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ABORIGINAL ROCK ART OF THE KIMBERLEY

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CONSERVATION MANAGEMENT OF WEST KIMBERLEY ROCK ART: MICRO-CLIMATE STUDIES AND DECAY MECHANISMS

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I will give you my perspective of the work done by the Museum in conservation of rock art over the last decade.

The work has also been done in close conjunction with the people in the west Kimberley and in the Murchison in every other area where the rock art has been worked on. We almost came to grief in terms of bureaucratic deadlines with the work in the west Kimberley because it took Phil some 6 months of negotiation with the traditional owners to be able to get access to the sites and to explain what we were on about, why we needed to take samples and why we would agree never to publish any photographs of the images. Thus when this talk is written up in printed form, you will not see any of the images that you are seeing today, unless clearance has been obtained.

Is Phil Playford still in the audience? If so he will say, "Yes! That's mine; it's mine." The great Devonian Reef is Phil Playford's territory because of all his research in the area. He didn't quite make it because he is not that old, but what we are going to be talking about are sites in the Napier Range and also some of them up in the Mitchell Plateau. A view coming in to the Napier Range from the helicopter is shown in Figure 1.

Because of limited access to some of the sites in the wet season we had to fly in by helicopter. There is no room for your feet or any other major part of your body in the helicopter, so you hang out while all your gear is carefully stowed on the inside.

The rock painting sites are really quite spectacular. You must remember that these sites are as sacred and as important and as spiritually powerful to the people as are the soaring columns in Durham Cathedral to an Anglo-Celtic person. This is the living embodiment of the spirit of the land and so when you walk upon it, you are walking in hallowed ground.

Figure 1. Aerial view of the Napier Range near Bilyarra.

We camped down there at Bilyarra and walked up the path to the site. Philip Haydock is seen setting up monitoring equipment, to look at the images and their environment. The sensors were held in place with green poles cut with a bush axe machete. The poles were cut to various lengths to pin the thermocouples and the humidity sensors up against the rock art. This was done so that we could understand what the microclimate was like at the surface. There is no point in just going down there and using a sling psychometer and trying to work out the relative humidity on the rock surfaces. You have to remember that this rock is breathing; it is alive and so we must measure its surface. The rock can be quite different in character as you move across the site.

If you apply single measurements to a site it is just like saying that all of you are all the same and you can all be treated in the same way. Now, if you were treated in the same way by a bureaucrat, you would say that this was appalling. In the same way the rock art at one point has to be treated and understood in a different way to another section of the site because it is a different micro-environment. It is a different microclimate.

With the natural spring in the green sapling you can hold the thermocouple right up against the rock and get a very close reading on the relative humidity. This is in fact on a spot where we found high levels of local moisture had been affecting this area of exfoliation and decay. In fact we have been able to pick up differences in the microbiological populations across the rock surfaces, depending on the fissures and the differing amounts of moisture coming in from above. This data relates to the specific forms of decay of the images.

In the sampling of degraded surfaces and pigments one takes advantage of nature: where there is exfoliation and pots of pigment coming off, you use that for taking your samples. Part of the answer to the question of what is happening behind the images to cause the delamination was found when we measured the surface pH of a freshly exfoliated spot on one of the images. The pH was about 8.5-8.8, so effectively it is active reprecipitation of calcium carbonate during the drying cycle and it is going 'rrr-ggk' and blasting the pigment to bits.

Some of the pigments that we identified at Bilyarra were calcite, but it is difficult to determine whether it was there as a pigment or an alteration product. Other phases were the weathering products of gypsum and the whewellite and this grey-white mineral sericite/illite a clay pigment, and the vivid white mineral huntite $Mg_3Ca(CO_3)_4$.

