AN INVESTIGATION INTO THE NEOLITHIC OF SOYO (NORTHERN MONGOLIA) THROUGH ANALYSIS OF LITHICS

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GLOSSARY

Biface: Lithic artefact with observable use-wear or retouch on both the dorsal and ventral face

Cmbd: Centimetres below datum (datum height is specific to each induvial Unit)

Core: Lithic artefact with a minimum of one negative flake scar, which does not additionally have observable use-wear or retouch

***Darkhadyn Khögtör*:** Darkhad Depression (Mongolian translation)

Dorsal face: Side of a lithic artefact facing the external portion of the core prior to detachment via percussion

Flake Piece: Lithic artefact with no observable use-wear or retouch

Flake Tool: Lithic artefact with observable use-wear or retouch

***Khog Gol*:** Khog River (Mongolian translation)

KRI: Kuhn's Reduction Index [value]

Level: Excavation spit

NBAT: Neolithic – Bronze Age Transition

NOMAD Science: Northern Mongolia Adventure and Discovery in Science program, coordinated by Dr Julia Clark and Dr Jamsranjav Bayarsaikhan

Projectile Point: Lithic artefact with observable use-wear or retouch, and with observable hafting

SDI: Simpson's Diversity Index [value]

***Soyo Tolgoi*:** Soyo Hill (Mongolian translation)

Unit: Excavation trench, square

Use-wear: Wear present on the edge or surface of a lithic artefact that may be attributed to past utilisation

Ventral face: Side of a lithic artefact facing the internal portion of the core prior to detachment via percussion

CHAPTER 1: INTRODUCTION

The research outlined here has focussed on a sample of 96 stone tools recovered from the area surrounding Soyo Hill in north-central Mongolia. Study into the region has been conducted via the Northern Mongolia Adventure and Discovery in Science (NOMAD Science) field school program; however, limited analysis has been consecutively performed on these assemblages. The analysis undertaken as a component of this thesis will allow greater archaeological understanding of north-central Mongolia and will benefit future studies into Mongolia's past.

1.1: RESEARCH QUESTION AND AIMS

The principal research question addressed by this thesis is:

"What do the lithic assemblages of Soyo (northern Mongolia) reveal about past human adaptions over time?"

This research focusses on four major aims, the results of which should enable response to the above question. These are provided in the table below (Table. 1)

Table 1: Outlining major aims associated with this research project.

Aim no.	Aim details
1	To determine the assemblage formality, assemblage diversity, and raw material variability of stone artefacts collected from Soyo throughout time.
2	To approximate the relatedness of raw materials used to produce lithics that were discarded at Soyo and determine how this has changed over time.
3	To identify the transition to pastoralism at the site of Soyo in context changes in the constitution of its lithic assemblage.
4	To approximate the social structure, subsistence strategies, mobility patterns, and economic trends of past communities at Soyo throughout time

1.2: OVERVIEW OF RESEARCH

Research into Mongolia's Neolithic (5,500 – 3000 BP) and Bronze Age (1300 – 700 BP) periods has been extensive but has focussed largely on the central and southernmost regions of the nation (Elston and Brantingham 2002; Ėnkhtör et al. 2018; Farquhar 2019; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Houle 2010; Janz 2006, 2012; Miller et al. 2018; Seitsonen et al. 2018; Rybin 2014; Taylor et al. 2015; Tyler 2018; White and Bush 2010). Past northern Mongolian social structures, regional subsistence and mobility patterns, trade networks, and religious tendencies are poorly understood; further research into associated technologies will improve our comprehension of crucial periods in the country's history. The

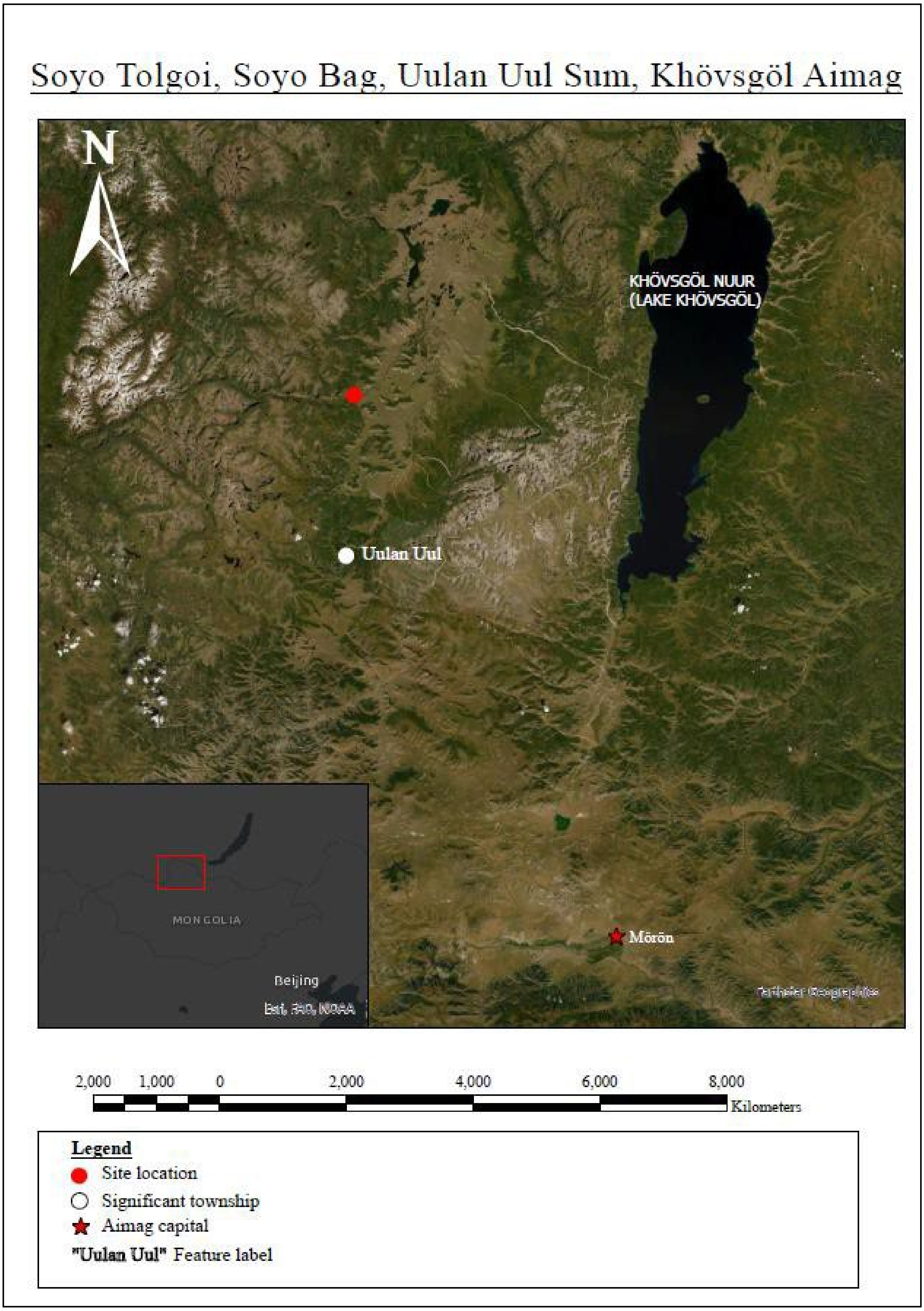


Figure 1: Indicating the location of Soyo Tolgoi, northern Mongolia; site marked by red dot.

site of Soyo, in the Darkhad Depression (Khövsgöl Province) of north-central Mongolia, has yielded stone and ceramic artefacts hypothesised to have been deposited within the Neolithic and Bronze Age. Analysis of these collections will increase our understanding of key technological and behavioural transitions in the Darkhad; however, such work has not yet been undertaken. Through associated modern mobility patterns and geomorphology have been reviewed (Clark 2014; Clark and Crabtree 2015; Vella 2018), much of the associated assemblages are yet to be analysed. Ongoing investigation of the Soyo collections will benefit researcher understandings of past human behaviour in the area.

These issues are pertinent to numerous cultural groups throughout northern Mongolia; the significance of this project is also bolstered by the application of analytical methods that have not previously been performed on Mongolian lithic collections. As a result of this research, human behaviour throughout the Neolithic and Bronze Age, associated with severe climatic changes (Arzhannikov et al. 2012; Blayarkharchuk et al. 2004; Derevianko et al. 2013), will be better understood. In addition, knowledge of Mongolia's north-central region will fill key research gaps currently plaguing the country's archaeological record; little is known of this area from the perspective of lithic analyses. This research will aim to answer the above question through employment of a combined macroscopic and microscopic lithic analysis approach, enabling a detailed understanding of lithic technology during Soyo's Neolithic and Bronze Age to be attained. Macroscopic analysis will include basic typological categorisation of artefacts, as well as metrical analysis and attribute descriptions (Andrefsky 1998; Farquhar 2019). Conversely, the microscopic component (requiring the use of technology with at least 500x magnification) is to include x-ray fluorescence analysis, proven to be beneficial to lithic researchers internationally (Frahm 2013a, 2013b; Frahm and Doonan 2014; Frahm et al. 2014; Goodale et al. 2012; Shackley 2008; Tykot et al. 2013; Williams-Thorpe 2008; Williams-Thorpe et al. 1999). Analysis combining macroscopic and microscopic techniques has been advocated for in recent years by numerous authors (Hyland et al. 1990 Luedtke 1992; Marreiros et al. 2015; Odell 1975; Odell and Vereecken 1980; Prentiss 1998). This is additionally the first archaeological study of the northern Mongolian Neolithic and Bronze Age aiming to categorise the chemical relationship between chert samples. The analysis approach applied here will benefit the nation's archaeological records and provide new perspectives on past raw material procurement.

The archaeological research herein outlined will enable a more detailed understanding of northern Mongolia's past to be established. As a result, key conclusions regarding the mobility patterns and stone artefact use of associated past groups will be produced. These results will benefit our understanding of Mongolia's past, its contemporary Indigenous groups, and will contribute to global debates concerning the Eurasian Neolithic and Bronze Age.

1.3: ORGANISATION OF THESIS

This thesis has been organised into 6 chapters, which aim to collectively discuss analysis conducted on assemblages from Soyo. Chapter 2 will introduce the reader to past archaeological studies of Mongolia, as well as key concepts and discussions regarding the analysis methods to be employed. This chapter will outline the global relevance of this study and detail the archaeological record of each of Mongolia's regions. A brief overview of Soyo's geographical context and history will be provided. Overview of both typological and chemical lithic analysis techniques will be given, with particular attention paid to those procedures to be employed here.

A detailed recount of the methods used will then be outlined in Chapter 3, again covering both macroscopic and microscopic techniques. In Chapter 4, the results of these analyses will be provided. Chapter 5 will then discuss the relationships between categories of data (macroscopic and microscopic techniques) and outline their implications for the archaeological record of northern Mongolia. Finally, Chapter 6, the conclusion, will summarise the research, and suggest possible avenues for future work.

Chapter 2: Literature Analysis

Mongolia's Bronze Age is characterised by the onset of nomadic pastoralism and is an era of immense social and economic change. Nomadic pastoralism, defined by Taylor (2017:270) as "those types of herding which rely on coordinated movement, and lack of permanent settlements", is believed to have been immediately preceded by hunter-gatherer lifestyles (Fitzhugh and Bayarsaikhan 2010; Maringer 1963; Shelach 2014; Taylor 2017; Weber et al. 2010). It is still practiced in many regions of modern Mongolia (Clark and Crabtree 2015; Fijn 2011; Vainshtein et al. 1983), and a significant body of research has been produced since the 20th century aiming to characterise its origins (Honeychurch 2013, 2014; Honeychurch et al. 2021; Fernández-Giménez 2000; Jeong et al. 2018; Orlando 2018; Taylor 2017; Taylor et al. 2019; Toshimitsu 1983; Wright 2017; Wright et al. 2008).

Studies concerning Mongolia's Neolithic period have also been produced, largely aiming to record key technological transitions and establish the nature of early hunter-gatherer groups (Derevianko and Dorj 1992; Séfériadés 2004; Tumen 2006). The development of microblade technology and its diffusion throughout Eurasia has been a primary focus of these studies (Gladyshev et al. 2010, 2012; Goebel 2002; Rybin et al. 2016; Smith 1974; Krivogonov et al. 2016), as will be discussed further below. The history of much of northern Mongolia, however, is still little understood; unravelling the past of this area will likely have significant global implications, as shall herein be discussed.

2.1: Global Relevance

Worldwide, numerous studies have been produced characterising the Neolithic period of various nations (Bettinger 2013; Brumm and Rainey 2011; Clarkson 2007; Elston and Brantingham 2002; Flenniken 1980; Henrich 2004; Honeychurch 2010, 2013; Honeychurch and Marakewicz 2016; Jeske 1992; Lycett and Bae 2010). Mongolia's Neolithic period, however, is unique in that it is associated with the earliest evidence of pottery and complex burial traditions (Guan et al. 2020; Houle 2010; Iizuka et al. 2018; Janz and Burr 2015; Johannesson 2011; Khenzykhenova et al. 2016; Ma et al. 2000; Séréfiadés 2004). While such technological advancements are observed, the onset of pastoral nomadism is not evidenced until the nation's Bronze Age (Allard and Erdenebaatar 2005; Johannesson 2015; Seitsonen et al. 2014; Taylor 2017; Wright 2006; Wright 2017; Zazzo et al. 2019). In many other regions of the world, groups are believed to have practiced semi-sedentism far earlier, and evidence of such behaviours is present from the Neolithic (Ambrose 1984; Bettinger 2013; Brumm and Rainey 2011; Clarkson 2007; Diamond and Bellwood 2003; Flenniken 1980; Henrich 2004; Kislev et al. 2006; Peltenburg and Wasse 2012; Sadowski 2017). The distinction between the Mongolian Neolithic and that of many other regions should be considered when assessing Mongolian archaeological assemblages.

Figure 2: Depicting the timing of major agricultural revolutions throughout north Africa and Europe during the Neolithic period. from Gronenborn et al. (2020). Removed owing to copyright restrictions.

The Neolithic period is perceived by many researchers to be an era of immense technological and sociocultural evolution (Figure 2) (Ambrose 1984; Bettinger 2013; Brumm and Rainey 2011; Clarkson 2007; Diamond and Bellwood 2003; Elston and Brantingham 2002; Flenniken 1980; Gronenborn et al. 2020; Henrich 2004; Kislev et al. 2006; Peltenburg and Wasse 2012; Sadowski 2017). Elston and Brantingham (2002:103) describe this transitional period as a time where "culture origin and typology are foremost". These changes are seen internationally, with sites throughout the Levant, Africa, the Americas, Australia, and the wider Eurasian steppe zone yielding evidence of pastoral nomads (Ambrose 1984; Bettinger 2013; Brumm and Rainey 2011; Clarkson 2007; Diamond and Bellwood 2003; Flenniken 1980; Henrich 2004; Honeychurch 2010, 2013; Honeychurch and Makarewicz 2016; Jeske 1992; Kislev et al. 2006; Lycett and Bae 2010; Peltenburg and Wasse 2012). The Neolithic period is associated with great technological change, in part through advancing variation or refinement in lithic and ceramic technologies (Hiscock 2015; Houle 2010; Janz 2012). In many cases, these changes have been seen as responses to changing environmental conditions (Bleed 1986; Beck and Jones 1990; Buchanan and Collard 2008; Clarkson 2007; Flenniken 1980; Frison 1989; Jeske 1992; Jones et al. 2003; Henrich 2004; Hiscock 2015; Lycett and Bae 2010; Lycett and Norton 2010; Odell 1975), population constitution (Fitzhugh and Bayarsaikhan 2008; Henrich 2004; Taylor et al. 2015; Shelach 2009), or as a strategy to increase efficiency of tools (Bamforth 1986; Binford 1980; Clarkson 2007; Elston and Brantingham 2002; Hayward 2010; Jeske 1992; Newcomer et al. 1986; Watts 2013). The technological and social revolutions associated with the Neolithic Period have generated extensive discussion regarding their influences on human behaviour, largely revealed through analysis of stone and ceramic remains (Hiscock 2015; Houle 2010; Janz 2012).

Within Central Asia, however, major sociocultural and technological transitions are attributed to the Neolithic and Bronze Age Transition (NBAT), thought to be characterised by an intensification of site use and increased sedentism. Studies focussed on the NBAT of Central Asia have been conducted throughout the region (Bayar 2007; Bulag and Diemberger 2008; Honeychurch 2010, 2013, 2014; Janz et al. 2015, 2020, 2021; Liu et al. 2016; Park et al. 2011; Taylor 2017; Taylor et al. 2015a, 2015b; Vainshtein et al. 1983). Perceived increases in settlement frequency and intensity are reported (Allard and Erdenebaatar 2005; Houle 2010; Schneider et al. 2016; Wright 2017; Zhao et al. 2021) in addition to widespread increases in assemblage diversity (Allard and Erdenebaatar 2005; Janz 2006; Janz et al. 2015, 2020, 2021; Houle 2010; Park et al. 2011; Rybin 2014, 2016; Schneider et al. 2016; Wright 2017; Zhao et al. 2021). Understandings of this period are crucial for further appreciation of the Silk Road economy (Honeychurch 2010, 2013, 2014) and perceived advances in social complexity throughout the region (Houle 2010; Wright 2017).

Studies of Mongolia's Neolithic period are further valuable in their capacity to provide evidence for social complexity in Xiongnu societies (Bayar 2007; Bulag and Diemberger 2008; Derevianko et al. 2008; Fernandez-Giminez 2000; Fijn 2011; Honeychurch 2010, 2013, 2014; Park et al. 2011; Taylor 2017; Taylor et al. 2015a, 2015b; Vainshtein et al. 1983). Studies of the Xiongnu ethnic group (2159 –1857 BP), a "group… that formed a major focus of the Han imperial policy and military… [and] controlled the entire steppe belt of northeast Asia" (Wright 2017:373) are a major focus. The work of Honeychurch demonstrates Xiongnu participation in the Silk Road trade complex, as documented in Chinese historical literature (Honeychrch 2010; 2013, 2014). The Xiongnu were associated with a hierarchical social structure (Allard et al. 2002; Honeychurch 2010, 2013, 2014; Honeychurch and Makarewicz 2016; Park et al. 2010, 2015, 2016, 2017; Schneider et al. 2016; Taylor et al. 2015b; Vella 2018, White and Bush 2010) believed to have formed as a result of an “incremental process of combining different practices from across a larger and more diverse region” (Honeychurch 2013:313). Evidence of a structured social economy has been reported in numerous studies, but the precise nature of this complex is unknown (Honeychurch 2010, 2013, 2014; Park et al. 2010, 2015, 2016, 2017; Taylor et al. 2015b; Vella 2018). Despite the significance of Neolithic and Bronze Age groups to researchers of nomadic social complexity and the mechanisms of the Silk Road trade empire, the formation of relevant groups throughout Mongolia is little understood.

The dispersal of various stone artefact forms throughout Eurasia and the Americas has been attributed by some to Central Asian influences, bringing Mongolian lithic technologies into the international spotlight (Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Lycett and Bae 2010; Lycett and Norton 2010). The appearance of hand-axes throughout the Americas is of particular interest (Lycett and Bae 2010; Lycett and Norton 2010). Lycett and Bae (2010) observe significant geological barriers that may have limited the spread of technological knowledge throughout Central Asia. However, they also assert that the similarities between Chinese, Korean, and western Eurasian hand-axe traditions are numerous, and that their development is likely to be intertwined (Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Lycett and Bae 2010; Lycett and Norton 2010). The spread of knowledge over such great distances is little understood; geographically, northern Mongolia is central to many proposed major trade networks, and as such its investigation will likely yield valuable information of relevance internationally. The research of Fitzhugh and Taylor (Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Taylor 2017; Taylor et al. 2015a) throughout central and northern Mongolia has been focussed on the spread of “transformation images” (Fitzhugh 2002:8) depicted on Neolithic burial monuments. The prevalence of such imagery throughout the Eurasian steppe region suggests possible communication pathways throughout Russia and the Bering Strait (Fitzhugh 2002, 2006, 2017; Fitzhugh and Bayarsaikhan 2010; Gladyshev et al. 2012; Ishikawa and Yamkhin 2016; Zwyns et al. 2014). Though it is clear that Neolithic communication routes existed throughout Eurasia, Mongolia's role in this is not well-understood; further investigation of their lithic technologies and social structures may be advantageous.

Finally, Honeychurch (2010) has argued extensively against the marginalisation of modern nomadic groups and their perception as being unsophisticated, in both the archaeological record and in contemporary times. According to Honeychurch (2010), many contemporary pastoral nomads are considered minorities throughout Africa and Europe. These opinions are often reflected archaeological literature. Houle (2010:25) similarly discusses the perceived "'invisibility' or ephemeral nature" of nomadic peoples and Fitzhugh (2002:15) admits that "habitation sites seem nearly non-existent". Archaeological research throughout Mongolia has proven the presence of complex social systems throughout the Neolithic and Bronze Age, adverse to the claims of Fitzhugh, Houle and others (Clark and Crabtree 2015; Fijn 2011; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Honeychurch 2010, 2013, 2014; Houle 2010). Honeychurch further observes that studies of Mongolia's NBAT indicate "flexibility [of past groups] to modulate production according to changing conditions and dependency on social networks" (2010:407), regarding both environmental and social transitions. As such, arguments from both researchers and international governments that endorse the impracticality of nomadism are unlikely to be accurate (Honeychurch 2010; Taylor 2014). Further research into the resilience, innovativeness, and social complexity of past Mongolian nomads will advance global political recognition of pastoral groups and allow their capabilities to be appreciated.

2.2: ARCHAEOLOGICAL INVESTIGATION OF MONGOLIA

Extensive research has been conducted throughout central Mongolia over the past two decades (see section 2.2.2) (Figure 3), and has largely concerned subsistence and mobility practices of past groups, particularly during the NBAT (Arzhannikov et al. 2012; Choi et al. 2014; Elston and Brantingham 2002; Ėnkhtör et al. 2018; Fernandez-Gimenez 2000; Gladyshev et al. 2010, 2012; Houle 2010; Ishikawa and Yamkhin 2016; Krivogonov et al. 2016; Madsen et al. 2014; Seitsonen et al. 2018; Taylor et al. 2015a, 2015b; White and Bush 2010), with work intensifying in the Gobi Desert (Farquhar 2019; Janz 2006; Janz et al. 2012, 2015; Makarewicz et al. 2018; Miller et al. 2018) and northern regions (Clark and Crabtree 2015; Derevianko et al. 2008; Khatsenovich et al. 2017; Park et al. 2010, 2015, 2016, 2017; Smith 1974; Vella 2018; Zwyns et al. 2014). Honeychurch (2013:284) observes that Mongolia has been characterised by "strongly independent local groups and marginal environments", with the many regions of Mongolia each requiring unique human adaptions. However, he also asserts that Mongolia as a whole is ideal for pastoral groups due to its ecological variability (2010:407). Understanding the evolution and nature of this lifestyle throughout Mongolia thus continues to be a significant focus of archaeological work.

Figure 3: Map indicating locations of key research areas throughout Mongolia; Soyo Tolgoi marked in red. Adapted from Janz (2012:32). Reprinted with permission from L.Janz and Maps.com.

2.2.1 : Archaeological Research of Southern Mongolia

Research into southern Mongolia has largely focussed on regions throughout the Gobi Desert (Figure 4) (Derevianko and Rybin 2003; Farquhar 2019; Janz 2006, 2012; O'Malley et al. 1999; Yoshida et al. 2004). Janz et al. (2012), studying sites throughout the East Gobi and Gobi-Altai, have used AMS radiocarbon dating to establish a chronology of pottery production in southern Mongolia. Their investigation has resulted in their allocation of the Mongolian Neolithic as beginning between at least 5720-5561 BP, although two of the studied areas suggested even earlier dates (extending to 7733 BP [Janz et al. 2015]). Previous to this research, the Neolithic period of the Gobi Desert was estimated to have spanned only from 4000 to 1500 BP (Janz et al. 2015). Janz et al. assert that "bead-making was an important craft and ostrich eggshell an essential material" (2015:126) during the Neolithic, and an abundance of eggshell has similarly been noted in many sites of the East Gobi and Gobi-Altai regions (Derevianko and Rybin 2003; Janz 2012; O'Malley et al. 1999, Yoshida et al. 2004). Janz et al.'s work represents the most recent chronological reconstruction of Neolithic eggshell use. Increased complexity in ceramic vessel morphology further indicates possible interaction between small, mobile groups (Janz 2006, 2012; Janz et al. 2015, 2017); this subsistence style is in line with the pastoral nomadic lifestyle. The work of Janz throughout the East Gobi and Gobi-Altai has allowed for the reconstruction of past Mongolian lifeways in the Neolithic of southern Mongolia.

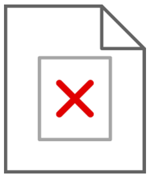


Figure 4: Sites throughout the Gobi Desert of archaeological significance. 1) Jabochin-Khure; 2) Gashun; 3) Yingen-Khuduk; 4) Dottore-Namak; 5) Mantissar; 6) Chikhen Agui; 7) Shabarkh-Usu; 8) Barun Daban; 9) Ulan Nor Plain; 10) Orok Nor; 11) Shara Kata Well; 12) Shara Murun Crossing; 14) Ta Sur Heigh; 15) Spring Camp; 16) Alkali Well; 17) Chilian Hotoga Well. From Janz et al. (2015:121). Removed owing to copyright restrictions.

Recently, numerous researchers (Farquhar 2019; Schneider et al. 2021) have worked extensively throughout the Ikh Nart Nature Reserve (East Gobi) and have dated the region's Neolithic period to between 3000 and 4000 BP. Janz (2012) and Janz et al. (2015) have observed an abundance of lithic artefacts in 'productive' regions of the Gobi Desert. These sites are positioned most around "wetlands and small lakes [which] must have supported higher plant and animal diversity" (Janz 2012: 220). This trend is also observed throughout the Ikh Nart Nature Reserve; their work observes the clustering of assemblages around ecologically productive water holes and oases (Farquhar 2019). Their analysis additionally observes decreases in residential mobility during the Bronze Age, which has been argued to reflect a move to agricultural practices (Farquhar 2019; Janz 2012; Janz et al. 2017). However, archaeological understandings of the Gobi Desert's Bronze Age and NBAT remain little understood. The work of Farquhar, Janz and Schneider et al. have thus enabled the lifeways of past southern Mongolian groups to be partly characterised.

2.2.2 : Archaeological Research of Central Mongolia

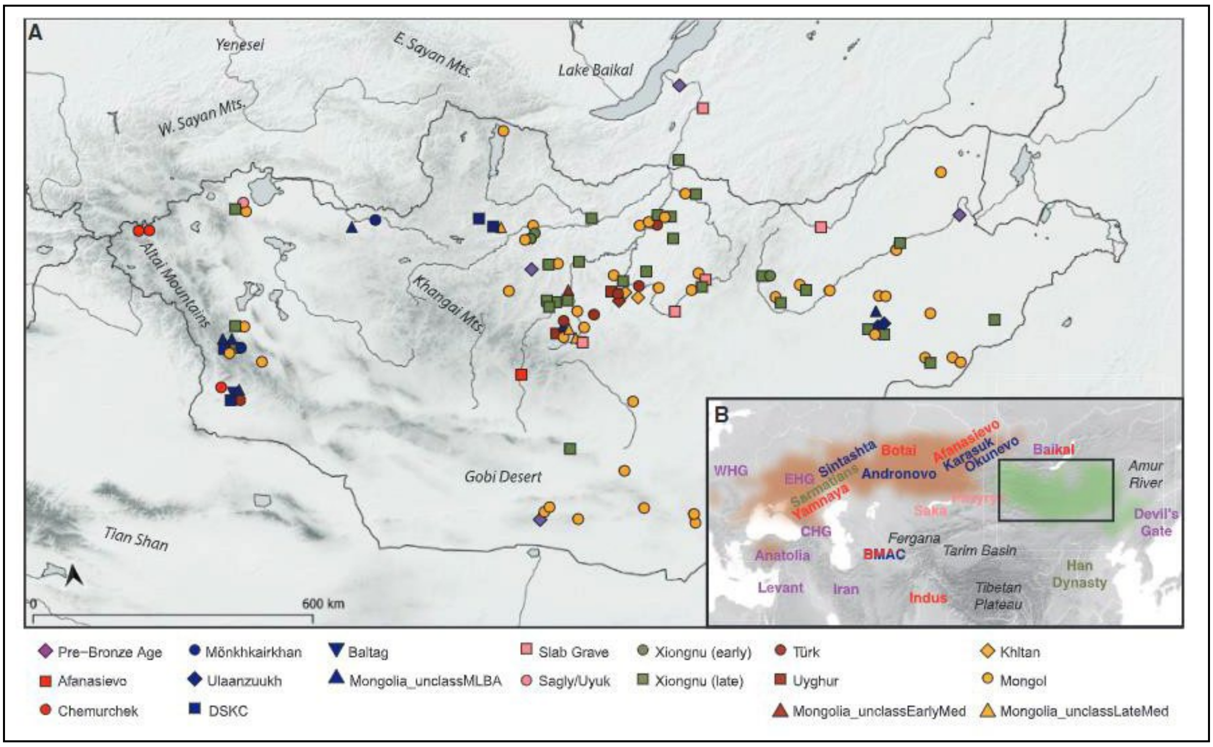


Figure 5: Map of key archaeological sites of various periods throughout Mongolia. From Jeong et al. (2018:892). Reprinted with permission from Elsevier.

Of all researched areas in central Mongolia, the assemblages of the Egiin Gol and Khanuy valleys have been the most extensively investigated (Figure 5) (Ėnkhtör et al. 2018; Gladyshev et al. 2012; Honeychurch 2010, 2013, 2014; Houle 2010; Makarewicz et al. 2018; Park et al. 2010; Rybin et al. 2016; Schneider et al. 2016; Wright et al. 2008; Zwyns et al. 2014), resulting in the establishment of detailed timelines for the Neolithic period and Bronze Age. Honeychurch (2013:411) identifies the Egiin Gol Valley as a “region with a particularly complex history of pastoral adaption”. Assessment of various sites throughout Egiin Gol (Figure 1) reveals evidence of nomadism through “’ditch-like’ trash-filled [pits]” (Honeychurch 2013:381) containing the remains of herd animals and pottery sherds. Sites appear to be located between five and nine kilometres apart, typical of nomadic pastoralist mobility (Fijn 2011; Clark and Crabtree 2015; Taylor 2017; Wright 2017). Occupation has been interpreted as being seasonal in nature, intensifying during summer (Wright 2017).

Analysis of ceramic, stone, and bone assemblages show significant diversification of resource use and perceived specialisation in product manufacturing around the NBAT (Gladyshev et al. 2012; Honeychurch 2013, 2014; Wright 2017). Burials found throughout the region indicate extensive mixing of monumental burial styles over time (Honeychurch 2013, 2014; Houle 2010; Taylor 2017; Taylor et al. 2015b). Reuse of spatially diverse sites and evidence of animal herding suggest continual reliance on pastoral adaptive strategies throughout central Mongolia during the Bronze Age.

The Neolithic of the Khanuy Valley (5450 – 2650 BP [Houle 2010]; uncalibrated) is associated with the Xiongnu Empire (Honeychurch 2013; 2014; Honeychurch and Makarewicz 2016; Houle 2010; Makarewicz et al. 2018; Seitsonen et al. 2018; Taylor et al. 2015b). Analogies to modern nomadic lifestyles (Clark and Crabtree 2015; Fijn 2011) have allowed Houle (2010) to place the development of pastoralist lifestyles within the late Neolithic (5450 – 3250 BP; uncalibrated). Houle's investigation of burial complexes throughout the Khanuy Valley has allowed him to conclude that "[groups] probably did not move more than a few kilometres from one seasonal campsite to another" (Houle 2010:180). Furthermore, he identifies "pan-regional similarities in ritual and burial structures" (Houle 2010:182), implying the existence of large-scale organisational systems. Adversely, Seitsonen et al. (2018) have analysed lithic clusters throughout the Khanuy Valley, placing the development of microblade technology in the late Pleistocene (40000-25000 BP). On the basis of this, they have placed the development of pastoralism in the Neolithic. Both Seitsonen et al. (2018) and Houle (2010), however, admit that much more expansive work needs to be done in the region, with the precise age of pastoralism's onset still open to debate.

2.2.2.1 : The Deer-Stone Khirigsuur Cultural Complex

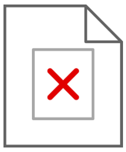


Figure 6: Example of a Bronze Age slab burial. From Bemmann and Brosseder (2017:9). Removed owing to copyright restrictions.

A large body of research (Allard and Erdenebaatar 2005; Clark and Crabtree 2015; Ėnkhtör et al. 2018; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Houle 2010; Makarewicz et al. 2018; Park et al. 2010; Taylor 2017; Taylor et al. 2015b) has been produced investigating the surface assemblages of the *Deer-Stone Khirigsuur* (DSK) cultural complex (1300-700 BP). The DSK is characterised by the presence of large stone monument/slab mound complexes from southern Siberia to the Gobi Desert (see Figure 6). Stone monuments often feature elaborate carvings depicting individuals and deer, though high thematic variability has been noted (Clark and Crabtree 2015; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Taylor et al. 2015b). Destruction and vandalism of ‘competing’ cultures, which have been identified through regionally varying imagery, has been recorded both in the contemporary period and throughout Mongolia’s past (Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Honeychurch 2014; Taylor 2017; Rybin 2014; Rybin et al. 2016). The prevalence of such practices has been argued to indicate both competition between neighbouring Bronze Age groups (Honeychurch and Makarewicz 2016; Rybin 2014; Rybin et al. 2016), and reinforce the need for preservation efforts by modern researchers (Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010). Although often associated with human remains, these complexes "might not have been solely mortuary in function" (Taylor 2017:272), although all are presumed to have had strong ritual significance (Allard and Erdenebaatar 2005; Clark and Crabtree 2015; Ėnkhtör et al. 2018; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Houle 2010; Makarewicz et al. 2018; Park et al. 2010; Taylor 2017; Taylor et al. 2015b; Seitsonen et al. 2018; Zwyns et al. 2014). Analysis of both excavated remains and grave goods, as well as the monuments' symbolic repertoire has given some insight into Bronze Age cultural complexity throughout Mongolia.

Complex social systems have been associated with DSK monument construction, allowing further characterisation of Bronze Age groups. Taylor (2017) hypothesises that the tradition may have developed first among groups inhabiting the Mongolia-China border, and subsequently spread as far as modern Siberia. It is probable that a significant, multi-person effort would have been required to construct each monument, suggesting cooperation between groups (Fitzhugh 2002, 2006; Honeychurch 2014; Taylor 2017). *Khirigsuur* burials can reach up to 400m in length, and according to Fitzhugh (2002, 2006) may be up to 3m tall (see also Honeychurch 2013). It is unlikely that one person, or even a small group of people, could manoeuvre such large stones on their own (Honeychurch 2010, 2013, 2014). DSK sites are consistently dated to the Bronze age, with several researchers observing significant differences between these and burials in subsequent periods. In addition, pathological analysis of equine premaxilla excavated from deer-stone sites has indicated that Bronze Age Mongolian groups comprised a "pastoralist society, combining equine transport with a diverse livestock economy" (Taylor 2017:278). Such evidence contributes to arguments associating the Bronze Age with the emergence of nomadic practices. Analysis of DSK complexes throughout central and northern Mongolia has indicated to researchers that the

Bronze Age was likely characterised by pastoralist societies, with strong communicative ties likely existing between groups.

