Modern behaviour in ancient South Africans: evidence for the heat treatment of stones in the Middle Stone Age

Judith Sealy

To what extent was fire used as an engineering tool by early modern humans? Kyle Brown and co-authors marshal an impressive array of evidence to show that by 72 000 years ago, and perhaps as far back as 164 000 years ago, prehistoric people prepared the stone from which they planned to make artefacts by intentionally heat-treating it to improve its flaking qualities.[1] This practice is well known from later sites but the increased time depth reported here is remarkable, and contributes to a growing body of evidence that Middle Stone Age people in South Africa were capable of far more sophisticated behaviour than previously realised.

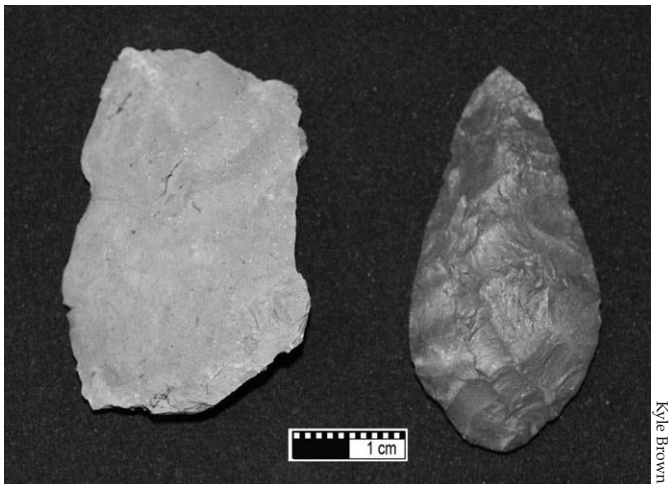
The study is part of a major research project focused on the caves at Pinnacle Point, near Mossel Bay, led by Curtis Marean from Arizona State University. Marean and an international team are excavating a series of archaeological sites near Mossel Bay and researching environmental conditions between about 400 000 and 30 000 years ago,[2,3] obtaining detailed information about environmental conditions during the period in which modern humans—people like us—evolved. There is general agreement among palaeoanthropologists that modern human anatomy developed between 250 000–150 000 years ago, but much less agreement on the beginnings of 'modern behaviour', i.e. the highly-developed intelligence and cognitive abilities of people alive today.

For many years, the dominant view has been that behaviour lagged behind anatomy, developing perhaps as recently as 40 000 years ago. This was based on the observation that archaeological sites older than 40 000 years contain a narrower range of artefacts and food waste than more recent sites, consistent with a more limited behavioural repertoire. As more sites are excavated, this picture is changing, though disagreement persists about the origins of modern behaviour, and the criteria by which we can recognise it. Most archaeologists agree that evidence of abstract thought (in the form of obviously symbolic artefacts, including 'art') is distinctively modern, as are complex technologies involving a high degree of forethought and planning, e.g. the manufacture and use of poisoned arrows in hunting.

Many of the stone artefacts at Pinnacle Point are made from silcrete, a rock type consisting of quartz grains cemented together by microcrystalline silica (SiO_2). Textures and lithologies are variable: coarse-grained silcrete is granular, like quartzite, whereas fine-grained silcrete usually has a relatively greater proportion of cementing silica, and may have a texture approaching that of chert. As fine-grained silcrete fractures more evenly and predictably, it is a more desirable material for making stone artefacts. It has been known for many years that prehistoric stone-knappers heated silcrete (and other rocks) in order to improve their flaking characteristics. This works because the poorly ordered cryptocrystalline matrix of such rocks becomes more crystallised after heating, so that fractures follow the direction of force initiated by the tool-maker, rather than being deflected by the internal structure of the rock.[4] This enables the craftsman to control the shape of the end product more closely, and achieve a sharper edge, although the trade-off is that the rock also becomes more brittle. Heat-treated rock is more lustrous, and frequently redder, as goethite transforms to haematite during heat treatment. This practice is well documented across the world in stone artefact assemblages dating from the last 20 000 years, and has been observed among recent stone knappers in Australia. Brown *et al.*'s contribution is to push the time depth of this behaviour much further back into the past.

