



KEYWORDS: *Superimposition – D-stretch – Graphic layer – Arnhem Land – Australia*

A METHOD TO VISUALLY RATIONALISE SUPERIMPOSED PIGMENT MOTIFS

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Abstract. Through combining the functions of three different digital image programs, a method to document and interpret superimposed pigment motifs is described.

Introduction

The study of superimposed motifs is one of the principal methods of developing sequences in rock art (Leroi-Gourhan 1967; McCarthy 1974; Keyser 2001). Although widely used, it is rarely visually documented other than by a single photograph or drawing (e.g. Trezise 1971; Morwood 1976; Chaloupka 1977; but note Clegg 1980; Chippindale and Taçon 1993). These graphics are generally inadequate to illustrate or describe the complexities that can occur, particularly on panels with many motifs in multiple superimposed layers (cf. Clegg 1983: 95–99); to date, very few such sites recorded in detail have been published. In Australia, notable exceptions are those of McCarthy (1976) and Coutts and Lorblanchet (1982). This paper proposes a method to resolve some of these problems. Initially, the methods are described and then an example is used to illustrate the process.

Methods

Following a close visual inspection of the art panel and making notes on what superimposition can be observed, it is essential to capture an adequate photograph of the art panel. In many cases, large panels cannot be photographed in a single image due to either a lack of distance between the ceiling panel and the floor, or lack of any vantage point to photograph the wall. This problem can be overcome by either taking overlapping photographs at right angles to the panel and stitching the individual photographs into a single composite image (photomosaic) using software such as PTGUI® (Panorama Tools Graphic User Interface), Hugin®, or recent versions of Adobe Photoshop® (version 7 or above); or using a 'fish-eye' lens and an appropriate program to remove the distortion (such as with the Fisheye-Nikkor 10mm and the Nikon Capture® software; Figs 1 and 2).

Image stitching is, mathematically, a complex task (Szeliski 2004). It is also a very popular and common

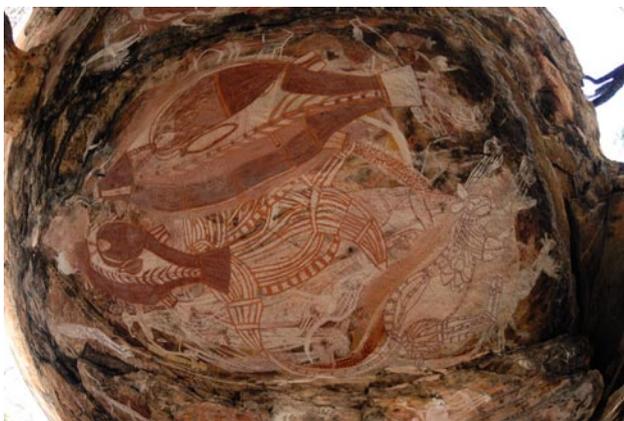


Figure 1. Nikon Fisheye photograph and software corrected image (Nawarla Gabarnmung panel D).



Figure 2. Nikon Fisheye photograph after software correction (Nawarla Gabarnmung panel D).



Figure 3. Stitched panorama from eight 18 mm wide-angle photographs (Nawarla Gabarnmung panel D).

method for photographers to create large, photomosaic images from multiple photographs, which means that for most users the algorithm is irrelevant as the software is readily available. Most image stitching software currently uses a feature-based approach, where the software searches through the matrix of pixels in a digital image seeking patterns or trends. These are then located in the other images being joined, and geometric and radiometric transformations applied to the images. They can then be joined seamlessly into a much larger picture (Fig. 3).

The resultant stitched image is then imported into a graphics program that utilises layers, such as Adobe Photoshop®. This enables the isolation of motifs from different layers of the superimposition onto their own layer 'sheet', either through drawing (outlining or detailed tracing), or selective capture using the magic wand feature. This process is relatively easy with the upper and most recent layers, where all or most of the motif is readily visible.

