KEYWORDS: ***Petroglyph – Age estimation – Microerosion – Colorimetry – Saudi Arabia***

SCIENTIFIC STUDIES OF SAUDI ARABIAN ROCK ART

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Abstract. The principal purposes of this paper are to report the preliminary results of analytical work conducted in the Kingdom of Saudi Arabia; to evaluate the susceptibility of some Arabian rock art to direct dating techniques; and to evaluate its susceptibility to the application of a variety of other research methods. The authors have together studied more than forty rock art sites in northern, central and southern Saudi Arabia, and they secured preliminary age estimations from ten motifs at seven of these locations. These are the first scientific rock art dating results ever reported in the Middle East. The teams of the Deputy Ministry of Antiquities and Museums included also specialists in epigraphy and indigenous Bedouin custodians. They examined site complexes considered for tourist access in the context of associated resource management issues. In the Najran region of the country's south, extensive research to test previously proposed stylistic chronologies of the petroglyph traditions of southern Arabia was conducted. These were found to be not only internally inconsistent, they were also decisively refuted by the results of dating work, superimposition sequences and precision colorimetric analyses.

Introduction

The corpus of rock art on the Arabian Peninsula is thought to roughly match in size that of the considerably greater area of the Sahara desert, but whereas the latter has attracted very sustained attention from researchers for well over one and a half centuries, the rock art of Arabia has remained largely ignored. Some of the quite limited published information about it is considered to be severely misleading. Whereas north-African rock art has been the subject of thousands of papers and hundreds of books, the amount of reliable published information about Arabian rock art remains miniscule.

Arabian rock art represents one of the largest concentrations of the world (rivalling those of India, southern Africa, the Andean region and Australia), but research of this vast cultural patrimony has been patchy, opportunistic and concerned with local rather than generic issues. The major seminal work on Arabian rock art, consisting of four volumes (Anati 1968a, 1968b, 1972, 1974), has been presented by an author who had not been to the sites he described, or even to the country, but who used, interpreted and 'analysed' the photographs travellers had made. Most of the more recent authors have relied on the notional stylistic and chronological constructs derived from that approach, which renders their work just as unreliable. There are a few notable exceptions, for example Khan (2000) has conducted an in-depth study of tribal symbols, which occur both as brands on stock animals and as territorial markers on rock (see also Harrigan 2002). Besides the work in Saudi Arabia we are focusing on here, limited surveys have also been conducted elsewhere on the peninsula (e.g. Clarke 1975; Jäckli 1973, 1980; Preston 1976). A good deal of work has also been presented on the written inscriptions of Saudi Arabia and nearby regions (e.g. Albright 1969; Bellany 1981; Jamme 1966; Khan 1993a; Livingston et al. 1985; Winnett 1937). The study of the bulk of Arabian rock art, however, has been severely neglected in comparison to other major rock art regions. In particular, there is a complete lack of analytical work and of data derived through modern techniques.

The single greatest inhibitor of developing the research of rock art is generally the need to know its approximate age in order to place it into the cultural and technological time-frame archaeology provides us with. Although great strides have been made in recent years in rock art dating, estimating the age of rock art remains one of the most difficult challenges still faced by archaeology (Bednarik 2001a).

In 2001 the Deputy Ministry of Antiquities and Museums of the Kingdom of Saudi Arabia commenced a project to briefly assess the analytical potential of Saudi petroglyphs. This was envisaged to be a logical extension of the work of the past three decades of the Epigraphic and Rock Art Survey of the country (Khan 1990; Khan et al. 1986, 1988; Kabawi et al. 1989, 1990). Because of the importance of facilitating the creation of a chronological framework it was suggested that this mission would focus on the specific aspect of rock art dating. It was decided that brief but intensive and carefully designed field projects would be the most effective means of gaining some initial scien-

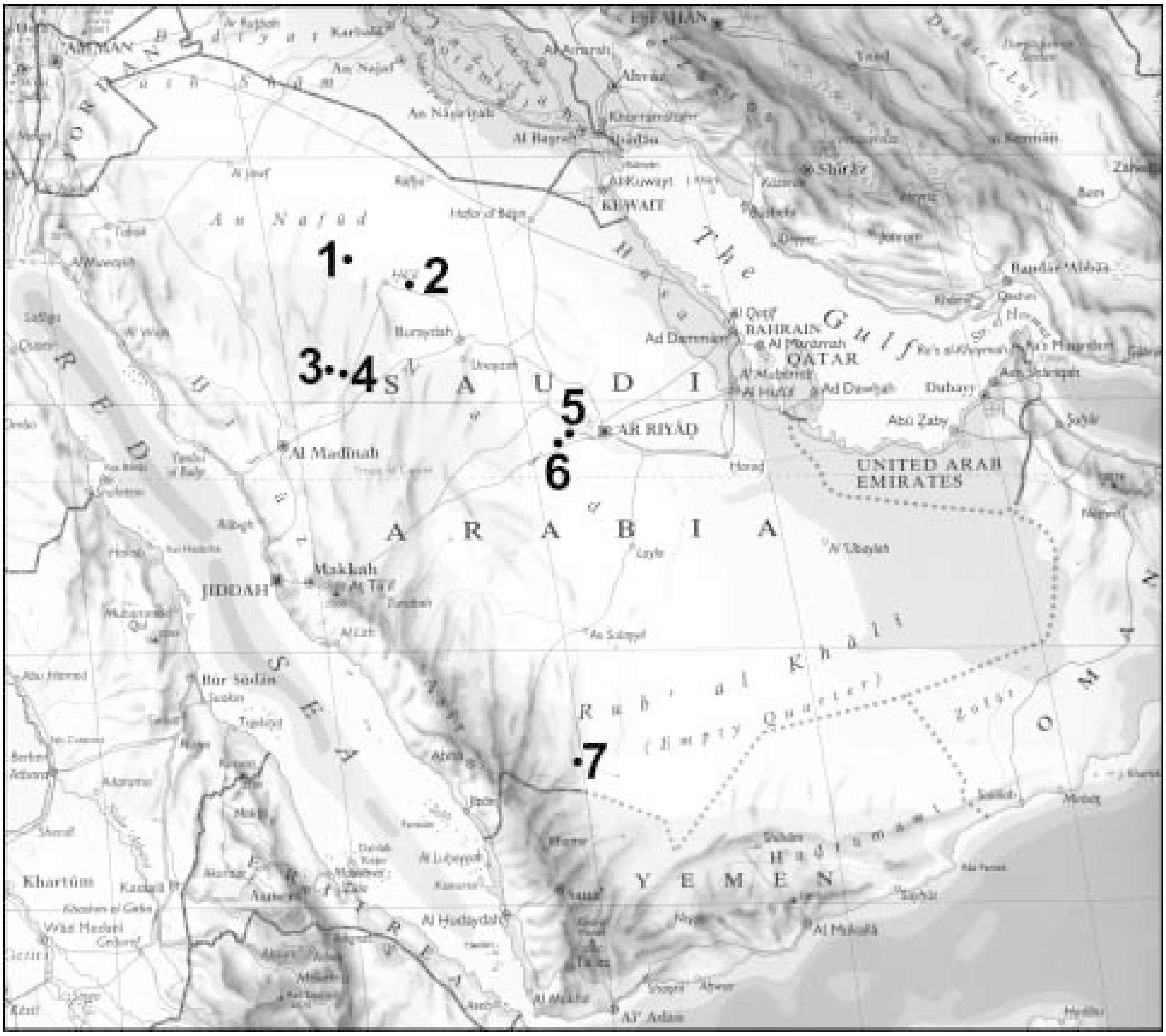


Figure 1. The sites forming part of this study: 1 – Umm Sanman main complex and northern complex; 2 – Janin Cave, Janin main site, Milihiya, Yatib; 3 – Shuwaymas complex; Jabal al-Barg; 4 – Qilat al-Hissan; 5 - Umm Asba'a; 6 – Al-'Usayla; 7 – Jabal Qara precinct.

tific dating information, so the itinerary of the project was carefully tailored to accommodate some pressing research questions. A primary objective was to determine which of the suite of methods currently available for estimating rock art age (Bednarik 2002a) might be applicable to Arabian petroglyphs. This involves an investigation of the conditions of sample procurement, of calibration in those cases where it is required, and a determination of which methods could be employed with any reasonable promise of success. Most published information abut this vast corpus of rock art lacks comprehensive information of such aspects as geomorphic surface conditions, types of accretionary deposits, rates of exfoliation or repatination, petrographic descriptions or weathering rates, and even relevant details of site morphology and geology are uniformly lacking. Yet before preferred analytical approaches could be selected, such basic information was required. Therefore the first objective of the recent field missions was to gather the preliminary data to formulate research strategies that might ultimately lead to a chronology of Arabian rock art based on 'direct dating' methodology.

While the project described here considered also various other aspects of rock art research, such as conservation and site management, clear priority was given to the dating of carefully chosen key motifs at a series of selected sites. This intentional bias is also reflected in the present preliminary report, and we are well aware that considerably more systematic work is essential than can be presented here. Indeed, we acknowledge that our work so far was no less opportunistic than much previous work in the region, but we are fully aware of the need to conduct more comprehensive studies. We did, however, examine the potential of introducing new methodology, and we even managed to secure some preliminary results.

The present paper reflects the preliminary state of our project, in that we were only able to focus on a few specific issues. We justify our preliminary approach by the massive overall size of the Saudi Arabian corpus of rock art, and by the endemic dearth of empirical information about it. Moreover, access to the remote rock art sites of Saudi Arabia is difficult, involving considerable logistic efforts. It needs to be appreciated that Saudi Arabia, with an area of about 2.15 million square kilometres, is more than eight times the size of the United Kingdom, or over three times the size of Texas. Rock art occurs in many parts of this large country, and we selected the following 'sample' on the basis of several given variables, including priorities of Saudi researchers, presumed research potential, site accessibility and specific management issues. In the following we first provide brief descriptions of the sites so far examined as part of this project, followed by dating work conducted, and by a discussion of the so far dominant chronological model especially of southern Arabian rock art.

The sites

Over forty sites were selected for examination: two to the west and south-west of Riyadh, central region; nine in the north of the country, in the southern Nafud Desert, the western Najd and to the east of Ha'il; and the remainder in the far south (Fig. 1). Most of them occur on sandstone facies (Umm Asba'a, Al-'Usayla, the two Umm Sanman sites, Milihiya, Janin and all the Najran sites), Yatib is on a partially metamorphosed sandstone, Qilat al-Hissan on a tuffaceous rock comprising large clasts of basalt, Jabal al-Barg on a sandstone with small-fraction veins of conglomerate, and Shuwaymas on a sandstone containing occasional pebble-grade grains. The absence of granitic facies from this list rendered the application of microerosion analysis difficult, limiting it to where well-developed fractures were present on grains greater than sand fraction (although we managed to secure data also from a single coarse-sand-fraction grain at one site, Shuwaymas).

Primary patination as well as repatination of petroglyphs had occurred at all sites, but degrees of rock varnish deposition varied considerably and such accretions were in all cases relatively weakly developed. Only one site, the Janin main site, was judged to possess sufficiently substantial varnish cover on petroglyphs to encourage sampling for radiocarbon analysis. No well-developed silica, carbonate or oxalate accretions were observed on petroglyphs at any of the sites examined. Although we took GPS bearings, precise locations of sites are not given here, except where it facilitates the re-location of certain sites, such as calibration sites, that would otherwise be hard to accomplish among major rock art complexes.

Umm Asba'a

This site is located in the Nafud Qunayfidhah, c. 85 km west of Riyadh, 3 km from the village of the same name, in flat to slightly undulating sand desert. It consists of a very prominent, widely visible mushroom-shaped sandstone column of about six metres height (Fig. 2) on an eroding rocky hill with occasional Upper Palaeolithic stone tools. Petroglyphs occur on and near the column, on coarse sandstone of sand- to small pebble-sized grains. They consist of *Wusum* (tribal marks), abraded grooves and several inscriptions. One of the latter, on a vertical panel on the western base of the column, presents a two-line early Islamic text, datable by its content to about 1120 years BP. The upper line is on sand-fraction rock, which at 500 – 800 µm grainsize is unsuitable for microerosion analysis, but the lower line is on much coarser material, with grains occasionally reaching 15 mm size.

Figure 2. *Umm Asba'a, central region, looking north. The Beduin guide points to the panel analysed at this site.*

Al-'Usayla

About 115 km south-west of Riyadh, a few kilometres north of the highway to Mecca, a distinctive west-facing escarpment forms the background to an isolated rocky hill of about 40 m height. Thousands of petroglyphs occur on its cliffs and eroding boulders. The rocky shelves and plateaus of the nearby escarpment seem almost devoid of rock art, and there is evidence that Bedouin tribesmen still today use the shady recesses and shelters around the base of the Al-'Usayla hill. It is also in the lower reaches of the knoll that the *Wusum* seem to predominate. The largest decorated panel is a flat vertical cliff facing south, on the upper part of the hill, densely covered with petroglyphs over a length of 7 m and to a height of 4 m (Fig. 3). These 400 to 500 motifs bear a thin and very patchy coating of rock varnish, whose consistency suggests that the figures were made in a relatively short time span, perhaps within 250 years or so. They consist of numerous zoomorphs,

Figure 3. *Al-'Usayla, central region. Section of the largest of the many decorated panels. The scale on the lower right indicates the ibex-like motif sampled for microerosion analysis.*

anthropomorphs and early written characters. The rock facies is homogenous, of well-sorted grains among which the 400 – 800 µm fraction dominates. However, there are occasional grains of up to 1.5 mm diameter. Several motifs were examined microscopically, but were found to offer no suitable conditions for microerosion analysis. Relative weathering suggested initially that the writing symbols are at least twice as old as the Arabic text at Umm Asba'a. However, good data could be secured from a figure resembling an ibex, on the lower part of the site's panel (Fig. 4).

Umm Sanman main complex

The Great Nafud desert of northern Saudi Arabia covers an area of about 68 000 square kilometres. Near the small oasis township of Jubbah, 90 km north-west of the city of Ha'il, runs a distinctive rocky escarpment roughly in a north-south direction, facing west and rising 300 to 400 metres above the sand desert. Near the remains of a former lake is a major petroglyph site complex, extending along the foot of the escarpment for about 4.5 km. It is thought that the Jubbah lake, about 20 km long and 5 km wide at its peak, still existed 8000 years BP and then vanished in mid-Holocene times (McClure 1978; Garrard and Harvey 1977). Radiocarbon dating of lacustrine deposits suggests that conditions were still humid about 6600 years ago. The aquifer level is now between 50 m and 75 m below the plain, but the extensive occupation evidence in areas free of sand dunes suggests the former existence of settlements in what is now a very arid region. The depositional sequence of Jubbah lake is very similar to that described by McClure (1978) from Lake Mundafin at the western end of the Rub' al Khâlî and from other localities in the Empty Quarter. McClure found evidence of two main generations of lake deposits, the earlier dated between

***Figure** 4. Microerosion sampling site at Al-'Usayla, a zoomorph resembling an ibex.*

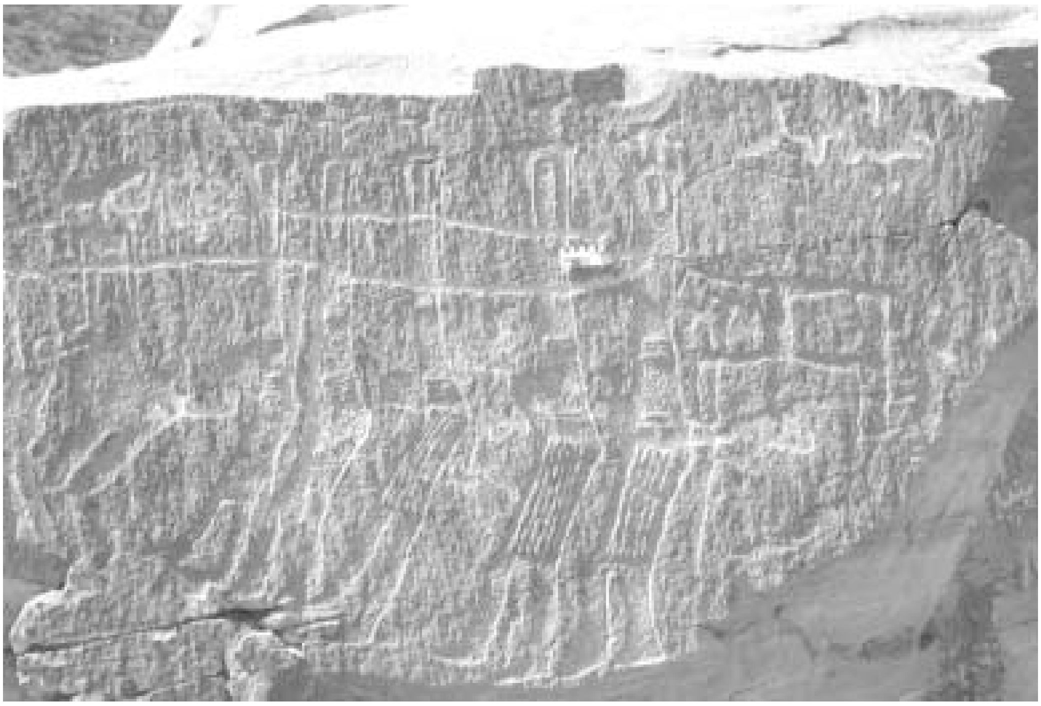


Figure 5. *Anthropomorphs of the so-called 'Jubbah style', Umm Sanman main complex, near Jubbah, northern region.*

36 000 and 17 000 years BP, with a concentration of dates between 30 000 and 21 000 BP and the later between 9000 and 6000 BP.

