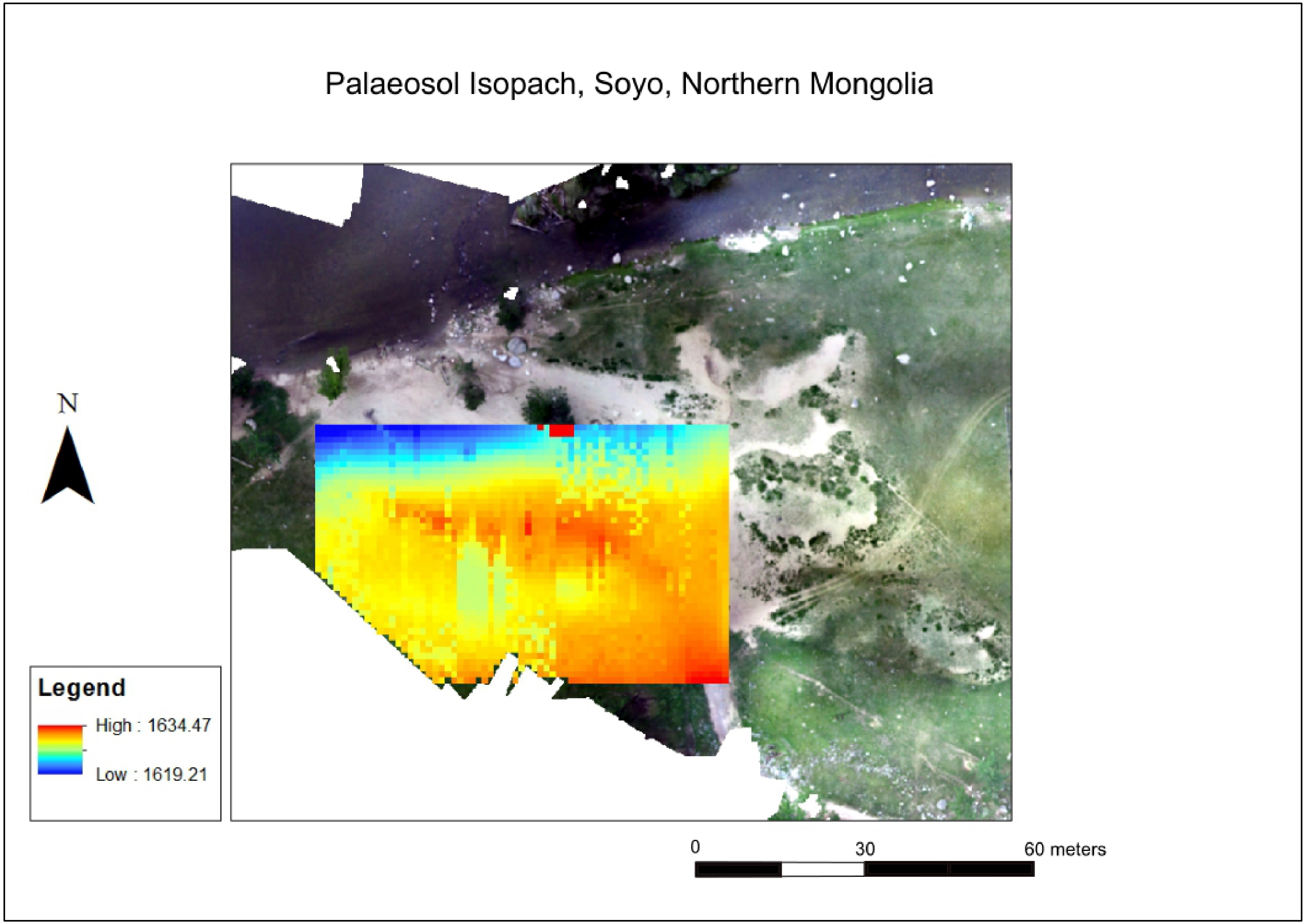


Figure 22. Palaeosol Isopach Map

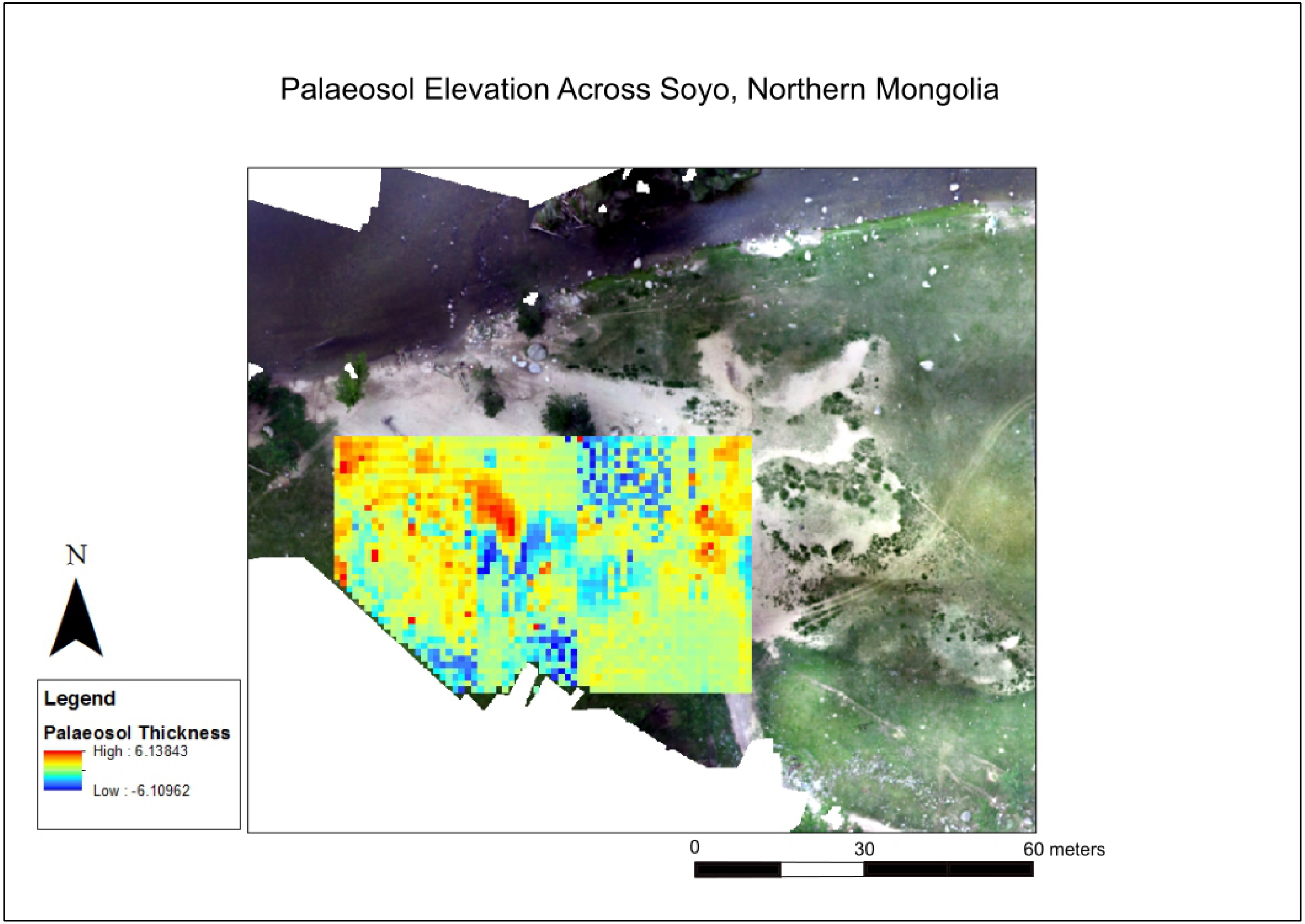


Figure 23. Palaeosol Elevation Map

5.4 Sediment Analysis

As detailed in the methods chapter, sediment was described in the field and later collated in the lab. The details of the master stratigraphy list can be found in Appendix C. Table 18 lists the different types of sediment present at Soyo. Overall there were thirteen strata identified, and the definition for each is detailed below.

Table 13. List of Sediment

Black Palaeosol
Light Colored Soil
Reddish Silty Sand
Lower Black Palaeosol
Brown Soil
Basal Substrate
Upper Slightly Darker Colored Soil
Lower Slightly Darker Colored Soil
Lower Light Colored Aeolian Sand
Upper Light Colored Aeolian Sand
Light Colored Aeolian Sand
Slightly Darker Colored Aeolian Sand
Darker Colored Sand

The upper black palaeosol was present in 85.71% of the excavated units; and the lower black palaeosol was present in 28.57% of the excavated units. Light colored soil was represented by 28.57%, reddish silty sand by 42.86%, and brown soil by 28.57%. Similarly both, upper and lower, slightly darker colored soil was present in 14.29%. Both light colored aeolian sands were present across 100% of the excavated units. The slightly darker colored aeolian sand was present in 28.57%, and the darker colored bedrock sand was present in 85.71% of the excavated units. Finally, the basal substrate was reached in 71.43% of the excavated units.

The following is a description of the sedimentary layers across unit T1.2 to T1.7, and Excavation Unit 6.

Black Palaeosol

This layer has very fine-to-fine grained sand, and is well to moderately sorted. Clay/silt may be present, as well as some muscovite, and organic structures. There is no evidence of cryoturbation. Munsell colours include 7.5 YR 2.5/1 Black, 10YR 2/1 Black, 10 YR 4/3

Brown, 10 YR 3/2 Very Dark Greyish Brown, 10 YR 2/2 Very Dark Brown, 10YR 5/2 Grayish Brown.

Light Coloured Aeolian Sand

This layer has very well sorted sandy silt/clay. There is no sign of muscovite present, and no sign of cryoturbation. Munsell colours can include 2.5 YR 5/2 Greyish Brown, 2.5 Y 6/2 Light Brownish Grey, 10YR 6/2, Light Brownish Grey, 2.5YR 3/2 Very Dark Greyish Brown, 2.5 Y 4/4 Olive Brown, 2.5Y 5/2 Greyish Brown, 10YR 7/2 Light Grey, 10YR 6/3 Pale Brown.

Reddish

This layer has very fine and very well sorted silty sand. Munsell colours can include 2.5Y 4/4 Olive Brown, 10 YR 5/3, 10 YR 2/1 Black, 10 YR 3/2 Very Dark Greyish Brown.

Slightly Darker Coloured Aeolian Sand

This layer may be a possible palaeosol. It has very fine sand, and is very well sorted. Muscovite may be present. Munsell colour may include 2.5Y 3/2 Very Dark Greyish Brown and 10YR 3/3 Dark Brown.

Lower Light Coloured Aeolian Sand

This layer has very fine and very well sorted sand. Some muscovite may be present. Munsell colour ranges from 2.5Y 5/2 Greyish Brown, and 10YR 5/2 Greyish Brown.

Basal Substrate

This layer ranges from glacial fill, cobbles and boulders, to gneiss and limestone. Munsell colours include 2.5Y 5/2 Greyish Brown.

Brown Soil

This layer has very fine sand with abundant silt/clay, well sorted. Some modern roots present. The munsell colour for this layer is 10 YR 4/3 Brown.

Darker Coloured Bedrock Sand

This layer has very fine, very well sorted sand with silt. Some mica and muscovite are present, and frozen chunks of sand may also be present. Munsell colours range from 10YR 6/3 Pale Brown, 2.5Y 5/3 Light Browninsh Grey, 2.5Y 6/2 Light Greyish Brown, 2.5Y

5/3 Light Olive Brown, 10YR 4/2 Dark Greyish Brown, 10YR 5/2 Greyish Brown, 10YR 4/3 Brown, 2.5Y 5/2 Greyish Brown, 2.5Y 6/3 Light Yellowish Brown, 10YR 2/2 Very Dark Brown, 10YR 6/6 Dark Yellowish Brown.

Light Coloured Aeolian Sand Slightly Darker

This layer has silt with some very fine grained sand and abundant mica fragments. Some roots are present, and the layer appears mottled and also may be a palaeosol. The munsell colour for this layer is 10YR 5/6 Yellowish Brown.

Light Coloured Soil

This layer has very fine, very well to moderately sorted sandy soil. There is some muscovite present with other minerals such as feldspar and biotitie. Munsell colours range from 10YR 3/3 Dark Brown to 10YR 5/3 Brown.

Slightly Darker Coloured Soil

This layer has very fine grained and very well sorted sand with abundant clay/silt. There is some mica is present. This layer holds moisture and the basal geometry is affected by cryoturbation. There is also light mottling throughout. Munsell colour includes 10YR 5/3 Brown.

Table 19 details the initial stratigraphic layers identified, which are then correlated to the corresponding stratigraphic description.

Table 14. Presence of stratigraphic layers in excavated units

Stratigraphic Layer	Unit Number
Black Palaeosol	T1.2, T1.3, T1.4, T1.5, T1.6, T1.7, Excavation Unit 6
Light Coloured Aeolian Sand	T1.2, T1.3, T1.4, T1.5, T1.6, T1.7, Excavation Unit 6
Reddish	T1.2, T1.4, Excavation Unit 6
Slightly Darker Coloured Aeolian Sand	T1.2, T1.6
Basal Substrate	T1.2, T1.3, T1.4, T1.5, T1.6,
Brown Soil	T1.3, T1.5
Darker Coloured Bedrock Sand	T1.3, T1.4, T1.5, T1.6, T1.7, Excavation Unit 6
Light Coloured Aeolian Sand Slightly Darker	Excavation Unit 6
Light Coloured Soil	T1.7, Excavation Unit 6
Slightly Darker Coloured Soil	Excavation Unit 6

5.5 Stratigraphic Data

As detailed in the methods chapter, there were six stratigraphic pits excavated for geological testing and one archaeological pit. Table 20 below details the stratigraphic information for each excavated pit, including the types of sediment, thickness of each layer, and features that are present. Photos of the stratigraphic pits and excavated pits are located in Appendix A, and detailed drawings of each pit are located in Appendix B. The stratigraphic data and sedimentary analysis conducted in the field and detailed above also described the thickness of each layer. Overall the thickest layer across the stratigraphic excavated units was the darker colored bedrock sand in T1.7 at 0.85 meters, representing 66.93% of the overall sediment in T1.7. The overall two thinnest layers were located in stratigraphic unit T1.6, the slightly darker colored aeolian sand and the lower black palaeosol, both at 0.01 meters, and individually represent 1.52% of the total sediment in T1.6. Features such as the presence of palaeosols and cryoturbation were clearly present in 83.33 % of the overall excavated units.