In the case of lower layers, the motifs can be enhanced using image processing software optimised for pictograms, such as D-Stretch®, which highlights colours selectively depending on the enhancing combination (or colour space) used (Alley 1996; Harman 2008). The process undertaken by D-Stretch® is an image processing technique frequently used with multi-spectral satellite imagery; the de-correlation of colour bands via transformation into alternative colour spaces, and then performing a contrast 'stretch' or enhancement to highlight the differences (Alley 1996; Mark and Billo 2002; Gillespie et al. 2006). The process is very similar to a Principal Component Analysis that can be applied to many data sets where there may be a relationship between one variable and another, including bands of light intensity values found in digital images. This image transformation can be achieved with advanced image processing and analysis software, but the image manipulations in D-Stretch® have been optimised by a rock art researcher (Harman 2008) as being the most useful for analysing pictograms. While not replacing the more manual methods previously

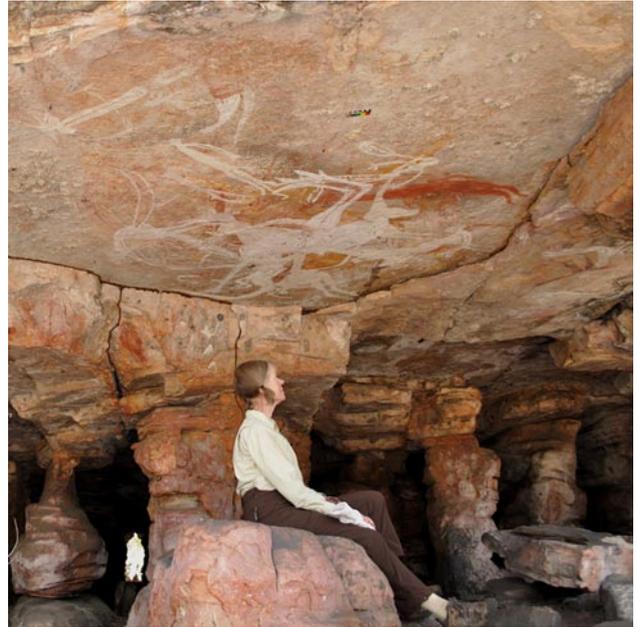


Figure 4. Nawarla Gabarnmung panel A3.

used (Ogleby 1995; David et al. 2001; McNiven et al. 2002), as the D-Stretch® colour spaces are standardised, the resultant images can be readily repeated by other researchers. Also, while only rarely revealing 'invisible' motifs, D-Stretch® makes the visualising of very faint images much clearer and in a number of cases where only traces of pigment can be seen on the original photograph, D-Stretch® will permit the form of the motif to be defined. D-Stretch® operates as a plug-in for ImageJ (Abramoff et al. 2004), a public domain, Java-based, image processing and analysis program freely available through National Institutes of Health (U.S.A.) [<http://rsb.info.nih.gov/ij/index.html>, accessed January 2010].

Using software like Photoshop® that incorporates multiple layers within a single file, if the superimpositions are simply those of one colour layer over another, each colour can be given its own layer sheet and when the visual analysis has been completed, the layers can be printed separately, motifs numbered and described, and the layers flattened to give a drawing of the mosaic. If the superimpositions are complex with different colours or colour combinations represented in each layer, then, starting from the upper layer, each layer of motifs is given a layer sheet and the above process repeated. The ability to keep the interpreted layers of superimposition separate also gives an opportunity for greater analysis of regional and chronological styles or features.

To produce the final interpretation of the underlying layers, where possible the disparate fragments of each motif (such as legs and body) are joined and filled with a less intense colour of the pigment so that the interpretation can be visually appreciated. In many instances, however, the full interpretation of the underlying motifs will not be possible due to their high