Jubbah lies on an ancient caravan route, which has led to many thousands of rock inscriptions and camel images in recent millennia. Several concentrations of rock art were inspected in this impressive site complex, and numerous Neolithic and earlier stone tools were located near some of them. Twelve Neolithic or Chalcolithic occupation sites have been documented near Jubbah (Parr et al. 1978; see also Ingraham et al. 1981). Some of these are located near rockshelters and close to some rock art panels on the nearby rocks. The stone artefacts are usually arrowheads, bifacial points, blades, side and biface scrapers, and disc cores which are supposed to be typical of prepottery Neolithic in Arabia.

Figure 6. *Large bovid petroglyph at the Umm Sanman main complex.*

Figure 7. *Protective 5-km fence at Umm Sanman main site, Jubbah, northern region.*

One of the most prominent genres of the rock art is expressed in large (1.1 – 1.2 m high), elongate and detailed anthropomorphs, of the so-called 'Jubbah style' (Fig. 5). Another notable feature of the rock art at Jubbah is the apparent depiction of boomerangs or 'throwing sticks', unique in Arabia, and featured only rarely outside of Australia. The depicted fauna is said to include images of cattle, deer, gazelle, oryx, ibex, lion, dog, horse or donkey, ostrich and camel (we note this without endorsing the identifications). While these have been ascribed to Neolithic times and to the Metal Ages, it is to be noted that tracks of the ostrich (*Struthio camelus*), now extinct in all of Asia, were still observed in the western Nafud as late as 1909. The horns of the male and female goitered gazelle (*Gazella subgutturosa*) are still today displayed in Jubbah houses.

The apparently oldest rock art at the Jubbah site complex consists of human and animal figures, depicted at prominent places, mostly facing east. The typical anthropomorphs with thin linear arms holding 'bow and arrows' often occur with large bovid figures with tapering faces and long horns. The skill and technological sophistication evident in the petroglyphs suggests a very well established convention or genre of rock art production (Fig. 6). A second type of rock art consists of anthropomorphs and zoomorphs found in more isolated places, of mostly smaller size. Relatively large-sized 'camel' figures with Thamudic inscriptions are frequently located where episodic or periodic water was available. The third of the three distinctive phases of rock art at Jubbah consists primarily of early Islamic or Kufic inscriptions.

Of the four Jubbah localities examined most closely as part of this project, the southernmost provided a calibration site, while a second place some hundreds of metres to its north offered suitable conditions for microerosion analysis. The entire Umm Sanman main complex is enclosed by a well-constructed steel-mesh fence over its entire length, erected by the Ministry of Antiquities and Museums (Fig. 7). It is relatively inaccessibly from the east, i.e. from the mountain range. The site also has a resident caretaker and is well managed. Despite the close proximity of Jubbah, no fresh graffiti were observed.

Umm Sanman northern complex

A few kilometres to the north of the main complex occurs a morphologically different group of sites, which also has markedly different motif ranges. Rather than being at the foot of the rock escarpment, numerous petroglyph clusters occur well above the plain, among the peaks and hills of the mountain range. Pre-Arabic scripts are numerous, as are zoomorphs and anthropomorphs, but more recent inscriptions as well as the large Jubbah figures are absent. Use of the site complex seems temporally more confined, and since it is less accessible and some distance from even ancient water sources, it is more likely related to people who crossed the mountain range at this locality. The complex extends over several hundred metres and stone tools are again present on the surface. At one of the major concentrations of petroglyphs, among several Thamudic inscriptions, two written characters were selected for microerosion analysis.

Janin Cave

In the absence of carbonate facies that would promote the formation of caves, this is the only known example of cave art in northern Saudi Arabia. Janin Cave, located about 30 km east of Ha'il and north of the highway to Buraydah,

Figure 8. *Petroglyphs on the south wall of Janin Cave, northern region, about 40 m from the entrance.*

was formed in light-coloured sandstone. The tectonic adjustment of a large portion of rock on the south face of a steep mountain along a vertical fault line created a cleft, which erosion enlarged to a horizontal passage that is up to 20 m high and 10 m wide. It can be followed for about 100 m, its floor of sand and a few boulders progressively steepening until the passage ends in a talus slope. Petroglyphs are numerous along both walls as far as faint daylight can reach, but then peter out and decoration is lacking in the deepest and permanently dark part of the cave (Fig. 8). There are no accretionary deposits on the petroglyphs and the latter are unsuitable for microerosion analysis, not only because of the uniformly small grain size, but also because the petroglyphs are well sheltered from precipitation. The cave is located about 15 m above the sand plain, and access to it is controlled by a fence closing off the approach from the plain, and through the care of a nearby resident Bedouin custodian.

Figure 9. *Large fully repatinated cupules at Janin main site, with petroglyphs and very faint pictograms on the wall above.*

Janin main site

A few kilometres to the east of Janin Cave, located at the foot of a prominent vertical cliff atop a ridge, and on large boulders on the upper part of the slope below the cliff, is a major concentration of rock art. It consists mainly of petroglyphs but the vertical rock face also bears a series of red pictograms. The latter are too faded to permit ready recognition of motifs, and no attempt was made to record them. More attention was paid to the significantly older rock art that also oc-

Figure 10. *Petroglyphs on the cliff face at the Yatib site, northern province.*

curs, and the site appears to have been in use over a long period of time. On the upper surfaces of some floor boulders immediately adjacent to the cliff occur a few groups of large cupules, of up to 25 cm diameter and 15 cm depth, and fully repatinated (Fig. 9). They number about one dozen and seem to predate any other remaining rock art present at the site by a considerable time span. The elevation of the site, well above the surrounding plains, and its steepness suggest that this was perhaps not an occupation site, an aspect that may be confirmed by the apparent absence of archaeological surface remains.

The fine-grained sandstone at Janin is generally unsuitable for microerosion analysis, but the rock varnish covering many of the petroglyphs is somewhat better developed here than at any other site so far examined as part of this project. A sloping flat panel, 3 m high and 2.4 m wide, located just a few metres from the cupules and pictograms, is among the many petroglyph-bearing boulders on the slope. It bears more than fifty fully patinated petroglyphs and was chosen for analysis. A quadruped figure resembling an antelope near the bottom of the panel was selected for destructive sampling of part of the ferromanganous accretion covering it.

Milihiya

In the same region east of Ha'il, but closer to the town and about 12 km north of the highway, the topography differs greatly from the imposing sandstone stacks of the Janin mountains. The hills at Milihiya are low, flat and mesa-like, consisting of various horizontal facies of sandstone. Petroglyphs occur sporadically on some of the low cliffs and on boulders on the scree slopes below them, with individual sites or panels spread over a considerable area. Stone tools abound around the base of such rises, including lithics of Palaeolithic typology. The sandstone facies in this area are generally fine grained and are readily affected by granular exfoliation. These sites are therefore unsuitable for microerosion study and they were not closely examined in the course of this survey.

Yatib

This spectacular petroglyph site consists of a rocky hill, rising about 60 m above the plain and almost one kilometre long. A sturdy wire-mesh fence of several kilometres length encloses the entire hill and there is a guard's building at the usually locked entrance, just below the main concentration of rock art. The site is located about 20 km east of Ha'il and is protected by a local site custodian residing nearby. Thousands of often visually spectacular petroglyphs occur on the prominent cliff face at one end of the hill, and especially on the boulders strewn over the hill's slopes in the vicinity of the main cliff. Noteworthy are the prominent petroglyphs on the upper, vertical cliff panels, some of which are only accessible by climbing the cliff (Fig. 10). The sandstone has been partially metamorphosed and it is much more weathering resistant than at the sites described above. About 20% of the motifs at Yatib were fashioned with metal tools rather than stone hammers, and in view of the relative hardness of the rock facies there it would appear that steel tools were involved. However, the grains of the sandstone are mostly only between 100 and 200 µm, which renders the rock unsuitable for microerosion analysis. Repatination of petroglyphs ranges from very slightly to substantially repatinated condition.

Qilat al-Hissan

This minor petroglyph and inscription site is located just outside the township Hayet, about 250 km SSW of Ha'il. This region is geomorphologically dominated by recent basaltic lava flows and other evidence of extensive volcanic activity. The rock art site occurs on volcanic tuff that contains occasional basalt clasts, a lithology offering no dating evidence in terms of the currently available methods.

Jabal al-Barg

Jabal al-Barg is a minor petroglyph site close to and south of Shuwaymas village, on a cliff formed along a wadi in the Harrat Khaybar region. It was found to be of particular interest because some of the rock art occurs on well-developed thin veins of conglomerate embedded in the coarse sandstone. One of the specific objectives the project had been requested to consider was the potential of estimating the time the date palm arrived in Saudi Arabia. In many cases petroglyphs thought to depict date palms are executed in such detail that this identification seems highly plausible. Details of individual palm fronds are sometimes shown, as well as clumps of fruit (for instance at Yatib, Fig. 11). The date palm is an important emblemic and historical icon, but the time of its introduction remains unknown. It was hoped that by attempting to estimate the age of this frequent rock art motif we might succeed in throwing some light on the matter. The 'date palm' motif occurs at many of the sites we examined, but in other cases we detected no means of direct dating. At Jabal al-Barg, the lithology facilitated reliable age estimation. A vertical panel includes a prominent 'date palm' motif of over two metres height, which was analysed even though it occurs on a poorly accessible cliff. Smaller figures on the faintly patinated panel resemble quadrupeds such as cattle and ibex.

Shuwaymas Site 1

The Shuwaymas site complex was discovered only in recent years and at present its spatial extent can only be conjectured. The remote and relatively inaccessible area far to the west of Shuwaymas village features several Pleistocene lakebeds and a series of widely spaced, eroding cliffs. The area is now unsuitable for human habitation, but even at mid-Holocene times it was still densely settled, as shown by the abundance of archaeological evidence, such as numerous megalithic burial sites. So far only a very few of these cliff localities have been examined and they are rich in rock art. During this project only Site No. 1 was studied and it is easily the most spectacular of the sites listed here from northern Saudi Arabia. It consists of a slope of jumbled, sub-angular boulders, mostly 5 to 10 m in size, on which many thousands of motifs occur. Some compositions bring to mind monumental masonry work, in that the very detailed and meticulously pounded figures of one or two metres are rendered 15 – 20 mm deep, relief like (Fig. 12). The profusely decorated panels on many of these huge boulders are no longer right way up, and as they changed their orientation every time the boulders moved down the slope, new compositions were added at various times. These are all orientated differently now, some of them occurring entirely upside-down, and many are truncated by subsequent fractures. The site therefore offers good potential for in-depth seriation studies.

Figure 11. *Petroglyphs of the western boulders of the Yatib site, which apparently include depictions of date palms.*

The geomorphology of the site explains its present state. The boulders are of a relatively weathering-resistant facies in the horizontal strata, supported by an argillaceous, more readily decomposing sandstone stratum. As the latter deteriorates it can no longer support the rock mass above it, large portions of the decorated upper layer broke off through gravity and rolled or slid a few metres, only to be engraved again in their new positions as they gradually made their way down the scree slope.

The site has thus been in use over a prolonged period if time, certainly for some millennia at least. On one steeply sloping panel, about fifteen large cupules of 8 – 14 cm diameter occur. They appear to be the oldest surviving component of the site, and they are very likely of Late Pleistocene age (Fig. 13). The surface of the panel has largely fallen victim to exfoliation since the cupules were made, and the original surface has best survived within the cupules (Fig. 14). The same panel bears also a series of archaic geometric motifs, such as circles, chronologically followed by 'hoof-prints' and superimposed larger motifs.

Figure 12. *M. Khan at one of the many carved boulders of Shuwaymas Site 1, northern region.*

Figure 13. *Cupule panel at Shuwaymas Site 1, almost certainly dating from the Late Pleistocene.*

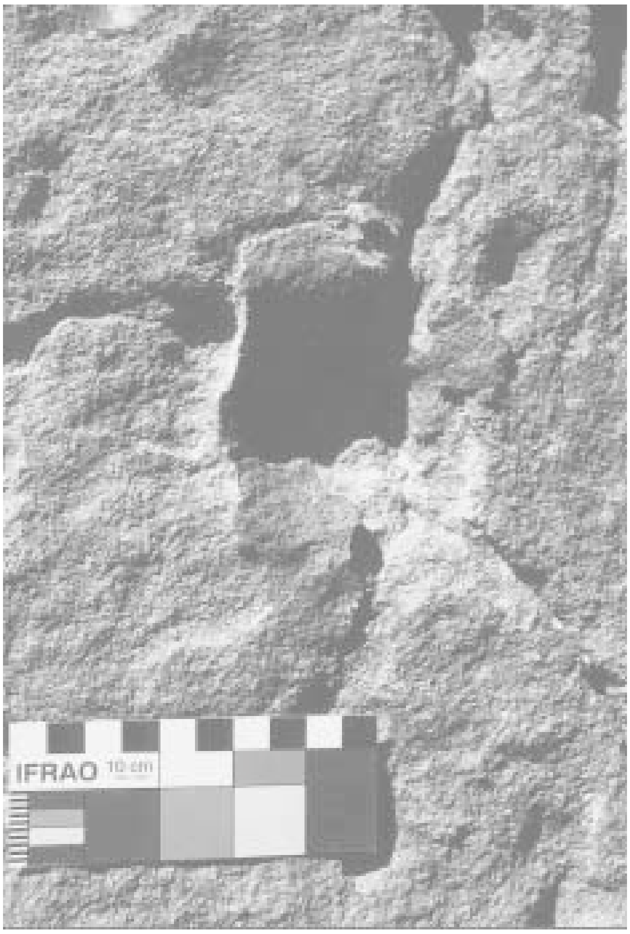


Figure 14. *Close-up view of one of the cupules at Shuwaymas, showing exfoliation of subsurface.*

Figure 15. *Hammerstone used in the production of petroglyphs at Shuwaymas 1.*

Figure 16. *Petroglyphs on granite building block of the ruined city of Ukhdoud, Najran, southern region, showing light repationation.*

Much of this panel is no longer accessible to work on because of a massive boulder now placed above it. This boulder in turn has petroglyphs on its vertical surface, which clearly postdate its positioning in its present orientation. One of these relatively recent motifs offered conditions suitable for microerosion analysis, as did two more figures at another huge boulder about 25 m to the west. Because of the extraordinary density of petroglyphs at this major site, petroglyph-making stone tools (hammer stones) can be found readily. They were mainly made from a dark siliceous contact-metamorphic quartzite occurring locally (Fig. 15). These tools were in every formal respect similar to such stone implements found and studied in many other countries around the world (Bednarik 1998). Other stone implements occur also and seem to be of archaic types.

Shuwaymas 1 appears to be entirely free of recent petroglyphs (of, say, less than 3000 years age) and inscriptions, and there are no images thought to depict camels or date palms. Similarly, recent graffiti are notably lacking. This confirms the strong impression that the site, and perhaps the site complex as a whole, comprises only relatively early rock art traditions. There are vague stylistic and technological elements bringing to mind not only the early petroglyph tradition at Jubbah (although there are also significant differences), but in the broadest sense also northern African petroglyphs, such as the probably mid-Holocene genres of the Sahara.