Table 15. Thickness of stratigraphic layer for each unit

Stratigraphic Unit	Sediment Classification	Thickness of Sediment (m)
T1.2	Upper Black Palaeosol	0.05
	Light Coloured Aeolian Sand	0.08
	Reddish	0.42
	Slightly Darker Coloured Aeolian Sand	0.06
	Light Coloured Aeolian Sand	0.24
	Lower Black Palaeosol	0.35
	Basal Substrate	N/A
T1.3	Brown Soil	0.05
	Upper Black Palaeosol	0.1
	Reddish	0.07
	Light Coloured Aeolian Sand	0.26
	Darker Coloured Bedrock Sand	0.19
	Basal Substrate	N/A
T1.4	Upper Black Palaeosol	0.1
	Light Coloured Aeolian Sand	0.49
	Darker Coloured Bedrock Sand	0.2
	Basal Substrate	N/A
T1.5	Upper Black Palaeosol	0.12
	Brown Soil	0.18
	Light Coloured Aeolian Sand	0.26
	Darker Coloured Bedrock Sand	0.24
	Basal Substrate	N/A
T1.6	Upper Black Palaeosol	0.14
	Light Coloured Aeolian Sand	0.12
	Slightly Darker Coloured Aeolian Sand	0.01
	Light Coloured Aeolian Sand	0.08
	Darker Coloured Bedrock Sand	0.3
	Lower Black Palaeosol	0.01
	Basal Substrate	N/A
T1.7	Light Coloured Soil	0.3
	Light Coloured Aeolian Sand	0.12
	Darker Coloured Bedrock Sand	0.85
Unit 6	Light Coloured Soil	0.2
	Slightly Darker Coloured Soil	0.19
	Upper Black Palaeosol	0.11
	Slightly Darker Coloured Soil	0.12
	Light Coloured Aeolian Sand	0.37
	Darker Coloured Bedrock Sand	0.4

5.6 Correlated Data

Following the interpretation of the results for each individual method, all the data was correlated and interpreted. The interpreted GPR data demonstrates the identification of two palaeosols across the site, which was not always apparent in the stratigraphy. The position of each excavated unit is shown in Figure 24, and the position of the GPR lines can be found above in Figure 17.

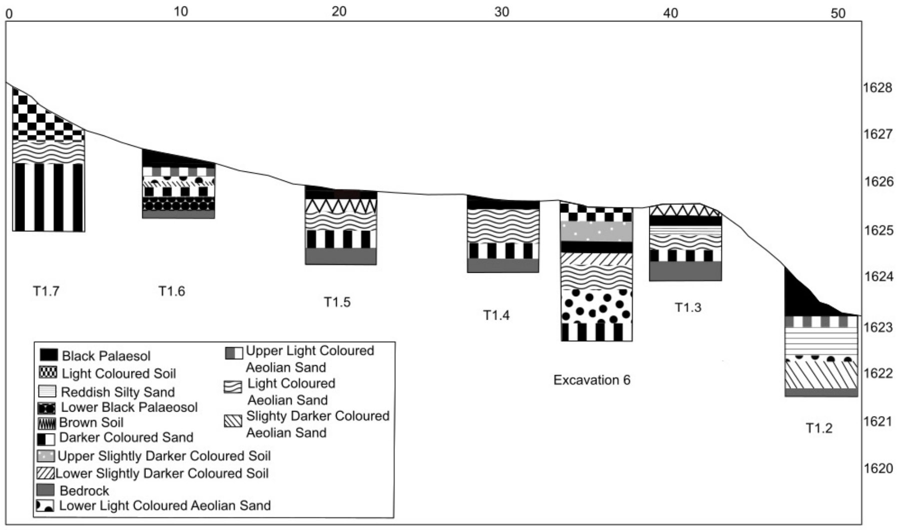


Figure 24. Position of the excavated units along GPR line 13, and sedimentary layers

For Excavation Unit 6, 33.33% of the samples were from the upper palaeosol, another 33.33% of the samples were from aeolian sand; 22.22% were from the reddish siltiy sand layer; and the remaining 11.11% of the bone samples were taken from the aeolian sand layer.

6. Discussion

This chapter will explore the data presented in the previous results chapter, and will also place this research within the wider literature. This will be achieved through a correlation of the data sets, firstly, GPR, then radiocarbon dating and stratigraphy; and sediment analysis and stratigraphic data. The radiocarbon dating of Soyo has given it a chronological place within the wider literature, and environmental processes such as cryoturbation and the deposition of aeolian sands from the river, have had an impact on the way in which this site has been formed. The combination of geoarchaeological techniques has provided both a substantial dataset and the basis for demonstrating that the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP) can be a pastoral dominated technological culture rather than an agricultural one. This data will also be interpreted in relation to the research question, which will address Soyo as a site and the wider Neolithic in Mongolia. The chapter will conclude with an overview of the interpreted data.

6.1 Correlation between data sets

As stated above, the data sets have been paired up and correlated in order to dissect the data. The result of each technique will be detailed individually and then later combined with the other technique.

6.1.1 GPR

As detailed in the results chapter, two palaeosols were mapped across the site. The upper palaeosol is a dark/black colour, and a very well developed soil. The lower palaeosol is brown/black in colour, and less developed when compared to the upper palaeosol. The upper palaeosol was identified in 100%, and the lower palaeosol was identified in 80.5% GPR lines. As defined in chapter 5.1, palaeosols were determined to be unbroken, banded lines that had a strong amplitude. The strong reflectance of the palaeosol and the repeated location and pattern of it over the processed GPR lines made it extremely clear within the data. However, it is interesting to note that it was much more difficult to identify the lower palaeosol in the field. The lower palaeosol varies in colour, and within this sediment there is also a high presence of sand. Sand was identified in 75% of the palaeosol. This impacts upon the ability to clearly define strata. Still, the presence of sand within the sediment can be interpreted to mean that during the formation of this soil there was aeolian activity, but it was irregular. This irregular aeolian activity hindered the lower palaeosol from forming as well as the upper palaeosol did.

Other features such as hyperbolas, boulders, and moraines were also successfully mapped across the site. As shown in Figures 14 and 15, hyperbolas were found across the entire site. These were attributed to being small metal objects/fragments, small rocks, or granite boulders of varying sizes. The small metal objects/fragments that were closest to the surface (0.00 – 0.20 meters) can be attributed to modern metal, and are also correlated with the modern radiocarbon dates present. Hyperbolas that were 1.48 – 2.62 meters below the surface are deeper than the stratigraphic and excavated units. These can be attributed to large boulders, or could also be evidence of bioturbation or cryoturbation at the site.

Also, boulders were identified in 97% of the overall GPR lines, which is a reflection of the surrounding environment. Alongside the upper palaeosol, moraines were also identified in 100% of the processed GPR lines. Moraines were recognized by high amplitude hyperbolas with a strong reflectance, and were present in a continuous layer. The depth of the moraine across the site varies, and is fundamentally a part of the landscape. Moraines are a common feature within the wider landscape at Soyo. Topographically, the elevation of the moraine, Figure 23, varies across Soyo. Parts of the moraine are visible on the surface, whilst the rest of the moraine layer is in the subsurface. Directly across from Soyo on the other side of the Hog River there are several terraces and moraines. The lowest moraine sits at the same height as the one at Soyo. These glacial advances have shaped the landscape, and the moraines are evidence of that. Essentially, the landscape was shaped from the process of the ground being completely covered with ice, and the soil then being scraped off the surface.

Although the lower palaeosol has not been dated as yet, it is considered most likely to not be older than the end of the Pleistocene/LGM due to the extensive presence of glaciers within the region. Furthermore, moraines and boulders were a frequent feature across the site and similarly demonstrate the climatic conditions present. The moraines record the last period that the landscape was covered by ice. Therefore, it is likely that the moraines are younger than the LGM. During the late Pleistocene, the mountains surrounding the Darkhad Basin were glaciated at 17,000 – 19,000 and ~35,000 – 53,000 (Gillespie et al.

2008:183). From the glaciated mountains, outlet glaciers moved through the landscape. The moraines at Soyo and in the wider landscape represent the biggest glacial advance in recent times. Based on this, it is probable that the moraines at Soyo are dated to ~17,000 – 19,000 years. In the palaeoenvironmental climate record this time period is associated with a cold, dry climate (Choi et al. 2014). Batbaatar and Gillespie (2016:20) indicate that glaciers in northern Mongolia reacted more to changes in temperature rather than changes in precipitation.

The upper palaeosol has been radiocarbon dated to 1,200 BP, and with this date we are able to bracket the strata in between in order to give a basic estimate of age. Further dating of the site will improve the chronology, and the implications of this will be discussed below.

The topography of Soyo is also interesting. The site slopes down the hill towards the Hog River. On the other side of the river there is a glacial moraine that matches the elevation of the buried glacial moraine identified in the processed GPR data. The slope over the site towards the river, can be attributed to the presence of a larger moraine located above the site, and the presence of the basal substrate at the Soyo Hill. Soyo is also a well-preserved and stratified site. The currently buried moraine mapped in this study using GPR can be attributed to the armouring of sediment from fluvial activity behind the moraine. As the moraine stops the movement of soil, it is for this reason, that it would be more likely that archaeological material would be present behind the moraine.

6.1.2 Radiocarbon Dating and Stratigraphy

As detailed in the results chapter, the associated dates from Excavation Unit 6 range from such cultural periods as modern times to the Mesolithic in Mongolia, with a date of 10,900 BP.

Excavation Unit 6 portrays an interesting archaeological story at Soyo. The radiocarbon dates provide a chronology for the site, but they also demonstrate the active cryoturbation and bioturbation processes. Although the dates of 1,200 and 10,900 BP are correlated to stratigraphic unit G, the upper palaeosol, there is a big change in the ages for the one stratigraphic layer. However, palaeosols take time to develop, and also require a steady, stable climate. This 9,700 year time period essentially spans the entire Holocene. During this period the climate ranged from warm, humid, and wet conditions in the early Holocene (An et al. 2008), to arid and warm conditions in the middle Holocene. The late Holocene ended with a humid, cold period. The consistent climate condition throughout is the humid one. Therefore, it is unlikely that this palaeosol spans the length of the entire Holocene, and it is more likely that the radiocarbon date of 10,900 BP is a result of a combination of cryoturbation and bioturbation.

This freeze/thaw process allows for the intermixing of artefacts, bone, and sediment, which makes understanding the stratigraphy of the site extremely complex. This intermixing also includes the movement of these artefacts through the soil. The freeze/thaw process is subsequent to glacial activity. Further dating of the site would demonstrate how extensive cryoturbation is at Soyo.

Bioturbation, rodent burrows, were observed in several of the test pits, and during the 2016 field season a ground squirrel colony was also observed on the site. Artefacts, including stone tools and bones, are systematically pushed out of their burrows and up to the surface. This is a likely way for artefacts to be displaced within the stratigraphic layers. Further test pitting at the site would demonstrate how extensive this is.

The regional palaeoenvironmental data (Chapter 3.7) establishes that there were set periods of wet, cool, and finally warm climates within the past 10,000 years. The Hog River, which is adjacent to Soyo, also affects this as it deposits a large amount of sediment at the site. The presence of aeolian sands within the stratigraphy demonstrates how fluvial processes, which can also be attributed to flooding events, have deposited sediment. The run off of water down the slope and into the river is another process, which has affected the deposition of sediment and the stratigraphy.

The radiocarbon date of 1,200BP from Excavation Unit 6, can be correlated to the upper palaeosol apparent across the site. This palaeosol was identified in the stratigraphy, and the dating of this has chronologically secured it within the site. This date correlates to the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP). The palaeoenvironmental data indicates that the climate at this time was humid with cold intervals (An et al. 2008). Whilst this palaeosol date does not correlate with the Neolithic as initially anticipated, it does demonstrate that the climate was stable enough for this soil to form, and for people to inhabit it. The same stratigraphic layer, also had a radiocarbon date of 10,900 BP. This date is correlated with the transition from the Mesolithic to Neolithic (12,000 to 5,500 BP). The presence of this date within the data can be attributed to cryoturbation and bioturbation processes that are present at the site. This will also be detailed further below.

Radiocarbon age determinations from Soyo demonstrate periods of occupation and abandonment. During periods when Soyo was unoccupied, this locality on the Hog River could have been used as a crossing during times of greater mobility.

6.1.3 Sediment Analysis and Stratigraphic Data

The combination of the sediment analysis and the stratigraphic data provides the basis for determining the climatic conditions present at Soyo over the past 10,000 years. The sedimentary layers identified within the stratigraphy detail the both the depositional environment, environmental variation, and additional processes active at the site. These factors are fundamental to Soyo's site formation processes, and can be used in conjunction with the interpreted GPR data to ground truth the methods used. Additional processes active at Soyo include the freeze-thaw process, which has heavily affected the stratigraphy, and which also makes it a complex site to interpret. There is a high level of preservation at the site, because for the majority of the year the climate is relatively cold (Clark 2014:56). However, the repeated cryoturbation process has impacted the integrity of the stratigraphy. This disturbance is apparent in the sediment analysis and stratigraphic data. The freeze-thaw process affected several stratigraphic units, while other excavated units were not impacted. The moraines apparent at the site, both on the surface and the subsurface demonstrate the many climatic events, which have affected the soil/sediments. These glacial moraines, the subsurface in particular, occurred in a period of cooler environmental conditions, before the development of the lower palaeosol, which is thickest in Excavation Unit T1.2 at 0.35 meters. As detailed above, although this lower palaeosol has not been dated, it is expected to be of an age near the last glacial maximum (LGM, ~20,000BP). This expected date is associated with cultural material, typical of the LGM found at other archaeological sites. Artefact typologies suggest an LGM age for Soyo, however further radiometric age determination are required to confirm this hypothesis.

At ~20,000 BP the climate was decidedly colder, and from here to the Holocene the climate began to warm. The upper black palaeosol is thickest in Excavation Unit T1.6 at

0.14 meters, and it is this upper palaeosol which has been radiocarbon dated to 1,200BP. The lower black palaeosol is 0.35m thick in Excavation Unit T1.2. Although the lower palaeosol is much thicker than the upper, the upper palaeosol is much better developed. This is also indicative of the climate, and aeolian processes at the site at that time. Location near the Hog River may explain why this less developed soil is so much thicker in T1.2 than in T1.6. However, the trend is different when comparing the depth of the following stratigraphic layers from T1.2 to T1.7. The black palaeosol changes in depth across the site from 0.05 meters in T1.2 to 0.61 meters in T1.6. The light coloured aeolian sand changed in depth across the site from 0.85 meters in T1.2 to 0.42 meters in T1.7. The reddish stratigraphic layer changed in depth across the site from 0.55 meters in T1.2 to 0.22 meters in T1.3. The slightly darker coloured aeolian sand changed in depth across the site from 0.61 meters in T1.2 to 0.42 meters in T1.6. Brown soil changed in depth across the site from 0.05 meters in T1.2 to 0.3 meters in T1.5. Darker coloured bedrock sand was 0.46 meters deep in T1.3, and changes in depth to 1.22 meters in T1.7. This change in trends may be partly due to the elevation of the stratigraphic units and the presence of the moraine.

