23 March 1979, Volume 203, Number 4386 **SCIENCE**

Dating and Context of Rock Engravings in Southern Africa

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Rock art at its best provides a contemporary view of some of the most essential elements of prehistoric environment and culture, an invaluable human dimension to an otherwise mute archeological record. Yet rock art shares with all art, ancient or modern, an innate subjectivity that renders interpretation difficult. Additionally, prehistoric rock art is difficult to link with the more general archeological record, being commonly found on standing rock faces rather than within cultural strata. Dating of rock art has consequently posed a major problem, contributing significantly to a dichotomy between archeologists who study rock art and those who concentrate on other vestiges of human activities.

Summary. Rock art is seldom recovered from sealed archeological contexts and is therefore difficult to date or integrate with other artifactual assemblages. South African engravings, found on low rocks at open-air sites, exemplify the problem. Multiscale spatial study of technique, thematic variation, faunal content, geoarcheological patterning, settlement history, and ethno-archeological setting provides coherent information on environment, time, and group identity. The major periods of naturalistic animal engravings coincide with wetter and warmer climates about 3200 to 2500 and 2250 to 1800 years before present, but the earliest engravings may be older than 4000 years. Geometric designs were favored after 1300 years before present, when climate was drier and when one identity-conscious population of Bushman engravers first encountered domesticated animals.

Problems of Dating Rock Art

Rock art includes paintings, in the strict sense, and engravings (petroglyphs), scratched, grooved, pecked, and hammered into stone. One can also distinguish "fixed" (parietal) art, depicted on the walls or ceiling of a cave or rock overhang, or on discrete rocks or cliffs outside, from "portable" art (*art mobilier*), on loose objects such as stones, possibly buried within archeological deposits.

Traditional methods of dating have relied on: (i) stylistic typologies, commonly based on paradigms of art evolution from "primitive" to sophisticated and ultimately "degenerate" forms; (ii) sequences of superpositioning, establishing that representations of a particular style, color pattern, or content are partly covered by those of one or more different types (*1-4*); (iii) visual differences in preservation or "weathering" of engravings: freshness of color, degree of glazing by calcite or silica (*5-7*), discoloration and varnishing by ferromanganese compounds in a cemented skin of clay minerals (patination) (*8*), or rock disintegration (including partial destruction by exfoliation, as well as reduction of line depth by granular rock face deterioration or direct abrasion by geomorphic or animal agencies) (*9-12*); and (iv) archeological associations, provided when portable art is recovered from sealed and datable contexts, occasionally linking composite typologies based on style, superpositioning, and physical state.

Direct dating is yet only exploratory. So, for example, the proteinaceous binders of traditional paints include amino acids that disintegrate as a function of age; paper chromatography can detect the number of amino acids preserved and, given a dated control series from known historical contexts, can provide age estimates (*3, 13, 14*). Direct isotopic dating has not yet proven possible, since engravings provide no primary carbon accretion and those of paintings are minimal in quantity, and possibly diluted by older carbon (*15*); however, new isotope-counting techniques currently being developed for minute samples (*16*) may eventually prove practical.

Each of these methods has theoretical and practical difficulties. Paradigms of art evolution are as controversial as ontogenetic interpretations of history or prehistory that view civilizations or culture-complexes as organisms. Even when sequential patterning of art media, form, coloration, and composition can be locally verified by superimpositions, extrapolation of these findings may be difficult if not suspect (*17, 18*). Distinct groups of a single culture and time may depict different subjects, or in different frequencies or associations, or in different ways, depending on available resources or the idiosyncrasies of their craftsmen. Thus a style or subject may be absent, rare, or occur later with one prehistoric group than with a neighboring one (*19, 20*).

Physical state varies at an even finer

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0036-8075/79/0323-1201$02.00

scale, as a function of natural and cultural processes peculiar to the micro- and macroenvironment. Thus, exfoliation or granular rock disintegration in an arid environment may be several times more rapid in a moist, shaded spot than on a dry, sunny face. Although patination is incompletely understood, rates appear to vary enormously according to climate, lithology, and biotic factors (*21*).

Portable art may or may not be coeval with an archeological stratum from which it is recovered. Older painted rocks can be retrieved and left on a younger occupation floor, or younger objects may be intrusive in older strata, often as burials undetected by careless excavation. A chromatographic time-curve established inside European cathedrals may differ significantly from one on a dry, sunny African hillside, where amino acids break down in response to different environmental controls (*22*).

These examples show that care must be exerted in evaluating the age of rock art. The problems are complex and require a broad but integrated contextual approach (*23*).

Age of Prehistoric Art in Southern Africa

Mapping of the several thousand rock art sites in southern Africa (*24, 25*) (Fig. 1) shows that engravings are typical of the semiarid part of the country, whereas paintings are largely confined to subhumid or humid environments. There are some sites with both engravings and paintings (*10, 12*), at least some of the engravings were also painted (*2, 26, 27*), and the basic content of both styles is essentially identical (*12, 28-30*). Paintings in the semiarid sector of the area are mainly found in caves or shelters, whereas the engravings are peculiar to exposed rock walls, low outcrops, or clusters of surface stone. Distinct human groups may have executed engravings and paintings. There is almost general concensus today that all but a very few of the rock art clusters were the product of San "Bushmen" and their prehistoric ancestors (*31*). Some of the latest examples of the genre, however, may have been imitations by Bantu-speaking or Khoikhoi ("Hottentot") pastoralists, as well as early travelers, farmers, and latter-day vandals of European extraction.

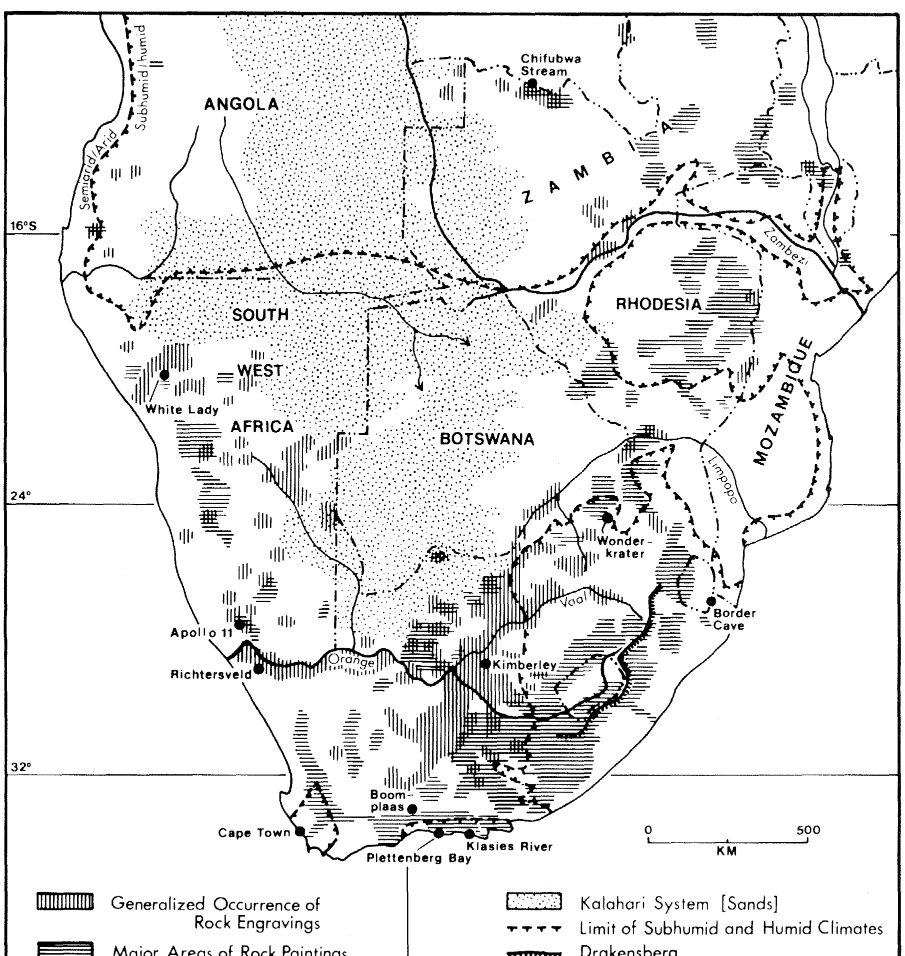

Fig. 1. Distribution of rock engravings and paintings in southern Africa. The semiarid-subhumid moisture boundary follows the Thornthwaite classification (*118*).

The antiquity of rock art in southern Africa has recently been demonstrated by contextual radiocarbon dating. The first indications of great age came from Chifubwa Stream Shelter in Zambia, where a single phase of the earliest Nachikufan, a Later Stone Age industry with backed bladelets, crescents, geometrics, and backed flakes, underlies some 2 meters of quasisterile sand, with charcoal from near the base dated 6310 ± 250 years before present (B.P.); the sand was embanked against extensive wall surfaces with numerous geometrical engravings, some with paint on them (*27, 32*). The minimum age is 6300 years since the earliest Nachikufan dates from 8450 to greater than 21,500 years B.P. (*33, 34*).

In South Africa a number of painted stones ("gravestones") were subsequently found in datable archeological deposits near Plettenberg Bay (*35*), at Klasies River Mouth (*36*), and at Boomplaas Cave (*37*) (Fig. 1). These stones are associated with artifacts of the Later Stone Age Wilton industry, which is characterized by microlithic convex scrapers and backed tools, especially crescents, as well as by stone adzes, grinding stones, and bone, shell, and wood tools and ornaments (*38*). Only one interior site provides a direct association in South Africa. At Glen Elliot Shelter (Fig. 2), a collapsed sandstone roof slab with painted red animals was found just below a level ^{14}C-dated 90 ± 90 and 235 ± 80 years B.P., providing a minimum date (*34, 39*). The associated artifacts probably belong to the final phase of the Smithfield industry, whose makers were in the interior while Wilton peoples occupied the mountains and coast to the south. Smithfield assemblages are similar to Wilton ones, but include more backed blades and points, fewer crescents, and longer scrapers (*40*).

The dating range of 250 years to more than 6300 years B.P. established by these site-specific associations in southern Africa may contradict Denninger's chromatography dates on rock paintings: no paintings in the southwestern Cape were older than 500 years, none were older than 1000 years in the Natal Drakensberg, and 85 percent of 133 samples from South West Africa were younger than 1000 years (*6, 13, 14, 41*). The young dates obtained by this method may be explained by a shorter life for exposed rock paintings than for buried, painted rocks (*42*). There may also be systematic error, so that chromatography dates should be viewed as minimal approximations unless applied under controlled conditions in a well-understood regional setting.

The oldest known rock art site is that of the Apollo 11 Shelter, in South West Africa (*43*). Whether 19,000 or 27,000 years old, this site demonstrates that art in southern Africa was not limited to the single technocomplex represented by the Wilton and Smithfield but goes back to the very beginnings of the Later Stone Age (*44*).

Problems of the South African Rock Engravings

We do not yet know whether the Wilton and Smithfield peoples of southern Africa shared an identical rock art tradition or whether paintings and engravings were peculiar to different cultural or ethnic groups. The Chifubwa Stream Shelter engravings suggest that both art genres are of similar antiquity (*45–47*), but the age and overall context of the engravings found in the semiarid interior remain undetermined. The basic problem is not only inadequate information but even more a lack of systematic analysis of the context of engraving sites. This article outlines our present scientific understanding of the rock engravings.