Jabal Qara region

The city of Najran is located in the extreme south-west of Saudi Arabia, at the western boundary of the Rub' al Khâlî (the Empty Quarter) and only a short distance from the country's border with Yemen. The town has been built around the ruins of the ancient fortified Christian city of Ukhdoud (Okhdud), which was sacked by Jews after having existed for about a millennium. Zu-Nuwas, the last king of the Jewish Himyarites in Yemen, blackmailed the city's inhabitants into becoming Jews, and when they refused he had his army lay siege to the well-defended city in A.D. 525 (*Qur'an*, Sura Buruj 85, verses 1 to 7). Upon conquering the city he had it substantially destroyed and killed its 20 000 inhabitants. Seven huge trenches were dug, fires were lit in them, into which the people of Ukhdoud were thrown alive.

The archaeological town area being excavated occupies about eight square kilometres. One of the former gates of the fortified city is partly preserved, as is a great deal of the masonry, in hard sandstone as well as granite. There are several metal-inscribed written characters of the South-Arabian script as well as images (Fig. 16) on some of the building blocks. Similarly, stone blocks reused in subsequent centuries, including in the construction of a mosque, also bear occasional decoration dating from before the destruction of Ukhdoud. Of particular interest here are the parallels between these petroglyphs and those out in the nearby desert.

About 50 km north of Najran begins one of the Arabian Peninsula's largest rock art concentration, which with some outliers extends up to about 130 km north-south. It consists of many hundreds of sites, mostly scattered around the countless stacks of Wajid sandstone, which rise to a height of several hundred metres above the sand plains in the massifs of Jabal Qara and Jabal al Kawbab. Initially reported by the Philby-Ryckmans-Lippens expedition in 1951–52 (Grohmann 1962; Lippens 1956; Ryckmans 1952,

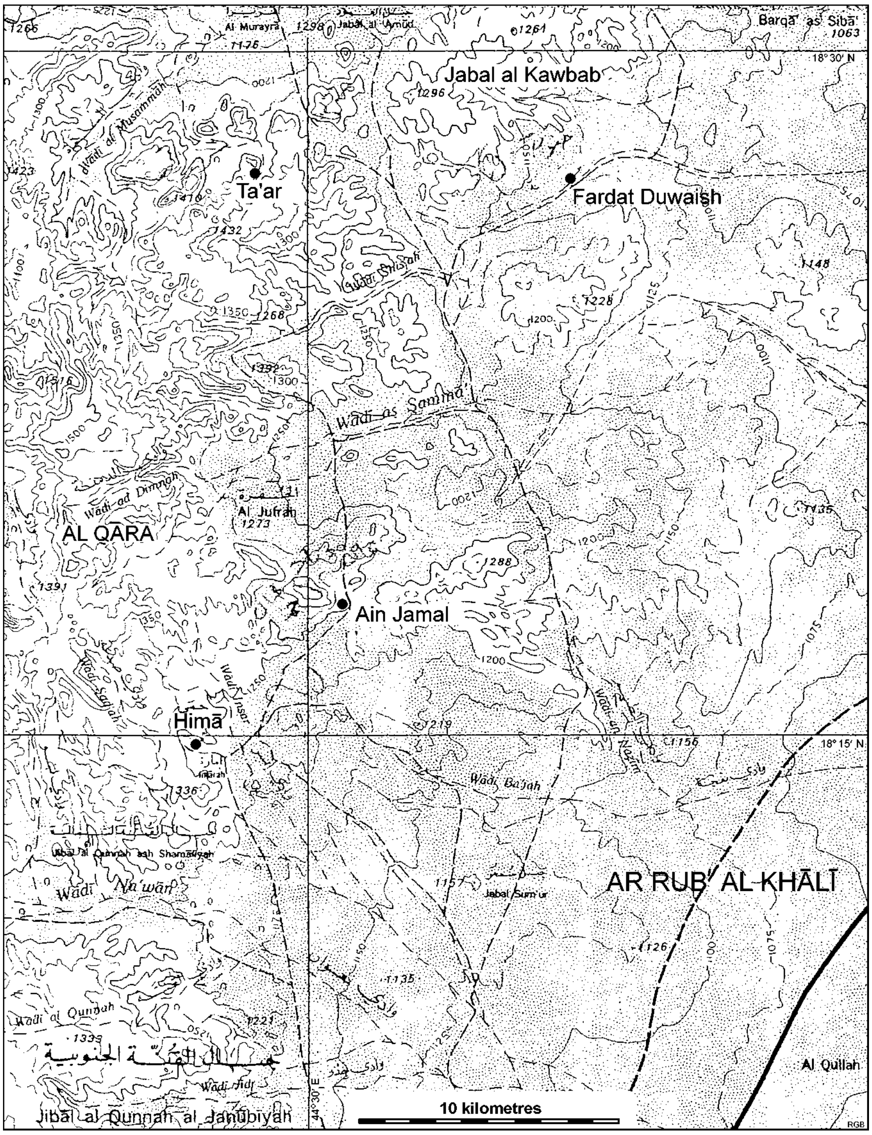


Figure 17. The Jabal Qara rock art precinct north of Najran, with some key sites indicated.

1954), a survey of the rock art was commenced by the Deputy Ministry of Antiquities and Museums in 1979 (Zarins et al. 1980, 1981; Hester et al. 1984). This was successfully continued in 1990 (Kabawi et al. 1990, 1996), by which time some 126 sites had been recorded. In addition to the ubiquitous sandstone, the region also has exposures of granitic facies, but so far no rock art has been reported from those areas. It is regarded as a priority that petroglyphs be located on the granite exposures. Many more rock art sites are probably still to be found, and in addition to the extensive corpus of petroglyph sites, there is a similarly dense concentration of inscription sites.

Among the rocky mountains of the region (Fig. 17) occurs ample evidence of extensive former surface water, especially in the form of carbonate and gypsum encrustations on low rock exposures. These appear to derive from stagnant pools, most probably of mid-Holocene times, before the intensive phase of desertification just over 4000 BP. Extensive occupation evidence of earlier times suggests that the region was perhaps more hospitable in the Late Pleistocene as well. Lithic implements occur commonly around the fringes of the mountains and in their valleys and wadis. They include Acheulian handaxes, Mousterian flake tools (e.g. at Sha'ib Hinmat, Aïn Jamal), Upper Palaeolithic stone tools (e.g. at Sha'ib Mahash) and Neolithic artefacts. Ceramic finds of mid- to late Holocene periods occur also, including at a series of tumuli in the Najd Sahî area. At present the entire region is very arid and devoid of any surface water, except episodic pools in clay pans after adequate rain. Vegetation is very sparse indeed, even within the valleys of the massifs. The only settlement in the region is the small hamlet of Himâ, located near Bir Himâ, where two deep wells are carved into the sandstone. Other than that, only a few hardy Bedouin families live in isolated tent camps in this spectacular but barren scenery.

Previous attempts to estimate the ages of rock art in the general Jabal Qara region have been influenced by a scheme by Anati whose chronology of southern Arabian rock art is based primarily on this area (Anati 1968a, 1968b). The Archaeological Survey has been more guarded in its suggestions of rock art ages, vaguely referring to the predicted ages of other archaeological features, such as lithic remains and pottery shards, and to rock inscriptions, relative repatination and presumed depictions of artefacts such as weapons. As noted by Nayeem (2000: 35), no attempt has ever been made to quantify relative repatination. On the basis of mostly archaeological evidence it has been suggested that the Jabal Qara rock art is generally between 1000 and 5000 years old, but that the bulk of it is perhaps younger than Anati's scheme predicts. Moreover, over the years certain inconsistencies in that chronology have been noted by a few writers (McClure 1971: 77ff; Khan 1988, 1989, 1993a, 1993b, 1998, 2000; Khan et al. 1986, 1988). In these circumstances it was considered appropriate to discuss and review Anati's chronology. Before doing this we will now review the analytical methods we have used or are using in our ongoing project, and then turn our attention to the central and northern Saudi Arabian sites we have investigated so far as part of this project.

Dating methods

The techniques we considered for estimating the ages of petroglyphs at the Arabian sites listed here were direct methods (Bednarik 2002a), including carbon isotope analysis of organic inclusions in rock varnish, microerosion analysis, uranium series analysis of reprecipitated carbonates, optically stimulated luminescence determination of quartz grains covered by thick mineral encrustations, degree of granular exfoliation (surface retreat), calibrated colorimetry of repatination, superimposition sequences and development of macro-wanes. Traditional methods such as the apparent iconographic content of the imagery ('identification' of depicted objects) and stylistic considerations were at best used in subsidiary roles, if at all. The iconography of rock art provides only non-scientific information, because our notions about pictorial content cannot be falsified. Repatination is a useful general guide to approximate antiquity, but to what extent it can be used for metrical age estimates still remains to be established securely. Style is another non-falsifiable factor and can only yield meaningful data in combination with direct dating information.

Of the direct methods considered for application in this project, OSL is still to be applied to rock surfaces under deposits precipitated from lacustrine water. This will provide relatively reliable estimates of the time when the most recent major bodies of surface water existed in the region. Although no carbonate crusts have so far been found superimposed directly over petroglyphs, such carbonate accretions do occur below rock art panels at several of the Jabal Qara sites, where they can be used to determine at what time lakes last occurred in this now totally arid landscape. Similarly, uranium-based radiometric methods such as $^{230}Th/^{234}U$ analysis have found no use so far, but it is planned to apply them in due course to crosscheck accretion age estimates.

Surface retreat offers a viable means of estimating petroglyph age on these sandstone facies we are mostly concerned with, but its use remains seriously hampered by the lack of comprehensive basic research as well as certain analytical problems (Bednarik 2001a: 137). More promising is the measurement of macro-wanes, especially in combination with facture-surface weathering and other direct methods (Bednarik 1979). However, such a study would require extensive fieldwork, which so far it has not been possible to invest. Moreover, as in other rock art dating work, the database currently available is inadequate, but it should be emphasised that this kind of 'integrated' approach would be particularly suited for the conditions found at Arabian petroglyph sites.

Carbon isotope analysis

We are well aware of the limitations of radiocarbon results from accretionary deposits, including rock varnish (Bednarik 1996, 2001a: 111–2, 134–5). Among them are not only those inherent in all radiocarbon data, but more specifically the qualifications applying to any claimed relationships between such data and the date of rock art production. This complex subject has been considered in some detail, and until radiocarbon sampling can be focused on either specific compounds or substances, i.e. at the molecular level, or on specific objects such as pollen grains, we cannot know what it is we are 'dating' (Bednarik 1996). Most importantly, the ubiquitous presence of datable carbon in rock substrates, together with the openness of the carbon system (as demonstrated in Bednarik 1979), limits reliability of this approach significantly. Nevertheless, carbon isotope analysis has provided many useful results in several parts of the world, and as long as the tentative nature of such results is appreciated and they are not over-interpreted, there should be no objection to utilising this popular method.

Figure 18. *Radiocarbon sampling site at Janin main site, a zoomorph resembling an antelope.*

Of the sites we investigated, only one, the main site of Janin in the Ha'il region of northern Saudi Arabia, offered rock varnish of an adequate thickness to render physical sampling advisable. There are numerous decorated panels at this location, their orientation ranging from vertical via inclined to horizontal. The antelope-like zoomorph selected for sampling is 26 cm long. Under the binocular microscope, the rock varnish coating was found to be poorly developed and consolidated, showing no nanostratigraphy. An area of 9 cm^2 had to be sampled because the varnish cover was thin and discontinuous, occurring mainly in the depressions between the quartz grains. The sample was collected with dental tools under sterile conditions and immediately sealed in an airproof glass phial (Fig. 18). It was processed at the AMS facility of the Australian Nuclear Science and Technology Organisation in Lucas Heights, Sydney, as sample No. OZF900. After the sample removal was completed, the scar left in the varnish coating was repaired by a procedure similar to that established by Elvidge and Moore (1980), using chemicals prepared specifically for this purpose.

OZF900 yielded the following analytical results: -25.0‰ $\delta^{13}C$, 79.77% of modern carbon at 1 sigma error, or 1820 ± 50 years BP. Bearing in mind the inherently open carbon system of rock varnishes (Bednarik 1979), this is to be viewed as a most conservative minimum bulk or mean age of the accretion. Depending on the rate and degree of rejuvenation (e.g. from micro-organisms) its true age could be as much as two or three times the measured radiocarbon age, and this in turn must be less than the age of the petroglyph covered by this deposit. Thus the age of the petroglyph cannot be determined in this way, except that it must be significantly greater that 1820 years and could quite realistically be as much as 4000 to 6000 years. In contrast to other researchers who have secured such analytical data under very similar conditions and implied that they have thus dated the rock art, we emphasise that we regard this result as inconclusive, but as part of an ongoing process of deriving falsifiable data from rock art that helps in our understanding of rock art.

Figure 19. *Boulder with Arabic inscription at Umm Sanman site complex, which provided the microerosion calibration sample.*

Microerosion analyses

Despite the often-stated reservation about the use of sedimentary rock (including sandstone) in microerosion analyses, this method has emerged as the most suitable under the circumstances of this project (i.e. lithologies encountered and time available). Sandstones of the former Gondwana plates, where well over half the world's rock art is located, are typically of well-sorted, fine-grained facies, which are usually unsuitable. In both central and northern Saudi Arabia, however, coarser grades are frequently available, at least as banded deposits or random inclusions. Where pounded designs extend over them, such grains may feature abundant evidence of microscopic impact damage, including conchoidal fracture facets, crushing and step-fractures. Any edges formed by one or two surfaces dating from the time the petroglyph was made are suitable for analysis, provided that the angle between the surfaces forming the edge is of a nominated standard range. In our work we used only angles of between 85º and 95º. The width of the micro-wane (*A*) is measured in microns and recorded for tabulation, using field binocular microscopy (Bednarik 1992). The method has been used successfully on granite and quartz inclusions in other facies. On granite and similar rock types it can have a range of several tens of millennia, especially in arid environments (Bednarik 2001b). It has been applied to rock art in all continents, and calibration curves are now available from seven regions in Asia, Europe and Australia. The method's strengths are its superb reliability; ease of use; that it involves no physical and destructive sampling; and that it remains the only direct method of rock art dating that addresses the actual age of petroglyphs, rather than the age of some substance related physically to the rock art (which inevitably must be either younger or older than the art). Its weaknesses are that its results lack significantly in accuracy, as reflected in large tolerance margins; that it can only be applied where remnants of the fractured crystal surfaces remain from the petroglyph-making event; that the presence of calibrated minerals is essential (only quartz and feldspar have so far been used); and that it depends substantially on the precision of calibration curves. The latter reservation means that the method can only be used in regions offering geomorphic or anthropic surfaces of known ages (such as inscriptions or stone structures of known ages, featuring crystals of the same minerals as those used in the analyses).

We have attempted the creation of three calibration curves for Arabia. At Umm Asba'a, we used the lower of two lines of an inscription to obtain four micro-wane determinations from pebble-sized crystalline quartz grains. They averaged a wane width A = 3.25 µm, but in view of the very small sample we regard this result as highly preliminary. It relates to an inscription of about 1120 years BP, suggesting a wane width growth rate of 2.9 µm per millennium. This is by far the lowest recorded anywhere so far, which is entirely consistent with the fact that the area's present annual precipitation is only about one third of that of the region with the next-lowest previously recorded rate, the Australian Pilbara (Bednarik 2001b).

Moreover, the provisional Umm Asba'a value closely matches the more robust calibration value from another site, even though it is 610 km to the north-west. At the extensive Umm Sanman site complex near Jubbah, an Islamic inscription yielded twenty-five micro-wane measurements from two grains in a long Arabic inscription dating from about A.D. 800 – 850. The prominent inscription is on a slightly concave boulder panel 6 m up from the base of the escarpment slope, facing ENE and sloping 57º from the vertical (Fig. 19). Data are from a character 12 cm from the left end of the fifth line (grain size 2.2 mm), and 28 cm from the right end of the sixth line (grain size 2.35 mm). They provide a mean value of A = 3.32 µm, which yields a wane width growth rate of 2.83 µm per millennium (Fig. 20). This calibration value forms the basis of all microerosion estimates from northern Saudi Arabia in the present report.

