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## A GLOBAL PERSPECTIVE OF ROCK ART PROTECTION

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### General observations

The previous issue of *Coalition* was dedicated to aspects of the conservation of rock art. Here I will continue with this subject, briefly placing it in a global context and highlighting current pressing matters.

Efforts to preserve rock art vary greatly around the globe, ranging from the truly exemplary treatment of the outstanding Chauvet Cave in France, arguably the best-protected rock art site in the world, to numerous regions where rock art enjoys no protection whatsoever. While we do have the superb site protection systems of several countries, in many others the relevant authorities are simply not aware of their international obligations in respect of the rock art heritage. Examples the International Federation of Rock Art Organisations (IFRAO) has addressed in the past have occurred in, among other countries, Portugal, Peru, Santo Domingo, Canada, U.S.A., Namibia, India and Australia. IFRAO, the world's foremost advocate for the preservation of "prehistoric"

cultural heritage, has found that many, even most of the preservation problems due to inappropriate development are the result of local lack of information or awareness. There needs to be a much stronger public promotion of the principle that all rock art is part of the common heritage of humanity. Nation states merely manage this resource on behalf of us all. Allowing its destruction contravenes international law, and the *Unesco Declaration concerning the Intentional Destruction of Cultural Heritage* (especially Article VI) needs to be better promoted among those who are effectively managing rock art in the various Member States of Unesco. It is clear from my experience that most of the officials theoretically responsible for the protection of rock art around the world – who might be attached to forestry departments, cultural management offices, heritage or land management departments of various types – simply have limited awareness of what their responsibilities concerning the immovable cultural heritage entail. This is not necessarily a condition endemic to developing or badly governed countries; it can be just as profound in developed countries. The example of Portugal could be cited, or the fact that the vandalistic treatment of petroglyph sites in Scandinavia (e.g. by painting them) is still being continued in some regions. Fortunately we have been able to convince Unesco in October 2005 that the guidelines for the protection of rock art need to be significantly upgraded.



Figure 1. Umm Sanman, near Jubba, one of many rock art sites protected in Saudi Arabia. The escarpment is densely covered by petroglyphs, and the fence is about 4 km long

It is also apparent that in those parts of the world that possess particularly famous archaeological tourist attractions (e.g. Egypt, India, Mexico, the Andean countries), rock art tends to be more neglected than in other, comparable countries. Another issue is that there has traditionally been a reluctance in most Moslem countries to recognise the importance of rock art, essentially because of religious bias against imagery, but this, fortunately, is now being overcome by Saudi Arabia taking a strong lead in rock art preservation (Figure 1), and protection is also improving in Morocco, Algeria and Libya. It is to be hoped that other Islamic countries will follow these examples in the coming years.

The global inventorying of rock art is not only important for research or site management, but also for protection: it is impossible to effectively protect a resource that remains unrecorded. IFRAO has been very successful in eradicating damaging recording practices that were still widely used by researchers up to the 1990s in several major rock art regions. It has also facilitated the development of modern recording techniques and digitised processing and manipulation of data by introducing an international standard scale for rock art recording. Moreover, IFRAO has been quite effective in the implementation of improved research standards in most parts of the world, and in a scientifically standardised terminology for the discipline, by creating a rock art glossary and translating it into several of the major languages.

But perhaps the most spectacular success of IFRAO has been its promotion of protection and preservation of rock art. In this work, IFRAO has found itself opposed by many interest groups, ranging from local administrations, developers and industrial corporations to national governments. All of these confrontations have resulted in better appreciation of the need to take care of rock art, and most of them have brought about the preservation of rock art that would otherwise have faced certain destruction.

The most severe confrontations IFRAO has had with state heritage agencies were those in Portugal, first in the Côa valley (Bednarik 1995), later in the Guadiana valley (Arcà et al. 2001; Bednarik 2004), where these agencies were exposed as intellectually corrupt and incompetent. This has led to major remedial

action in that country. The third time IFRAO has had to challenge a government, in Western Australia, has become the greatest confrontation in history for rock art protection.

#### **Australian rock art protection**

In terms of its rock art, Australia is a privileged continent. Not only do the researchers of this country have the best access to the traditional ethnographic significance or meaning of its rock art, it also has been blessed with an unusually large corpus of surviving rock art. The reason for this wealth is not, as often assumed, that most Australian rock art is comparatively recent. Rather it is the result of the predominantly semi-arid country's excellent preservation conditions, the absence of any historical iconoclastic tradition, the relatively low population density in most of Australia, and of conservation efforts by various agencies.

Due to the size of the Australian body of rock art, the largest national corpus in the world, a full inventory of it will take many more years, and we still have to expect major new discoveries. Nevertheless, it can safely be concluded that the largest concentrations are those of, from the west, the Pilbara, the Kimberley, Arnhem Land and Cape York Peninsula. The largest single site complex, which is also the largest rock art complex in the world, is that of the Dampier Archipelago, located in the Pilbara. It has been partially surveyed and is thought to comprise well over a million petroglyphs. It is little known that most Pleistocene rock art is in Australia, where it is thought to include many thousands of sites, and that all of it refers to people of a Middle Palaeolithic technology. Therefore there is far more surviving Middle Palaeolithic rock art in the world than Upper Palaeolithic.

