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## Geology of the Deer stones at the Uushigiin Uvur complex, Khuvsgul Province, Mongolia

**Abstract**. Geological assessment of rock lithologies of the fourteen deer stones at the Uushigiin Uvur deer stone complex, west of Мьгън in north-western Mongolia, indicated that natural jointing a product of regional geological stresses in the insitu rock-was an important component in stone selection by the deer stone fabricators. Near surface exfoliation fracturing of granite may also have been an important factor in generating stone that could be extracted in sizes and shapes suitable for deer stones. The deer stone fabricators also selected stone with natural ferruginous staining along joint surfaces, enabling a colour patterning in the finished chipped deer stone surface. The presence of two distinctly different rock lithologies in the deer stones (both previously referred to as ‘granite’) may point to different regions of origin for the individuals personified by the deer stones: twelve of the deer stones are made from (presumably) local pink granite: two are from a greyer more mafic intrusive not seen in the immediate locale.

Key words: Khuvsgul, Uushigiin uvur, deer stone

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## Хөвсгөл аймгийн Уушгийн Өвөрт буй буган чулуун хөшөөний цогцолбор дурсгалын геологийн судалгаа

**Хураангуй**. Монгол орны баруун хойд хэсэгт, Мөрөн хотын баруун тийш орших Уушгийн өврийн 14 буган чулуун хөшөөний чулуулгийн геологийн үнэлгээгээр тухайн газрын гүний чулуулагт бүс нутгийн геологийн даралт нөлөөлсний үр дүнд үүссэн ан цавууд нь урлаачдад буган чулуу хийх чулууг сонгоход гол нөлөөтэй байжээ. Боржин чулууны гадаргын ойр хэсэгт үүссэн ан цав нь буган чулуун хөшөөнд зориулан тохиромжтой хэмжээ, хэлбэртэй чулууг гарган авахад чухал үүрэгтэй байж магадгүй. Буган чулуун хөшөө урлаачид мөн байгалийн төмөр агуулсан толботой чулууг сонгож, үүний үр дүнд хөшөөний гадаргуу дээр өнгөний хээ үүсгэх боломжийг олгож байжээ. Буган хөшөөнүүдэд хоёр өөр төрлийн чулуулаг (өмнө нь “боржин” гэж нэрлэгдэж байсан) илэрсэн нь буган хөшөөнүүдээр дүрслэгдсэн хүмүүсийн гарал үүслийн бүс нутгийн ялгааг зааж магадгүй. Арван хоёр буган хөшөө нь (магадгүй) орон нутгийн ягаавтар боржин чулуугаар хийгдсэн бол хоёр нь ойр орчимд байдаггүй, хар саарал өнгийн, мафит агуулсан интрузив чулуулгаар хийгдсэн байна.

Түлхүүр үг: Хөвсгөл, Уушгийн өвөр, буган чулуу


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**Introduction**

The Uushigiin Uvur (also spelled Uushigiin Цvцr or Uushgiin Ovor) Deer Stone Complex in Khцvsgцl (Hovsgol) aimag (province), 20 km west of the city of Мьгьn (Moron) in north-western Mongolia contains 14 more or less intact deer stones, with a number of associated khirigsuur (*khereksur*) burials closely adjacent (10s to 100s of metres) to the east and northeast. These are part of the Late Bronze Age Deer Stone-Khirigsuur Complex (DSKC) of Fitzhugh (2009). The site is at latitude 49°39.334’N, longitude 99°55.701’ E[9].

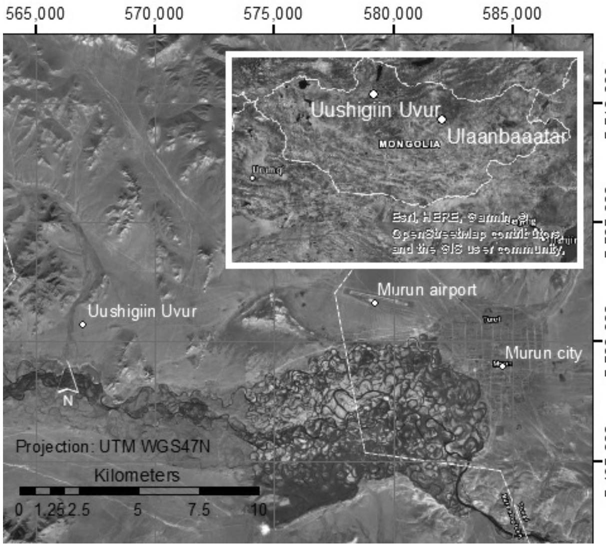



Figure 1: Location map

The 14 numbered deer stones Uushigiin Uvur, each with an explanatory card adjacent to the deer stone, are in two slightly irregular north-south rows, numbered 1 to 3 from south to north in the eastern row, and 4 to 14 from north to south in the western row. Two of the deer stones (#5 and #7) are broken in half horizontally, and the upper half is placed on (#5) or cemented in (#7) the ground several metres north of the basal section. In addition there are a number of partial or broken deer stones lying on the ground in the vicinity of the others. The site is a significant tourist area (Appendix A).

Archaeological excavation of the burials at the Uushigiin Uvur deer stone complex in 2013 are described in detail in Kovalev et al (2016) and summarised in Fitzhugh (2017). Repositioning of deer stones was undertaken as part of the 2013 archaeological investigation.

Mongolian deer stones are stone stele, standing upright and embedded in the ground. They are typically oriented towards the east (i.e. slightly longer in an east-west direction than north-south), with a stylised or symbolic (represented for example by three diagonal incised lines) human face at the top on the eastern side, with incised circles on the side of the head and a beaded line interpreted as a necklace below the head (Fitzhugh 2017, pp. 160, 163). The deer stones are seen to represent or memorialise actual individuals rather than, for example, ‘generic ancestors’ (Fitzhugh 2017, pp. 160, 164-166, 172), and, although they have a ‘direct mortuary association’ with associated stone mound khirigsuur burials, are not directly linkable to specific burials and may in fact memorialise people not buried in the complex, people whose bodies are elsewhere.

Orientations for deer stones at Uushigiin Uvur is front being the side to the east, back to the west, and sides to the north and south – with the exception of deer stone #14 with a very clearly defined face to the south. Fitzhugh (2017, p. 160) argues that deer stones deviation from the standard orientation are generally a result of inaccurate restoration.