6.2 Soyo

This section will bring in all the correlated data in order to address the research questions and the wider literature.
The regional palaeoenvironmental records indicate that from ~7,000 BP onwards it was a warmer climate with reduced forest vegetation (Prokopenko et al. 2005, 2007), and the climatic optimum in the region occurred between 6,500 to 2,500 BP (Prokopenko et al. 2007:15). When compared to the local palaeoenvironmental record at Soyo, it is clear that Soyo is similar to the wider palaeoenvironmental region, but also varies locally. This is shown by the sedimentary data, stratigraphic analysis, radiocarbon dating, and the identification of the palaeosols in the GPR data. By correlating the local palaeoenvironmental data to the wider regional data it is possible to conclude that people have occupied similar sites within the region at 1,200 BP and earlier. Based on this, Soyo could be used as a case study for predicting the location of other archaeological sites within the region.

Although the upper palaeosol has been dated to 1,200 BP, which is younger than the first appearance of domesticated animals in the archaeological record during the Early Bronze

Age ~3400 BCE – 1600 BCE (Clark 2014; Fitzhugh 2008), it does present evidence that people at Soyo were primarily pastoralist, as there is currently no evidence for agriculture within the geophysical or stratigraphic data. Mongolian pastoralist sites are much more common in the literature, than Mongolian agricultural sites (Allard and Erdenebaatar 2005:548; Volkov 1995:320). Pastoralism was also used as an adaptive strategy (Eng 2016:173), and can be readily applied to a marginal site like Soyo. Although Janz (2007) cites areas such as northern Mongolia and southern Siberia as having more evidence for agriculture, Soyo is one such site where this is not the case.

The palaeoenvironmental data implies that from ~5,000 BP onwards the climate at Soyo was humid, with cold intervals. This is evidenced at Soyo with the upper palaeosols with a correlated date of ~1,200 BP. Further to this is the drop in lake levels at Lake Hövsgöl, which is generally related to an increase in wet climatic conditions (Orkhonselenge et al. 2013:107). In terms of placing Soyo within the wider Mongolian chronology, this would be from the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP). Occupation of the upper levels of the Soyo site are situated within the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800 BP).

Soyo is a prime research site that would allow us to answer questions about the Neolithic, Mesolithic, and Palaeolithic in Mongolia. The data presented in this thesis strongly demonstrates that climatic conditions were present for the adoption of agriculture, but it is also possible that cultural reasons saw that pastoralism and nomadic settlements were favoured. The data presented here has also demonstrated that this would be a poor place for agriculture.

6.3 Wider Neolithic in Mongolia

As noted throughout chapter two, few archaeological sites in Mongolia have been chronometrically dated and the Neolithic period is poorly understood. Most archaeological sites in Mongolia that have been dated date to the Bronze Age, and more recent historical periods.

At Soyo with the radiocarbon dates of 1,200 BP, the upper palaeosol fits well into the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP). However, the radiocarbon date of 10,900 BP, would correlate it to the

Mesolithic/Neolithic in Mongolia. Although this date is an outlier within Excavation Unit 6, it does demonstrate the impact of soil movement and freeze-thaw processes at Soyo. This is one such reason as to why there is such a dramatic change in the presented radiocarbon dates. Bone samples OZV580 and OZV584 are in the stratigraphic layer directly above OZV577 (10,900BP), and have been dated to 1,200BP and 1,205 respectively. Furthermore, the other dated stratigraphic layers in Excavation Unit 6 increment in age quite steadily. OZV577 could simply be a bone that has moved through the soil faster than other bone samples. If samples OZV578, OZV583, and OZV579 had sufficient levels of collagen to be radiocarbon dated, then a more detailed picture of the sites chronology would have been created.

Cultural material has been identified within the lower palaeosol. It is possible that this material forms a continuous occupation, which would be evidenced through further dating of the stratigraphy.

With a chronologically dated stratified site in northern Mongolia, Soyo can now be compared to other stratified sites in the wider region. One such site in Siberia is Ulan-Khada, Lake Baikal. It is a site which covers the entire Neolithic, and similar to Soyo, this is a site where the term Neolithic does not imply agriculture. Ulan-Khada is an example of the introduction of pottery and metallurgy (McKenzie 2006). Modern climatic conditions began to be reached between 5,000 – 3,000 BP (McKenzie 2006:13), and gradual cooling occurred to reach the current climate from ~6,000 BP (Shimaraev and Mizandrontsev 2006:260-261). At Soyo this occurred around ~5,800 BP, with humid, cold conditions (Batbaatar and Gillespie 2016; Narantsetseg et al. 2013).

The occupation and habitation of marginal sites such as Soyo and the Gobi Desert demonstrates human and societal resilience. Although sites in the Gobi Desert have evidence of agriculture, this demonstrates that people used a combination of subsistence strategies including hunting and fishing during the mid-Neolithic (Janz 2012:87). This interpretation can also be applied to Soyo.

Whilst the Neolithic began around 8,000 BP in Siberia (Lieverse et al. 2015:25), and in China began around 10,000 – 8,900 cal BP (Cohen 2011:274), Mongolia does not see the arrival of the Neolithic till 5,500 BP (Hanks 2010:471). However, this does not mean that the Neolithic did not begin 8,000 BP in Mongolia as it did elsewhere. This can be attributed to reflect the research focus on later periods and limited application of C14 dating in Mongolia, and the restriction of foreign researches to conduct archaeological research in Mongolia whilst under Soviet control. Radiocarbon sample OZV577 from Excavation Unit 6 was dated to 10,900+/-40 BP. While the dating does jump between chronological periods, it is possible that Soyo contains evidence of Mesolithic/Neolithic (12,000-5,500 BP) (Hanks 2010) occupation in northern Mongolia. This research has provided evidence that the archaeology of Soyo is consistent of the wider regional archaeological patterns.

6.4 Conclusions

In concluding this chapter, it is apparent that the environmental history of Soyo is consistent within the wider region with specific differences related to the local area. This environmental history spans throughout the Holocene and is evident from the palaeoenvironmental data, primarily from the presence of the palaeosols at Soyo. The upper palaeosol that is visible across the site has been dated to 1,200 BP, which has been correlated to an environmental period of a humid climate, and a moderate expansion in forest vegetation. This essentially meant that it was easier for people to move throughout the landscape and enabled the occupation of optimal areas where food sources were readily available. This research has presented a methodology for investigating archaeological sites within a geoarchaeological framework, for the region.

Environmental processes such as cryoturbation and the deposition of aeolian sands from the river, have had an impact on the way in which this site has been formed. The presence of aeolian sands within the stratigraphy demonstrates how different processes have deposited this sediment. The run off of water down the slope and into the river is another process, which has affected the deposition of sediment and the stratigraphy.

The combination of geoarchaeological techniques has provided both a substantial dataset and the basis for demonstrating that the transition from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP) can be a pastoral dominated technological culture rather than an agricultural one. The research undertaken has also investigated the environmental history for this period. This thesis has also developed a new palaeoclimate record and has mapped the subsurface stratigraphy of the site.

7. Conclusion

The archaeological site of Soyo in northern Mongolia is significant for understanding pastoralism and the surrounding environment changes. This chapter will detail the overall conclusions to come from this research, revisit the research questions and conclude how they have been addressed within this thesis. The limitations of this research will also be acknowledged, and future recommendations for the continuation of this research will be made.

7.1 Research Questions and Aims

The research questions and aims have shaped the direction of this research over the course of this thesis. These questions have been formed in order to fill the research gaps present in the literature. These questions and aims are revisited below and form the conclusions for this thesis.

<u>Research questions</u>

1. What is the environmental history of the site of Soyo from the Neolithic to the Bronze Age?

In the wider region, the optimum climate occurred between 6,500 and 2,500 BP, which chronologically ranges from the Epipaleolithic/Neolithic to the Bronze Age in Mongolia. The warmer climate at Soyo allowed for the development of soils and for plants to grow and thrive. The palaeoenvironmental data implies that from ~5,000 BP onwards the climate at Soyo was humid, with cold intervals. This is evidenced at Soyo with the upper palaeosols with a correlated date of ~1,200 BP.

When comparing the wider regional palaeoenvironmental record to the local palaeoenvironmental record at Soyo, it is clear that Soyo is an example of the wider region, but also varies as evidenced by the glacial moraines and the presence of the palaeosols. This has been evidenced through the sedimentary data, stratigraphic analysis, radiocarbon dating, and the identification of the palaeosols in the GPR data. By correlating the local palaeoenvironmental data to the wider regional data it is possible to conclude that people have occupied similar sites within the region at 1,200 BP and earlier.

This research has also investigated the regional palaeoenvironmental record further than the research question originally detailed by extending the time period to more recent times. This site demonstrates that in the Late Holocene this region experienced fairly frequent periods of climatic stability, which has been evidenced through the development of local palaeosols.

2. How does the site of Soyo fit into occupation patters within the wider region in the mid Holocene?

Though the Neolithic in Siberia and China have been chronometrically dated to 8,000 BP and 10,000 – 8,900 cal BP respectively, the Neolithic did not occur in Mongolia until ~5,500 BP. However, this does not mean that the Neolithic did not begin at 8,000 BP in Mongolia as it did elsewhere. This can be attributed to reflect the lack of chronometric dating available to researches in Mongolia, efforts to investigate the Neolithic by past and present researchers, and the restriction of foreign researches to conduct archaeological research in Mongolia whilst under Soviet control. While the dating for Excavation Unit 6 does jump between chronological periods, it is possible that Soyo has occupation during the Mesolithic/Neolithic period (12,000 – 5,500 BP) (Hanks 2010).

Whilst Soyo does not fit into occupation patterns within the wider region in the mid-Holocene, it does strongly support a pastoralist economy. The data presented in this thesis strongly demonstrates that climatic conditions were present for the adoption of agriculture, but possibly cultural and environmental reasons saw that pastoralism and nomadic settlements were favoured.

Aims

1. Examine the relationship between local environmental history and that of the wider region.

The relationship between the local environmental history and the wider region was established through the wider palaeoenvironmental history, chapter 3; and the stratigraphic and sedimentary analyses. It can be concluded that Soyo largely reflects the wider regional environmental history, but also has its own unique palaeoenvironmental record.

2. Examine the sedimentary processes and local topographic context at Soyo to establish a taphonomic history of the site

A taphonomic history of the site was established through the examination of the sedimentary processes and local topographic context. This demonstrated the range of complex site formation processes at Soyo, and how the glacial moraines from the LGM affected the site. This includes the preservation of the archaeological material.

3. Analyse the relationship between occupation deposits and the wider stratigraphy of the Soyo site.

The sedimentary layers identified within the stratigraphy detail the depositional environment, environmental factors, and additional processes active at the site. These factors play heavily into the way Soyo has formed as a site, and were used. Interpretation of the GPR data assisted with developing an understanding of site formation processes. Depositional aeolian processes from the Hog River impacted upon the development of the lower palaeosol, and this also affected the topographic terrain of the site. Understanding the relationship between the occupation deposits and the wider stratigraphy of the site is important, as it forms the basis of the formation of the site, and how people have interacted with it.

4. Establish a local site chronology

The local site chronology was established through radiocarbon dating, with a maximum age of 10,900 BP through to modern times. The core finding in establishing a local site chronology was that the upper palaeosol that is visible on the surface of the site has been dated to 1,200 BP. Whilst the 10,900 BP date might not have been useful to this research, it cannot be disregarded. Further investigation of this site could demonstrate Neolithic, or possibly even Mesolithic, occupation.

Although the research presented in this thesis has demonstrated that the stratigraphic layers researched are not Neolithic in context, it does demonstrate that Soyo belongs to a pastoralist time period.

The environmental history of Soyo fits into the environmental history of the wider region. This environmental history spans throughout the Holocene and is evident from the palaeoenvironmental data, primarily from the presence of the palaeosols at Soyo. The correlation of the upper palaeosol at 1,200 BP, and the humid environmental period strongly demonstrates that as a marginal environment, people were occupying this site.

7.2 Limitations and Future Recommendations

The site of Soyo in northern Mongolia has presented an interesting case for the use of geophysical techniques on archaeological sites.

7.2.1 Limitations

One such limitation of using geophysical techniques is the vast amount of data gathered, which affects the time needed to process, interpret, and map the data. Using multiple techniques also adds to this limitation.

7.2.2 Future Recommendations

Future recommendations to come out of this project is to process, interpret, and map the remaining GPR data, which will in turn detail where other non-invasive geophysical methods can be used to answer further research questions about this site. This data can also be used to determine what section of the site would be beneficial for possible excavation. For example, having mapped the location of the moraines through GPR, it would now be apparent which areas to avoid, in order to get closer to the bedrock and more archaeological data, or to excavate these moraines in order to further ground truth the interpreted data.

More radiocarbon dating is needed for the lower palaeosol layer in order to establish an initial date for the first period of sustained warmer climate. This data will then be able to be compared with the first set of radiocarbon dates for the site, which will also demonstrate how the freeze-thaw processes apparent affect the lower stratigraphic layers of Soyo. If archaeological material is found in between these the lower palaeosol and upper palaeosol, then it can be inferred that the site was occupied continuously.

In addition, magnetometry data can also be collected across the site where the rest of the GPR data was collected. Both of these data sources could then be correlated and interpreted in regards to Soyo. Further magnetometry data could also be used to determine possible areas of habitation, or possible areas of technological production.

The site boundaries used for this research could be further extended to look at an area across the Hog River, Figure 25. As the river is a vital place for crossing, both banks of the river should be investigated in order to determine the possible extent of the site, areas of habitation, and a more detailed chronology for Soyo. This should be done in conjunction with multiple geoarchaeological techniques.

Figure 25. The Hog River

In terms of literature, future work should investigate further into marginal Neolithic sites, and compare work done at Soyo to these sites in detail. Further research needs to include comparison studies across the border in Siberia, and at Lake Baikal in order to determine if a similar palaeoenvironmental climate existed at this time, and if people occupied this area continuously. What is evident from this research is that further research is vital to furthering our understanding of what it means to live in a marginal environment and how technology was used in this setting. Also of importance to future research is what technology was used, when, and why it was used over other available technology.

As with any archaeological fieldwork, any future research needs to be conducted in consultation with local and regional communities, and with their own research interests in mind.

The research presented in this thesis proposes the incorporation of a geoarchaeological approach in future archaeological work in order to develop a wider palaeoenvironmental literature base within the archaeological literature. The scope of the data that is acquired from this approach is invaluable, and in many cases non-invasive. Whilst this thesis may not have answered prevailing questions about the arrival of pastoralism to the region, it has formed the basis for the future research in this field. By now understanding the regional palaeoenvironment at Soyo we are able to begin to reconstruct pastoral life in northern Mongolia during a changing environment.