Despite the large size of the body of Australian rock art, its conservation is in comparison to the rest of the world of a relatively good standard (Watchman 2005). The great majority of sites are quite remote and of limited access to visitation, and they most often occur on private land. Positive publicity campaigns have prompted many landowners to be quite protective of sites. Only a small number of rock art places have been "sacrificed" to the public, and these have been well developed for visitation. Access paths, raised walkways and viewing

platforms have been erected, there are psychological barriers as well as physical ones, and good interpretation material and visitor books are widely employed at unsupervised sites. As a result of subtle public education measures, the incidence of site vandalism has been reduced significantly. Most of this enlightened public attitude is the result, directly or indirectly, of the work of the Australian Rock Art Research Association (AURA). That organisation has been instrumental in galvanising researchers into a discipline, and in raising public awareness about rock art through the media and various public agencies, at both state and federal levels. Perhaps the most important lesson we have learnt in rock art site management is that positive public perception is the key issue in site protection.

Rock art research is very well served in Australia, with well-established traditions. AURA is the largest rock art organisation in the world, producing the discipline's major refereed academic journal, as well as two newsletters and a series of monographs on rock art. Apart from survey work, the country's researchers have focused primarily on two areas of research: analytical studies, especially on the dating of rock art; and ethnographic studies involving the traditional owners of all Australian rock art. Most of the analytical rock art dating methods currently in use worldwide were initially developed in Australia, and the country continues to be a leader in the field of estimating rock art antiquity. Other research interests being pursued by Australian scholars are conservation or preservation techniques, advanced methods of recording and a variety of specialised analytical approaches.

### **The Dampier rock art**

Unfortunately, in one state, Western Australia, current legislative protection of rock art remains inadequate, and the principal rock art vandal there is the state itself. This emergency state has become especially acute at the huge Dampier petroglyph site complex, where massive industrial development has already destroyed well over 100,000 petroglyphs since 1964. The rest of this substantial monument is being subjected to gradual deterioration from acid rain caused by a petrochemical complex that could easily be located anywhere else in Western Australia. IFRAO is currently engaged in a long-term

campaign to have several planned new hydrocarbon-processing plants located at alternative sites (Figures 2 and 3).



**Figure 2. Sacred rock art site at Dampier, Australia, with massive petrochemical industry encroaching**



**Figure 3. Largely destroyed stone arrangement of 138 stelae, King Bay, Dampier, with nearby industry**

The rock art at Dampier, presumed to be the largest concentration in the world, was discovered by me in the 1960s and I have been engaged in trying to preserve it since 1969. The campaign of the state government of Western Australia and its archaeologists has so far destroyed between 20 % and 25 % of the magnificent Murujuga cultural precinct (on the archipelago's main island) through unnecessary development and appalling planning. Although some significant concessions have been made during recent years, the destruction of rock art and megalithic stone arrangements is still continuing at Dampier, and the campaign is in desperate need of international support. The state government of Western Australia is the world's worst cultural vandal, exceeding in its fervour the former Taliban regime of

Afghanistan. The producers of the Dampier rock art, the Yaburarra tribe, were the victims of police-perpetrated genocide, when they were extinguished in a series of incredible massacres taking three months, commencing 17 February 1868 (Bednarik 2002). No compensation has ever been made to the Aborigines, nor have any of the murderers faced a court. Today this historical incident is such an acute embarrassment to the state government of Western Australia that it is keen to see the cultural patrimony of the Yaburarra eradicated as well.

This example shows that in cultural heritage management, there is often more at stake than just cultural values. Rock art, like much other "prehistoric" cultural heritage, is frequently the work of those who were dispossessed, destroyed or defeated — history's "losers". This applies not only in Australia, it is valid globally. Contrary to archaeological claims, we do not really know the correct meaning of "prehistoric" monuments, we have merely appropriated them. It is contingent upon civilised society of the present century to ensure that the destructive powers of the "winners" of history, the powerful and the corrupt, are limited. If we fail in taking those to task who would like to write their preferred versions of history, and who appropriate cultural monuments for political reasons, we have no right to consider ours a civilised society.

To help in the battle to save the rock art at Dampier, please visit <http://mc2.vicnet.net.au/home/dampier/web/index.html> and sign the Petition. Thank you.

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## ROCK ART PRESERVATION IN BOLIVIA AND ARGENTINA

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### Abstract

In the present article, the authors present a brief introduction to rock art protection and conservation in Bolivia and Argentina, explain strategies and actions taken in the last 10-20 years and suggest what should be done in the future. We also refer to initiatives in other Latin American countries.



### Bolivia

More than 1,000 rock art sites have been registered by "Sociedad de Investigación del Arte Rupestre de Bolivia" (SIARB), a private scientific society, over the last 20 years; however most of them have not yet been recorded in detail (map showing the distribution of sites is available at <http://www.siarb-bolivia.org/esp/principal.htm> - "Galería"). Rock art research in Bolivia is still in its initial stages if we consider the lack of an exact chronology and the lack of intensive investigations in many regions (Strecker, 2001a).

State policies concerning the cultural heritage are characterized by centralism of the Viceministry of Culture and the National Institute of Archaeology (DINAR, former INAR), as well as decentralization with a more active role of the administration of regional 'departamentos' and municipalities which, however, lack preparation for this task and experience in this field (Strecker and Taboada, 1999).