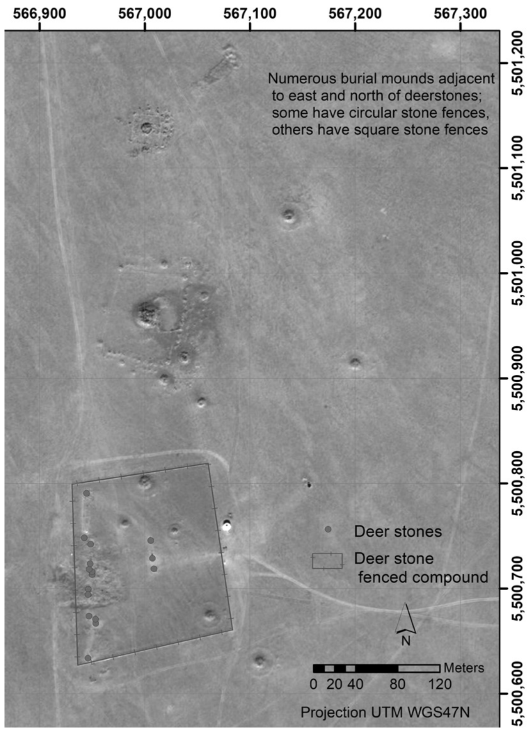



Figure 2: Deer stones within a fenced compound, burial mounds and stone-fenced *khirigsuur* burial mounds

9 This project was undertaken in conjunction with archaeological fieldwork in Khцvsgцl aimag organised by Nomad Science (https://www.nomadsciencemongolia.com/) under the direction of Dr J. Bayarsaikhan (National Museum of Mongolia) and Dr Julia Clark.

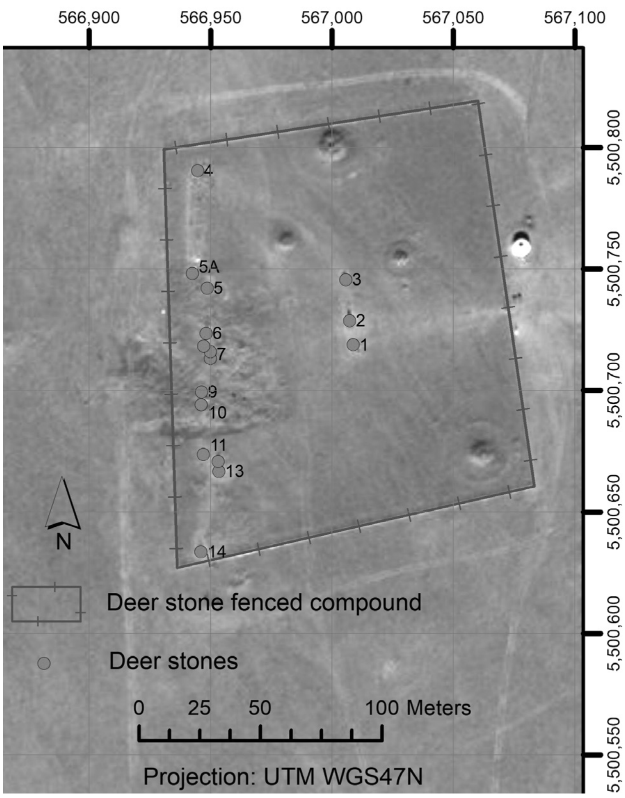



Figure 3: Deer stones numbered 1 to 14 within the fenced compound. The archaeological excavation area reported by Kovalev (2016) is visible surrounding deer stone 6 to10.

Although the imagery and archaeology of the deer stones in Mongolia and at Uushigiin Uvur have been described in detail (Kovalev et al 2016; Fitzhugh 2017), the rock that the deer stones are constructed from has received only superficial attention. Fitzhugh (2017, p. 160) indicates they are made from 'granite', in contrast to granite and basalt elsewhere in Mongolia, and softer slate in the Altai in southwestern Mongolia, while Kovalev et al. (2016) make only passing reference to the granite slabs in some stone burials.

The stone of the deer stones is important: its physical properties – hardness, resistance, ease of carvability, ease of extraction, perhaps even colour and texture – were an important aspect in the selection of stone by the deer stone fabricators. Understanding these properties can help us understand the choices that were made by the fabricators.

**Methods**

The Uushigiin Uvur Deer Stone Complex was visited on 9th and 28th July 2018; deer stone data was obtained by simple visual and hand lens inspection of rock types: grain size, mineral colour and (crystal) shape, reflectance and any internal mineral texture. In general, this was sufficient to determine rock type and mineralogy, and alteration (silicification and ferruginisation) along joint planes; the only exception was the interpreted post-fabrication thin and patchy carbonate coating in several deer stones which would have required scratching and testing with acid to confirm the mineral identification.

Deer stones and burials were mapped onto Esri satellite imagery on a UTM UPS WGS84 (North) projection. The deer stone numbering system adopted is that used on the ground at the deer stone complex, and by Fitzhugh (2017) and by Kovalev et al. (2106).

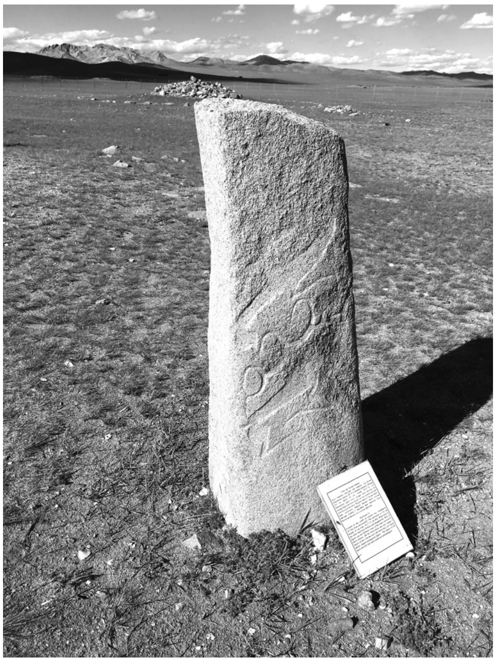
**Results**

Data for the 14 deer stones are included in Table 1 (rock types), Table 2 (jointing and fracture descriptions) and Table 3 (joint and fracture spacing).