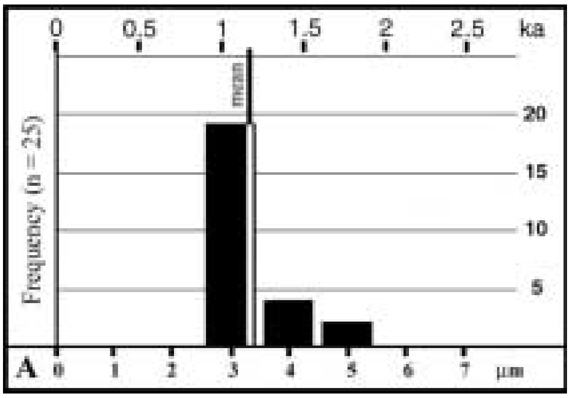


Figure 20. *Microerosion calibration curve for crystalline quartz, Umm Sanman site complex, Jubbah.*

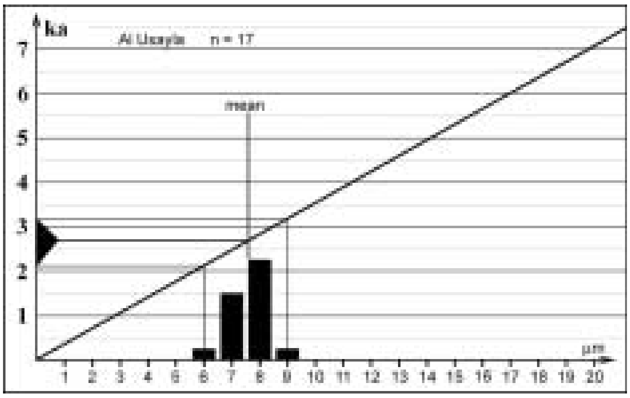


Figure 21. *Al-'Usayla, microerosion analysis of the 'ibex' motif in Figure 4.*

Conditions at Al-'Usayla were not favourable, because the grain size was small, the rock poorly cemented, and some evidence of granular exfoliation was evident. However, an apparent ibex figure offered two suitable edges, one on a grain in the upper 'horn' of the figure, the other in its 'body' (Fig. 4). Eight values were taken over 1.5 mm of the first 90º edge, nine over 1.2 mm of the second, yielding a mean value of 7.59 µm (Fig. 21). About ten other fractures observed on the motif were unsuitable, either because the angle was between 60º and 80º, or because percussion had resulted in sub-pyramidal fractures. Grains are generally well rounded, of frosted surfaces and tightly packed. Using the Umm Sanman calibration value (rather than the geographically relevant, but less reliable Umm Asba'a value), the provisional age of the Al-'Usayla 'ibex' is E2680 + 500 / -560 years BP (the 'E' prefacing all microerosion results indicates that the result is erosion derived). This result can be regarded as *reliable* in terms of its order of magnitude, but is not to be considered as *precise*. It is derived from only one component mineral, quartz, and the calibration conditions are not optimal. In microerosion analyses it is preferred to check one mineral's reaction against another, e.g. quartz against feldspar.. This is not possible in siliceous sandstone. In practical terms his means that if there were any significant climatic changes, they could not be detected. However, the available palaeoclimatic evidence suggests that the most recent significant change in climate occurred more than 3000 years ago.

The situation is slightly better with the one determination made at the Umm Sanman main site, only a few hundred metres from the calibration site. It comes from a large anthropomorph with a horned zoomorph facing it from the left. This vertical panel is about 35 m above the base of the escarpment. The human figure is 2.19 m high and is crossed by several bands containing occasional coarse grains, two of which offer good fracture edges. One is an extensively crushed 8.8-mm-long grain c. 10 cm below the figure's right 'knee', the second sample's grain is on the left of the 'trunk', at the level of the accompanying zoomorph's 'muzzle'. The total of nineteen values determined ranged from 12 – 16 µm, providing a mean of 13.84 µm (Fig. 22). This translates into a provisional date of E4890 + 760 / -650 BP for the large anthropomorph.

At the Umm Sanman northern site complex, two Thamudic writing characters, only 1.5 m apart but belonging to two different inscriptions, were selected for detailed analysis after coarse quartz grains were detected in them. The first is the letter 'sh', where a grain of 12.9 mm provided twelve readings from one edge, yielding a mean of 8.0 µm. The approximate age of E2830 ± 700 years BP places this inscription somewhere between the second and the fifteenth centuries B.C. (Fig. 23). The second letter analysed is a 'þ', in which a 3.25 mm grain offered only five readings with a mean of 7.2 µm. This date of E2540 + 990 / - 420 BP is perhaps less reliable, but it does support the previous result (Fig. 24). Together the data from these

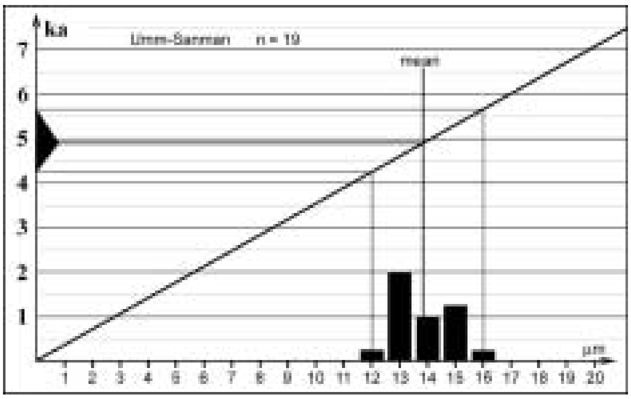


Figure 22. *Umm Sanman main site, microerosion analysis of large anthropomorph.*

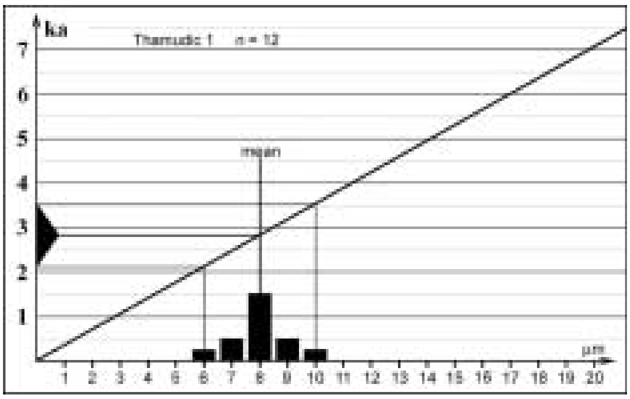


Figure 23. *Umm Sanman northern complex, microerosion analysis of Thamudic letter 'sh'.*

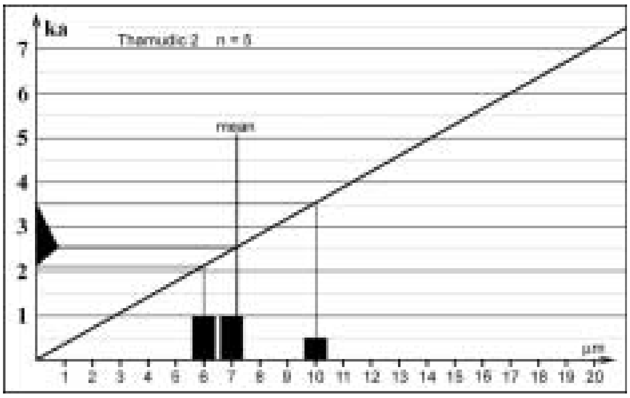


Figure 24. *Umm Sanman northern complex, microerosion analysis of Thamudic letter 'þ'.*

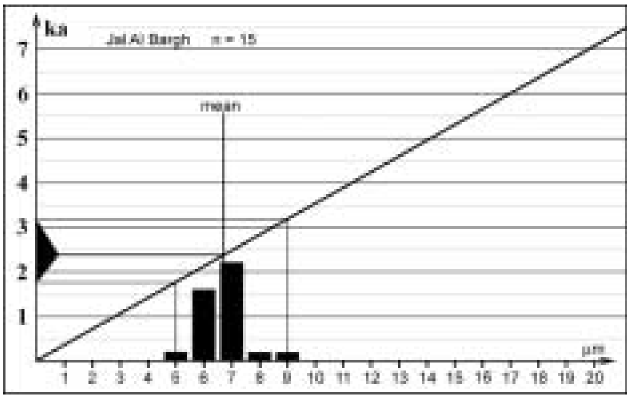


Figure 26. *Jabal al-Barg, microerosion analysis of petroglyph resembling a date palm.*

Thamudic inscriptions should put to rest some of the controversies concerning early scripts in the Middle East.

The conditions at Jabal al-Barg were excellent for analysis, due to the presence of some large quartz grains on the dominant 'date palm' motif. Two such grains in the motif's exceptionally long 'trunk' offered suitable edges, one a pebble of 21.7 mm (Fig. 25), the other not far above it being a smaller grain. Together they yielded fifteen micro-wane widths, ranging from 5 to 9 µm, and providing a mean value of A = 6.71 µm. The provisional age calculated from these data is E2370 + 810 / - 600 years BP. If this motif does indeed depict a date palm, the introduction of this important species into the region should have occurred before 2500 years ago (Fig. 26).

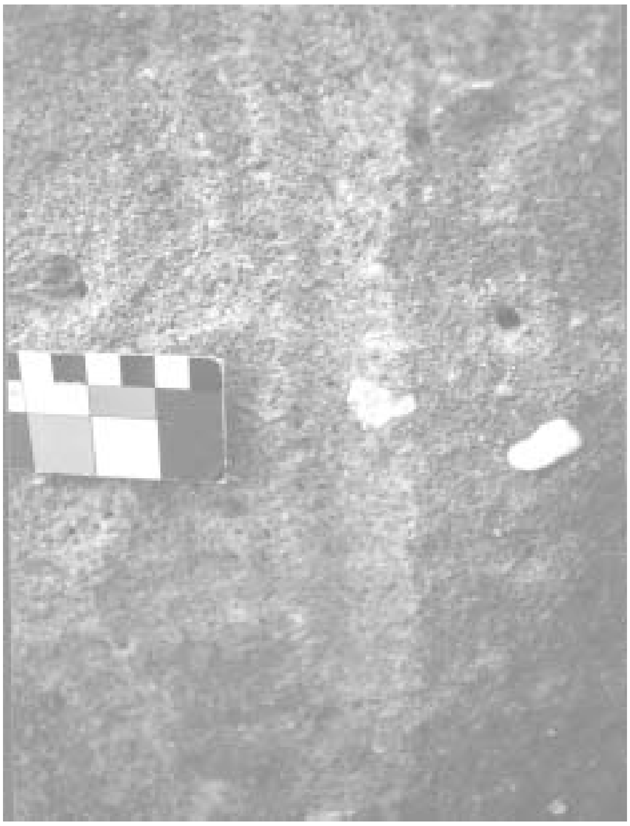


Figure 25. *Jabal al-Barg, detail of 'trunk' of 'date palm' motif, showing extensively shattered pebble-grade quartz grain that was sampled.*

The main site of the Shuwaymas complex appears to include very heavily weathered Pleistocene petroglyphs, such as cupules, but these are so eroded that microscopic analysis proved futile. Suitable conditions were detected on three much more recent figures, two on a vertical panel 25 m west of the cupules and facing east, and one immediately above the cupules, in a composition of several anthropomorphs. The latter postdate the cup marks by a very long time span, as evidenced by the sequence of boulder movement, weathering and patination. The first two figures are a very tall anthropomorph, in which a quartz grain of 13.0 mm size provided seven micro-wane measurements, and an equally large 'ibex' with most impressive horns to the left of it. A mean wane width of 15.0 µm was secured from the anthropomorph, translating into a preliminary age estimate of E5310 ± 350 years BP (Fig. 27).

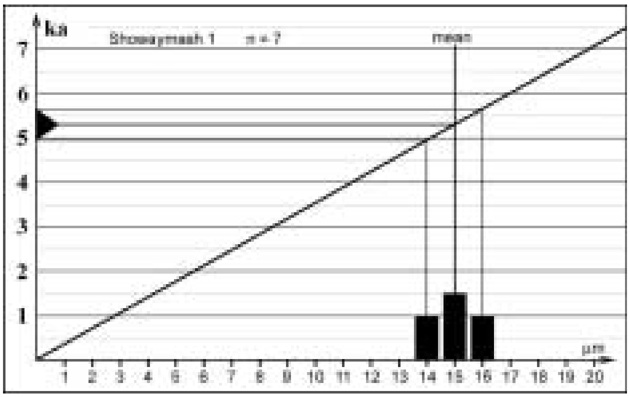


Figure 27. *Shuwaymas Site 1, microerosion analysis of a large anthropomorph.*

The immediately adjacent ibex-like figure, apparently of similar age, provided ten closely ranging readings from edges on a 1.45 mm grain, with a marginally higher mean value of 15.7 µm. This range corresponds to an age of between 6000 and 5300 years, with a preferred estimate of E5550 + 450 / - 250 BP. Since the tolerance ranges of the two motifs overlap by 360 years it remains perfectly possible that the anthropomorph and adjacent 'ibex' image were executed at about the same time (Fig. 28).

Above the cupule panel, a 96-cm-tall anthropomorph

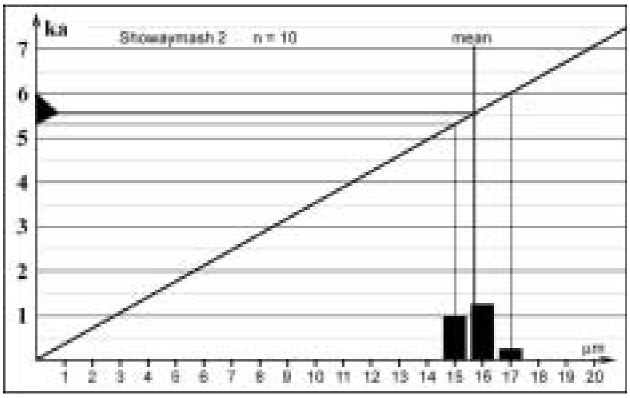


Figure 28. *Shuwaymas Site 1, microerosion analysis of large 'ibex' motif next to the anthropomorph in Figure 13.*

was scanned because it provides a very conservative minimum age for the cupules and subsequent motifs on the boulder below it. The upper part of the early, cupule-bearing panel is now concealed by a huge boulder that has come to rest on it, and which in turn bears a few petroglyphs on its vertical face. The latter remain right-way up and the precarious access to them only became available after the upper boulder came to rest in its present position. Two suitably fractured grains were detected in this anthropomorph, one of 9.9 mm occurring 28.5 cm from the top of the figure, the other measuring 5.5 mm and located 61 cm from the top. The first grain yielded thirteen values, the second seven, with a perfectly narrow range from 12 – 14 mm and a symmetrical histogram. The mean wane width of 13.0 µm corresponds to a tentative age estimate of E4590 ± 350 years, and the measured range suggests that the age is likely to be between 4940 and 4240 years BP (Fig. 29).