The National Archaeological Institute created four parks to protect rock art which were fenced in and whose guardians are responsible for maintaining a vigilance: the sculptured rock at Samaipata in the Dept. of Santa Cruz; the rock paintings of Calacala in the Dept. of Oruro; the rock seats at Copacabana in the Dept. of La Paz; and, more recently, in collaboration with the municipality of Sucre, the rock art sites at Incamachay and

Pumamachay, Dept. of Chuquisaca. (In this latter case, SIARB's offer to act as a consulting agency in the planning stage was rejected. Once the site was vandalized, presumably by workers constructing a wall around it, the municipality and DINAR recognized the need for a more comprehensive project involving rock art experts and supported the new project directed by SIARB).

The archaeological institute also tried to protect a few other isolated sites by fencing them in, without providing vigilance, which has had devastating negative results: fences surrounding the petroglyphs of Toro Muerto and the rock paintings at Cerro Banquete, both in the Dept. of Santa Cruz, were destroyed and more vandalism occurred. In these cases, fences only served to attract attention to the sites and provoke their destruction.

In December 1998, Samaipata was inscribed in the list of World Heritage by UNESCO. Mass tourism is being managed by restricting access of visitors to a wooden platform constructed around the sculptured rock and to the area of a 'lookout', a hill which allows a splendid view of the site.

Due to very limited funding of the responsible state institutions, the work of the private society SIARB has increased more and more regarding investigation, recording and preservation of rock art sites. In 2002 SIARB received the Conservation and Preservation Award by the American Rock Art Research Association (ARARA).

SIARB has collaborated with the archaeological parks of Copacabana, Calacala, Samaipata and Incamachay-Pumamachay by publishing flyers and a booklet for visitors. In the case of Calacala and Incamachay-Pumamachay, SIARB is directing long-term projects based on agreements with the regional administrations responsible for maintaining the sites; it has achieved documentation (Strecker and Taboada 2001), provided training for the guardians, planned and installed appropriate infrastructure. In Calacala, a visitors' platform was inaugurated in 2002 (Figure 1). In Incamachay, a conservation treatment (cleaning of graffiti) was carried out in 2004 (Loubser and Taboada, 2005) followed by the inauguration of the park in May 2005. A footpath in front

of the rock art panels of the rock shelter was paved to avoid stirring up dust which would settle on the paintings, and information boxes for visitors were set up (Figure 2). A metal fence was installed at the entrance to the small cave of Pumamachay permitting only guided visits.



Figure 1. Visitors' platform in the archaeological park of Calacala, Oruro, Bolivia. (Photo by M. Strecker)

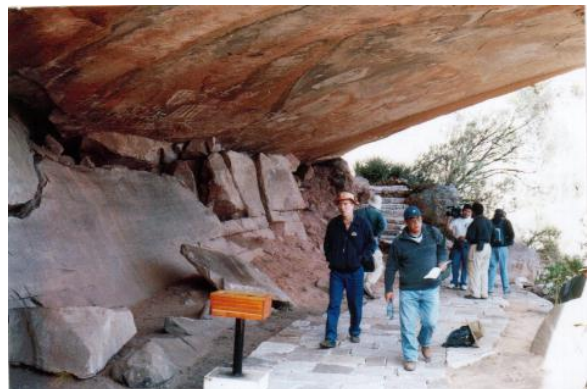


Figure 2. Paved path and information box, Incamachay rock shelter, Bolivia. (Photo by M. Strecker)

Collaboration between SIARB and another private organization proved fruitful for the protection of rock paintings at Torotoro, in the Dept. of Potosí. The site is situated in the National Park of Torotoro, created in 1989, which includes a deep canyon, an extensive limestone cave, and palaeontological and archaeological sites. In its first years, the administration of the park was assigned to the conservation association of Torotoro (ACT). Fernando Huaranca, member of SIARB and ACT, proposed a project, carried out in 1991, to protect rock paintings in the section Batea Cocha. Holes in a vertical cliff that had been used by visitors to climb up to the paintings at 4 m height were filled in with natural stones of local origin, thus impeding access to the rock art (which is still accessible for

investigation by using a ladder). This low-cost project did not interfere with the natural setting of the site, and Huaranaca also used plants to conceal the remedial work (Huaranaca, 1995). (Figure 3)



Figure 3. Construction of natural stone walls impeding access to rock paintings at Torotoro, Dept. of Potosí, Bolivia. (Photo by A.C.T.)

SIARB is collaborating with local municipalities in the region of Vallegrande, Dept. of Santa Cruz where new archaeological parks are in the planning stage. World Monuments Fund has included four rock art sites of Vallegrande in its Watch List of 100 endangered sites selected world-wide for the year 2004. As a preliminary measure of protection, access to the cave of Paja Colorada was closed by installing a fence in December 2003, as uncontrolled tourism had resulted in vandalism. Recently, another site of outstanding importance in the region, cave Mataral was also vandalized. SIARB has prepared a project to preserve rock art in these caves by carrying out detailed documentation and a condition survey, a preliminary archaeological survey, conservation of panels affected by recent graffiti, an education campaign, training guides, preparing a management plan and developing the sites for cultural tourism. Participation of the local communities and the regional municipalities will be decisive for the outcome of the project.

Community involvement has recently increased in the archaeological parks of Calacala (where a new guardian was appointed who was chosen by the community) and Incamachay (where the municipality of Sucre and the community of Tumpeca negotiate an agreement which will define how the entrance fees are used for

maintaining the park and benefit of the community).