**Deer Stone Rock Composition**

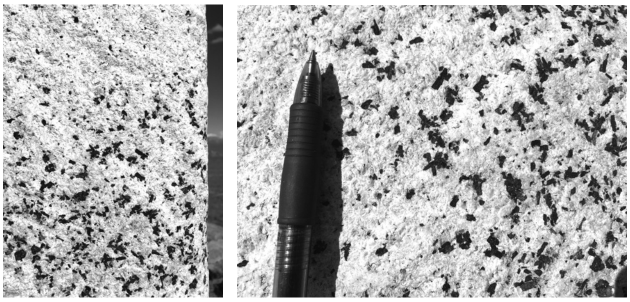
Twelve of the 14 deer stones are fabricated from variants of fine to medium grained to coarse grained granite, well within the mineralogical range of typical granites, containing varying proportions of two feldspars (a pink feldspar, probably plagioclase, and a white feldspar, probably orthoclase), quartz and biotite. Colours range from pale to darker pink, dependent on the proportion of plagioclase and on bleaching from surface weathering of the exposed surfaces; some (e.g. #11) have weak patchy orange iron staining extending through the rock (distinct from the ferruginous jointing discussed below).

Two of the deer stones, adjacent to each other near the centre of the western row, have a significantly different rock composition – still a coarse grained igneous or at least strongly heated and tectonically stressed rock (i.e. metamorphosed) but certainly not a true granite nor of granitic composition. Deer stone #7 is fine to medium grained grey gneiss. Most of the rock is very weakly layered fine to medium grained grey mafic groundmass (the actual mineralogy is difficult to determine without scratching or chipping the stone, but probably includes biotite and amphiboles), with blebby to lenticular and irregular thin (2-15mm) layers of white felsic minerals (probably orthoclase or albite). The environment where these rocks recrystallised from a precursor metasediment or mafic / intermediate intrusive was deep, hot, and moderately tectonically stressed. Deer stone #8 is of a similar overall composition to #7 and probably quite closely related geologically, but without any layering or separation of white felsic layers.



**Deer stone #1**
Pink coarse grained granite, pink plagioclase, white orthoclase, quartz, with only minor biotite.
Chipped and weathered faces

**Deer stone #4**
Pale pink coarse grained granite: pink plagioclase, white orthoclase, and mafics (hornblende)



Granite has weak oblique coarse layering evidenced by layering of coarse grained, glossy black, finely striated hornblende (amphibole), especially on north face.

**Deer stone #11**
Light yellow-pink coarse grained granite, with patchy orange Fe staining.
North and south faces are broadly wavy and parallel to each other.

**Deer stone #12**
Light pink coarse grained granite; all faces chipped

Photo Group 1: Granite deer stones (no significant ferruginous jointing)


Basal portion; and upper portion cemented into the ground closely adjacent

Upper surface of lower portion: fine grained mafic grey groundmass, with irregular coarser grained white elongate quartz (feldspar) blebs a few mm wide and several cm long, giving a weak gneissic layering

Fine to medium grained grey intermediate intrusive: grey matrix with a scatter of fine white feldspar and quartz. Remnant patches of orange brown Fe staining on wavy / irregular jointing across rock face.

Photo Group 2: Deer stones 7 and 8, the more mafic / intermediate intrusives

**Deer Stone Rock Jointing**

Of the 14 deer stones, four (#4, #10, #13, #14) were chipped smooth prior to chipping of the design, with no remaining vestige of any prior jointing.

The presence or otherwise of jointing surfaces on Deer stone #1 could not be determined due to excessive post-fabrication deterioration and erosion of the stone and rounding of vertical corners; there is significant exfoliation weathering of the granite on the east face, and the design still remains on south face only, while minor surficial carbonate at base of west face indication some post fabrication (partial) burial. Deer stone #1 shows the greatest deterioration of deer stones at this site.

The remaining 9 deer stones all show evidence of jointing or semi-planar fracturing along at least one of the front-to-back or side-to-side vertical planes of the deer stone. The sides without obvious jointing have been chipped flat. Many of the sides with remnant jointing have also been chipped in part, to flatten the stone or remove weaker altered rock along the joint plane

For the two more mafic deer stones, #7 has remnant patchy ferruginous jointing along the north and south sides of the stone with chipped surfaces (no evident jointing on the front and back (east and west) sides, while deer stone #8 has remnant wavy to irregular weak orange brown stained ferruginous jointing on all four sides, and also across the top – being almost completely bounded by joint surfaces.

Four (#2, #5, #6, #9) of the remaining seven granite deer stones – all with at least some remnant jointing along the vertical planes of the deer stone – also have ferruginous staining along at least one of the joint planes. For three of these (#5, #6, #9), this ferruginous staining is extensive enough over the face of the stone to give a possible r patterning to the chipped deer stone design. This is particularly noticeable on the southern side face of deer stone #9 and on the western face of deer stone #6, where a strong ~15mm thick ‘rind’ of ferruginous staining and cementing has developed within the granite along the jointing. This rind is dark orange brown on the outer surface of the granite, lightening in colour to paler orange towards the inner portion of the rind, and very strong colour patterning of the deer stone design is achieved by chipping through the outer dark orange brown to expose the inner lighter orange colour. For neither of these is the design chipped through to the fresher light pink granite.

Deer stone #12 has no obvious jointing on any of the faces. However  a vertical side to side north-south cuts across the deer stone near the centre of the north and south faces, parallel to front and back faces, pointing to the probability that the source rock had other jointing along this orientation, jointing that enabled extraction of suitable stone, but that was then chipped to expose fresher rock.

Deer stones #3 and #11 have some different characteristics. For deer stone #3, the north and south faces, both with remnant ferruginous staining, are not parallel, but converge to the east and to the base, and with numerous irregular vertical 1-20cm long east-west oriented weakly Fe stained fractures on the east and west faces. For deer stone #11, the north and south side faces are broadly wavy and sub-parallel and with no ferruginous staining. In both cases, these surfaces are probably not planar enough to be joints and are probably cleaned up irregular natural exfoliation fracture surfaces caused by near-surface thermal stresses in the granite as it is exposed to seasonal cycles of heating and cooling that expand and contract the granite (Collins et al 2018). There are also numerous small irregular incipient fractures within the rock, sub-parallel to these surfaces.

**Deer stone #2**

South face

**Deer stone #5**

East face; basal section

West faces, base and broken top

**Deer stone #6**

N & W faces

W face

**Deer stone #9**

W & S faces

W face

Fe staining in from N & S joint faces

Photo Group 3: Deer stones with ferruginous jointing and colour patterning

**Deer Stone Joint Spacing**

Deer stone dimensions (front to back lengths, and side to side widths) were measured and checked against dimensions on the explanatory placards on site. Joint spacings were rounded to the nearest 5 cm.