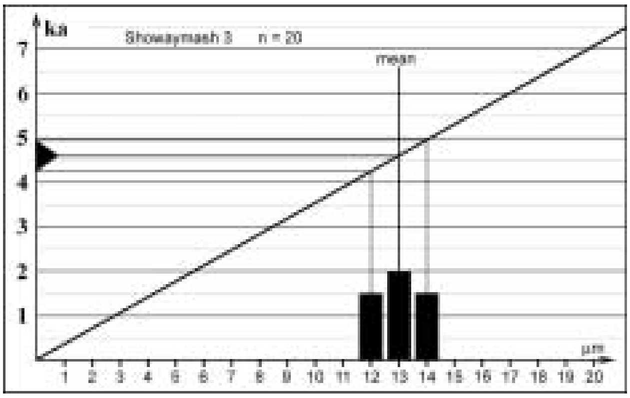


Figure 29. *Shuwaymas Site 1, microerosion analysis of an anthropomorph above the cupule panel in Figure 3 and predating it.*

Some preliminary microerosion data were also acquired from the sites north of Najran, in the Jabal Qara region. We secured a calibration curve from Ain Jamal, a prominent site with numerous decorated panels located at N 18º 17.808, E 44º 30.877. The actual sampling site is at an elevation of 1253 m a.s.l. The site comprises several huge angular boulders decorated with petroglyphs, as well as vertical cliff panels with rock art (Fig. 30). Its large upper-

Figure 30. *Partial view of the petroglyph site Ain Jamal, eastern Jabal Qara, southern region.*

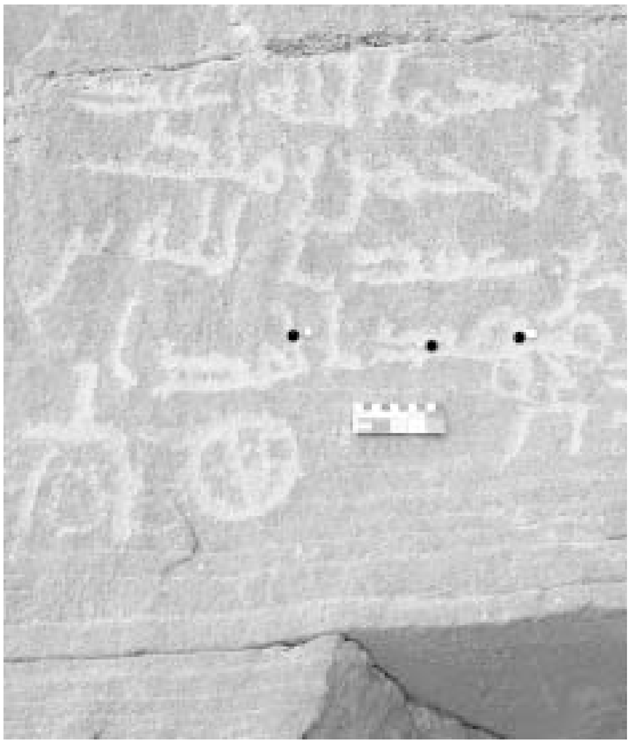


Figure 31. *Early Islamic inscription at Ain Jamal, used for microerosion calibration. Located on the far left of the large vertical main panel shown in Figure 30 above. The three sampling sites are indicated.*

most petroglyph panel includes a four-line Islamic inscription whose style indicates an age of 1300 to 1350 years BP. It was selected for an attempt to calibrate the quartz microerosion rate in the area (Fig. 31). Three characters on the bottom line offered suitably fractured grains, with angles of about 90°. Within the sandstone facies occur strata of 5–10 cm thickness formed by granulometrically coarse grades (commonly sizes of 1–3 mm, coarse sand to small pebbles), one of which facilitated this analysis. One of the wanes shows micro-battering and suggests that it was rubbed with a hard stone, but two others yielded a total of ten measurements, providing a mean wane width A = 6.6 ì m. If we

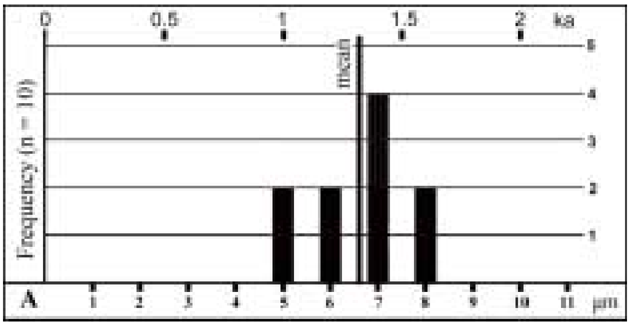


Figure 32. *Microerosion calibration curve for crystalline quartz, Ain Jamal, Jabal Qara, north of Najran.*

assume an age of 1300 years, as a best estimate, this provides a rudimentary calibration curve for Jabal Qara. Interestingly, it differs significantly from the equally tentative Umm Sanman calibration curve (Fig. 32).

Based on this local calibration, we then determined a microerosion age estimate of one typical 'oval-headed' anthropomorph (see below), being one of a group of four such figures, together with two 'long-haired female' figures, at Ta'ar (Fig. 33).

Figure 33. *Anthropomorph at Ta'ar, northern Jabal Qara. The microerosion sampling sites are marked at the lower 'legs', see Figure 34.*

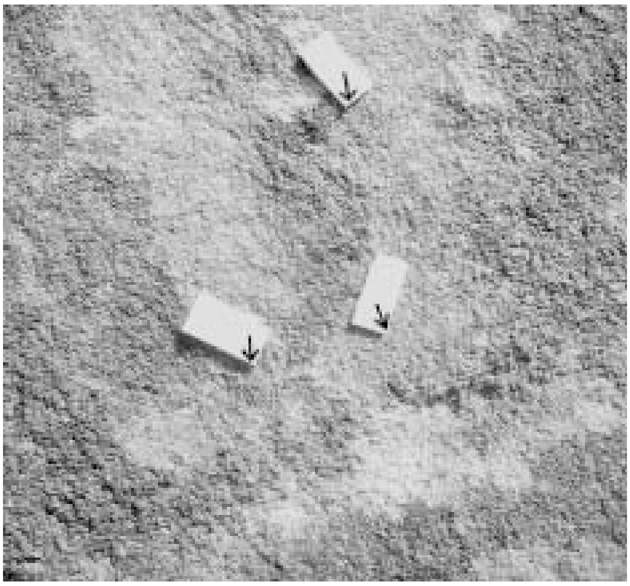


Figure 34. *Detail of Figure 33. The three microerosion sampling sites are indicated.*

Similar to many of the northern sites, there are again numerous Southern Arabic and Thamudic inscriptions that match the repatination of the anthropomorphs, as well as some prominent camel images. The site is located at N 18º 27.691, E 44º 28.836, elevation 1248 m a.s.l. Its sandstone is slightly coarse, with grains typically in the 0.5 to 1.0 mm fraction, slightly frosted and well rounded. There are also occasional pebble-grade grains, but none occurring in the six large anthropomorphs are suitably fractured to allow analysis. However, three smaller fractured grains were located in the lowest part (lower legs) of the second 'oval-headed' figure from the left (Fig. 34). They permitted seventeen measurements on right-angled micro-wanes, yielding a mean wane width A = 10.706 ì m.

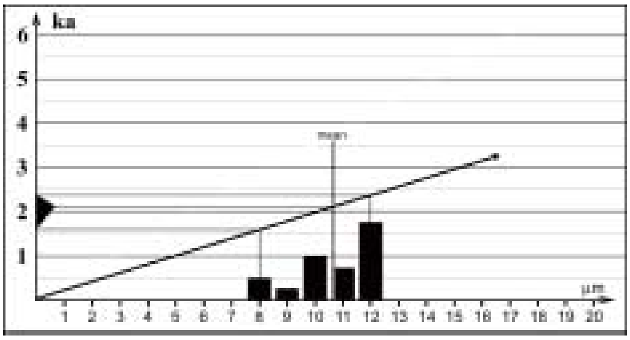


Figure 35. *Ta'ar, microerosion analysis of the anthropomorph shown in Figure 33.*

A tentative age estimate of the 'oval-headed' anthopomorph at Ta'ar, east of al-Kawbab, is possible by placing this value into the calibration curve from Ain Jamal, located about 17 km to the south. This yields an age estimate of E2109 + 254/ -534 years BP (Fig. 35). It needs to be regarded as provisional, because the calibration curve it is based on is coarse and in need of considerably more primary data, and it refers to an imprecise reference date. Moreover, it was derived from a single mineral. However, even an adequate consideration of these qualifications renders it still realistically impossible that the ‘oval-headed’ figure could predate the literate period. This is very broadly confirmed by the repatination of the numerous inscriptions on this panel (as well as on numerous other panels), which generally matches that of the anthropomorphs. Although we have not quantified the colorimetric data from the images at Ta’ar so far, we are confident that they will agree with this visual assessment.

Discussion of the microerosion results

The analytical results presented here need to be immediately qualified by several considerations:

a. These age estimations rely entirely on the veracity of the calibration curves used in calculating them. Although the Umm Sanman curve appears to be closely matched and thus confirmed by the primary data from the Umm Asba’a inscription, this can still be pure coincidence in view of the geographical distance involved. More importantly, the calibration is based on epigraphic assumptions, on a rather small sample of measurements, and necessarily on a single mineral. It would greatly bolster confidence if a duplicate curve could be obtained from feldspar, even if the target sites should only provide quartz values.
b. Most of the sample sizes reported here need to be considered as comparatively small, and the scattered histograms obtained from inscriptions at Umm Sanman north site are probably reflections of inadequate sample sizes. This adds further to the impression that all the age estimates presented here are rather preliminary and tentative.
c. While the age determinations tendered here are certainly reliable in terms of their order of magnitude, much more fieldwork is required to improve their precision, by excluding the possibilities of distortions due to calibration, climate changes in the past, and inadequate sample sizes.
d. Crystalline quartz occurs in different forms. While their solution characteristics are unlikely to differ sufficiently to affect the rather coarse resolution of microerosion analysis, this assumption needs to be tested by analysing surfaces of known age but different quartz types.
e. Since a single-mineral calibration curve provides no safeguard against the effects of major climatic variations in the past the preliminary results listed here may be somewhat distorted. For a period significantly wetter than today, results would be ‘too high’.
f. Most data derived from microerosion analysis need to be regarded as referring to the most recent working of the petroglyph in question. The possibility that an older petroglyph had been retouched more recently cannot always be excluded with adequate certainty. However, we detected no evidence of re-working in the Arabian petroglyphs we derived quantitative data from.
g. The preliminary dates in Table 1 should not be used to interpret archaeological traditions, occupation duration, or any of the other types of archaeological constructs often extracted from rock art. The few determinations now available tell us nothing about population densities, artistic trends, ‘styles’ etc. Saudi Arabian rock art will probably yield much older dates in due course, for instance from cupules.

The results offered here do not constitute secure and precise datings of the motifs they refer to. Substantial tolerances are attached to each age determination, reflecting the spread of the primary data. The true ages of the motifs dated do not necessarily lie within the tolerance values, although this is highly probable. Moreover, the motifs were selected randomly, essentially on the basis of suitability, therefore these results have little or no bearing on the dating of ‘styles’, traditions, and even less of whole site corpora. Many sites include the work of more than one rock art tradition; some were undoubtedly used for many millennia. Therefore these results should not be applied uncritically to whole ‘schools’ or regions, and they should not be used without an appreciation of the qualifications that apply to all scientific rock art dating methods (Bednarik 2001a).

One of the principal shortcomings of the microerosion method of estimating petroglyph age is that some rock art has been retouched at a time intermediate between its original execution and the present. If such retouch is extensive, all surface features of the previous pounding may have been obliterated. However, often the later re-working was not complete, and where traces of both phases remain intact, microerosion analysis can easily distinguish between the two (Bednarik and Kumar 2002). Retouch of petroglyphs has often been noted in cupules.

Of particular interest is the considerable difference between the Umm Sanman and Ain Jamal calibration curves. Although the linear distance between the two sites is only about 1200 km, and both occur in arid environments, the amount of microerosion is significantly greater at the latter site. This confirms how important it is to secure local calibration rather than relying on previously derived data from regions of ‘similar’ environment. The principal factor to be considered is precipitation, which for northern and central Saudi Arabia averages in the order of 100 mm annually. But rainfall is very erratic in occurrence, and none may occur in a region for several years in succession. The south-west of the country, however, is affected by the monsoons of the Indian Ocean between October and March, and the average annual rainfall is around 300 mm. The Najran region, although quite arid, lies in the eastern foothills of the Asîr mountain range, which affects local precipitation. It is also clear that animal species requiring a considerable supply of water were in the area still 2000 or 3000 years ago, at which time the Jubbah region in the far north had already experienced much greater desertification. These factors appear to be well-reflected in the two calibration curves presented here, and the very crude estimate for Umm Asba’a suggests that this central region was climatically closely comparable to Jubbah.

The extensive qualifications we attach to these microerosion results may invite concern from those used to being presented with more definitive rock art dating results, therefore it needs to be mentioned that these limitations

Site	Rock type	Calibration	Dating	Range (BP)	Approx. age (BP)
Um Asba'a site	Sandstone	Inscription		Known age 1120 BP	
Al Usayla	Sandstone		'Ibex' figure	3180 - 2120	E2680 + 500 / - 560
Um Sanaman main complex	Sandstone	Inscription		Known age 1150 to 1200 BP	
			Anthropomorph	5650 - 4240	E4890 + 760 / - 650
Um Sanaman north complex	Sandstone		Inscription 1 Inscription 2	3530 - 2130 3530 - 2120	E2830 ± 700 E2540 + 990 / - 420
Janin main site	Sandstone		'Gazelle'	Greater than 1820 ± 50	
Jal Al Bargh mountain	Conglomerate sandstone		'Date palm'	3180 - 1770	E2370 + 810 / - 600
Shuwaymas main site	Sandstone with pebbles		Anthropomorph 1 'Ibex' Anthropomorph 2	5660 - 4960 6000 - 5300 4940 - 4240	E5310 ± 350 E5550 + 450 / - 250 E4590 ± 350
Ain Jamal	Sandstone	Inscription		Known age 1300 to 1350 BP	
Ta'ar	Sandstone		Anthropomorph	2360 - 1570	E2109 + 250 / - 540

Table 1. *Preliminary results from calibration, microerosion analysis and radiocarbon analysis, from nine sites in central, northern and far-southern Saudi Arabia.*

are only stated to avoid misinterpretation and over-interpretation of our results. All dating methods ever used to estimate the age of rock art are subject to similar, and in many cases even more severe, qualifications (Bednarik 2002a). The over-confidence sometimes apparent in the presentation of such results is in all cases misplaced, and archaeologists can be shown to misinterpret archaeometric data frequently. Nevertheless, the amount of dating work we were able to accomplish did confirm the utility of microerosion analysis in the Middle East. We have so far secured a total of ten dates from seven Saudi Arabian sites, and three calibration readings from early Islamic inscriptions (Table 1). The preliminary ten dates cover much of the Holocene period.

Colorimetric analysis

Rock patinae have long been recognised as a potential means of estimating the age of petroglyphs (Belzoni 1820), but the difficulties of quantifying and calibrating the processes involved and their products have fostered the view that these are too intractable. Belzoni examined the numerous petroglyphs along the Nile and noted the different stages of repatination, compared to the evenly dark-brown accretion on the unworked rock surface. Among the researchers trying to use this approach were Basedow (1914), Rhotert (1938, 1952), Mori (1965, 1974), Goodwin (1960) and Anati (1960, 1961, 1963, 1968a). The role of engraved groove depth in repatination rates remains poorly understood, as does the influence of cation-scavenging micro-organisms and non-organic processes of re-cycling accretionary matter. The use of such phenomena to estimate rock surface ages, including those within a petroglyph, requires an intimate understanding of the processes active in repatination. If the principal component of the patina were rock varnish, repatination would proceed independent of the substrate, but if the process relied largely on the oxidation of resident iron cations it would be affected by the state of the exposed substrate. To make this judgment it is essential to analyse the patination products responsible for the macroscopic appearance of the surface. This is certainly not beyond the means of the determined researcher (Bednarik 1979: Fig. 2), using field microscopy (Bednarik 2001: 164–7).

Most altered rock surfaces experience more than one patination process, so what is simplistically called ‘patination’ is then in fact the macroscopically visible outcome of several factors and their interplay. The word patina, in rock art science, defines a visually obvious surface feature that differs from the unaltered rock in colour or chemical composition (Bednarik et al. 2003). It is a collective, almost colloquial term for many phenomena, but they all share one common attribute: they are acquired gradually over time. Hence they are an indication of antiquity, as researchers have appreciated for centuries.

In a very general sense, patinae can conveniently be divided into those involving the deposition of extraneous matter and endogenous alteration products (although some forms, such as the oxalate patina on marble statues, might be attributable to a combination of local and introduced substances; Del Monte and Sabbioni 1987; Lazzarini and Salvadori 1989). The form of patination most frequently encountered in the study of petroglyphs consists primarily of iron compounds, and it is the only one considered here. It presents itself as the ubiquitous dark-brown coating of rock surfaces, found particularly in arid and semi-arid regions around the world. In all cases analysed by one of us (RGB), in every continent except Antarctica, this is not the product of just one process, and it often combines exogenous and endogenous components. Archaeologists frequently assume this to be either an oxidation product or a rock varnish.

Microscopic examination of brown-patinated non-varnish surfaces usually presents evidence of a variety of processes (Bednarik 2001a). A large component is of aeolian nature, especially on granites. Crusts of the dunkle Rinden-type consist of several iron compounds that are subjected to progressive and probably ongoing modification, both morphologically and chemically: maghemite, haematite, lepidocrocite and goethite. While the colour of such patinae is thus determined by the combination and state primarily of iron salts, especially through the taphonomy favouring haematite, other cations are also present, particularly manganese, and these crusts comprise significant clays and aeolian detritus. Quartz, tourmaline and other crystal grains, plant matter and charcoal fragments have been observed in these accretions (Bednarik 2001a: 64), caked together most often by iron compounds and amorphous silica. They are subjected to continuous modification by rainwater, which favours the formation of distinctively 'laced' or 'terraced' micro-morphologies. However, despite their macroscopically homogenous appearance, such extraneous deposits are usually quite discontinuous at the micro-level, so that exposed surface can be found on all but the very oldest petroglyphs.