The discontinuous patterning of sites can be compared with the distribution of the Tertiary Kalahari System, an area of surficial sands with few suitable rock outcrops for rock art and where archeological exploration has been difficult. The major concentrations of paintings are found in subhumid to humid parts of Rhodesia and the eastern half of South Africa, but a substantial portion are in semiarid parts of the Cape Province and South West Africa. Although most of the engravings are found in semiarid parts of the Orange-Vaal Basin and in South West Africa, a number of sites are scattered across several subhumid areas. There is then no simple macroenvironmental delimitation between paintings and engravings that could be related to the production, preservation, or content of art in one genre or the other. But the main concentrations of engravings and paintings do not overlap, and most coincidences of the two are found in peripheral areas with few sites of either type. This implies cultural or temporal differences, or both.

At an intermediate scale (Fig. 2) (*24*, *25*), lithology is relevant to the distribution of engravings, both in terms of opportunity and potential preservation (*48*). Optimal are the Precambrian andesites of the Ventersdorp System and, to a lesser degree, the scattered outcrops of dolerite intrusives of the Karroo System, mainly of early Mesozoic age. To the north and west of the andesite-dolerite zone (Fig. 2) a variety of Precambrian rocks (dolomite, quartzite, granite-gneiss) and surficial sands or calcretes are exposed; friable sandstones, basalts and shales (Karroo System), or quartzites (Paleozoic Cape System) are found to the east and south (*49*). The concentrations of engraving sites show a decided preference for the andesite-dolerite zone but are also common on dolomite and even on intractable gneisses or quartzites. However large "optimal" areas (andesite rock, semiarid climate) have no sites, while a substantial part of the core area of engravings extends into the subhumid landscapes of the upper Vaal and adjacent Limpopo basins. These points suggest that macroenvironmental constraints to art production and preservation did not determine the location of engraving sites or site-clusters. Instead, the limited spatial relationships between sites and environmental opportunities appear to be of the highly generalized type more representative of an ecological adaptation, that is, the interactions between a complex of human communities and their available resources.

The engravings of the semiarid interior of South Africa can be examined from several perspectives to determine whether cultural or temporal factors or both are implicated in these spatial distributions. These include stylistic sequences, spatial variations of thematic and faunal content, as well as geomorphologic, archeological, and ethnographic contexts.

Style and Technique

The different ways the engravings are rendered offer clues for stylistic sequences that may have temporal implications. Wilman distinguished "classes" and "styles" (*47*), whereas subsequent

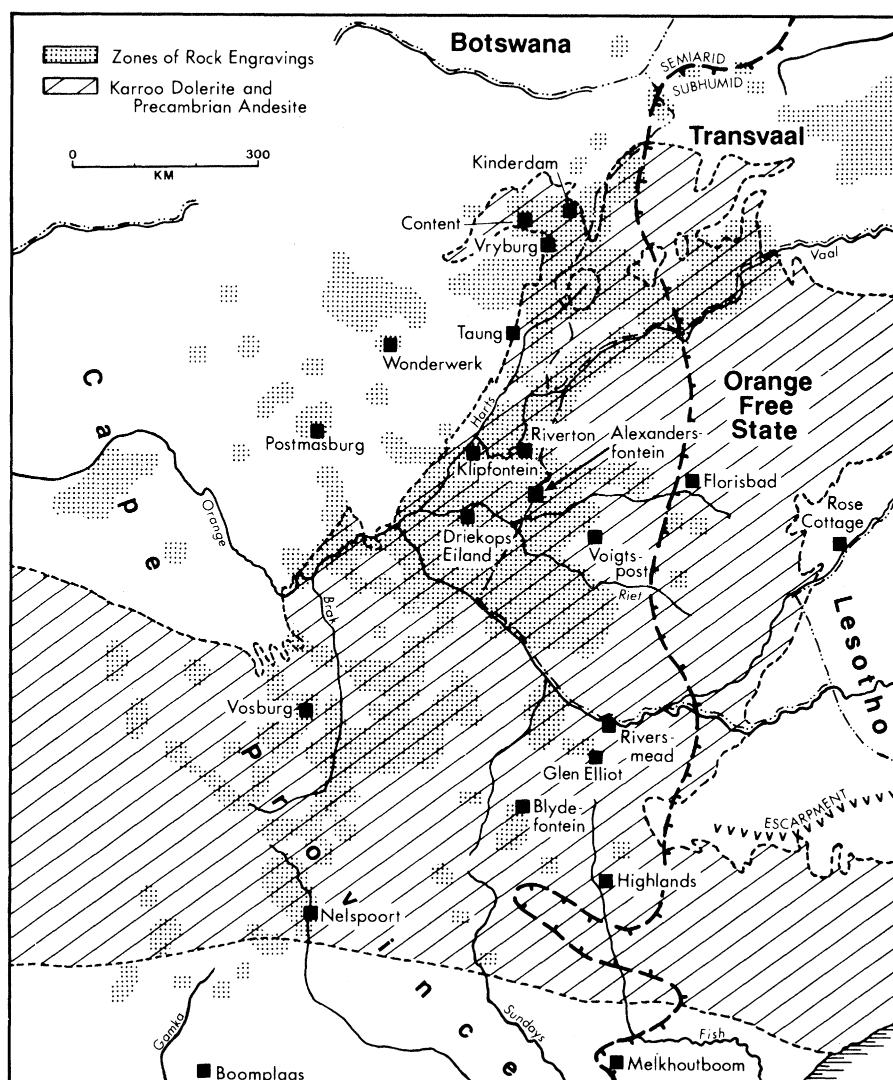

Fig. 2. Environmental context of rock engravings in the South African interior.

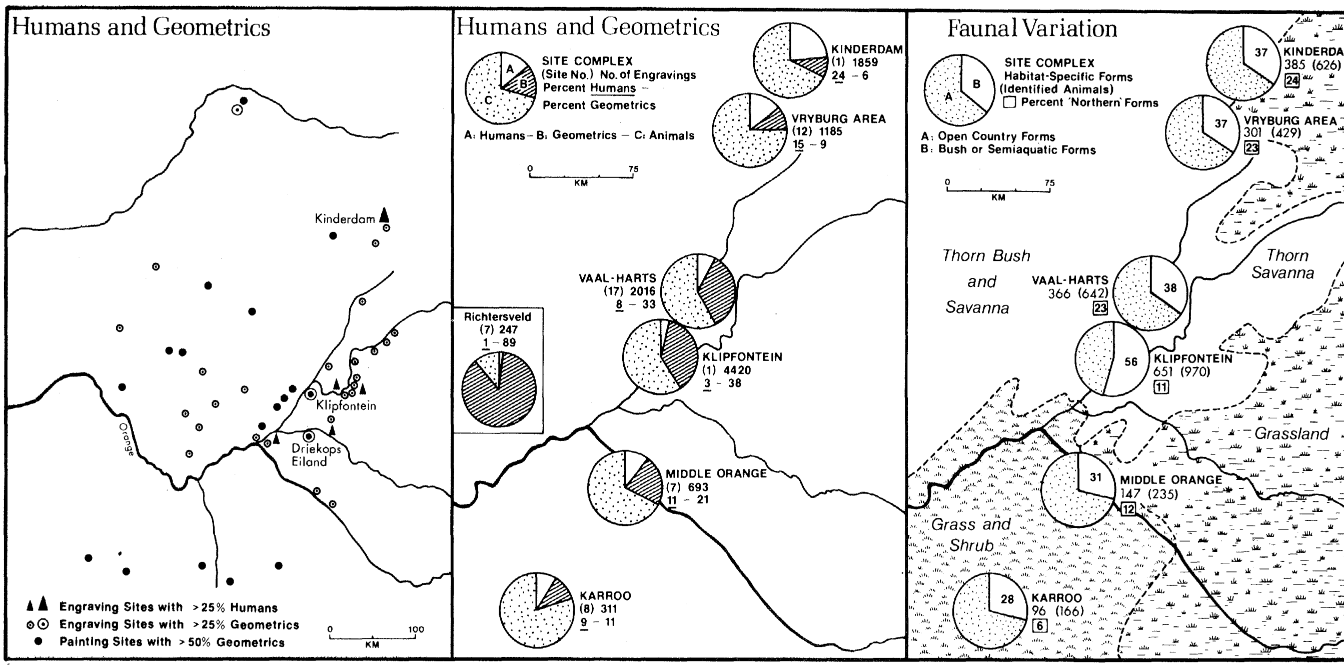

Fig. 3. Regional variation of human, geometric, and habitat-specific animal representations. (Left) Location of major sites with humans and geometrics. (Center) Regional site clusters showing percentage of human and geometric engravings. (Right) Regional site clusters showing proportion of open country and bush or semiaquatic animals.

classifications have tended to mix content, style, technique, and chronology (*12, 46, 50, 51*). Fock (*20*) has developed an objective typology based primarily on technique: (i) scraped engravings, produced by graving multiple, closely spaces lines; (ii) polished engravings, produced by rubbing and grinding down the rock surface to create shallow forms; (iii) incised engravings, produced by pressure grooving; (iv) pecked engravings, produced by controlled, uniform impact points that form dots or dashes, depending on whether the blows were vertical or inclined; (v) hacked engravings, produced by uncontrolled, irregular blows, vertical or inclined, generally creating large holes (> 10 millimeters). Stylistic attributes can be linked to this classification, for example, the pecked engravings were commonly made in outline (profile), in silhouette (fully pecked), or in mixed outline and silhouette (with partial pecking of the contained surface). Fock further recognizes a special, "classical" technique that produced engravings of animals pecked in silhouette to give a three-dimensional effect, either by leaving color markings, skin folds, or bony protuberances unpecked, or through deeper incision of partial outlines that commonly terminate in sharp, deep external profiles.

A technological approach can be systematically applied to recognize spatial variation within a site or between site clusters or regions. Stratigraphic study is also possible, and Fock's survey allows a number of qualified conclusions. The oldest engravings are very thin (< 1 mm), incised lines, in cases of superpositioning always found under any other types of engravings (*52*). Such "hairlines" are common but faint and difficult to detect. Pecked engravings in the classical technique are intermediate in age, younger than many rough outline engravings but older than outlined animals that are simplistic, overgeneralized, or poorly proportioned. Although classicals are limited in number, they are linked in both style and technology to other, more common representations that lack the unmistakable three-dimensional effect: animals and humans in silhouette and profile, as well as naturalistic silhouettes that leave various character marks unpecked; occasionally, a partial or complete outline provides a vividly naturalistic profile. These "classical and related" engravings may not be of the same age at every site, but they do provide a conveniently broad category of intermediate antiquity. Hacked engravings are younger than classicals, but in part overlap temporally with other engravings; they commonly include poor animal representations that are unidentifiable as to genus.