For the first four (#2, #5, #8 and #9) with at least two opposing stone faces formed by joint surfaces, joint planes across the shorter dimension have a spacing ranging from 15 to 30 cm, centred more or less around 25cm spacing (a rounded off mean, including mean of dimensions where dimensions vary down the stone), while the longer dimensions range from 35 to 70 cm, centred around ~60cm. Of these, #8 has ferruginous stained jointing or remnant jointing on four faces and the top.

For the next three deer stones with at most one obvious joint surface in each direction (#6, #7, #12), there exist the possibility that opposite faces were also joint surfaces (but probably more altered and less cemented) that were chipped back to expose fresher rock. Then somewhat tautologically, if the opposing faces are interpreted as chipped back joint faces, then the deer stone dimensions point to joint spacing in the rock. For these three deer stones, joint spacing on the shorter dimension ranges from 15 to 25cm, centred around 20cm, and joint spacing on the longer dimension ranges from 35 to 75cm, centred around 55cm – comparable to the range and means for the first four deer stones.

Inferred (e.g. from deer stone dimensions) joint spacing for the remaining deer stones is even more tenuous, but still broadly in the range of the above deer stones.

**Discussion**

Inspection of the geological / lithological nature of the Uushigiin Uvur deer stones highlights three main factors. Firstly, the relationship between natural fracturing and jointing in the rock and overall deer stone morphology and ease or otherwise of ease of extraction of suitable deer stone roughs. Then secondly, the role of ferruginous staining along some of the joint planes, and the way that the deer stone fabricators used this to enhance the colour patterning of the deer stone, and perhaps deliberately selected stone with these characteristics. Then lastly, the possible significance of obvious differences in deer stone lithology – the paler pink granitic deer stones versus the darker more mafic deer stones, and possible implications for stone sources and transport distances.

**Jointing and Exfoliation Fracturing**

Quite obviously, sourcing of stone suitable for extraction as deer stone 'roughs' (or precursor blocks) may not have been straightforward for people using only held stone or bronze tools (Erdenebaatar 2004), even though suitable rock – granites, other intrusives and metamorphics, and hard cemented sandstone and quartzite – is widespread in outcrop in the broader region around Мьгьп. Eons of erosion have exposed the once deeply buried magmatic intrusive and metamorphic rocks, and the present terrain is deeply incised by the current phase of erosion, such that the harder once-deeper rocks are exposed on the flanks of most of the hills. However most of the exposed outcropping rock has a gross morphology unsuitable for deer stone fabrication: the rock in outcrop is too large, too irregular, too small, or just the wrong shape.

Rock of a suitable shape can be the product of several factors. Many rocks have natural *jointing* (fracturing) at regular spacing through the rock – a product of regional de-stressing of the rock during post-intrusion / post-metamorphism erosion and uplift. This jointing can be almost planar, generally parallel to sub-parallel, and is generally steep to vertical, less commonly at lower angles; there can be multiple sets of orthogonal jointing. The joints can be planes of weakness, or can be cemented with a thin film of remobilised minerals (silicates, iron oxides, carbonates), or can be almost completely annealed. In terms of extraction of deer stone roughs, parallel joint sets, or orthogonal joint sets, can lead to natural fracturing of the rock into broadly suitable sizes.

Jointing is a complex geological phenomena, profoundly affecting the earth's surface physiography and outcrop morphology (Pollard and Aydin 1988). Jointing is generally differentiated from faulting by having no visible movement or offset and can occur as single fractures or complex sets (Mandl 2005). Jointing is brittle failure induced by strain (Pollard and Aydin 1988) with wide ranging causes. Jointing can occur as early post-magmatic cooling / tensile fractures infilled with late magmatic fluids (Segall and Pollard 1983). Mandl (2005) indicates a range of mechanisms for joint formation including cooling or shrinkage joints, and jointing relating to regional tensile stress (also emphasised by Jaeger et al. 2007) emphasising the role of pressurised pore fluids in transmitting stress from higher to lower stress regions, with systematic joints developed normal to the direction of greatest tensile stress.

As well as jointing, granites (and variants) in outcrop can develop a sub-horizontal planar to curved exfoliation fracturing, based on expansion and contraction of the granite as it is exposed to seasonal cycles of heating and cooling (Collins et al. 2018). Careful selection of the flattish sub-horizontal slabs produced by this weathering could also yield suitable deer stone precursors.

Hence the importance of jointing in selection by the fabricators of deer stone roughs, and the importance of recognising jointing and fracturing in and on the surfaces of the deer stones as a key to understanding why specific stones may have been chosen, out of the multitude, possibly millions, of available rocks exposed in outcrop on the local or regional landscape.

From the assessment of deer stones at Uushigiin Uvur, it is clear that natural jointing and fracturing is a significant characteristic of the overall morphology of the deer stones – without at this point differentiating between the generally vertical, planar and parallel to sub-parallel joint sets and orthogonal joint sets relating to regional scale and even tectonic de-stressing of rocks, and the more localised generally sub-horizontal and wavy to curved near-surface exfoliation fracturing of the granite. From this, it is then inferred that jointing was a significant aspect of stone selection by the deer stone fabricators.

At Uushigiin Uvur, the importance of natural jointing and fracturing is evident: nine of the 14 deer stones have jointing or semi-planar fracturing along at least one side, and where joint spacing is discernible it is on a scale comparable to the front – back or side to side dimensions of the deer stones. Where jointing is not obvious, the interpretation is that the block was selected and extracted based on jointing but surfaces were then chipped back to fresher rock.

Several of the deer stones – in particular #8 and #11 – have noticeably curved eastern and western faces (i.e. the narrow sides) such that the east-west width varies up and down the deer stone. Given that other deer stones are close to rectangular with more planar sides, it is unlikely that the deer stone fabricators would choose to deliberately chip out an irregular shape; rather, the shape is intrinsic to the particular piece of rock – a consequence of irregular exfoliation fracturing or less probably irregular jointing – and the fabricators have worked with this shape.

In some deer stones, no jointing is visible on the outer surfaces but weak or incipient jointing or fracturing is visible within the body of the rock indicating the presence of jointing or fracturing in the rock in-situ, and the interpretation is that jointing in the in-situ rock was a factor enabling extraction of suitable stone, but that joint surfaces – possibly weathered or weakened or stained – were chipped back to fresher rock as part of deer stone fabrication.