7.3 Overall Conclusions

In conclusion, this thesis has investigated the relationship between marginal environments and the people that lived, and continue to live, within them. The subsurface of Soyo details how people were able to live in a marginal environment during the transition between from the Iron Age (~1,800 BP) to the emergence of the Mongol Empire (~800BP). Through the use of geoarchaeological techniques, in particular archaeological geophysics, a clear image of the subsurface has been created. The investigation of the palaeosols formed a core component to this research. This thesis has correlated environmental data with the known archaeological record in order to demonstrate that a flourishing pastoralist economy formed the basis of culture in northern Mongolia. Soyo is a prime example of an occupied marginal environment. This thesis has directly demonstrated how archaeological data can be used in conjunction with and compliment existing environmental data. The adoption of pastoralism across Mongolia and the steppe environments has shaped the way in which people interacted, and continue to interact, with the environment.

Soyo is an example of the wider palaeoenvironmental region, but also has its own palaeoenvironmental record. It and is a prime research site that would allow us to answer questions about the Neolithic, Mesolithic, and Palaeolithic in Mongolia. The research undertaken has also investigated the environmental history for this period. This thesis has also added into the existing palaeoclimate record and has mapped the subsurface stratigraphy of the site.

The research conducted for this thesis has demonstrated how an environmentally marginal site in northern Mongolia can be used to test the environmental history of the wider region, and can also be used as a case study for future comparisons. This research has presented a methodology for investigating archaeological sites within a geoarchaeological framework, for the region.

Finally, this thesis has challenged the importance placed upon agriculture, and has presented an important pastoralist archaeological site by using the palaeoenvironmental history to tell its story.

8. Appendices

Appendix A: Stratigraphic Photos

T1.2

T1.3

T1.4 **T1.5**

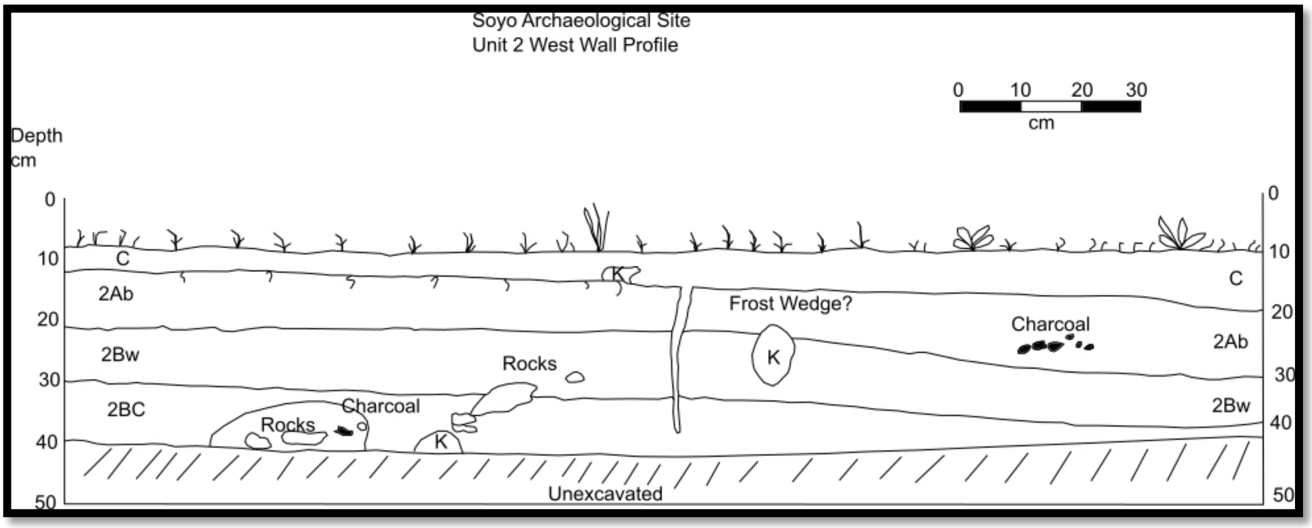
T1.6

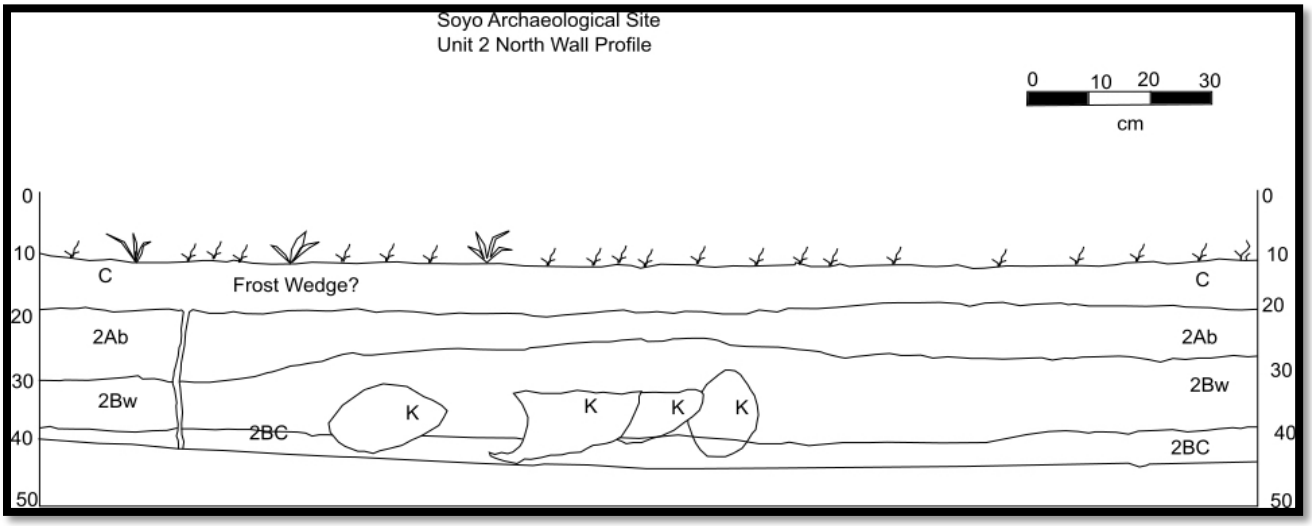
T1.7

Excavation Unit 6

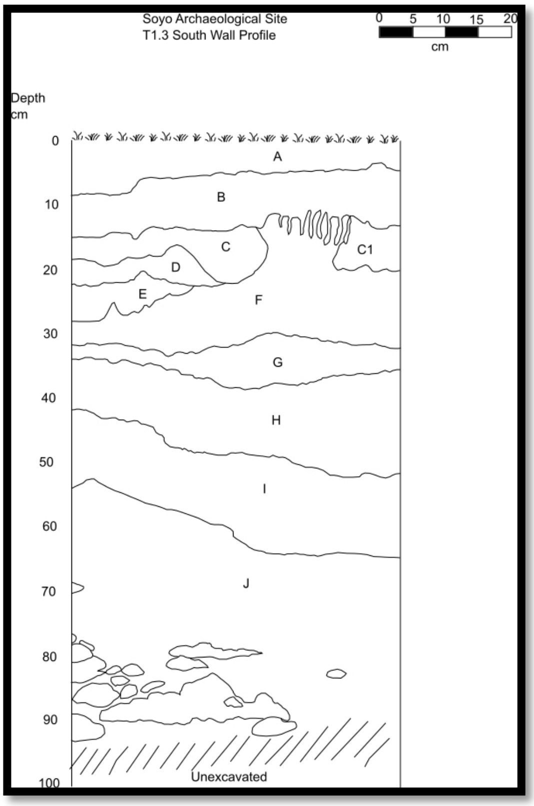
Appendix B: Stratigraphic Drawings

T1.2





T1.3



Soyo Archaeological Site
T1.3 South Wall Profile
0 5 10 15 20
cm
Depth
cm
0
10
20
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60
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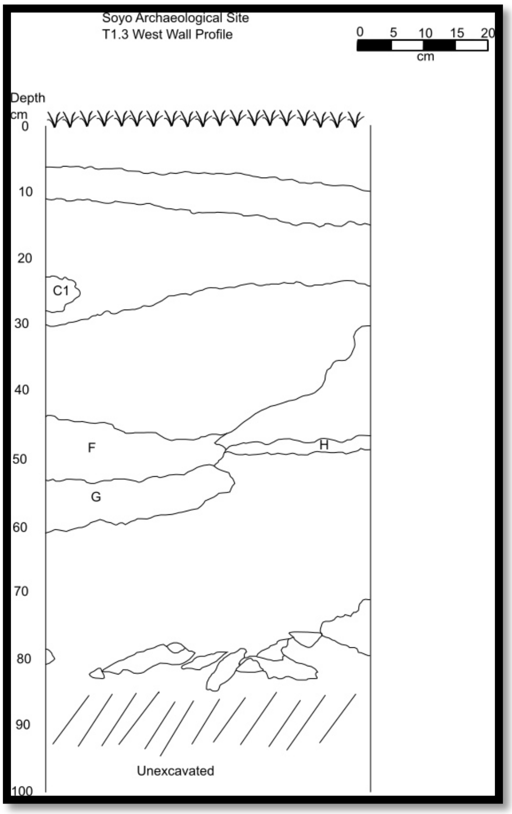
80
90
100
A
B
C
C1
D
E
F
G
H
I
J
Unexcavated



Soyo Archaeological Site
T1.3 West Wall Profile
0 5 10 15 20
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Depth
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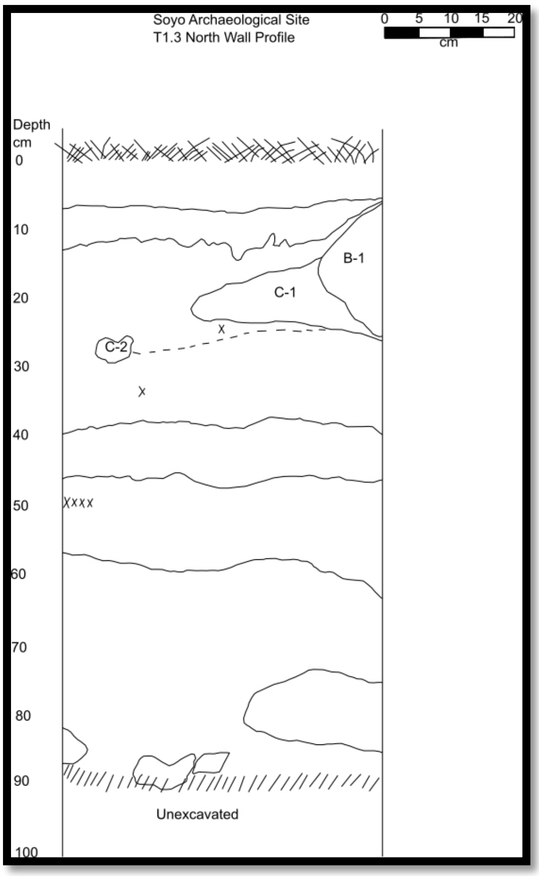
100
C1
F
H
G
Unexcavated



Soyo Archaeological Site
T1.3 North Wall Profile
0 5 10 15 20
cm
Depth
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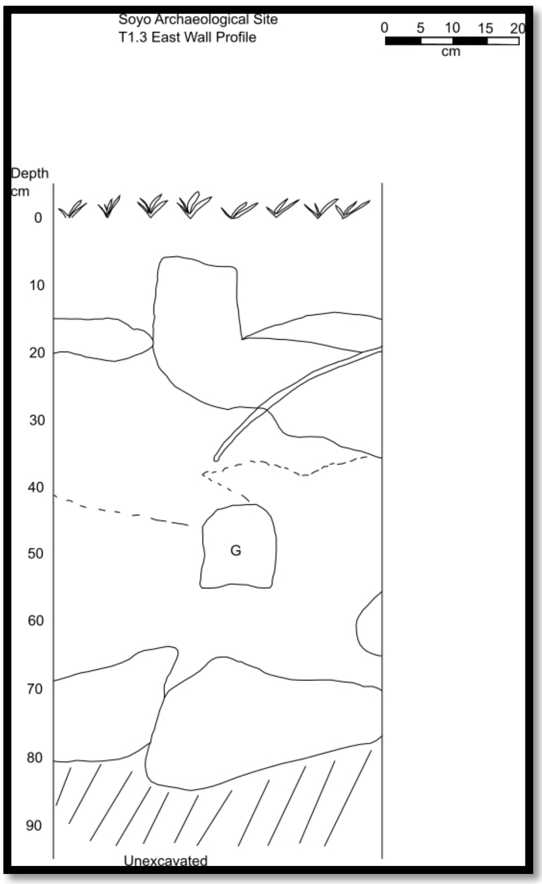
100
B-1
C-1
C-2
Unexcavated



Soyo Archaeological Site
T1.3 East Wall Profile
0 5 10 15 20
cm
Depth
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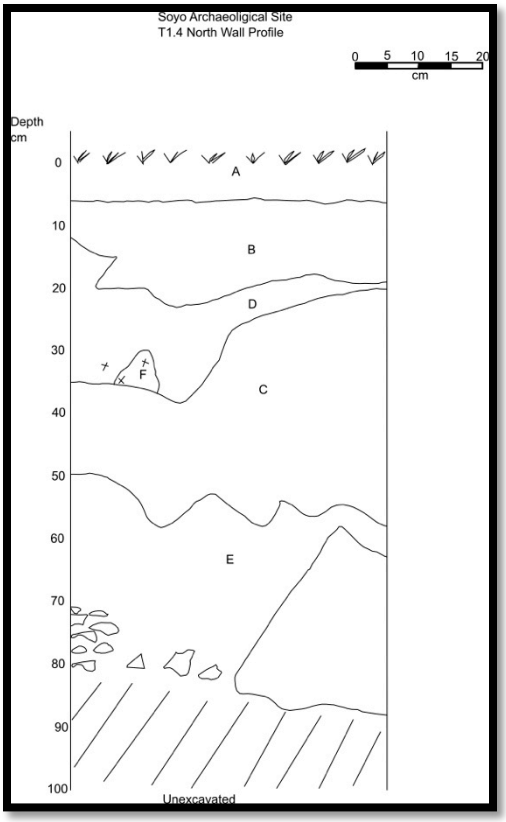
90
G
Unexcavated

T1.4



Soyo Archaeological Site
T1.4 North Wall Profile
0 5 10 15 20
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Depth
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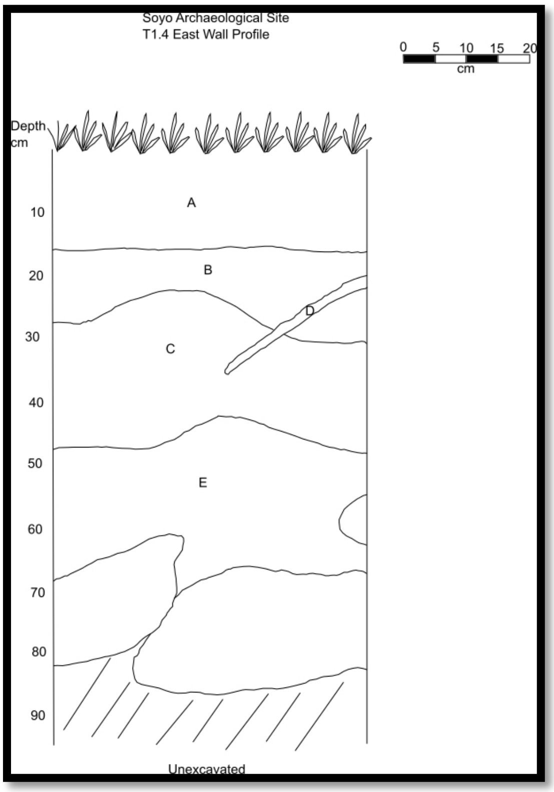
C
E
Unexcavated