Despite their rather complex compositions at the microscopic level, in the macroscopic sense these deposits appear quite uniform. Directional aspect, while being of significance microscopically (both in water-caused migratory precipitation patterns and in the influence of aeolian variables), has little macroscopic effect. Comparisons of regional differences show that, apart from precipitation, the ambient pH regime is a principal influence, both in the deposition and the stableness through time of these formations.

The phenomenon we describe as 'patina' thus needs to be seen as usually comprising both types of products, extraneous and intrinsic, and their complex interplay and ongoing modification regimes seem to imply that these phenomena are difficult to assess quantitatively. There are other significant difficulties with using patination and weathering states in estimating ages of petroglyphs, or in quantifying patina changes for other purposes. Both weathering and patination processes are variable, depending on petrography, climate, micro-topography, surface geometry, orientation, chemical environment and other factors (Bednarik 1979). Repatination can be affected by numerous factors besides the underlying lithology, among them water presence, epilithic organisms, coarseness of surface texture, and the proximity of cation sources, such as sediments or nearby accretions.

Secondly, there is no simplistic method of quantifying such changes, and attempts to quantify colorimetric indices in rock art research (e.g. by measuring reflective properties of accretionary deposits such as rock varnish or paint residues of pictograms) have not been pursued with much persistence. This is in spite of the obvious importance of such work to the dating as well as preservation of rock art (Bednarik 2002b). Lambert (1995) describes the use of a chroma-meter to measure reflective colours of rock paintings for the purpose of monitoring pigment changes. The same equipment could be used to measure colour properties of petroglyph patinae, but there are several practical problems. The need to make contact with the rock art is itself unwelcome, especially in the case of fragile pictograms. In using this instrument, a circular perspex baffle with a small opening through which a light dose is fired is rested against the rock surface. This is usually impracticable on the uneven contours of a petroglyph (Bednarik 2004). Moreover, one of the most important potential applications of colorimetric analysis of rock art concerns the use of pre-existing photographic records, such as images acquired many years ago that can now be used to determine or monitor changes over time (Bednarik 2002b). In such research it is necessary to calibrate the photographs against a known standard before they can be subjected to analysis. For that reason alone it is already preferable to conduct this work by digital means rather than direct measurement of reflected light. Other reasons for this preference include the avoidance of physical contact, which is always preferable in rock art-related analytical work, and the greater flexibility and potential precision.

Colorimetry is related to chromatography and spectroscopy (for an introduction to colour science in rock art research see Bednarik and Seshadri 1995). Electronic optical colorimetry uses a combination of a spectrometer (e.g. Tristan UV/VIS, 250–850 nm), a standard light source, a reception adaptor from the sample to the spectrometer, dedicated proprietary colorimetric software and a portable computer. This arrangement has to be individually adapted to each and every application, which deters its use in the field. In taking measurements, a dark current and a reference or calibration reading are necessary first to determine the standard colour. These values can be stored to file. Measurements are then secured from the production targets. The deviation between the sample and the reference is displayed. Limits for deviation can be pre-set by making a test series. All standards are based on algorithms, which consider the performance of the human eye and are correspondingly complex.

In typical rock art fieldwork, which often occurs in very remote locations, simplicity and compactness of equipment are of utmost importance, and field dependence on sensitive technology needs to be minimised. Moreover, the ferromanganous crusts that we are usually concerned with here are far from homogenous. They exhibit variations in visual as well as other properties (morphological and chemical) at the micro-level, and what is perceived as the colour of a petroglyph is in reality an agglomerate of many colours, even at the sub-millimetre scale. Therefore colorimetric readings that merely reflect random averages would be obtained. An alternative method is based on the results of an experimental colorimetric study of a series of repatinated

Figure 36. *Section of one of the panels at Najd Sahî, Jabal al Kawbab, which was selected for detailed colorimetric analysis (cf. Fig. 39, back cover).*

engraved dates in the eastern Pilbara region of Western Australia (Bednarik in press). When plotting the colour values of microscopic sampling areas from these dates as a function of time, it was found that they formed an almost perfect parabolic curve, which suggests that this may be a valid dating method, at least for relatively recent rock art (up to a few thousand years of age). Obviously it requires much more calibration and it can at this stage only be used at single sites of uniform repatination conditions. However, at the very least the method is superbly suited for relative age estimates on single panels. It was primarily for this purpose that we applied the method at one of the Al Qara sites.

The Australian trials had suggested that thirty-six pixels was the smallest sample size offering reasonably representative data from the often quite variable repatination colours at the resolution range used (300–600 dpi), and for ease of handling a square sampling area was preferred over a circular one. Digital photographs were first colour corrected as described previously, using the IFRAO Standard Scale as the reference device and Adobe Photoshop software for colour management (Bednarik and Seshadri 1995). They were then carefully scanned to establish the type and range of colour variation present within the engraved areas. In selecting suitable sampling sites any visually obvious patches of dense precipitates from saturated solution, especially iron salts, were avoided. Test readings were taken in various parts of the object area to establish the broad ranges present. Typically areas of smallest variation located in the lighter range of the spectrum were then selected and marked with surrounds of one pixel width. The RGB values of each pixel in each aliquot were determined and tabulated. At this point in its development, the method resembles traditional visual comparison, except that it is very much more accurate (the process discriminates over sixteen million colours, which is several times the ability of the human visual system). However, if there are means of anchoring such a relative sequence to values of known age, these data can provide ‘absolute’ dating criteria as well. For this it is essential to have, among the material being studied (which must have been exposed to similar weathering and climatic regimes, and occur on similar or identical rock facies), some instances of repatinated rock surfaces of known ages. So far, very few such sequences have been secured anywhere (Bednarik in press). Whilst absolute age estimates derived from this method must be viewed as experimental and tentative at this stage, our subsequent pronouncements about the *relative* sequence of the region’s petroglyphs are significantly stronger, and are most certainly capable of testing earlier proposed chronologies. This is because what we use here is merely a greatly refined version of their primary basis, repatination and superimposition.

Among the sandstone massifs and wadis of Jabal Qara and Jabal al Kawbab we selected Najd Sahî for detailed analysis, where we have so far taken a total of 1620 colorimetric readings from five partially repatinated petroglyphs on a single prominent panel (Fig. 36). Here we present some of our preliminary findings. Three sampling areas measuring a few hundred microns were selected from each petroglyph to be analysed, and their average colour values were established. Those that are closest numerically are also closest chronologically:

c: One of the bullet impacts, on inside of hind leg of largest zoomorph, known to be <52 years BP.
d: The most recent anthropomorph on the panel.
e: The larger of the several 'ostrich' figures.
f: One of the Thamudic letters within the body of the 'ostrich' of sample 'e', and apparently contemporaneous with it, based on both repatination and spatial arrangement.
g: The largest of the 'oval-headed' figures, central on panel, apparently ithyphallic, in profile and facing right.

In each of these five motifs, three representative sampling areas were carefully selected and subjected to the calibrated sampling procedure, based on square aliquots of 36 pixels. In other words, a total of 324 readings were taken from each motif, and then averaged in each case. The resulting consolidated matrix is shown in Table 2.

Motif	R	G	B	Mean
c	205.05	135.64	86.60	142.43
d	203.56	127.48	74.81	135.28
e	176.38	101.44	52.69	110.17
f	182.54	98.94	46.07	109.18
g	175.72	98.21	46.07	106.67

Table 2. *Summary of the colour values of the five motifs sampled at Najd Sahî, Jabal al Kawbab.*

The reason for including in these determinations the mean values of the combined primary colours is that they have been found to have a much closer correlation to age than individual values (Bednarik in press). Apparently, random variations in primary colours are compensated for in this way, as shown, for example by samples e and f in the above instance (which are probably of the same age). In this case it is readily evident that that samples e–g must be of very similar ages, although g might be marginally older than the two others. However, there is not sufficient difference in the quality of the reflected light to assume a consequential age difference. It is also clearly apparent from Table 2 that sample d is distinctly younger than the group of three early surfaces, and that sample c, from the bullet impact, is again younger.

The first deductions from these considerations are that the 'ostrich' figure (e) is probably contemporaneous with the inscription within it, and of very similar age as the 'oval-headed' figure (g). The second anthropomorph, which resembles 'oval-headed' figures, is significantly younger (Fig. 37). It follows that some of Anati's 'oval-headed' figures

Figure 37. *Detail of panel at Najd Sahî, showing recent anthropomorph (motif d), superimposed over much more repatinated, older motifs. Three sampling areas for colorimetric analysis marked (cf. Fig. 39).*

are no older than writing, but some may be much younger than some writing (cf. Anati 1968a). While the time of the introduction of writing is not securely known, no date greater than 2830 ± 700 years BP has so far been suggested for Saudi Arabia (Bednarik and Khan 2002). All the evidence we have collected so far from Najran sites implies that most of Anati's 'pre-literate phases' post-date the introduction of Southern Arabic, or at least the preceding Thamudic scripts. The sequence we found at Najd Sahî is repeated throughout the region, excepting a small series of clearly much older sites that were not recorded by the Philby-Ryckmans-Lippens expedition, and therefore could not be considered by Anati (see below).

The chronology of southern Arabian rock art reconsidered

Anati's chronology

Anati's (1968a) seminal work on Saudi Arabian rock art is widely regarded as the standard information on this large corpus of petroglyphs, as attested by its frequent citation and use in the decades since it appeared. This work is based on a series of 232 photographs taken by the Philby-Ryckmans-Lippens expedition in 1951–52 (Grohmann 1962; Lippens 1956; Ryckmans 1952, 1954), which applies also to his other volumes on Arabian rock art (Anati 1968b, 1972, 1974). Planned by J. B. Philby and led by Gonzague Ryckmans, the expedition crossed from Jiddah to Riyadh, meandering its way through Makkah, Ta'if, Abha, Najran, Qarya, Wadi Dawasir and Masil. Most of the rock art was recorded at or near Jabal Qara, north of Najran. Anati, who himself has never been to Saudi Arabia, analysed patina shades, techniques, styles and superimpositions from enlarged projections of diapositives made from the negatives of the Philby expedition. In all, he examined the images of about 200 engraved panels, and he did acknowledge some of the limitations of this approach. He believes, nevertheless, to have identified at least twenty 'stylistic groups' of which over ten 'belong to Pre-literate times' (Anati 1968a: 4). He groups the entire sequence into four major chronological units: an 'Islamic' period (after A.D. 622), a 'Literate' period associated with 'South-Semitic' writing (South Arabian script), a 'Herding-Hunting' group which he divides into about ten styles and attributes to non-literate peoples, and an 'Early Hunters' group. The last is made up of three styles, two of which largely lack human figures. The 'oval-headed' assemblage, which he singles out for special attention, belongs to the 'herding-hunting' phase of this sequence. He further states that his 'literate' period might date from about 2300 BP to 1800 BP, and that several of his 'herding-hunting' styles are 3000 to 5000 years old, while the late part of this main-phase dates to 2000–3000 years BP. Roughly contemporary with his 'oval-headed' anthropomorphs, Anati perceives other major 'styles', found in the same area, which he calls 'realistic-dynamic style' and the tradition of the fat-tailed sheep (1968b). On the other hand, he notes (1968a: 169, 171, 173) that there can be considerable differences in the repatination colour of 'oval-headed' figures on the same panel, implying a very great duration of this 'style'. He also concedes that there are anthropomorphs that cannot safely be attributed to, or excluded from, his 'oval-headed' style (1968a: 173). These factors question the integrity of the styles he perceives even before the issue is examined scientifically.

Despite the self-evident fact that Anati only had access to a selectively assembled and relatively small sample of the rock art corpus he tried to analyse he arrived at numerous further conclusions. Most of them are manifest over-interpretations of limited and non-random data (i.e. data not obtained by random sampling, but from biased samples), and in some cases they are even self-contradictory. For instance, he suggests that his 'oval-headed' people probably had domesticated the fat-tailed sheep, even though he admits that there is only one potential association between the two features among his data. Everywhere else in his data the two entities are depicted on different rock panels. He proposes that the 'oval-headed' people may have been one of the Cushite tribes mentioned in the Bible, that they 'identified themselves with the ostrich, which may have been for them some sort of totemic animal' (Anati 1968a: 184), that they performed elaborate cult ceremonies connected with an ox worship, with sexual rituals and with hunting magic. Their cults also concerned the use of some unknown flower or fruit, perhaps connected with the use of some narcotic. Anati thus creates aspects of an entire civilisation of a people whose existence is purely hypothetical, from his own subjective interpretations of an often very ambiguous iconography. He even invents a dating for this hypothetical tradition, again without valid justification, placing it from the beginning of the third millennium to the advent of the first millennium B.C. His vivid description of this hypothetical 'Negroid' ethnic group (there is no acceptable evidence of such an ethnic attribution, be it historical, ethnographic, cultural, anthropological or genetic) is one we have sometimes encountered elsewhere in the fringe literature on rock art:

> They appear as beautifully built people of high stature, with elegant body features, slender and long legs and harmonious shapes and movements. They seem to have been fully conscious of their physical beauty as is emphasized by their depictions (Anati 1968a: 180).

This compares closely with the more recent definitions of Walsh (1994) who discusses the early phases of Kimberley rock art in Australia. Such emotive, severely idiosyncratic interpretations of an entirely alien iconography, to which the interpreter has absolutely no emic or hermeneutic access, belong entirely into the realm of fiction.

Anati's chronological formulations are just as ambiguous. Whilst he suggests that the late phase of his fictitious 'oval-headed Negroids' might overlap with literate times, he also postulates a 'pre-literate' and post 'oval-headed' major group' of petroglyphs (1968a: 143). These two formulations seem to be mutually exclusive. His temporal framework is predicated largely on the superimposition sequences he believes to recognise in the photographs, and on his iconographic 'identifications' of objects in the art, which range widely from the plausible to the thoroughly implausible. For instance, an object frequently depicted crossing human torsos diagonally at waist height (1968a: 134–5), pointed at the lower end and with a variety of morphologies at the upper end, would appear to depict quite naturalistically rendered swords (Fig. 38).

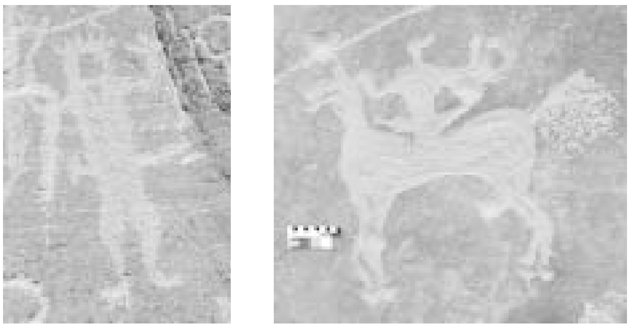


Figure 38. *Two examples of anthropomorphs with Anati's giant 'toggle-pins' from Jabal Qara.*

For Anati, however, these objects are 'giant toggle-pins', and he notes the occurrence of (very much smaller!) toggle-pins from Tepe Gawra and Maayan Baruch in Israel, thousands of kilometres away. There, such pins are not found more recently as the late third millennium B.C. He thus regards these 'toggle-pins' as 'good hints as to the age of the figures' in the rock art — a far-fetched proposition indeed. Not only does the absence of evidence in Israel not demonstrate evidence of absence, these sites are geographically remote from southern Saudi Arabia. But most importantly, Anati's iconographic interpretation of the objects depicted with the anthropomorphs is most probably false. In numerous motifs identical objects are held in the hands of stylistically similar anthropomorphs (see e.g. Fig 33), often above their heads, including by riders on horseback. Why would all these people wave about their 'giant toggle-pins'? To base chronologies of rock art on such 'interpretations' is a practice often encountered in naïve rock art 'studies', particularly in Europe, but it is severely misleading.

