

WARRARI STONE ARRANGEMENTS

Relocation and Dating Programme, Pilbara, Western Australia

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and the Innowonga Bunjima Naipaili & Martu Idja Banyjima Native Title Claimants

Introduction

The Project

In the early 1970's, stone arrangements were identified in close proximity to Goldsworthy Mining Limited area of operations in the Packsaddle area north of Newman, WA. Subsequently, BHP Billiton acquired Goldsworthy's leases, and established that the stone arrangements were on top of rich iron ore deposits. Extensive negotiations between BHP Billiton and the two Native Title Claimant groups resulted in an agreement to relocate the stone arrangements. The relocation project involved recording and then relocating 10 stone arrangements located at the base and slopes of the Warrari Range (see Map). In addition, an attempt was made to date the sites using Optically Stimulated Luminescence dating (OSL).

Stone Arrangements in the Pilbara

Over 70 stone arrangement sites have been recorded in the wider Pilbara region.

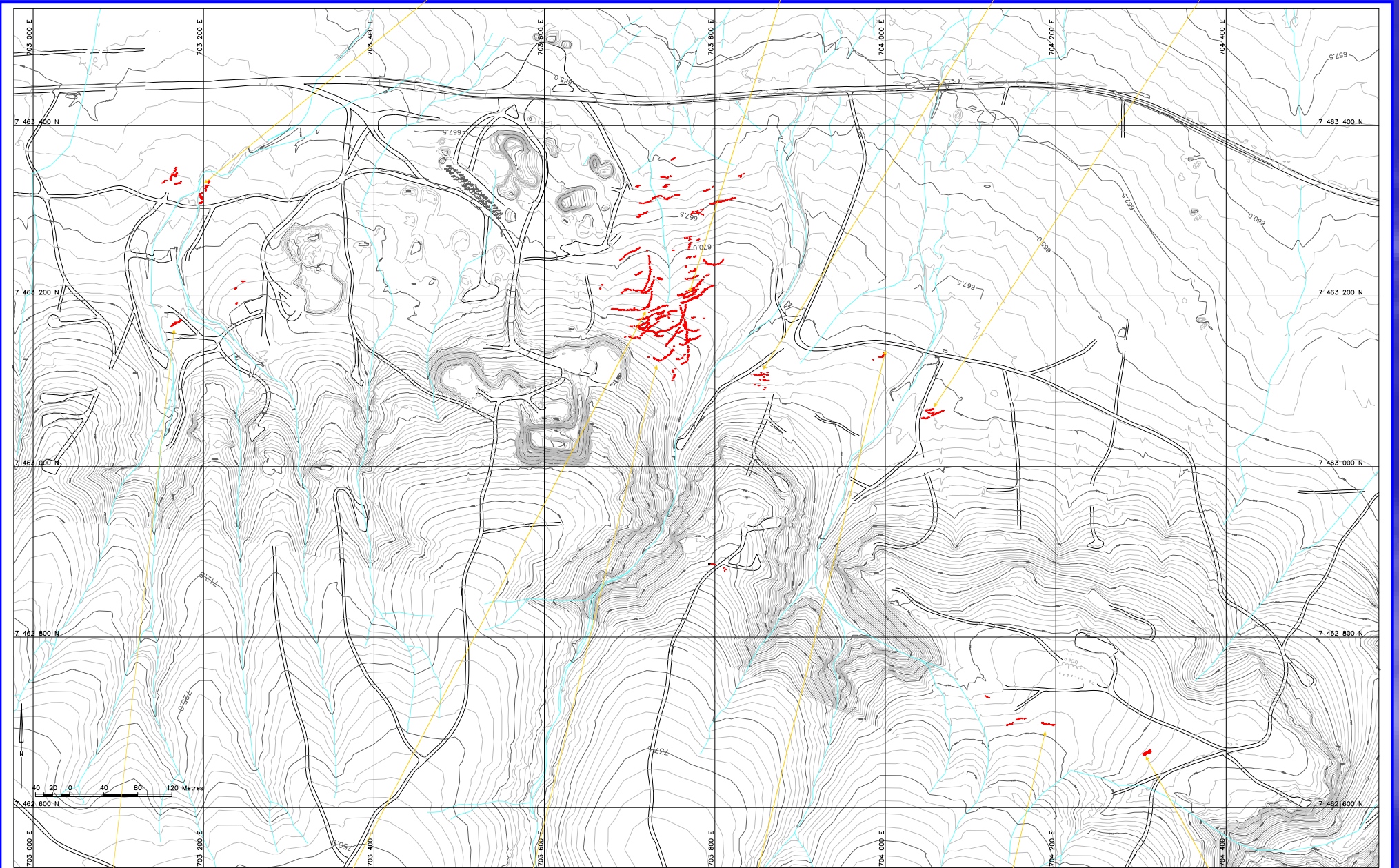
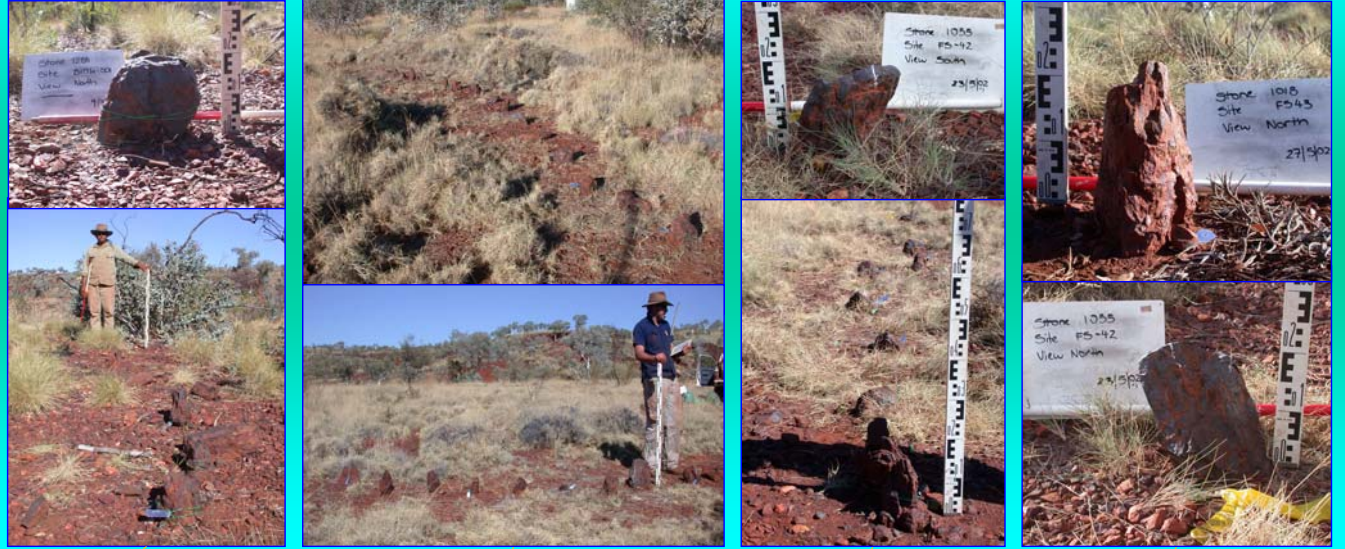
- The average area that a stone arrangement covers is 581 m² with a minimum area of 0.02 m² and a max of 324,300 m².
- The average number of stones is 34 with a minimum of 1 and a maximum of 711.
- The average number of features is 3, the minimum is 1 and the maximum is 51. A feature is a set of embedded or placed stones arranged in a pattern.