Soyo Archaeological Site
T1.4 East Wall Profile
0 5 10 15 20
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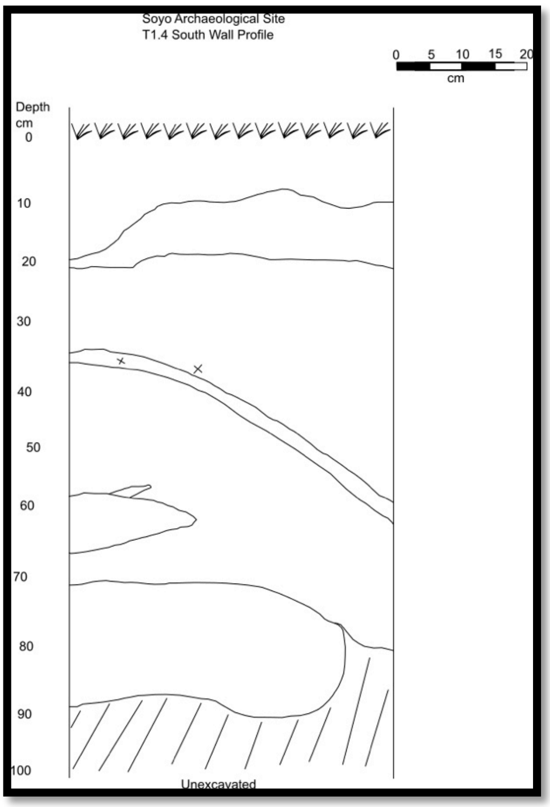
Unexcavated



Soyo Archaeological Site
T1.4 South Wall Profile
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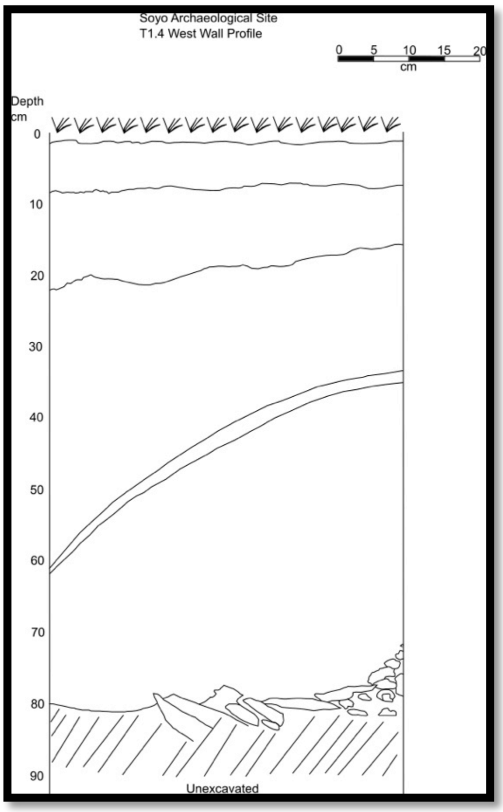
Unexcavated



Soyo Archaeological Site
T1.4 West Wall Profile
0 5 10 15 20
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Depth
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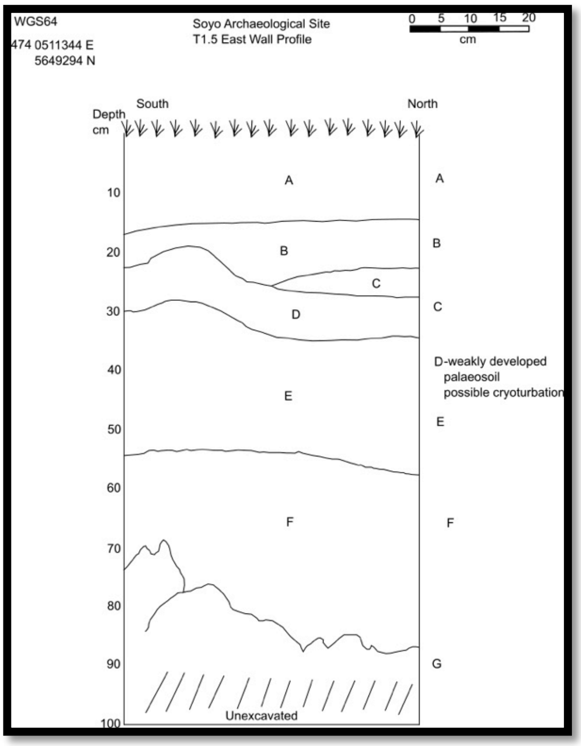
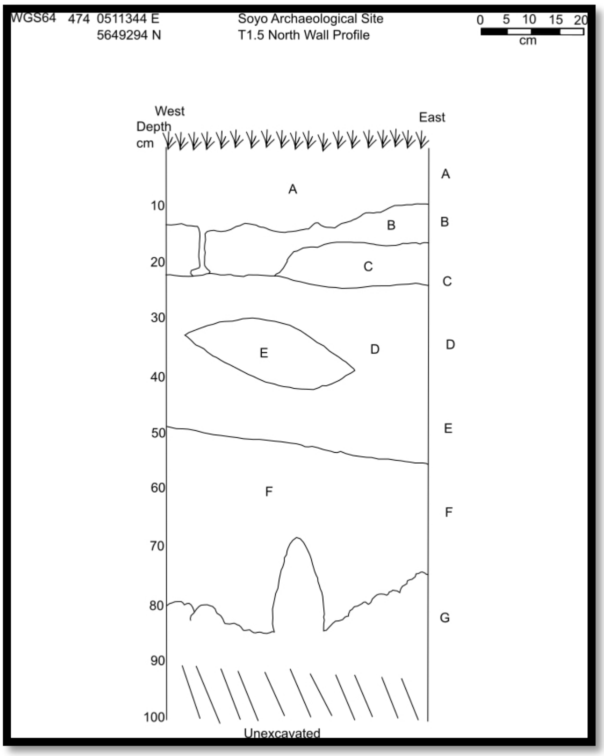
80
90
Unexcavated

T1.5


WGS64
474 0511344 E
5649294 N
Soyo Archaeological Site
T1.5 East Wall Profile
0 5 10 15 20
cm
South
North
Depth
cm
A
B
C
D
E
F
G
D-weakly developed palaeosoil possible cryoturbation
Unexcavated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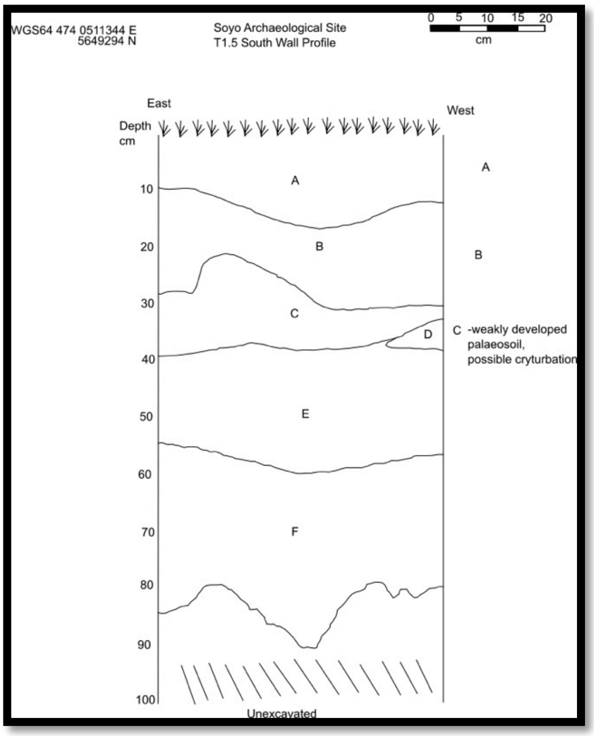
5649294 N
Soyo Archaeological Site
T1.5 North Wall Profile
0 5 10 15 20
cm
West
East
Depth
cm
A
B
C
D
E
F
G
Unexcavated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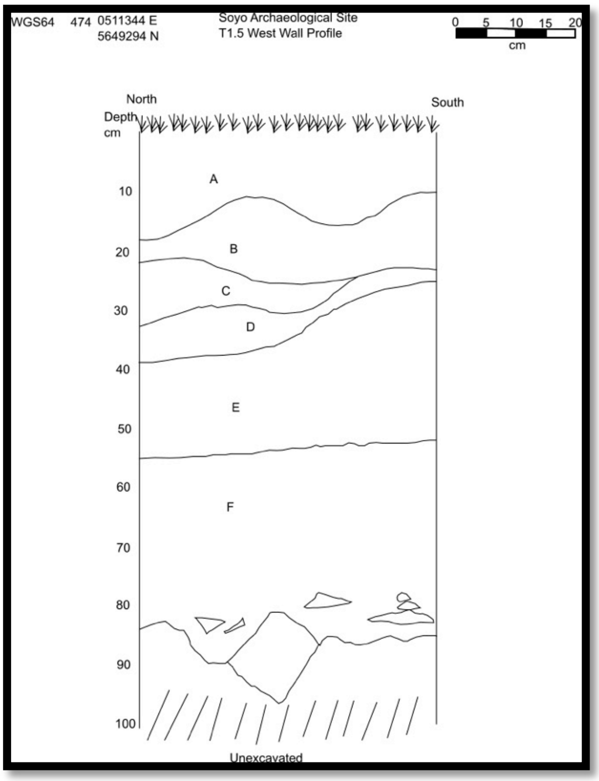
5649294 N
Soyo Archaeological Site
T1.5 South Wall Profile
0 5 10 15 20
cm
East
West
Depth
cm
A
B
C
D
E
F
C -weakly developed palaeosoil, possible cryturbation
Unexcavated


WGS64 474 0511344 E
5649294 N
Soyo Archaeological Site
T1.5 West Wall Profile
0 5 10 15 20
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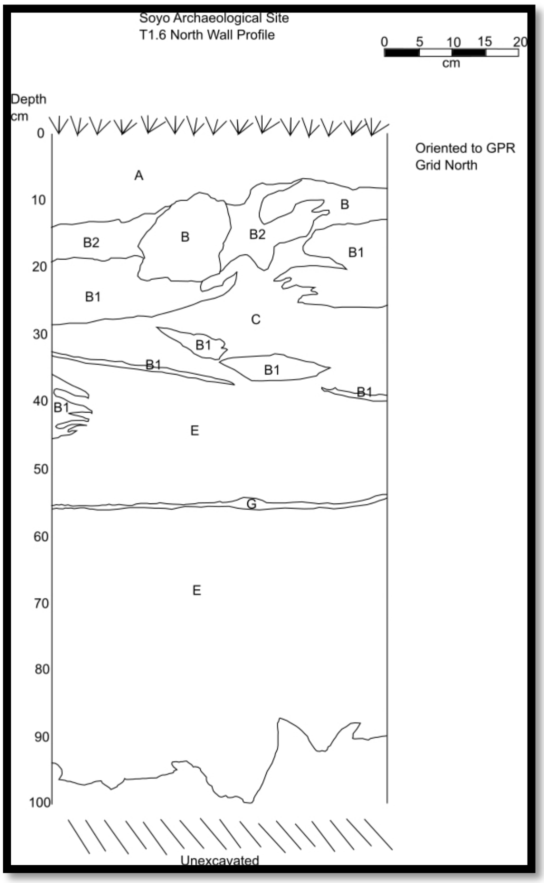
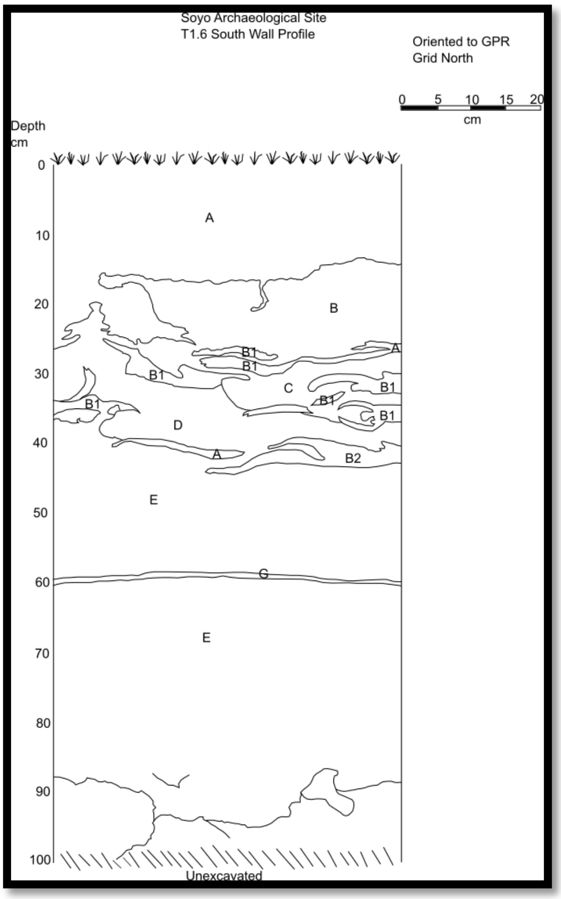
North
South
Depth
cm
A
B
C
D
E
F
Unexcavated

T1.6


Soyo Archaeological Site
T1.6 North Wall Profile
Oriented to GPR Grid North
0 5 10 15 20 cm
Depth cm
A
B
B2
B1
C
E
G
Unexcavated