In spite of successes in improving the preservation of rock art in several archaeological parks in Bolivia, unfortunately, more and more sites are vandalized and there is a permanent threat to rock art and other archaeological sites by tourism agencies whose activities are not regulated and which tend to promote visits to unprotected heritage sites. An obvious answer seems to carry out an education campaign (Strecker and Taboada, 1999: 40; Strecker 2001b); SIARB tries to inform the public on the importance of rock art and promote an appropriate visitors' etiquette (for example, in the web page [www.siarb-bolivia.org](http://www.siarb-bolivia.org)).

### Argentina

Archaeological sites, including rock art sites, are protected by the state law of protection of the archaeological and palaeontological heritage N° 25743. Besides, each Argentine province has its own legislation concerning the protection of the archaeological heritage. A national register enlists 1,500 rock art sites investigated till 1986 all over the country (Renard de Coquet 1988). We estimate that the actual number of sites could be between 4,000 and 5,000 sites which are distributed in all parts of Argentina except the northeast (Podestá 1996 and 2003; map in: [www.inapl.gov.ar/invest/arterup.htm](http://www.inapl.gov.ar/invest/arterup.htm))

On a nation-wide level, rock art sites are rarely valued as part of the national heritage, and are endangered by their recent inclusion in tourist routes without the previous proper planning and administration. In order to counteract this threat, in 1995 the National Institute of Anthropology (Instituto Nacional de Antropología y Pensamiento Latinoamericano, INAPL), institution dependent of the National Secretary of Culture, initiated a program with the aim of preserving some rock art sites of exceptional value. Sites were also selected with the view of their inclusion in the ever-growing tourism industry. We will outline briefly the actions taken and the results of the program achieved so far.

This program called "Documentation and Preservation of Argentine Rock Art" aims at devising management plans for selected sites that are to be implemented by the responsible authorities. INAPL acts as consulting agency

throughout the different stages of the program. The following steps have to be taken:

- 📁 Documentation of rock arte sites.
- 📁 Recording of rock art deterioration processes.
- 📁 Computarised image databases.
- 📁 Treatment of natural and cultural processes of degradation.
- 📁 Proposal to lessen the impact of natural degradation and vandalism.
- 📁 Diffusion and education for the general public and information exchange with local authorities responsible for the administration of the sites.
- 📁 Training courses for professionals.

The program aims at an effective collaboration with the provinces and specifically the local communities (Podestá and Onetto 2004) which are closely related to the rock art sites. Among the regions that have been included in the activities of the program are the following:

### 1. Patagonia:

Cueva de las Manos. INAPL, in collaboration with Santa Cruz province, has paid special attention to this site in Rio Pinturas area because of its exceptional cultural, scientific and aesthetic values. Finally, in 1999 the institute achieved that Cueva de las Manos was declared World Heritage by UNESCO, the first site in Argentina to receive this distinction (Podestá *et al* 2000). In the following years, and not only because of the increasing popularity of the site, Cueva de las Manos received considerable more tourist visits. The nearest settlement (Perito Moreno) has put into practice a management plan as recommended by INAPL. These activities have reversed the process of abandonment in which the site was until 1998. In 2005 a new infrastructure is being constructed that was found necessary to receive visitors during the summer season (Figure 4) and a new management of the site is about to begin (Onetto 2001).

Very attractive scenery of lakes and mountains characterize Comarca Andina in the region of 42° parallel of latitude and the lower valley of Manso river (Río Negro and Chubut provinces). In the last 10 years tourism has

tripled causing a larger offer of ecotouristic activities in this region. In consequence a project was initiated to present an adequate frame for public use of rock art sites. Several sites were prepared for tourism by private or municipal enterprises (for example Cerro Pintado at Cholila, Figure 5) assisted by archaeologists who investigated the regional archaeology (Bellelli *et al.* 2005, [www.inapl.gov.ar/invest/comarca.htm](http://www.inapl.gov.ar/invest/comarca.htm) (photo Cerro Pintado)).



Figure 4. Cueva de las Manos, Pinturas river, World Heritage site in Santa Cruz province, Argentina. (Photo by María Onetto)



Figure 5. Rock art site Cerro Pintado in the region of Cholila, 42° parallel of latitude, Argentina. (Photo by Cristina Bellelli)

Some private enterprises in Patagonia which promote tourist visits to rock art sites are not included in this national program, but are supported by provincial programs and advised by archaeologists so that the sites are preserved (for example Estancia La María, Figure 6).





Figure 6. Rock art site Estancia La María, Santa Cruz province, Argentina. (Photo by Rafael Paunero)

### 2. Pampa Area:

With the assistance of provincial authorities (La Pampa) and the administration of national parks (APN), the program has also worked in the central area of the country, especially in Lihue Calel National Park (Podestá *et al.* 2004)

### 3. West-central and northwest area:

The INAPL program is working in the northern regions of Salta, Catamarca, San Juan and La Rioja provinces. The sites Cuevas Pintadas in Guachipas (Salta) include various rock shelters with paintings, frequently visited by students and groups of tourists. Due to these visits the deterioration of rock art has increased, and in spite of the efforts so far no effective protection of some sites of exceptional value has been achieved (Rolandi *et al.* 2002). At present, the program is carrying out intensive work in Ischigualasto Provincial Park which was included in the World Heritage List in 2000, due to its palaeontological resources. It has now been suggested to include the region as a mixed site as it also contains several petroglyph locations which are being studied by INAPL archaeologists. A similar situation occurs in the National Talampaya Park in the neighboring La Rioja province where APN tries to protect archaeological sites ([www.talampaya.gov.ar](http://www.talampaya.gov.ar)). Apart from investigation, educational activities (traveling exhibit) are realized and members of local communities are trained as tourist guides (Rolandi *et al.* 2003).