Thematic Variation

The South African engravings can be divided into (i) animals (mainly larger mammals and ostrich, but also including a few other birds, reptiles, fish, and invertebrates), (ii) human figures (including footprints and rare anthropomorphic animals), and (iii) a mixed class of geometric forms or inanimate objects. The animals can frequently be identified as to genus or even species and are therefore of zoogeographic interest. Human representations are less detailed and fewer than those among the rock paintings, and group scenes are relatively uncommon. The geometrics include a wide range of problematic shapes (*29, 53*): circles, some with a dot in the center (?bored eggshell water containers); circles, some concentric, with rays or sets of rays (?sun, ?flowers of Compositae group); ovals, often crosshatched with vertical or horizontal lines (?game traps, ?bulbs of geophytic plants); asterisks (?stars, ?flowers); rows of short lines linked by one or two longitudinal lines (?single and double ladders); wavy or squiggly lines (?snake spoors, ?snail tracks under water); simple or complex mazes or zigzag patterns (?settlement layouts, ?rock patterns, ?cobwebs, designs used on various artifacts); rectangles crossed with parallel lines (?game traps); spirals, as well as a variety of irregular "tectiforms" (?group markers). Interpretation of these geometrics ranges from Wilman's botanical identifications (*47*) to the symbolic approach of Vinnicombe (*4, 47, 54*), and even the proto-alphabets or hieroglyphs of the sensationalists. Some irregular but more tangible forms are rare; they appear to represent such objects as tasseled food bags, pegged animal skins (such as zebra), the leather apron or kaross, and game traps.

The spatial frequency of human or geometric representations varies considerably, but they are relatively important at only a few sites (Fig. 3, left). Figure 3, center, shows quantitative data from 46 sites with over 10,500 engravings and provides a north-south transect through the core region of engravings in southern Africa. Geometrics are most prominent near the center, between the Harts and Middle Orange rivers (*55*). Their proportion decreases to both north and south, whereas human figures, scarce at both Klipfontein and Driekops Eiland, increase outward from this central area. All of the sites with geometrics of any frequency are found on river beds or adjacent to wells. Human figures are poorly represented at sites with abundant geometrics and are entirely absent at sites with fewer than 25 engravings.

Within the major site of Kinderdam, the distribution of geometrics and humans (Fig. 4, C and D) and their relative concentrations with respect to animals show clear disjunctions. Different areas were used for different purposes; at the same time, adjacent rock outcrops of similar physical type have few or no engravings and none of human figures. Similar but less pronounced micropatterning can be observed at Klipfontein, where a random sample of 571 engravings in six geographical areas showed a range of 0 to 14.5 percent human figures. At both the large and the small scale, these distributions imply that different sites or parts of sites (i) had different functions, (ii) were used at different times, or (iii) represent use by different groups or peoples.

The absence of human representations at minor sites and their concentration in specific parts of major sites suggest a functional, possibly ritual, interpretation. On the other hand, the localization of geometrics adjacent to water sources and the consistent repertoire of types across a variety of macroenvironments can be better explained in temporal or ethnic terms. This view finds support in the limited distribution of geometric motifs on paintings of the key study area. Painted geometrics are found primarily along the Kalahari margins, between the Molopo and the Orange-Vaal-Harts (Fig. 3, left), where they overlap with a number of sites specializing in geometric engravings. However, the paintings, which are quite fresh, include only a few of the design types present among the local geometric engravings. In particular, the dotted circles, circles with rays, and asterisks so prominent at engraving sites are totally absent from the paintings, which include no forms absent from among the engravings. We hypothesize that the geometric rock engravings were made primarily by a single people at a time of drier climate when demographic concentrations centered about permanent water sources; at a later time, a related group of people, restricted to the fringe of the Kalahari, continued to draw a smaller selection of identical designs with paint.

Another distributional feature is the anomalous character of the engravings south of the Orange River Valley. While geometrics are less common, the scraping technique is as typical here as the pecking technique is north of the Orange. There are no classical engravings. These anomalies suggest a temporal or ethnic disconformity or both near the Orange River.

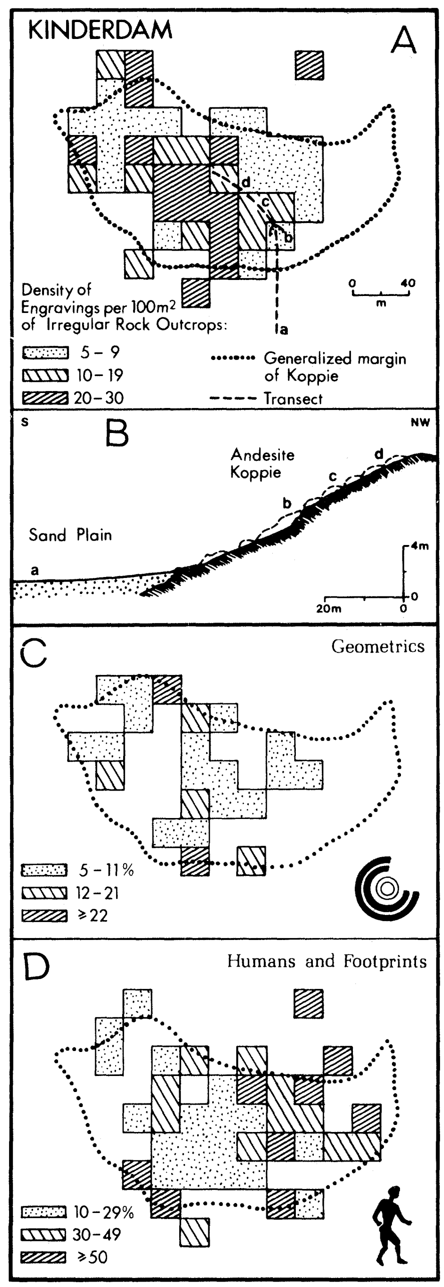

Fig. 4. Topography and relative distributions of engravings at Kinderdam, Vryburg District. (A) Map of engraving density. Lower case letters refer to sites on the transect. (B) Topographic section. (C) Map of geometric concentrations. (D) Map of concentrations of human figures. The sample included 1979 identifiable engravings. Data are plotted in 20-m squares.

In sum, the spatial variability argues for: (i) the presence of functionally discrete sites or site segments, (ii) a degree of correspondence between site location or size and demographic patterning, and (iii) a cultural identity and territorial delimitation for at least those engravers producing the full range of geometric designs (*56*). The absence of most key forms among the few painted geometrics of the painting zone to the east (*3, 4, 10, 18, 57*) leaves little doubt that the eastern painters were distinct from the geometric engravers. This contrast within an otherwise similar cultural framework may also apply at a broader level, as judged, for example, by the preponderance of human representations in the Drakensberg [52 percent human and 31 percent animal of 3438 paintings in Pager's study area (*3, 18*); 53 percent human and 42 percent animal of 8478 paintings in Vinnicombe's (*4*)] and of animals we have recorded in the Orange-Vaal Basin (9.7 percent human and 64 percent animal of 10,483 engravings).

Faunal Content

Of the 6719 animal representations, 46 percent can be identified by genus or species. More than half of the identifiable mammals have distinct habitat preferences and, during the 19th century, environmentally defined ranges (*58*).

Many of the animals shown on the engravings are characteristic of open country, whether grassland or grass savanna with interspersed bush and scattered deciduous trees or scrub, commonly thorny (*59*). These forms include: zebra (*Equus burchellis* and *E. quagga*), warthog (*Phacochoerus aethiopicus*), giraffe (*Giraffa camelopardalis*), springbok (*Antidorcas marsupialis*), gemsbok (*Oryx gazella*), hartebeest (*Alcelaphus buselaphus*), black and blue wildebeest (*Connochaetes gnou* and *C. taurinus*), aardvark (*Orycteropus afer*), hunting dog (*Lycaon pictus*), cheetah (*Acinonyx jubatus*), as well as ostrich. Others of the identifiable animals are characteristic of bush or thickets, and the margins of wooded areas or aquatic habitats. These include elephant (*Loxodonta africana*), white and black rhinoceros (*Diceros sim-*

us and *D. bicornis*), hippopotamus (*Hippopotamus amphibius*), impala (*Aepyceros melampus*), waterbuck (*Kobus ellipsiprymnus*), roan and sable (*Hippotragus* spp.), kudu (*Tragelaphus strepsiceros*), buffalo (*Syncerus caffer*), leopard (*Panthera pardus*), as well as flamingo and herons. We have identified 1946 animals belonging to these environmentally sensitive species or genera for the six major sites or site clusters (Fig. 3, right). The regional distribution of these culturally biased faunal assemblages can be compared with the hypothetical "natural" vegetation (Fig. 3, right) (*59*). The proportion of "open" versus "bush-savanna" fauna compares well with the broad ecozonation as modifed by local microhabitats: a strong predominance of open-country grazers in the arid Karroo grass-shrub, an intermediate ratio of open and bush forms in the open savannas of the north, and a high proportion of bush or aquatic forms near the wooded floodplains as well as at Klipfontein (only 8 kilometers from the Vaal, and a site providing abundant surface water amid an extensive tract of bush and parkland). This logical pattern of spatial variation argues that, despite the hunting preferences and cultural perceptions of the engravers, their artistic selection from the regional macrofauna was reasonably representative of the underlying ecozonation (*60, 61*).

The engraved fauna also suggests an environmental shift. Several species (white rhinoceros, giraffe, gemsbok, impala, waterbuck, roan and sable, and blue wildebeest) were rare south of the Vaal and unknown south of the Orange River in the early 19th century (*58*). They are "northern," semitropical forms of lower latitudes or areas with milder winters than those of the modern Karroo. These semitropical forms increase northward at the Orange and then again at the Vaal River. Even so, four of the eight species were not depicted south of the Orange River Valley. The reasonableness of this zonation attaches some significance to the minor shifts of range suggested by representations of nine gemsbok, three blue wildebeest, two white rhinoceros, and one giraffe in the Karroo, and of five impala, seven waterbuck, and 12 roan or sable between the Vaal and Orange rivers. Although the engravers were mobile people, a faunal shift may be indicated, reflecting a period of milder winters.