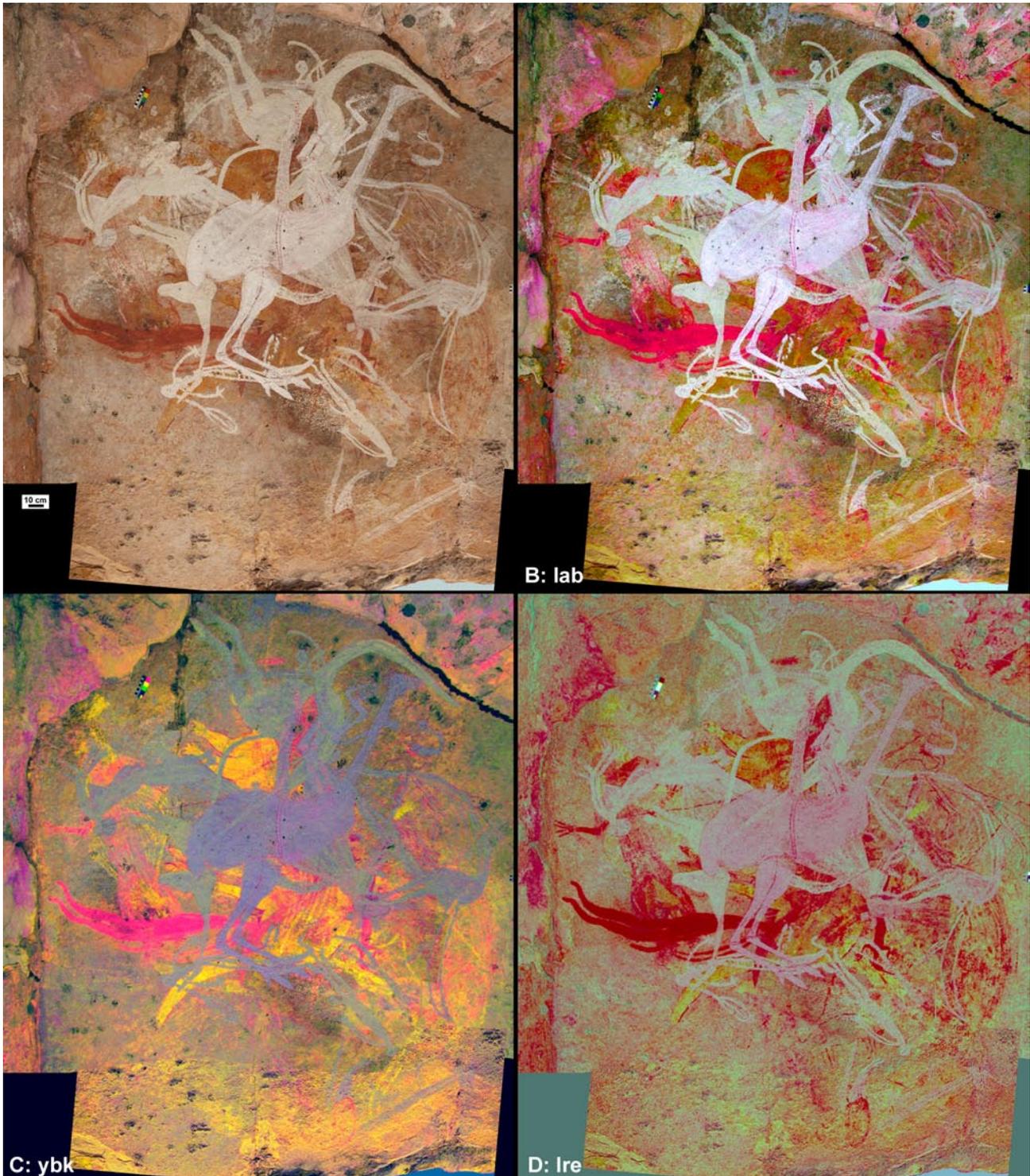


Figure 5. Photomosaic of the A3 panel with D-Stretch enhancements. A: photomosaic. B: white enhancement. C: yellow enhancement. D: red enhancement.

degree of fragmentation.

Example

The demonstration panel is from Nawarla Gabarnmung, an unrestricted Jawoyn site from the central Arnhem Land plateau. The panel is 4 × 3.5 m in size on a horizontal ceiling, 2 m above the ground (Fig. 4). It is dominated by several layers of different white paintings (Fig. 5A). Underlying the white layers are

less distinct layers of yellow and red paintings. Apart from one large red figure (which overlays a yellow figure) the sequence appears to be coherent but the results have yet to be checked against the original.

A photomosaic of the panel was produced in PTGUI from five 18 mm wide-angle photographs acquired with a Nikon D90 in RAW/jpg format. This process can include corrections for lens distortions (usually generalised from the camera information

