

Review of report on Accelerated weathering studies (Final report) and Field studies of rock art appearance (Progress report)

Background

The West Australian Department of Industry and Resources Burrup Rock Art Management committee has in 2004 commissioned scientific investigations on possible adverse effects of pollution on the condition of rock art in the Pilbara region on the Dampier archipelago. The undersigned has been asked to serve as an independent reviewer of this ambitious project. The present review concerns the 3rd interim report issued in March 2007.

Results obtained

In the period since the 2nd interim report was issued substantial progress has been made. The present report contains final results from the accelerated laboratory fumigation investigations including dust deposition and results obtained in the meantime in the field activities including evaluation of colour changes and spectral mineralogy, where the final evaluation will take place in August 2007. In the following a brief valuation of the results obtained will be given concerning the accelerated testing (fumigation), dust deposition, colour changes and spectral mineralogy.

Laboratory investigations

Fumigation. After a thorough definition of test conditions concerning pollutant doses and condensation cycles exposures were performed replicating 40 years in the natural environment. In addition the role of dust in the degradation was investigated. A suitable realistic testing methodology has been developed including a wetness cycle that proved to be critical for the interaction of pollutants with the rock surface. The fumigation experiments were performed using pollutant concentrations on the anticipated future industry level and in the accelerated exposures on 10 times this level. As early indicators of damage different sensitive advanced techniques were used. FTIR indicates that the fumigation process did not induce any measurable changes in the mineralogy of either engraved or background rock surfaces. The ESEM/EDS analyses have shown that the elemental concentrations of both types of surfaces after the x1 and x10 exposure did not lead to changes in elemental concentrations compared to the control specimens. The surface colour measurements performed before and after the exposure have shown that the colour changes were within the same range for exposed and control specimens. This applies also for samples exposed with dust and at the increase of pollutant concentration to x10.

Dust deposition. The response of iron ore dust to extreme pollutant conditions with respect to colour changes was investigated to be used as end points for changes of industrial dust and as a predictor for the response of hematite on rock surfaces to concentrated pollutants. The results of the fumigation experiments suggest that exposure to expected emissions of pollutants on the Burrup peninsula will give minimal effects on mineralogical and colour changes.

Field investigations

Dust deposition. The measurements are aiming at characterization and quantification of dust that actually deposits on rock surfaces. Collection of dust on the tiles gave similar results as in the earlier periods. In general the deposition rates are very low. There is a clear difference in the composition of dust on the Northern, more remote sites than on the Southern sites which are closer to the industrial activities. There the dust resembles the iron ore dust while on the remote sites the dust is consistent with that of local soil and marine salt. Dust was observed to build up substantially more on surfaces protected from wind and washed by rain, which is confirmed by observations of the uneven deposition of dust on real surfaces depending on the surface roughness.

Colour changes. One of the key issues is the risk that changes in the environment from industrial activity may cause colour changes. The selected methodology, which has been further developed for use under prevailing field conditions, gives the possibility for measurements of changes based on an objective numerical method. It describes the colour in a 3-dimensional colour space for each measurement points. It has been applied on a series of selected measurement points within the researched area. The methodology seems to work well, however, with only two annual measurements taken so far it is difficult to establish whether the colour changes observed constitute a trend. Confidence can be improved when additional data points will be available from measurements which will be performed in 2007 and possibly also in following years.

Spectral mineralogy. Using the portable reflectance spectroscopy (ASD) the mineralogy of the samples can be characterised on the basis of key spectral features. On the points where colour measurements are being performed the surface is also characterized with spectral mineralogy. The mineralogy of the rocks has not changed, the absorption features are similar to those found in 2004 and 2005. The changes in brightness observed in the previous years have been systematically studied, demonstrating that moisture has an impact on spectral behaviour and has to be taken into account in future measurements. Additional spectra which will be acquired in 2007 should provide data for more definite conclusions.

Concluding remarks

The 3rd interim report shows that the investigations follow the original plan. The report documents completion of two components of the study, fumigation and dust deposition, while the field studies of rock appearance and spectral mineralogy will continue until August 2007. The results obtained are presented in a systematic way in a report of high quality containing to my judgement no errors. The individual components of the study are interconnected and can be expected to add substantially to an overall understanding of the surface chemistry and mineralogy. The results obtained are discussed in an objective way which will give the public an unbiased view on potential risk. They will greatly contribute to a fundamental understanding of the degradation processes on the rock art in the Burrup region due to the combined effects of gaseous airborne emissions and industrially generated dust.

28 May 2007

**REVIEW OF
ACCELERATED WEATHERING STUDIES
(FINAL REPORT)
FIELD STUDIES OF ROCK ART APPEARANCE
(PROGRESS REPORT)
(CSIRO, March 2007)**

General Comments

The Report includes the conclusions drawn within the research performed in the accelerated weathering study and the progress achieved on the evaluation of colour change in the field studies of rock art appearance, which will be concluded by August 2007.

The experimental work carried out is clearly described by the Report, which provides an in-depth account of the advanced methodologies and analytical techniques applied in the fumigation study as well as in the colour change evaluation. The exposure conditions, analyses performed on the samples and results are all well described.

Of particular interest is the description of how the fumigation study has been included in the context of the different investigations finalised to the evaluation of the impact that air pollution may have on the rock art in the Burrup Peninsula situated in the Pilbara region of Western Australia, which is of both cultural and historical significance.

Overall, the Report entirely fulfils the objectives of the project and the conclusions it draws are well founded.

The Authors may wish to take into account a few minor points.

Page 3 – Check editorial error “This area is also is the location of....”.

Page 33 Table 8 – It needs to be pointed out that only non-carbonate carbon (CnC) is linked to air pollution.

Page 38 2nd paragraph from the bottom – The statement “rougher surfaces inhibit the deposition of smaller particle fractions” needs to be better explained. Roughness mainly affects the adhesion and capture mechanisms. When the particle size is taken into account in evaluating the deposition efficiency, the deposition mechanisms under consideration need to be defined, i.e. Brownian deposition, thermophoresis, diffusiophoresis, Stefan flow, inertial impaction etc. and specific reference to stone surfaces may be included (e.g. see Camuffo 1998).

Page 47 – check last line “can be considered to be.”

Page 57 - 3rd line from the bottom – Table number need to be included.

Concluding Remarks

The analysis carried out is thorough and appropriate in terms of the objectives of the project.

In conclusion, no part of the Report is misleading and it can therefore be released into the public domain with confidence.

D. Camuffo, *Microclimate for cultural heriatge*, Elsevier, Amsterdam, ISBN 0-444-82925-3, 1998.