En 2004 INAPL carried out a conservation survey of Inca Cueva 1, a site which includes rock art representations belonging to various chronological phases typical of NW Argentina. The provincial authorities of Jujuy are considering the proposal to manage the site

as part of plans for the Humahuaca gorge recently declared World Heritage site by UNESCO.

### Conclusions and outlook: rock art preservation in Latin America

Rock art conservation, as well as administration of sites play an ever-increasing role in rock art investigation, with the object of preserving this cultural heritage for future generations. In South America, well administrated archaeological parks with rock art are still very scarce, though efforts are beginning in several countries to coordinate the preservation of sites (Taboada and Strecker 1998; Strecker and Pilles 2005).

In Argentina there is an increasing concern regarding rock art site preservation. Apart from the national program mentioned above, several provinces have started working on their own projects. Nevertheless, few results have been achieved so far considering the great number of rock art sites in the country. Some places, prematurely opened to the public, are suffering acts of vandalism which will lead to their complete destruction, a process that cannot be reversed. Considerable efforts must be made in preservation, visitor management and interpretation of rock art sites in the future (Podestá 2003).

South American state institutions responsible for the protection and maintenance of archaeological sites are poorly funded and normally lack professionals in the field of administration of cultural resources. Due to this situation in Bolivia a private institution, SIARB, is assuming the task of coordinating rock art preservation projects.

On the other hand, with the exception of Argentina and Chile, there are only a few investigators specialized in rock art studies though the number is on the rise due to increased interest in this subject, and an increase of academic meetings dedicated to rock art studies. In some South American countries invasive recording methods (such as chalking out or making rubbings of rock engravings) are still frequent among investigators having a negative effect on the conservation of rock art and the possible application of direct dating methods. However, non-invasive recording methods are being used more widely (Taboada and Strecker, 2002), following such models as the

IFRAO and SIARB codes of ethics; there is also an increased awareness of the responsibility of investigators for taking part in the decisions about the administration of sites open to the public. Mexico has already started several projects to protect rock art sites, foremost in Baja California. Central America seems to lack behind, but similar processes are likely to begin soon (Künne and Strecker, 2003).

An indicator of the awareness of rock art sites as cultural heritage in Latin America is the fact that several sites have been inscribed in the list of World Heritage by UNESCO. Apart from Samaipata and Cueva de las Manos mentioned above, the following rock art sites already belong to the list: Baja California / Mexico; Nazca / Peru (geoglyphs); Sierra da Capivara, Piauí / Brazil. Others have been inscribed because of their status as natural heritage sites, but include rock art: the area of Plátano river in Honduras; La Amistad park in Panama; Ischigualasto, San Juan and Talampaya, La Rioja, Argentina; Humahuaca gorge, Jujuy, Argentina. More sites are likely to be inscribed in the near future.

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## COMPUTER-ASSISTED PHOTOGRAPHIC DOCUMENTATION OF ROCK ART

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Rock art documentation usually involves four related activities: forms, maps, drawings, and photographs. A narrative description is usually accomplished with the aid of forms. Many rock art recording forms are in use, but customization is often required for particular recording projects. Site location information, and maps at regional and site scales are usually prepared. With the general use of GPS devices, accurate site locations can be obtained, but it is critical to record the datum used (e.g. WGS84 (GPS default) or NAD27 (widely used in the United States)). Sketches and/or scale drawings are usually prepared. Of particular importance is photographic documentation, aspects of which are the focus of this paper.

We are involved with the ongoing development of two digital imaging techniques. The first is the process of generating panoramas and mosaics (Mark and Billo, 1999). The second are algorithmic

methods of image enhancement (Mark and Billo, 2002).

### Panoramas and Mosaics

We define panoramas as the stitching together of overlapping images taken by rotating the camera about a specific point (Fig. 1a) and mosaics as the stitching together of overlapping images taken from a series of different positions (Fig. 1b).