2.2.3 : Archaeological Research in Northern Mongolia

Figure 7: a) spatial patterning of sites within northern Mongolia during the Neolithic period, b) spatial patterning of sites in northern Mongolia dated to the Bronze Age; c) locations of archaeological sites dated to the second and third millenniums BC in northern Mongolia. From Hosner et al. (2016:1589). Removed owing to copyright restrictions.

In recent years, northern Mongolia has received far more attention than previously (Figure 7), though archaeological understanding is still minimal in comparison to that for central Mongolia and the Gobi Desert (Clark 2014; Clark and Crabtree 2015; Taylor 2017; Taylor et al. 2015a, 2015b, 2019). Archaeological research has been hindered by the inaccessibility of research papers produced by Russian institutions during the 20^{th} century (Julia Clark 2018 pers. comm.; Vella 2018) and Fitzhugh (2002) has also observed that, prior to the early 21^{st} century, the majority of work conducted throughout northern Mongolia focussed on its Palaeolithic. In the last ten years Clark and Crabtree (2015) have used agent-based modelling to examine the mobility patterns of contemporary nomads, observing seasonal movement between ecologically productive regions; research in adjacent areas has concluded that modern mobility patterns are likely to reflect those of the past (Fijn 2011). Research has also been produced by Taylor et al. (2015b) that has established the development of pastoralism in the region from 1200 BP, as evidenced through increased herding behaviour. This has been supported by the intensification of horse-riding between 3000 and 4000 BP (Taylor et al. 2015b; Taylor 2017), in part evidenced by horse skeletal remains with "marked [depressions] to the bridge of the nose" (Taylor 2017:278) and incisions in teeth, both hypothesised to have been caused by bridle use. Semi-pastoralist reindeer herders (*Tsaatan*) are also ethnographically reported to have been most numerous during the Neolithic and Bronze Age (Fitzhugh 2002, 2006), and are thought to have varied their occupation patterns depending on environmental conditions (O'Brien and Surovell 2017; Rasiulis 2021; Taylor et al. 2019). Preliminary studies into the Neolithic and Bronze Age periods of northern Mongolia provide a pivotal starting point for future work, with the development of many nomadic processes are attributed to this period.

2.2.3.1 : Archaeological Research of Soyo Tolgoi and the Darkhad Depression

The research proposed here includes analysis of lithic assemblages from the site of Soyo in the south of north-central Mongolia's Darkhad Depression (*Darkhadyn Khögtör*), a lake basin adjacent to the major tourist destination of Lake Khövsgöl (Fitzhugh 2002). Named after the nearby Soyo Hill (*Soyo Tolgoi*) (Julia Clark pers. comm. 2019), Soyo (Figure 3) features several widespread clusters of (largely) chert, bone, and ceramic artefacts eroding out of riverine dune beds. Research into the region was instigated through the Northern Mongolia Adventure and Discovery (NOMAD) Science program, following the site's discovery during the joint American-Mongolian Deer Stone Project (Fitzhugh 2005). As with many other regions of the nation, there is still much to be understood regarding its past. The exact character of the site's Neolithic and Bronze Age periods has not been extensively researched (Clark and Crabtree 2015; Honeychurch 2013); however, preliminary investigations of the site suggest occupation throughout the Neolithic and Bronze Age (Clark 2015, 2017, 2018; Clark and Bayarsaikhan 2016; Vella 2018).

2.3: Climatic and Environmental Trends of Northern Mongolia

The modern climate of Mongolia has been described by Taylor (2017:271) as "[an] arid climate, at both high latitude and high elevation", as may be observed in Köppen-Geiger climate classification maps (Beck et al. 2018). Researchers such as Arzhannikov et al. (2012), Blyarkharchuk et al. (2004), Derevianko et al. (2008) and Gillepsie et al. (2008) have conducted studies into the environmental and climatic history of northern Mongolia.

2.3.1: Geographic Context

The physiography of northern Mongolia has been extensively studied (Arzhannikov et al. 2012; Blyarkharchuk et al. 2004; Derevianko et al. 2008; Gillepsie et al. 2008; Vella 2018). Khan and Clyde (2013) have identified that Lake Khövsgöl is currently bordered by the Sayan mountains, "[one of] the two oldest mountain chains in north-western Asia" (Sabloff 2011:89). The basin is bordered by the Sayan, Bayan Nurhiin Nuruu, Horidol and Ulaan Taiga mountains, and is characterised by a steppe-taiga ecosystem. Mongolia shows significant ecological variation between regions (Blyarkharchuk et al. 2004; Honeychurch 2013, 2014; Kovalenko and Petrov 2017; Sabloff 2011; Taylor 2014; Taylor 2017; Taylor et al. 2015a; Vella 2018). While the southern region is dominated by a desert system and the north-east by mountainous taiga (Honeychurch 2013; Kovalenko and Petrov 2017; Sabloff 2011; Taylor 2014; Taylor 2017; Taylor et al. 2015a), Mongolia's northern and central regions are dominated by a steppe environment characterised by grass species and birch-dominated forest (Blyarkharchuk et al. 2004; Honeychurch 2013, 2014; Taylor 2014; Taylor 2017; Taylor et al. 2015a; Vella 2018). Vella (2018) has outlined the character of stratigraphic levels at Soyo Hill along the basin's Hog River (*Khog Gol*); Clark (Julia Clark pers. comm. 2019) has further noted the presence of two major paleosols in the region. Major paleosols have been identified throughout the Darkhad Basin (Derevianko et al. 2008; Gillepsie et al. 2008; Vella 2018), composed primarily of sandy silt. Of these, a later layer dated to 1200 BP (Vella 2018) is believed to be significant to Mongolia's Bronze Age and contains the highest density of cultural artefacts of all layers (Clark 2017). The ecological character of the Darkhad Depression has been investigated with direct relevance to Soyo (Gillepsie et al. 2008; Vella 2018), benefitting research of the site's key historical periods.

2.3.2 : Darkhad Basin Glaciation

Gillepsie et al. (2008) argue that the glaciation of the Darkhad Basin likely took place during MIS-2 and MIS-3 (17,000 – 19,000 BP and 35,000 – 53,000 BP respectively) (Derevianko et al. 2008; Gillepsie et al. 2008; Vella 2018). Glacial moraines indicate the formation of a paleolake at ~10,000 BP (Gillepsie et al. 2008; Vella 2018) with a depth of up to 1602m. Arzhannikov et al. (2012) identifies four major glacial groups believed to have formed during the Last Glacial Maximum (LGM), including that of the Azaz Volcanic Plateau occupying the Darkhad Basin. Bylarkharchuk et al. (2004:269) suggest the presence of "retreating glaciers and barren areas" prior to ~15,900 BP, although Gillepsie et al. (2008) approximate highly variable glacial trends throughout much of the region's prehistory (Figure 8); as such, regional trends are unlikely to accurately represent those of the Darkhad Basin. Trends discussed here are surmised in Table 2.

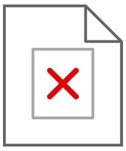


Figure 8: Timing of major climatic changes as compared to glaciation periods. A) Indicating presumed glaciation periods throughout the Darkhad; B) showing correspondent oxygen isotope trends; C) Maximimum summer temperatures of the Darkhad. Adapted from Gillepsie et al. (2008). Removed owing to copyright restrictions.

Table 2: Outlining ecological conditions of northern Mongolia from the Last Glacial Maximum (LGM) to present and the occupation phases associated with each major period. Adapted from Arzhannikov et al. (2012), Blyarkharchuk et al (2004), Derevianko et al. (2008), and Gillepsie et al. (2008).

Climatic conditions	**Date**	**Occupation phases**
Glacial maximum; 'blocking' of Darkhad Basin (restriction of human movement and vegetative spread). Constriction of forests to high altitudes.	19000–17000 BP	-
Gradual warming event; spread of forest cover to lower altitudes	15000–13000 BP	Projected gradual increases in occupation
Semi-aridity; "dry summers and wet winters" (Blyarkharchuk et al. 2004:272); spread of steppe environments and forest cover	13000–2,500 BP	6,000 – 5,700 BP 4,000 – 2,500 BP
Semi-aridity; increased ecological productivity	2500–1200 BP	2500-1200 BP
Modern conditions	1200 BP – present	1200 BP - Present

2.3.3 : Stone Tools of the Mongolian Neolithic and Bronze Age

Lithic collections have been used to characterise the Palaeolithic (Gillam et al. 2012, 2014; Kaifu et al. 2015) Bronze Age, and Neolithic of Mongolia (Deverianko et al. 2008; Farquhar 2019; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Houle 2010; Janz 2006, 2012; Janz et al. 2015; Khatsenovich et al. 2017; Seitsonen et al. 2018; Vella 2018; Zwyns et al. 2014), and to argue for the complexity of nomadic pastoralist societies (Deverianko et al. 2008; Honeychurch 2010, 2013, 2014; Houle 2010; Seitsonen et al. 2018; Zwyns et al. 2014). Application of Binford's (1980) model has allowed for identification of foraging groups throughout Mongolia's history (Farquhar 2019; Janz 2006, 2012; Janz et al. 2015), with recent emphasis on reduction models (Deverianko et al. 2008; Goodale et al. 2008; Farquhar

2019; Janz 2006, 2012; Janz et al. 2015; Gladyshev et al. 2010, 2012; Houle 2010; Khatsenovich et al. 2017; Park and Reichert 2015; Rybin 2014; Rybin et al. 2016; Seitsonen et al. 2018; Zwyns et al. 2014). Throughout southern Mongolia, Janz (2006, 2012; Janz et al. 2015) has identified a heightened prevalence of bifacial technologies throughout the Neolithic of the Gobi Desert; prior to this period, unifacial technologies had dominated assemblages. This, she argues, provides evidence of increasing technological complexity (Janz 2006, 2012; Janz et al. 2015; Honeychurch 2010, 2013, 2014; Houle 2010; Taylor 2017; Taylor et al. 2015b; Seitsonen et al. 2018). Similar patterns have been observed nation-wide (Deverianko et al. 2008; Farquhar 2019; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Houle 2010; Janz 2006, 2012; Janz et al. 2015, Khatsenovich et al. 2017; Rybin 2014; Rybin et al. 2016; Seitsonen et al. 2018), with the emergence of key technologies, such as microblades, being highlighted in many studies (Fitzhugh 2002; Gladyshev et al. 2010, 2012; Honeychurch 2015; Janz 2006, 2012; Janz et al. 2015; Khatsenovich et al. 2017; Rybin 2014; Rybin et al. 2016; Seitsonen et al. 2018; Vella 2018; Zwyns et al. 2014). Janz (2006) has established a preliminary chronology outlining ages associated with the development of various lithic forms throughout Northern Asia (Figure 9). The stone artefact assemblages of Mongolia have been used in archaeological studies to characterise past human behaviour throughout the nation.

Figure 9: Depicting the approximate age of technological innovations and major climatic variations in northeast Asia. Taken from Janz (2006:31), concerning study of Shabarakh-Usu (Gobi-Altai site). Removed due to copyright restrictions.

The emergence of microblade technologies in northern Mongolia during the early Holocene (11,230 BP – present [An et al. 2008]) has been argued to be of immense significance (Park et al. 2018; Derevianko et al. 2008; Gladyshev et al. 2012; Goebel and Buvit 2011; Ineshin and Tetenkin 2017). Gladyshev et al. (2012) and Smith (1974) both believe their development in northern Mongolia to have instigated the use of this technology throughout the wider north-eastern Asian region; their studies further suggest the origin of the microblade production technique as being within Mongolia. Increasing reliance on so-called ‘ski-spalls’ as microblade cores (Figure 10) has been cited as evidence for this (Gladyshev et al. 2012; Smith 1974). These long, thin segments characterise reduction sequences throughout central Asia and Siberia (Desrosiers 2012; Ineshin and Tetenkin 2017); in lithic literature, their use as microblade cores is often referred to as the Yubetsu or Diuktai technique (Goebel and Buvit 2011; Ineshin and Tetenkin 2017; Potter et al. 2013). Use of this procedure has been recorded worldwide (Clarkson 2007; Goebel and Buvit 2011; Ineshin and Tetenkin 2017; Lycett and Bae 2010; Lycett and Norton 2010; Newcomer et al. 1986). Such studies have been bolstered by the application of reduction indices (Deverianko et al. 2008; Farquhar 2019; Janz 2006, 2012; Janz et al. 2015; Gladyshev et al. 2010, 2012; Houle 2010; Khatsenovich et al. 2017; Kuhn 1991; Park and Reichert 2015; Rybin 2014; Rybin et al. 2016; Zwyns et al. 2014), further exemplifying the value of this approach to stone artefact analysts. Evidence of microblade production techniques is considered a significant component of Mongolian archaeological assemblages and is associated with widespread technological revolutions throughout Central Asia.

Figure 10: Showing a ski-spall (dk. grey) refitted to core. From Coutouly (2012:363). Removed owing to copyright restrictions.

2.5: CONCLUSION

Lithic analysis has benefitted from the development of typological analysis schemes, as well as microscopic analysis methods; a combination of these approaches will herein be applied to assemblages from Soyo, north-central Mongolia. Data collected as a result of these approaches will allow for key questions regarding changing human adaptions throughout time to be characterised for the site and contribute to a growing research base from across the nation. The NBAT of Mongolia is perceived as a period of immense socio-technological change throughout the nation; however, these understandings fail to take into consideration archaeological evidence from the Darkhad. The assemblage of Soyo will assist in the reconstruction of past behaviours from this region. This will be supplemented by the performance of pXRF analysis, which has successfully been used to identify trace elements in chert (and other stone raw materials) worldwide. This thesis will contribute to an expanding body of work currently being produced on Mongolia, and benefit archaeological understandings of Central Asia.

CHAPTER 3: METHODS

Artefacts were collected from the riverine surroundings of *Soyo Tolgoi* (Soyo Hill), located in the Darkhad Depression of northern Mongolia as a component of the 2015 – 2016 NOMAD Science field schools. The *Soyo* site comprises a discontinuous area of approximately 5 hectares (Vella 2018) and is a largely flat in form with some undulating swells. The *Khog Gol* runs alongside the eastern edge of the site.

Lithic artefacts identified at *Soyo* have been subsequently macroscopically analysed and subjected to pXRF testing to determine the degree of chemical relation between chert stone artefacts. Selected samples were transferred to the Flinders University Archaeology Laboratory in Adelaide, South Australia, following their storage at the National Museum of Mongolia. Several limitations have been identified in the chosen method, most significantly the lack of a robust lithic chronology. Sources of error, and their potential implications, are also discussed below.

3.1: 2015-2016 NOMAD SCIENCE FIELD SCHOOL

The NOMAD Science field school runs annually from June-August, employing both domestic and international students under the guidance of professional archaeologists. At present, a total of 7 units (excavation squares) have been excavated at the Soyo site, with additional test pitting and pedestrian surveys being undertaken in parallel. Within the 2015 and 2016 field schools, 340 lithic artefacts were recovered from excavated units; a further 1351 stone artefacts were retrieved from the site surface. Bone fragments, charcoal, ceramic, and metal artefacts also contributed to the Soyo assemblage. An overview of the sampling and collection techniques employed by NOMAD Science, in addition to the analytical processes subsequently undertaken, are summarised below.

3.1.1: Geological Sampling and the Preliminary Construction of a Chronology

In 2016, geologist Dr David Putnam was involved in the NOMAD Science project to undertake geological test pitting and establish a preliminary understanding of site stratigraphy. Seven 50cm x 50cm test pits were opened to complete this (Figure 11), orientated in a north-south line across the site, 20m apart. Spacing between test pits was controlled with a measuring tape, and their positions recorded with a static GPS; results were post processed using the AUSPOS service and correlated to GPR data (Clark 2016; Vella 2018).

In addition to test pits, 12 bone samples were selected from various Levels within Unit 6 for radiocarbon dating, providing an indication of site age; however, no ages have been established for other regions of the site. The results of this analysis have been presented by Vella (2018), in combination with the disposition of geomorphology as recorded in Test Pits 2-7. Table 3 provides a description of each test unit.

Table 3: Description of test pits opened in the 2016 NOMAD Science field school at Soyo, northern Mongolia.

Test Pit	***Easting***	***Northing***	***Final Depth (cm)***
TI-2	0511342	5649325	150
TI-3	0511342	5649315	93
TI-4	0511342	5649305	86
TI-5	0511342	5649295	85
TI-6	0511342	5649285	83
TI-7	0511342	5649275	123

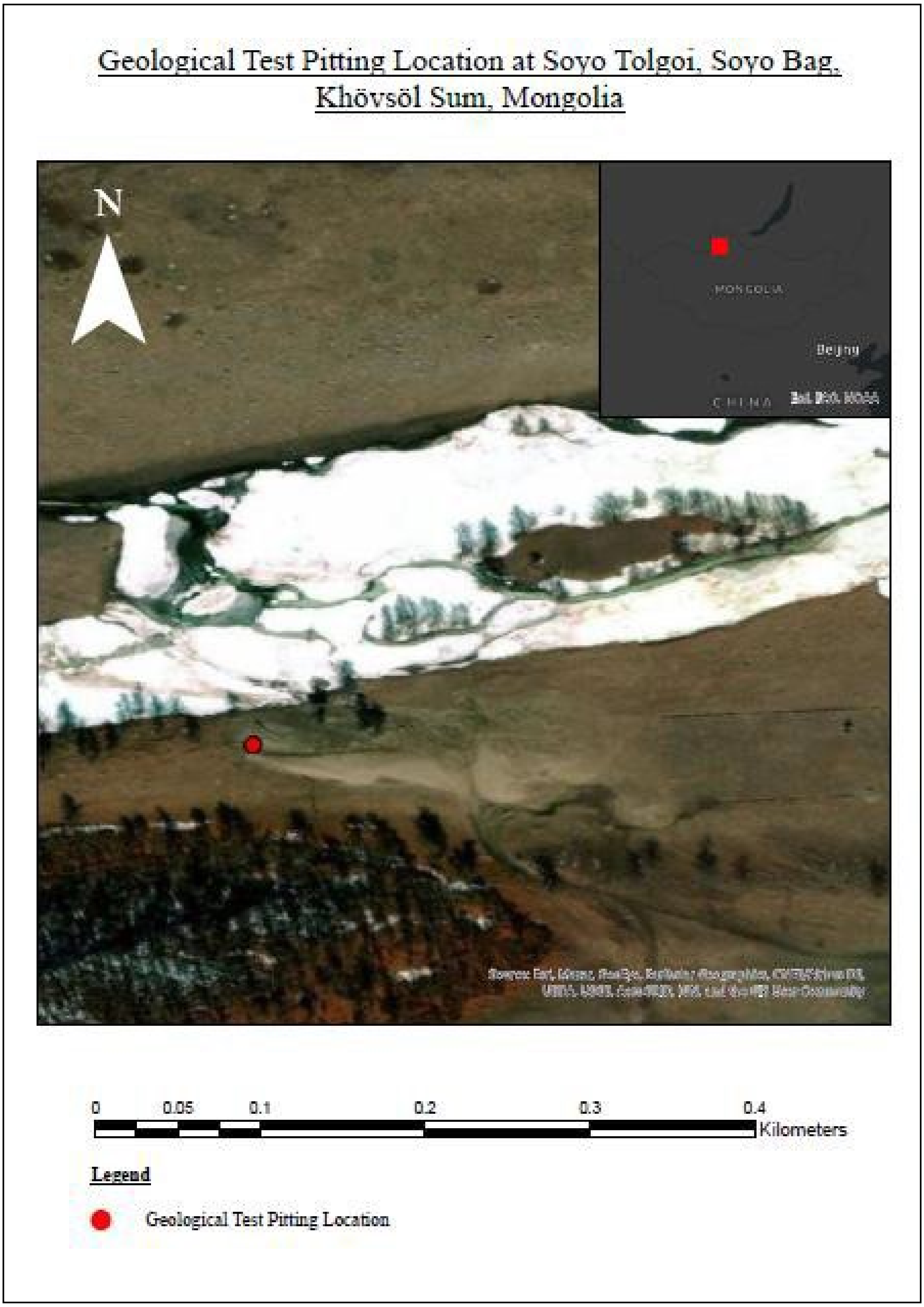


Figure 11: Showing approximate location of test pits opened as a component of the 2016 NOMAD Science field school.

This analysis has here been used to approximate a complete chronology for all Units. Extrapolations of age for individual Levels have been concluded based on similarities in description of stratigraphic sections, and as such are highly subjective in nature. Research is currently being undertaken that aims to better establish a robust chronology for the site, which will greatly enhance our understandings of past site use.

3.1.2 : PEDESTRIAN SURVEY

Surface scatters have been identified and collected from across the Soyo site by way of pedestrian survey. As aforementioned, the site is a component of a large-scale eroding dune-dominated landscape, with ongoing erosional processes revealing materials of archaeological significance. Under the guidance of professional archaeologists, newly exposed artefacts have been recorded and collected via pedestrian survey of 20m x 20m grids. As with excavated materials, collected remains are catalogued and stored at the National Mongolian Museum.

3.1.3 : EXCAVATION

Areas of interest, identified either through cluster analysis following pedestrian survey, or based on photogrammetry and/or geophysical analysis results, have been subjected to test-pitting and potential formal excavation. Excavation squares or pits are referred to as **Units** in all summary documents of the excavations, and this terminology is also applied here; similarly, spits are referred to as **Levels**. The depth of individual Levels was consistently 5cm throughout both 2015 and 2016.

The locations of Units opened as a component of the 2015 – 2016 NOMAD Science program are provided below (Figure 12; Table 4): trenches were excavated to varying depths and were abandoned when cultural material had not been observed for a minimum of 2 Levels. Units were excavated by hand, with removed materials then sieved through 1/8th of an inch meshes;

pits containing artefacts estimated to be smaller than 2mm in length were sifted instead through 1/16th of an inch mesh. Artefacts are bagged according to pit and context level and were stored on-site until their subsequent transfer to the National Mongolian Museum. Trench drawings were also produced (see Figures 13-19); lack of access to physical copies stored at the National Mongolian Museum over the duration of this project has resulted in the presentation of sketches here as opposed to formalised level forms or digitised copies.

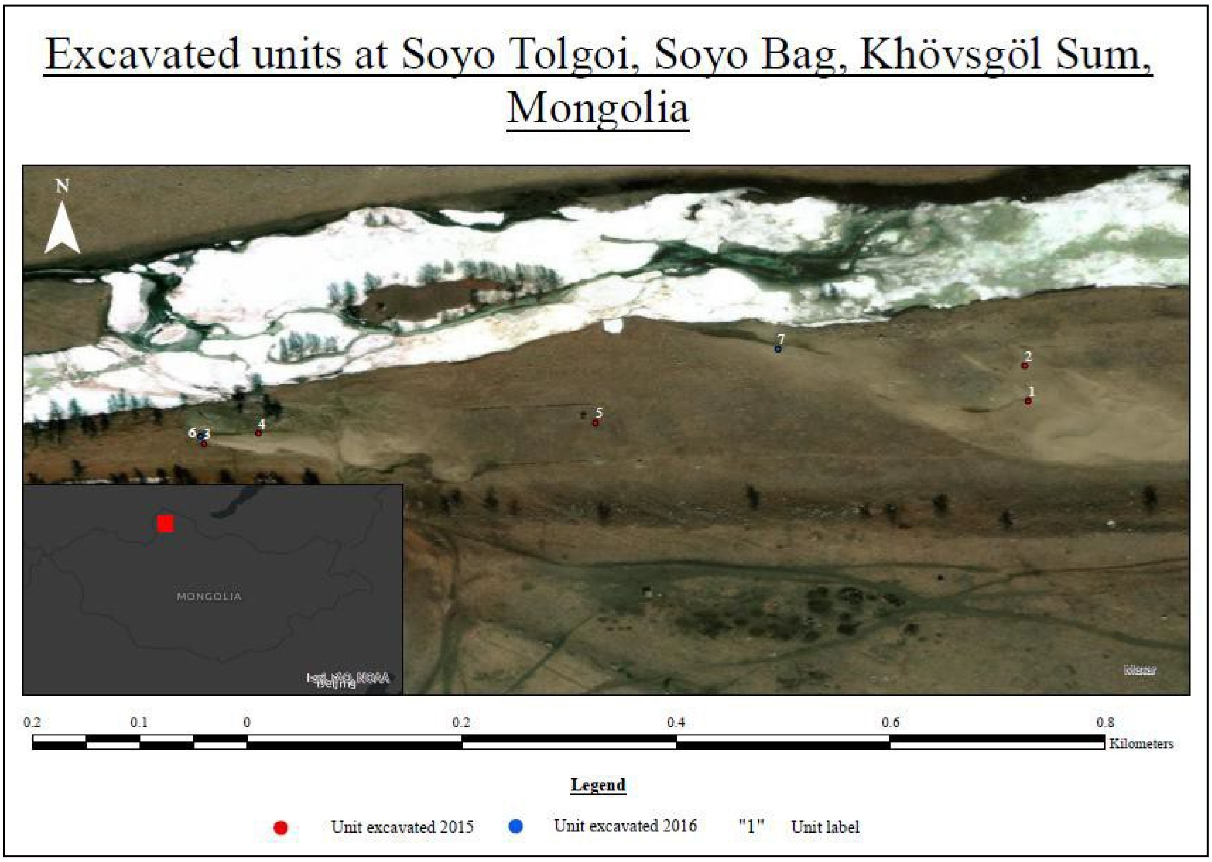


Figure 12: Showing locations of units opened in the 2015 and 2016 sessions of the NOMAD Science field school (Soyo Tolgoi, Soyo Bag, Khövsgöl Sum, northern Mongolia).

3.2: Analysis of Stone Tools

According to Flenniken, "99.5% of the history of mankind is represented by stone tools" (1980:1). Stone tool analysis has been implemented to facilitate understandings of a wide array of human behaviours, with such artefacts being found on every continent on Earth (excluding Antarctica) (Beck 1995; Clarkson 2007, Shea 2011). A variety of models have been hypothesised by numerous authors (Andrefsky 1994, 2005, 2008a, 2008c; Binford 1980; Bleed 1986; Clarkson 2007; Dibble and Pelcin 1995; Fernandez and Giminez 2000; Gladyshev et al. 2012; Goodman 1944; Hiscock 2015; Hiscock and Attenborough 2003; Knauth and Epstein 1976; Knauth and Lowe 1978; Knecht 1997; Luedtke 1992; Marreiros et al. 2015; Newcomer 1971; Odell 1975; Odell and Odell-Vereecken 1980) that attempt to explain human behaviour through lithic traits, with the design of such models often dependent on the methodological orientation of their creator. Lithic analysis may be either macroscopic or microscopic in nature; according to Andrefsky (1994) and Marreiros et al. (2015), magnifications of over 500x may be considered microscopic, and are appropriate for studies that incorporate residue and use-wear analysis. In contrast, macroscopic analysis methods involve the classification of artefacts into categories based on morphological traits (e.g., distribution of retouch, artefact shape and size), which are identified without the benefit of high magnification. Both macroscopic and microscopic analysis methods may be enhanced by the use of mathematical indices, which aim to quantitatively measure various aspects of stone artefact production (Andrefsky 2008a, 2008c; Clarkson 2002; Kuhn 1990, 1991; MacDonald 2008; Schott and Nelson 2008).

3.2.1 : Macroscopic Lithic Analysis

Models for understanding the connections between lithics and past human behaviour have been developed and implemented since the early 20th century. Their use has allowed for the mobility and subsistence patterns of past human groups to be estimated, often permitting theories as to wider-scale trade networks, group dynamics, and global technological developments to be hypothesised (Ambrose 2002; Bettinger 2013; Bleed 1986; Jones et al. 2003; Pecora 2001; Odell 1975; Odell and Odell-Vereecken 1980). Perhaps the most influential models have been those produced by Andrefsky (1991) and Binford (1980), whose work has formed the basis for numerous subsequent studies (Chatters 1987; Goldstein 2019; Jeske 1992; Kuhn 1991; Pecora 2001; Watts 2013).

Andrefsky's model differentiates between two subsistence strategies; a group may either rely primarily on formal tools, or more expedient forms. Formal tools are defined by Andrefsky as being "tools with more effort expended in their production" (Andrefsky 1994:21), where expedient (or informal) tools are produced quickly and often for limited use. The work of Andrefsky has been widely implemented, although its effectiveness has been extensively debated (Bradbury and Carr 2004a, 2004b; Clarkson 2007; Elston and Brantingham 2002; Goldstein 2019; Holdaway et al. 2004; Janz 2012; Jones et al. 2003; Pecora 2002, 2003; Seitsonen et al. 2018, Watts 2013). Its accuracy has been questioned (Elston and Brantingham 2002; Pecora 2002, 2003) in cases where authors are perceived to have misunderstood key definitions integral to the model. Further, some researchers (Chatters 1987; Jeske 1992; Kuhn 1991) have questioned the applicability of the term 'expedient' to certain assemblages. Flaws in Andrefsky's model have been referenced in debates concerning the suitability of typological analysis systems (discussed below) (Bradbury and Carr 2004; Elston and Brantingham 2002; Farquhar 2019; Goldstein 2019; Jeske 1992; Pecora 2002, 2003; Watts 2013). Although it has been relied upon for many decades, interpretive models produced by Andrefsky are widely critiqued in archaeological literature.

Binford (1980) and colleagues (Bleed 1986; Chatters 1987; Jeske 1992; Kuhn 1991) use lithic analyses to differentiate between two classes of past peoples; 'foragers' and 'collectors'. Foragers may be defined as those who are "scattered but ubiquitous" (Bleed 1986:741), travelling in small groups and using occupying wide expanses of land (Binford 1980). Such populations must undergo "regular daily food-procurement" (Binford 1980:9). Characterised by the production of maintainable and varied toolkits, foraging groups will travel widely and manufacture tools that are functionally diverse. Bleed (1986) predicts the use of multi-component toolkits by foraging groups as they would have been easier to maintain, allowing broken implements to be easily replaced (Binford 1980; Bleed 1986). In contrast, a 'collector' strategy revolves around stockpiling seasonally available resources (Binford 1980; Bleed 1986; Clarkson 2007; Janz 2012). This approach requires forward-planning, and often relies on hunting strategies that "optimally use reliable weapons" (Bleed 1986:741) to maximise efficiency (Ambrose 2002; Bamforth 1991; Bettinger 2013; Flenniken 1984; Henrich 2004; Jeske 1992; Keeley 1974, 1982; Kelly 1988; Meltzer 1981; Moss 1983; Pecora 2002, 2003; Prentiss 1998; Seitsonen et al. 2018; Shott 1989; Speth 1972; White and Bush 2010). A collector strategy necessitates the transport of materials to more sedentary 'bases' (Ambrose 2002; Binford 1980) and requires that artefacts be prepared in anticipation of extensive use. As a result, the frequency of multi-component tools as described by Bleed (1986) will likely be less common in cases where a collector strategy is applied. Binford's model aims to categorise past human behaviour and has been used as a basis for many subsequent studies.

Many authors (Andrefsky 1991, 1994, 2005, 2008c; Binford 1980; Bradbury et al. 2008; Clarkson 2007; Hiscock and Attenborough 2003; MacDonald 2008) advise caution when applying generalised models, arguing that they should be used in conjunction with discussions of raw material availability and variability. Despite the advantages of homogenous, cryptocrystalline raw materials in controlling final flake form (Flenniken 1980), their availability is often limited (Andrefsky 1991, 1994, 2005, 2008c; Binford 1980; Bleed 1986; Clarkson 2007; Hiscock and Attenbrow 2003). The use of high-quality materials must be carefully managed to extend the "amount of time that a [tool] is able to do its job" (Bleed 1986:739). Further, environmental, cultural, and social factors often present system pressures that may affect toolkit disposition. Variations in toolkit diversity and constitution are argued to reflect environmental and social context, wherein lithic producers had the "capacity to create and control fracture" (Hiscock 2015:161) in response to emerging complications (Bousman 1992; Hiscock 2015). The behaviour of various groups can be seen as a response to changing conditions; in a response to the work of Binford (1980), Bleed (1986) predicts that the adoption of either a 'foraging' or 'collecting' will strategy more accurately "[reflect] different hunting patterns and different systematic relationships" with environmental factors (Bleed 1986:744). A vast number of researchers advocate for autonomous communities that produced stone artefacts most appropriate for their situation (Bamforth 1986; Binford 1980; Clarkson 2007; Elston and Brantingham 2002; Hayward 2010; Jeske 1992; Newcomer et al. 1986; Watts 2013); this perspective is known as *design theory* (Clarkson 2007). In addition to environmental factors, numerous researchers (Andrefsky 1991, 1994, 2005, 2008a, 2008c; Clarkson 2007; Meltzer 1981; Parry and Kelly 1987; Prentiss and Clark 2008; Schiffer and Hayden 1979) recommend "consideration of multiple lines of evidence" (Clarkson 2007:8). The effects of social pressures are suggested as a key consideration, and it has been proposed that they should not be disregarded in favour of perceived ecological demands (Metlzer 1981; Parry and Kelly 1987; Prentiss and Clark 2008; Schiffer and Hayden 1979). In summary, toolkit constitution is seen by many as an attempt to "improve foraging returns" (Clarkson 2007:14) in the face of changing sociocultural and environmental factors.