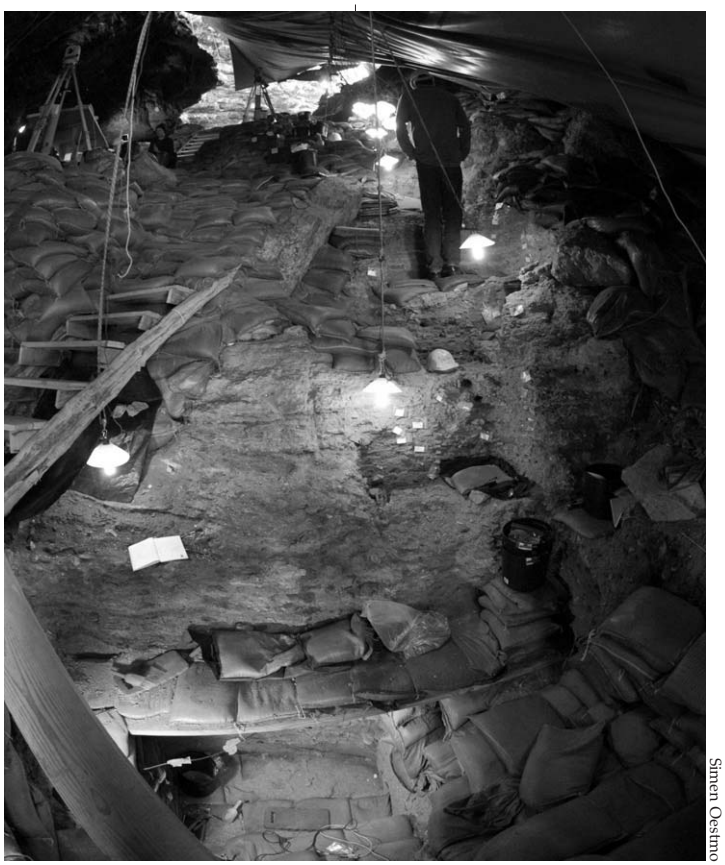
The study began as an investigation of silcrete sources in the Mossel Bay area. Silcrete is uncommon in the vicinity of the Pinnacle Point sites, and usually occurs in discrete outcrops. If archaeologists can find the sources of the rocks from which artefacts were made, they can tell how far people were travelling—or trading—to obtain desirable raw material. A number of silcrete sources were located, but none yielded the reddish-coloured material seen in many of the archaeological artefacts. Brown attempted to make replicas of the artefacts from the excavations, but found that the silcrete simply wasn't of sufficiently high quality to make very fine pieces. These and other clues alerted the team to the possibility that the silcretes they were looking for actually don't exist in outcrop form. In order to obtain silcrete of this quality, colour and texture it would be necessary to use heat to alter it.

Sceptics argued that the team hadn't yet found the best silcrete sources, and suggested that chunks of rock might have been heated accidentally if they were left lying around and then campfires built close by. In response, Brown conducted an extensive series of experiments in which he found that, to obtain silcretes like those seen in the archaeological artefacts, he had to heat them to a high



Kyle Brown

Unheated silcrete (left) can show dramatic changes in colour and texture after heating and flaking (right).



Simen Oestmo

Stratigraphic layers visible in the lower section of the PP5-6 archaeological site at Pinnacle Point, Mossel Bay.

temperature (350°C) for many hours. This is far beyond the degree of heating that would occur in an ordinary campfire, and required a great deal of fuel (20 kg of dried hardwood per 3 kg stone).[5] To properly modify silcrete, ancient tool-makers would have had to expend considerable time and energy collecting firewood before beginning the process, making heat-treated silcrete a valuable commodity. The treated silcrete was found to have much improved flaking qualities, allowing the production of thinner points.

The most persuasive part of the study, however, was the battery of analytical techniques which the team applied to unheated silcrete, experimentally heated material and archaeological specimens, comparing gloss, magnetism and thermoluminescence in each sample set. Experimentally heat-treated silcrete was significantly glossier (had higher reflectance) than untreated. Most archaeological specimens dating to 65–60 kya were within the heat-treated range, as were some of the oldest artefacts recovered, *c.* 164 kya. Magnetic analyses showed that the sediments surrounding the archaeological artefacts were not burned, but that the artefacts themselves were. The final technique used was thermoluminescence analysis, which measures the amount of trapped charge that accumulates in the crystal lattice of minerals over time, as a result of naturally-occurring radioactivity in the soil. Heating releases the trapped charge, zeroing the signal. All the archaeological samples analysed gave thermoluminescence signals indicating that they had been heated in prehistory. These concordant results from three independent techniques provide wholly convincing evidence for Brown *et al.*'s argument.

The next question is the role of heat-treatment in the Middle Stone Age, including how widespread it was. Opinions vary among researchers working at similar sites elsewhere in South Africa. For instance, in a recent study of silcrete bifacial points from Blombos Cave, less than 100 km west of Pinnacle Point, Villa *et al.*[6] note that many of their artefacts are made of silcrete that is grey or yellowish in colour, rather than red, and therefore that heat treatment may not always have been practised.[6] Of course, the change to red colouration with heating occurs only if iron is present. Further work will no doubt address this issue.

As Brown *et al.* point out, one of the reasons this study is of interest to a wider audience is that it helps chart the development of human mastery over fire, a key component of our ability to manipulate the world around us for our own purposes. In later times, this led to the firing of pottery and eventually metal working. In addition, if people were using fire in a highly controlled way to alter the properties of stone raw materials, they were clearly capable of complex goal-oriented behaviour that included solving a range of problems along the way. Brown *et al.*'s study gives us precious insight into the chain of purposeful, planned, interlinked activities required to heat-treat silcrete. It is rare to be able to identify anything in archaeological sites of this age that allows reconstruction of ancient behavioural processes in quite such detail. The more information we accumulate, the more it appears that complex human behaviour goes back a long way. There is now a sizeable body of evidence dating from 70 000 to 100 000 years ago,[7–10] but stretching it as far as 164 000 years ago constitutes a substantial extension, to a time close to the emergence of modern human anatomy.

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