If jointing was then an important factor in initial stone selection, it may also be a mixed blessing. It can enable easier extraction of suitable sized stone, but can also weaken the stone. This is evidenced in deer stones #2 and #3 where there are numerous small internal irregular fractures parallel to the wider north and south faces, which are themselves slightly irregular joint faces; this fracturing has led to significant post-fabrication erosion of the stone on these faces. Deer stone #11 also has incipient internal fracturing parallel to the wider north and south faces, but with minimal, as yet, erosion of these faces. Deer stone #12 has a more significant internal north-south joint/fracture running through the stone, which may eventually weaken the stone. For stone properties, there is a probably a balance from the viewpoint of the fabricators between too little jointing which would make it much harder to fabricate the overall form, versus too much jointing which creates internal planes of weakness.

Differentiating the more regional and generally vertical and orthogonal joint sets from the more localised and sub-horizontal exfoliation fracturing is more difficult, perhaps impossible, in the fabricated deer stones away from their original geological setting. Sub-horizontal exfoliation fracturing is generally more wavy to curved, while the ~vertical joint sets are more planar and closer to parallel; exfoliation in a dry near surface environment is a faster process with less exposure to mineral-bearing ground fluids and is less likely to lead to generation of iron stained rinds in the granite. It is more than probable that some of these effects – some of the curvature and weathering along exfoliation fractures, some of the weathering and alteration along jointing – were deliberately removed by the fabricators as part of stone preparation.

While most of the flatter joints, especially those with orange ferruginous staining or rind development (deer stones #2, #5, #6, #7, #8, #9), are fairly certainly from the vertical orthogonal joint sets, it is possible that the more curved faces (with no ferruginous staining) on #3 and #11 were near surface exfoliation surfaces.

Exfoliation fracturing of granite outcrop is widely visible in outcrop across the landscape around Мьгьп. Natural almost vertical jointing is visible (even at a distance) in granite outcrop to the north of Uushigiin Uvur. Both mechanisms and provide opportunity for sourcing stone of about the right size in at least one dimension.

Photo Group 4: Sub-horizontal thermal exfoliation fracturing in granite outcrop in in Khövsgöl aimag south of Mürün

In terms of overall morphology, it is interesting to note the effect that natural jointing and fracturing has, or does not have, on the roundness of the vertical corners of the deer stones, and how the fabricators have dealt with this. For some deer stones (for example #9), the naturally jointed corners are fairly sharp and unrounded and the chipped pattern goes to corners, indicating the stone was and is hard and competent at the joint intersections. For other deer stones (for example #7, #11, #14) the vertical corners are slightly to more obviously rounded and the chipped patterning is intact around the corners, indicating the corners were deliberately rounded off prior to patterning; the stone may have been slightly weaker at the joint intersections and was chipped back to fresh prior to patterning. In other cases (for example #1, #3, #12), rounding of the vertical corners appears to be mostly post carving weathering, and stone weakness at this point was not recognised by the fabricators.

**Colour Patterning**

Most importantly for some of the deer stones, geological fluids moving along the jointing in deep and/or nearer surface environments can remobilise silicates and iron oxides from within the granites themselves, or from other rocks in the geological environment. In some cases the stone is etched and corroded by these fluids: the stone may become less competent for several millimetres in from the joint. In other cases, the fluids moving along the joint can precipitate silica and / or iron within the granites, creating a varyingly discoloured – generally ferruginous in shades of orange-brown – 'rind' along the joint planes, penetrating up to ~15mm into the granite, a rind that is exploited by the deer stone fabricators to create a colour patterning to the deer stone design.

The near surface exfoliation fracturing is less likely to have mineral-bearing fluids moving through the fractures, and hence unlikely to produce a coloured rind along the fracture.

Given that the colour patterning is such a striking feature on several of the Uushigiin Uvur deer stones, the interpretation is that these blocks were deliberately chosen in order to exploit the colour patterning.

**Deer Stone Lithology**

After jointing as a means of sourcing suitable rough blocks, and jointing as a cause of the ferruginous rind that enables colour patterning, the third obvious comment is that the deer stones at Uushigiin Uvur are fabricated from two noticeably different rock types. Twelve are carved from fine to medium to coarse grained pink to pale pink granite, generally containing quartz plus two feldspars (interpreted as pink plagioclase and white orthoclase) and a mafic mineral – most often biotite, but hornblende in the case of deer stone #4.

In contrast, two adjacent deer stones (#7, #8) are fabricated from a noticeably greyer rock – an intrusive or layered gneiss of mafic to intermediate to intermediate composition with a higher proportion of darker fine-grained mafic minerals (probably hornblende and biotite), a white feldspar (probably orthoclase) and some translucent grey quartz. Deer stone #8 shows some high temperature high pressure metamorphic effects as some the more felsic components separate into thin irregular layers. To a non-geological eye this might still be a 'granite', though the colour is quite different, both at close inspection and when looking at the deer stone complex as a whole.

There appears to be little difference between the two rock types in terms of hardness, ability to be carved, or long-term resistance to weathering, though the pink granites are more variable in their resistance to weathering, but this would probably not have been obvious to the fabricators of the stones.

If the stones are comparable in their properties, then what reasons might underpin the use of one rather than the other? Might the answer lie in colour-based cultural symbolism? – perhaps relating to some difference in gender or rank or status between the individuals who are inferred to be represented (Fitzhugh 2017, pp 160, 164-166, 172) by each of the deer stones. This would be extremely difficult to establish or test. The deer stones are associated with burials (on a scale of tens to hundreds of metres; as shown on the map in Kovalev et al 2016; Fitzhugh 2017) but not close enough that there is a clear link between specific deer stones and burials. Even if there were a clear link, there may not be discernible differences between the burials that match the stone differences.

Neither Kovalev et al. 2016 nor Fitzhugh 2017 nor preliminary visual inspection of the deer stones in 2018 indicated design differences corresponding to the colour differences (though we await with interest the translation from Mongolian to English of Bayarsaikhan's 2016 PhD thesis containing detailed descriptions).

There is plenty of the pale pink granite in the Мьгьп; shortage of supply is not a cause for the greyer deer stones. If the stone for the deer stones came from another location, then perhaps the deer stones were prepared and carved in another location, and transported to Uushigiin Uvur in their completed form. Which hints at the possibility that they memorialise persons from another location but remembered at Uushigiin Uvur. Which brings us to sources of supply and transport distances.