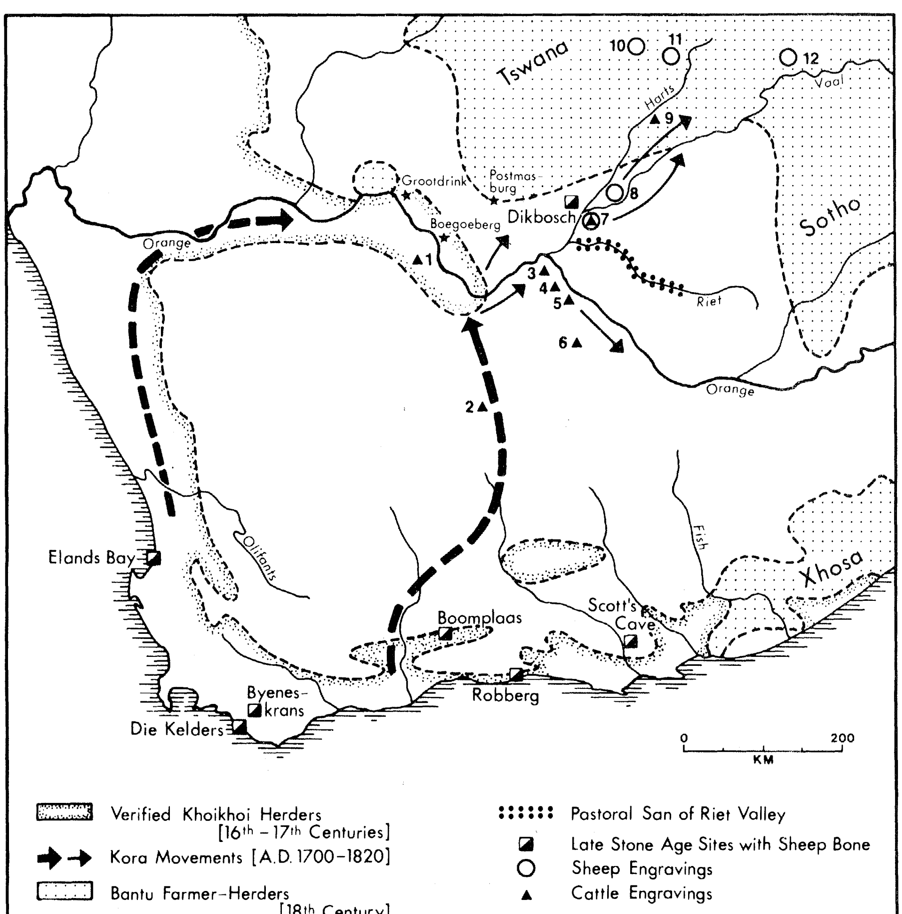

Fig. 5. Distribution of pre-European herding economies in western South Africa. Sites with engravings of domesticated animals: 1, Eindgoed; 2, Witvlei; 3, Slypsteen; 4, Brandfontein; 5, Disselfontein; 6, Pienaarspan; 7, Klipfontein; 8, Barkly West; 9, Home Rule; 10, Content; 11, Kinderdam; 12, Rhebokfontein.

Extinct and Domesticated Animals

The presence of extinct animals or domesticated stock among the engraved fauna may add an internal temporal dimension. If one ignores various claims for extinct genera of elephant or mastodon, and of Holarctic forms such as bear, elk, or bison (*62*), there is reason to consider the possibility of an extinct, large-horned creature occasionally identified as a giant buffalo ("*Bubalus antiquus*" = *Pelorovis antiquus*), for example, at Doornkloof in the western Transvaal (*11, 51*). The impressive engraving of a gigantic set of curved horns on a stylicized head at Kinderdam (*63*) could be the ancestral form of the modern wildebeest (*64*) or, more likely, the giant hartebeest, *Megalotragus priscus* (*65*), which became extinct in coastal South Africa about 10,000 years ago (*66*); its latest known record in the interior is early Upper Pleistocene, but we do not know when *Megalotragus* became extinct in the interior.

Another potentially archaic form is suggested by a detailed, fully pecked engraving at Klipfontein of what appears to be the extinct Pleistocene antelope *Damaliscus niro* (Hopwood), an ancestral blesbok. Although such an identification cannot be made with absolute certainty from rock art, Brain and Vrba (*67*) agree that it is highly likely. Unfortunately, the time of extinction of this Middle to Upper Pleistocene form is uncertain. Controversial horn cores and even casings recently attributed to *Damaliscus* cf. *niro* were found in Wonderwerk Cave (*68*).

Field exploration has greatly increased the number of sites with engravings of domesticated sheep (*69, 70*) and cattle (*71*) (Fig. 5). The sheep are of the fat-tailed variety, wherever type can be determined, and are recorded only in the north of the study area. The cattle, which are long-horned and of Afrikander type, are found primarily along the southern margins of the Orange River. These sets of engravings include several fully pecked cattle, but none pertain to the category classical and related; they show limited or moderate patination but are clearly fresher than most but not all adjacent wild animal representations; they are more weathered and better rendered than representations of Europeans or their stock in the Karroo. In terms of style and technique, these domesticated animals were evidently carved by the same people as the other, traditional engravings, rather than by intrusive herders.

Except for a single sheep tooth of Dikbosch I (*61, 72*), none of the archeological faunas of the Orange-Vaal-Harts region that predate the 19th century provides sound evidence for domesticated stock. This seems to be confirmed by the oral tradition of the Kora (Korana), a group of Khoikhoi tribes that moved into the study area from the lower Orange River during the late 18th century (Fig. 5) (*73-80*). The Kora claim they found only Bushman hunter-gatherers until they encountered Tswana tribes farther north. Yet travelers' reports in the early 1800's frequently comment on sheep, goat, and cattle herding by "Bushmen" along the Riet River (*81, 82*), and the pastoral Kora raided "Bushman" settlements to steal cattle after 1825 (*83*). These pastoral San are identified with the "type R" settlement record, a string of stone houses and animal enclosures found along the Riet River (Fig. 5) (*81*). Calibrated dates on associated Later Stone Age burials are A.D. 1845 ± 50 and A.D. 1590 (or 1475) ± 50; historical evidence indicates these settlements had ceased to exist by 1837.

It is probable that some Bushman groups had adopted a semipastoral way of life by the 15th or 16th century, certainly prior to the arrival of the cattle-herding Kora. The emphasis on sheep and goats and the adaptation of stone architecture suggest that the primary cultural contacts were with the Tswana (*84*), whose iron, copper, and glass trade goods appear at Postmasburg as early as the 12th century (*79*). Consequently, the sheep and cattle engravings north of the Riet River have a time depth of between two and eight centuries. On the other hand, the cattle engravings south of the Orange River appear to be related to contacts with Kora or other Khoikhoi since at least 1120 years B.P. (*73*). These examples could therefore be as old as 1200 years.

The engravings of domesticated stock consequently provide a useful time dimension when found among other engravings of variable style, technique, content, patination, and superimposition. They indicate that outline-and-silhouette engravings of modest to relatively good quality were still being made during the initial centuries of Tswana and Kora contact, but that the large body of naturalistic wild animals—particularly the classical and related engravings—is older than 1200 years.

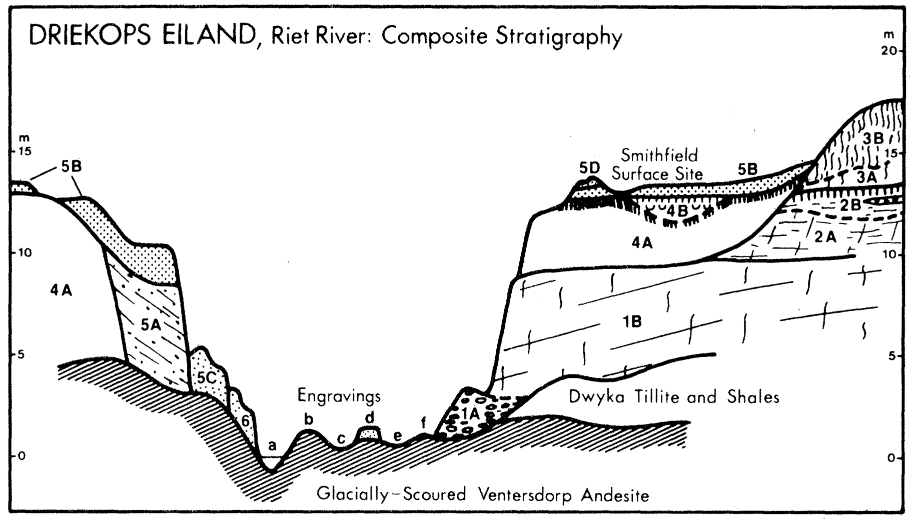

Fig. 6. Composite stratigraphy and generalized geomorphology of the Riet River near Driekops Eiland, Herbert District. Numbers and upper case letters refer to stratigraphic units, lower case letters to location of engraving clusters. There is no horizontal scale.

Geology and Archeo-Stratigraphy

A composite archeological stratigraphy, focused on the major engravings along the Riet River at Driekops Eiland, is given in Fig. 6. Overlying the glacially scoured Precambrian andesite (or Dwyka tillites and shales of Permian age) are three distinct bodies of alluvium (units 1 through 3), with fresh Acheulian artifacts, that combine to form a terrace 20 m above Riet low water. They postdate Acheulian "Younger Gravels" exposed upstream and appear to be of late Middle Pleistocene age (*85*). Unit 4, with fresh blades and points of Middle Stone Age type, forms a terrace at +13 to 15 m embanked against the older alluvia, and comprises two generations of flood sands or silts separated by an episode of channel cutting and soil formation; the youngest channel beds are no younger than a shell bed in position of growth and dated 38,500 ± 1150 years B.P. (Smithsonian Laboratory number SI-3381) (*86*). Unit 5A represents an alluvial terrace at +10 m dated 13,740 ± 110 years B.P. (SI-3384) about 5 kilometers upstream and correlated with other alluvial fills of terminal Pleistocene or early Holocene age (*87*). Unit 5B forms a useful regional marker horizon (Drab Sand) of colluvial origin that sweeps down onto a second +10-m floodplain and locally grades into gray vertisols; it has radiocarbon dates ranging from 4475 to 3040 years B.P. (*88*), including 2665 ± 65 years B.P. (SI-III4) on soil carbonates below such a vertisol near the upper Riet. Unit 5D provides another widespread marker (Pale Cover Sand), of eolian origin, overlying units 5B and 5C and dating from 1220 to 800 B.P. (*89-91*). Both the Drab Sand and Pale Cover Sand commonly include Smithfield occupation residues. The minor +5-m alluvial terrace, unit 5C, accordingly appears to be about 2250 to 1300 years old (*91*). Finally, the loose sands to +3.5 m (unit 6) represent subrecent bedload, augmented by repeated flood surges during the rainy seasons of 1974 through 1976. The alluvial fills 5A, 5C, and 6 seem to lack artifacts anywhere in the Riet drainage.

The physical and settlement history at Driekops Eiland can be summarized: (i) aggradation or floodplain stability contemporary with Middle Stone Age or Acheulian activities, for long spans of time before 37,000 years B.P.; (ii) a low river bed during the late Upper Pleistocene, with no local record of human occupation; (iii) rapid aggradation during the terminal Pleistocene, about 17,000 to 13,500 years B.P., but no occupation record; (iv) after some river downcutting, extensive accumulation of slope wash by intensive rains, later grading into an increasingly moist, stable floodplain near +10 m, 4500 to 3000 B.P.; Smithfield occupation is verified midway in the related sediments (*92*); (v) rapid downcutting of river to bedrock by 2500 B.P., with renewed aggradation to +5 m (but no settlement record) from about 2250 to 1300 years B.P.; (vi) downcutting to about bedrock by about 1000 B.P., with initial deflation from floodplain; new Smithfield settlement is recorded by one or more occupations on top of the +13-m terrace, with a date of 340 ± 75 years B.P. (SI-3388) (*93*), and by the presence of pastoral San for several centuries before A.D. 1835 (*94*).

The engravings are found highly concentrated on 1 hectare of andesite exposed on the Riet bed (Fig. 6). Stow (*74, 95*) reported that heavily patinated petroglyphs occurred in clusters, with semioxidized reproductions in the intermediate space and a scattering of late, unweathered scratchings. All engravings, including "C. Aucamp 1916," found near the low-water channel and within 1 m above the October 1977 watermark are almost as black as the heavily patinated bedrock, but they lack the semiglossy finish of normal bedrock patina, that is, the clay mineral coat is thinner. The degree of abrasion varies also, with engravings on convex surfaces that face upstream (including the 1916 name) conspicuously worn by fluvial sand. Engravings at least 1.5 m above low water, in zones *d* or *f*, and particularly if mantled by sediment, are fresh (*96*).