Particularly in recent years, a number of researchers have begun to question the use of typological analysis systems, faulting them for their assumption that an artefact's function can be definitively identified on the basis of morphological traits (Blades 2008; Bleed 1986; Brumm and Rainey 2011; Clark 1982; Clarkson 2007; Dibble 1987; Hayden and Kamminga 1979; Hiscock 2015; Hiscock and Attenbrow 2003; Meltzer 1981; Moore 2004; Moss 1983; Nelson 1991; Parry and Kelly 1987; Prentiss and Clark 2008; Quinn et al. 2008; Root 2004; Schiffer and Hayden 1979). Instead, many researchers are adopting the view that "continuous variation reflects different stages in a continuous reduction process" (Hiscock and Attenbrow 2003:239) (Bradbury and Carr 2004a, 2004b; Bradbury et al. 2008; Cotterell and Kamminga 1987; Dibble 1987; Hiscock and Attenbrow 2003; Moss 1983; Nance 1971). One of the earliest contributors to this discussion was Dibble (1987:115) through his analysis of Mousterian assemblages recovered from a number of archaeological sites throughout France. His research indicated that there was "no association between particular types of scrapers and particular functions", and that instead, typological variability was most likely to reflect "variability in the intensity of retouch" (Dibble 1987:116) (Hiscock and Clarkson 2008). Moore (2004) outlines an extensive study conducted on stone adzes collected from the Georgina River in northern Australia. The results of his study are akin to those produced by Dibble (1987), revealing that tools that had previously been categorised as having separate functions were more likely to be indicative of the various stages of tula production. Similar studies have been undertaken elsewhere in Australia (Bleed 1986, Brumm and Rainey 2011; Hayden and Kamminga 1979; Hiscock 2015; Hiscock and Attenbrow 2003). Hayden and Kamminga (1979) have commented on the issue more generally, dictating that the term 'scraper' is overgeneralised and "almost certainly has little functional integrity as a category". Many authors also predict that changes to artefact form may merely serve to "enhance certain performance characteristics" (Clarkson 2007:18) (Clarkson 2007; Eerkens and Bettinger 2001; Elston and Brantingham 2002; Nance 1971; Odell and Odell-Vereeken 1980; Speth 1972; Stahle and Dunne 1982), or may simply represent mistakes in the manufacturing process; Henrich (2004) is in agreement with these claims and adds that the capacity of individuals in a group to successfully replicate modelled technologies is dependent on many factors, such as group size, effectiveness of the teacher, and accessibility of appropriate raw materials (Henrich 2004; Lycett and Bae 2010; Lycett and Norton 2010; Moss 1983; Smith 1974; Watts 2013). As can be seen from these studies, there are a number of flaws inherent in the use of typologies for artefact analysis, with a number of researchers advising against their application.

Despite the growing body of evidence advising against the use of typologies in lithic studies, many suggest they maintain value. While Dibble (1987) advises caution when applying classification schemes to lithic assemblages, he also notes that (in an ideal situation) "typological variability would be seen as reflecting variability of retouch" (116). In other words, while typologies may not be definitively reflective of specific functions, they may be useful in their capacity to outline specific stages in the reduction process. Odell (1981) similarly refutes that "a side-scraper is called a side-scraper… because it is retouched along at least one side, presumably for the use of that side" (336). It is suggested that researchers simply apply caution when analysing such collections (Dibble 1987; Flenniken 1984; Moore 2004; Odell 1981; Wilmsen 1986) and acknowledge the inherent bias present in such methodologies. Such arguments are bolstered by experimental studies, many of which argue the accuracy of typological models (Flenniken and Raymond 1986; Jeske 1992; Newcomer 1971; Odell and Odell-Vereeken 1980; Walker 1978).

2.4.1.1: Mathematical Assessment in Lithic Analysis

Lithic research has benefitted from the development of various indices designed to quantitatively measure factors such as retouch, similarity between artefact forms, and the flake removal process during retouch (Clarkson 2007; Eerkens and Bettinger 2001; Eren and Prendergast 2008; Henrich 2004; Kuhn 1991; Shott and Nelson 2008; Speth 1972; Wilson and Andrefsky 2008). The applicability of these indices is dependent on the assemblage in question; Eren and Prendergast note that "all indices are lacking somewhat when applied to diverse assemblages" (2008:70). A body of research exists comparing the accuracy of various measures. Perhaps the two most popular are Kuhn's Reduction Index (KRI) (Equation 1)

(Eren and Prednergast 2008; Farquhar 1989; Kuhn 1990, 1991; Shott and Nelson 2008; Wilson and Andrefsky 2008), and Clarkson's (2002) Index of Invasiveness.

$$\frac{Vertical\ \ thickness\, of\ flake\, at\, term\, of\, retouch\ (t)}{Maximum\, median\, thickness\, of\ flake\ (T)}$$

Equation 1: Showing equation required for calculation of Kuhn's Reduction Index. Adapted from Kuhn (1991).

Comparison of various reduction indices within individual assemblages indicates non-linear relationships (Eren and Prendergast 2008; Harper and Andrefsky 2008; Shott and Nelson 2008; Wilson and Andrefsky 2008). As such, authors advise caution when selecting the index used. The KRI, for example, "should not be used as a proxy for mass" (Eren and Prendergast 2008:75); Clarkson's Index of Invasiveness "is not sensitive to resharpening after the reduction phase" (Wilson and Andrefsky 2008:95). Where necessary, researchers such as Henrich (2004) and Shott and Nelson (2008) advise the use of multiple reduction indices to permit understanding of numerous characteristics. While the Coefficient of Variation (CV) (Equation 2) is generally accepted as valid for most assemblages, this is not true in all cases. When considering mathematical assessment of stone assemblages, researchers must be careful to select the method most suited to their assemblage.

$$CV = \Sigma(n_i - 1)s_i^2$$

Equation 2: Showing equation required for the calculation of the Coefficient of Variation. Where n_i = the number of elements in the ith group, and s_i^2 = the variance of the ith group. Adapted from Drennan (2009).

3.2.2 : MICROSCOPIC LITHIC ANALYSIS

Particularly within recent decades, a growing body of research has begun to recognise the value of microscopic lithic analysis (Andrefsky 1991, 1994, 2005, 2008a, 2008c; Marreiros et al. 2015; Moss 1983; Nance 1971; Odell 1975; Odell and Odell-Vereeken 1980). This approach incorporates a variety of possible analysis techniques, including chemical analysis, and more popularly, use-wear and residue analysis (Marreiros et al. 2015; Odell and Odell-Vereecken 1980). The benefits of microscopic methods have been heralded by numerous researchers (Andrefsky 1991, 1994, 1998; Moss 1983; Odell and Odell-Vereecken 1980), with such practices as residue and use-wear analysis attributed with the potential to permit more accurate appraisals of past tool use. Conversely, isotope analysis of carbonate lithic material has been used to provenance raw materials (Jahren et al. 1997; Ineshin and Tetenkin 2017; Szakmány and Kasztovszky 2004; Kolodny and Epstein 1976; Marin-Carbonne et al. 2014; Marreiros et al. 2015; Mathur et al. 2020; Pearsall et al. 2004; Price and Burton 2011; Tykot 2004). Similar analysis of silicate materials for archaeological purposes has not been attempted, though processes for isotope analysis of silicates have been developed.

Andrefsky (1991, 1994, 2005, 2008a, 2008c) advocates for the use of a combined microscopic-macroscopic method, reporting that implementing microscopy can result in increased accuracy. The development of this field is such that collections of reference material have been produced which aim to guide the inexperienced researcher in identification of residue and use-wear attributes. Odell and Odell-Vereeken (1980) provide an in-depth list of use-wear patterns that may be found on stone tools. Marreiros et al. (2015) provides both imagery and a written classification scheme to assist with identification of residues on chert tools (Hyland et al. 1990). With direct regard to Mongolia, researchers such as Blyakharchuk et al. (2004) provide pollen identification resources that may be used to distinguish between individual species in the Altai-Siberia region. The use of microscopic analysis methods to support lithic research is becoming increasingly popular, and the application of such procedures to northern Mongolian stone tool collections may significantly increase archaeological understanding of Neolithic and Bronze Age tool use.

2.4.2.1: Chemical Analysis

Analysis of the chemical constitution of stone tools has been applied to assemblages worldwide (Chakrabarti et al. 2012; Craig et al. 2007; Frahm 2013a, 2013b; Frahm and Doonan 2013; Frahm et al. 2014; Forster et al. 2011; Fouillac and Girard 1996; Glascock 2002; Goodale et al. 2012; Jahren et al. 1997; Knauth and Epstein 1976; Knauth and Lowe 1978; Kolodny and Epstein 1976; Makarewicz et al. 2018; Malyk-Selinova et al. 1998; Mathur et al. 2020; Pollard 2018; Reniere 2018; Shemesh et al. 1995; Stefurak et al. 2015; Stremtan et al. 2012; Szakmány and Kasztovszky 2004; Tártese et al. 2016; Tykot 2004; Williams-Thorpe 2008; Williams-Thorpe et al. 1999; Yang et al. 2013). Comparison between the chemical character of various artefacts and the soils in which they have originated in or been found within allows for materials to be sourced (Hermes and Ritchie 1998; Jenkins 1989; Pollard et al. 2007). This occurs typically by either trace element analysis or isotope analysis. Isotope analysis involves the measurement of various stable isotopes and has been widely applied to numerous archaeological studies (Hardy et al. 2001; Knudson 2009; Knudson et al. 2005; Madgwick et al. 2021). Conversely, trace element analysis measures abnormalities in the chemical structure of the studied material in question; such irregularities often occur as a result of environmental or developmental factors.

The geochemistry of Soyo has been preliminarily analysed by a number of researchers (Gillepsie et al. 2018; Putnam 2016; Vella 2018); however, a definitive chert source matching the characteristics of lithic artefacts recovered from Soyo is yet to be identified. Research undertaken by Putnam (2016) as a component of the NOMAD Science 2016 field school has allowed for the identification of several sedimentary strata at the site. Test pitting revealed the presence of eight distinct strata, summarised below (Table 4). Most significantly among these are the presence of two paleosols, from which high quantities of artefacts have been collected (Julia Clark pers. comm 2018; Putnam 2016; Vella 2018). Among those lithics collected, the majority are composed of black chert; communication with local communities suggested a nearby outcrop. Investigation of this location revealed that cherts native to the area were of a different colour; as such, the possibility that chert artefacts may have been constructed of materials from this outcrop was rejected (Julia Clark pers. comm. 2019). Chemical analysis may be beneficial in this circumstance, with the potential to identify the degree of chemical similarity between samples.

Table 4: Outlining the characteristics of strata as observed in Unit 6 of Soyo, northern Mongolia. From Putnam (2016).

Stratum	***Characteristics***
I	Limestone bedrock – early Cambrian carbonates. Outcrops observable to the South of Soyo
II	Glacial Till – coarse diamict. Largely granitic with some sandstone inclusions.
III	Glaciofluvial gravel and some glaciolacustrine sand
IV	Angular limestone colluvium
V	Paleosol 1; dark brown/black sandy substrate with dark brown lenses
VI	Fine aeolian sand
VII	Paleosol 2; Soil with fine aeolian sand. Distinct soil horizons evident.
VIII	Eolian sand

The development of x-ray fluorescent (XRF; portable XRF [pXRF]) is most used) technologies has allowed for the characterisation of lithic raw materials in several archaeological research settings (Craig et al. 2007; Frahm 2013a, 2013b; Frahm and Doonan 2013; Frahm et al. 2014; Forster et al. 2011; Goodale et al. 2012; Stremtan et al. 2012; Williams-Thorpe 2008; Williams-Thorpe et al. 1999). Heralded for its non-destructive nature (Forster et al. 2011), pXRF has been applied in various research projects (Goodale et al. 2012; Tykot et al. 2013; Williams-Thorpe et al. 1999) to enhance geochemical understanding. Some dispute over the reliability of XRF testing has been generated (Frahm and Doonan 2013; Shackley 2008), however it remains an accessible technique proven to benefit archaeological understandings (Craig et al. 2007; Forster et al. 2011; Goodale et al. 2012; Tykot et al. 2013; Williams-Thorpe 2008; Williams-Thorpe et al. 1999). As with macroscopic lithic analysis, it is advised by various researchers that XRF techniques be used in combination with other geological approaches to achieve an accurate understanding of raw material origin (Frahm and Doonan 2013; Goodale et al. 2012; Williams-Thorpe et al. 1999). An understanding of a site's geochemistry is imperative to such investigation; while carbonate and silicate materials are frequently present in the structure of lithic materials (Jenkins 1989; Madgwick et al. 2021; Marreiros et al. 2015; Pollard 2018), environment-specific elements likely to be included in the composition of materials should be understood prior to study. XRF analysis of lithic materials has not been undertaken in Mongolian-based research, however, may be of immense benefit to archaeological understandings of the region.

3.3 Investigation of the Soyo Lithic Assemblage

In late 2019, 92 stone artefacts (representing 28.23% of the total lithic assemblage) originating from Units 2-7 were transferred from the National Mongolian Museum to the Archaeology Laboratory located at Flinders University (Adelaide, South Australia). Also included were 4 lithics collected from surface scatters retrieved from the 2015-2016 NOMAD Science fieldwork. Two non-artefactual stone objects were catalogued with the lithic assemblage and subsequently included in the chosen sample. It is unclear whether these are manuports or environmentally transported samples. At least 50% of the stone artefacts from each distinct excavation level were randomly selected for inclusion in the sample, although the entirety of the Unit 6 collection (from which only one stone artefact was collected) was chosen. Following their transport to Flinders University, the dorsal and ventral sides of all artefacts were photographed. Appendix B contains artefact photos of all 96 lithic objects provided for use in this research.

Collaboration with Jennifer Farquhar, an instructing professional participating in the 2019 NOMAD Science field school, has allowed for the development of an analysis typology (Jennifer Farquhar pers. comm. 2019). Farquhar's involvement in previous research conducted throughout the Gobi Desert resulted in the development of an analysis typology befitting artefacts recovered from those sites. This has been subsequently adapted to be representative of the Soyo lithic assemblage and applied here.

A summary of the analysis typology is provided here with the full outline provided in Appendix A. Definitions of designated artefact categories are provided in the Glossary. Lithic artefacts were categorised into one of 5 divisions based on diagnostic features; the potential artefact classes were flake pieces, projectile points, bifaces, cores, and flake tools. Further sub-categorisation of artefact form has been avoided, to prevent inaccurate assumptions regarding past tool function. Definitions of each of these categories were deduced through a combined method of collaboration with Farquhar, and independent research. Following this overarching categorisation, artefacts were analysed according to class-specific requirements most appropriate for those types. Raw material types, dimensions, and weights have been recorded for all artefacts. In the case of flake pieces, artefact dimensions were not specifically measured, but were instead placed onto a card containing overlapping circles of various known diameters increasing in 1cm increments. This is akin to the strategies employed by Farquhar and serves to give only a preliminary indication of flake piece size. The colour of artefacts was also recorded; in accordance with Farquhar's methodology, a standardised colour identification scheme was not applied. Rather, colours were observed and recorded in pre-designated arbitrary classes according to the perspective of the researcher. The full results of these examinations are provided in Appendix D.

3.3.1 : Mathematical Analysis

In addition to the calculation of the Kuhn's Reduction Index (KRI) for flake tools (see Appendix A), assemblage formality and diversity have been calculated, in compliance with methods outlined by Andrefsky (1991, 1994, 2008a, 2008b; Farquhar 1989). The diversity of stone assemblages has been analysed according to distinct excavation levels via the Simpson's Diversity Index (SDI) (Equation 3).

$$D = 1 - \left(\frac{\Sigma \mathrm{n}(\mathrm{n}-1)}{N(N-1)}\right)$$

Equation 3: Simpson's Diversity Index (SDI). D denotes diversity, N is the relative proportion of each class represented, and n is the number of tool class represented in a component assemblage. Adapted from Farquhar (2003).

Assemblage formality has been assessed to approximate the frequency and duration of site visitation at Soyo; this will allow for claims of Neolithic and Bronze Age semi-pastoralism in the Darkhad to be evaluated. Formality is represented as a ratio between formal and informal tools (Andrefsky 1991, 1994, 2008a, 2008b; Binford 1980; Farquhar 1989). Formal tools are deemed to be those showing evidence of use or re-working; this included all flake tools identified, bifaces, and projectile points. Assemblage formality and diversity have been calculated to enable approximation of past human behaviour at Soyo. The statistical significance of all calculated results has been established where $\alpha = 0.05$, in accordance with practices outlined by Drennan (2009). The complete results of mathematical analysis on the Soyo assemblage are presented in Appendix F. The implications of these results are summarised in Appendix G.

3.4: Microscopic Analysis

pXRF analysis was performed on all artefacts to allow the degree of chemical relativity between them to be estimated. pXRF was performed by trained representatives of Flinders University, using a Bruker Tracer 5i handheld device. The device was remotely manipulated by the Bruker Remote Control program and set within a stand specifically designed for the Bruker Tracer. Artefacts were subjected to X-ray fluorescence for a duration of 60 seconds, a period considered sufficient given the research of Frahm (Frahm 2013; Frahm and Doonan 2013).

Data received from the Tracer 5i was transferred to Artax, a program allowing for chemical spectra to be visually produced; numeric levels of individual elements detected were also provided. Artax contains a variety of calibration curves specific to various materials; in this instance, the 'Geoexploration' setting was deemed most appropriate. Similar strategies have been applied by Frahm (Frahm 2013; Frahm and Doonan 2013).

Following measurement of the chemical attributes of artefacts, results were categorised according to perceived raw material type, colour, and Level. According to Chatzimpaloglou (2020; Adachi et al. 1986; Morris and Horwitz 1983), chemical relation between chert samples is most accurately established through analysis of trace elements present in such material, particularly iron; Fe/Ti and Al/(Al + Fe) results have been focussed on here in accordance with the observations of Chatzimpaloglou (2020; Mather et al. 2020; McCormick 2021). The strength of inter-sample relationships has been established through single-tail analysis of variance (ANOVA) testing (McCormick 2021). The application of this technique will allow for comparison between the chemical compositions of artefacts from various origins simultaneously. Lithic samples have been subjected to pXRF testing and the degree of chemical similarity between chert artefacts has been subsequently analysed. The number of quartz, quartzite and sandstone artefacts included in the sample was too low to produce statistically significant results, and as such they have been omitted from the results of this analysis. A complete list of all data collected through this process is provided in Appendix E.

3.5: Constraints of the Study

Several potential sources of error have been identified in the research method described above. Subjective methods of analysis are here criticized, in addition to discussions regarding pXRF analysis, the absence of a robust chronology for the site, and inherent complications associated with the volatile landscape from which artefacts have been collected.

Previous research that has aimed to establish a chronology of site use and technological evolution in and around Soyo is not applicable to this research project; this is a significant barrier to archaeological understanding of the region. As aforementioned, most of the research in the nation has focussed on the north-eastern and southern quadrants of Mongolia, with the north-west often being excluded from major investigations (Clark 2014; Clark and Crabtree 2015; Taylor 2017; Taylor et al. 2015, 2019). Until recently, limited funding opportunities have been available to NOMAD Science operators (Julia Clark 2018, 2019, pers. comm.), prohibiting geological and charcoal samples from being dated. While research conducted by Vella (2018; Clark et al. 2016) has allowed for the aging of some Levels of Unit 6, contexts investigated were of a different composition to those from which lithics were recorded and are spatially separated from other Units. A general maximum age for the site can be assumed to be ~10,900 BP (see Chapter 4, Table 5) in at least the western portion of the site, however specific occupation dates cannot be determined for much of the Soyo lithic assemblage. Only relative dating methods can be applied to the sample analysed for this project, however, key transitional periods in the history of the site may still be identified through observable trends in the data. The ages of Levels containing stone artefacts at Soyo have not been confirmed, and as such, only approximations of past site use within the Neolithic and Bronze Age are provided here.

The relatively small size of the stone artefact sample discussed here must be considered. Stone artefact assemblages often contain lithic objects numbering in the hundreds or thousands (Adams and Blades 2009; Beck and Jones 1990; Brantingham et al. 2004; Carlson and Magne 2008; Derevianko et al. 2008, 2013; Kuhn et al. 1996; Seitsonen et al. 2018) allowing statistically accurate deductions to be made regarding past human activities (Drennan 2009). As the sample discussed here contains only 96 artefacts, the statistical accuracy of claims made based on its analysis is weak relative to studies relying on larger samples (Adams and Blades 2009; Beck and Jones 1990; Brantingham et al. 2004; Carlson and Magne 2008, Derevianko et al. 2008, 2013; Kuhn et al. 1996). However, similar research conducted throughout Mongolia have relied on lithic assemblages of a similar size (Janz 2012), implying that the Soyo lithic assemblage is consistent with that of the nation as a whole and robust conclusions may still be drawn. The small size of the Soyo assemblage sample must be considered when contemplating the significance of results, however, may be considered in line with Mongolian assemblages.

A crucial outlier has been identified in the lone artefact collected from within Unit 6. This artefact was retrieved from a deeper deposit than recognised in any other Unit, discovered at 125cm below surface, the only Unit to contain cultural material deeper than at 110cm below datum. While this may be indicative of site occupation older than that represented in other areas, the numerous post-depositional factors (discussed below) affecting the site must be considered. It is possible that Level 25 is of the same age as higher excavation Levels. These issues impact on the validity of assumptions made regarding the Unit 6 deposit. Further, only one artefact was collected from this trench, and as such any analysis conducted that includes the Unit 6 assemblage is likely to be unrepresentative and holding little statistical validity (Drennan 2009). For this reason, this artefact has been excluded from most statistical analyses, given it cannot be anchored securely in the site chronology. The artefact associated with Unit 6 likely represents an outlier owing to post-depositional processes, and any conclusions drawn based on this example may be considered insecure.

Analysis of results has been made with comparison to behavioural models proposed by Andrefsky and Binford; however, there are some potential sources of error that have been identified in their work. The methodologies developed by Andrefsky (1991, 1994, 1998, 2008a, 2008b,) and Binford (1980) have largely been criticized for their over-reliance on tool form (Blades 2008; Bleed 1986; Brumm and Rainey 2011; Clark 1982; Clarkson 2007; Dibble 1987; Hayden and Kamminga 1978; Hiscock 2015; Hiscock and Attenbrow 2003; Meltzer 1981; Moore 2004; Moss 1983; Nelson 1991; Parry and Kelly 1987; Prentiss 1998; Prentiss and Clark 2008; Quinn et al. 2008; Root 2004; Schiffer and Hayden 1979; Wilmsen 1986). Efforts have been made to reduce the effects of this here, by providing robust definitions for each artefact category and omitting commonly discussed tool forms and applying technological analyses (Andrefsky 1998; Hiscock 2015; Hiscock and Attenbrow 2003; Hiscock et al. 2011; Kelly 1988; Moore 2004) from the applied analysis typology. It is additionally acknowledged that the nomenclature applied within the chosen typology may not be representative of the artefacts' true function. While efforts have been made here to avoid over-reliance on perceived artefact form, the behavioural models of Andrefsky and Binford (Andrefsky 1991, 1994, 2008a, 2008b; Bleed 1987; Binford 1980; Chatters 1987; Jeske 1992; Kuhn 1991) are inherently flawed in their dependence on such factors, which should be considered when applying these models to current research.

The reliance of researchers on measures such as assemblage variability has also been criticised, further calling into question the validity of results proposed here. Eerkens and Bettinger criticize researchers emphasizing variability, claiming that their analysis often "lacks a robust statistical approach" (2001:494). According to Eerkens and Bettinger, the number of factors impacting artefact variability is too numerous for assertions made based on this measure to be valid. This is likely the case for the assemblage of Soyo and the results of its analysis; as aforementioned, the calculated variability of the assemblage fluctuated through time with no significant correlation evident between variability and level depth. Based on criticisms such as that presented by Eerkens and Bettinger (2001), this may be interpreted as a result of the inherent volatility of variability studies. The simultaneous measure of the KRI, assemblage diversity and raw material availability has allowed for approximations of past Darkhad transitions to sedentism to be made nonetheless; as such, it is unlikely that an ambiguous assemblage variability result will affect the validity of claims made here. A lack of obvious change in assemblage variability over time is contrary to the expectations of Andrefsky, Binford, and their supporters; however, measures of assemblage variability have been questioned in archaeological research and conclusions can still be drawn regarding major transitions in the behaviours of past Darkhad occupants.

3.5.1 : VOLATILITY OF THE SOYO LANDSCAPE

The area surrounding Soyo Tolgoi is an unstable dune bed with ongoing erosional processes that regularly expose new surface assemblages. As a result, the NOMAD Science Program has been established partially to monitor this environment and catalogue revealed deposits (Clark 2015; Clark et al. 2016, 2017,2018; Fitzhugh 2009; Fitzhugh and Bayarsaikhan 2010; Vella 2018). This region is characterised by constant change, with numerous exposed dunes subject to ongoing weathering that is likely to affect not only surface deposits, but underlying stratigraphy (Vella 2018). As such, it can be assumed that post-depositional factors heavily influence the Soyo deposit, with significant movement between stratigraphic layers likely at the site. Research conducted by Vella (2018) has allowed for characterisation of other Units, and it is evident that stratigraphy is highly variable throughout the site (see Chapter 4). The use of relative dating may thus be insufficient to permit understandings of changes in lithic assemblage constitution over time. The significant geomorphological variability of the region surrounding Soyo Tolgoi is a significant barrier to archaeological understanding.

CHAPTER 4: RESULTS

4.1: INTRODUCTION

In 2015 and 2016, a total of 340 stone artefacts were recovered from the region surrounding Soyo Tolgoi; 96 of these artefacts have been included in the sample analysed here. Investigations into assemblage constitution are outlined below, in addition to a preliminary chronology established for the site. The research conducted here has included macroscopic, mathematical, and microscopic analysis of stone artefacts collected from the site, which will provide clarity on the behaviours of past occupants.

4.2: GEOMORPHIC CATEGORISATION AND RADIOCARBON DATING

Vella (2018) has outlined the geomorphic constitution of various test pits (Figure 6) at Soyo, and Unit 6. The site has been dated to between 10,900 BP and the 19th century BP, established through radiocarbon dating of bone samples retrieved from Level 22 and above. No lithic materials were recovered from these Levels or Unit 3 (most spatially related to Unit 6). An indication of stratigraphic age can be interpreted from this data (Table 5). Stratigraphic imotscodes have been arbitrarily designated by Vella (2018) and are found in Table 5. Stratigraphy forms completed as a component of the 2015 (Figure 13–17) – 2016 (Appendix I) NOMAD Science field investigations are presented below and in Appendix I; these have been used to establish a relative site chronology for Soyo. Figure 18 has been produced based on these reports. An overview of the process applied here in Appendix H.

Table 5: Showing results of radiocarbon dating undertaken on stratigraphy from Unit 6, Soyo, northern Mongolia. Adapted from the results of Vella (2018).

Stratigraphic Level	**Soil Character**	**Quantity of Bone Samples Retrieved**	**Depth (m)**	**Age**
A	Light coloured soil; fine sand	0	0.2	N/A
B	Slightly darker coloured soil; very fine sand	3	0.19	115 BP – Present
C	Black paleosol; very fine sand with abundant clay/silt	2	0.11	265 BP – 85 BP
D	Slightly darker coloured soil	2	0.12	905 BP
E	Not described; silt/clay with very fine sand	0	Not provided	N/A

F	Light coloured aeolian? Sand; very fine sand with clay	1	0.37	Inconclusive
G	Light coloured Aeolian? Sand, slightly darker; silt with some very fine sand	3	Not provided	At 115cm below surface – 1200 BP At 120 cm below surface – 10,900 BP
I	Reddish; silt with some very fine sand	0	Not provided	N/A
J	Reddish; abundant silt and some very fine sand	0	Not provided	N/A

K	Darker coloured bedrock? Sand;	0	0.4	N/A
	Very fine to fine sand			
O	Not described	1	Not provided	Inconclusive

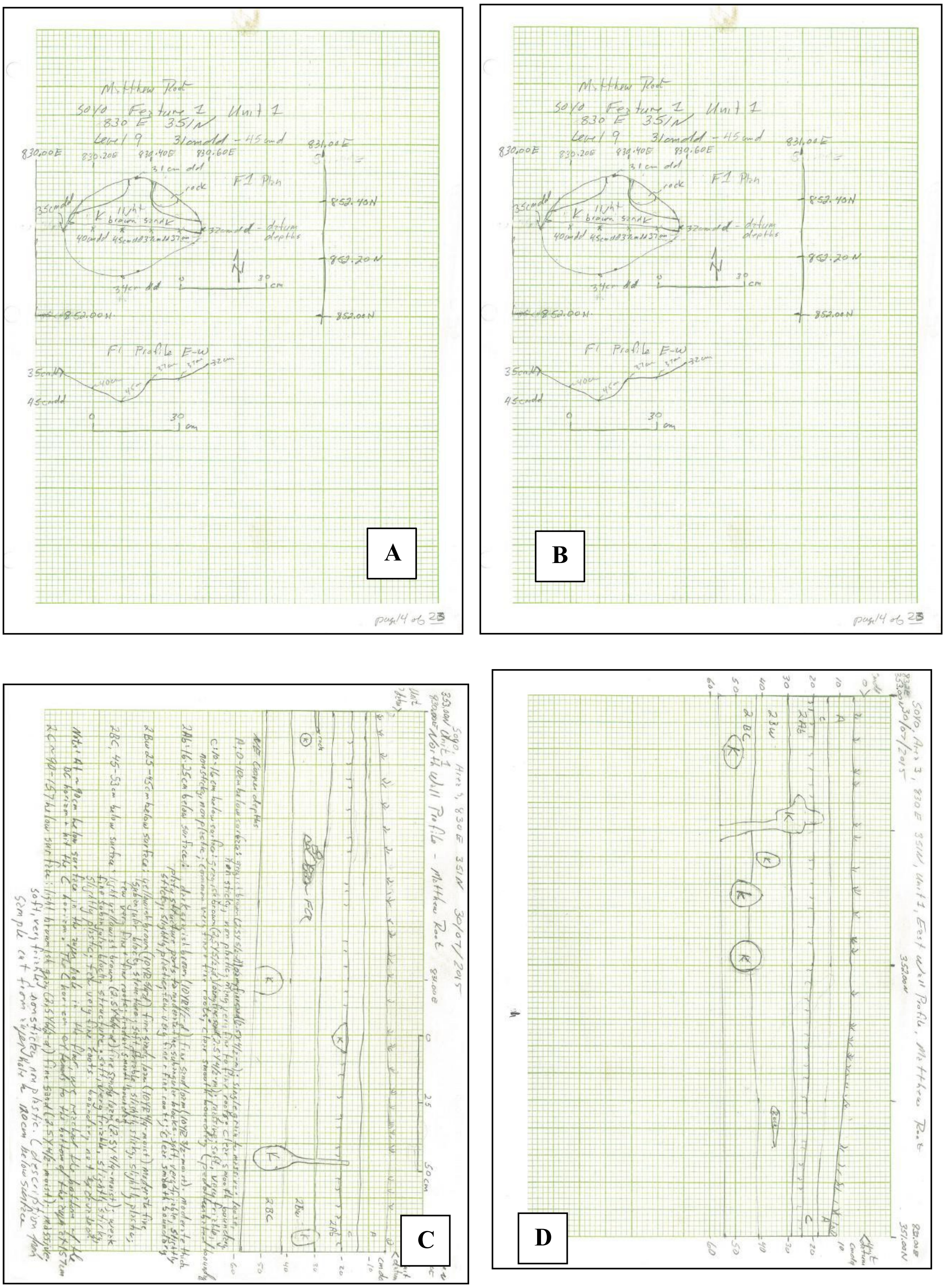


Figure 13: Stratigraphy depictions and descriptions produced by Root and Jasparro (2015) of Unit 1 (pages 1-4; 9a, 9b, 9c, and 9d respectively), Soyo Tolgoi. Reprinted with permission from Dr. Julia Clark.

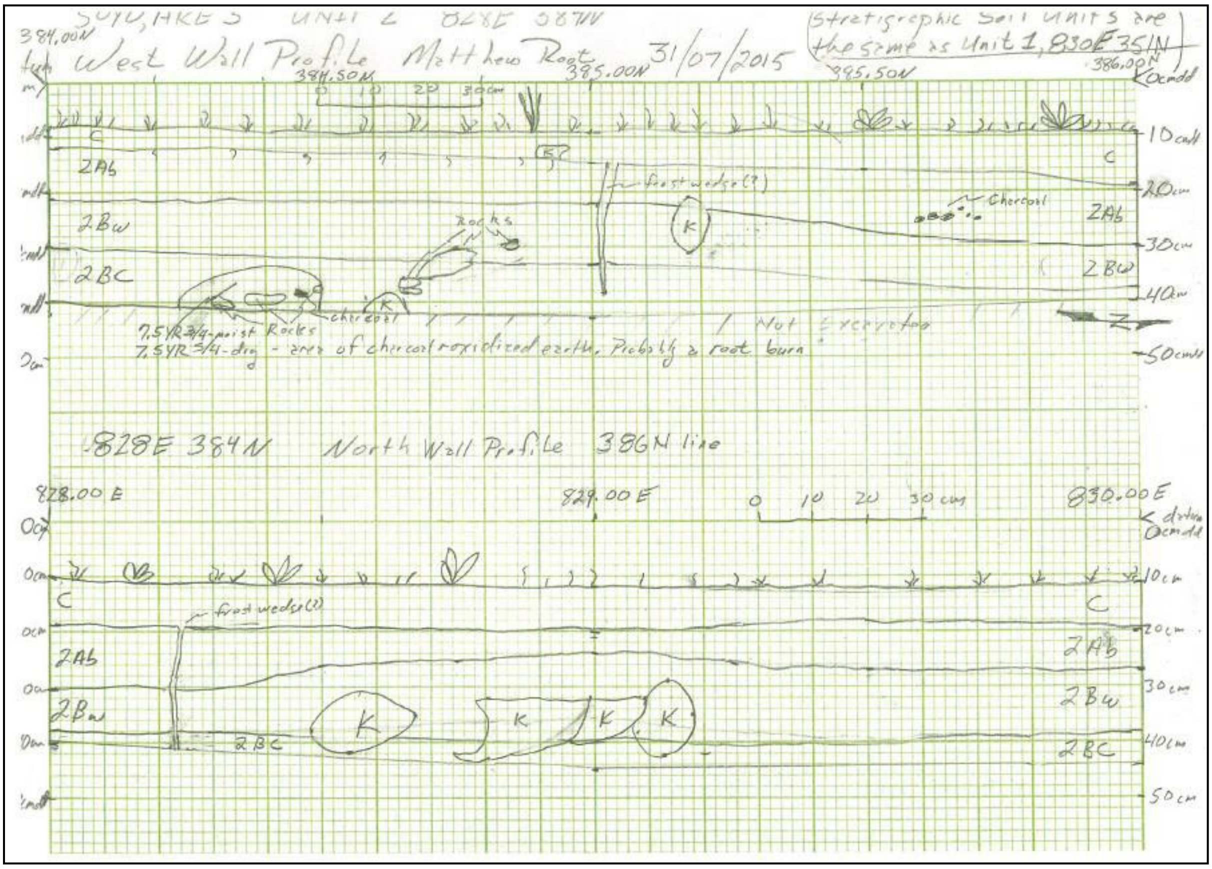


Figure 14: Depiction and description of the stratigraphy of Unit 2, Soyo Tolgoi, as produced by Root (2015). Reprinted with permission from Dr. Julia Clark.