Transport Distances

As well as ease of stone extraction, which – as argued – depends largely on natural jointing and fracturing – transport distances were probably an important, though possibly not overriding, pragmatic factor in stone selection and usage. If transport distance alone was paramount, then the complex would be close to outcrop. In terms of pragmatic factors, there was probably a balance between closeness of suitable stone, and stone characteristics (extractability, hardness, carvability), but aesthetics of colour and appearance may also have been important.

Based on Google Earth imagery, nearest hard rock outcrop (with outcrop morphology indicating it to be granite) are at 0.9km to the north-northeast and northwest, and 1.9km to the east-southeast (Fig. 1). Simple drive-by inspection of the outcrop and Google Earth imagery indicated that much of the hillside outcrop has joint patterning that could probably enable sourcing suitable sized stone. So clearly transporting stones of more than 700kg[10] over distances of a kilometre or more was not an issue for the deer stone fabricators. A question remains: is there a distance or deer stone weight beyond which transportation became difficult or unfeasible?

Another question is where were the deer stones fabricated?: at the source of the stone, or at or closer to the deer stone complex?. Preliminary roughing out of the stone probably took place close to the source of the stone: a stone that has been shaped (even if not finally carved) would be lighter and easier to transport than a rough as-found block, and it would be wise to completely rough out the deer stone prior to transport so that any internal defects or weakness (e.g. joint planes) that might break in transit are evident. Given that several authors including Fitzhugh (2017, pp 163-166), have argued that each deer stone memorialises and is visually representative of a specific person, it is very possible that the deer stone was prepared and carved by people who knew the person being represented, probably at or near to where that person lived, and possibly even during the lifetime of the person being represented. In this scenario, the rock of the deer stone would most likely be from the area where the person lived, and differences in rock type would relate to spatially different areas of origin for the people being memorialised at this one common centre.

Part of the solution to unravelling this complexity could lie in locating sites of deer stone fabrication, the areas of rock where the raw stone is extracted, and areas where the stone is prepared and decorated. The first of these, the places where rough stone is extracted, could be narrowed down somewhat to areas of good outcrop, probably near the margins of the outcrop with access for the people (or carts?) that will carry the stone, and natural jointing or fracturing that enables easier extraction. The second of these, places where the stone is shaped and carved, could well be close to the extraction sites, but may be hard to locate. There would very likely be at least temporary habitation sites nearby, given the probable time needed for stone fabrication; there may also be evidence in the form of hammers and possibly bronze chisels (Erdenebaatar 2004), and perhaps broken stone debris.

10 Using dimensions for Deer stone #14, adding a metre for buried length, and an average SG of 2.65 for granite.

**Summary**

Inspection of the rock lithology and remnant joint and fracture surfaces on the 14 deer stones at Uushigiin Uvur indicates that 12 are fabricated from a light pink fine to medium to coarse grained granite, and 2 from a darker grey intrusive of intermediate to mafic composition, and with similar properties of durability and carvability as the pink granite.

It is clear from its presence in the deer stones that natural jointing and fracturing of the rock was an important factor in selection and extraction of the raw deer stone blocks. Moreover, some of the natural joint surfaces have an orange to brown discoloured rind, up to 15mm thick, caused by ferruginous alteration along the joint surface. The deer stone fabricators deliberately exploited this characteristic to chip through the rind exposing the deeper unaltered rock, thus creating colour patterning across the deer stone face.

The assessment created many questions. Is there any significance to the lithological difference between the pink granite deer stones and grey more mafic deer stones. Based on pure pragmatism, if suitable stones can be sourced from appropriately jointed zones of the pink granite which is visible in outcrop within several kilometres in several directions from Uushigiin Uvur, why would any deer stone be fabricated from a different rock obtainable elsewhere? The source of the greyer mafic rock is as-yet unknown, and at what distance from Uushigiin Uvur.

If deer stones represent individuals, and if the stone was sourced and possibly carved in the home range of these individuals then brought to the Uushigiin Uvur complex, then 12 of the 14 individuals (the pink granites) are local to Uushigiin Uvur and the other two (the greyer mafic intermediate lithologies) may not be.

The role of natural joining and/or exfoliation fracturing in generating extractable stone blocks of suitable proportions is evidenced by the jointing on the deer stone surfaces, as is the importance of ferruginous staining on joint surfaces enabling colour patterning of the finished deer stone. But the actual extraction sites are unknown, and what the deer stone fabricators saw when they looked at the insitu rock with its jointing or exfoliation fracturing is unknown.

A geological perspective on the deer stones illuminates and adds complexity. It is far too simple to just call all the stone of the deer stones ‘granite’ and overlook what lithological variants and jointing patterns might tell us about the choices that the deer stone fabricators made and constraints they faced in stone selection.

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## TABLES

Table 1: Deer Stone Rock Composition

| | | |
|---|---|---|
| The 'granite' deer stones | | |
| Eastern row, south to north | | |
| #1 | Pink coarse grained granite. | #1, #2 & #3: Only minor biotite. |
| #2 | Pink fine to medium grained granite. | |
| #3 | Pink fine to medium grained granite. | |
| Western row, north to south | | |
| #4 | Pale pink coarse grained granite. | The mafics (coarse grained, glossy black, finely striated) look like hornblende (amphibole) rather than biotite. The granite has weak oblique diffuse layering, possibly intrusive cumulate layering, evidenced by layering of mafics, especially on the north face. |
| #5 | Fine to medium grained pale pink granite. | Some irregular patches with abundant disseminated biotite<br>The deer stone has broken, post fabrication, along a cross cutting west-dipping planar thin quartz vein. |
| #6 | Pale pink medium grained granite; pinker mottling on south face crosses / predates? chipped design. | |
| #9 | Coarse grained light pink granite. | |
| #10 | Coarse grained light pink granite. | Some coarser biotite; most of the feldspar is white (orthoclase?) |
| #11 | Light yellow-pink coarse grained granite. | Patchy orange Fe staining. |
| #12 | Light pink medium to coarse grained granite. | Some biotite rich irregular patches |
| #13 | Light pink medium to coarse grained granite. | Rare small mafic xenoliths |
| #14 | Medium to coarse grained pale pink granite | |
| The mafic / intermediate intrusive / gneissic deer stones | | |
| Centre of western row | | |
| #7 | Fine to medium grained grey intermediate felsic – mafic gneiss. | Fine grained mafic grey groundmass of quartz, white feldspar and finer mafics; with irregular coarser grained white elongate quartz-feldspar blebs a few mm wide and several cm long – almost leucosomes. Alignment of blebs gives a weak gneissic layering. |
| #8 | Fine to medium grained grey intermediate felsic / mafic intrusive / gneiss. | Grey 'salt and pepper' matrix of fine white feldspar (orthoclase?) and grey quartz grains, and finer mafics |