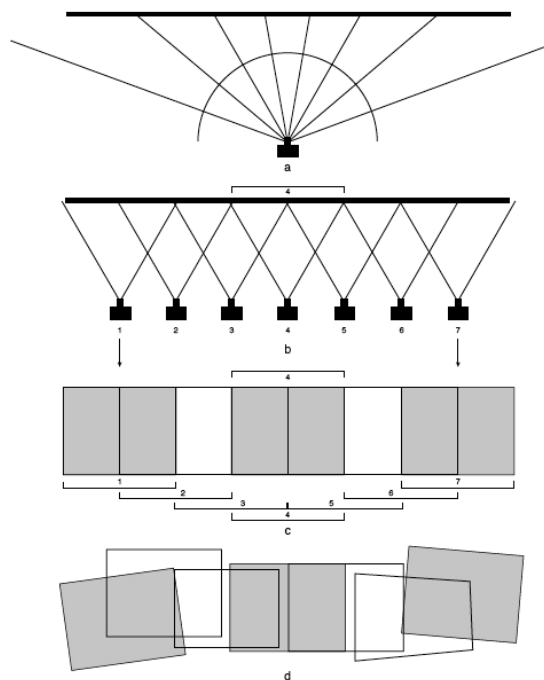


Figure 1. Camera and frame orientations for mosaic stitching. (a) Camera setup for normal panorama, with overlapping images from camera rotated about an axis perpendicular to the lens and the film, through the nodal point of the lens. The axis is normally, but not necessarily, vertical. This is the usual setup for automatic stitching. (b) Straight-on-camera setup for linear mosaic. (c) Ideal results of photography from b are best achieved if moving the camera along a fixed rail, and with image overlap of 30-50%. (d) Real-world photographs, shown as the overlapping frames would more normally appear when taken hand-held or with a movable tripod. Thus, the images have differences in scale, orientation, and skew

Panoramas are used to show rock art panels, entire alcoves, and the view outward. A full 360° panorama records the setting of a site. Close up views can be linked to a panorama. Figure 2 is an example of a panorama of a portion of a site using a spherical projection.

Images to be stitched into panoramas should be taken by rotating the camera about the point on the optic axis that produces no parallax error. This is determined by experiment and special pan heads are available to permit the rotation about one or two axes. See, for example [http://www.tawbaware.com/nodalninja\\_review.htm](http://www.tawbaware.com/nodalninja_review.htm)

Panoramas can usually be stitched by a variety of off-the-shelf applications of varying sophistication and ease-of-use. Some stitching programs allow the user to choose a spherical as well as the standard cylindrical projection. The newest software will either render the panorama or generate a Photoshop file with each image as a separate layer with an editable layer mask. See, for example <http://www.realviz.com/products/st/index.php>

Mosaics are used where panoramas are inappropriate or impossible (e.g. in narrow cracks or where distant views are not possible). If all the images can be acquired from straight on with the same scale, stitching is not difficult (Fig 1c). In reality, this is rarely accomplished (Fig, 1d) and therefore stitching is usually difficult, requiring the use of rectification software of the type used for aerial photographs. Corresponding points are selected, a mathematical transformation model computed, and the process repeated for each photograph. Figure 3 is an example of a mosaic created from many photographs in a difficult setting.



Figure 2. Spherical panorama showing part of Panther Cave, Seminole Canyon State Park and Historic Site, Texas. Anthropomorphs are larger than life size



Figure 3. Mosaic stitched together from numerous photographs taken in a narrow crack. New Mexico

### Digital Image Enhancement

Perhaps the most exciting contribution of computer science to rock art studies is the applications of digital image enhancement. For us, it started with a project documenting the rock art of Hueco Tanks State Historic Site near El Paso, Texas. Figure 4 was our first attempt; a successful experiment. Over the years, we developed a growing number of procedures for enhancing rock art images. These techniques, most of which use Adobe Photoshop, are based upon global algorithms (filters, histogram stretches, etc.) and do not make use of subjective applications of brushes or erasers.

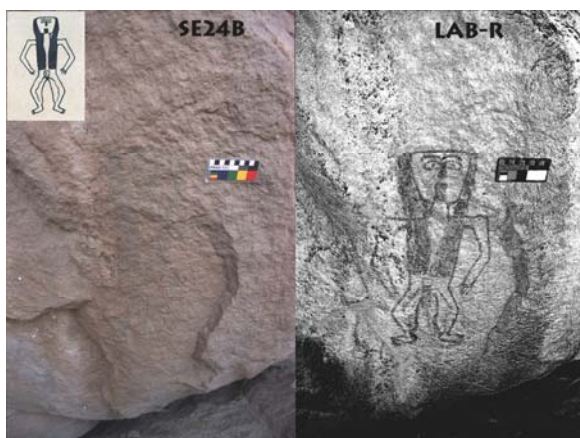


Figure 4. Panel in Hueco Tanks State Historic Site near El Paso, Texas. Left side is the original photograph; insert is an illustration made in the 1930's. The right side is a gray scale image created by enhancing the two color channels in Lab color space, then saving the RGB red channel as a gray-scale image

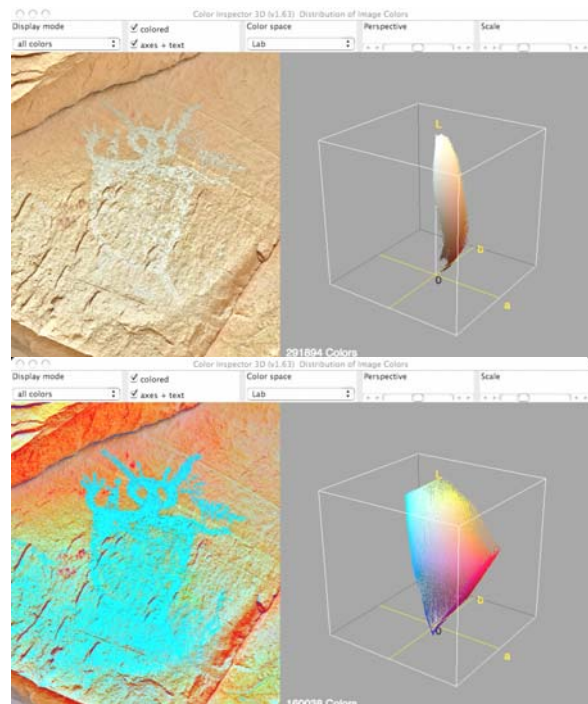


Figure 5. Image and Lab color space pixel distribution before (top) and after (bottom) histogram spread of a and b channels. Photograph by David Sucec, Utah. Images from ImageJ Color Inspector 3D plugin

In addition to the usual Photoshop tools, we make extensive use of the high pass filter, alternate color spaces (Photoshop CMYK and Lab modes), layer blending modes, and computations. The Lab color space is particularly useful, as it separates the channels into a luminosity channel (L) and two

orthogonal color channels (a and b). Figure 5 shows an image and the distribution of pixels

in Lab color space, before and after the spreading of the a and b channels.