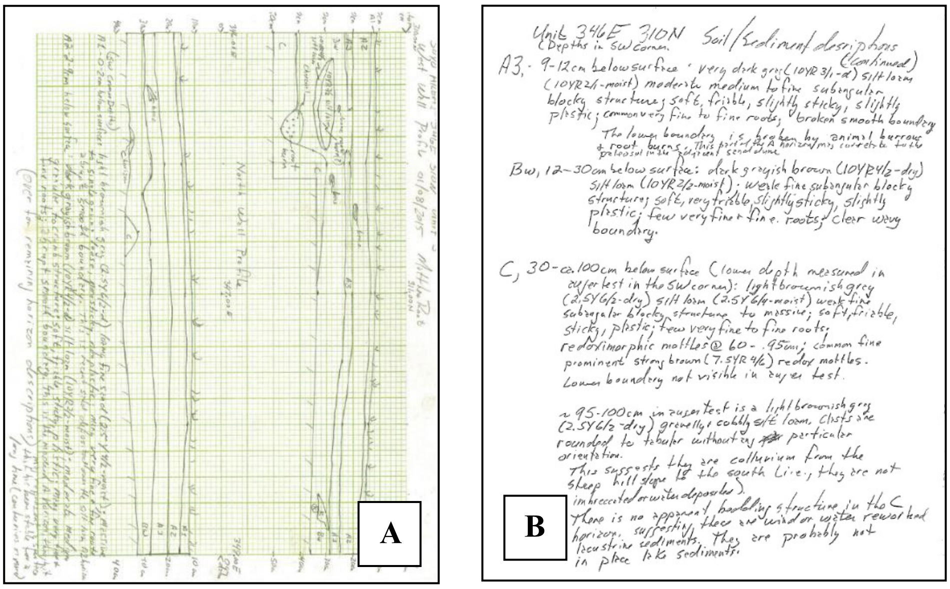


Figure 15: Depiction and description of the stratigraphy of Unit 3 (pages 1-2, 11a and 11b respectively), Soyo Tolgoi, as produced by Root (2015). Reprinted with permission from Dr. Julia Clark.

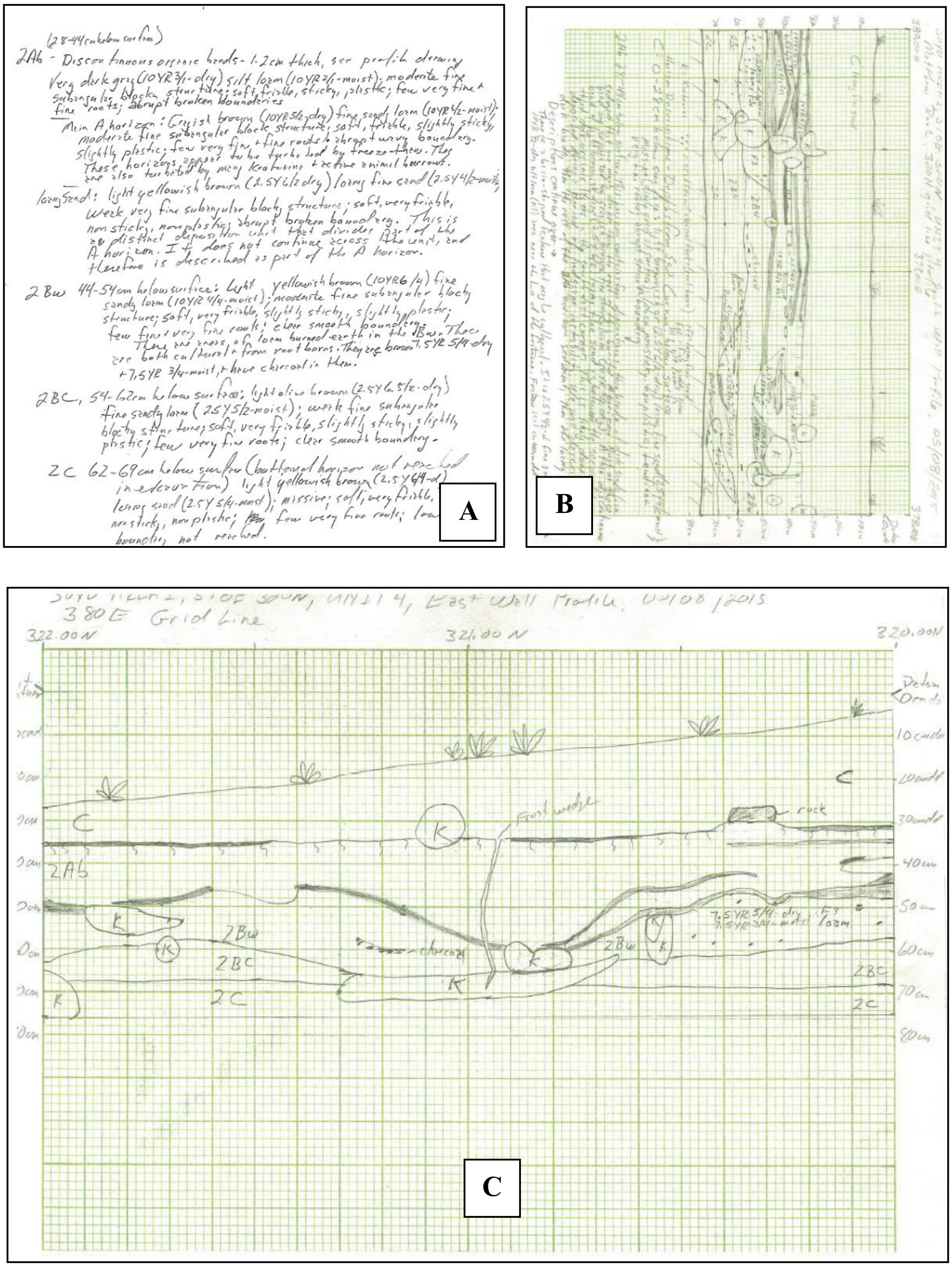
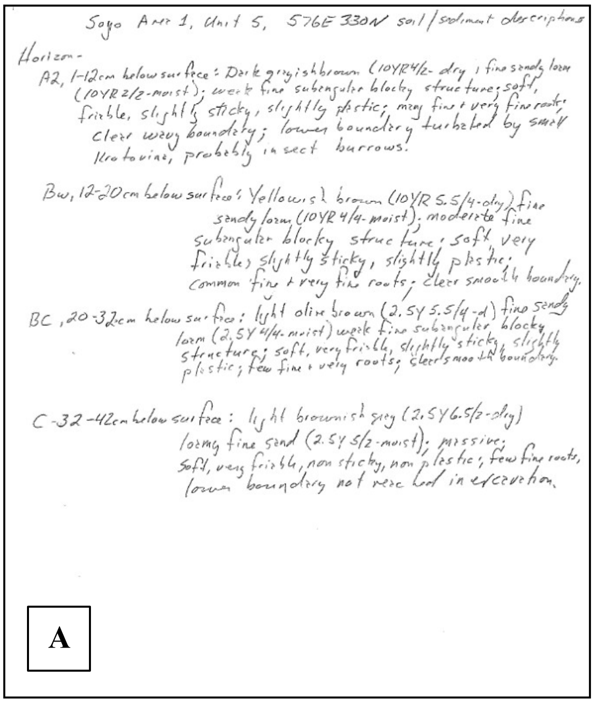


Figure 16: Depiction and description of the stratigraphy of Unit 4 (pages 1-3; 12a, 12b and 12c respectively), Soyo Tolgoi, as produced by Root (2015). Reprinted with permission from Dr. Julia Clark.


Soyo Area 1, Unit 5, 576E 330N soil/sediment descriptions

Horizon-

A2, 1-12cm below surface: Dark grayish brown (10YR 4/2- dry ; fine sandy loam (10YR 2/2-moist); weak fine subangular blocky structure; soft, friable, slightly sticky, slightly plastic; many fine + very fine roots; clear wavy boundary; lower boundary turbated by small krotovina, probably insect burrows.

Bw, 12-20cm below surface: Yellowish brown (10YR 5.5/4-dry) fine sandy loam (10YR 4/4-moist); moderate fine subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common fine + very fine roots; clear smooth boundary.

BC, 20-32cm below surface: light olive brown (2.5Y 5.5/4-d) fine sandy loam (2.5Y 4/4-moist) weak fine subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; few fine + very roots; clear smooth boundary.

C-32-42cm below surface: light brownish grey (2.5Y 6.5/2-dry) loamy fine sand (2.5Y 5/2-moist); massive; soft, very friable, non sticky, non plastic; few fine roots, lower boundary not reached in excavation.

A

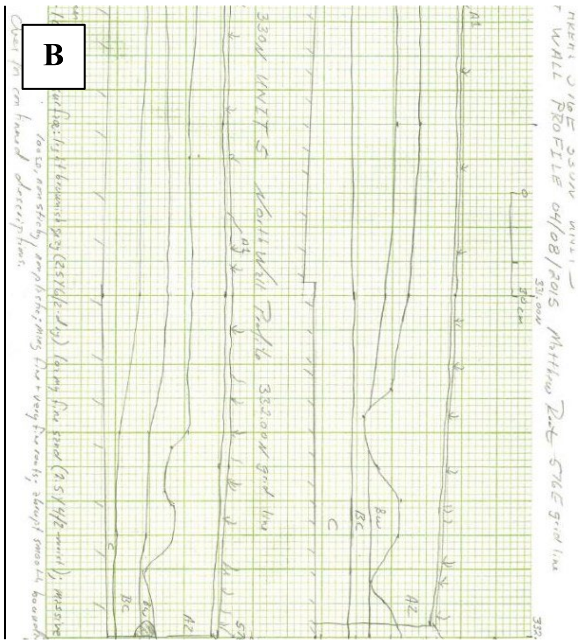


Figure 17: Depiction and description of the stratigraphy of Unit 5 (pages 1-2; 13a and 13b respectively), Soyo Tolgoi, as produced by Root (2015). Reprinted with permission from Dr. Julia Clark.

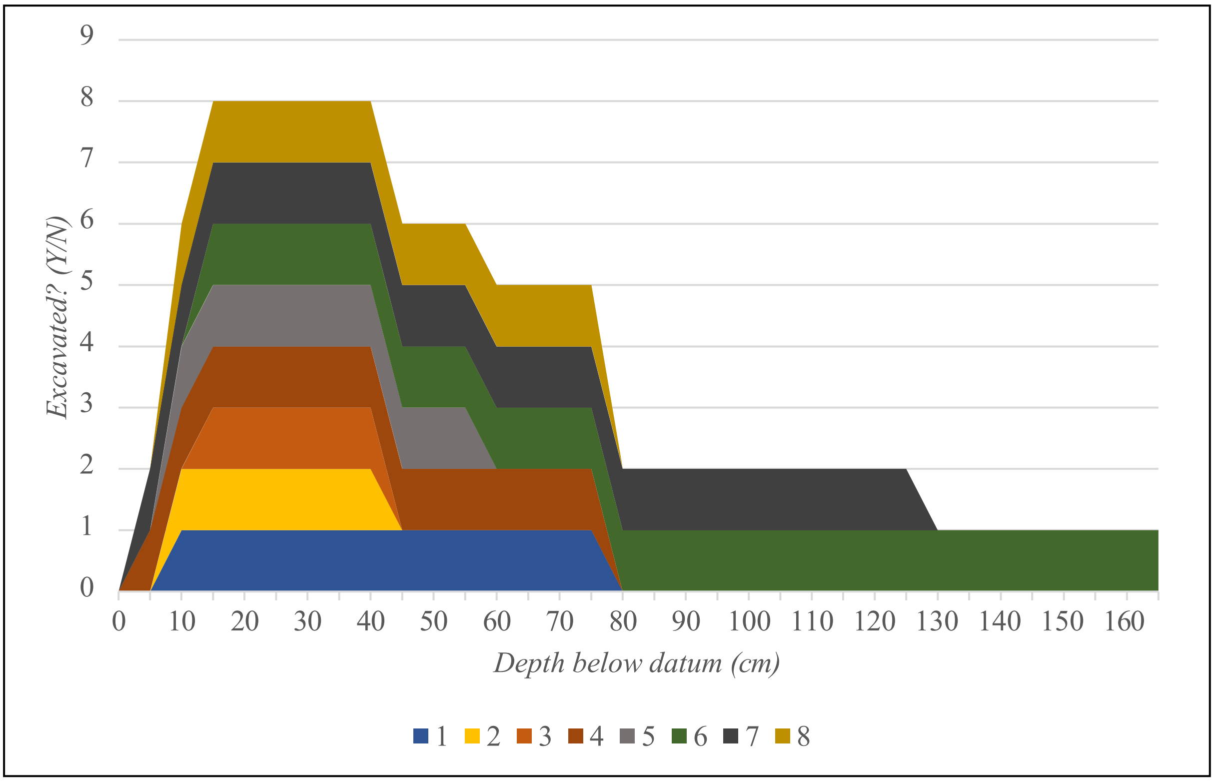


Figure 18: Depths excavated by NOMAD Science representatives in 2015-2016 at Soyo Tolgoi, northern Mongolia.

4.3: Raw Material Analysis

4.3.1 : Macroscopic analysis

An overview of the number of stone artefacts recovered from individual Units at Soyo within the analysed sample can be found in Table 6. Units which did not contain lithics are excluded from further analysis. Summaries of the raw materials composing the Soyo assemblage are provided below.

Table 6: Detailing the number of stone artefacts recovered from each Unit excavated at Soyo (northern Mongolia) in 2015 - 2016, and the proportion of the total sample represented.

Unit Number	**Number of Stone Artefacts Included**	**Percentage of Total Sample (%)**
Surface	4	4.17
1	38	39.58
2	7	7.29
4	18	18.75
5	7	7.29
6	1	1.04
7	21	21.88

Table 6 and Figure 19 provide an overview of raw material types represented in the Soyo lithic assemblage; Figure 20 depicts examples of each raw material type as observed in the sample. Chert artefacts comprise much of the collection (69.79%), with quartzite and quartz both present in significantly lower frequencies (25.00% and 3.13% respectively). One sandstone artefact was also identified. A secondary anomaly is represented by A40, (other) (1.042%), being comprised of quartz granules encompassed in a clay-like matrix.

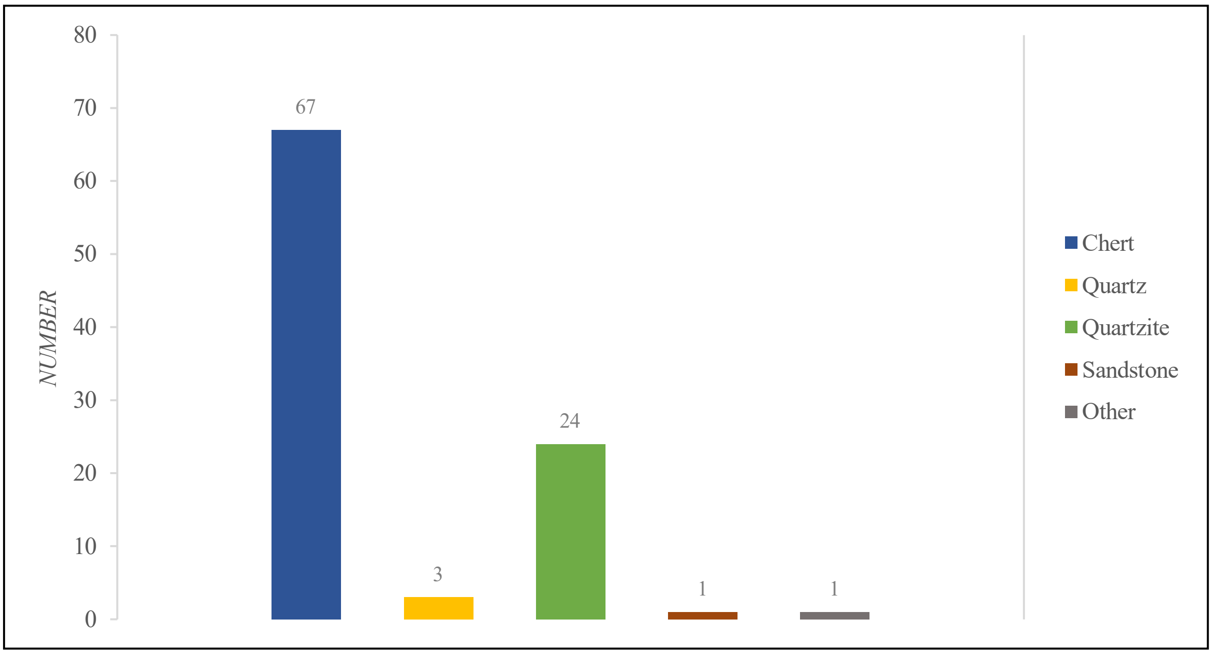


Figure 19: Indicating the proportions of distinct raw materials identified in the Soyo lithic assemblage.

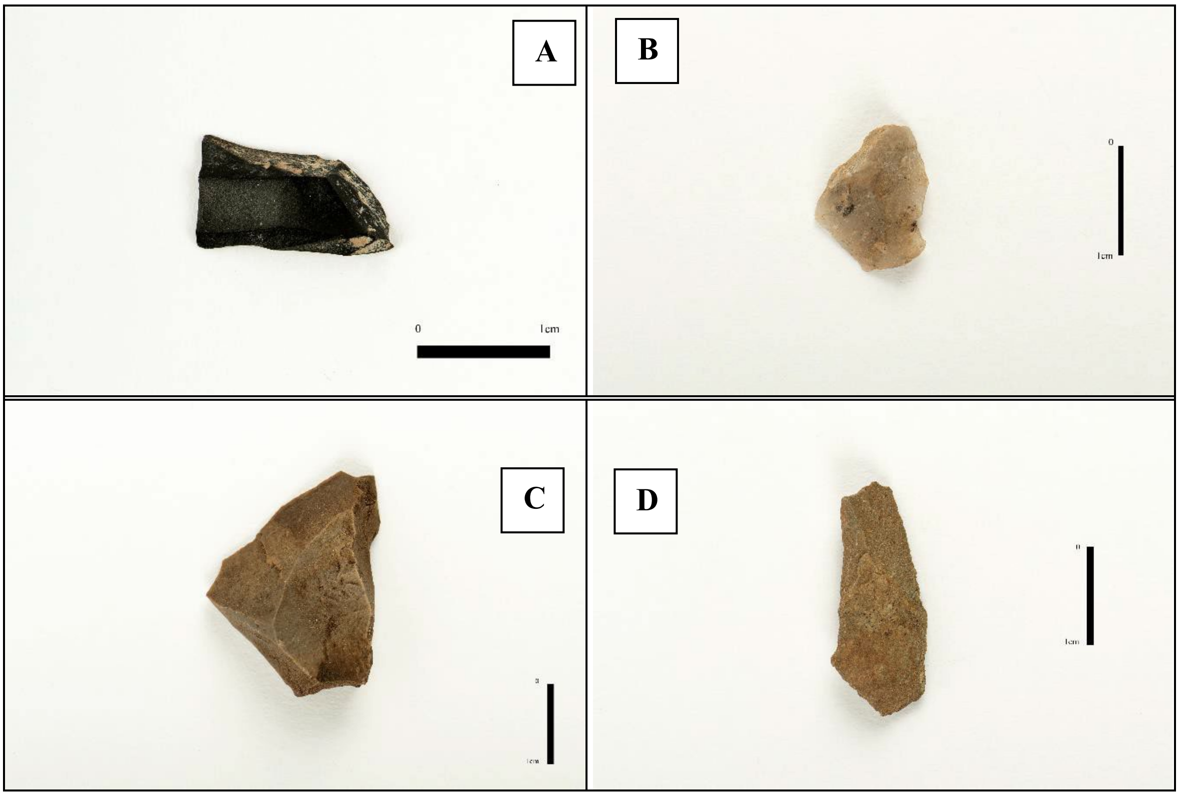


Figure 20: Examples of chert (17a, A82), quartz (17b, A29), quartzite (17c, A17) and sandstone (17d, A31) artefacts observed in the Soyo sample.

Figures 18 – 20 indicate similar information as that in Figure 12, though displays the frequency of raw material types by levels in individual units. Four artefacts retrieved during pedestrian surveys of the site have also been included, representing 4.17% of the total sample. All artefacts included were composed of chert.

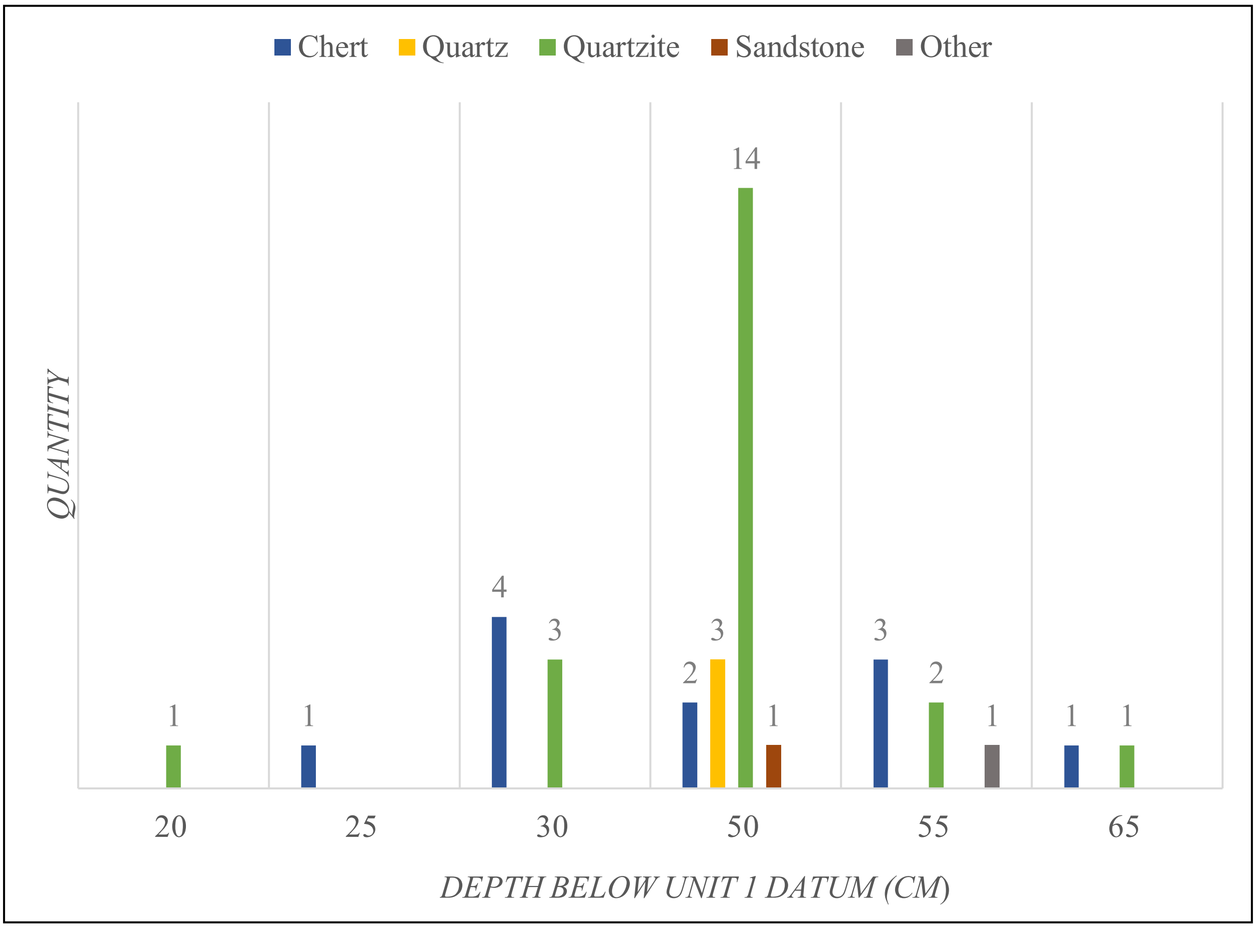


Figure 21: Showing numbers of artefacts of various raw material types as identified in the Unit 1 assemblage from Soyo, northern Mongolia.

Most stone artefacts collected from Unit 1 (Figure 21) were retrieved from 50cm below datum (cmbd) (20; 54.05%), of which a larger proportion of artefacts were quartzite than in any other level generated at the site. Only one lithic artefact was recovered from 20 and 25cmbd (5.000%); two were retrieved from 65cmbd (10.00%). Level 11, at 55cmbd, contained the second-highest number of artefacts (6; 30.00%).

Seven lithics (7.292%) were collected from Unit 2. Two were identified in Level 3 (20cmbd), and 5 in level 7 (40cmbd) (28.57% and 71.43% of the Unit 2 assemblage respectively). The majority of stone artefacts from this unit were composed of chert (6; 85.71%), with one quartzite artefact being present.

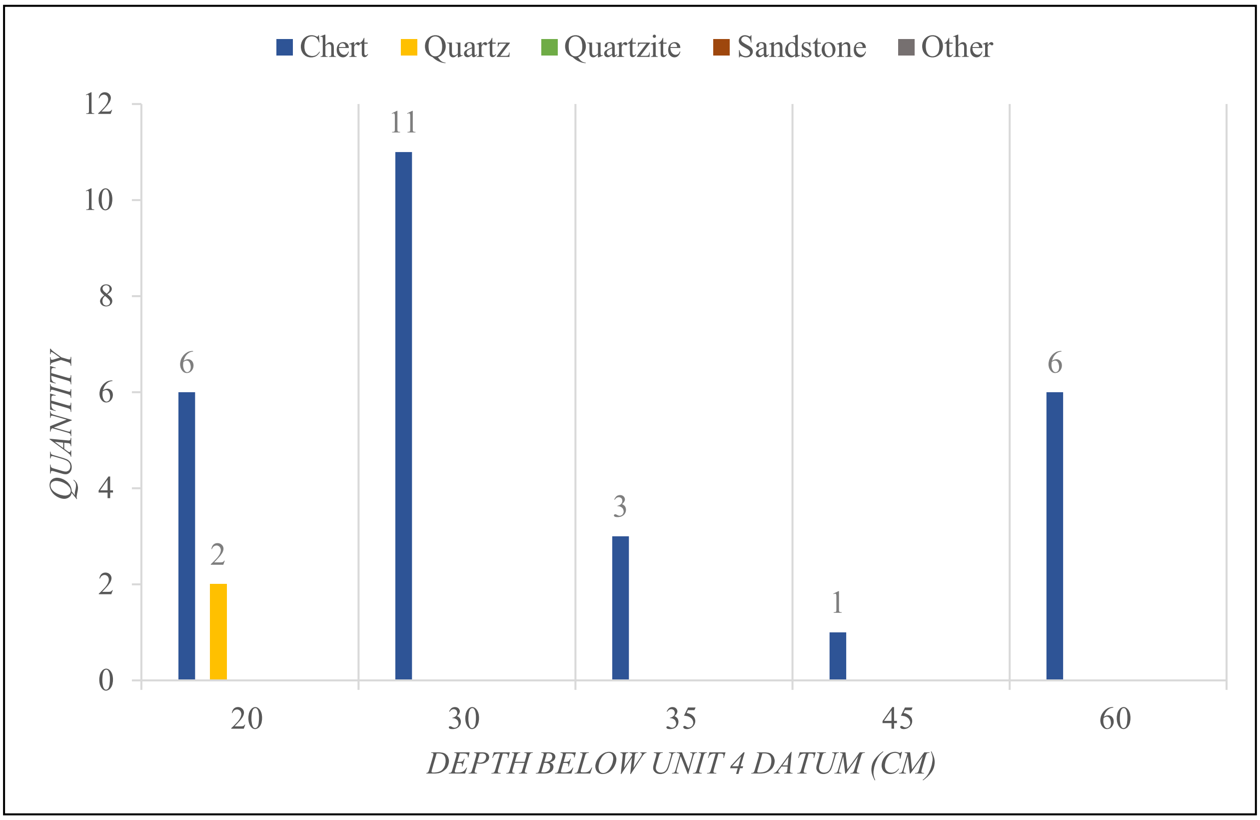


Figure 22: Showing numbers of artefacts of various raw material types as identified in the Unit 4 assemblage from Soyo, northern Mongolia.

The assemblage associated with Unit 4 (Figure 22) is dominated by chert artefacts, with only 2 quartz artefacts (6.897% of the Unit assemblage). Level 4 (20cmbd) contained the largest number of artefacts collected from this unit. Unit 5 contained relatively few artefacts. Of these, the vast majority were chert (85.71%) with one additional quartzite artefact. All artefacts were found in Level 3 (20cmbd). Unit 6 contained only one artefact (A76), composed of chert.

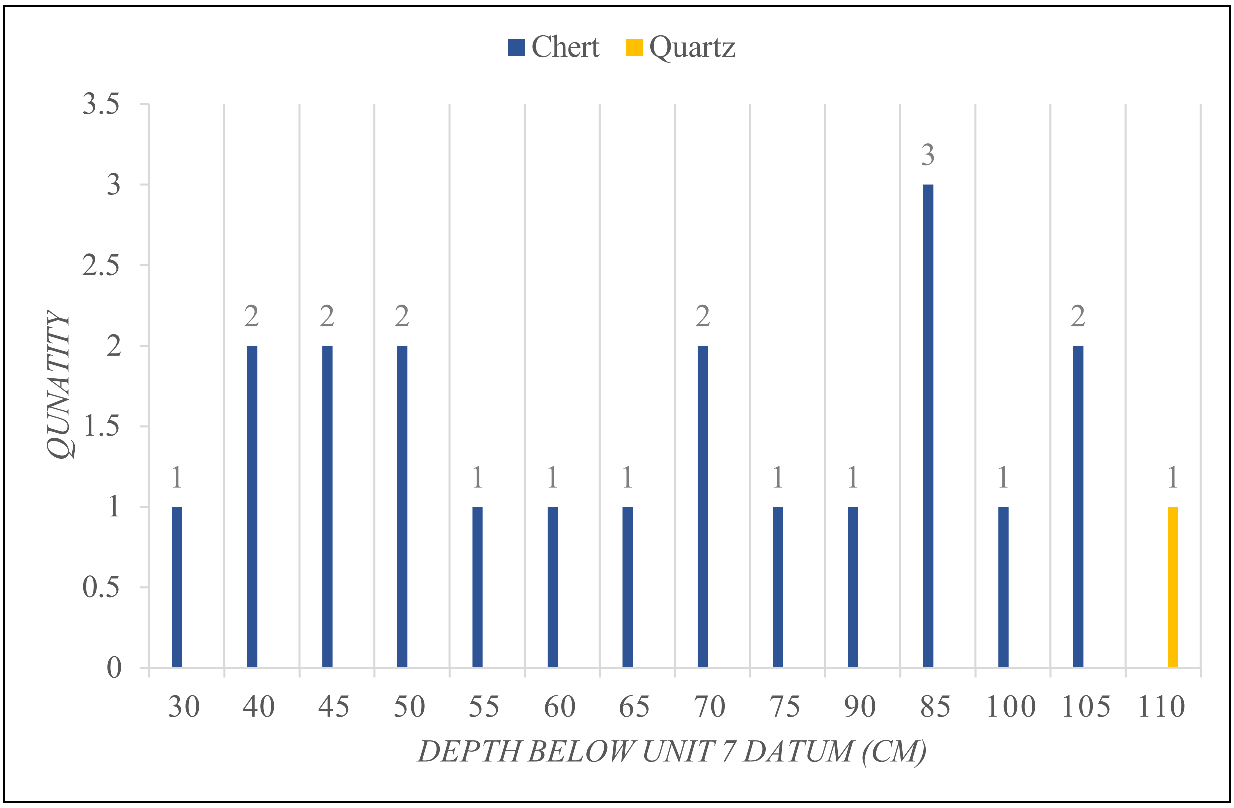


Figure 23: Showing numbers of artefacts of various raw material types as identified in the Unit 7 assemblage from Soyo, northern Mongolia.

Most artefacts recovered from Unit 7 (Fig 23) were composed of chert (95.24%), with only one quartz artefact observed (4.762%). This artefact (A06) was significant in that it contained numerous veins of ochre, with pockets containing a high proportion of iron (identified through pXRF, section 4.3.1).

Figure 21 provides an indication of the distribution of raw materials across all Units and Levels. The implications and limitations of this form of analysis are discussed in Chapter 6.

4.3.2 : X-Ray Fluorescence

Artefacts have been classified based on raw material types as identified through macroscopic analysis. Chert has been subsequently sub-categorised based on colour, given that this characteristic is a consequence of chemical variations in the structure of stone (Burchell et al. 2013; Kolodny and Epstein 1976; Luedtke 1992; Sharp et al. 2002). The full chert sample has also been analysed as a whole, regardless of colour variations. Three distinct chert colourations were identified, with the majority of the chert assemblage being black (64; 95.52%); all other chert samples were red (3; 4.478%). Non-artefactual objects were included in this analysis, as they have been considered representative of the site's geomorphology.

The chemical composition of chert artefacts appears in two major clusters (Figs 24 and 25) when considering the relative quantities of titanium (Ti), iron (Fe), and aluminium (Al) present. Variation is most significant between 30 and 35cmbd, indicated below as Levels 6 and 7. A low percentage of iron appears to be present in all samples. The full geochemical report and preliminary interpretation of results is presented in Appendix E.

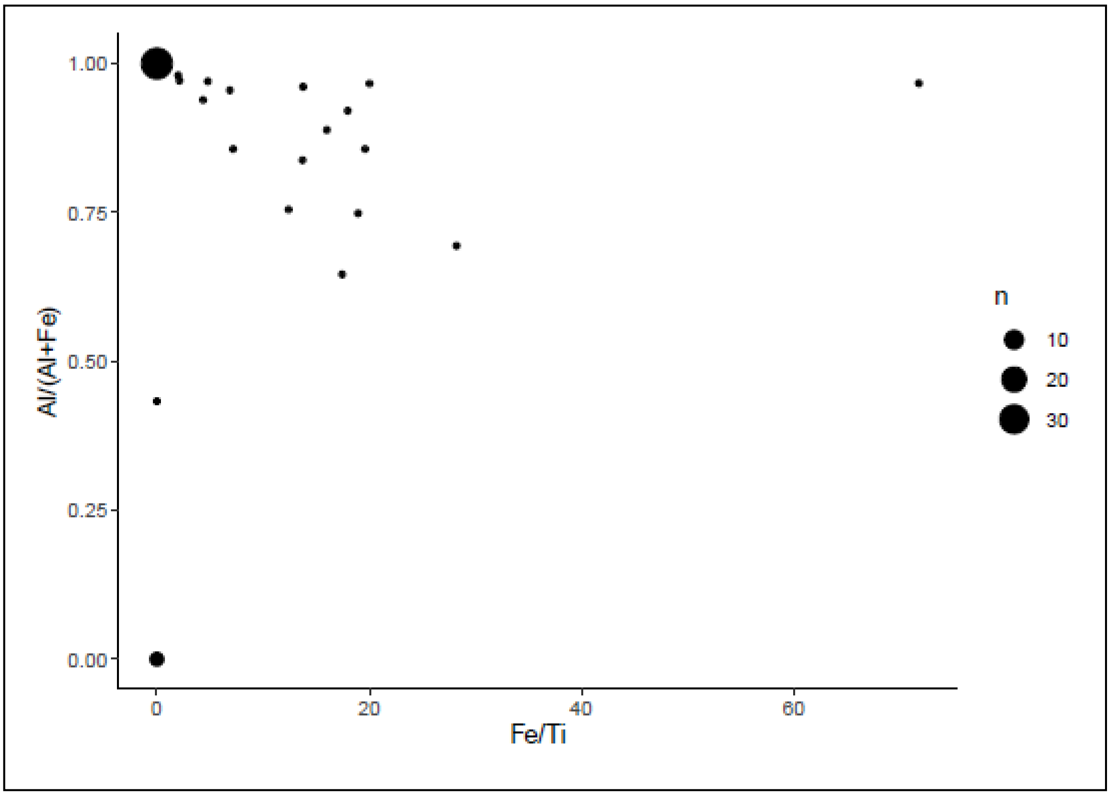


Figure 24: A binary representation of variance in the chemical composition of chert as observed in the lithic assemblage of Soyo, northern Mongolia. From McCormick (2021:2). Reprinted with permission from author.