Soyo Archaeological Site
T1.6 South Wall Profile
Oriented to GPR Grid North
0 5 10 15 20 cm
Depth cm
A
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B1
B2
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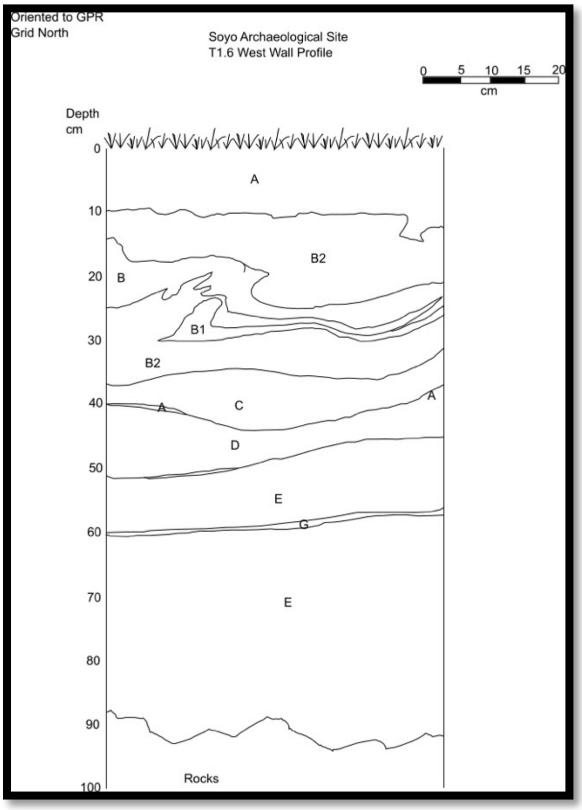
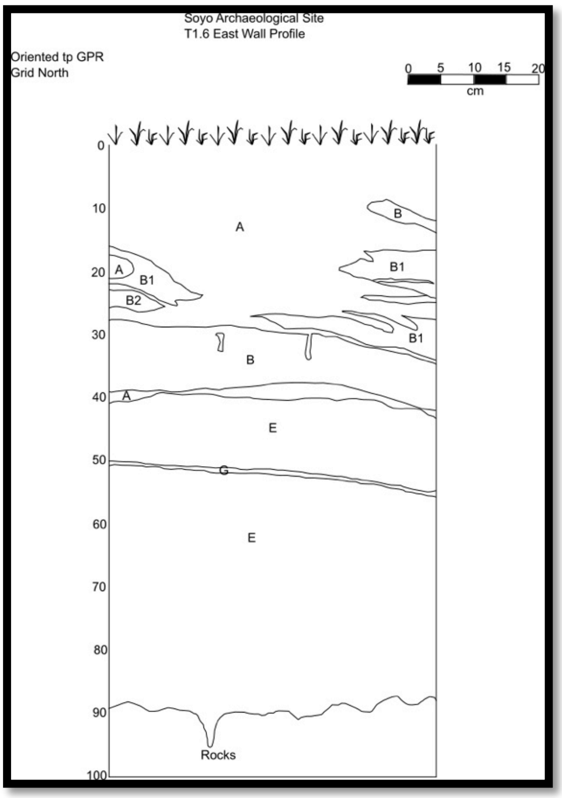
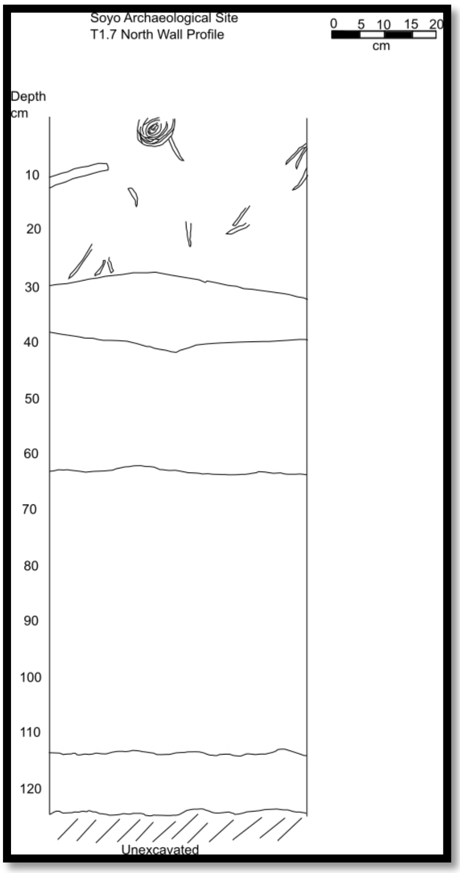
E
G
Unexcavated


Oriented to GPR Grid North
Soyo Archaeological Site
T1.6 West Wall Profile
0 5 10 15 20 cm
Depth cm
A
B
B2
B1
C
D
E
G
Rocks


Soyo Archaeological Site
T1.6 East Wall Profile
Oriented tp GPR Grid North
0 5 10 15 20 cm
A
B
B1
B2
E
G
Rocks

T1.7



Soyo Archaeological Site
T1.7 North Wall Profile
0 5 10 15 20
cm
Depth
cm
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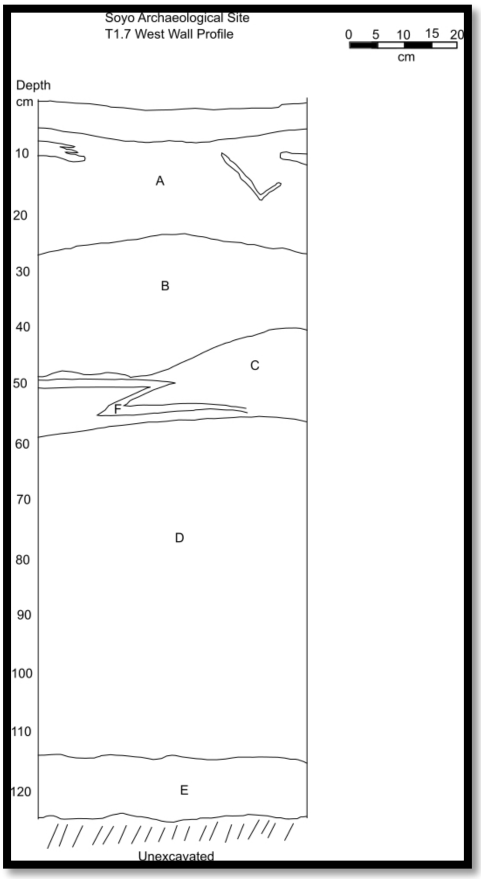
110
120
Unexcavated



Soyo Archaeological Site
T1.7 West Wall Profile
0 5 10 15 20
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Depth
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A
B
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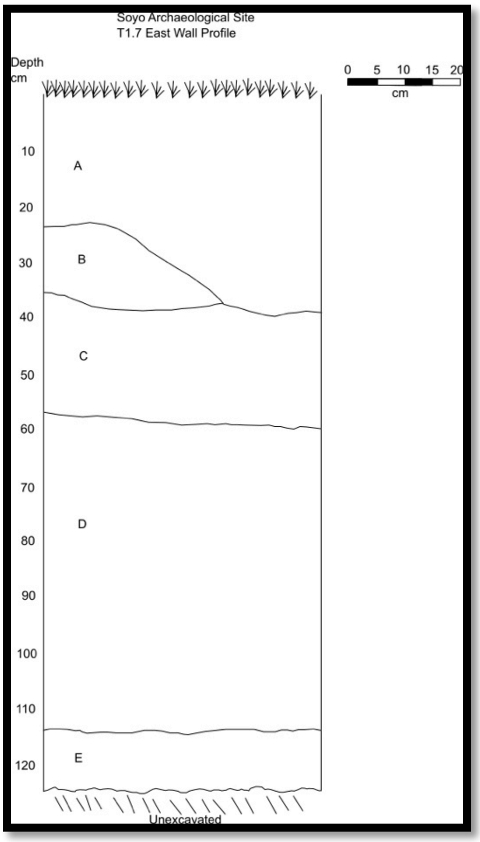
F
D
E
Unexcavated



Soyo Archaeological Site
T1.7 East Wall Profile
Depth
cm
0 5 10 15 20
cm
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90
100
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120
A
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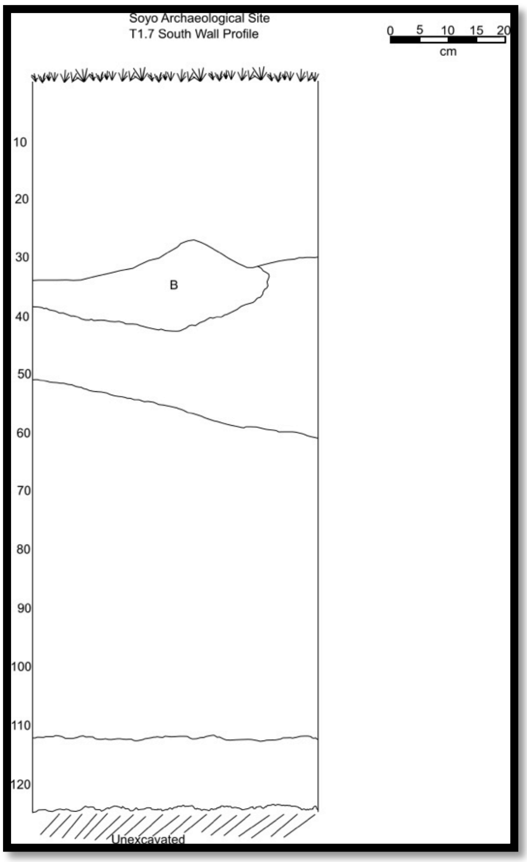
E
Unexcavated



Soyo Archaeological Site
T1.7 South Wall Profile
0 5 10 15 20
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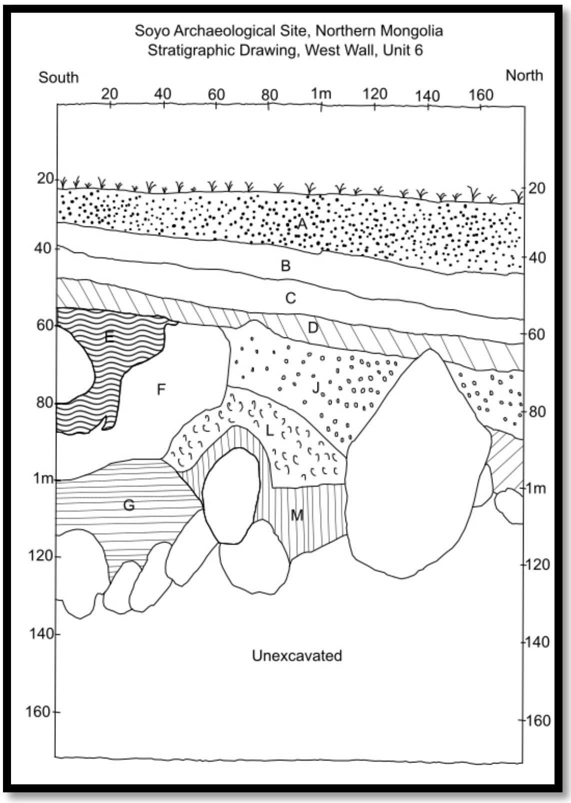
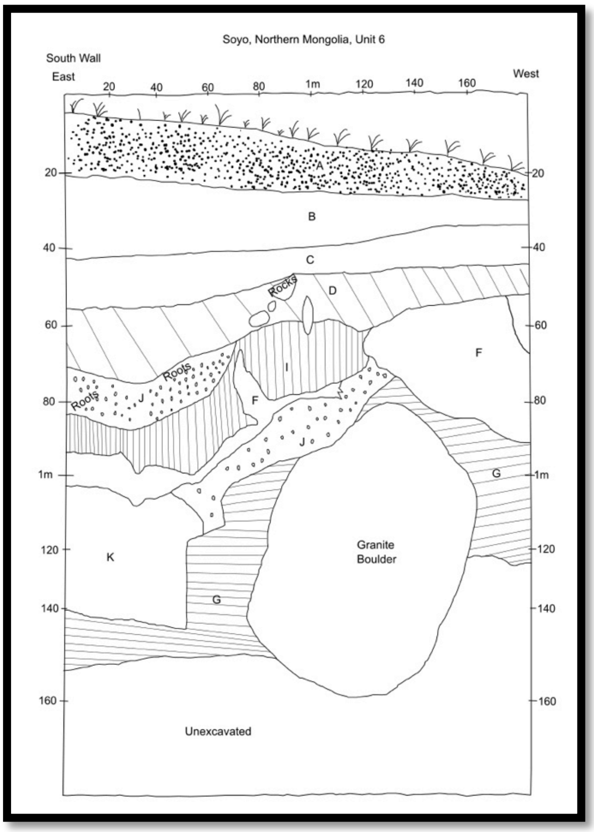
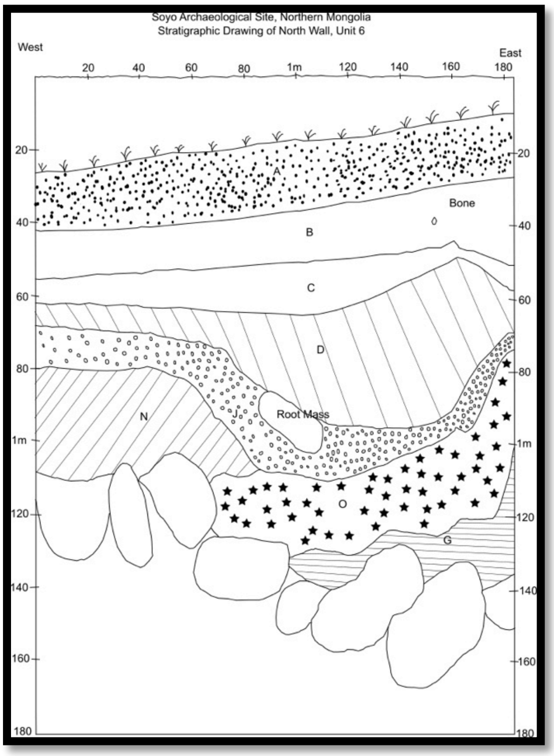
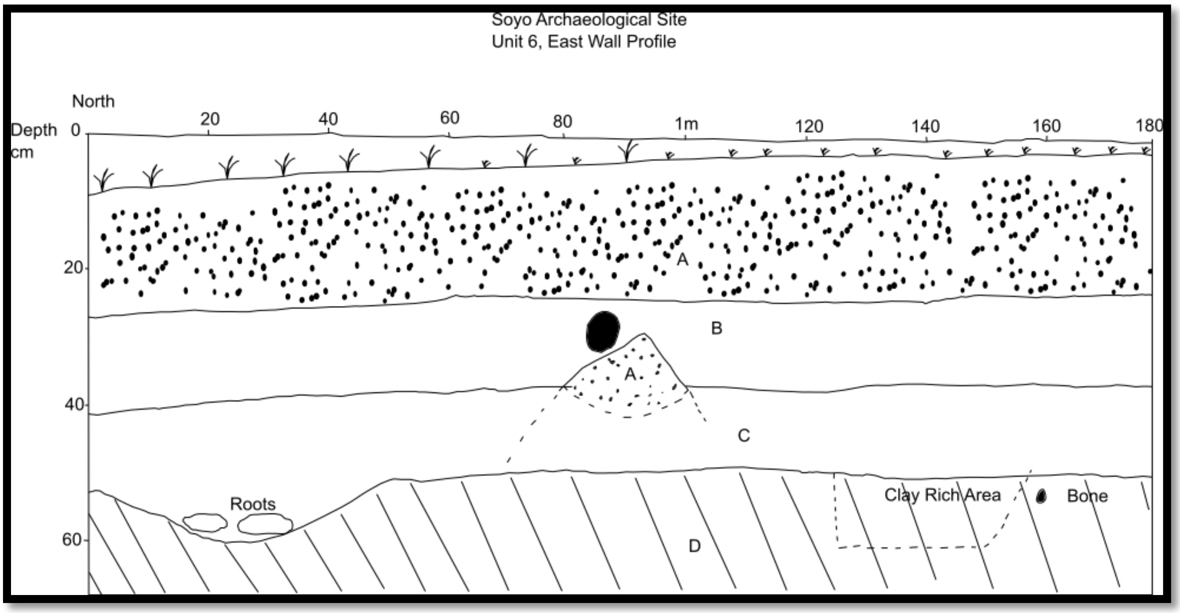
110
120
B
Unexcavated