The white huntite is the major *Wandjina* pigment and we wanted to understand what was going on with all the huntite. When a sample was equilibrated at normal room temperature - good museum conditions, 55 per cent relative - humidity it was weighed. As we desiccated it over some very drying salts like lithium chloride, it didn't lose much weight but there was massive absorption of the water as you start going up above 56 per cent relative humidity. This is a double reason why you should have climate control in museums to stop your artefacts absorbing massive amounts of water if in fact you have got huntite painted images in your collection (see Fig. 2). If you compare it with talc, a pigment with relatively little sensitivity to the moisture, the reason for the sensitivity of huntite is the multi-layered platelets of the natural mineral. They absorb water and the pigment begins to go 'rrr-mmrr' and swell as the humidity comes up. Therefore it is not unrealistic to expect to see a change in the image of the *Wandjina* because as the relative humidity begins to increase, as the signs of the rain come, so too the spirit comes into the *Wandjina* and it swells and becomes alive and then - 'shsh-woo' - down comes the rain.

In this process the huntite can react with moisture (with water) to partly dissolve and then interact with acidic metabolites from the plants trickling down through the vegetation to form the whewellite, or it can react with oxalate directly from other sources such as rain or can partly dissolve in water to form its component dolomite and magnesite and then react with the oxalate. It is important to note that there are many pathways for getting this oxalate crust which is very important for those who are passionately interested in dating these materials. It also has a major impact on the survival of the huntite which is very prone to spalling off the rock surfaces.

The people who talked with Phil and me said, "No, we don't want you to do any dating." We understood that the reason why was because they knew that the images were old, because their ancestors had painted them. That was good enough for them and it was good enough for us. It is vital to respect the wishes of the custodians of the sites.

One of the things that is important in understanding the way in which the pigments are behaving is to look at the climate in the local area and also against the rock surface. We set up our little micrometeorological screen a few hundred metres away from the rock sites and then placed other sensors on the rock surfaces. If you look at the output of the data loggers and the plots of temperature versus time, for the dry 1990 season, you are going from temperatures around about 33 down to about 16 degrees at night. However, the relative humidity (RH) is very low from 15 per cent down to 5 per cent. If you want to dry out and age and undergo the best field test for "Oil of Ulan", try working in the Kimberley in these environmental conditions.

The above environmental parameters can undergo major rapid changes. The temperature and RH plots change when there is a moisture front coming in and then it settles down to the normal swings associated with the diurnal cycling of relative humidity. We have taken the rock surface temperature profiles and we find that we have been able to use a computer model to replicate the rates of change. In the case of the climate at Bilyarra we

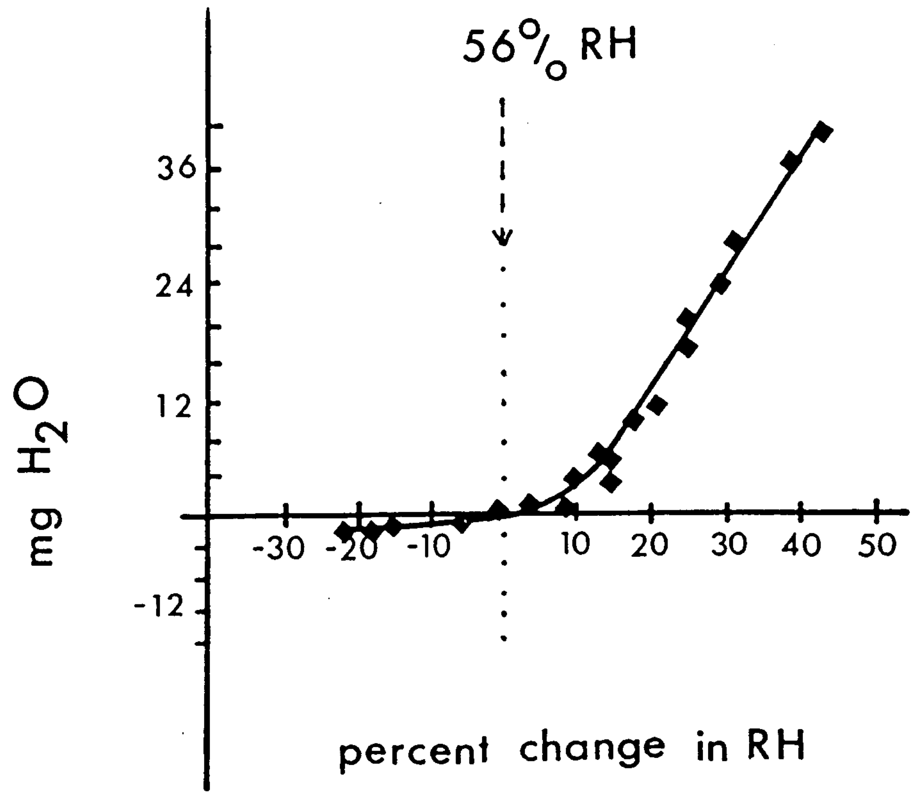

Figure 2. Water absorption on huntite ($Mg_3Ca(CO_3)_4$ as a function of relative humidity