Figure 24 suggests that the majority of chert samples recovered from Soyo were characterised by a high Al/(Al+Fe) ratio and a low Fe/Ti ratio. However, the spread of data in this instance is significant. While there is a degree of chemical similarity between all chert samples tested from Soyo, their composition is not uniform.

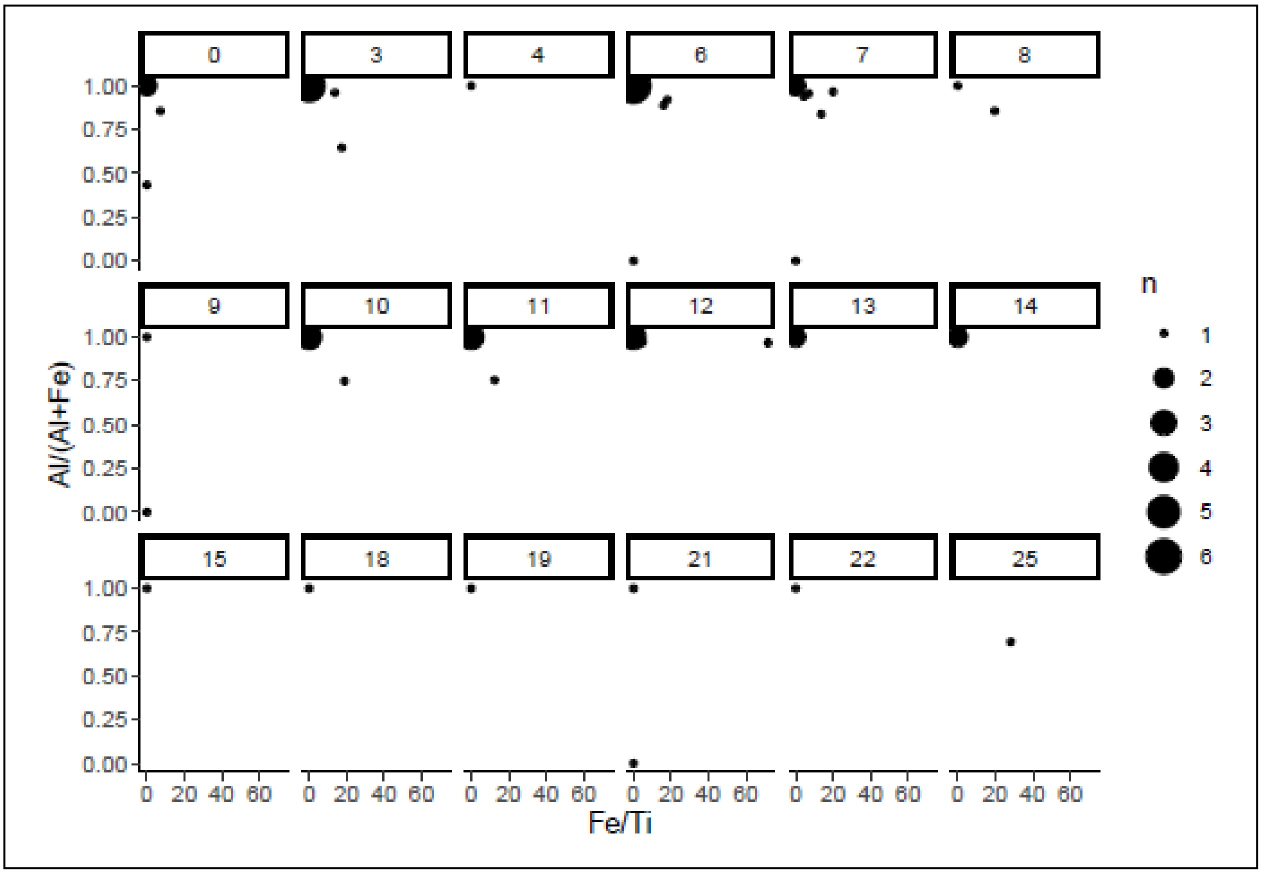


Figure 25: Binary representations of the presumed depositional environment from which the chert samples of Soyo may have been originally collected; numbers within main body of graph are representative of Levels. From McCormick (2021:3). Reproduced with permission from the author.

Two significant increases in chert chemical variability are evident in Figure 22. The first of these is observed at 60cmbd, where an additional source of chert is suggested from the assemblages of Units 4 and 7. Between 40cmbd and 30cmbd (Unit 7, Level 6 and Unit 6, Level 6 respectively), chert chemistry increases in complexity once again. However, a low Fe/Ti vs high Al/(Al+Fe) cluster is observed at all levels. It is thus probable that a single source was relied upon for the majority of chert artefacts, with possible additional sources exploited in later periods.

4.4: Macroscopic Analysis

4.4.1 : Metrical Analysis

Variations in artefact size, represented by the volume of individual artefacts, is presented in Figure 26. Flake pieces were not individually measured but recorded as fitting one of several arbitrary size classes; as such, comparison between these samples at varying depths is presented separately in Figure 27.

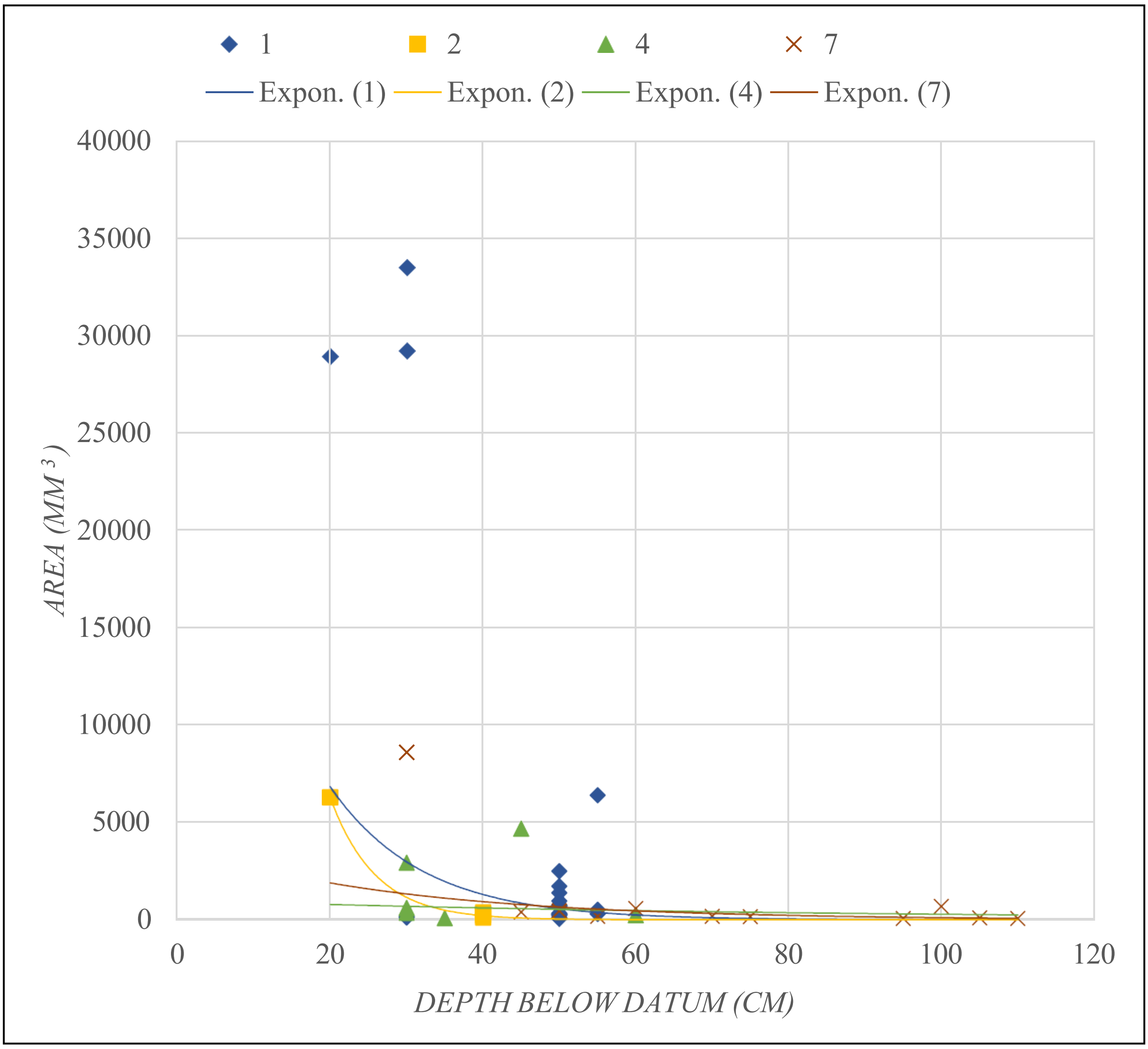


Figure 26: Indicating changing trends in stone artefact size at varying excavation depths as observed in the assemblage of Soyo, northern Mongolia.

Table 7: Indicating the nature and significance of relationships between deposition depth and stone artefact size at Soyo, as shown in Figure 26.

Unit	**Exponential Equation**	**R-Value**	**Significance (P)**
1	$y = 3577e^{-0.083x}$	0.7359	0.000095
2	$y = 186584e^{-0.17x}$	0.9994	0.0006
4	$y = 1008.8e^{-0.013x}$	0.0600	0.9101
7	$y = 3831.6e^{-0.035x}$	0.7921	0.0037

Figure 26 suggests there is little relationship between depth and artefact size after 40cmbd; a decrease in artefact size is observed in Units 1 and 2 in deeper deposits. As shown in Table 7, these relationships are significant where $\alpha = 0.05$; this is not the case, however, for Unit 4. As such, the suggested correlation between depth and artefact size in Unit 4 may be inaccurate; this should be considered when assessing the implications of results.

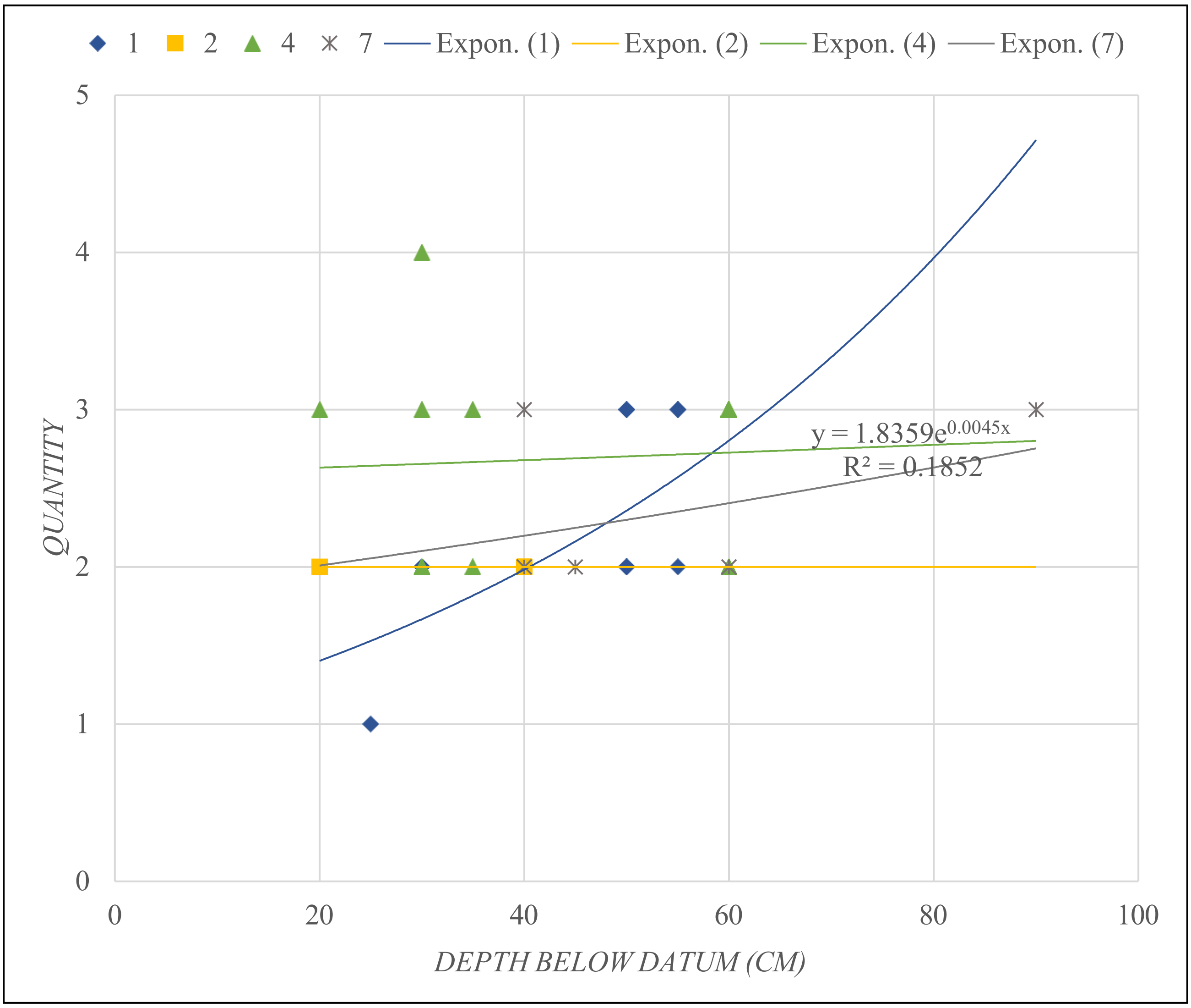


Figure 27: Indicating variations in the size of flake pieces across excavation depths as observed in the lithic assemblage of Soyo, northern Mongolia.

Table 8: Indicating the nature and significance of relationships between deposition depth and flake piece size at Soyo, as shown in Figure 27.

Unit	Exponential Equation	R value	Significance (P)
1	$y = 0.9918e^{0.0173x}$	0.6277	0.0216
2	$y = 2$	N/A	N/A
4	$y = 2.584e^{0.0009x}$	0.0249	0.9841
7	$y = 1.8359e^{0.0045x}$	0.4463	0.4512

Figure 27 indicates that the relationship between flake piece size and depth (cmbd) at Soyo is highly variable. Results calculated for Unit 1, however, are the only observed that are significant when α = 0.05 (Table 8). As such, the accuracy of all other results may be questioned, which should be considered when considering the implications of this analysis. Unit 1 suggests there may be a positive correlation between flake piece size and depth.

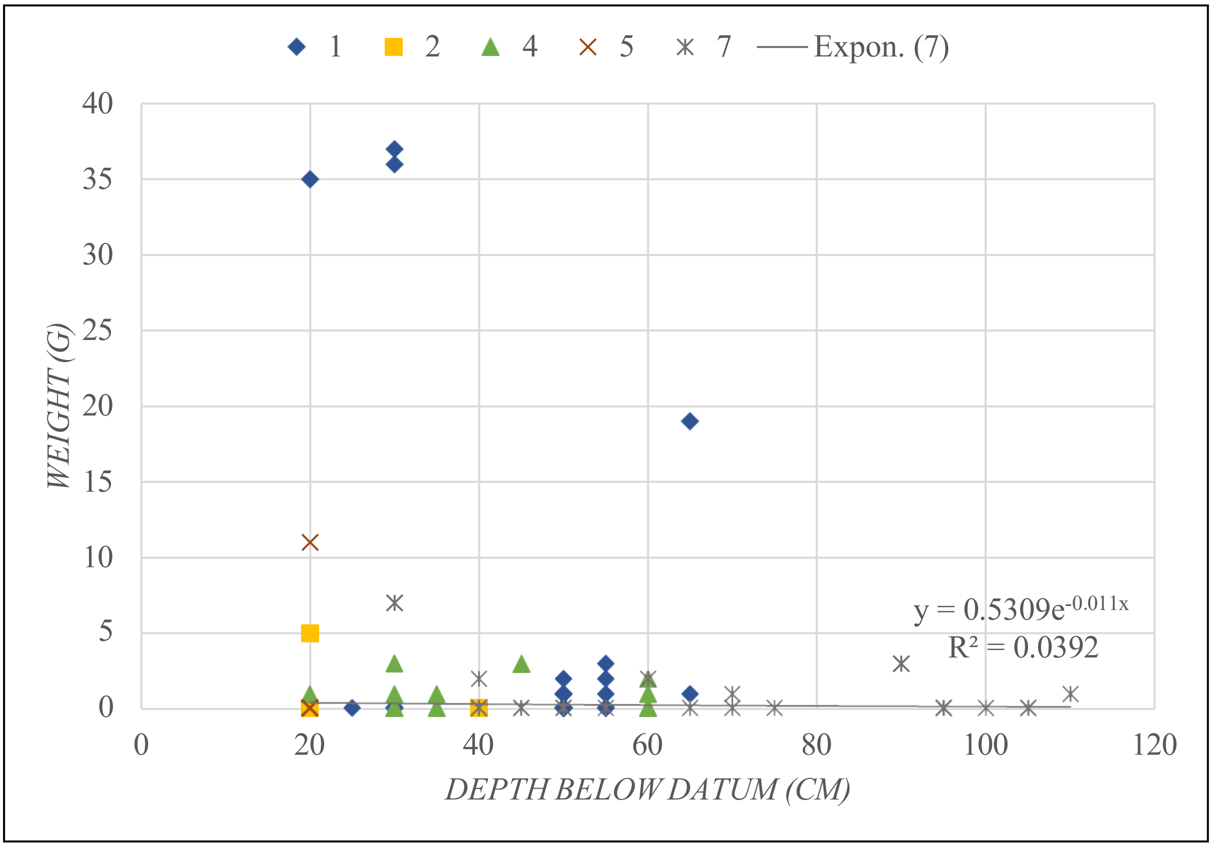


Figure 28: Indicating variations in artefact weight across excavated depths at Soyo, northern Mongolia.

Table 9: Indicating the nature and significance of relationships between deposition depth and stone artefact weight at Soyo, as shown in Figure 28.

Unit	**Exponential Equation**	**R value**	**Significance (P)**
1	$y = 0.8509e^{-0.019x}$	0.4524	0.0043
2	$y = 5e^{-0.098x}$	0.6455	0.1174
4	$y = 0.428e^{-0.002x}$	0.0648	0.7984
5	N/A	N/A	N/A
7	$y = 0.5309e^{-0.011x}$	0.3772	0.0919

As suggested in Figure 28, there is no correlation between artefact weight and deposition depth within the chosen sample. Excluding Unit 1, however, none of these relationships may be considered statistically significant when $\alpha = 0.05$ (Table 9). This must be considered when analysing these results.

4.4.2 : Assemblage Composition

Figure 29 (below) provides an overview of lithic artefact types observed in the assemblage of Soyo, northern Mongolia; examples of each artefact type observed in the sample are given in Figure 30. The majority of the collection (51; 53.13%) have been identified as flake tools; the implications of this are reviewed in Chapter 5: Discussion.

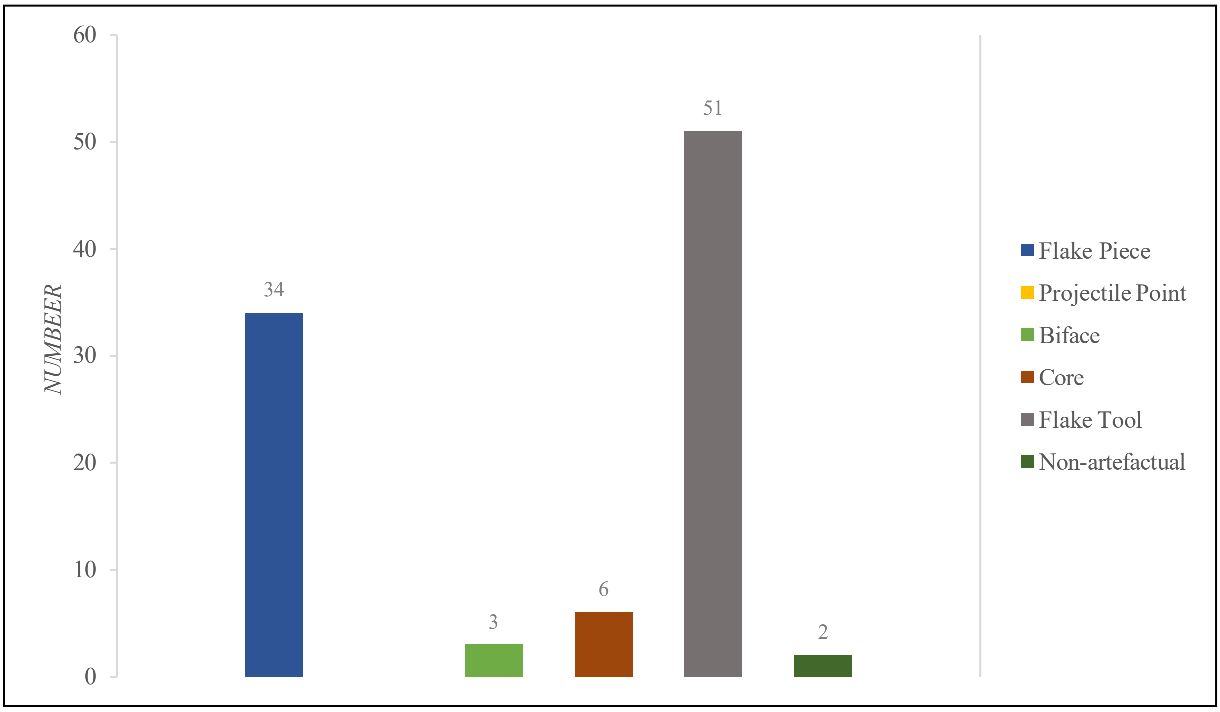


Figure 29: Showing frequencies of lithic artefact types as represented in the assemblage collected from Soyo, northern Mongolia.

Secondary to flake tools, flake pieces represent the largest lithic classification of the sample (34; 35.42%). Bifaces and cores comprise a low percentage (3.125% and 6.250% respectively) of the Soyo assemblage. 2 specimens were identified as being non-artefactual. No projectile points were observed.

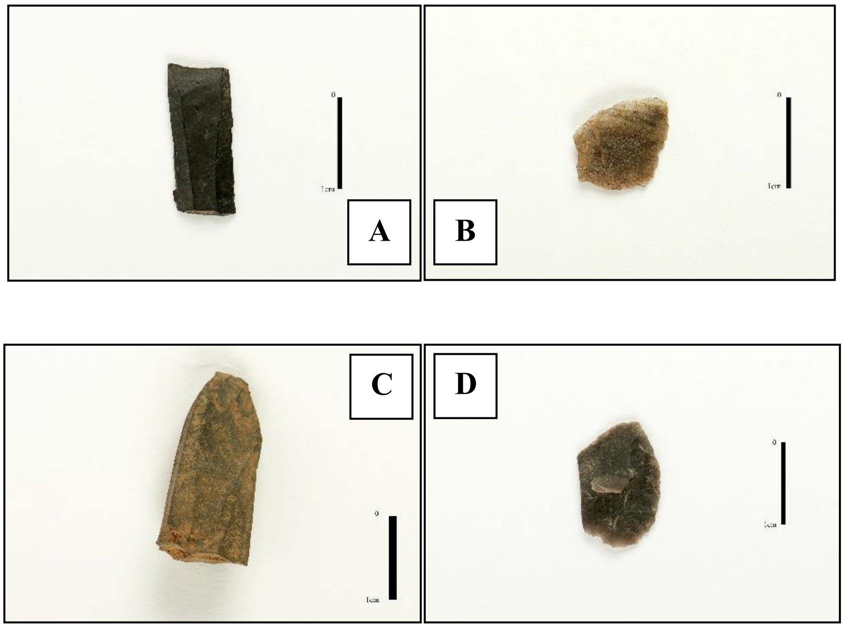


Figure 30: Examples of a flake tool (30a; A20), a flake piece (30b; A25), a core (30c, A56), and a biface (30d; A27) as observed in the Soyo lithic sample.

Three of the artefacts included in the surface collection sample (75%) were identified as being flake tools, with only one being identified as a flake piece (25%). No projectile points, bifaces, cores, or non-artefactual objects were present in the surface collection.

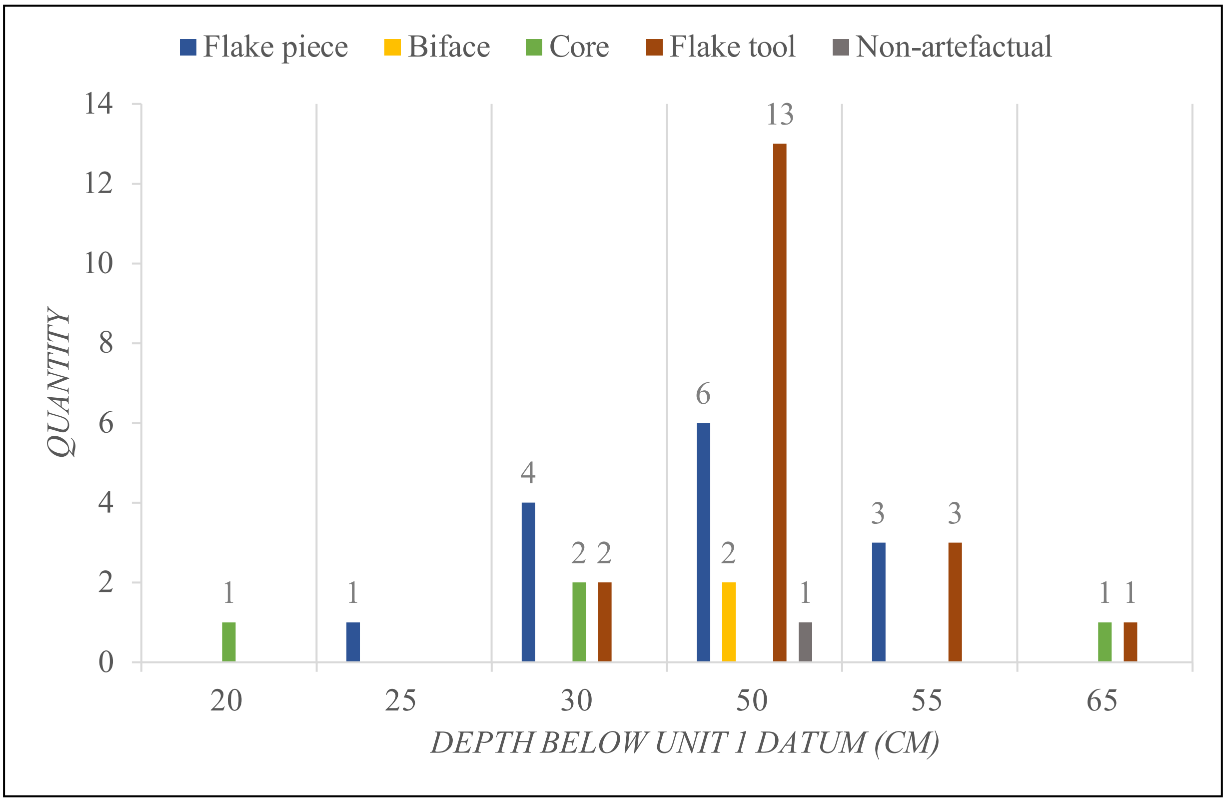


Figure 31: Showing numbers of artefacts from distinct categories as present in Unit 1, Soyo, northern Mongolia.

A wide range of artefact types are represented in the Unit 1 assemblage (Figure 31). Level 10 (50cmbd) contains the highest number of artefacts (21; 53.85%), with flake tools (61.90% of the level assemblage), flake pieces (28.47%) and bifaces (9.52%) represented. Level 6 (30cmbd) is second to this, with flake pieces (50%), cores (25%), and flake tools (25%) present. Levels 4 and 5 (20cmbd and 25cmbd respectively) contain only one artefact each, a core, and a flake piece respectively. Cores appear only in Level 10, though flake tools and cores appear to have been produced throughout the entirety of the sequence.

One non-artefactual object was included, originating from the assemblage of level 10 (A34).

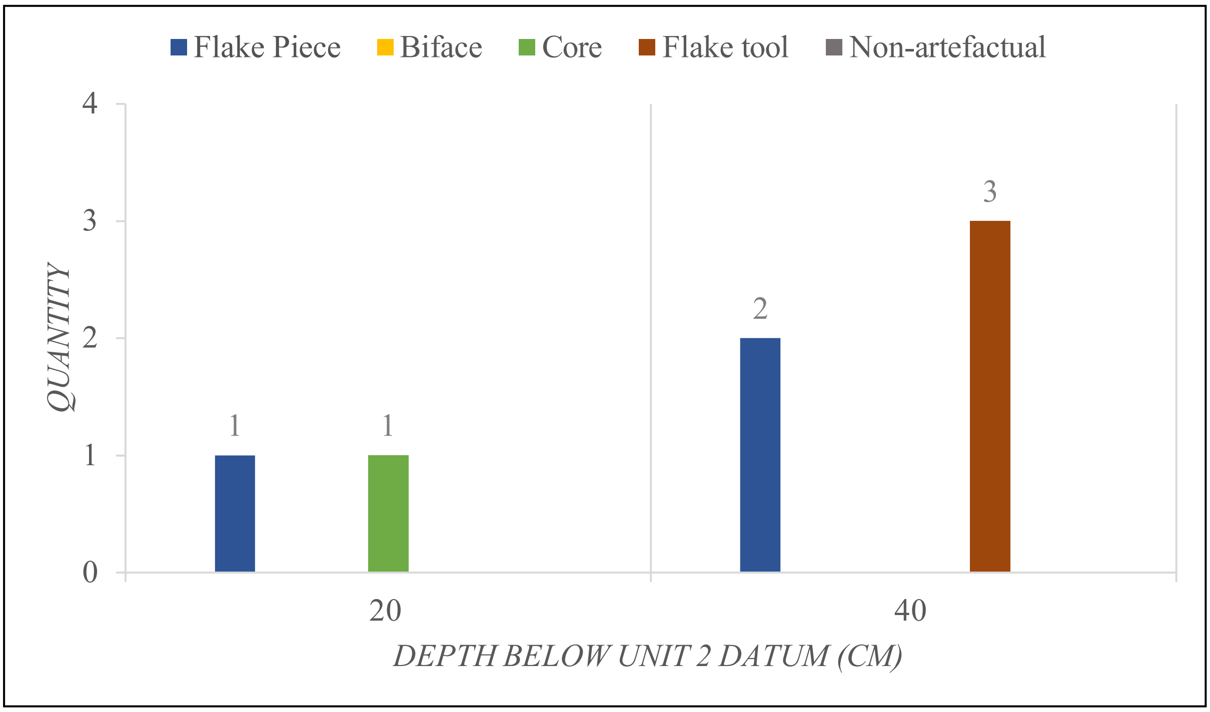


Figure 32: Showing numbers of artefacts from distinct categories as present in Unit 2, Soyo, northern Mongolia.

Most artefacts retrieved from Unit 2 (Figure 32) were either flake pieces (3 from 40cmbd) or flake tools (1 from 20cmbd and two from 40cmbd). One core was also identified 20cmbd.

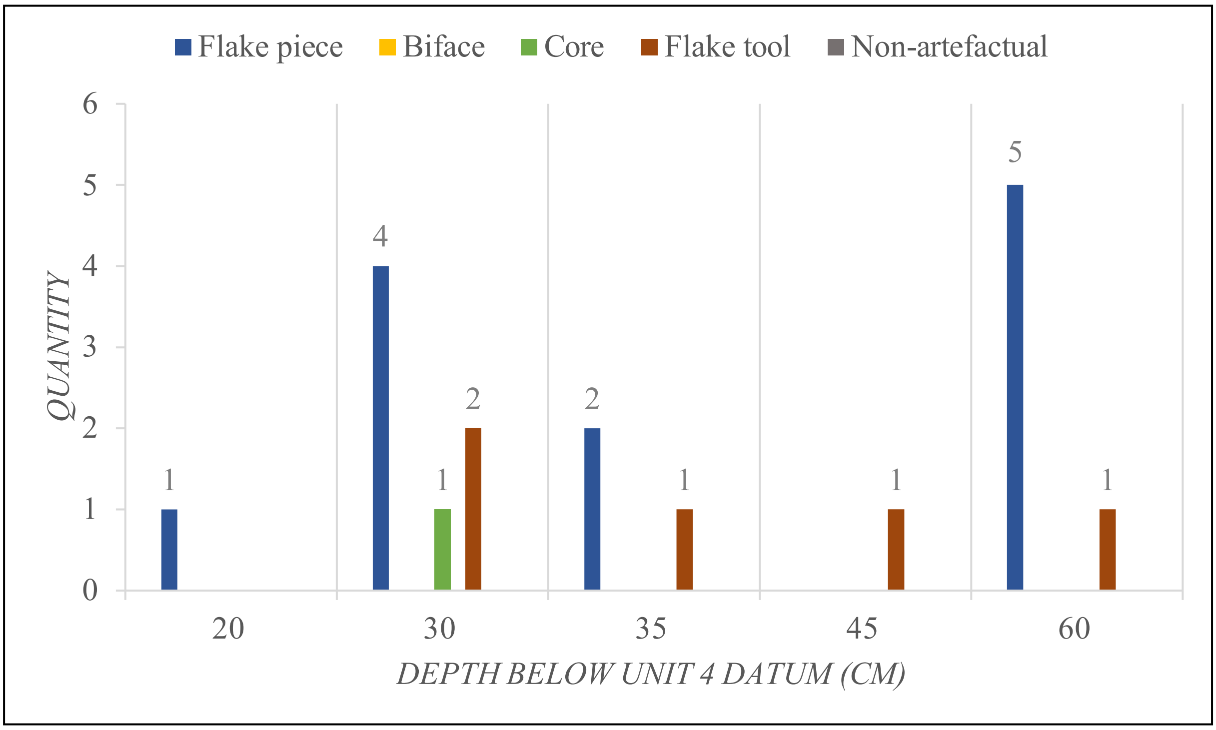


Figure 33: Showing numbers of artefacts from distinct categories as present in Unit 4, Soyo, northern Mongolia.

As in Unit 2, the Unit 4 assemblage (Figure 33) is largely composed of flake tools (66.67%) and flake pieces (27.78%). One core was also identified in 30cmbd. Artefacts are most abundant at this depth, though Level 12 (60cmbd) also contains a high proportion of the Unit's assemblage.

Only one Level (3; 20cmbd) contained stone artefacts in Unit 5. The majority of these were flake tools (57.14%), with a notable number of bifaces (2; 28.57%) being present, as well as one non-artefactual object.