Warrari Arrangements

There are a total of 52 stone arrangements identified on the Warrari Range. The sites range from a very extensive arrangement to a single standing stone. The arrangements are constructed from small ironstone, banded ironstone formation, ironstone conglomerate and chert boulders. The majority of stones in the arrangements are buried upright in the ground, however one arrangement has placed stones only.

The ironstones/BIF boulders comprise close to 80% of the embedded stones and are quite heavy with their geological component comprising 60% pure iron ore. The stones are usually locally derived.

The most common design element in the stone arrangements is the curvilinear line, followed by straight lines (see Map below). Lines are often arranged in parallel formation.



WARRARI STONE ARRANGEMENTS

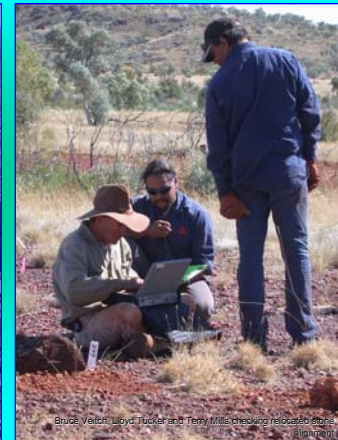
Research, Salvage and Dating Programme, Pilbara, Western Australia

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Aims

The aims of the project were to:

- Map the stone arrangements accurately to aid in the relocation programme, analysis and the creation of a digital elevation model of the arrangements.
- Document each stone with digital photographs – including north, south and plan shots.
- Excavate a sample of stones to determine if there are any stratigraphic features associated with the stones and any associated cultural material.
- Collect 70 soil samples for OSL dating from the casts around the base of the embedded stones, as well as a series of control samples away from the embedded stones. These dates were designed to provide estimations on the period(s) of construction of these sites, and of maintenance activities that may have occurred there.
- Relate dates returned from these sites to C¹⁴ dated sites in the immediate region.
- Record characteristics of each relocated stone to aid in future analysis.
- Place each stone in its original relative position, orientation, angle and depth at the relocation site.
- Examine the formation of casts around the base of relocated embedded stones.
- Double check orientation, placement, angle and depth of relocated stones.



Methods

Mapping

Each stone was allocated a unique number and tagged accordingly. The surveyor then picked up the long axis of each embedded stone or a series of points using DGPS. The points were then plotted on the ground at the relocation areas.

Excavation and OSL Samples

Initially, several trial excavations of embedded stones were conducted in full daylight. It was discovered that, while there were no visible stratigraphic features, there was a zone of compaction around each stone. This compaction zone comprised fine sediments which formed a cast around the base of each embedded stone. It was hypothesised that the casts may have formed as a result of:

- Back filling of sediment around the base of the stones when they were either embedded, or at the last major maintenance episode.
- Fine material being washed into the cavity formed around the stone just after the base was embedded or last maintained.
- A combination of the two above.

The casts ranged from 1 to 2 cm in thickness. It was also hypothesised that the casts may have formed very quickly after the stones had been embedded and backfilled, possibly after the first few wet seasons.

For the OSL dating it was decided to target these casts. During the day a series of test pits measuring 30 cm by 30 cm were excavated. These test pits were placed 10 cm in front of an embedded stone. All excavated material was sieved in 6 mm and 3 mm fraction nested sieves.

The team returned at night and excavated toward the base of the stone to expose the cast under red light conditions. Prior to excavating 2 cm of the ground surface was cleaned off to remove more recent contaminants.

After the casts were exposed, OSL samples were then taken by Nigel Spooner. The OSL soil sample was taken from 2-4 cm above the base of each stone to avoid obtaining a "geological" sample.



Removal and Recording

After the OSL sampling was completed each stone was carefully excavated, the sediment below inspected.

Before removal each stone was:

- Tagged and a north point marked in chalk.
- Digitally photographed, with a minimum of three photographs taken of each stone; north, south and overhead (plan). Most lines also had context photographs taken.

Each embedded stone was then measured (see diagram to right) and its characteristics recorded.

They were then wrapped in rubber, packed into crates lined with industrial foam and driven carefully to the relocation area.

Relocation

Each stone was reburied to the same depth and orientation as it was originally found. This was achieved by using a triple redundancy system:

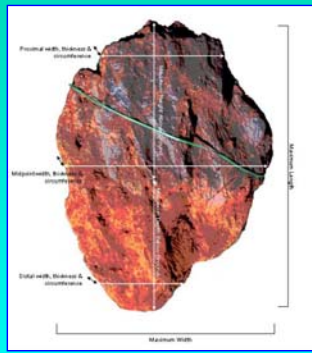
- Each stone had the north point and a clear "Plimsoll line" marked on it.
- The major axes were marked on the ground by the surveyors.
- North, south, plan and context photographs could be referred to.

Given this three way check it was possible to rebury the stones accurately.

During the relocation programme a small number of stones were excavated at any one time. These stones were then reburied before any further stones were excavated, to limit the potential for error.

Further, attempts will be made to examine the formation of casts around the base of embedded stones by excavating several stones after they have been reburied. This examination will be done by comparing the results of:

- The re-excavation of relocated stones around which we have poured 1 litre of water. This was done to firm-up the embedded stones in their new location by washing fine sediments into the excavated and backfilled cavity into which the stones were placed.
- The re-excavation of other stones that we have not poured water around the base of as a form of control.