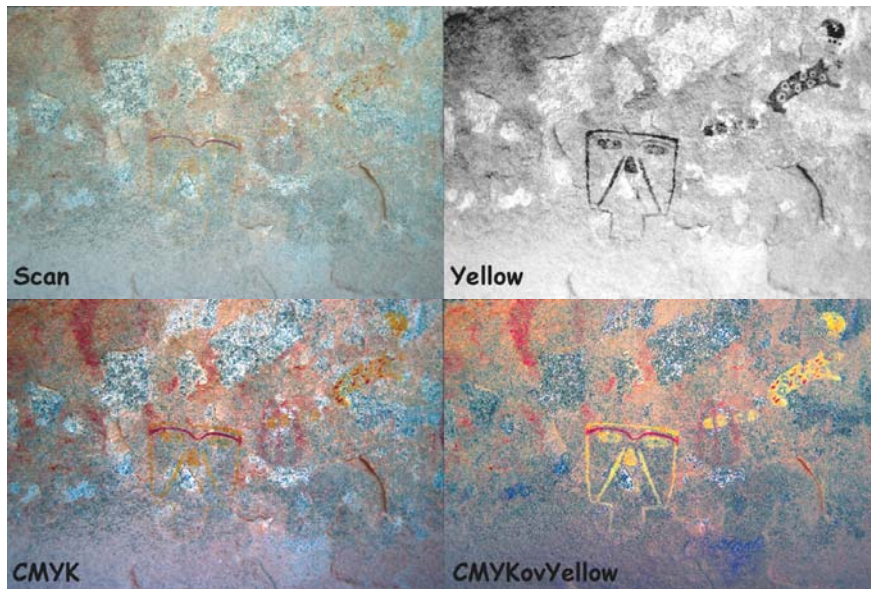


Figure 6. Upper left: Original image from Hueco Tanks State Historic Site, Texas. Upper right: enhanced Lab channel b. Lower left: enhanced C, M, Y channels. Lower right: C, M, Y, enhanced overlaid with inverted Y

Digital enhancement often involves identifying the color channels that are of interest and manipulating these to produce optimal grey-scale, intensified-color, or false color images. Sometimes good results are achieved from single color channels after application of a

histogram stretch (Photoshop levels). In other cases, complex blends and computations are required. Examples are shown in Figures 6 and 7. The captions describe the general techniques used.

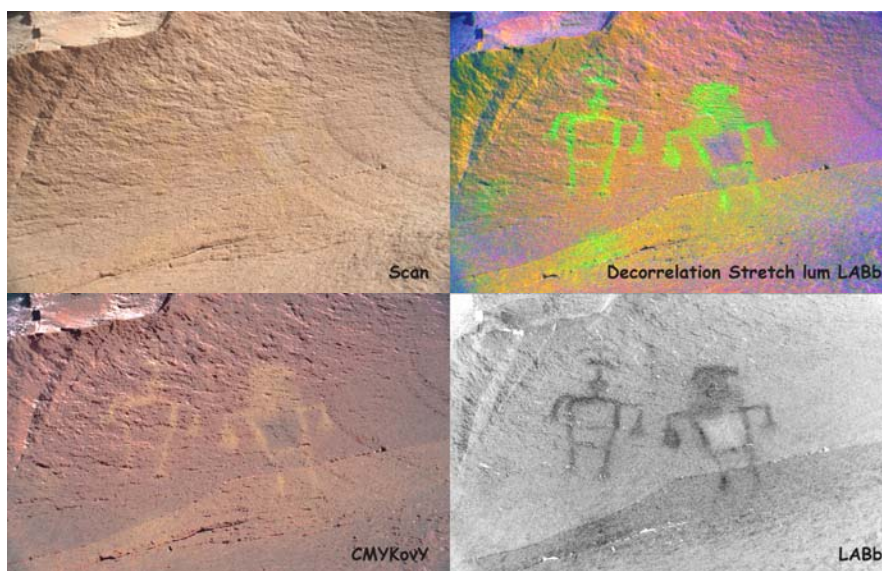


Figure 7. Upper left: original image from Arizona. Lower left: enhanced channels C, M, Y overlay with inverted Y. Lower right: enhanced Lab channel b. Upper right: color from decorrelation stretch, luminosity from inverted Lab b channel

Methods beyond those currently available in Photoshop are sometimes useful. These include the application of principal components and decorrelation stretch. We first observed the use of the decorrelation stretch algorithm on some of the Mars rover

images. We collaborated with Jon Harman, PhD, to develop this tool for rock art applications ([http://www.petroglyphs.us/article\\_using\\_decorrelation\\_stretch\\_to\\_enhance\\_rock\\_art\\_images.htm](http://www.petroglyphs.us/article_using_decorrelation_stretch_to_enhance_rock_art_images.htm)). The decorrelation stretch procedure involves rotating the color space to principal

components axes, a histogram stretch along the independent axes to better fill the color space, and a rotation back. Figs. 8-10 show

an application of this algorithm applied to the same image shown in Fig. 5.