Unit 6 contained only one artefact, a flake tool present in Level 25 (125cmbd).

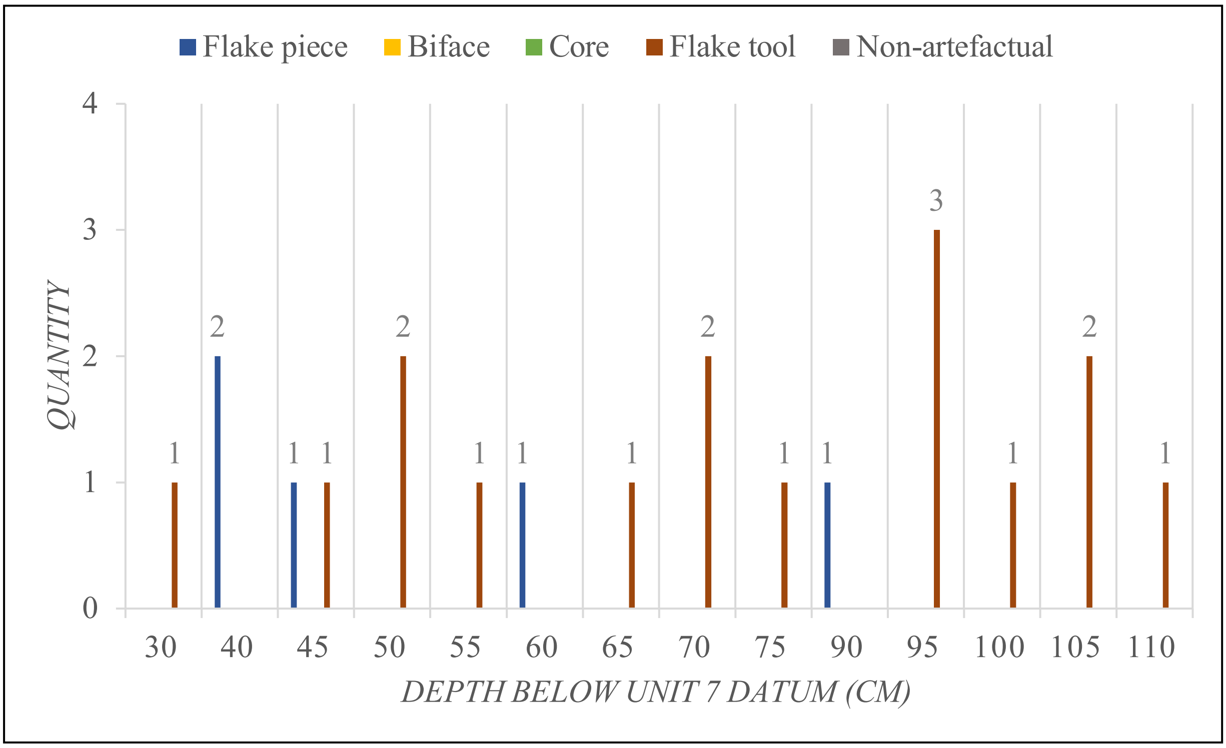


Figure 34: Showing numbers of lithic artefacts from distinct categories as present in Unit 7, Soyo, Northern Mongolia.

All artefacts recovered from Unit 7 (Figure 34) were either flake tools (16) or flake pieces (5). Stone artefacts are found in consistent numbers throughout the deposit, though the sample chosen for Level 19 (95cmbd) contains one additional object. Flake pieces are only evident above 95 cmbd.

The emergence of various artefact types across all Units is represented below in Figure 33. Only depths from which lithic artefacts were retrieved are included. The potential implications of this are presented in Chapter 6.

4.4.3 : Mathematical Analysis

In accordance with behavioural approximations outlined by early lithic researchers, assemblage formality and diversity have been calculated for distinct contexts visible in Soyo's archaeological record. Figures 35 – 38 indicate the frequency of artefacts with varying numbers of worked edges within distinct Units. Only levels containing flake tools have been included, excluding Unit 6.

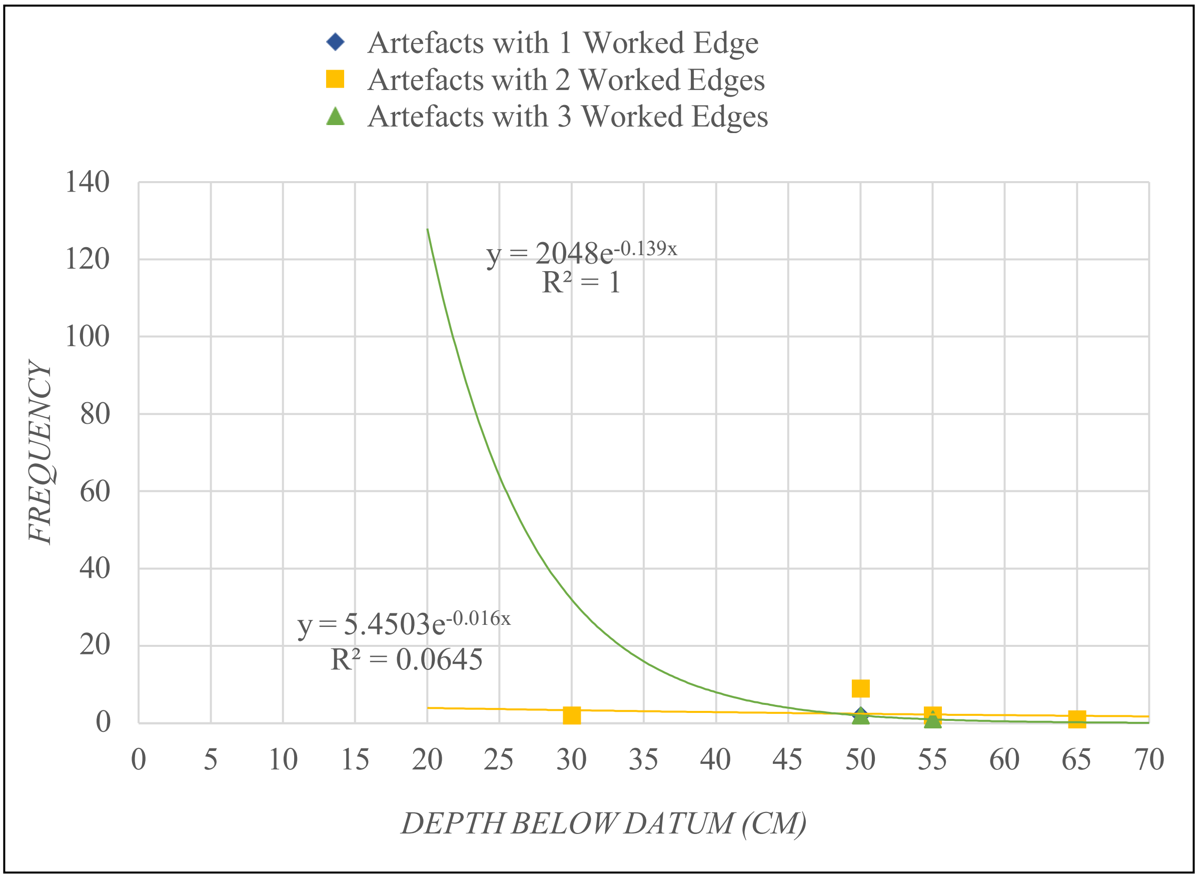


Figure 35: Depicting the relationship between frequency of artefacts with varying numbers of worked edges and depth below datum in Unit 1.

Figure 35 indicates that in Unit 1 there is a negative correlation between number of worked edges and deposition depth of artefacts that have either 2 or 3 worked edges. For those artefacts with 2 worked edges, this correlation is only slight, and the relationship has been calculated to be statistically insignificant ($P = 0.97$) when $\alpha = 0.05$. The statistical significance of relationships concerning artefacts with 1 or 2 worked edges cannot be established given the low number of variables available in the chosen sample.

All artefacts recovered from Unit 2 were shown to have 3 worked edges and were observed at 40cmbd. The statistical significance of this relationship cannot be calculated due to the low number of applicable artefacts within the chosen sample and cannot be assessed at varying depths.

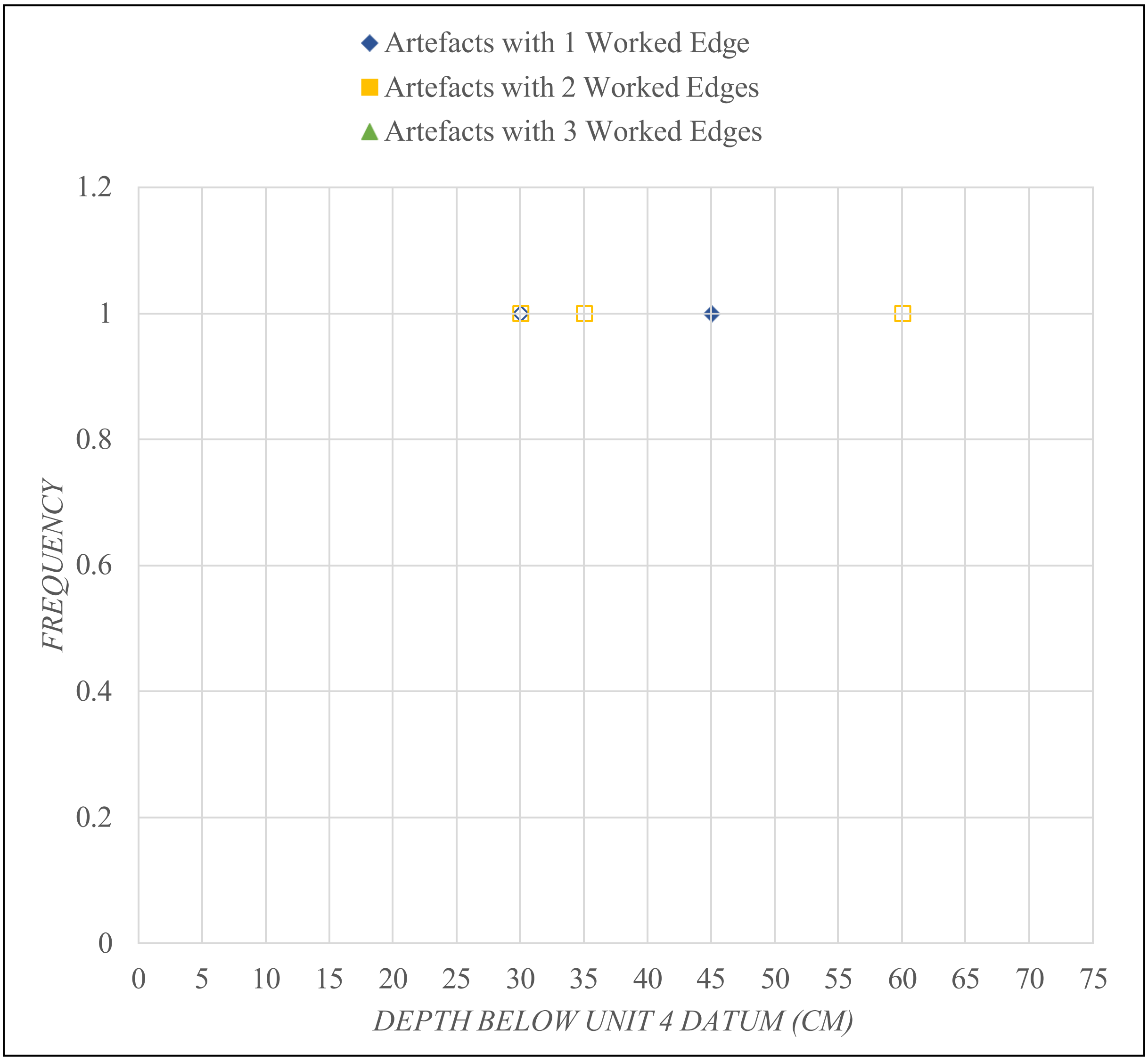


Figure 36: Depicting the relationship between frequency of artefacts with varying numbers of worked edges and depth below datum in Unit 4.

Only artefacts with either 1 or 2 worked edges were recovered from Unit 4 (Figure 36). No relationship is suggested between frequency and depth below datum for either of these artefact types. Unit 5 contained only artefacts with either 1 or 2 worked edges, akin to Unit 4. Flake tools were only recovered from 20cmbd; as such, the strength of the relationship between frequency of artefacts with varying numbers of worked edges and depth cannot be established.

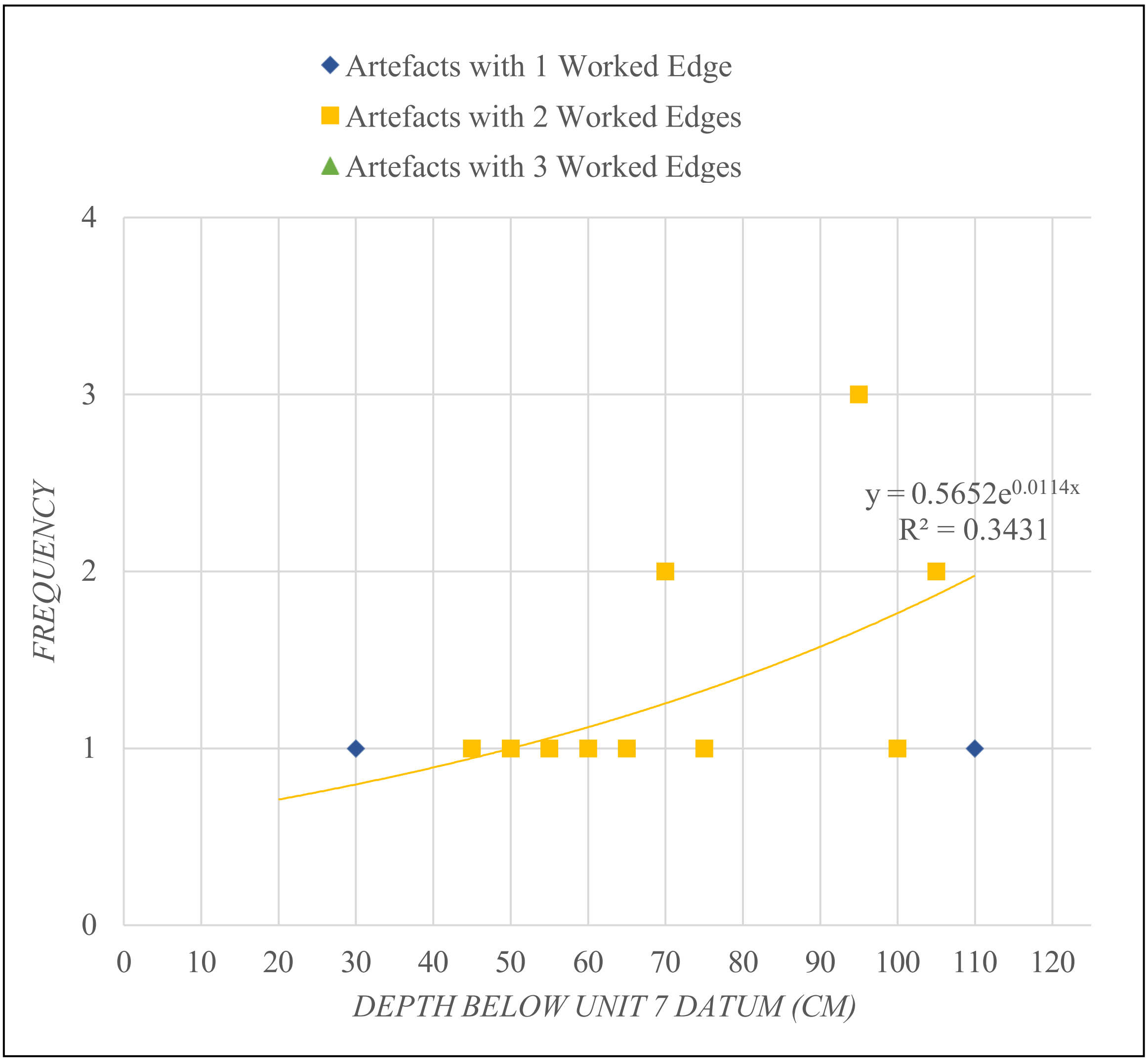


Figure 37: Depicting the relationship between frequency of artefacts with varying numbers of worked edges and depth below datum in Unit 7.

As shown in Figure 37, a positive relationship is evident between frequency of artefacts with 2 worked edges and deposition depth within Unit 7. This correlation has been calculated to be statistically insignificant ($P = 0.0556$) where $\alpha = 0.05$. No relationship is identifiable between deposition depth and frequency of artefacts with 1 or 3 worked edges, however the former of these is present in the assemblage from this Unit. 6 cores were recovered from Soyo Tolgoi;

the majority of these were recovered from within Unit 1. Figure 38 suggests that there is a positive relationship between the number of rotations evident on cores recovered from within this Unit and deposition depth. Cores are also observed in the assemblages of Units 2 and 4; however, only one such artefact was recovered from each of these areas, and as they cannot be analysed for relationships between number of core rotations and deposition depth.

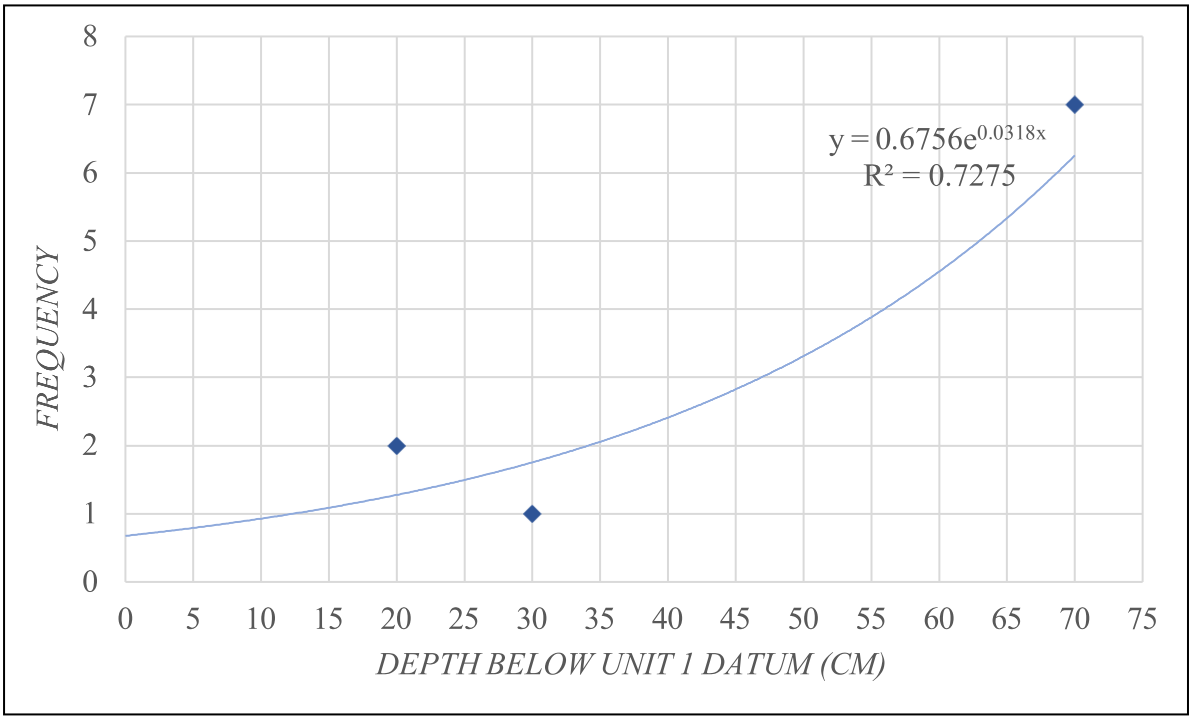


Figure 38: Number of rotations on cores excavated from Unit 1 by depth (cmbd).

The relationship indicated between number of core rotations and deposition depth (Figure 38) has been calculated to be statistically significant ($P = 0.0294$) when $\alpha = 0.05$. This suggests that as excavation depth in Unit 1 increases, so too does the number of rotations evident on individual cores.

4.4.4 : Kuhn's Reduction Index (KRI)

The intensity of worked edges has been calculated via the Kuhn's Reduction Index (KRI); distribution of this in distinct excavation Units at Soyo Tolgoi is represented below in Figures 36 – 38; Unit 6 is not included.

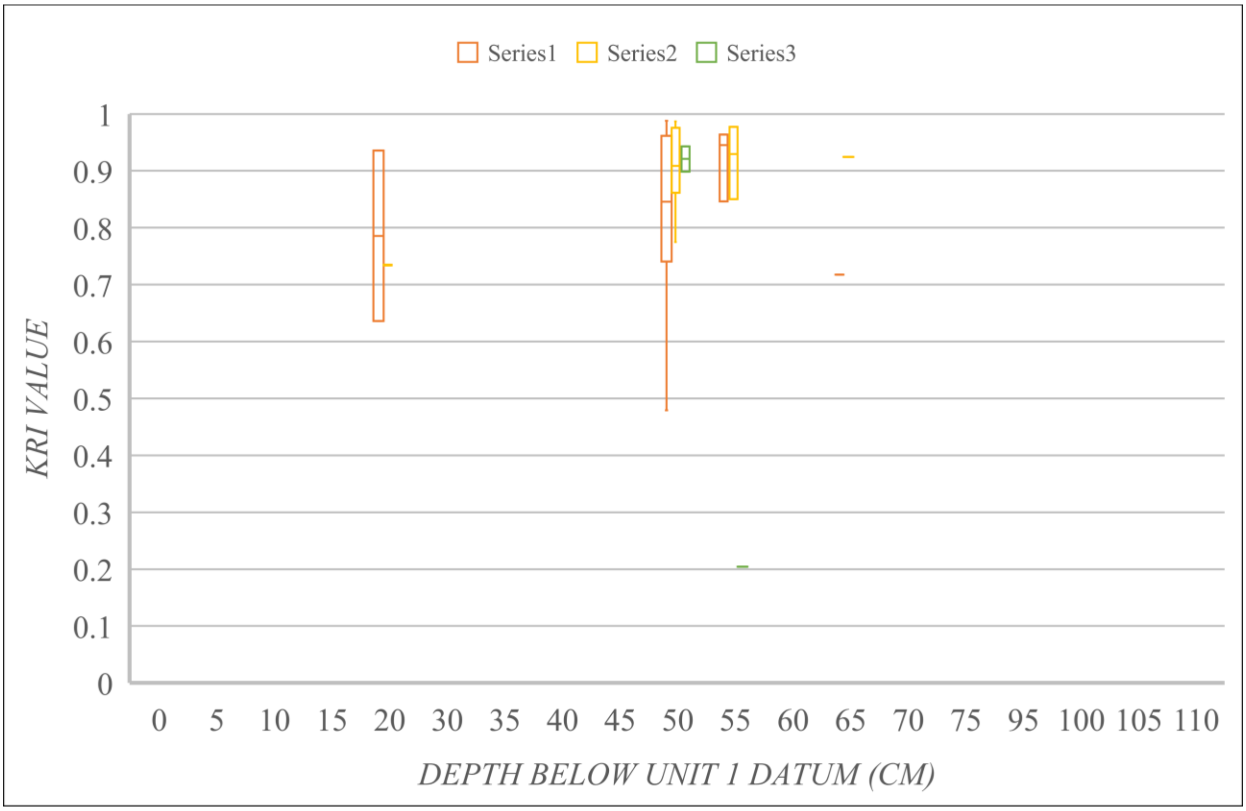


Figure 39: Showing KRI values of Flake Tools recovered from Unit 1 at varying depths below datum.

KRI values associated with artefacts excavated from Unit 1 do not appear to vary significantly over time (Figure 39). Mean values are consistently above 0.5, except in the case of one artefact discovered in 55cmbd with 3 worked edges; this artefact (A41) has a KRI of 0.2044. Within Unit 1, however, KRI can be seen to be largely static regardless of depth.

Flake tools observed in the Unit 2 assemblage were found only at 40cmbd; all had either one or two worked edges. Mean KRI values for all artefacts are high, being above 0.8 in all cases. Change in KRI at varying depths cannot be established in this case.

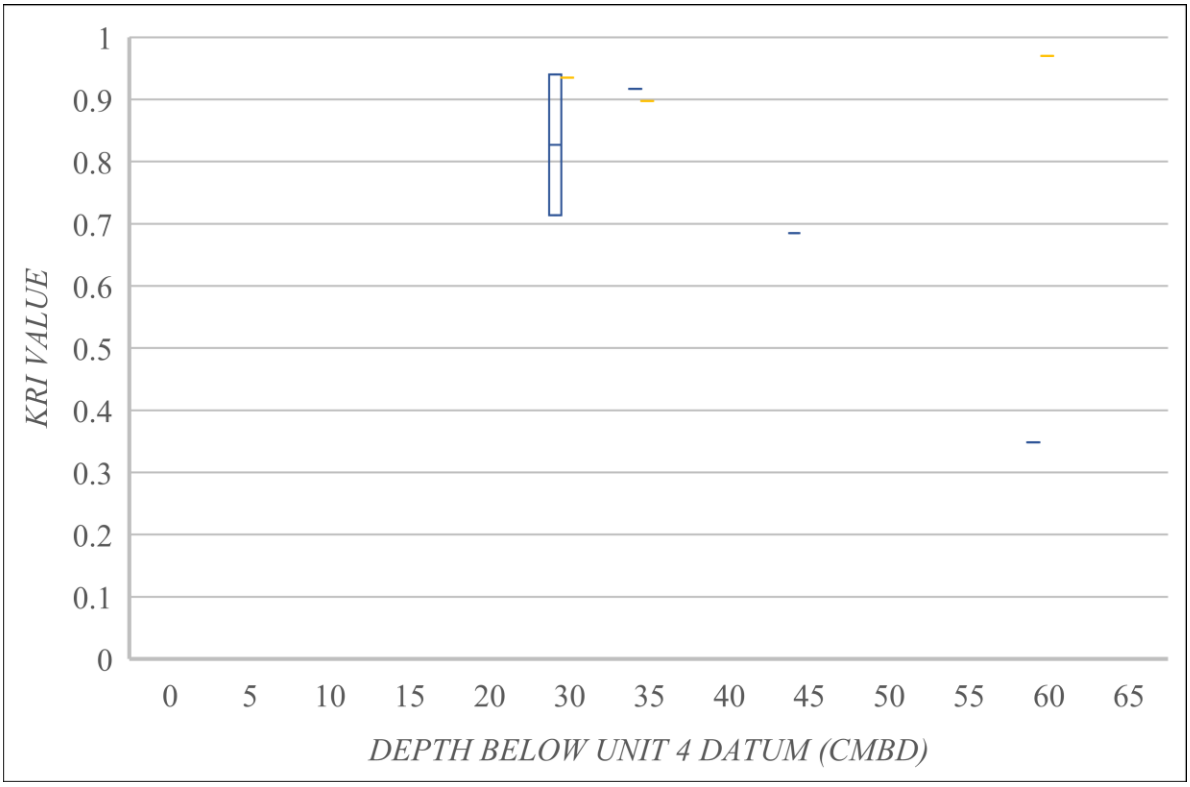


Figure 40: Showing KRI values of Flake Tools recovered from Unit 4 at varying depths below datum.

All flake tools found within Unit 4 had either one or two worked edges (Figure 40). While the majority of artefacts were associated with a mean KRI of 0.75 or higher, one artefact (A66) features a worked edge with a KRI of 0.3485. It can be assumed that mean KRI within Unit 4 remains relatively static at varying depths, with one notable exception at 60cmbd. Within Unit 5, flake tools were only observed at Level 3 (20cmbd). The mean KRI of all artefacts was 0.7 or greater; however, variation over time cannot be assessed in this case.

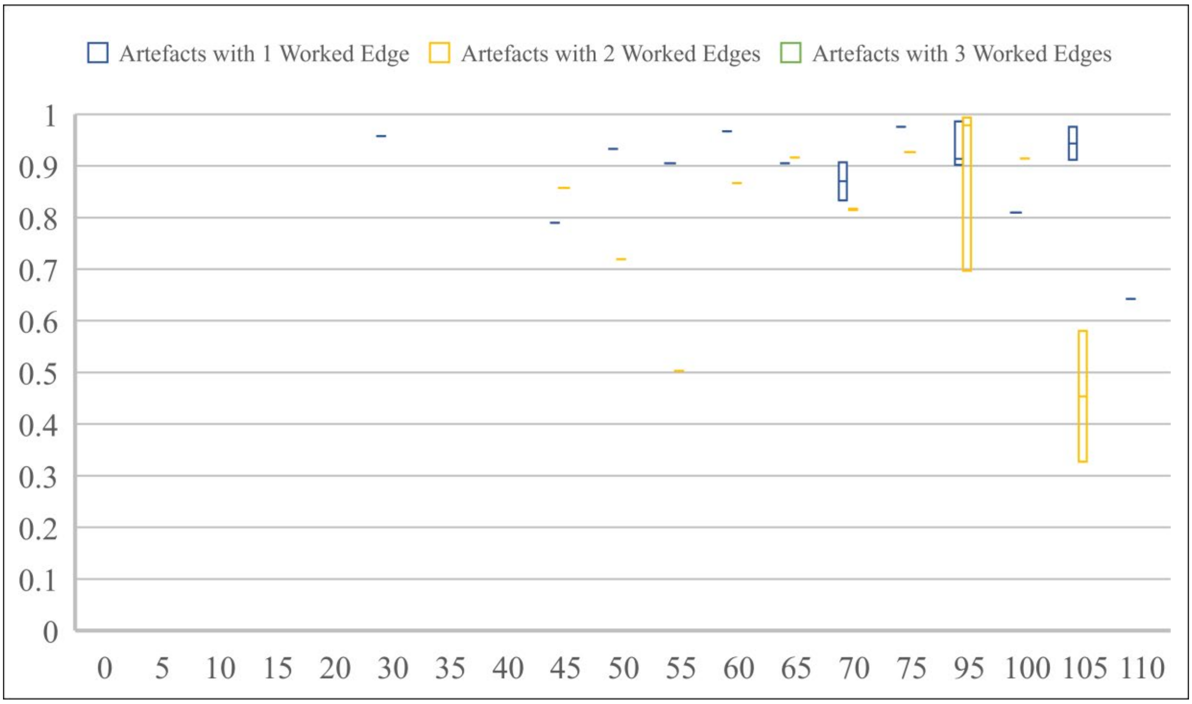


Figure 41: Showing KRI values of Flake Tools recovered from Unit 7 at varying depths below datum.

As observed in the assemblages of other Units here assessed, flake tools of Unit 7 (Figure 41) have been calculated as having a mean KRI above 0.7 in most cases. However, a general decrease in mean KRI is observed from 105cmbd; in this case, mean KRI of artefacts found in Unit 7 remains static until 105cmbd, where a decrease is observed.

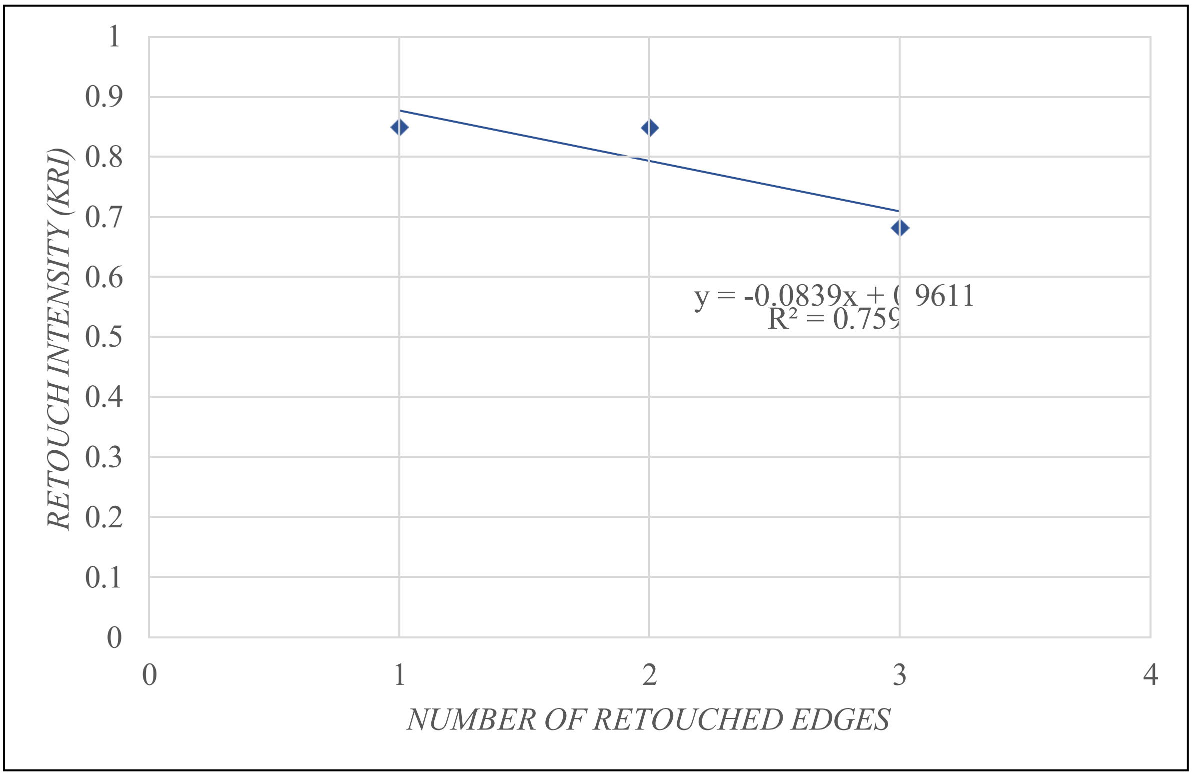


Figure 42: Indicating the relationship between KRI and number of retouched edges present on artefacts retrieved from Soyo, northern Mongolia.

A negative correlation is observed between the number of worked edges present on an artefact and it's KRI (Figure 42); the relationship between these factors has been calculated to be statistically significant ($p = .00001$) when considering a significance level of $\alpha = 0.05$. There is a strong negative correlation between these results (-0.0882).

4.4.5 : ASSEMBLAGE DIVERSITY

Simpson's Diversity Index (SDI) has been used to compare variations in assemblage complexity both over time (as cmbd) and between Units; this will enable the characterisation of temporal and spatial changes with regards to human behaviour over time. A full review of all SDI calculations is provided in Appendix C; representations of SDI trends over time for distinct Units are shown in Figures 43 – 46.