were able to reproduce these sharp curves in the variation of the rock surface temperature by modelling in the effect of the cooling factor of wind going through the sites, plus the accompanying effects of cooling from moisture evaporation.

In attempting to understand the microclimate you have to take into account not only the temperature and the relative humidity but also the movement of the wind because that is either helping to dry or to rehumidify the site, depending on whether the wind has a higher or lower moisture content.

Microclimate measurements at the *Baralama* I site were taken as a model of a site that has recently been repainted. During the first season we found that the cattle were rubbing against the rock art. So we thought, since this was leading to significant pigment loss a barbed wire fence was erected in front of the site and that stopped the cattle but it didn't stop other factors significantly affecting the deterioration of the images.

Behind the site are caves which contain bats and in the wet season the odour of their excrement is marked. You almost have to walk around with a peg on your nose! When we sampled the biological populations in the dry and in the wet in these areas around the cave the surface pH went from about 7.4 down to 4.2. This fall of 3 pH units means a 1000 times increase in acidity. The microbiological population went from about 30 000 bacteria per millilitre to 1.8 million.

When bacteria reproduce and live they produce acidic metabolites and therefore there is a major impact on the survival of the pigments. The mechanism of decay of the huntite involves significant interaction of the carbonaceous pigment with acidic metabolites. Therefore, one of the principal mechanisms of decay being promoted at this site is due to the bat colony. The bacteria are utilizing the ammonia and other nitrogen compounds from the bat urine to act as a food source to help them metabolize their food and to reproduce faster in the wet with more moisture around. This produces more acid and so the painted images degrade at a faster rate.

The early stages of disbondment can be seen in the cupping of the surface of the repainted images which at this stage were only a few years old. The problems of the loss of the huntite are in part overcome by conversion to the calcium oxalate whewellite ($CaC_2O_4.H_2O$) which has much better adhesion to the surface.

At a nearby site, which is only a few hundred metres away, we set up the data logging equipment and we found that looking at the relative humidity and the temperature data is very confusing because they are logarithmically related. It is rather difficult thinking of one axis in a linear frame (time) and the other as a logarithmic function. We were able to solve the confusion of the apparently conflicting trends by changing the way in which we present the data.

Since all the data is logged with the computer and imported into the software program 'Excel' you convert all the relative humidities and temperatures into absolute humidity, and plot the actual amount of water in millimetres of mercury pressure as a function of time. This data format showed us that for any one point on the rock surface the rate of change of temperature during the night would be different. You think: why? It could be due to differences in the rate at which moisture was moving in or out of the environment. In fact this supposition was correct.

Normally the rate of night time cooling is dependent on the thermal mass of the rock and the amount of sky that can be seen from that point. This "sky view factor" controls the long wave cooling. When moist air came in the cooling rates fell and vice versa. We were able to pick up night-time heating on some of these points that have no view of the sky. The only way in which you can heat up at night is if the surface is chemically absorbing water. As water vapour is absorbed it gives off heat. We are seeing actual physical absorption of the water, during the night. We now have proven that even in the dry season when it is still believed that everything shuts down - there is no water-based deterioration - we are getting active absorption of water at night in the atmosphere. That is incredibly valuable in understanding the business of decay, since it means the processes of deterioration are ever present. It is just that many processes become more active in the wet season.

The wet season is often a very stressful time for the pigments because of the changes in moisture content and biological activity. The research workers on sites must ensure that they are not damaging the rock art through their measurements because it is pretty crass to go around doing measurements that go and destroy the objects that you are trying to save.