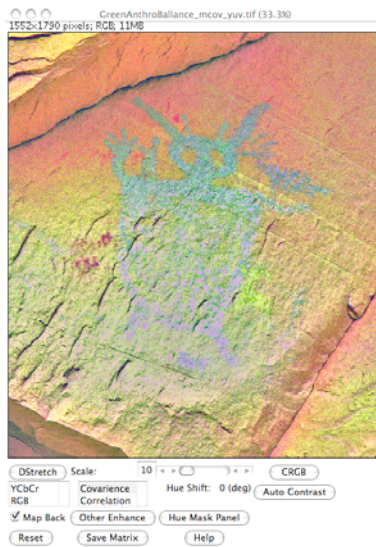


Figure 8. The ImageJ DStretch plugin window (<http://www.dstretch.com/>)

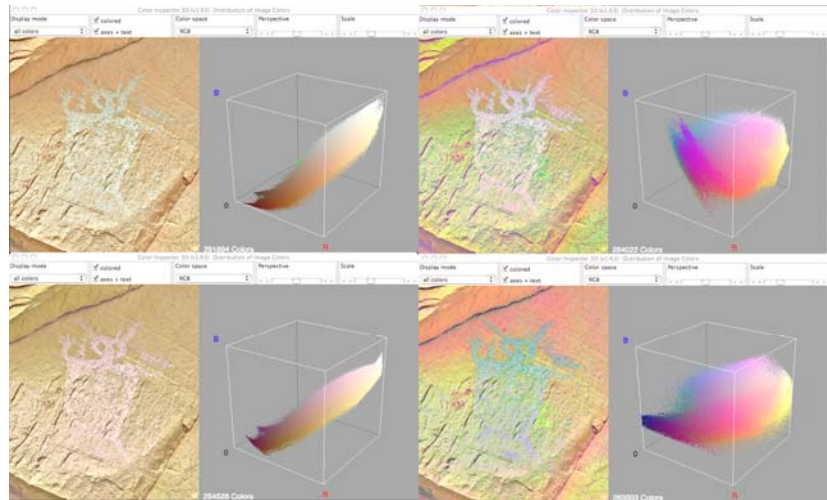


Figure 9. Application of decorrelation stretch (ImageJ using DStretch and Color Inspector 3D plugins) to image in Fig. 5. Upper left: original image. Lower left: rotation to principal components. Upper right: histogram stretch of components. Lower right: rotate color space back

In all cases, enhanced images must be so identified in the file name, the metadata, and perhaps in the image itself. Ideally when

publishing, the original image should be published as a comparison with the enhanced one.

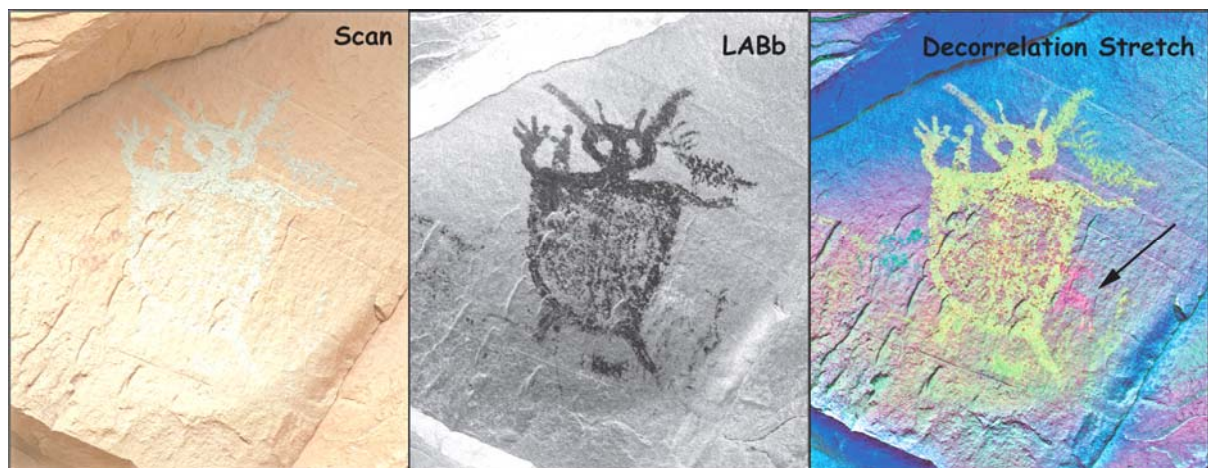


Figure 10. Fig. 5 image, as scanned, Lab stretch channel b, and decorrelation stretch image, with the color space rotated to best show the small quadruped (arrow)

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The authors are currently curators of the exhibit *Stories on Stone: Rock Art of the Colorado Plateau*. The exhibit, which includes over 200 photographs of rock art, will be on display at the Museum of Northern Arizona, Flagstaff, Arizona, USA, through May 28, 2006, <http://www.musnaz.org/>.



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