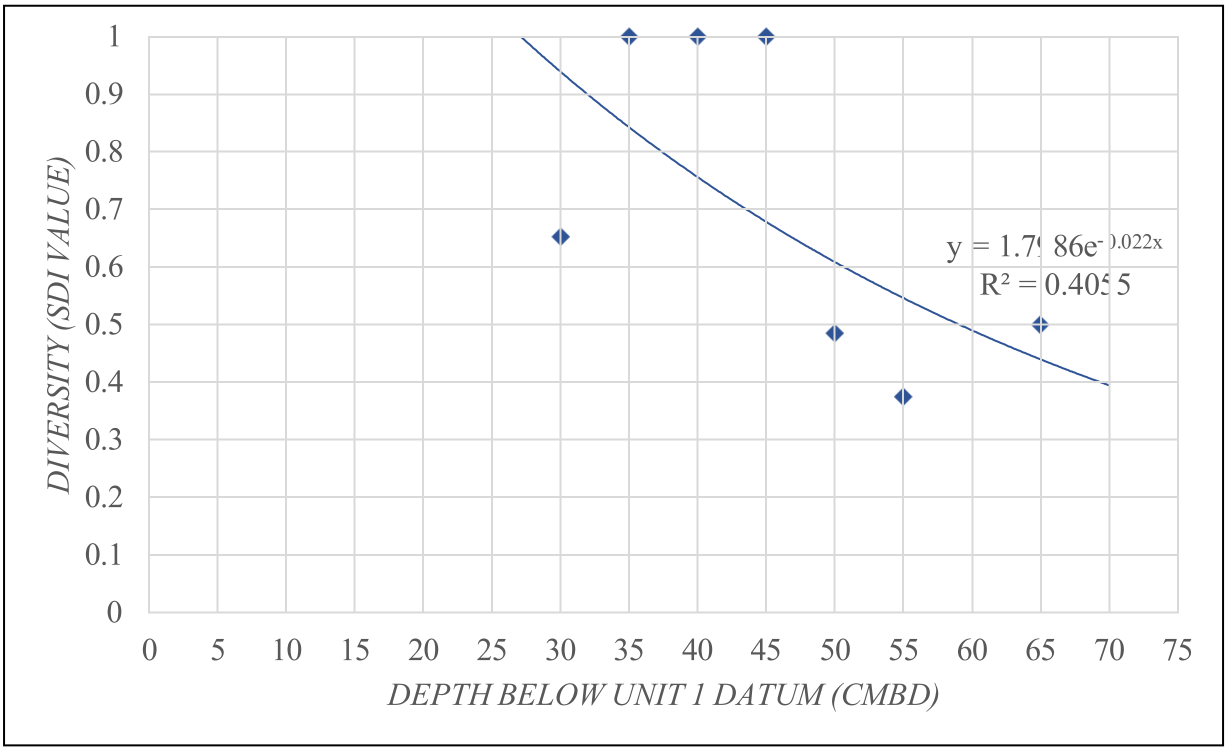


Figure 43: Variations in assemblage diversity (SDI) as observed in Unit 1, Soyo Tolgoi (north-central Mongolia).

Figure 43 indicates a negative correlation between assemblage diversity and depth below datum within Unit 1. This relationship has been found to be statistically significant (P = 0.0006) when α = 0.05. It may thus be stated that SDI increases proportionally to proximity to the surface.

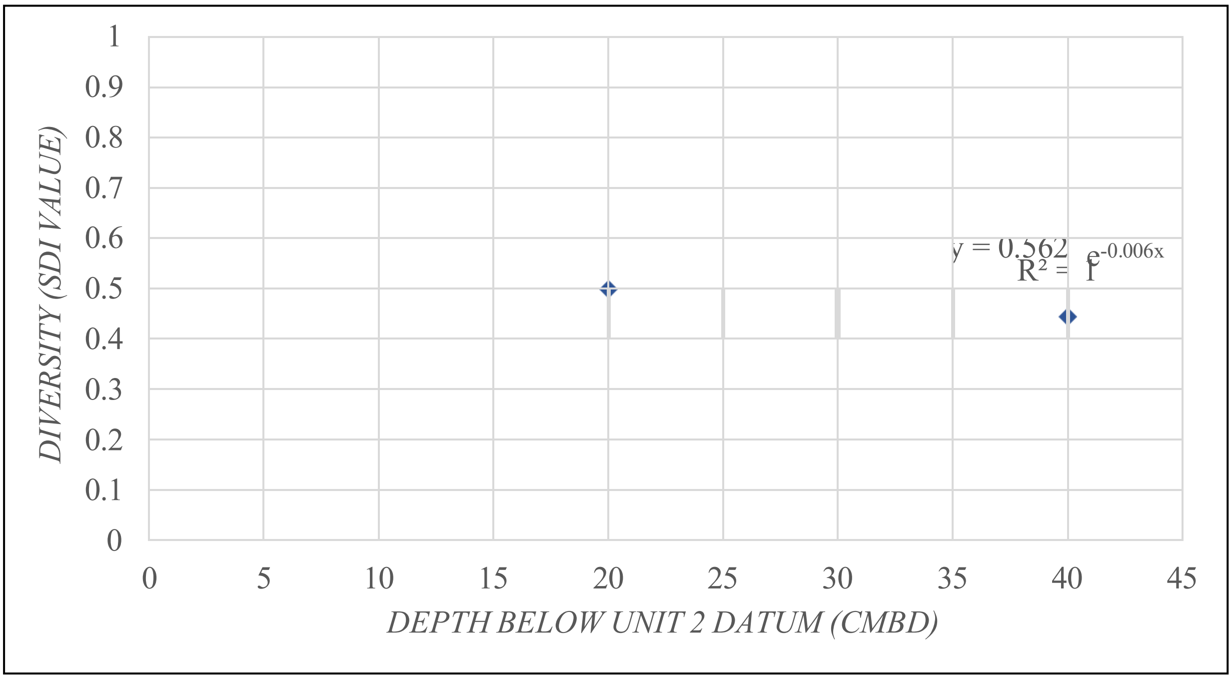


Figure 44: Variations in assemblage diversity (SDI) as observed in Unit 2, Soyo Tolgoi (north-central Mongolia).

As shown in Figure 44, there is little variation in SDI between 20cmbd and 40cmbd. This relationship is statistically significant (P = < 0.0001) when α = 0.05. It can thus be assumed that SDI increases slightly with proximity to surface in Unit 2.

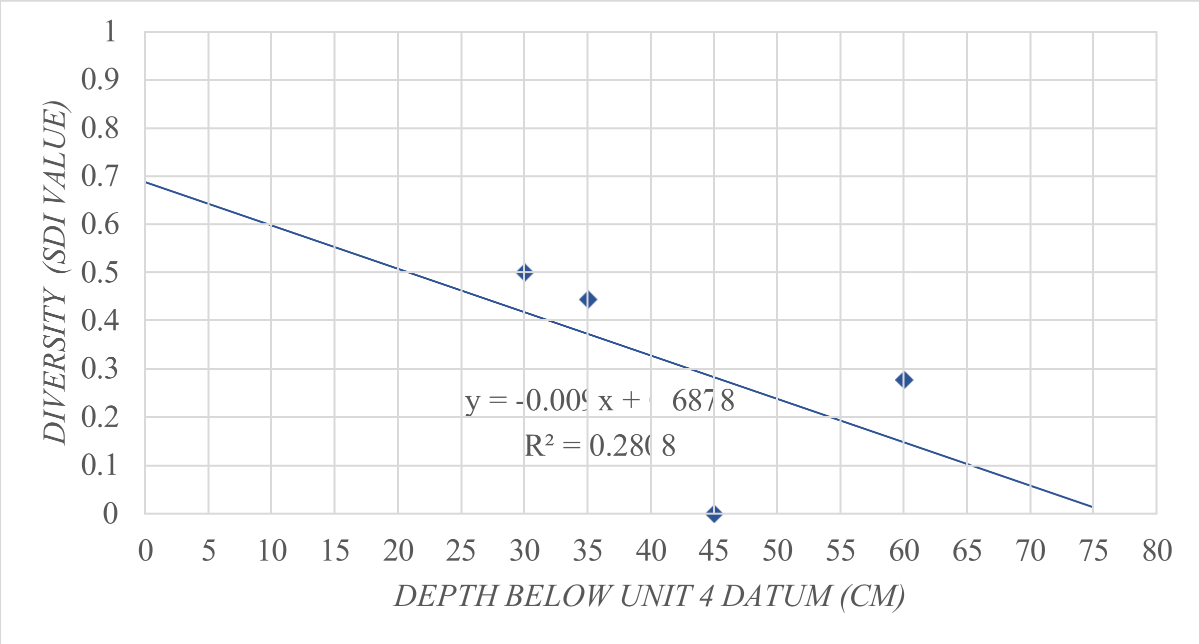


Figure 45: Variations in assemblage diversity (SDI) as observed in Unit 4, Soyo Tolgoi (north-central Mongolia).

A similar trend to that observed in Units 1 and 2 is evident when assessing the assemblage diversity of Unit 4 (Figure 45); a negative relationship exists between SDI and depth below datum. This has been calculated to be statistically significant (P = 0.2371) when α = 0.05. Assemblage diversity can thus be said to increase with proximity to surface. The relationship between deposition depth and assemblage diversity cannot be assessed for Unit 5, as stone artefacts are only observed in Level 3 (30cmbd). SDI at this depth has been calculated to be 0.2778.

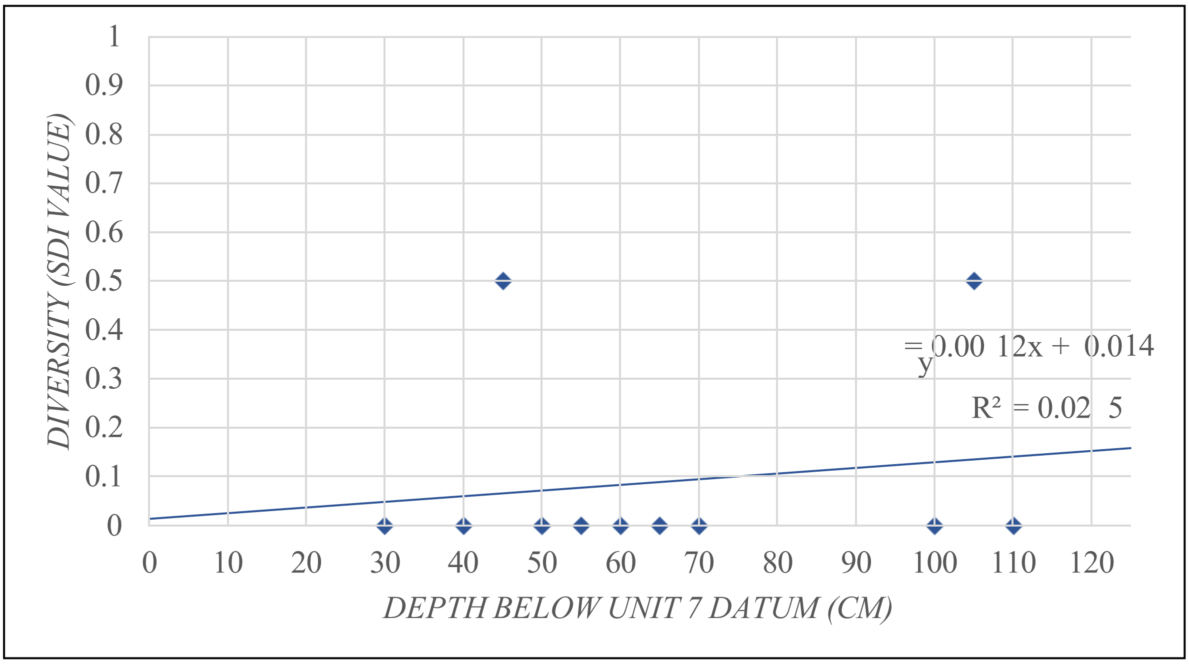


Figure 46: Variations in assemblage diversity (SDI) as observed in Unit 7, Soyo Tolgoi (north-central Mongolia).

A slightly positive correlation is observed between deposition depth and assemblage diversity when considering the assemblage of Unit 7 (Figure 46). This relationship, however, has been calculated to be statistically insignificant ($P = 0.4981$) when $\alpha = 0.05$.

Figure 47 indicates variance in assemblage diversity (calculated via the SDI) between excavation units opened at Soyo. Unit 6 has been excluded from this analysis, as assemblage diversity in this case was too low to be accurately measured. Figure 8 (Chapter 4) indicates the spatial relationship between Units. Units 1 and 2 are in close proximity to one another; the SDI of each of these is within one standard deviation ($1\sigma = 0.12$), implying a possible relationship between proximity and diversity. Units 7, 5, and 4 are located west of Units 1 and 2; SDI between these Units also appears to be similar. It is thus possible that diversity increases with proximity to the eastern extent of Soyo.

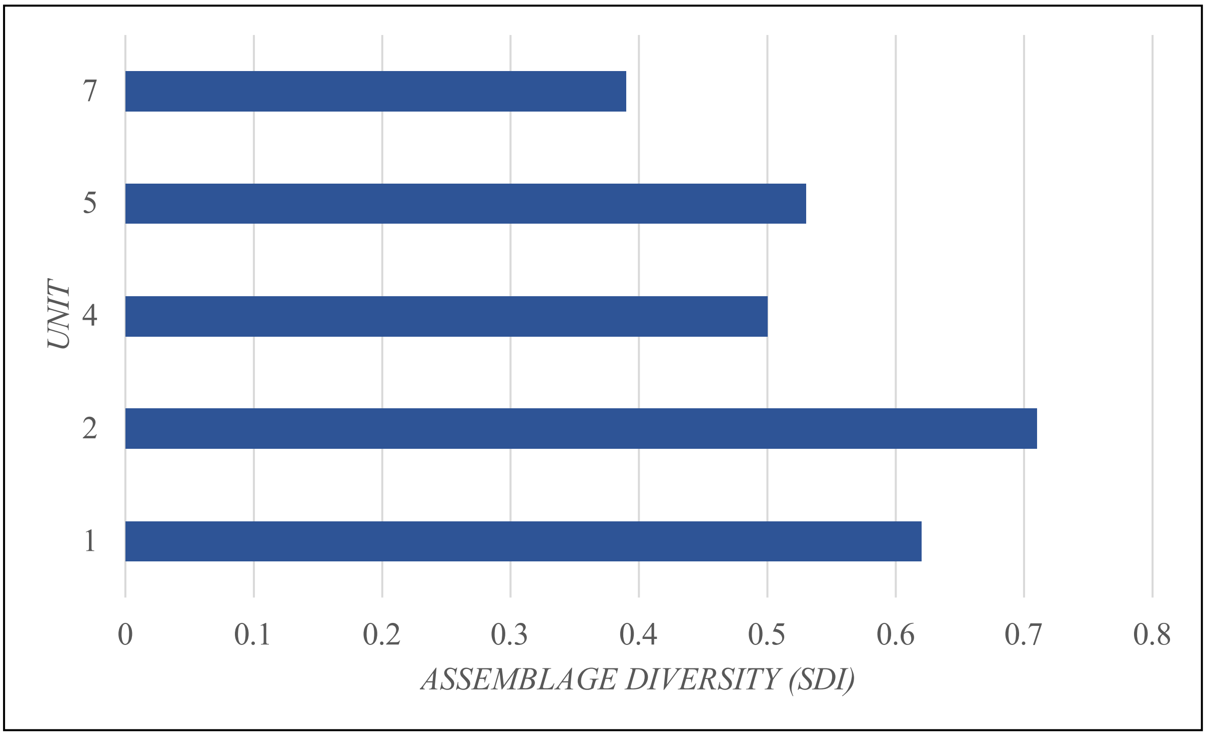


Figure 47: Indicating the assemblage diversities of various units excavated at Soyo, northern Mongolia (excluding Unit 6).

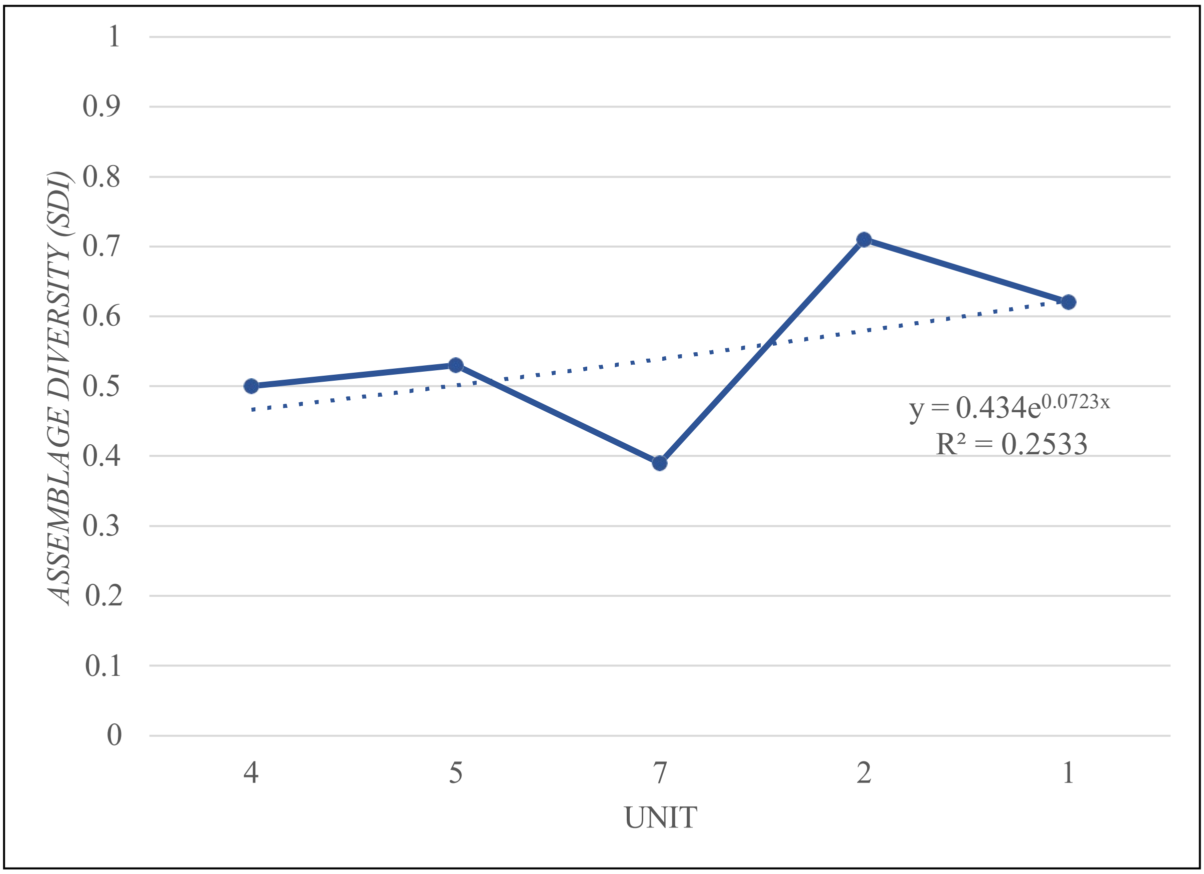


Figure 48: Showing relationship between east-westerly orientation of Units at Soyo and assemblage diversity (excluding Unit 6).

Relationships between Unit location and SDI implied in Figure 47 may be further analysed through consideration of Figure 48. A slight positive correlation is implied between Unit location and assemblage diversity; this relationship has been calculated to be statistically insignificant ($P = 0.3301$) when $\alpha = 0.05$. Thus, it cannot be confidently asserted that there is a relationship between proximity to the eastern extent of Soyo and SDI.

4.4.6 : Assemblage Formality

Formal tools have been defined as those showing evidence of intentional shaping or working for the purpose of later use (Downey 2009). Stone artefacts identified as flake tools or bifaces were selected only when such features were evident; as such, all artefacts here classified as flake tools may be considered formal. Figures 49 – 52, below, indicate the proportion of distinct Unit assemblages represented by bifaces and flake tools.

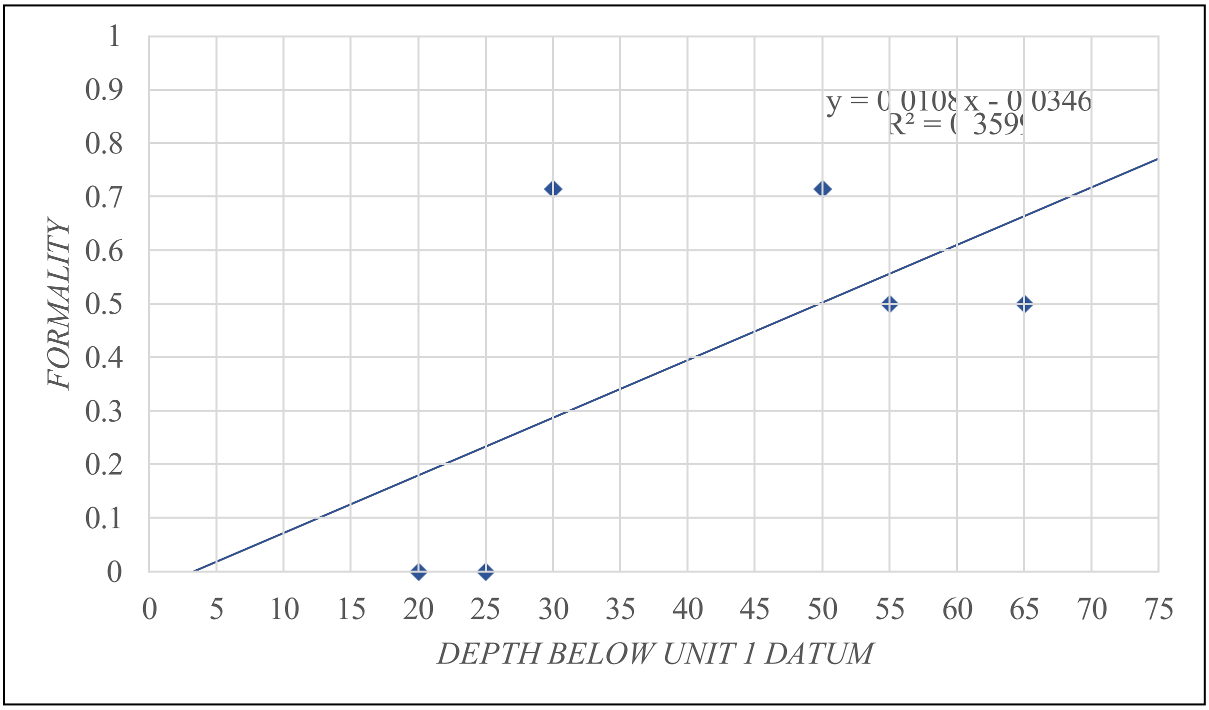


Figure 49: Showing formality of the stone artefact assemblage collected from Unit 1, Soyo (north- central Mongolia) as it relates to depth below datum.

Assemblage formality is shown to increase proportionally to depth in Unit 1 (Figure 49); this has been determined to be statistically significant (P = 0.000069) when α = 0.05. Therefore, within Unit 1, formality can be said to increase proportionately to deposition depth of artefacts.

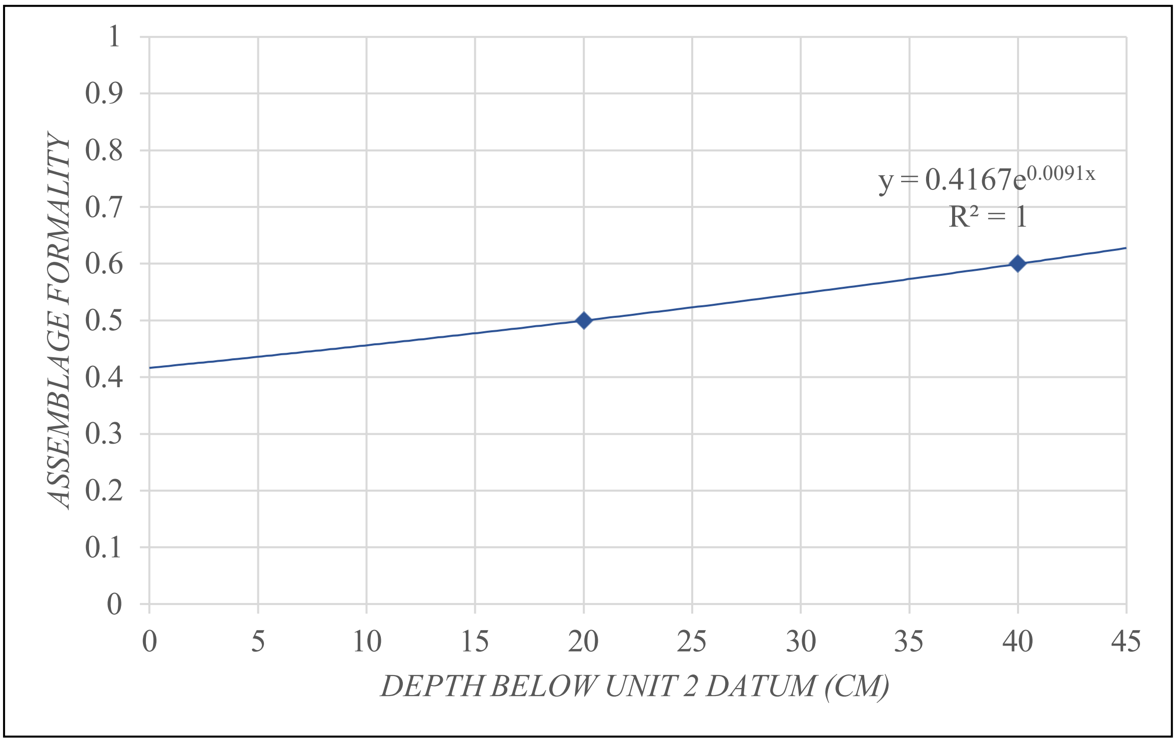


Figure 50: Showing formality of the stone artefact assemblage collected from Unit 2, Soyo (north- central Mongolia) as it relates to depth below datum.

Assemblage formality in Unit 2 (Figure 50) has been shown to increase proportionally to cmbd. This relationship has been calculated to be statistically significant (P = < 0.0001) when α = 0.05.

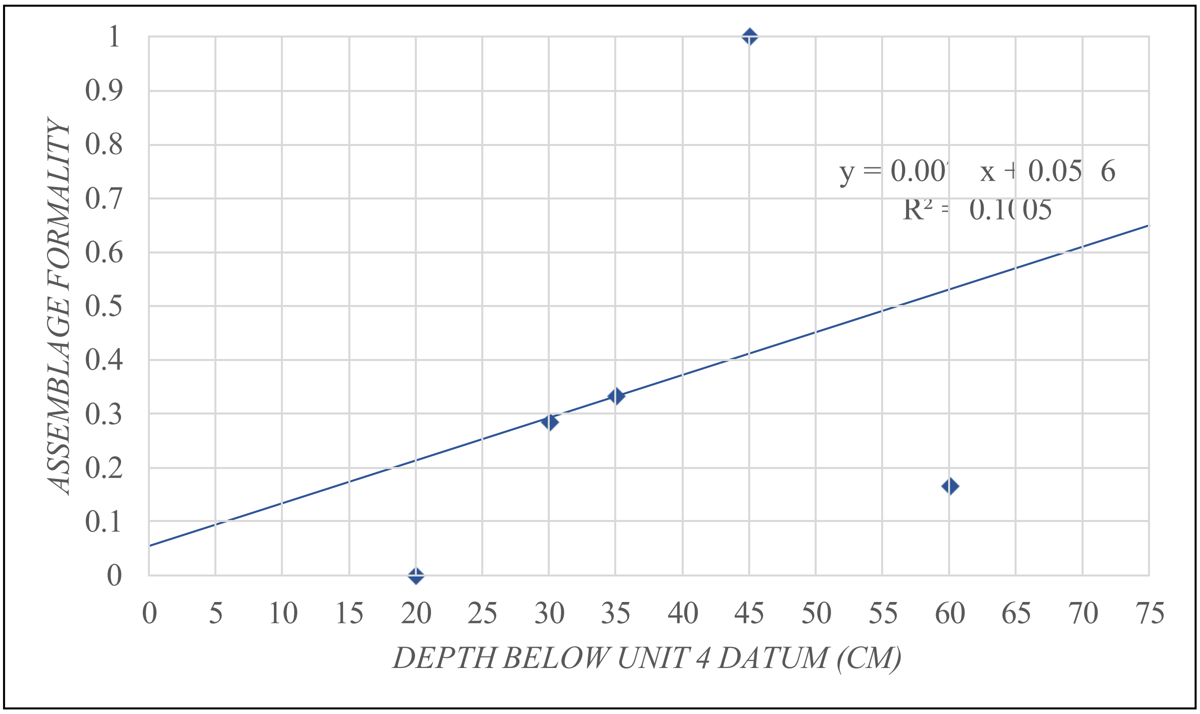


Figure 51: Showing formality of the stone artefact assemblage collected from Unit 4, Soyo (north- central Mongolia) as it relates to depth below datum.

As shown in Figure 51, assemblage formality appears to increase proportionately to depth below datum in Unit 4. This correlation has been calculated to be statistically insignificant (P = 0.1999), however, when α = 0.05. Variations in assemblage formality at different depths could not be assessed with regards to Unit 5 of the Soyo assemblage, as stone artefacts were only retrieved from 30cmbd. Lithics collected from this Level were associated with a calculated formality of 0.8715.

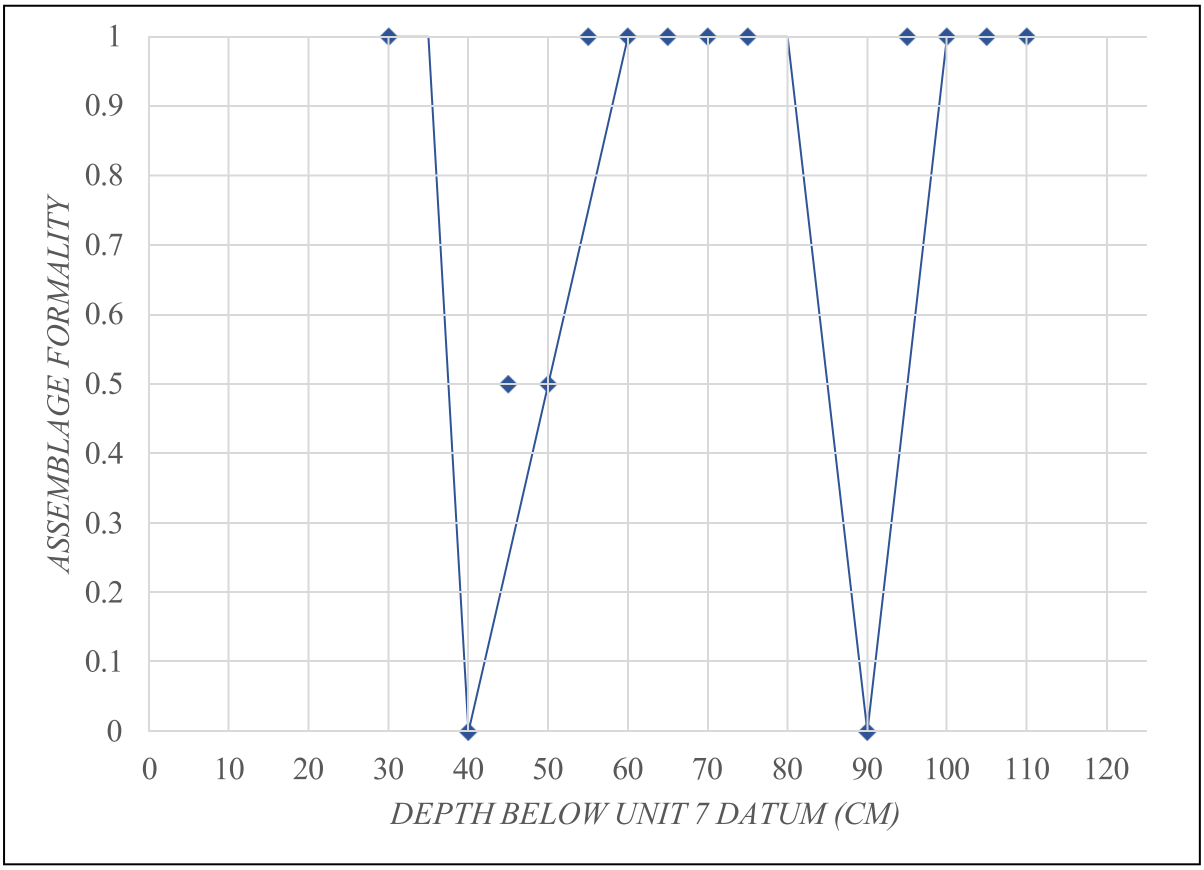


Figure 52: Showing formality of the stone artefact assemblage collected from Unit 7, Soyo (north- central Mongolia) as it relates to depth below datum

The formality of the Unit 7 assemblage appears to vary significantly over time (Figure 52). Two major plateaus can be identified, appearing from 55cmbd – 75cmbd, and between 95cmbd – 110cmbd.

The assemblage formality of individual Units has also been assessed and is represented below in Figure 50.

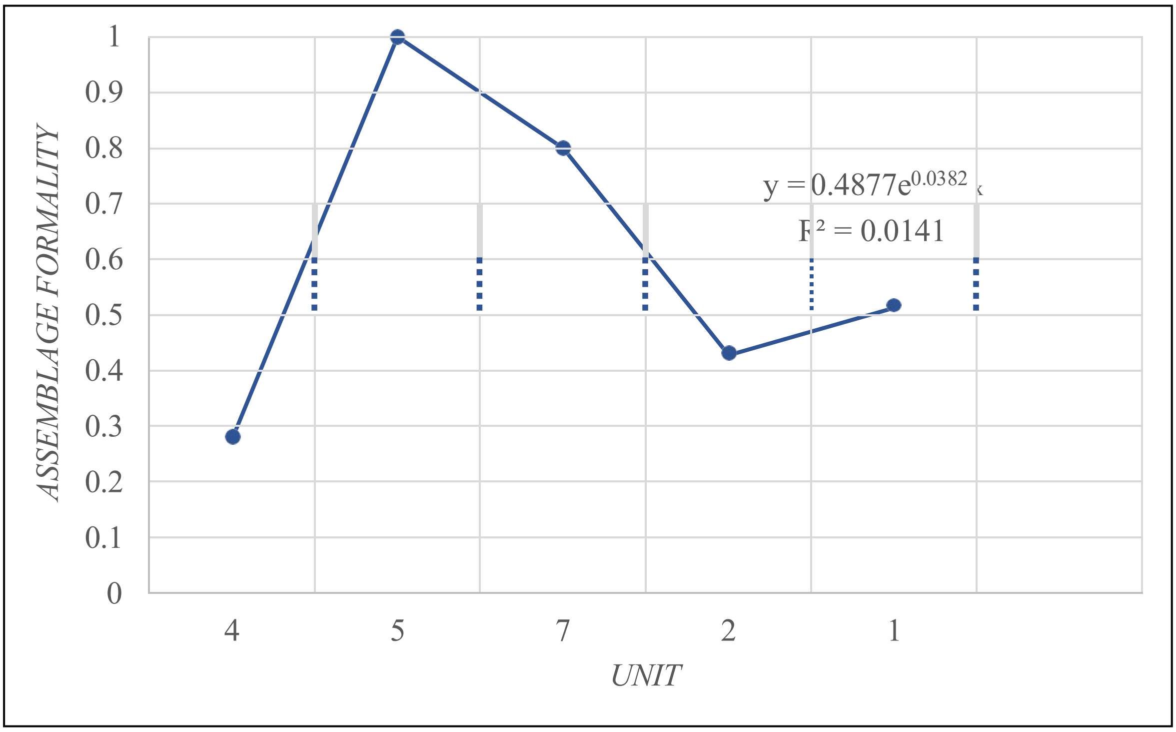


Figure 53: Indicating variations in assemblage formality between excavation units at Soyo, northern Mongolia.