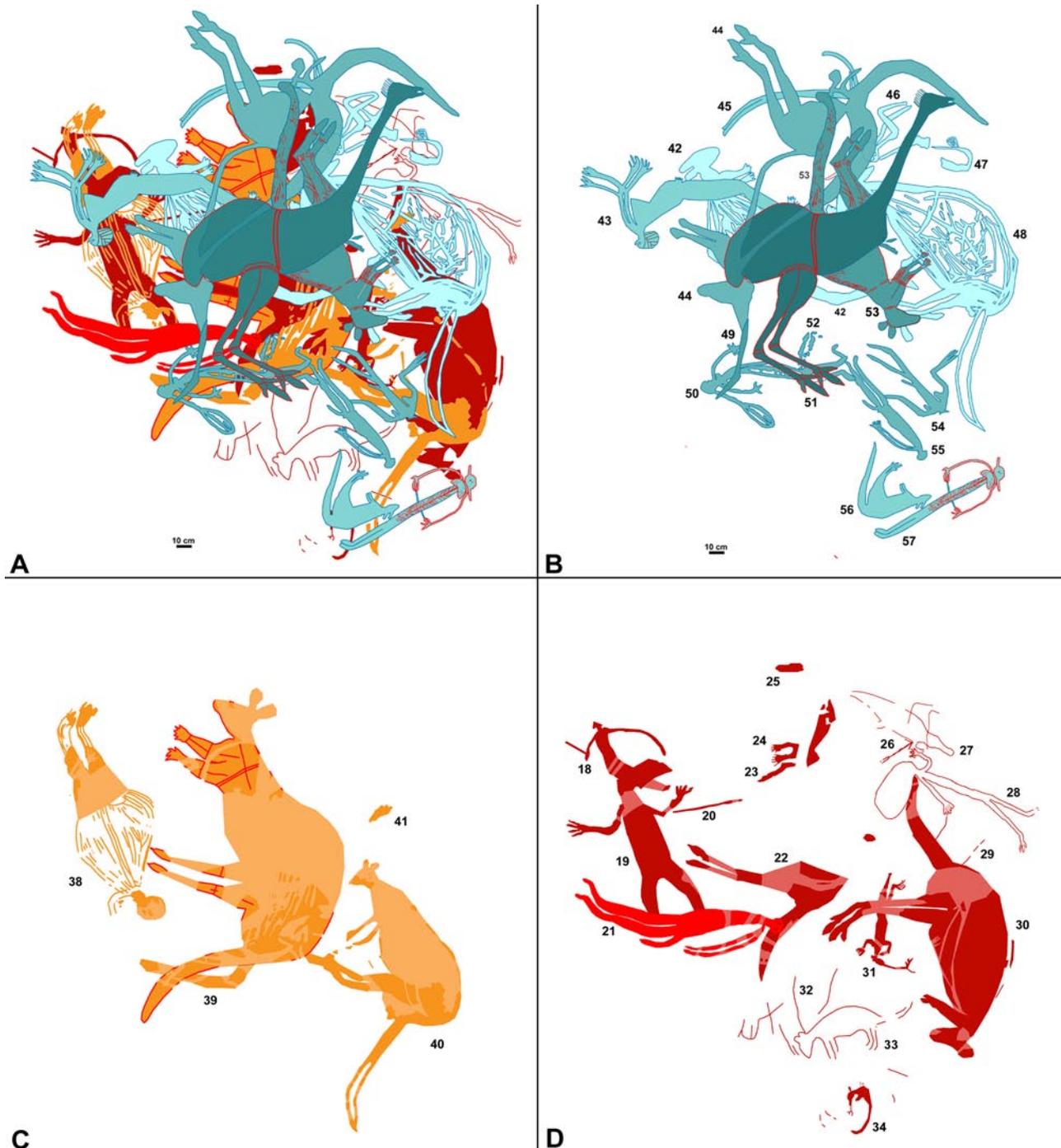


Figure 6. Traced interpretations of the A3 pigment sequence. A: full composite B: white C: yellow D: red.

in the EXIF header of a JPG image), but the image is effectively scale free. This mosaic was then opened in Photoshop and saved in the software's native format and the first layer added. The upper white figures were then drawn in a dark blue although, as some of these white paintings had fine red linear infill, this was delineated in red on this layer. The successive white layers (Fig. 5B) were distinguished by progressively lighter tones of blue (Fig. 6B). (Blue is used for white as white does not reproduce on white paper, and blue motifs are particularly rare in Australian rock art). The interpretation of the white motifs was checked

against a D-Stretch 'lab' image. This showed that the white of the central and most recent 'emu' motif was a different pigment from the earlier white motifs; it was slightly pink (Fig. 5B).