Our use of the bush poles to gently press the probes against the painted surface is a subtle approach since after our measurements only our records show where we have been. At *Baralama* II the plot of temperature and relative humidity as a function of time shows just the normal diurnal cycling. As the temperature falls, the relative humidity goes up and the repetitive cycling of going up and down shows that the system is closed. There is no external input or output of moisture. It is essentially locked up.

Comparisons are always made between the external environmental conditions recorded at the meteorological screen and that on the actual rock surfaces, When such comparisons are made you can see that the range of relative humidity variation on the rock surface is much less. By comparing the way in which the rock surfaces behave compared with the external climate, you can get an idea of what the physical stresses are and the way in which the rock itself buffers the change in external climate.

The other major area studied is the sandstone sites in the Mitchell Plateau where, even when it was dry, it was occasionally wet. Despite doing measurements in July 1990 in the dry season there were some rain events which seemed to mess up our nice little theory of getting dry season data followed by wet season data. Nevertheless, the information gave us a much better understanding of the inpact of such events when they occur out of season.

Ian Crawford made the comment that the *Wandjina* paintings are often very close to water. In fact, this is the case at Moonooroo where we saw some quite spectacular exfoliation of the surface, which contained pigments. We think we now know the cause. In part it is due to the interaction of the acidic metabolites from the bacteria and moisture coming down through fissures in the rock surface. We were able to pick up a totally different micro-environment for this *Wandjina* compared with some around the corner and around the back. Yet one couldn't physically observe any difference in the microclimate when relying on normal senses. It was only when you had the analysis of the logged microclimate data that you could find it. The *Wandjinas* near a rock fissure were more degraded owing to the greater availability of moisture after rain had wet the upper rock surfaces. This led to a greater water vapour at the *Wandjina* and so it decayed at a faster rate.

From samples of painted flakes that have disbonded from the rock, Bruce Ford was able to show that the *Wandjina*s were composed of multiple layers of repainting and building up of the silica skins on the surface. A typical section is shown in Figure 3: such a section may have taken several thousand years to accumulate.

The images at Yalgi were in good condition compared with those at Moonooroo. From analysis of the microbiological activities the surface pH and the water vapour pressing the better survival rates of the same type of pigments correlate with the microclimate.

For me, one of the most powerful and profoundly humbling experiences was to be on a site and to go and check on your equipment and then know that you are being watched. You just quietly explain who you are, why you are there and what you are doing and that you have permission from the custodians to be here. The spirits tell you that you can go on, and so you go on about your business. Good results come and your computer doesn't fail. The power source works to keep backing up your batteries and you get the results the site needs and then all is well.

In summary our studies have shown a great diversity in the wide range of things that are used as pigments in Kimberley sites. There was huntite, then whewellite ($CaC_2O_4.H_2O$), then weddelite ($CaC_2O_4.2H_2O$) in the more damp parts of the caves. The mineral teranakite found on

Figure 3. Cross-section of a fragment of a painted surface from a site in the Mitchell Plateau showing silica skins (banded white material of non-uniform thickness) and multiple layers of painting. (Height of image is equivalent to 2.22 mm.)

the sites is probably due to a bacterial alteration product: the mineral is a potassium, aluminium, hydrogen, phosphate. Other minerals found included dolomite, calcite, antigorite, illite, haematite and goethite.

In the future we hope we can continue to do more studies, looking at the microclimates of the rock surfaces. We now understand much more about the mechanisms of decay but there are still so many questions that need to be answered. Many scientists refuse to do work in a field like this because you cannot control it. You cannot quantify it because you have got bacteria, you have rain, you have wind. You have too many variables. That is why you have to take lots of measurements. You have to go to lots of sites before you can begin to see the pattern. It is hard but in the end the results come.

We now believe we are well on the way to understanding part of the mechanism for the underlying causes of the exfoliation of these pigments. That is the reason why we did the study in the first place, because if you don't understand the pigments, if you don't understand the surface, how on earth can you make any valued judgment about how to manage the physical preservation of these rock art sites?

We have been able to monitor and model the temperatures on the sites and this is important, because we are not going to be able to be there all the time to check on things. Since we have found a way in which we can model the rate of change of the rock surface temperatures we are well on our way to understanding what is going on. It is indeed the beginning of a new era. Thank you.