Many of his other interpretations are just as tenuous, and in all probability inappropriate. For instance he interprets an indeterminate motif as the head and forelimbs of a large rodent (Anati 1968a: Fig. 87), yet neither the petroglyph itself nor Anati's rendering of it justifies this fanciful description. His claims for various cultural activities are generally untestable and spurious. For instance the claim of worship of oxen is based on a single depiction (not of an ox, conversely; the testes of the bovid are prominently shown; cf. Anati 1968a: Fig. 39) providing no such objective evidence. Similarly, the claim for the use of narcotics is based on one singular depiction of what resembles a branch held by an anthropomorph. All the claims concerning ritual sex, dances, hunting-magic and supernatural beings are presented without any hard evidence or objective justification. They are simply the reflections of Anati's cortical processes of locating iconicity in a corpus of rock art to which he has no valid interpretational access. They have therefore no currency in rigorous research, because Anati's (or our) perception is of no relevance to the discipline. Their only scientific role is in the study of Anati's (or our) perception.

One of the several difficulties Anati has had to contend with is that the photographs that provided his only data bear no size scale, so he had to guess the true sizes of the motifs. Another is that he misunderstands the patination process, in that he perceives rock varnish deposition, which occurs largely as extraneous matter, as part of gradual surface *modification* processes. Moreover, his information lacked details of site geography, topography, geomorphology, petrography and panel orientation or exposure. He was therefore comparing relative repatination without any context. For instance, in comparing two quite distant panels, perhaps located on different sandstone facies or exposed to different patination conditions, two apparently similar shades of patina might be of different ages, or two dissimilar patina colours could relate to the same chronological phase. Even the photographs themselves were not calibrated, or susceptible to calibration, so even at this level Anati had to compare incompatible data, unable to control for numerous variables. Finally, in establishing his various styles he applies circular reasoning, such as, for instance, when he defines the 'oval-headed' style:

> The 'Oval-headed' people appear to have been primarily interested in man, and more particularly, in themselves. The human figure is by far the most important subject they depicted (Anati 1968a: 6).

If we reconstruct how he arrived at this view the fallacy of this approach soon becomes evident. He in fact selected from the record 74 anthropomorphs, on the basis that they seemed relatively large (he could not be certain about their actual sizes), shared some iconographic similarities and seemed lightly to moderately patinated, and he included with them 21 other motifs which he felt were contemporary. Because he had thus selected the human figures as his stylistic marker, and was not able to include with his 'style' many other motif types (even though they may have been of similar ages), he created the bias that led him to assume the existence of a 'style' dominated by certain anthropomorphs. He then observed from the iconographic consistencies among the population of petroglyphs he had arbitrarily chosen that they had consistent features, without realising the circularity of the process. He then used the consistent features to determine the morphology of the people concerned, and found that these racially 'compact and autonomous' people he perceived were 'preoccupied with themselves'. In reality his conclusion is merely a reflection of Anati's own mental and deductive processes, and the model he produces is either largely or completely fictional. This applies even more to his various further pronouncements about the 'oval-headed' people he had created, such as where they came from, who they were, who displaced them, or to where they migrated. All of this is without any factual basis. In all probability, no such distinctive ethnic group existed anymore than a distinctive rock art tradition of 'oval-headed' people such as Anati describes. His photographic record is neither comprehensive nor does it represent a random sample. It is simply a set of photographs taken by travellers who located a series of sites along their route through the desert, and who recorded only panels they found interesting or worthwhile. It is obvious from our own surveys of the region that they ignored some of the panels they must have seen, presumably because they were not considered photogenic enough. It is even more obvious that they managed to locate only a minute number of the petroglyph sites in the general region. Thus their record was never intended to be a representative sample of the area's rock art. Anati then emphasised the bias already inherent in their data by focusing even more on over-represented features.

Testing Anati's sequence

Anati's sequence of, from the most recent, Islamic, 'literate', pre-literate animal figures, 'oval-headed' figures and early animal figures (e.g. at Ain al-Jamnal, Sha'ib Samm, Baraq Sib, Najd Musamm) is fundamentally flawed. His explanation of changes in the depicted fauna, that ethnic groups such as his 'oval-headed people' moved about, taking with them when they left southern Arabia 'their domestic oxen and possibly … domestic fat-tailed sheep, bringing with them their cultural heritage', is demographically unsupported. There is no evidence that such a tradition re-appears elsewhere, and the changes through time in the domesticated as well as undomesticated fauna are much more related to the dramatic changes in climate and hydrology in Holocene times (McClure 1984) then to movements of fictional ethnic groups. Much the same has been found to be the case in Saharan rock art (e.g. Muzzolini 1990; Le Quellec 1998), and it is also perceived to be generally applicable in the Arabian Peninsula. Indeed, the environmental changes through time are of much greater consequence to dating the region's rock art than any perceived stylistic characteristics.

As one of us has pointed out previously, Anati applies his own stylistic constructs inconsistently, and he ascribes stylistically consistent motif types, such as the region's very distinctive 'long-haired female' figures (see below), to several different periods (Khan 1998). Therefore such a prominent motif indicates cultural continuity more than any of the factors he engages. Some of these females are clearly contemporary with his 'oval-headed' figures, as evident through arrangement and identical patination, and Anati places both well before the introduction of writing. Khan has already shown that many of these motifs are either superimposed over inscriptions, or inscriptions are associated with them spatially and appear to be contemporary on the basis of repatination. He also observed that most of Anati's 'oval-headed' figures are shown with what appear to depict swords or daggers, and therefore could not possibly predate the introduction of metal in this remote region (about 3500 BP). Most pertinently, he notes that the frequently found depiction of human females with long hair, narrow waist, half-raised and angled arms and other consistent features probably dates from the Iron Age. Khan (1998: 436) concludes:

> Perhaps the Oval Headed People rock art was depicted in the 1st millennium B.C. and continued until the literate period. There is no evidence to prove Anati's dating of 4th millennium B.C. for the beginning of this art.

This prediction is strongly corroborated by the results of our present analysis. None of the oval-headed figures is even remotely 5000 to 6000 years old, we argue categorically that they are all under 3000 years, and that they coincide with writing. Therefore all of Anati's 'pre-literate styles' are in fact of literate periods, with the possible exception of early outline zoomorphs. His styles are all subjective and most of them probably denote neither a tradition nor a discrete time period. Some perceived stylistic entities, such as the oval-headed anthropomorphs, the long-haired females or the *Wusum* are evidently diachronic phenomena, which is already sufficient to refute the basis of Anati's styles. Indeed, the rock inscriptions may well be the only stylistically reliable time marker, which at least in some instances is almost a tautology.

There is, as we noted in the introduction, only limited literature available on Arabian rock art, and most of it follows Anati's basic chronology and interpretation (e.g. Jung 1991a, 1991b, 1994; Thomson 1975; Zarins 1982; Zarins et al. 1980, 1981). The only consistent opposition to this model is reflected in some of the work of the Rock Art and Epigraphic Survey of Saudi Arabia (Kabawi et al. 1989, 1990; Khan 1988, 1989, 1993a, 1993b, 2000; Khan et al. 1986, 1988), and most particularly in the sustained critique of Khan (1998). We have examined many of the rock art panels photographed by the Philby expedition, and many more not featured in their photographic coverage. We consider that most of Anati's absolute chronology is severely mistaken, and that most of his relative sequence is also false. Our only major agreement with him concerns his pronouncement that the most recent phase relates to the Islamic period, and that this is preceded by a period featuring various scripts. Other than on this one, almost self-evident detail, we must disagree with all of Anati's views on the chronology of the rock art of southern Saudi Arabia.

Among the major petroglyph panels Anati considered from the Jabal Qara region is the one Ryckmans photographed as R.42.11 on 14 January 1952 'between Najd Musamm and Nahd Sahî'. This panel was selected by us for discussion because it comprises markings of a wide age range, including bullet impact craters that are not present on Ryckmans' photograph and an excellent complement of repatination hues. The site's name is Najd Sahî (Fig. 39, see back cover of this issue). One of the visually most obvious features of this impressive panel is that an anthropomorph that stylistically resembles Anati's 'oval-headed' figures is clearly one of the most recent on the panel. It is not much more repatinated than the bullet holes which we know to be under 53 years old. Anati is ambivalent on placing this 'non-conforming' motif chronologically, but his mention of a human figure in the Islamic phase suggests that it refers to this recent motif. As described above, we selected five motifs on this panel for sampling by calibrated colorimetry. This test of Anati's sequence showed conclusively that it is false, as did the preliminary direct dating attempt described above.

Wusum *and the 'long-haired female' figures*

Another concern is that there are several notable omissions in Anati's sequence. Obviously he has missed the older component of the local succession of rock art traditions (see below), but two other oversights are of more immediate concern. Firstly, one of the most common motifs are the *Wusum*, tribal ownership marks of considerable longevity (Khan 2000). Repatination places many of them clearly into recent history, but they occur not only in the Islamic period (where Anati overlooked them altogether), they extend beyond that period. It appears that Anati was not aware of their significance, which is understandable, as he had limited access to ethnographic information. But what is of more relevance is that he failed to notice that certain distinctive, often repeated symbols were shared by different periods, because they can be found with varying degrees of repatination and different epigraphic documents. This observation already negates the idea of 'styles' denoting cultures. Rather, these universal signs, which remain in use today among the Bedouins (particularly in the form of ownership marks on camels; Fig. 40), show *continuity*. Bearing in mind that *Wusum* occur with, for instance, 'oval-headed' anthropomorphs, supposedly of a pre-writing period, this alternative view renders Anati's far-flung hypotheses of migrations and ethnic groups not just severely weakened, but absurd.

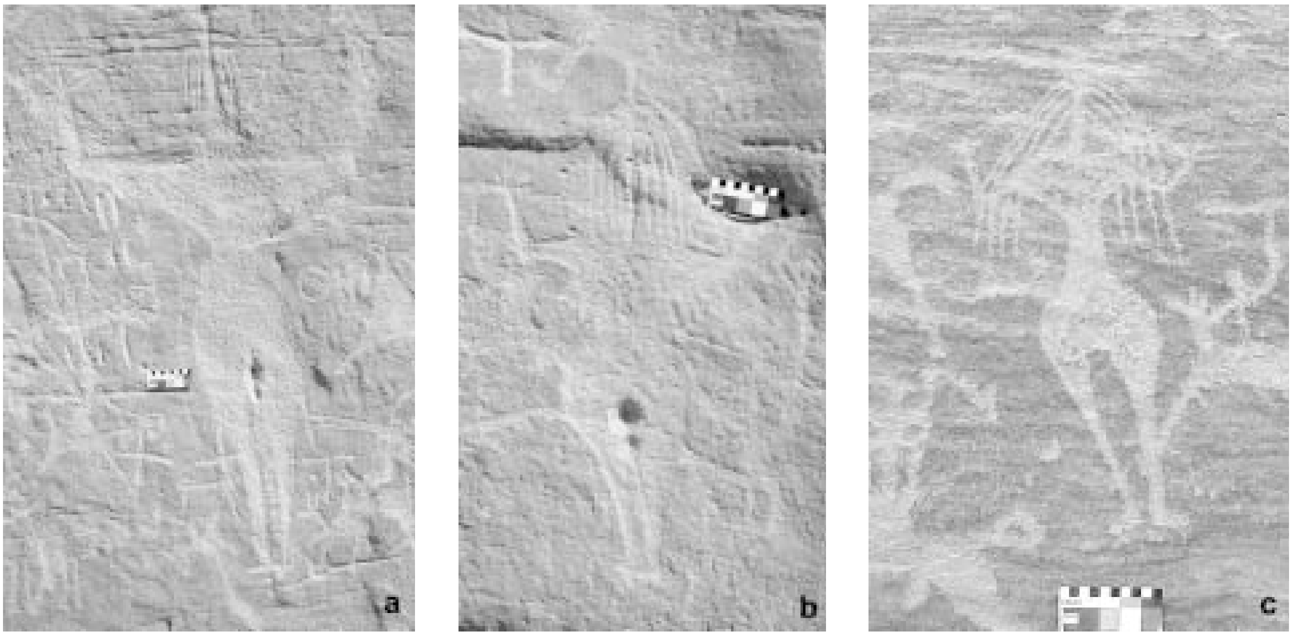
An even more obvious omission is that, in his preoccupation with finding identifiable 'periods' or 'styles', he has

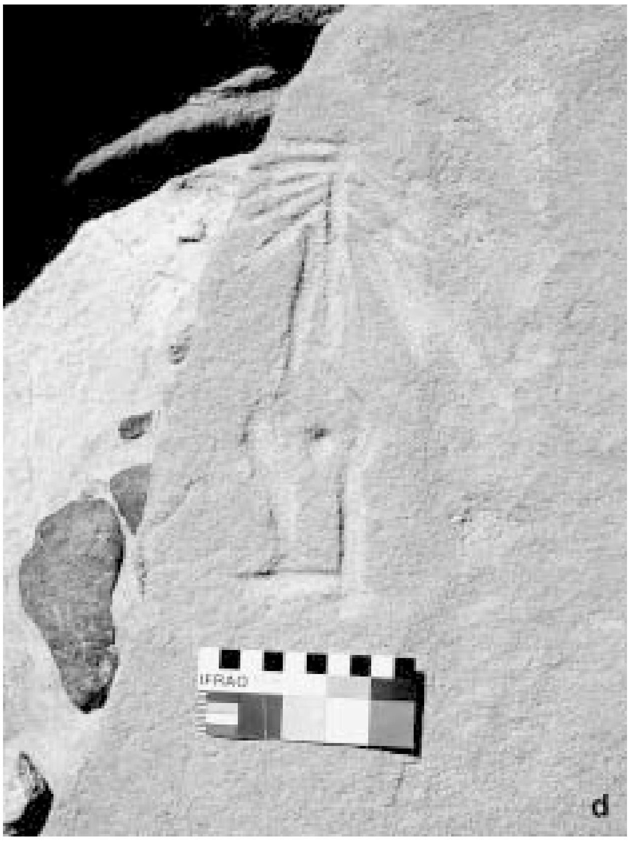
Figure 40. Wusum, *a tribal ownership mark, on a camel near Najran.*

failed to notice the most prominent standardised motif in the region's rock art: the 'long-haired female' anthropomorphs. These are of such distinctive iconography that it is hard to understand that Anati failed to identify them as a major entity, bearing in mind that his entire approach was guided by iconography. This motif occurs in hundreds of cases, and on most panels where it is found it arguably dominates the iconography. It is far more distinctive than the vaguely defined 'oval-headed' figures, and several factors suggest that it depicts a specific personality or event. For instance, there are many instances where, immediately besides this female figure, a horse-rider is depicted holding a long object, perhaps a lance, above his head. This pictorial syntax occurs far too often to be coincidence, and the two figures are always of identical repatination. However, the most distinctive features of the 'long-haired females' are a symmetrical frontal stance, the horizontal upper arms and the vertically angled lower arms, with fingers depicted, the ample long hair (sometimes shown as apparent braids), a narrow waist, wide hips and an almost always distinctively carved vulva (Fig. 41). The torso tends to be triangular, and breasts are depicted occasionally, but not in most cases. The head is always undistinctive and featureless, often consisting of no more than a thick vertical line extending above the hair. There is considerable stylistic variation, which is not surprising in view of the long use of the motif. While we may safely assume, on the basis of consistent repatination colours and inscriptions, that most of these figures are in the vicinity of 2000 years old, it is equally clear that there are prominent and very typical examples that are significantly younger, certainly of the Islamic period (e.g. at Najd Sahî and, nearby, at one of the un-named Jabal al Kawbab sites).

The Bedouins of the region claim uniformly that this distinctive personage depicts Alia, a pre-Islamic princess and deity of the region, and the Islamic instances of this motif confirm the persistence of her story into more recent times. In reviewing Anati's characterisation of the rock art it is important to note that the method he has employed, first, failed to detect the importance of this most distinctive motif of the region and, second, that his assumption that characteristic motif types define styles which define periods, has equally failed here. Stylistic continuity across the incredibly important introduction of Islam, which had a profound impact on the country, disproves a key-tenet of stylistic sequences (as does the occurrence of 'oval-headed' anthropomorphs in the Islamic period). Moreover, it is evident that considerable stylistic latitude, probably on the

Figure 41. 'Long-haired female' anthropomorphs superimposed over older motifs, Jabal al-Kawbab. It is the most recent marking on this panel, apart from the bullet marks, and almost certainly dates from the Islamic period.