In other words, discoloration is a function of ferromanganese enrichment during water immersion, and can be used only to discriminate engravings on generally dry surfaces. Thus, partly discolored petroglyphs postdate the youngest high floodplain stage, and unpatinated examples probably do not substantially predate Stow's visit of 1873. A large number of fresh geometrics and the few animal "scribblings" in areas *d* or *f* can hardly be older than a few centuries, while scattered, semioxidized geometrics or "retraced" engravings in these same areas are probably a little older. Most of these poor-quality, recent engravings can best be attributed to the semi-pastoral San verified here as late as the early 19th century.

No fully discolored petroglyphs are found in area *f*, above +1.5 m. Indeed, heavily patinated animal engravings are approximately limited to areas *b* and *d* and only found 1 m or more above low water, whereas heavily patinated geometrics span areas *a* through *d*, and are found to well below 1977 low water. These animal engravings are generally more worn than the geometrics, and in one case a gridded circle with rays is superposed on an outlined antelope; although both are slightly abraded, the details of the geometric are better preserved. No engravings of any kind were found on bedrock recently exposed by undercutting of the sediments of units 5A, 5B, or 5C. The fully discolored geometrics must therefore relate to a low-river stage, when the channel was about as free of sediment as it is today. The geoarcheological framework implies that they can be no older than 1000 ± 200 years B.P. The limited distribution of outline-pecked animals, restricted to higher, convex surfaces, suggests a river bed obscured with more sediment, during initial incision of the +5-m floodplain or even coeval with it, since at least some bedrock would have been exposed in the channel way (*97*). Consequently, the oldest animal engravings at Driekops Eiland must be older than 1300 years but younger than 2750.

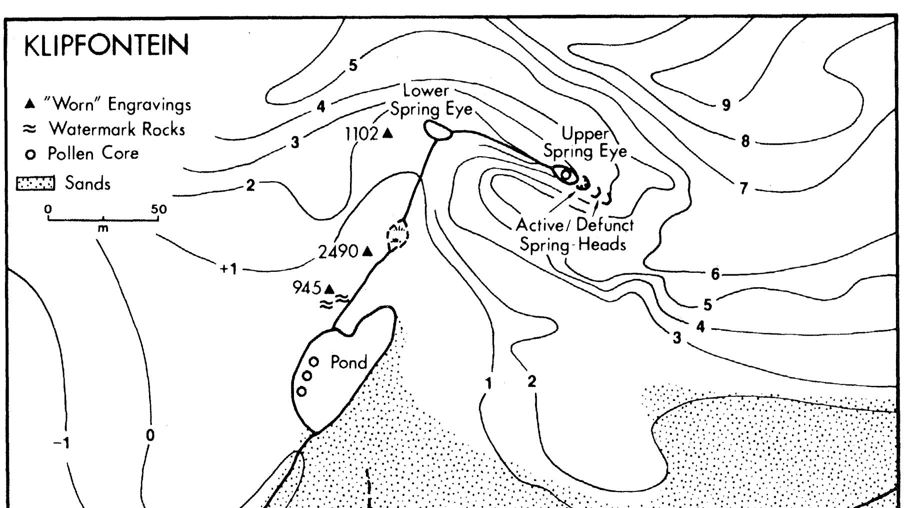

Fig. 7. Topographic setting (above) and longitudinal section (below) of Bushman's Fountain, Klipfontein. Triangles designate rock drawings described in the text. Relative contours are given in meters.

There are no hairline engravings at Driekops Eiland, nor are there any classical and related types. Perhaps no andesite was exposed at the time: for example, the Riet floodplain was at +10 m during the period of 4th-millennium settlement. At Schanskop, near Riverton-on-Vaal, fully discolored classicals (*98*) are found only on rocky slopes above +5-m floodplain deposits, while geometrics are found along the active river bed. This argues that the classicals were contemporary with the Drab Sand floodplain stage. The generally younger age of geometrics is confirmed at many sites, such as along the Vaal River, where animal engravings are commonly more worn, or in the Richtersveld, where animals are frequently glazed with calcite, whereas geometrics are not.

Further links between engravings and the geomorphic record can be shown at Klipfontein (Fig. 7), where almost all of the engravings are found on rocks scattered over a low andesite koppie (hill). Only three engraved rocks are found on lower ground, in the shallow Bushman's Fountain valley that links the waterholes (*99*) to a small depression (pan) now artificially dammed. These rocks generally have smooth edges (with some fresh, angular fractures) and unusually thin, reddish brown patinas on exposed faces (0.5 mm compared with over 3 mm on almost every hillside rock). Furthermore, the engravings on two of these rocks and on the lower half of a third are quite indistinct, 75 percent of original line depth having been lost; the worn items include an outline antelope and a silhouette eland (on No. 2490 Fig. 7), a silhouette as well as an outline equid (on No. 945), two other, indistinct mammals, and a silhouette ostrich (on the lowest slab of No. 1102). The one eland and the ostrich suggest the classical and related category, and the whole group appears to be intermediate.

Sand blast is precluded: wear is greatest on the upper face and rim of these rocks, not on their sides; the rocks are located in the wind shadow of the koppie; and the brown (Munsell 7.5 YR) soil matrix below is a humified, poorly sorted, pebbly, loamy sand. The rocks are too low and their configuration is unsuitable for animal rubbing, and hoof impact marks as on nearby rocks are also absent. Although lichens may be visible during wet years, these are associated with rough faces below the upper rim; surfaces do not retain water after rains and lack the rough fringes generally found around areas hollowed out by biochemical processes. If decomposition was responsible, it was unique to the low bedrock platform of the short valley where these worn rocks are found to a maximum of 75 centimeters above the channel way. On the other hand, fluvial abrasion is a reasonable interpretation on a platform littered with crude rubble and mantled by a heterogeneous soil wash of subrounded grit-to-pebble grade, andesite gravel, subangular to rounded andesitic amygdales, and silty sand. A part of the sand is derived from the yellowish red (5 YR), sandy loams of eolian origin that form the koppie soil.

A broader geomorphic context is available for Bushman's Fountain (Fig. 7). First, two defunct spring heads developed as stepped rock concavities 1.2 and 2.0 m above the upper waterhole record periods when the deep-seated, fault-related aquifer (*100*) emerged at a higher level. Second, rocks around the pan show a ferromanganese-stained watermark at 20 ± 5 cm above the 1974 low-water level that corresponds to the elevation of the overflow threshold; these watermarks represent long periods when the pond was full, with about double its present volume. Third, several generations of sediment can be identified under the disturbed bottom sediments of the pond (*101*).

1) A 30- to 50-cm thick, upper horizon of unconsolidated yellowish to grayish (10 YR to 5 Y), reduced fine sediment with dispersed rubble. Facies variation indicates at least three stratigraphic subdivisions—an upper subunit of sandy marl, then interbedded silty clay and silty sand, and finally a marl or marly sand. Basal marl gave a carbonate age of 6820 ± 115 B.P. (SI-2292), probably a minimum date; the upper subunit has pollen.

2) An intermediate body of white (10 YR), mottled calcrete, 20 to 50 cm thick, with a residual of gravelly silty sand and a carbonate date of 20,500 ± 900 years B.P. (SI-2858). Some pollen is present. This stoney calcareous horizon outcrops in several areas and includes worn Middle Stone Age artifacts.

3) A lower horizon, up to 1 m thick, of yellowish red (5 YR), gritty coarse sand with a major, reworked eolian component. The basal sands represent a late Pleistocene fan, blocking off a depression (Fig. 7) in which discharge was ponded over 20,000 years ago.

In sum, three lenses of subaqueous sediment, built up behind this sandbar beginning before 7000 years B.P., apparently parallel units 5A, 5B, and 5C at Driekops Eiland. The +75-cm platform would have provided a wetter microenvironment during these Holocene moist intervals, subjecting the low-lying engravings to both corrosion and abrasion.

In sum, the worn engravings are linked to one or more geomorphic events at Bushman's Fountain. Specifically, the classical and related animal engravings are older than the last significant moist interval and perhaps coeval with an earlier one, that is, no younger than 2000 years (the climax of phase 5C alluviation and spring activity) and more probably older than 3000 years B.P. (the closing stage of phase 5B).

The pollen spectrum (200 grains) of the youngest, undisturbed, subaqueous pan sediment is dominated by Gramineae (37.5 percent), *Tarchonanthus* (17.5 percent), and Chenopidiaceae (22.5 percent), with some other Compositae (6.5 percent), Cyperaceae (3.5 percent), cf. *Olea* (2.0 percent), and Aizoaceae (1.5 percent). That of the late Pleistocene calcrete is similar; of a 100 grain count, Gramineae (39 percent), *Tarchonanthus* (31 percent), Chenopodiaceae (10 percent), and other Compositae (9 percent) are dominant. Compared with three modern spring-eye reference spectra (200 grains each), where Gramineae range from 56.5 to 65.5 percent, *Tarchonanthus* 0.5 to 4.0 percent, other Compositae 3.3 to 16.0 percent, and Chenopodiaceae 1.2 to 9.5 percent, the fossil spectra indicate either reduced grass cover, much expanded bush and thorn thicket, or both, mainly with *Tarchonanthus* and some scattered wild olive and *Acacia*. The presence of Combretaceae together with *Diospyros*, *Rhus* and cf. *Boscia* in the mid-Holocene sample supports the hypothesis of expanded bush (*102*). These pollen data match the predominance of bush or semiaquatic forms in the Klipfontein fauna, and suggest vegetation such as that now found north of the Vaal Valley. The southward shift of giraffe, white rhinoceros, sable, and blue wildebeest (Fig. 3, right) consequently finds a reasonable explanation.

The Klipfontein record is complemented at Content, northwest of Vryburg, where engravings are found on low andesite boulders on an undulating plain. A recent reduction of ground cover favored removal of 10 to 25 cm of soil [a poorly structured, reddish brown (5 YR) loamy sand with 10 percent clay fraction], as can be deduced from oxidation rinds or discoloration on most rocks, local evidence of rock cavitation below these marks, as well as flat termitaria that form low pedestals, the tops of which coincide with this level. Many naturalistic animal engravings, frequently in outline-and-silhouette technique and all intensively patinated, were partly or entirely buried under the former soil mantle and locally remain covered by 5 to 10 cm of loamy sand. Younger outline engravings with little patination are found well above these soil markers. The Content record shows that sheet erosion preceded the period of naturalistic engravings; subsequently, accelerated eolian activity covered many with sand; the later engravings, including several sheep, were made while the new, higher soil surface was stable; and renewed sheet erosion during recent decades or centuries has partly exhumed the older engravings. The period of eolian activity correlates with phase 5D at Driekops Eiland (1000 years B.P.) or with the dry interval of 2500 years B.P.