Preliminary Results

Optical Dating

Sediment samples were collected from the casts, as described, and also from trenches of up to 1m length cut into the soil adjacent to selected stones, which were chosen on account of their emplacement in soil types representative of the range of soils encountered at this site.

On return to ANU, each sample was unpacked under low-level red light darkroom conditions, and the *in situ* water content measured for later use in environmental dose-rate calculation. Splits of each sample were submitted to Becquerel Laboratories for assay for the radioisotopes U, Th and K, using neutron activation and delayed neutron analysis (NAA/DNA), and to AGSO for assay for K using X-ray fluorescence (XRF). The alpha and beta irradiation dose-rates were evaluated from the measured isotopic compositions and added to the calculated cosmic ray dose-rate, and the gamma dose-rates derived from *in situ* measurements made at the time of sample collection, using a NaI scintillometer.

Quartz grains were extracted by a series of physical and chemical treatment steps conducted under darkroom conditions; these included HCl and NaOH digestion, sieving to select the 350-425 µm grain size fraction, heavy liquid flotation to extract the quartz, and finally HF acid etching to remove the outer 6 µm alpha-particle-irradiated shell of each quartz grain.

The Palaeodose (P), the radiation dose accrued since last exposure to sunlight, was measured from each individual quartz grain using a known strength laboratory beta source to calibrate the natural optically-stimulated luminescence emitted under exposure to green light. Individual grain age results are forthcoming, and the age histograms constructed using a statistically-significant number of individual grain ages for each sample are anticipated to reveal the time elapsed since either the original emplacement of the corresponding stone, or the last important act of maintenance.

It is expected that the OSL dates will be available mid to late next year.

Excavation

Apart from the fine sediment casts, no cultural features were identified during any of the 70 test excavations.

One isolated flake was identified near the surface of one stone. The absence of habitation material was not unexpected, given that these sites were probably non-secular in nature.

The casts were present around every stone excavated, and appear to be a consistent sub-surface feature associated with embedded stones.

Relocation

1,439 stones have been relocated. What remains to be done is to verify the accuracy of the relocation programme. This process will entail examining digital photographs of individual stones, and context photographs, taken before the stones were moved and comparing these with the stones in the relocation area. Adjustments will be made where necessary.

In addition, we intend to re-excavate a series of relocated stones to examine the effects of water on the formation of casts around the base of embedded stones.

Removal and Recording

The initial results of the stone measuring indicates that:

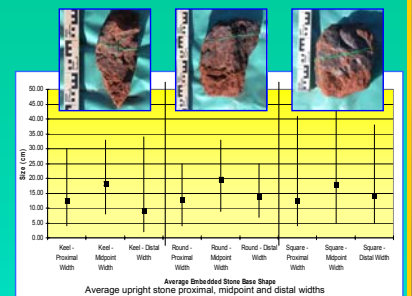
- Of the total number of stones 62% are upright, 25% have fallen and 14% are broken.
- The average maximum length of the upright stones is 29 cm (range 3 - 68 cm), they are buried to an average depth of 13 cm (range 2 - 30 cm) and are 16 cm high above ground level (range 1 - 38 cm).
- 68% of the upright stones have a keel base shape, 20% have a round shape, 11% have a square shape and 1% are flared (see graph to right).
- The average upright stone has an mean proximal circumference of 34 cm, a midpoint circumference of 50 cm and a distal circumference of 31 cm.

The basic analysis of the measured stones has still to be fully completed. It appears, however, that there is a heavy selection bias towards stones with a keel base shape. This bias may be related to the relative ease of digging a conical pit as opposed to a square or rounded one.

Conclusion

This research has demonstrated that:

- OSL dating is feasible in the ironstone rich areas of the Pilbara uplands, well beyond the regions usually associated with OSL dating in sandier regions of Australia.
- The OSL method may now be used in the Pilbara to assist dating cultural deposits where charcoal has not survived in typically acidic deposits.
- The potential exists to obtain absolute dates on cultural features, such as arrangements of standing stones, rather than relying on relative dating.



Acknowledgements

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The photographs with the BHP Billiton logo were taken by Don Palmer on behalf of BHP Billiton. The remaining photographs were taken by Archae-ous personnel.

1 = Archae-ous;
2 = BHP Billiton;
3 = Australian National University