Excavation Unit 6









Soyo Archaeological Site
Unit 6, East Wall Profile
North
Depth cm
0
20
40
60
80
1m
120
140
160
180
A
B
A
C
Roots
D
Clay Rich Area
Bone

Appendix C: Master Stratigraphic Table

Unit	Easting	Northing	Elevation	Stratigraphic Thickness (m)	Depth to Top in SW Corner (m)	Depth to Base in SW Corner (m)	Elevation to Top	Elevation to Base
T1.2	511342.1	15649324.43	1622.54	0.05	0	0.05	1622.54	1622.49
T1.2	511342.1	15649324.43	1622.54	0.08	0.05	0.13	1622.49	1622.41
T1.2	511342.1	15649324.43	1622.54	0.42	0.13	0.55	1622.41	1621.99
T1.2	511342.1	15649324.43	1622.54	0.06	0.55	0.61	1621.99	1621.93
T1.2	511342.1	15649324.43	1622.54	0.24	0.61	0.85	1621.93	1621.69
T1.2	511342.1	15649324.43	1622.54	0.35	1.1	1.45	1623.64	1623.99
T1.2	511342.1	15649324.43	1622.54	N/A	0.85	??	1621.69	??
T1.3	511342.494	15649314.56	1623.745	0.05	0	0.05	1623.745	1623.695
T1.3	511342.494	15649314.56	1623.745	0.1	0.05	0.15	1623.695	1623.595
T1.3	511342.494	15649314.56	1623.745					
T1.3	511342.494	15649314.56	1623.745	0.07	0.15	0.22	1623.595	1623.525
T1.3	511342.494	15649314.56	1623.745					
T1.3	511342.494	15649314.56	1623.745					
T1.3	511342.494	15649314.56	1623.745	0.12	0.2	0.32	1623.545	1623.425
T1.3	511342.494	15649314.56	1623.745	0.04	0.32	0.36	1623.425	1623.385
T1.3	511342.494	15649314.56	1623.745	0.1	0.36	0.46	1623.385	1623.285
T1.3	511342.494	15649314.56	1623.745	0.19	0.46	0.65	1623.285	1623.095
T1.3	511342.494	15649314.56	1623.745	N/A	0.65	??	1623.095	??
T1.4	509819.654	16316864.29	1624.477	0.1	0	0.1	1624.477	1624.377
T1.4	509819.654	16316864.29	1624.477	0.1	0.1	0.2	1624.377	1624.277
T1.4	509819.654	16316864.29	1624.477	0.35	0.2	0.55	1624.277	1623.927
T1.4	509819.654	16316864.29	1624.477	0.04	0.56	0.6	1623.917	1623.877
T1.4	509819.654	16316864.29	1624.477	0.2	0.6	0.8	1623.877	1623.677
T1.4	509819.654	16316864.29	1624.477					
T1.4	509819.654	16316864.29	1624.477	N/A	0.8	??	1623.677	??
T1.5	511342.537	15649294.46	1624.444	0.12	0	0.12	1624.444	1624.324

T1.5	511342.537	15649294.46	1624.444	0.18	0.12	0.3	1624.324	1624.144
T1.5	511342.537	15649294.46	1624.444	0.02	0.3	0.32	1624.144	1624.124
T1.5	511342.537	15649294.46	1624.444	0.05	0.32	0.37	1624.124	1624.074
T1.5	511342.537	15649294.46	1624.444	0.19	0.37	0.56	1624.074	1623.884
T1.5	511342.537	15649294.46	1624.444	0.24	0.56	0.8	1623.884	1623.644
T1.5	511342.537	15649294.46	1624.444	N/A	0.8	??	1623.644	??
T1.6	511343.261	15649284.55	1625.159	0.14	0	0.14	1625.159	1625.019
T1.6	511343.261	15649284.55	1625.159	0.12	0.14	0.26	1625.019	1624.899
T1.6	511343.261	15649284.55	1625.159					
T1.6	511343.261	15649284.55	1625.159	0.01	0.41	0.42	1624.749	1624.739
T1.6	511343.261	15649284.55	1625.159	0.08	0.27	0.35	1624.739	1624.809
T1.6	511343.261	15649284.55	1625.159	0.03	0.37	0.4	1624.809	1624.759
T1.6	511343.261	15649284.55	1625.159	0.27	0.61	0.88	1624.759	1624.279
T1.6	511343.261	15649284.55	1625.159	0.01	0.6	0.61	1624.279	1624.549
T1.6	511343.261	15649284.55	1625.159	N/A	0.88	??	1624.549	??
T1.7	511342.408	15649274.85	1626.939	0.3	0	0.3	1626.939	1626.639
T1.7	511342.408	15649274.85	1626.939	0.12	0.3	0.42	1626.639	1626.519
T1.7	511342.408	15649274.85	1626.939	0.2	0.42	0.62	1626.519	1626.319
T1.7	511342.408	15649274.85	1626.939	0.6	0.62	1.22	1626.319	1625.719
T1.7	511342.408	15649274.85	1626.939	N/A	1.22	??	1625.719	??
T1.7	511342.408	15649274.85	1626.939	0.05	0.5	0.55	1626.439	1626.389
6	511342.355	15649317.55	1623.51	0.2	0	0.2	1623.51	1623.31
6	511342.355	15649317.55	1623.51	0.19	0.2	0.39	1623.31	1623.12
6	511342.355	15649317.55	1623.51	0.11	0.39	0.5	1623.12	1623.01
6	511342.355	15649317.55	1623.51	0.12	0.5	0.62	1623.01	1622.89
6	511342.355	15649317.55	1623.51					
6	511342.355	15649317.55	1623.51	0.2	0.7	0.9	1622.81	1622.61
6	511342.355	15649317.55	1623.51	0.35	0.9	1.25	1622.61	1622.26
6	511342.355	15649317.55	1623.51					
6	511342.355	15649317.55	1623.51					
6	511342.355	15649317.55	1623.51	0.4	1.05	1.45	1622.46	1622.06

Unit	Local Strat Unit	Soyo Strat Unit	Grain Size	Sorting	Mineralogy	Munsell Code	Munsell Colour
T1.2	A	Black Palaeosol	Very Fine Sand	Well	Some Muscovite present	7.5YR 2.5/1	Black
T1.2	B	Light Coloured Aeolian? Sand	Sandy Clay	Very Well	Muscovite present	2.5Y 4/4	Olive Brown
T1.2	C	Reddish	Very Fine Sand with Silt	Very Well	Muscovite present	2.5Y 4/3	Olive Brown
T1.2	D	Slightly Darker Coloured Aeolian? Sand	Very Fine	Very Well	Muscovite present	2.5Y 3/2	Very Dark Greyish Brown
T1.2	E	Light Coloured Aeolian? Sand	Very Fine Sand	Very Well	Some Muscovite present	2.5Y 5/2	Greyish Brown
T1.2	F	Black Palaeosol				2.5Y 5/2	Greyish Brown
T1.2	Bedrock	Basal Substrate				2.5Y 5/2	Greyish Brown
T1.3	A	Brown Soil	Very Fine Sand			2.5YR 4/2	Weak Red
T1.3	B	Black Palaeosol	Very Fine Sandy Silt Loam			2.5YR 2.5/2	Very Dusky Red
T1.3	B1		Very Fine Sandy Silt			5YR 4/3	Reddish Brown
T1.3	C	Reddish	Very Fine Sand			10YR 5/3	Brown
T1.3	D		Very Fine Sandy Silt			10YR 6/3	Pale Brown
T1.3	E	Light Coloured Aeolian? Sand	Very Fine Sandy Silt			10YR 7/2	Light Grey
T1.3	F	Light Coloured Aeolian? Sand	Very Fine Sandy Silt			10YR 6/3	Pale Brown
T1.3	G	Light Coloured Aeolian? Sand	Very Fine Sandy Silt			10YR 4/2	Dark Greyish Brown
T1.3	H	Darker Coloured Bedrock? Sand	Very Fine Sandy Silt			10YR 6/3	Pale Brown

T1.3	I						
T1.3	J	Basal Substrate					
T1.4	A	Black Palaeosol	Fine Sandy Soil	Moderate	Some Muscovite present	10YR 2/1	Black
T1.4	B	Light Coloured Aeolian? Sand	Very Fine Silty Sand	Very Well	Some Muscovite present	2.5Y 3/2	Very Dark Greyish Brown
T1.4	C	Light Coloured Aeolian? Sand	Very Fine Sandy Silt	Very Well	Muscovite present	10YR 6/2	Light Brownish Grey
T1.4	D	Light Coloured Aeolian? Sand	Fine Sand (Some Clay and Silt)	Moderate		2.5Y 5/2	Greyish Brown
T1.4	E	Darker Coloured Bedrock? Sand	Very Fine Silty Sand	Very Well	Some Muscovite present, as well as other minerals	2.5Y 6/2	Light Brownish Grey
T1.4	F	Darker Coloured Bedrock? Sand				2.5Y 5/3	Light Brownish Grey
T1.4	Bedrock	Basal Substrate				2.5Y 5/2	Greyish Brown
T1.5	A	Black Palaeosol	Medium Soil and Fine Sand (Some Clay/Silt)	Poor	Some Mica present	10YR 2/1	Black
T1.5	B	Brown Soil	Very Fine Sandy Silt/Clay	Well		10YR 4/3	Brown
T1.5	C	Light Coloured Aeolian? Sand	Very Fine Sand with Silt/Clay	Poor		2.5Y 6/2	Light Brownish Grey
T1.5	D	Light Coloured Aeolian? Sand	Very Fine Sand with Clay/Silt	Well	Mica present	10YR 4/3	Brown
T1.5	E	Light Coloured Aeolian? Sand	Very Fine Sand with Silt/Clay Present	Well	Muscovite and Mica present	2.5Y 6/2	Light Brownish Grey

T1.5	F	Darker Coloured Bedrock? Sand	Very Fine Sand with Some Silt/Clay	Very Well	Muscovite and Mica present	2.5Y 5/3	Light Olive Brown
T1.5	G (Bedrock)	Basal Substrate					
T1.6	A	Black Palaeosol	Silt/Clay with some Very Fine Sand	Moderate		10YR 4/3	Brown
T1.6	B	Light Coloured Aeolian? Sand	Very Fine Sand	Very Well	Quartzite present	10YR 5/2	Greyish Brown
T1.6	B1				Muscovite Present	10YR 3/2	Very Dark Greyish Brown
T1.6	B2	Slightly Darker Coloured Aeolian? Sand			Occasional Muscovite	10YR 3/3	Dark Brown
T1.6	C	Light Coloured Aeolian? Sand	Very Fine Sand	Very Well	Abundant Muscovite	10YR 5/2	Greyish Brown
T1.6	D	Darker Coloured Bedrock? Sand			Muscovite Present	10YR 4/2	Dark Greyish Brown
T1.6	E	Darker Coloured Bedrock? Sand	Very Fine Sand	Very Well	Muscovite Present	10YR 5/2	Greyish Brown
T1.6	G	Black Palaeosol	Clay with Occasional Very Fine Sand		Abundant Muscovite	10YR 3/2	Very Dark Greyish Brown
T1.6	Bedrock	Basal Substrate					
T1.7	A	Light Coloured Soil	Very Fine Sandy Soil	Moderate	Some Muscovite Visible	10YR 3/3	Dark Brown
T1.7	B	Light Coloured Aeolian? Sand	Very Fine Sandy Clay	Well	Muscovite Present	10YR 4/4	Dark Yellowish Brown
T1.7	C	Darker Coloured Bedrock? Sand	Very Fine Sand wilt Silt/Clay	Very Well	Muscovite Present	10YR 4/3	Brown
T1.7	D	Darker Coloured Bedrock? Sand	Very Fine Silty Sand	Very Well	Some Muscovite Present	2.5Y 5/2	Greyish Brown

T1.7	E	Darker Coloured Bedrock? Sand	Frozen chunks of sand			2.5Y 6/3	Light Yellowish Brown
T1.7	F	Darker Coloured Bedrock? Sand	Very Fine Sand	Poor		10YR 2/2	Very Dark Brown
6	A	Light Coloured Soil	Fine Sand	Very Well	Feldspar, Biotite, and Muscovite Present	10YR 5/3	Brown
6	B	Slightly Darker Coloured Soil	Very Fine Sand	Well	Muscovite Present	10YR 5/3	Brown
6	C	Black Palaeosol	Very Fine Sand with Clay/Silt	Well		10YR 2/2	Very Dark Brown
6	D	Slightly Darker Coloured Soil	Very fine Sand with abundant clay/silt	Very Well	Some Mica Present	10YR 3/2	Very Dark Greyish Brown
6	E		Silt/Clay with Very Fine Sand			10YR 3/1	Very Dark Grey
6	F	Light Coloured Aeolian? Sand	Very Fine Sand with Clay	Very Well	Abundant Mica Fragments	10YR 7/3	Very Pale Brown
6	G	Light Coloured Aeolian? Sand- Slightly Darker	Silt with Some Very Fine Sand		Abundant Mica Fragments	10YR 5/6	Yellowish Brown
6	I	Reddish	Silt with Some Very Fine Sand		Some Mica Fragments	10YR 3/2	Very dark Greyish Brown
6	J	Reddish	Abundant Silt and some Very Fine Sand	Well		10YR 2/1	Black
6	K	Darker Coloured Bedrock? Sand	Very Fine to Fine Sand	Well		10YR 6/6	Dark Yellowish Brown

Unit	Modern Roots	Sed. Structures	Organic Structure	Bioturbation	Cryoturbation	Pedogenesis	Mottling	Palaeosol	Other
T1.2	Few	None	Few		None	Yes		Yes	
T1.2	None		Some		None				
T1.2	None	Present	None		None		On west wall only	No	
T1.2	None	None	None		None			Possible	Possible decayed granite
T1.2	None	None			None				
T1.2									
T1.2									
T1.3	Abundant								
T1.3					None				
T1.3									
T1.3									
T1.3									
T1.3								Incipient	
T1.3									
T1.3								Yes	
T1.3									Angular limestone cobbles interstitial
T1.3									Glacio fluvial
T1.3									
T1.4	Present				None				Abundant grass roots
T1.4	Present		Present		None				
T1.4	None	None	None		None				
T1.4		Some		Possible					Possible bioturbation from tree falling and creating a pocket
T1.4	Some	None			None				
T1.4									
T1.4									
T1.5	Abundant		Mainly	Possible	None				rounded and angular pebbles found throughout section