These geoarcheological examples tie critical aspects of style, technique, and content into a chronostratigraphic and paleoenvironmental framework. The bulk of the geometric engravings, which are younger than 1300 years, relate to a drier climate when surface water was scarce. Although some animals, including domesticated stock (shown mainly in a rough outline technique), were still engraved during this late period, the classical and related category is older than 2000 B.P. and probably dates to the preceding moist phase. In fact, the geological, faunal, and palynological data suggest that the main body of animal engravings is best considered in conjunction with the evidence for periodic abundance of water, enrichment of carbonates, and an expansion of bush from warmer into cooler environments. The regional evidence indicates generally moist conditions before 6800, between 4600 and 2500, and between 2250 and 1300 years B.P. The complementary record of spring tufas from the dolomitic Gaap Escarpment argues for significantly augmented groundwater reserves from 9700 to 7600 years and from 3200 to 2400 years B.P. (*103*). However, the continuous pollen profile at Wonderkrater, near Naboomspruit in the north-central Transvaal, indicates that the period 7500 to 1800 years B.P. was a little milder or warmer than the Holocene mean in interior South Africa (*104*). A general coincidence of moister and warmer environmental conditions can therefore be inferred about 7500 to 6800 years and 3200 to 2500 years B.P.

Archeological and Ethnographic Frameworks

The engravers must have been responsible for a specific part of the archeological record, and, given useful spatio-temporal coordinates for the lithic assemblages, interpretation of the engravings will be enhanced. The record of terminal Pleistocene and Holocene settlement in the South African interior is now understood in no more than its general outlines. Valid spatiotemporal entities are still difficult to discern because of differences in raw materials, the problems of distinguishing tool-kit from geographical variations, the need for refined statistical procedures (applied to unselected assemblages), and inadequate or inconsistent radiocarbon control of apparent temporal units. Within the study area, two disjunct periods of Later Stone Age settlement can be distinguished.

The earlier phase of occupation is best represented at Wonderwerk Cave, Alexandersfontein (Benfontein), and Voigtspost. At Wonderwerk, the last Pleistocene archeological level (about 12,000 years B.P.), includes a high-debitage industry in cherty dolomite, mainly of pieces smaller than 2.5 cm, with amorphous small cores, irregular scrapers, and rare triangular points. Early Holocene occupation (about 6000 years B.P.) is characterized by many large, crude core-scrapers and laterally trimmed slabs, both made in banded ironstone; other artifacts are made on cherty dolomite and include simple blades, occasional notched pieces, rare end-scrapers, as well as a mass of chunky, amorphous flakes and cores (*105*). At Benfontein a small collection of lydianite (indurated shale) artifacts dates between 14,900 and 11,000 years B.P. and includes blades, a triangular point, an adze, large scrapers, and one trimmed slab (*106*). At Voigtspost a surface collection with rough core-scrapers, side- and end-scrapers, and subcircular platform cores is made on lydianite, with a few dolerite pieces; scattered ostrich eggshell dates 6350 ± 75 years B.P. (*90*). The assemblages from Wonderwerk, Benfontein, and Voigtspost differ among themselves (*107, 108*), but appear to belong to the Albany industrial complex (*109*).

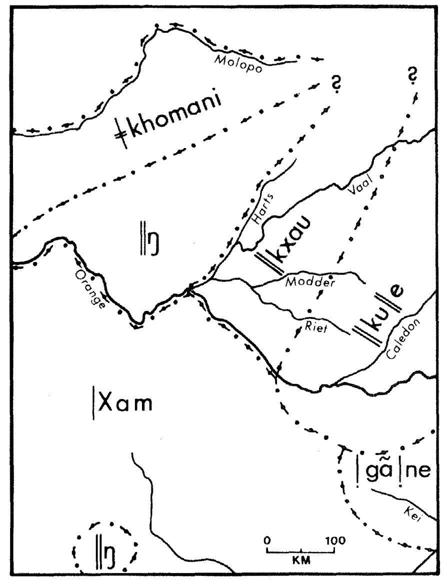

Fig. 8. Southern San linguistic groups about A.D. 1800: /Xam, south of the Orange and west of the Kei rivers; //ŋ, north of the Orange and west of the Vaal-Harts; //kxau, possibly a subgroup of //ŋ, north of the Orange and east of the Vaal-Harts; //ku//e or Seroa, Caledon Valley and upper drainage of Orange, Riet, and Modder; !gã!ne, east of the Kei; and ≠ khomani, south of the Molopo (*31, 47, 74, 75, 112, 114, 119*).

Smithfield settlement is first documented at Highlands, beginning about 4500 years ago (*40*); in the middle Orange River region, since ~ 4000 B.P. (*34*); at Alexandersfontein, since 3300 years B.P. (*106*); and at Taung, since 3700 years B.P. (*110*). Within the area of the engravings, these Smithfield collections consist mainly of unpatinated lydianite flake debitage, sometimes utilized and commonly made on older Middle Stone Age artifacts; there generally are a few characteristic end- or side-scrapers as well as bladelets and related cores; grinding equipment or bored stones are found locally; backed bladelets or geometric microliths are scarce. At Wonderwerk there are also pieces of decorated ostrich eggshell (crosshatched or multiple zigzag incisions) and a few shell beads (*111*).

An earlier review of the radiometric dates suggested an absence of archeological residues in the semiarid interior of South Africa from about 9500 to 4600 years ago (*23*). Although the record of early Holocene settlement remains enigmatically sparse in the engravings area, there may not have been real settlement lacunae of longer duration. Instead, the regional data now suggest several shorter archeological breaks, the youngest of which dates about 5500 to 4000 years B.P. Together with the other contextual evidence, this argues that the regional engravings pertain to the Smithfield occupation of the lower Vaal and middle Orange drainage after 4000 years B.P. The majority of the animal engravings, including the classical and related category, probably relate to the most extensive phase of Smithfield settlement, during the 4th and 3rd millennia B.P. The bulk of the geometrics as well as the first domesticated animals coincide with the appearance of pottery during the last 1300 years or so (*90, 108, 110*). Although convergent lines of evidence suggest that the first engravings date no earlier than 4000 years B.P., we do not yet know whether the hairline engravings—technologically but not stylistically distinct—are indeed substantially older than those in other techniques. The possibility therefore remains that the hairlines predate the Smithfield and pertain to the occupation verified during the 7th and early 6th millennia B.P. or even the terminal Pleistocene.

In subjective terms, the South African engravings show more continuity than disjunction in terms of style, technique, content, and physical condition. Such continuity would be most compatible with the single cultural system represented by the Smithfield. Turning to the ethnographic "present," the fragmentary observational and linguistic record of the South African Bushmen suggests great mobility and a highly flexible adaptational system, despite marked territoriality, linguistic diversity, and environmental contrasts (*112-114*). The broad comparability of material culture probably accounts for the difficulty of isolating regionally distinct archeological residues within the Wilton-Smithfield technocomplex of southern Africa.

The distribution of linguistic units during the late 18th and early 19th centuries, however poorly understood, illustrates the geographical range of large-scale identity-conscious groups. The linguistic entities of the study area (Fig. 8) all belong to the Southern San or "Bush C" group (*17*), but the degree of differentiation and the interrelationships are uncertain.

Territories of identity-conscious groups expand, contract, and shift with time. Certain engravings may have defined the operational area of an identity-conscious population during a specific period. For example, the sites with engraved geometrics may well delimit one such group during the last millennium or so. The restricted occurrence of classical engravings in the Kinderdam-Klipfontein area may represent another such case. The ethnographic record shows that, at the beginning of the 19th century, elaborate narrative paintings were still being made in /Xam, Seroa (or //ku//e), and !gã!ne country (Fig. 8), but a Seroa informant pointed out that the //kxau engravers were unintelligible to him (*115*). Furthermore, the limited range of painted geometrics west of the lower Vaal coincides with //ŋ territory. The Seroa that painted battle scenes with the Sotho near the Caledon River (*116*) about A.D. 1800 clearly were not identical with the population then engraving geometrics and poor quality animals at Driekops Eiland.

The South African rock art is all basically similar, including animals, geometrics, humans, as well as group scenes, many of which have narrative implications (*29, 117*). But characteristic subjects, technologies, and distributions show systematic temporal and spatial variation. Although the details of this variability are not understood, the most economic hypothesis is that they reflect processual change and group contrasts within a single cultural system.

Conclusions

1) Sequences of superpositioning, local differences in patination, as well as geoarcheological relationships verify the existence of temporal trends in technique and thematic content. Hairline engravings are oldest, followed by pecked animal representations, and then geometrics. Not all the geometrics are young nor all the pecked animals old, but a shift of emphasis is evident. The classical and related category fits midway in the animal phase, and the majority of human representations may be a little younger.

2) Intrasite and intersite distributions of humans, geometrics, and animals are distinctively patterned. Human figures are shown only at larger sites, where they are clustered, favoring a functional interpretation. Geometrics and objects are prominent only at sites with a permanent water supply, particularly on river bed rocks or near springs.

3) The faunal assemblage represented by the engravings may include extinct forms (*Megalotragus*, *Damaliscus niro*), but sound paleontological evidence is lacking. Of greater interest are engravings of domesticated cattle, sheep, and goat that probably reflect Khoikhoi contacts since 1200 years ago and Bantu (Tswana) since 700 years. Such engravings are demonstrably younger than the "classical and related" category.

4) The naturalistic representations of the animal phase suggest an expansion of bush and tree cover and a shift of semitropical forms such as giraffe, blue wildebeest, white rhinoceros, impala, waterbuck, and sable into environments with particularly cold winters. This interpretation is compatible with pollen evidence for warmer conditions from 7500 to 1800 years B.P. and for an expansion of bush into grassland settings during at least part of that time.

5) The geoarcheological context of various classes of engravings at key sites links the main geometrics phase to a period of stream downcutting and drier climate after 1300 years B.P. Animals of the classical and related category are no younger than the beginning of a minor episode of increased stream or spring activity from 2250 to 1300 years B.P.; the classical engravings most probably coincided with an earlier period of more abundant water about 3200 to 2500 years B.P.

6) The South African interior appears to have been essentially unoccupied between 5500 and 4000 years B.P. Many or most of the engravings from the animal phase appear related to especially widespread evidence of Smithfield settlement during the late 4th millennium B.P. The earlier hairlines pertain to the earliest phases of Smithfield settlement or possibly to more localized occupation before 5500 years B.P. or even during the terminal Pleistocene. Although no direct information is available on settlement repercussions of a dry interval about 2500 years ago, the onset of drier conditions after 1300 years B.P. clearly had demographic impact, and the few sites with many geometrics appear to represent base camps near water.

7) The time depth of the engravings approximately matches that of the archeologically dated, painted "gravestones" of southern Africa. Most of the engravings from the animal phase are older than almost all the parietal paintings, as dated by amino acid chromatography. Only a few geometrics and poor animal engravings in the semiarid interior were contemporary with the flourish of narrative Bantu or European-contact paintings by mountain Bushmen during the 18th and 19th centuries.

8) The rock engravers of the South African interior in contact times were //kxau Bushmen, a linguistic entity of the Southern San ("Bush C") language group. In general, the several rock art genres of southern Africa form part of the archeological record of the flexible cultural system represented by the Southern San. Systematic temporal and spatial variation of the engravings appear to reflect processual change and distinct identity-conscious groups within that system.