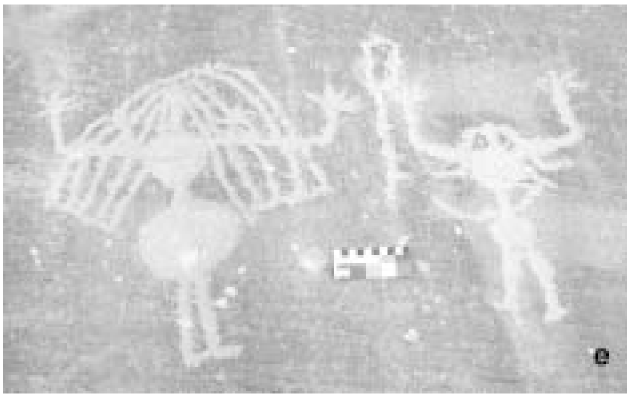


Figure 42. *A range of variations of the 'long-haired female' at Jabal Qara. While (a) to (c) represent the more typical stylistic treatment, the two lower examples differ significantly, yet they are from the same general period. Note the accompanying anthropomorph in (e), which features one of Anati's giant 'toggle-pins' at the waist.*

basis of individual aptitude and preferences, can exist in a single time interval (Fig. 42). Many of the images of this group belonging to its chronological main corpus show wide variation in execution, although still preserving the apparently 'crucial common denominator' (see Bednarik 1994a) features. There are even occasional' abstractions' of the 'long-haired female' motif (e.g. at un-named mid-wadi outcrop east of Jabal al Kawbab), and there is no indication that such 'aberrant' specimens are of a significantly different antiquity (Fig. 42d). Hence, like the almost timeless *Wusum*, the 'long-haired females' of the Najran rock art precinct provide evidence that a simplistic 'stylistic' approach, particularly of the type developed so strongly in Europe, is inappropriate in analysing the iconography of this rock art.

Early petroglyphs

As already implied, there is a body of rock art in this region that is of greater age than any of the material that has been available to Anati. Of particular importance are two sites we managed to locate near al-Kawbab. Fardat Duwaish is on the open sand plain south-east of al-Kawbab, consisting of a tumbled group of massive eroded boulders that have formed a shelter, located at N 18º 27.378, E 44º 36.059, elevation 1146 m a.s.l. On its floor, sheltered from sandstorms and precipitation, occurs a panel of bedrock with several dozen fully repatinated petroglyphs. They differ significantly from the more recent traditions, those Anati deals with. They are deeply carved outline figures, and among them occurs a good number of typical cupules (Fig. 43). This material obviously predates the major period of rock varnish deposition, which we have attributed to mid-Holocene times in northern Saudi Arabia (Bednarik and Khan 2002) and which may well be of a roughly similar age here. The cupules are up to 6 cm deep and comparatively narrow; i.e. they are of exceptionally low depth : diameter ratio. Some have been connected by pounded channels. There are also more recent petroglyphs at the site, but the cupules and associated components are substantially earlier than these.

A very similar situation can be found at an un-named site near Jabal al Kawbab, a more spacious shelter within the collapsing remains of a sandstone stack. On a horizontal bedrock panel within the shelter occur several cupules, including an elongate, almost 20-cm-long example, connected to another smaller cup mark nearby. These two sites, the only ones of this kind found in the area, bring to mind the earliest petroglyphs we have reported above from the Shuwaymas main site and Janin in northern Saudi Arabia. There, too, cupules occur together with deeply patinated archaic petroglyph motifs. Moreover, cupules and other deeply carved petroglyphs are common, even universal, among all very early petroglyph corpora of the world, even in those of immense antiquity (Bednarik 1993). This is in all probability a taphonomic phenomenon rather than one of cultural meaning (Bednarik 1997). Be that as it may, it comes as no great surprise that the oldest traditions we found in the area are consistent with what has been found elsewhere in the world.

In addition to these two notable sites, there are a few isolated fully patinated motifs at other localities, always underlying more recent motifs. They are outline figures of apparent animals (Fig. 44), such as single figures occurring at two un-named Jabal Qara sites. We would tentatively place them in the early- to mid-Holocene, on the basis that they are probably not much older than the main varnish phase. Nevertheless, the true age of these fully patinated figures and the early motifs in the shelters is certainly yet to be es-

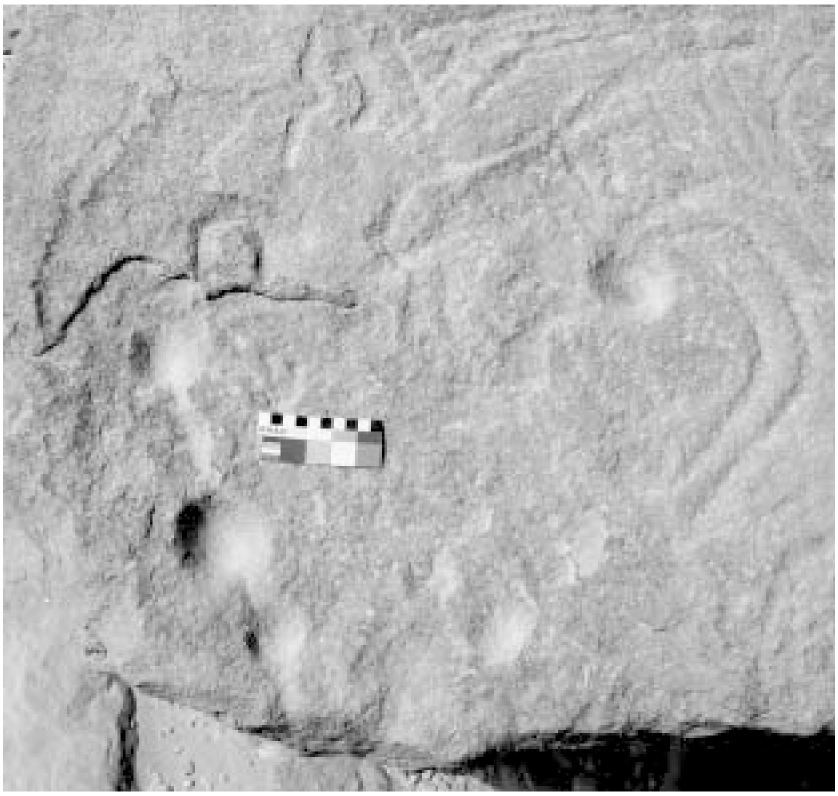


Figure 43. *Very weathered and fully repatinated cupules and linear grooves in the shelter Fardat Duwaish, near Jabal al-Kawbab.*

Figure 44. *One of the few fully repatinated outline motifs found (above the scale). Note the 'long-haired female' figure below.*

tablished.

This brings us to a timely generic observation about regional rock art sequences. On non-metamorphosed sandstones, even in a severely arid region, petroglyphs survive rarely beyond 5000 years on exposed cliff faces, and they survive rarely beyond 10 000 years in reasonably sheltered conditions. Petroglyphs on quartzites, granites and other vastly more resistant rocks can survive with little weathering for tens of millennia, even in fully exposed locations — and longer still where they are protected. Granite does occur in profusion within the Najran rock art precinct, but unfortunately no rock art has been located on it so far. To understand the significance of the chronological distribution of the region's petroglyphs, taphonomic logic needs to be applied. In the Najran rock art corpus, the quantitative distribution plotted against time seems to form a typical parabola — precisely the course shaped by taphonomic processes (Bednarik 1994b). This means, in effect, that the sequence must be truncated by natural attrition, which attaches a major limitation to any interpretation of it. Any such construct will be incomplete, and the composition of the sample of any time segment must be expected to be truncated — and the more so the older the segment in question is.

Conclusions and recommendations

In this paper we have proposed that in the rigorous study of Arabian rock art it will be necessary to approach this vast corpus with a very different framework than that applied by Anati, exploring its chronological dynamics, individual expressions and random variations — and to leave the analysis of age to rock art dating technology, which is better equipped to deal with these complexities than iconographic pronouncement. While it is acknowledged that Anati's synthesis suffered from his lack of first-hand knowledge about the rock art of Saudi Arabia, it is, nevertheless also true, that his approach would not have worked much better had he been to the sites. It has become increasingly evident over the years that alien interpretation of rock art iconographies may tell us something about the perception of the interpreter, but it tells us nothing of scientific relevance about the rock art in question. As in the rest of the world, humanistic and 'archaeological approaches' to rock art need to be replaced by scientific scrutiny. Naturally there is a great deal of resistance to this from some quarters, but this evaluation of a tiny portion of Saudi Arabian rock art, however preliminary, only confirms the need for such changes in epistemology. What renders the study of this corpus particularly rewarding are not just its outstanding attributes (quality and quantity), but also the fact that there is not a strongly established archaeological school defending its false interpretations. In contrast to many other world regions, pre-emptive archaeological pronouncements are quite limited here and will be easily displaced: Anati's model is so skewed that its defence would be pointless. The situation is very different in those world regions where major academic establishments find themselves challenged by scientific findings, reacting strongly and defiantly to them.

We are therefore quietly hopeful that Saudi rock art research, almost unburdened by the enormous ideological and academic baggage some other major rock art bodies have to contend with, might soon emerge as a model of rigour and innovation. Improving the standard of research is far easier in an area not defended by an academic enclave fearful of displacement.

The results presented here are the first scientific rock art age estimates from the Middle East. Their preliminary character does not prevent them from confirming the underlying findings from relative repatination, superimpositions, weathering and various types of inscriptions. According to all of them, key 'stylistic' markers, such as the *Wusum*, the 'long-haired female' motifs and even Anati's 'oval-headed' figures are all diachronic phenomena, they do not denote identifiable entities in the chronology. Consequently the Eurocentric concept of style is either of no or of limited value in deriving a valid timeframe for the rock art. Moreover, the iconographic content Anati tries to use to create an absolute chronology has no substantive basis, for several reasons. The entire sequence and stylistic structure Anati has created can safely be considered false, and in almost every detail so. Its only component to survive is the proposition that the most recent period is the Islamic period, commencing A.D. 622, and marked by Islamic inscription as well as iconic imagery — including several pre-Islamic key motifs.

Among other results of this work we are now able to estimate the time of the major rock varnish deposition period in the Ha'il area. It occurred some time between 6000 and 4000 years ago, apparently mostly in the first half of that period. Most certainly only limited patination has taken place in that region over the last 3500 years or so. This seems to suggest the occurrence of a period of extreme desertification in the north of the country in the middle of the Holocene. It was probably a result of a dramatic lowering of the region's aquifers (which has been accelerated over the last century), and can be assumed to have led to considerable environmental stress in late Neolithic times, and subsequent abandonment of many areas. It is possible that major rock art production phases coincided with such periods of environmental degradation, and the increased incidence of supplication ritual in harsh times. This is of considerable relevance to linking the rock art not only to archaeological data, but also to palaeo-climatological and hydrological issues in the region (such as the disappearance of so many lakes in the mid-Holocene). In this sense the rock art dating work will have wider scientific implications, being of interest also to questions of demographic and environmental history.

The newly discovered, pristine and most impressive main site at Shuwaymas as well as three other sites, two of them in the far south of the Kingdom, included panels that are substantially older than the middle Holocene, and a number of indications suggest that they might even date from the very final Pleistocene (perhaps 10 500 – 14 000 years BP). This very small known corpus is the oldest rock art currently known in western Asia (west of central India). No doubt much more of such ancient rock art exists in the region, but at this stage no such antiquity has been convincingly demonstrated anywhere between Egypt and India — or indeed in any Asian country other than India. Unfortunately this very early rock art offered no data suitable for direct dating, and our opinion about its antiquity is based on a combination of spatial and chronological deductions which we are confident about, but which cannot be considered to be proper dating. This is not to say that this particularly ancient art will not be dated eventually, only that so far such evidence eluded us.

A principal finding of this project is that, even in the very arid and unoccupied regions of Saudi Arabia, which offer optimum conditions for the survival of petroglyphs, the taphonomic threshold (for definition see Bednarik 1994b) of petroglyphs on exposed sandstone seems to be within the Holocene. It probably occurs around 8000 or so years ago. The threshold for petroglyphs on granites is many times greater, and in arid regions probably beyond 50 000 years ago. This emphasises the importance of focusing in Arabia on regions containing plutonic rocks, including granite, gneiss, rhyolite, quartz porphyry, granodiorite, rhyodacite, plagiophyre, quartz diorite, dacite, andesite, diorite and granophyre. There are two fundamental reasons for this: such lithologies would provide greater accuracy in microerosion analyses, by facilitating the acquisition of dual calibration curves, which are necessary for developing greater precision and confidence in the dating of the art; and they would facilitate a considerable extension of the temporal range of the rock art studied, in that such regions should offer sequences of Pleistocene traditions, covering at least the Upper Palaeolithic period. Such ancient rock art can reasonably be assumed to exist in Saudi Arabia, provided that the lithological supports have permitted its survival. But it can safely be predicted that in nearly all situations, it survived only either in deep caves or on weathering-resistant rock facies. The radiocarbon dating of accretionary deposits is not only fraught with various uncertainties (Bednarik 2002a), the method does not seem to have a great future in Arabia, because varnishes are poorly developed and lack the stratification demonstrated elsewhere. Other methods may be introduced in Saudi Arabia in the future, but in view of the ready availability of dated historical calibration surfaces the best short-term strategy in linking the country's rock art to its archaeological heritage by dating the art is probably through the comprehensive application of microerosion analysis.

One of the several rationales of this project was to evaluate issues of rock art site management and conservation. We intend to address these subjects elsewhere, but it is appropriate to briefly summarise our main findings here. In view of the almost unparalleled visual grandeur of much Saudi rock art, one of the major petroglyph complexes should be selected for nomination to the World Heritage List. Of the immediate three candidates, the Shuwaymas complex is perhaps better protected by preserving its remoteness and isolation. Its protection may be best implemented by securing maximum collaboration from the substantial Bedouin population along the only access road. The Najran complex is too close to a main road to effectively prevent alternative access, it is very scattered over a huge area and would be comparatively hard to police. By contrast, the Sanman sites at Jubbah are particularly well suited for development as a major public site, for the following reasons:

1. No alternative access is possible, and all access is easily managed. The sites are arranged in a relatively compact area, following essentially a single escarpment.
2. The sites are of great visual impact and natural beauty, the rock art is profuse, as is the other archaeological evidence of the area (including cairns and tombs, on Jabal Unayza, Jabal Shouwaith and Jabal Samaman).
2. Many of the sites are easily accessible on foot, and the establishment of effective and supervised visitor traffic facilities is readily feasible.
3. The proximity of the Jubbah oasis would enhance the experience of foreign visitors, and it may render the re-establishment of locally extinct fauna possible, some of which is apparently depicted in the rock art (e.g. ostrich, oryx, ibex, gazelle).
4. The Bedouins of Jubbah are proud of their local history and traditions, which include an ancient tradition of typical desert hospitality. They would keenly welcome the opportunity to bring their ancient cultural heritage to the attention of the world.
5. The site is about 90 km from Ha'il, a major town, to which it is connected by an excellent sealed road, so it is remote in a geographical sense, but quite accessible in a logistic sense.
6. Ha'il possesses a good airport that can readily be enlarged for international flights, and the town is easily capable of upgrading its hospitality infrastructure to cope with tourism.

High-standard development of the Jubbah sites as a prime destination for international cultural tourism would have considerable effects in various areas, most of all in the public appreciation of, and support for, rock art generally, and the need to protect it as a valuable component of the Kingdom's cultural heritage. In any country this tends to have a beneficial flow-on effect on rock art elsewhere. Jubbah would be a prime candidate for nomination to the UNESCO World Heritage List. Inclusion in that list would obviously facilitate the promotion of the site, as well as of Saudi rock art generally.

We have suggested that, after an extensive impact and feasibility study, a major interpretation centre be established at Jubbah, and that some of the existing facilities be dismantled. We have proposed to the newly established Supreme Commission of Tourism of the Kingdom that the Jubbah development be of a quality and design without precedent anywhere. All development would be undertaken without affecting the area's natural, cultural or ecological fabric. In some ways, traditional site fabric would in fact be re-established or enhanced. For instance, all recent development in the vicinity of the sites would be removed, the access area reinstated, and public access would be only on foot, by camel or donkey. Accommodation at Jubbah would be by modern versions of traditional caravansaries, the museum/interpretation centre would be concealed under a sand dune, and site interpretation would be engraved on transported rock slabs. Thus the sites would be presented in pristine condition and ambience. For longer hikes (e.g. to Umm Sanman northern complex), we envisage the establishment of Neolithic-type stone huts with skin roofs for weary travellers to rest in. All of these proposals, and others in the same vein, are eminently feasible. Whilst current rock art protection practices in the Kingdom of Saudi Arabia are equal to best practice anywhere else, the Jubbah development would have a significant effect on the public appreciation of rock art elsewhere in this rock art-rich country.

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