Figure 53 suggests that spatially related Units opened at Soyo are not associated with a similar assemblage formality. A slight positive correlation is suggested between formality and proximity to the eastern extent of the site; however, this has been calculated to be statistically insignificant (P = 0.9127) when $\alpha = 0.05$.

4.5: Conclusion

Analysis of the stone artefact assemblage sample discussed here has allowed for an understanding of past lithic use. Macroscopic analysis has allowed for the introduction of both raw material and lithic artefact types to be identified with regards to excavation depth. The variability and potential provenance of chert samples has also been preliminarily estimated via pXRF, suggesting two possible sources of this material at Levels 6 and 7. While a negative correlation has been established between the number of worked edges on flake tools and KRI, no quantifiable change is observed over depth. In contrast, assemblage diversity appears to decrease with increasing depth, although no definitive relationship between the position of Units and SDI was identified. No relationship between formality and either depth or location was identified. The implications of these results are discussed further in Chapter 5.

CHAPTER 5: DISCUSSION

Analysis of lithic assemblages collected from Soyo, northern Mongolia, permits insight into the potential behaviours of past occupants. Key behavioural transitions are evident, suggestive of a possible date for the transition from hunter-gatherer to semi-sedentary lifestyles. However, there is much that remains to be understood regarding the behavioural trends of Darkhad occupants of the Neolithic and Bronze Age.

5.1 : THE NEOLITHIC AND BRONZE AGE AT SOYO

Analysis of the chosen lithic assemblage has allowed for several approximations of past Darkhad behaviours to be made. While there may be a variety of issues associated with these deductions, this research has enabled a clearer understanding of human mobility and technological trends around Soyo Tolgoi and may give further indications as to potential group social dynamics in the Neolithic and Bronze Age periods of the Darkhad basin.

5.1.1 : TEMPORAL CONTEXT OF THE SOYO ASSEMBLAGE

Soyo has been identified as being a Neolithic site given several diagnostic trends visible through data analysis of ceramic artefacts; a similar approach has been adopted here to confirm this hypothesis. In addition to the site age approximated by Vella (2018), the lithic assemblage of Soyo is typologically similar to that observed in other Neolithic sites throughout the country. Research conducted throughout the Gobi Desert (Farquhar 2019; Janz 2012; Janz et al. 2021; Derevianko et al. 2008; Wright 2017) has revealed the presence of microblade technologies and bifaces similar in form to those collected from the area around Soyo Tolgoi (Jennifer Farquhar 2019, pers. comm.). Many of these sites have been dated to within the Neolithic (Farquhar 2019; Derevianko et al. 2008; Wright 2017), with other assemblages representative of the transitional period between the Neolithic and Bronze

Age (Janz 2012; Janz et al. 2021). However, marked differences are also observed between Gobi Desert and northern Mongolian assemblages. Foremost is the absence of projectile points observed in the Soyo collection. Projectile points have been observed in Gobi Desert lithic assemblages (Farquhar 2019; Janz 2012; Janz et al. 2021); the implications of this technology being absent are discussed below. It should be considered, however, that Mongolia's climate and environment varies significantly throughout the country (Honeychurch 2013, 2014; Rybin et al. 2016), requiring unique socio-economic adaptions to be developed in various regions (Honeychurch 2013, 2014; Rybin et al. 2016). The presence of distinct lithic technologies in the Soyo assemblage may suggest that the site dates to the Neolithic or early Bronze Age.

Comparison between Unit stratigraphy and the work of Vella (2018) has allowed for a preliminary chronology to be established at Soyo. Several key periods (with relation to technological reliance) can be identified through analysis of the site's lithic assemblage, each of which may be associated with unique behaviours. Assemblage diversity appears to increase in most cases with proximity to the surface; bifaces are only present in the assemblages of Unit 1, Level 10 (50cmbd) and Unit 5, Level 3 (20cmbd). Comparison with the research of Vella (2018) has allowed these deposits to be preliminarily dated to 10,900 BP and 115 BP, respectively. The work of Janz (2006) suggests the introduction of bifacial technologies throughout the Gobi Desert from 5000 BP; it is possible that a similar introduction age is observed at Soyo. Similar trends are observed in raw material variability, quartz and quartzite artefacts observed once at 110 cmbd (Unit 7, Level 22), but most frequently from 50cmbd (Unit 1, Level 10) and above. It is likely that these deposits are representative of socio-behavioural change. Prior to this, the composition of lithic deposits at Soyo – both regarding artefact form and raw materials – remain largely static. Increases in chert chemical diversity (Figure 24 – 25) between 60 and 30cmbd further evidence these potential changes in behaviour. It is likely that assemblages found 50cmbd and higher within the selected sample represent period of enhanced technological innovation and potential behavioural transitions.

5.1.2 : Lithic Technologies of Soyo

The composition of the lithic assemblage collected from around Soyo Tolgoi can be used to form speculations of past human behaviour in north-central Mongolia. A number of stone artefact types frequently observed in both Mongolian and international deposits are absent in the Soyo assemblage. In addition to projectile points (discussed below), grindstones and hammerstones, documented throughout Central Asia and internationally (Andrefsky 1998; Eoin 2016; Janz 2006; Madsen 1984; Smith et al. 2015; Williams-Thorpe and Thorpe 1993) are not included in the analysed sample. Such stone artefact types have been argued to evidence seed and grass processing. Thus, their absence at Soyo may suggest that Neolithic and Bronze Age occupants of the region were not practicing these behaviours. If this is the case, groups habituating the region are likely to have relied on higher mobility occupancy patterns (Andrefsky 1991, 1994, 2008a, 2008b; Farquhar 2019; Prendergast et al. 2021; Scerri et al. 2018). This may have included the use of specialist sites for food production (Andrefsky 1991, 1994, 2008a, 2008b; Farquhar 2019; Jacomb et al. 2010; Wendorf and Goldfine 1991). Grindstones have been noted in select Neolithic deposits within the Gobi Desert, though are not universal (di Cosmo 1994; Farquhar 2019; Janz 2006; Janz 2012; Rosen et al. 2019); in numerous cases this has been interpreted as evidence of semi-sedentism (Farquhar 2019; Janz 2012; Rosenberg et al. 2016; Schneider et al. 2021). Similar lithic records in north-central Mongolia may be consecutively argued to have employed similar mobility strategies. The absence of grindstones and hammerstones in the analysed sample may be indicative of increased mobility and a lack of seed or grass processing at the site.

The employment of high-mobility habitation strategies in the Darkhad is further suggested by the presence of small-sized artefacts and evidence of artefact curation at Soyo. As shown in Figure 34, all flake tools within the assemblage had a KRI greater than 0.2; this may be evidence of increased resource provisioning. Such strategies are hypothesised to be employed to conserve high-quality materials where access to them is limited (Clark and Barton 2017; Dibble 1997; Dibble and Pelcin 1995; Hayden 1987; Newman 1994; Odell 1989, 1996; Shott 1996; Shott and Nelson 2008). This may be the case in situations wherein groups move frequently (Clark and Barton 2017; Dibble and Pelcin 1995; Hayden 1987; Newman 1994; Odell 1989, 1996; Shott 1996; Shott and Nelson 2008). As will be discussed later, this may also be symptomatic of cases in which groups are reliant on trade networks or other separated sources for materials. In addition to consistently intensive retouch in the lithic record of Soyo, flake tools observed are consistently of a small size (compared to sites internationally) (Agam et al. 2015; Pargeter and Shea 2019; Venditti 2019), with evidence of increased decortification present. This further supports theories of resource provisioning, with such strategies employed to increase the use-life of raw materials (Kuhn 2004; Kuhn and Clark 2015; Magnin 2015; Terry 2010; Thompson et al. 2014; Newman 1994; Schoville et al. 2021). Similar behaviours are observed in contemporary nomadic groups in northern Mongolia (Fijn 2011), further supporting these arguments. Previous studies into the region surrounding Soyo Tolgoi have drawn parallels between contemporary and past Darkhad occupants, with similar conclusions being drawn regarding the likelihood of semi-pastoralist behaviours (Clark and Crabtree 2015; Fitzhugh 2002, 2008; Honeychurch 2013, 2014). Hightened KRI and small artefact sizes in the lithic assemblage of Soyo may be argued to evidence high-mobility strategies in the Darkhad's Neolithic.

Figure 54: A18 - example of a microblade as observed in the lithic assemblage of Soyo, northern Mongolia.

As aforementioned, no projectile points were observed in the studied lithic sample; this is likely representative of the behaviours being undertaken by past occupants of the Soyo Tolgoi region. The presence of projectile points is often interpreted as evidence of hunting (Andrefsky 2008c; Bousman 1992; Carlson and Magne 2008; Chatters 1987; Flenniken and Raymond 1986; Harper and Andrefsky 2008; Janz et al. 2017; Knecht 1997; Thomas 1986; Watts 2013); thus, their absence in the collection discussed here may be interpreted by some as representative of a lack of hunting behaviours. However, the presence of abundant and protein-rich species is observed in dated Neolithic assemblages of the area (Arzhannikov et al. 2012; Honeychurch 2010, 2013, 2014, 2015; Taylor 2017; Taylor et al. 2015); exploitation of such resources is likely given their high accessibility. The assumption that hunting was not practiced also ignores the presence of microblade technology in the Soyo assemblage. The analysis typology here employed has omitted secondary flake tool types such as microblades; however, several of these were included in the analysed assemblage (Figure 54). Such forms are typically observed in central Asian assemblages (Gladyshev et al. 2012; Smith 1974) and are likely to have been inclusions in weaponry (Coutouly 2018; Gladyshev et al. 2010, 2012; Kato 2017; Smith 1974), allowing for hunting. The absence of identified projectile points in the selected sample of Soyo does definitively evidence that no hunting behaviours were undertaken in the area.

Employment of the Yubetsu technique (Goebel and Buvit 2011; Ineshin and Tetenkin 2017) is evident in the assemblage of Soyo; this is expected given the frequency of such technologies throughout Europe and Asia (Clarkson 2007; Goebel and Buvit 2011; Ineshin and Tetenkin 2017; Lycett and Bae 2010; Lycett and Norton 2010; Newcomer et al. 1986). The application of Yubetsu reduction is valuable in assessments of national mobility patterns and knowledge diffusion. The spread of microblade technologies throughout Eurasia is the subject of critical debates among archaeological researchers and is suggestive of a sudden and widespread information dispersal on a continental scale (Clarkson 2007; Gladyshev et al. 2005; Goebel and Buvit 2011; Ineshin and Tetenkin 2017; Lycett and Bae 2010; Lycett and Norton 2010; Newcomer et al. 1986). The region has been described as a likely "seedbed for behavioural innovations" (Rybin et al. 2016:70) given the need for its inhabitants to adjust to perpetually changing conditions (Honeychurch 2013, 2014; Rybin et al. 2016); innovative production techniques that would assist in adaption to changing environments would thus be invaluable to Neolithic occupants throughout the country. The emergence of the Yubetsu technique in north-central Mongolia should thus be considered when approximating information dispersal routes, and potential routes of past migrations throughout Eurasia.

5.1.3 : Soyo Tolgoi and the Neolithic-Bronze Age Transition

Trends observed in the lithic assemblage of Soyo may relate to crucial behavioural transitions observed throughout Mongolia, particularly those that may be dated to the Neolithic-Bronze Age transition (NBAT). Studies conducted throughout central Mongolia and the Gobi Desert have observed the mass diversification of archaeological assemblages around the NBAT (Allard and Erdenebaatar 2005; Burentogtokh 2017; Houle 2010; Jeong et al. 2018; Liu et al. 2016; Schneider et al. 2016; Wright 2017; Zhao et al. 2021). Houle predicts that this period is likely to have been characterised by the "advent of social complexity" (2019:1). Researchers studying this vital transition zone have attributed it with the onset of agricultural pastoralism (Wright 2017; Zhao et al. 2021) and a marked increase in sedentary behaviour (Zhao et al. 2021). Debates regarding the Neolithic emergence of widespread technologies are observed in Mongolian academic circles (Park et al. 2018; Rybin et al. 2016; Taylor 2014, 2017; Taylor et al. 2015), often centred around the spread of technologies through northern Mongolia. The presence of microblade technologies and evidence of technological evolution at Soyo is significant in this case and may be suggestive of widespread communication routes throughout Eurasia (Rybin et al. 2016). However, it is noted that lithic technologies of the Bronze Age are little understood in Mongolian archaeology (Houle 2016); the sample analysed will benefit the Mongolian stone artefact record.

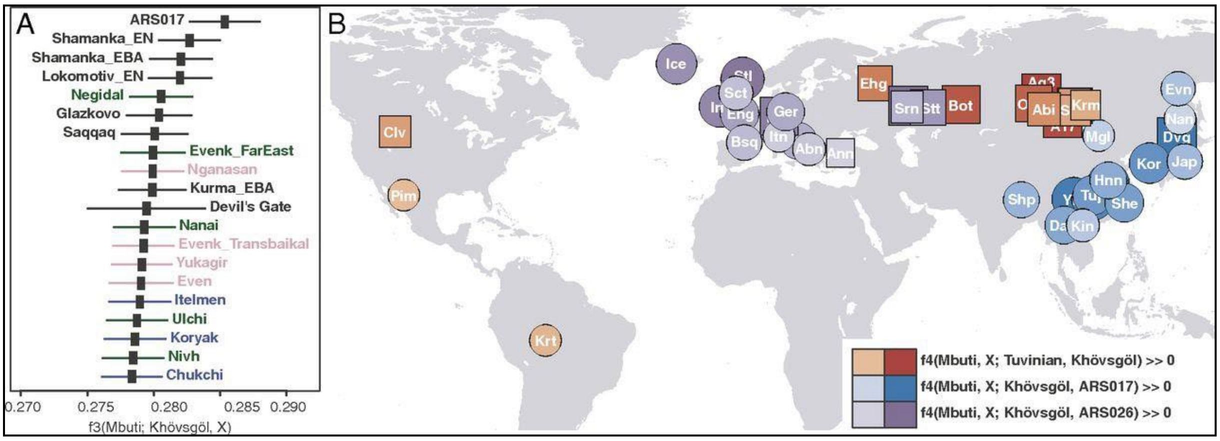


Figure 55: Indicating the spread of discrete genetic clusters in H. sapiens, one of many significant changes associated with the NBAT. From Jeong et al. 2018:E11251. Reprinted with permission from Elsevier.

This transition is not only seen in contemporary Mongolia, but throughout Eurasia (Allard and Erdenebaatar 2005; Houle 2019; Schneider et al. 2016; Wright 2017; Zhao et al. 2021) (Figure 55), with debates over its character having international significance. The period is associated with increased sedentism (Burentogtokh 2017; Houle 2016; Schulting and Richards 2016; Spengler 2015; Vanwezer et al. 2021; Zhao et al. 2021), which may be evidenced in lithic assemblages by low raw material variability, a low assemblage formality, and a high assemblage diversity (Andrefsky 1991, 1994, 2008a, 2008b, Bradbury and Carr 2004; Elston and Brantingham 2002; Farquhar 2019; Goldstein 2019; Jeske 1992; Pecora 2002, 2003; Watts 2013). The emergence of the Bronze Age in Mongolia's archaeological record has been highlighted by many as a period of immense social and behavioural change and is associated with key models implemented worldwide.

As previously discussed, (Chapter 2), artefact-rich deposits at Soyo are associated with distinct paleosols observable in site stratigraphy that have been attributed to the Mongolian Bronze Age (Julia Clark pers. comm. 2018, 2019). The high number of artefacts observed from 55cmbd (Units 6 and 7, Level 11; corresponding Levels in other Units show similar results) is likely to coincide with these deposits; approximations of site age provided in Chapter 4 suggest this may be attributable to the onset of the Bronze Age. If this is indeed the case, it acts as secondary evidence for an observable transition between the Neolithic and Bronze Age at Soyo and confirms the site's importance to researchers of the NBAT (Allard and Erdenebaatar 2005; Houle 2019; Schneider et al. 2016; Wright 2017; Zhao et al. 2021). Despite this valuable coincidence, microblade technology has been observed throughout the Soyo assemblage at all levels and is not restricted to excavation Levels currently associated with the Bronze Age. While distinct socio-cultural and mobility-related changes are observable in the archaeological record of Bronze Age Soyo, a sudden emergence of microblades (often attributed to the NBAT) is not (Allard and Erdenebaatar 2005; Houle 2019; Schneider et al. 2016; Wright 2017; Zhao et al. 2021). Mongolia has previously been suggested as the birthplace of widespread lithic assemblage developments across Eurasia, however, (Gladyshev et al. 2010, 2012; Smith 1974; Rybin et al. 2016) on the basis of this dataset, the consistent presence of microblade technologies throughout Soyo's history supports these theories. Increases in assemblage size coincide with the onset of Mongolia's

Bronze Age and may be indicative of international changes having originated within the country.

5.1.4 : Applicability of the Soyo Assemblage to Behavioural Models

Evidence of increased sedentism in the lithic assemblage of Soyo has been observed, however, the accuracy of these results may be questioned. Collections obtained from 50cmbd and above at Soyo evidence increased sedentism when compared with the expectations of Andrefsky, which suggest that increased sedentism should be accompanied by a decrease in raw material variability (Andrefsky 1991, 1994, 2008a, 2008b; Bradbury and Carr 2004; Elston and Brantingham 2002; Farquhar 2019; Goldstein 2019; Jeske 1992; Pecora 2002, 2003; Watts 2013). Expansion of the raw material record, as observed from significant levels in the analysed sample, however, is contrary to the expectations of such researchers. It is argued here that while increased raw material availability is not traditionally associated with increased sedentism, increased reliance on native resources (quartzite, quartz, naturally occurring at Soyo) rather than those imported from outside sources (chert) may suggest decreased mobility and the possibility of longer site habitation. Assemblage formality is difficult to assess in this case, given a lack of obvious correlation between level depth and formality trends in many cases. While trends are observable in most assemblages, no uniform trend between all trenches has been observed at varying depths (Figure 49 – 52); there appears to be significant variation in the proportions of formal tool types. The assemblage of Soyo can be argued to be representative of the NBAT, despite deviations from Andrefsky's often-applied model (Andrefsky 1991, 1994, 1998, 2008a, 2008b; Bradbury and Carr 2004; Elston and Brantingham 2002; Farquhar 2019; Goldstein 2019; Jeske 1992; Pecora 2002, 2003; Watts 2013).

Flake tool analysis via the KRI has been applied here to assess the degree of material provisioning in the Neolithic and Bronze Age of Soyo, in comparison with relative percentages of decortication. Intensive reduction of artefacts may suggest resource curation as discussed by Binford (1980), which in turn are often indicative of higher reliance on long-term habitation sites and decreased mobility (Bleed 1986; Binford 1980; Chatters 1987; Jeske 1992; Kuhn 1991). This is the likely case for artefacts found at Soyo Tolgoi, when compared with observable increases in raw material variability and assemblage diversity (discussed below). Rybin et al. (2016), however, notes that this is common in northern Mongolia, with heightened numbers of intense reduction notable in relevant sites; he associates this with increases in site frequency. If the models of Andrefsky (1991, 1994, 2008a, 2008b) and Binford (1980; Bleed 1986; Chatters 1987; Jeske 1992; Kuhn 1991) are accurate to Mongolia's history, this may suggest a widespread adoption of increasingly sedentary lifestyles. The lack of available data concerning the Darkhad and north-central Mongolia must be remembered in this case, and claims of widespread behavioural changes are only implied at the area surrounding Soyo Tolgoi until further investigation is undertaken. Investigation of the Soyo lithic assemblage suggests a possible transference to increasingly sedentary lifestyles as represented in all Units above 50cmbd.

Assemblage diversity in this case appears highly varied, which may be suggestive of the formation of a reliable toolkit employed by numerous generations of previous occupants of north-central Mongolians. This is in line with the suggestions of Honeychurch (2010, 2013, 2014, 2015) who argues for complex social systems that survived over extensive periods of time. The lack of apparent trends in variability may be perceived as evidence of such systems, given the significant environmental diversity inherent to Mongolia (Arzhannikov 2012; Gillepsie et al. 2008; Honeychurch 2013, 2014; Rybin et al. 2016). In such circumstances, it may be expected that lithic toolkit composition would vary to adapt to variations in climatic and environmental conditions (Buvit and Terry 2011; Derevianko and Pääbo. 2007; Hiscock 2013, 2015; Janz 2006; Will et al. 2013; Young 1994; Yue et al. 2020; Zhao et al. 2021). Variations in the climatic and environmental character of Soyo, however, are not obvious when analysing the lithic assemblage alone. It is here suggested that wider sociocultural traditions may have impacted on assemblage constitution observed in the Darkhad; there is significant evidence of long-standing cultural traditions within this and nearby regions (Allard and Erdenebaatar 2005; Clark and Crabtree 2015; Ėnkhtör et al. 2018; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Honeychurch 2013, 2014; Houle 2010; Makarewicz et al. 2018; Park et al. 2010; Taylor 2017; Taylor et al. 2015b; Seitsonen et al. 2018; Zwyns 2014), confirming the possibility of cultural influence on toolkit composition over time. Further research into the archaeology of the Darkhad is required to best understand the homogeneity of assemblage variability perceived at Soyo, however sociocultural impacts are potentially a significant factor.

5.2: RAW MATERIALS VARIABILITY AND IMPLICATIONS FOR NEOLITHIC AND BRONZE AGE BEHAVIOURS AT SOYO

While chert is ubiquitous in the archaeological record of Soyo, multiple raw materials have been identified in the lithic sample analysed. Reliance on various raw materials may be indicative of changing access to higher-quality materials, though may also be suggestive of changing socio-political environments (Andrefsky 1991, 1994; Honeychurch 2013, 2014; Rybin et al. 2016). Figures 18 – 20 provide an indication of this, however there are significant limitations associated with this method of analysis (macroscopic without supporting microscopic data) (Andrefsky 1991, 1994, 2005, 2008a, 2008c; Marreiros et al. 2015; Moss 1983; Nance 1971; Odell 1975; Odell and Odell-Vereeken 1980). Chert is evidently depended upon most significantly, being present in all excavation levels at the site.

However, below 50cmbd, chert is used exclusively; in later deposits diversification of the raw material record is evident. pXRF analysis reveals increased raw material variation between 25cmbd and 50cmbd, which may imply reliance on novel chert sources. Diversification of the raw material record of Soyo is evident around from 50cmbd (in Units 6 and 7; evidence from other Units does not contradict this claim), with the chemical composition of chert appearing to vary from 60 – 30 cmbd and later according to pXRF results.

Most stone artefacts collected from the Soyo site (69.79%) were composed of black chert. However, current geological and archaeological studies have failed to identify a local source of chert (Derevianko et al. 2008; Gillepsie et al. 2008; Julia Clark 2018, 2019, pers. comm.; Vella 2018). pXRF results (see Chapter 4) suggest a high degree of similarity between black chert samples, which may be indicative of their procurement from a spatially limited region. Theories developed by Andrefsky (1991, 1994, 2008a, 2008b, 2008c) may be applied here to suggest mobility patterns based on these lithological relationships. The temporal organisation of major typological changes is akin to that seen in analysis of assemblage variability and formality, with Levels above 55cmbd (Unit 6, Level 11 typifies this) again evidencing changes in raw material access. It is suggested that earlier periods in Soyo's history were characterised by increased mobility and the procurement of chert from significant distances; increased sedentary behaviours may then have coincided with the formation of chert trade networks throughout the region (discussed below). The formation processes underlying the generation of chert and similar materials, however, is highly susceptible to contamination, and significant chemical variation is often noted between cores removed from the same outcrop (Chakrabarti et al. 2012; Malyk-Selivanova et al. 1998; Stewart et al. 2020; Reynolds et al. 2007). This must be considered when formulating speculations about hominin movement and trade networks involving this material.

Quartzite was identified as a secondary major raw material relied upon by early Darkhad occupants. Quartzite deposits have been observed in the area surrounding Soyo, although the distance between the site and quartzite outcrop have not been outlined (Clark et al. 2015, 2016, 2017, 2018). However, quartzite artefacts only become evident from between 55cmbd (Unit 6, Level 11). This is again likely representative of sporadic mobility patterns, with a more restricted area being used that may have forced Soyo’s inhabitants to rely more heavily on local resources. Quartz, similarly, only becomes evident in the archaeological record from 55cmbd (Unit 6, Level 11) and does not appear after 50cmbd. Chert has been depended upon as a raw material over the entirety of Soyo’s lithic history and is known to be a suitable rock type for lithic manufacture (Andrefsky 1994, 1998; Clarkson 2007; Flenniken 1980; Goodman 1944; Luedtke 1992; MacDonald 2008). With such a high-quality material available, it is possible that increased reliance on quartz sources at Soyo was not perceived to be necessary by Neolithic and Bronze Age occupants (Andrefsky 1994, 2008c; Blades and Adams 2008). An abundant raw source of chert with pre-established accessibility may have been seen as an advantageous alternative to a singular quartz outcrop of unknown workability (Andrefsky 1994, 2008c; Blades and Adams 2008; Jones et al. 2003), promoting the ongoing exploitation of chert sources over locally available quartz. The quality of chert as a raw material for lithic manufacture may have encouraged past Neolithic occupants of the Darkhad to continue relying upon it over locally available materials.

Alternative explanations for the neglect of quartz as a lithic raw material at Soyo are also possible; the behavioural traits associated with nomads and semi-pastoralists must be considered, as well as perceptions of quartz being a low-quality raw material. Excavation of Unit 1 revealed an artefact composed of quartz fragments in a sand matrix, unlikely to have been knapped in a controlled manner given the high frequency of imperfections included (Andrefsky 1994, 1998; Flenniken 1980; Luedtke 1992; MacDonald 2008). As a result, similar materials may have been subsequently viewed as being insufficient for lithic manufacture. Finally, completed chert artefacts may have been transported into the site prior to use; this would be in line with theories of social organisation in semi-sedentary communities (Bettinger 2013; Brumm and Rainey 2011; Clark and Crabtree 2015; Clarkson 2007; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Flenniken 1980; Henrich 2004; Honeychurch 2010, 2013; Honeychurch and Makarewicz 2016; Jeske 1992; Lycett and Bae 2010; Taylor 2014, 2017; Taylor et al. 2015a, 2015b, 2019). These societies are characterised by the seasonal use of resource-rich occupation sites, travelling between regions (Clark and Crabtree 2015; Fitzhugh 2002, 2006; Fitzhugh and Bayarsaikhan 2010; Taylor 2017). A neglect of quartz sources at Soyo is unlikely to be representative of generally higher mobility for such communities, and chert may have been a more accessible raw material in such cultural conditions. The behaviours of semi-pastoralists must be considered when analysing the lithic assemblage of Soyo.

The presence of quartz artefacts in the Soyo Tolgoi area is geologically typical of the Darkhad; however, iron-rich ochre inclusions as observed in A06 have not been noted in previous studies investigating the region (Clark and Crabtree 2015). Quartz is abundant at Soyo, with outcrops occurring naturally throughout the area (Julia Clark pers. comm. 2018, 2019; Clark et al. 2016). Ochre-painted surfaces have also been found in burials, though many of these have been dated to the Paleolithic period (Derevianko et al. 2013; Kovalev and Erdenebaatar 2009; Ochir et al. 2010). From these examples, it is evident that ochre paintings comprise a valuable component of Mongolia's cultural traditions; however, the north-central regions of the country are little understood in this regard. Limited studies have been undertaken analysing rock art in northern Mongolia (Fitzhugh 2006; Jacobson-Tepfer 2006, 2013; Vanwezer et al. 2021), with the most significant examples being associated with the DSK tradition (Fitzhugh 2006; Jacobson-Tepfer 2013, 2015; Rozwadowski 2018; Vanwezer et al. 2021). Accessibility of ochre at Soyo would be beneficial to creators of these monuments. While being chemically similar to natural chert deposits at Soyo, it is possible that this ochre-rich sample has been procured elsewhere and introduced to the site. Further research is advised in this regard. The presence of quartz with ochre inclusions should be considered for its significance to researchers of the Mongolian Neolithic and Bronze Age.

5.2.1 : Trade networks in the Neolithic of the Darkhad

As alluded to previously, the presence of non-local chert in the area surrounding Soyo Tolgoi may be interpreted as evidence of extensive trade works and increased mobility of past settlers. This is supported by extensive historical and archaeological evidence highlighting Mongolian communities as crucial participants in the Silk Road trade network (Allard et al. 2002; Honeychurch 2010, 2013, 2014; Miller 2011, 2012, 2014; Miller et al. 2018; Park et al. 2011, 2016; Rogers 2012; Rybin et al. 2014, 2016; Sabloff 2011; Wright et al. 2008), particularly during the Xiongnu period. The establishment of extensive trade networks is a crucial prerequisite to such behaviour. In addition, the social complexity of semi-pastoral communities has been described ethnographically (Fijn 2011; Fitzhugh 2002, 2006, 2010; Honeychurch 2010, 2013, 2014; Honeychurch and Makarewicz 2016; Kaifu et al. 2015; Maringer 1963; Park et al. 2016; Rogers 2012; Salzman 1978; Vainshtein et al. 1983). It is likely that the Mongolian Neolithic was similarly characterised by such communication pathways, particularly given that the emergence of complex social structures is often associated with this period (Houle 2019; Taylor 2017). When considering the presence of non-local raw materials at Soyo, it is valuable to also keep such information in mind. While the tendencies of semi-pastoralists and the likelihood of groups to rely on known reliable sources is significant, trade networks may have affected the constitution of lithic assemblages in north-central Mongolia.

5.3: CONCLUSION

The site of Soyo (northern Mongolia) has yielded stone artefacts whose analysis has allowed for characterisation of past lifeways, and for the identification of crucial transition periods in the history of Mongolia's Darkhad. While the sample selected for analysis is relatively small, and the archaeological record would benefit from much further research being undertaken, theories regarding raw material usage, social complexity, and group mobility may be estimated. These are significant discoveries for north-central Mongolian archaeology given the sparsity of available research; it is hoped that this research will benefit our understandings of the area.

CHAPTER 6: CONCLUSION

The stone artefact assemblage retrieved from the surrounds of Soyo Tolgoi, northern Mongolia, has allowed for approximations of past nomadic lifeways to be made. The analysis provided here is sufficient to initiate important discussions regarding Mongolia's past and for archaeological researchers to gain an appreciation for the complex and ever-evolving history of the Darkhad.

Lithics collected from the area surrounding Soyo Tolgoi have provided insight into the NBAT, a crucial transition period frequently discussed by researchers throughout the country. Technological evolution in the Darkhad is evidenced in the shallowest parts of all excavation Units, through both increased diversity in tool forms and in raw material types.

6.1: DIRECTIONS FOR FUTURE RESEARCH

Despite advancements made here, the history of Soyo, and north-central Mongolia as a whole, remains little understood. There are several possible directions for future research. Primary among these is the inherent need for more extensive dating, and correlation between excavations and stratigraphy. Clarity regarding understandings of key transitions in Soyo's past is reliant on accurate dating mechanisms being applied. It cannot here be confirmed that the behavioural changes evidenced here are related to the Neolithic-Bronze Age transition in Mongolia. This issue will only become exacerbated where subsequent research projects rely on data presented here. Further research into the stratigraphic constitution of the Soyo subsurface is also required to validate claims made here. Characterisation of stratigraphy has been shown to allow for more accurate age assessments (Arzhannikov et al. 2012; Derevianko et al. 2012; Gillepsie et al. 2008; Harris 1979; Harris et al. 2014; Rybin et al. 2016; Vanwezer 2021) where formal dating has not been confirmed, however, which has been attempted in this case. For researchers hoping to understand both the archaeological record of the site itself, and wider trends in lithic production throughout north-central Mongolia, accurate dating of Soyo will be invaluable.

In addition to providing clarity regarding previous occupation of Soyo, an expanding database will enable comparisons to be made between other sites in northern Mongolia and Siberia and will allow for increasingly accurate behavioural models to be established. As previously outlined, the study discussed here has been undertaken with assistance from Farquhar (2019) and has relied upon their analysis methods to understand the Soyo assemblage. Comparison between the lithic record of the Gobi Desert and that presented here will allow for a greater appreciation of the nation's archaeological record. Similar research projects have been undertaken throughout the country, however, have failed to consider the north-central region (Gladyshev et al. 2010; Zwyns et al. 2014; Zwyns and Lbova 2019) in their investigations. It is highly unlikely that these regions of the country would not have featured in migratory patterns of past human societies, given the likelihood of continual accessibility through various regions of north-central Mongolia (Rybin et al. 2016; Zwyns et al. 2014) and evidence of long-term occupation of nearby regions (O'Malley et al. 1999; Rybin et al. 2016; Stobbe et al. 2015; Taylor et al. 2019; Weber et al. 2016; White and Bush 2010). The analysis presented here may be used to form further interpretations of human dispersal throughout Eurasia; this will be benefitted by comparison between Gobi Desert and Darkhad assemblages.

A greater understanding of potential tool use may be established through further analysis of materials. Residue analysis may be used to identify resources processed with stone tools (Anderson 1980; Hayden and Kamminga 1979; Hyland et al. 1990; Marreiros et al. 2015; Nance 1971; Newcomer et al. 1986; Odell 1975; Odell and Odell-Vereecken 1980). Material provisioning as a method of risk reduction in regions with limited resource availability is a strategy likely employed by nomadic populations of the Darkhad throughout the Neolithic, if behavioural models are accurate to northern Mongolia's past (Andrefsky 1991, 1994; Binford 1980; Bleed 1986; Chatters 1987; Jeske 1992; Kuhn 1991). The application of alternative measures of reduction intensity may provide more clarity, allowing understanding from multiple perspectives (Blades 2008; Clarkson 2007; Eren and Prendergast 2008; Goodale et al. 2008; Hiscock and Attenbrow 2003; Kuhn 1991; Sandgathe 2004; Schott and Nelson 2008). Finally, analysis of raw materials by oxygen isotope analysis has been shown to be effective for chert (Burchell et al. 2013; Crespin et al. 2006; Karhu and Epstein 1986; Knauth and Epstein 1976; Knauth and Lowe 1978; Marin-Carbonne et al. 2014; Sharp et al. 2002; Tartése et al. 2016; Yang et al. 2013). The application of such analysis methods will allow for an enhanced understanding of the Soyo Tolgoi site, as well as comparison between assemblages researched in a similar manner. If further work is undertaken on the assemblage here discussed, it is advised that these methods are considered.

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APPENDICES

Appendices may be found at the following address:

https://osf.io/ys8v6/?view_only=fd571026e1da410e890049a4dd41b805

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