This contextual analysis of the South African materials illustrates a multidisciplinary methodology suitable for scientific investigation of rock art. The broad regional interpretation is intended to be empirical, objective, and economical. Despite the wealth of information, however, data are either insufficiently specific, liable to multiple interpretation, or simply unequal to the task. The major limitations to our conclusions are due less to the nature of the rock art as a medium of study than to the deficiencies of prehistoric research in general and our understanding of the African Later Stone Age in particular.

Consequently, we believe that a major contribution of this study lies in elucidating the facets and issues of a contextual approach to prehistoric art—a broadly based methodology that would eliminate the dichotomy between rock art studies and other archeological research. Environmental and artifactual data of all kinds must be analyzed systematically and evaluated in an integrated, holistic framework.

References and Notes

1. Instructive cases at different scales from southern Africa are given by Cooke (*2*), Pager (*3*), and Vinnicombe (*4*).
2. C. K. Cooke, *Rock Art of Southern Africa* (Books of Africa, Cape Town, 1969).
3. H. Pager, *Ndedema: a Documentation of the Rock Paintings of the Ndedema Gorge* (Akademische Druck- und Verlagsanstalt, Graz, 1971).
4. P. Vinnicombe, *The People of the Eland* (Natal University Press, Pietermaritzburg, 1976).
5. E. Denninger, in *Felsbilder in Südwest-Afrika*, E. Scherz, Ed. (Böhlau, Cologne, 1975), vol. 2, p. 268.
6. Calcite is characteristic on limestone or dolomite and gradually obscures paintings with a translucent glaze. Silica or hydrated silica glazes are essentially transparent and found on granite, gneiss, mica schists, diabase, andesite, and other silicate rocks. Such silica glazes represent the initial stages of varnish or patination and are mineralogically far more complex, consisting of at least 70 percent clay (silicate) minerals, cemented and discolored by ferric and manganese oxides (*7*). Only as varnish thickens does appreciable discoloration take place. Calcite glazes can also be found on silicate rocks, as for example, at the White Lady Shelter of South West Africa's Brandberg: splashing of the paintings with water, drawn from a nearby hardwater stream by aspiring photographers, has created a glaze that partly obscures the paintings.
7. R. M. Potter and G. R. Rossman, *Science* **196**, 1446 (1977).
8. P. Cervíček, *Ipek* **23**, 82 (1973); A. J. H. Goodwin, *Viking Fund Publ. Anthropol.* **28**, 300 (1960).
9. For a discussion of rock weathering, see K. W. Butzer, *Geomorphology from the Earth* (Harper & Row, New York, 1976). Goodwin (*10*), Mason (*11*), and Willcox (*12*) each confuse pat-

ination with weathering and speculate as to relative rates of rock disintegration in engraved lines and adjacent to them. In fact, the initial discoloration and the increasingly visible patina acts as a preservative, a coating that protects the rock face and eventually also the incised line. The adjacent surfaces are liable to exfoliation and, in coarse crystalline rocks such as granite or diabase (dolerite in British and South African usage), are also subject to granular disintegration. If rock deterioration occurs after engraving, it would be plainly visible as a fresh surface, a very rare feature in South Africa. Far more common is a reduction of line depth by sand blast or fluvial abrasion. Locally, large animals may contribute to abrasion by their hides or hooves. Hyrax urination in Africa also creates organic mineral glazes that locally surge down rock exposures, particularly on carbonatites, and obscure rock art. Fires adjacent to cave walls or ceilings not only cover art with fatty carbon compounds but can also promote thermoclastic disintegration. Such weathering may also be favored by grass fires where rock faces rise directly above level ground.

10. A. J. H. Goodwin, *Ann. S. Afr. Mus.* **24** (No. 8), 163 (1936).
11. R. J. Mason, *The Prehistory of the Transvaal* (Univ. of the Witwatersrand Press, Johannesberg, 1962).
12. A. R. Willcox, *The Rock Art of South Africa* (Nelson, New York, 1963).
13. Denninger (*14*); A. R. Willcox, *S. Afr. J. Sci. Spec. Publ.* **2**, 84 (1971). Binders may include bird-egg albumin, milk casein, animal glue, and animal blood or serum. Recent paint registers ten amino acids by paper chromatography; the most stable has a life of up to 1800 years, as determined from whitewashes, paintings, and illustrated manuscripts in Germany and South Africa. Denninger's (*14*) probable error for paintings 100 to 1500 years old is ± 20 percent.
14. E. Denninger, *S. Afr. J. Sci. Spec. Publ.* **2**, 80 (1971).
15. Prehistoric paint pigments, mixed with albuminous binders, resins, or animal fat or marrow, consist of (i) charcoal, soot, or ground manganiferous concretions for black colors; (ii) pulverized ferric (limonitic or hematitic) concretions (ochre, specularite) or ferruginized shales and sandstones, sesquioxide-rich clayey to sandy soils, or animal blood for yellow, orange, brown, or red shades; and (iii) marl, gypsum, kaolin, or bird guano for whites.
16. R. A. Muller, *Science* **196**, 489 (1977); R. Berger, *J. Archaeol. Sci.* , in press.

J. D. Lewis-Williams [*S. Afr. Archaeol. Bull.* **29**, 93 (1974)] has systematically demonstrated that superimpositions may be intentional, rather than random, with the initial painting affecting the range of subjects or colors selected for later ones. See also (*18*).

18. H. Pager, *Stone Age Myth and Magic* (Akademische Druck- und Verlagsanstalt, Graz, 1975).
19. In the northern Cape Province, South Africa, such differences can be detected between disjunct rock art clusters as well as within them (*20*).
20. G. J. Fock, *Felsbilder in Südafrika I: die Gravierungen auf Klipfontein, Kapprovinz* (Böhlau, Cologne, 1978).
21. Potter and Rossman (*7*) favor moisture retention of windborne clays, particularly on rough, porous rock, with penecontemporaneous deposition of ferromanganese oxides within the clay matrix, so leading to cementation. For earlier discussions of patination, see C. G. Engel and R. P. Sharp [*Geol. Soc. Am. Bull.* **69**, 487 (1958)]; E. Schaffer, B. Meyer, and E. Kalk [*Z. Geomorphol.* **7**, 112 (1963)]; and R. L. Hooke, H. Yang, and P. W. Weiblen [*J. Geol.* **77**, 275 (1969)]. For regional contrasts in patination, see J. Tricart and A. Cailleux [*Le modelé des régions sèches* (Société d'Etudes pour le Developpement Economique et Social, Paris, 1969)] and K. W. Butzer and C. L. Hansen [*Desert and River in Nubia* (Univ. of Wisconsin Press, Madison, 1968)]. Important contrasts in patination can also be demonstrated at a microenvironmental scale: patination is faster above ground than below and notably darker under vegetation cover or in moist shade (*20*).
22. Denninger (*5, 14*) has not provided data on possible systematic differences between his German and South African control samples.
23. K. W. Butzer, *Am. Antiq.* **40**, 106 (1975); *Rev. Anthropol.* **4**, 125 (1977); *J. Archaeol. Sci.* **5**, 191 (1978).
24. C. Van Riet Lowe, *The Distribution of Prehistoric Rock Engravings and Paintings in South Africa* (Union of South Africa Archaeological Survey, Arch. Ser. 7, Pretoria, 1956).
25. J. D. Clark, Ed., *Atlas of African Prehistory* (Univ. of Chicago Press, Chicago, 1967), plates 25 and 26; with corrections and amplifications by G. J. Fock [(*20*); in preparation], on the basis of investigation of more than 300 sites with rock engravings. For South West Africa, see E. R. Scherz [*Felsbilder in Südwest-Afrika, I* (Böhlau, Cologne, (1970), vol. 1] and W. E. Wendt [*J. S. W. Afr. Sci. Soc. (Windhoek)* **32**, 7 (1978)].
26. C. Van Riet Lowe, *S. Afr. J. Sci.* **41**, 329 (1945); A. R. Willcox, *ibid.* **59**, 108 (1963).

J. D. Clark, *S. Afr. Archaeol. Bull.* **13**, 21 (1958).

A. R. Willcox, *ibid.* **20**, 139 (1965).

29. G. J. Fock, *Ann. Cape Prov. Mus. Nat. Hist.* **6** (Part 11), 103 (1969).
30. G. J. Fock, *Ipek* **23**, 90 (1973).
31. At least four major Bushman or San language groups are currently recognized [E. O. J. Westphal, *Africa* **33**, 237 (1963); *Curr. Trends Linguist.* **7**, 369 (1971)], and the languages, dialects, and tribal units within the now almost extinct "Bush C" language group of South Africa appear to have been complex.
32. Laboratory numbers are given only for unpublished radiocarbon dates.
33. S. F. Miller, in *Actes, Congrès Panafrican de Préhistoire (Dakar 1967)*, H. S. Hugot, Ed. (Imprimeries Réunies, Chambery, Paris, 1973), p. 565; for a list of Nachikufan dates, see (*34*).
34. C. G. Sampson, *The Stone Age Archaeology of Southern Africa* (Academic Press, New York, 1974).
35. In Robberg Cave D, dating 1925 ± 33 years B.P., and at Matjes River Shelter, dating 5600 ± 200 years B.P. [J. Rudner, *S. Afr. J. Sci. Spec. Publ.* **2**, 54 (1971)]; in Robberg Cave F (East Guanogat) (Rudner, *ibid.*), between 4180 ± 110 and 3610 ± 110 years B.P. [K. W. Butzer and D. M. Helgren, *Quat. Res.* **2**, 143 (1972)].
36. In Cave 5 one stone is dated 2285 ± 105 years B.P., and a second was found between this level and one dated 1410 ± 160 years B.P. [R. Singer and J. Wymer, *Nature (London)* **214**, 508 (1969)].
37. Dated at 6400 ± 75 years and at 1955 ± 65 years B [H. J. Deacon, J. Deacon, M. Brooker, *S. Afr. Archaeol. Bull.* **31**, 141 (1976)].