Beneath the white, there was a layer of yellow paintings. As the fragments were not readily apparent, the mosaic was run through D-Stretch, using the 'ybk' colour-space transformation and enhancement to emphasise the yellow (Figs 5C and 6C). As this is the same size as the original mosaic, the more extensive yellow pigment areas were traced from the D-Stretch image onto a Photoshop layer, and then the layer copied back

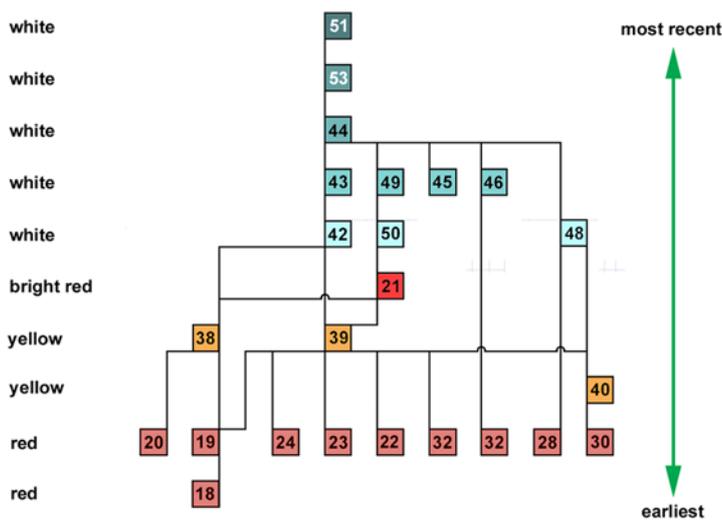


Figure 7. Harris matrix of the A3 panel of the motif sequence.

onto the master drawing as a separate yellow layer. At completion of the tracing of the yellow pigment areas, by turning off the white and background layers, the form of the original yellow motifs became clearer and, where possible, the missing parts of the motif were completed and filled with a lighter yellow.

A similar procedure was adopted for the red paintings (Figs 5D and 6D).

When completed, by turning off unwanted layers, each layer could be saved individually. This is particularly useful when numbering the motifs for classification as it reduces the number and complexity of motifs on any one sheet.

By turning on all traced layers (white, yellow and red) and turning off the background photomosaic, the image was flattened and a composite image achieved (Fig. 6a). The original Photoshop format file, with all of the drawn layers and background mosaic, can be saved for reference and checking by other researchers. From these layers it is a small step to then produce a Harris matrix of the motif succession on the panel by listing the sequence of any clear overlaps (Fig. 7; cf. Loubser 1997) in the hope of, with further sequences from other panels and sites, achieving a broader site and regional pattern of any changes within the art corpus (cf. McCarthy 1974).

It is noted that with very large and complex panels, the time required to undertake this process can be considerable (2–3 days per panel). While this level of detail may not be required in many instances, for more detailed recording it has proved an extremely valuable tool. Also, in many instances, the identification of superimposition sequences is not as clear as was presented in this example and may require the use of additional techniques such as microscopic examination or reflectance transformation imaging (RTI) to resolve the sequence (cf. <http://www.c-h-i.org/>).

Conclusion

The combined use of three different graphics programs and image processing approaches has been shown to provide a useful method for the rationalisation of complex superimposition. The technique can also be used to isolate any single motif or any particular group of motifs (such as all beeswax pellets on a panel to look at both overall and temporal distributions).

Despite these more recent techniques and the advances in digital imaging, it is acknowledged that they are not the best or most suitable in all cases as, relying on photographs, they have the problems of all photographic records (note Clegg 1991). Consequently, we continue to concur with Chippindale and Taçon (1993) in quoting Begouën and Clottes (1987: 180) that ‘no cave with wall art can ever be considered as entirely known’ and with Rosenfeld (1977: 10) that ‘no record, however carefully or imaginatively made can guarantee to fulfil future requirements’. Finally, we reiterate that any recording should not be confined to a single technique, but must utilise at least three different techniques, as all techniques uniquely capture distinct facets of our perception of the artwork (Gunn 1995).

Acknowledgments

The recording of the Nawarla Gabarnmung shelter was undertaken with the permission of the Jawoyn Association, Katherine, and funded by the Museums and Art Galleries of the Northern Territory through its ‘George Chaloupka Fellowship’. We also thank Chris Morgan for flying us to the site and Leigh Douglas for her support in the field and in making comments on the draft paper. Finally we acknowledge the positive comments and additional references by the RAR referees Liam Brady, Jannie Loubser, Ian McNiven and Bob Mark.

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Final MS received 31 March 2010.

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