T1.5	Some		Some	Yes	None		Some		Abundant charcoal flecs, extensive burrowing, rounded and angular pebbles found throughout section
T1.5	Some	None	Few		None				rounded and angular pebbles found throughout section
T1.5			Few		Possible			Weakly Developed	Rounded and angular pebbles found throughout section
T1.5	Some	None	None		None				Very similar to C, rounded and angular pebbles found throughout section
T1.5	Few		None		None				Very similar to E, rounded and angular pebbles found throughout section
T1.5									Rounded and angular pebbles found throughout section
T1.6							Moderate		Very extensive grass roots through this later
T1.6		None		Moderate	Yes				
T1.6									Similar to B
T1.6									Similar to B
T1.6		None			Yes				Crevass splay?
T1.6									Similar to B
T1.6									Homogenous grain size and composition throughout
T1.6								Possible	8-10 artefacst found in this layer
T1.6									

T1.7	Present		Present						Charcoal bits present
T1.7	Present		Some		None				Some charcoal
T1.7	Few	Few							
T1.7	None	None			None				
T1.7									Description very similar to D, permafrost layer, frozen chunks of sand present
T1.7	None		Present		None				Possible burnt root?
6	light	None		None					Only lightly rooted
6		None					Light	Weakly Developed	Extensively rooted, holds moisture
6								Well Developed	Extensivlely rooted organic materials
6	Few			Extensive on western wall	Yes		Light		Some gneiss cobbles present
6	None			None					Insitu decomposition of boulder?
6		None		None					Horizontal rooting along western wall
6	Some						Appears	Possible	Slightly sandier along the western wall than the southern wall
6	Some				Probably				Many charcoal fragments present, very odd geometry
6					Likely				Decomposing root material
6		None		None			Some		Layers of charcoal

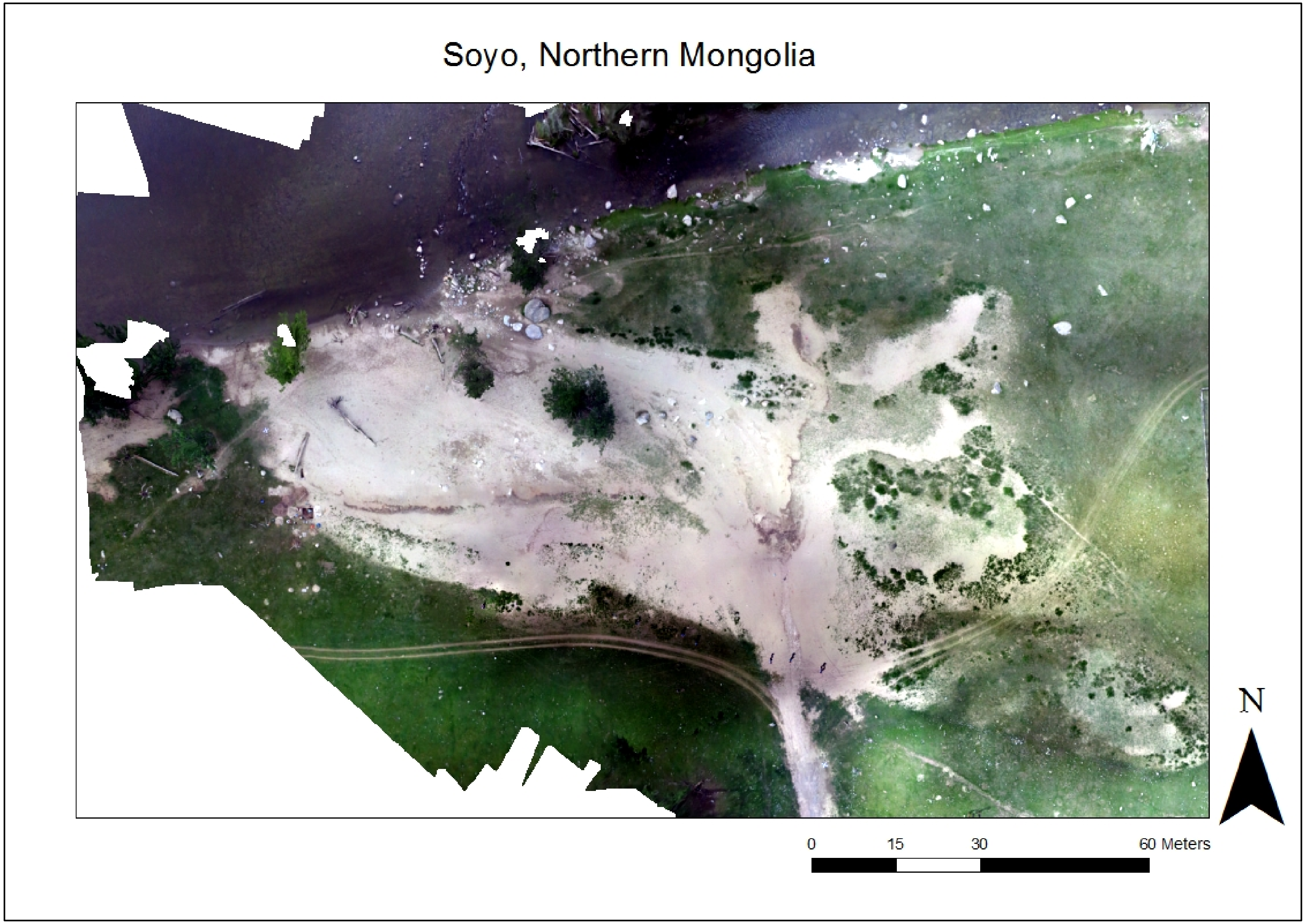
Unit	Description
T1.2	Paleosol, VF well sorted sand. Few modern roots, few organic stuctures, no sedimentary structures, some muscovite present, no signs of cryoturbation, 7.5YR 2.5/1 Black
T1.2	Very fine very well sorted sandy clay. Some organic structures, nomodern roots. Musocvite present. No signs of cryoturbation. 2.5Y 4/4 Olive Brown
T1.2	Very fine , very well sorted silty sand. Sedimentary structures present, mottleing on West wall only, no modern roots, no organic structures, no signs of cryoturbation, muscovite present 2.5Y 4/4 Olive Brown
T1.2	Possible palaeosol, very fine, very well sorted, moscovite present,no modern roots, no organic structures, possible decayed granite, no cryoturbation, no sedimentary structures, 2.5Y 3/2 Very Dark Greyish Brown
T1.2	Very fine, very well sorted sand, some muscovite, no modern roots, no sedimentary structures, no signs of cryoturbation, 2.5Y 5/2 Greyish Brown
T1.2	Granite Cobbles and Boulders, 2.5 Y 5/2, greyish brown
T1.2	Granite Cobbles and Boulders, 2.5 Y 5/2, greyish brown
T1.3	2.5YR 4/2, very fine sand, weak red, dune sand, modern roots, abundant grass roots
T1.3	2.5YR 2.5/2, very dusky red, very fine sandy silt loam, current soil horizon= top palaeosol/anthrosol beneath dunes in site, very dark brown O horizon, abundant roots, no sign of cryoturbation
T1.3	5YR 4/3, reddish brown, very fine sandy silt, B horizon
T1.3	10YR 5/3, very fine sand, brown, C horizon
T1.3	10YR 6/3, pale brown, very fine sandy silt, aeolian sand
T1.3	10YR 7/2, light grey, very fine sandy silt, aeolian sand with incipient palaeosol
T1.3	10YR 6/3, pale brown, very fine sandy silt, aeolian sand with some organic content-slower building surface
T1.3	Basal palaeosol, developed in aeolian sand-long term stable surface, 10YR 4/2, dark greyish brown, very fine sandy silt
T1.3	Angular limestone cobble colluvium, interstitial, very fine sandy silt, 10YR 6/3, pale brown
T1.3	Interstitial water rounded/borne pebbles <5cm, various lithologies, glacio fluvial
T1.3	Glacial fill ice contact, cobbles and boulders, various lithologies, no limestone, gneiss, granite,quartzite, slate
T1.4	Fine grain, moderatly sorted sandy soil, some muscovite present, modern roots present, abundant grass roots, no cryoturbation evident, 10YR 2/1, black
T1.4	Very fine, very well sorted silty sand, muscovite present, some modern root and other organic structures present, no signs of cryoturbation, 2.5YR 3/2, very dark greyish brown
T1.4	Very fine, very well sorted sandy silt, muscovite present, no modern roots, no organic structures, no signs of cryoturbation, no sediment structures, 10YR 6/2, light brownish grey
T1.4	fine, moderately sorted sand (some silt, some clay), some sedimentary structures, possible bioturbation?

	Could have been a tree falling creating a pocket? 2.5YR 5/2, greyish brown
T1.4	Very fine, very well sorted silty sand, some modern roots, no sedimentary structures, no signs of cryoturbation, some muscovite present, as well as other minerals,2.5Y 6/2, light greyish brown
T1.4	2.5Y 5/3, light brownigh grey
T1.4	Glacial fill made up of granite boulders, sub-angualr limestone rocks and smaller rounded river rocks, 2.5Y 5/2, greyish brown
T1.5	Organic rich medium grain soil with fine grained sand, some clay/silt, some mica, poorly sorted, mainly organic structures, no evidence of cryoturbation, abundant modern roots, some evidence of burrowing, 10YR 2/1, black
T1.5	Well sorted abundant silt/clay with very fine sand, some organic structures, no cryoturbation evidence, abundant charcoal flecs, some mottling, some modern roots, extensive burrows bring A material downwards, 10YR 4/3, brown
T1.5	Very fine sand with silt/clay, poorly sorted sand, some mica material, no sedimentary structures, some modern roots, few organic structures, no signs of cryoturbation, not laterally continuous however may be disturbed by ? Process, 2.5Y 6/2, light brownish grey
T1.5	Abundant clay/silt with some very fine, well sorted sand ,mica material, moderatly sorted not laterally continuous however may be affected by cryoturbation(possible), few organic structures, weakly developed palaeosol, 10YR 4/3, brown
T1.5	Very fine, well sorted sand with silt/clay present, mica material, modern roots, no sedimentary structures, ? Evuidence of bio or cryoturbation,no organic structures, muscovite present, no evidence of cyoturbation, very similar to C, 2.5Y 6/2, light brownish grey
T1.5	Very fine sand, very well sorted, some silt/clay, mica present, few modern roots, little organic material, very similar to E, more muscovite, no organic structures, no evidence of cryoturbation, 2.5Y 5/3, light olive brown
T1.5	Limestone and granite bedrock, mix of angular cobbles/pebbles including gneiss and limestone
T1.6	Moderately mottled, moderately oragnic rich, moderately well developed soil, silt/clay with some very fine sand, very extensive grass roots through this later, 10YR 4/3, brown
T1.6	Very well sorted, very fine grain sand, dominatly quartz, no obvious sedimentary structures, moderate bioturbation, moderate rhizomorphs, 10YR 5/2, greyish brown, unit geometry appears to be affected by cryoturbation
T1.6	Very similar to B but higher percentage of clay, more muscovite, 10YR 3/2, very dark greyish brown
T1.6	Very similar to B with higher percentage of silt, occasional muscovite, 10YR 3/3, dark brown
T1.6	Very well sorted, very fine grain sand with abundant muscovite, no obvious sedimentary layers,

	but extensively affected by croturbation, crevass splay? 10YR 5/2, greyish brown
T1.6	Very similar to B with higher percentage of clay and muscovite, 10YR 4/2, dark greyish brown
T1.6	Mainly sand, very fine grain, very well sorted, abundant muscovite, 10YR 5/2, greyish brown, homogenous grain size and composition throughout
T1.6	Predominantly clay, abundant muscovite, occasional very fine sand grain, 10YR 3/2, very dark greyish brown. 8-10 artefacts found in this layer, possible palaeosol
T1.6	Comprised of numerous angular blocks of limestone?, with possible granite and slate present
T1.7	Very fine, moderatley sorted sandy soil, modern roots and organic structures present, some muscovite visible, charcoal bit present, 10YR 3/3, dark brown
T1.7	Very fine, very well sorted sandy clay, some charcoal, some organic structures, modern roots present, muscovite present, no evidence of cryoturbation, 10YR 4/4, dark yellowish brown
T1.7	Very fine, very well sorted sand with silt and clay present, few sedimentary structures, few modern roots, muscovite present, 10YR 4/3, brown
T1.7	Very fine, very well sorted silty sand, no evidenced of cyoturbation, no modern roots, no sedimentery structures, some muscovite, 2.5Y 5/2, greyish brown
T1.7	Description very similar to D, permafrost layer, frozen chunks of sand present, 2.5Y 6/3, light yellowish brown, at 125cm permafrost became solid and were unable to continue excavation
T1.7	Very fine poorly sorted sand, organic structures present, possible burnt root?, no muscovite, no cryoturbation, no modern roots present, 10YR 2/2, very dark brown, depth to base taken on west wall profile
6	Fine grained, very well sorted sand with some other minerals present (e.e. feldspar, biotitie, and muscovite), no sedimentary structures or bioturbation, only lightly rooted, 10YR 5/3, brown
6	Very fine grained, very well sorted sand with muscovite, no sedimentary structures aside from light mottling, extemsively rooted, probably a weakly developed palaeosol, holds moisture, 10YR 5/3, brown
6	Organic rich, well developed palaeosol made up of clay/silt, some well sorted very fine grained sand and extensively rooted organic materials, 10YR 2/2, very dark brown
6	Very fine grained, very well sorted sand with abundant clay/silt and some mica present, few modern roots, some gneiss cobbles present, basal geometry appears affected by cryoturbation, extensive burrowing on western wall and light mottling throughout
6	Discrete cup-shaped unit, principally silt/clay with some very fine sand, no structures bioturbation or roots, insitu decomposition of boulder? 10YR 3/1, very dark grey
6	Very fine grained very well sorted sand with clay and abundant mica fragments, no sedimentary structures or bioturbation, contains horizontal rooting along western wall, 10YR 7/3, very pale brown

6	Silt with some very fine grained sand and abundant mica fragments, some roots present, appears mottled and may be a palaeosol, its slightly sandier along the western wall than the southern wall, 10YR 5/6, yellowish brown
6	Organic rich silt with very fine grined sand and some mica fragments, unit is extensively disturbed probably by cryoturbation and may interdigitate with other units at the edges, some modern roots, very odd geometry, many charcoal fragments present, 10YR 3/2, very dark greyish brown
6	Charcoal rich layer made of decomposing root material, abundant silt and some very fine grained well sorted sand, layer has very complex geometry, likely the result of cryoturbation, 10YR 2/1, black
6	Mustard coloured, well sorted very fine to fine grained sand with some charcoal flecks, mottling and layers of charcoal, no obvious sedimentery structures or bioturbation, 10YR 6/6, dark yellowish brown

Appendix D: Overall Site Map



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