Table 2: Deer Stone Rock Jointing

| | | | | |
|---|---|---|---|---|
| Granitic deer stones | | | | |
| Eastern row, south to north | | | | |
| | Jointing on or parallel to the side faces, i.e. the longer sides. | | Jointing on or parallel to the front & back faces, i.e. the shorter sides. | |
| #1 | Indeterminate due to post fabrication weathering, though faces are planar – probably chipped back jointing | | Indeterminate due to post fabrication weathering, slightly curved | |
| #2 | N face is planar to slightly wavy – an E-W joint surface(?) but with no Fe staining<br>S face is a planar joint surface with stronger Fe staining.<br>Numerous irregular vertical 1-60cm E-W fractures on E & W faces, with weak Fe staining. | FFF | E face comprises weak irregular patchy Fe stained N-S joints<br>W face is very clean & slightly irregular to almost planar but with no Fe staining – probably a joint surface. | |
| #3 | Remnant Fe stained jointing (fractures) on N & S faces which are not parallel but slightly curved, & converge to E & to base; the stone thins to base on E side; Numerous irregular vertical 1-20cm E-W weakly Fe stained fractures on E & W faces. | TTT | W face has planar Fe stained N-S jointing at the base; otherwise chipped & with rounded vertical corners.<br>E face is all chipped, with rounded corners.<br>Top is chipped. | |

| | | | | |
|---|---|---|---|---|
| Western row, north to south | | | | |
| #4 | Chipped all over; no visible natural joints, planar | | Chipped all over; no visible natural joints, planar | |
| #5 | N face has weak irregular Fe staining jointing which is chipped flat, planar. S face is all chipped, no jointing | FFF | E & W faces comprise planar & parallel Fe stained light reddish orange weak joint planes. Chipping of the design into these faces gives a colour patterning. | FFF |
| #6 | Planar faces weak thin & patchy surficial carbonate coating on some of N face; this may indicate that the deer stone has been partially buried in the soil profile at some time since fabrication and erection | | Strong dark orange Fe stained rind along planar joint surface of W face; extending 15mm into the rock. Very strong colour patterning in the design is achieved by chipping through near surface darker orange to expose underlying light orange less Fe stained inner rind. | FFF |
| #9 | N & S faces are irregular slightly curved & convergent joint surfaces. S face has 15mm orange Fe rind, becoming lighter towards inner side of rind. Very strong colour patterning in the design is achieved by chipping through the near surface darker orange to expose underlying light less Fe stained inner rind. | FFF | E & W faces chipped all over; no visible natural joints, planar | |
| #10 | N & S faces chipped all over; no visible natural joints, planar | | N & S faces chipped all over; no visible natural joints, planar | |
| #11 | N & S faces are parallel and slightly wavy. There are also irregular incipient fractures within the rock, sub-parallel to these surfaces. | TTT | E face may n part be a natural slightly curved fracture surface. W face is all chipped back. | TTT |
| #12 | N & S faces chipped all over; no visible natural joints, planar | | E & W faces chipped all over; no visible natural joints, planar<br>However there is a significant internal N-S joint. | |
| #13 | Chipped all over; no visible natural joints, planar | | Chipped all over; no visible natural joints, planar | |
| #14 | Chipped all over; no visible natural joints, planar | | Chipped all over; no visible natural joints, planar | |
| Mafic / intermediate intrusive / gneissic deer stones, centre of western row | | | | |
| #7 | Remnant orange Fe stained jointing on N & S faces, planar | FFF | E & W faces chipped all over; no visible natural joints, slightly curved | |
| #8 | Remnant patches of orange brown Fe staining on planar to wavy / irregular jointing across rock face on both faces; also on oblique top surface | FFF | Remnant patches of orange brown Fe staining on slightly wavy / irregular jointing across rock face on both sides | FFF |

FFF: Fe staining or rind along jointing
TTT: curved fracturing, possibly thermal exfoliation fracturing
CCC: faces chipped back, jointing inferred from dimensions

Table 3: Deer Stone Joint Spacing

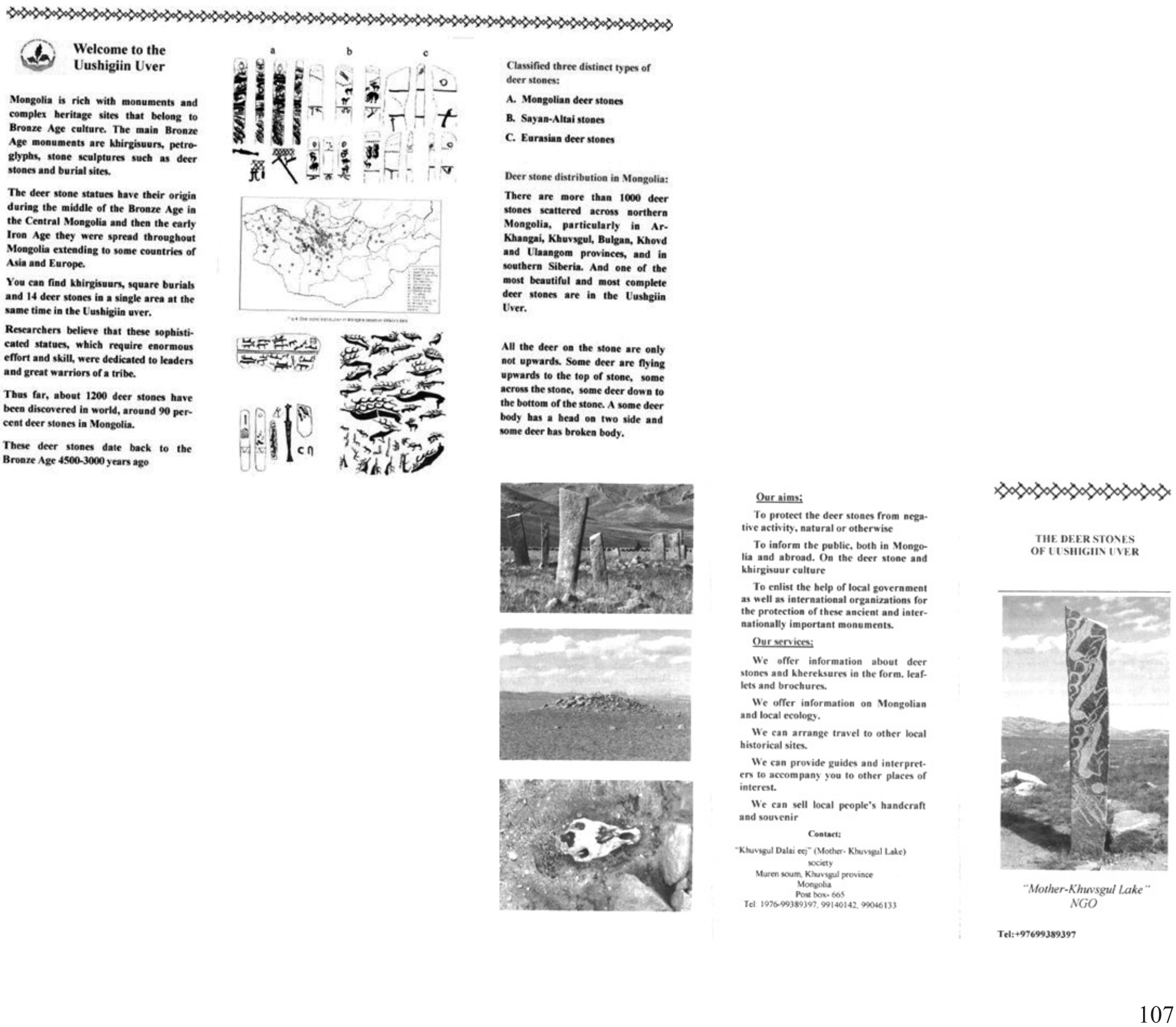
| Deer stones ordered from those with most evident joint faces to those with least | | | | | | | |
|---|---|---|---|---|---|---|---|
| Side-side width * | | Joint spacing on / parallel to front & back faces, i.e. shorter sides | | | Joint spacing on / parallel to side faces, i.e. longer sides | | |
| | | Inferred joint spacing | | Front-back length * | Inferred joint spacing | | |
| #8 | mafic | 20 cm | 20 cm | FFF | 53-24-36 cm | 35-55 cm (2 slightly curved Fe joint faces) | FFF |
| #2 | granite | 23-16 cm | 15-25 cm | FFF | 70 cm | 70 cm | |
| #5 | granite | 30 cm | 30 cm | FFF | 56 cm | 55 cm (2 Fe joint faces) | FFF |
| #9 | granite | 15-20cm | 15-20 cm | FFF | 27-23 cm | 25+ cm | CCC |
| #6 | granite | 20 cm | 20+ cm | | 45 cm | 45cm | FFF |
| #7 | mafic | 26 cm | 25+ cm | FFF | 69 cm | 70+ cm | CCC |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| #12 | granite | 22 cm | ~15 cm – based on central fracture & probability that faces are chipped back joints | ccc | 36-33 cm | 35+ cm | CCC |
| #3 | granite | 15 cm | 15-20 cm | TTT | 66 cm | 65cm (1 joint surface) | |
| #11 | granite | 24 cm | 20-25 cm | TTT | 32-26 cm | 25-35 cm (2 slightly curved surfaces, E face may be a joint / fracture) thermal? | TTT |
| #4 | granite | 24 cm | 25+ cm | CCC | 37 cm | 40+ cm | CCC |
| #10 | granite | 19 cm | 20+ cm | CCC | 55-51 cm | 50-55+ cm | CCC |
| #13 | granite | 30 cm | 30+ cm | CCC | 72-49 cm | 50-75+ cm | CCC |
| #14 | granite | 23 cm | 25+ cm | CCC | 33 cm | 35+ cm | CCC |
| #1 | granite | 24-27-31 cm | Weathered, probably ~35cm | | 43 cm | Weathered, indeterminate | |

* Where multiple measurements are given for a deer stone, these are top and bottom or top, middle, bottom. Dimensions are from the onsite explanatory placards, checked in the field.

FFF: Fe staining or rind along jointing
TTT: curved fracturing, possibly thermal exfoliation fracturing
CCC: faces chipped back, jointing inferred from dimensions

Appendix A: Mother Khuvsgul Lake Society, 2018, 'The Deer Stones of Uushigiin Uver', unpublished brochure.



**Welcome to the Uushigiin Uver**

Mongolia is rich with monuments and complex heritage sites that belong to Bronze Age culture. The main Bronze Age monuments are khirgisuurs, petroglyphs, stone sculptures such as deer stones and burial sites.

The deer stone statues have their origin during the middle of the Bronze Age in the Central Mongolia and then the early Iron Age they were spread throughout Mongolia extending to some countries of Asia and Europe.

You can find khirgisuurs, square burials and 14 deer stones in a single area at the same time in the Uushigiin uver.

Researchers believe that these sophisticated statues, which require enormous effort and skill, were dedicated to leaders and great warriors of a tribe.

Thus far, about 1200 deer stones have been discovered in world, around 90 percent deer stones in Mongolia.

These deer stones date back to the Bronze Age 4500-3000 years ago

Classified three distinct types of deer stones:

A. Mongolian deer stones
B. Sayan-Altai stones
C. Eurasian deer stones

Deer stone distribution in Mongolia:

There are more than 1000 deer stones scattered across northern Mongolia, particularly in Ar-Khangai, Khuvsgul, Bulgan, Khovd and Ulaangom provinces, and in southern Siberia. And one of the most beautiful and most complete deer stones are in the Uushgiin Uver.

All the deer on the stone are only not upwards. Some deer are flying upwards to the top of stone, some across the stone, some deer down to the bottom of the stone. A some deer body has a head on two side and some deer has broken body.

Our aims;

To protect the deer stones from negative activity, natural or otherwise

To inform the public, both in Mongolia and abroad. On the deer stone and khirgisuur culture

To enlist the help of local government as well as international organizations for the protection of these ancient and internationally important monuments.

Our services;

We offer information about deer stones and khereksures in the form. leaflets and brochures.

We offer information on Mongolian and local ecology.

We can arrange travel to other local historical sites.

We can provide guides and interpreters to accompany you to other places of interest.

We can sell local people's handcraft and souvenir

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THE DEER STONES OF UUSHIGIIN UVER

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