J. Deacon, *ibid.* **27**, 10 (1972).

39. C. G. Sampson, *Natl. Mus. Bloemfontein Res. Mem.* **6** (1972).
40. H. J. Deacon, *S. Afr. Archaeol. Soc. Monogr.* **1** (1976).
41. The Drakensberg dates are indeed compatible with other contextual data (including the retreat of Bushmen to this mountain refuge in order to evade the more numerous Bantu immigrants); radiocarbon dates of 870 ± 150 and 1020 ± 150 years B.P. are available for local, Later Stone Age artifactual levels (*3*).
42. Exposed paintings fade in response to insolation and deteriorate mechanically as a result of weather elements. Organic pigments can be expected to deteriorate in moist sealed contexts, but many mineral pigments such as ochre would be quite durable.
43. W. E. Wendt, *Acta Praehist. Archaeol.* **5**, 1 (1974); *Bild Wiss.* **10**, 44 (1975); *S. Afr. Archaeol. Bull.* **31**, 5 (1976).
44. A baboon fibula with 29 parallel, incised notches was recovered from the basal, early Later Stone Age level of Border Cave, Kwazulu, with four radiocarbon dates of between 35,700 and 37,500 years B.P. [P. B. Beaumont, *S. Afr. J. Sci.* **69**, 41 (1973); K. W. Butzer, P. B. Beaumont, J. C. Vogel, *J. Archaeol. Sci.*, **5**, 317 (1978)].
45. Earlier assertions as to the age of the engravings must be considered obsolete in view of the radiocarbon evidence presented here. Such opinions fall into two groups. Goodwin (*46*) associated his "oldest style" of engravings at Vosburg (Fig. 2), with the oldest surface artifacts nearby, the Middle Stone Age "Alexandersfontein Variant." Van Riet Lowe (*24*) maintained a similar position on equally unacceptable grounds and considered the engravings to be older than paintings, but with considerable overlap. The opposite was argued by Wilman (*47*), who felt that engravings would weather too rapidly to permit an age greater than perhaps 6 centuries. Willcox (*12*) reiterated this conclusion but later [*S. Afr. J. Sci.* **62**, 8 (19 *S. Afr. Archaeol. Bull.* **23**, 20 (1968)] extended this time range to a maximum of 2000 years.
46. A. J. H. Goodwin, *Ann. S. Afr. Mus.* **24**, 163 (1936).
47. M. Wilman, *The Rock Engravings of Griqualand West and Bechuanaland* (Deighton & Bell, Cambridge, 1933).
48. For an earlier discussion and illustrations of the relationships between engravings and rock type, see (*47*).
49. *Geological Map of the Republic of South Africa*, 1:1 million (Government Printing Office, Pretoria, 1970).
50. C. Van Riet Lowe, *Prehistoric Art in South Africa* [Union of South Africa, Archaeological Survey, Arch. Series R, Pretoria (1941)].
51. ———, *Trans. R. Soc. S. Afr.* **24**, 253 (1937).
52. G. J. Fock, *Mitt. Anthropol. Ges. Wien* **104**, 76 (1974).
53. "Schematics" is currently favored by many rock art specialists, but "geometrics" is preferred here as an objective term that describes the form but does not presume the intent of such representations. Despite the objective reality of most Bushman rock art, most representations appear to have had a second level of symbolic meaning.
54. P. Vinnicombe, *Africa* **42**, 192 (1972).
55. This observation would be strengthened if quantitative data were available for Driekops Eiland, where about 90 percent of several thousand engravings are geometrical. This major site was recorded in 1938 by L. M. Slack [*Rock Engravings from Driekops Eiland* (Centaur, London, 1962)], but only published as a selection of reproductions, without text or analytical data. Our sample includes Vosburg but counts were made from Goodwin's (*46*) illustrations.
56. The conspicuous circle and ray design is also found among engravings of the Transvaal as well as in Zambia and Angola [(*51*); R. F. H. Summers, Ed., *Prehistoric Art of the Federation of Rhodesia and Nyasaland* (National Publications Trust, Salisbury, 1959), plate 1 J. Rudner, *S. Afr. Archaeol. Bull.* **31**, 99 (1976)].
57. D. N. Lee and H. C. Woodhouse, *Art on the Rocks of Southern Africa* (Purnell, Johannesburg, 1970).
58. J. Meester and H. W. Setzer, Eds., *The Mammals of Africa: an Identification Manual* (Smithsonian Institution Press, Washington, D.C., 1971); E. A. Zaloumis and R. Cross, *A Field Guide to the Antelopes of Southern Africa* (Wildlife Society, Durban, 1975); S. F. Du Plessis, thesis, University of Pretoria (1969).
59. J. P. H. Acocks, *Veld Types of South Africa* (Botanical Survey of South Africa, Memoir 40, Pretoria, 1975).
60. The faunal assemblages of the engravings are also consonant with the limited archeological faunas of Holocene age in the South African interior (*61*).
61. R. G. Klein, *S. Afr. Archaeol. Bull.* in press.

E. Holm, *ibid.* **11**, 12 (1956).

63. G. J. Fock, *Natl. Mus. Bloemfontein Res. Mem.* **2** (No. 10), 349 (1972). There also is a problematic large-horned animal at Nelspoort.
64. *Connochaetes (Gordon) laticornutus*, a Middle Pleistocene form, identified as such by the late A. C. Hoffman (personal communication, 1969).
65. Tentatively suggested by R. G. Klein (personal communication).
66. R. G. Klein, *Science* **197**, 115 (1977).
67. C. K. Brain and E. S. Vrba, letter dated 15 March 1977, Transvaal Museum Ref. 3/7/1.
68. Identified by L. H. Wells [in *Background to Evolution in Africa*, W. W. Bishop and J. D. Clark, Eds. (Univ. of Chicago Press, Chicago, 1967), p. 104]. The specimen, originally identified as cf. *Capra wallie*, was recovered from sieve debris left behind by "guano" extractors digging in the cave's cultural debris [B. D. Malan and L. H. Wells, *S. Afr. J. Sci.* **40**, 258 (1943)]. The phenomenal partial preservation of horn sheaths (even in an absolutely dry cave) suggests linking these horns, described as somewhat leached, with the best preserved and richest faunal level, the Smithfield.
69. Domesticated sheep are recorded at Klipfontein (as many as four individuals, in part fully pecked but poorly proportioned) [figure 5 in (*20*)]; Barkly West (two individuals) (*48*); Content (up to six individuals, with limited patina and in an unusual outline style that emphasizes characteristic markings) [apparently identical to a site incorrectly referred to as 19 km southwest of Vryburg by Holm (*62*) Willcox (*70*) (Fock, unpublished); and Rhebokfontein in Transvaal (*70*). Although questioned by Wilman (*47*, plate 42.2), there is another, convincing fat-tailed sheep at Kinderdam. Goat

representations are limited to Klipfontein (*20*), with three individuals shown in crude outline style but with characteristic horns and muff.

A. R. Willcox, *S. Afr. Archaeol. Bull.* **20**, 214 (1965).

71. Contrary to A. R. Willcox [*S. Afr. J. Sci. Spec. Publ.* **2**, 44 (1971)], convincing domesticated cattle are shown by a number of engravings, mainly in rough outline style, with little patination but locally affected by sand blast [G. J. Fock, *Boll. Cent. Camuno Studi Preistorici* **4**, 131 (19(*S. Afr. Archaeol. Bull.* **25**, 71 (1970); *S. Afr. J. Sci.* **68**, 243 (1972); (*20*)]. The sites are Eindgoed (three individuals, younger than wild animals but older than a donkey representation) (Fig. 5); Witvlei (one individual, freshly reworked from an older antelope engraving by enlarging the body and head, and adding horns); Slypsteen (up to three individuals); Brandfontein (two individuals, one fully pecked and outlined); Disselfontein (at least four individuals, one fully and one partly pecked in silhouette and profile); Pienaarspan (one individual with udders, lightly scratched); Klipfontein (five individuals); and Home Rule (two individuals, including one fully pecked and outlined). Another possible example can be cited from Rietpan, near Riverton.
72. Other coast-near archeological contexts with sheep are based on Klein [(*61*); in preparation]. Sheep are verified in Mirabib rock shelter in the Namib about 1550 years B.P. [B. H. Sandelowsky, *Madoqua* **10**, 221 (1977)].
73. Kora traditions and travelers' reports indicate that the Kora left the southwestern Cape area after unfavorable contacts with the Dutch, and that most of the ancestral tribes had moved into the middle Orange Valley from both the west and south, well before 1779; they were engaged in warfare with the Tswana at Taung on the Harts River before 1797 [*74, 75*; L. F. Maingard, *Afr. Stud.* **23**, 57 (1964)]. Nonetheless, some of the Kora, the Einikwa or River People, speaking a distinct dialect, were indigenous to the lower Orange Valley long before immigration of the Cape Korakwa; a calibrated date of 1590 (or 1475) ± 35 A.D. (*76*) on a Kora settlement at Grootdrink probably relates to the Einikwa. Although Khoikhoi pottery is abundant adjacent to the lower Orange River around Boegoeberg and Grootdrink (*77*), there is no archeological or sound traditional evidence that the Kora or any other Khoikhoi herders were resident farther east along the middle Orange and lower Vaal valleys before A.D. 1700. contrary to the dispersal view of Elphick (Beaumont and Boshier (*79*) suggest that hematite miners near Postmasburg 1120 years B.P. were Khoikhoi hunter-gatherers, on the basis of the robustness of the human fossils and the presence of Khoikhoi pottery similar to that in Nama country. The overall distribution of Khoikhoi herders during the early Contact Period (Fig. 5) follows Wilson and Thompson (*80*), Elphick (*78*), and H. Vedder [*South West Africa in Early Times* (Oxford, London, 1938)]; and the occurrence of Strandlooper pottery (*77*).
74. G. W. Stow, *The Native Races of South Africa* (Macmillan, New York, 1905).
75. J. A. Engelbrecht, *The Korana* (Maskew Miller, Cape Town, 1936).
76. T. Maggs, *J. Afr. Hist.* **18**, 161 (1977).
77. J. Rudner, *Ann. S. Afr. Mus.* **49** (No. 2), 441 (1968).
78. R. Elphick, *Kraal and Castle* (Yale Univ. Press, New Haven, 1977).

P. B. Beaumont and A. K. Boshier, *S. Afr. Archaeol. Bull.* **29**, 41 (1974).

80. M. Wilson and L. Thompson, *The Oxford History of Southern Africa I* (Clarendon, Oxford, 1969).
81. T. M. Maggs, *S. Afr. Archaeol. Bull.* **26**, 37 (1971).
82. A. J. B. Humphreys, *Ann. Cap Prov. Mus. Nat. Hist.* **9**, 123 (1973).
83. The Kora had only few sheep and goats (*74*) and their settlements were made of perishable materials (*75*).
84. The southern and western limits of 18th-century Tswana-Sotho and Xhosa-Nguni settlement (Fig. 5) are based on P. L. Breutz [*Afr. Stud.* **15**, 157 (19 A. J. B. Humphreys [*S. Afr. Archaeol. Bull.* **31**, 54 (1976)]; T. M. O'C. Maggs [*World Archaeol.* **7**, 318 (1976); *Iron Age Communities of the Southern Highveld* (Natal Museum, Pietermaritzburg, 1976)]; Wilson and Thompson (*80*); and Stow (*74*). In detail this boundary was a transitional mosaic with isolated Bantu groups well to the west and Bushman or Khoikhoi enclaves to the east. Iron Age people began to infiltrate the south-central Transvaal as early as the 5th century A.D. [R. J. Mason, *J.S. Afr. Inst. Min. Metall.* **74**, 211 (1974)], although colonization of the Transvaal continued for as long as a millennium [R. M. Derricourt, *S. Afr. J. Sci.* **69**, 280 (19 G. P. Rightmire and N. J. Van der Merwe, *S. Afr. Archaeol. Bull.* **31**, 147 (1976); (*76*). Unfortunately, no Iron Age sites of the southwestern Transvaal or northern Cape Province have been excavated so far.
85. On the Younger Gravels, see D. M. Helgren [*S. Afr. J. Sci.* **73**, 303 (1977); *J. Archaeol. Sci.* **5**, 39 (1978)]. Morphostratigraphic and facies correlations can be made with Members I and II of the Riverton Formation [K. W. Butzer, D. M. Helgren, G. J. Fock, R. Stuckenrath, *J. Geol.* **81**, 341 (1973)], although Member I now requires further subdivision.
86. Unit 4 at Driekops Eiland represents Member III of the Riverton Formation (*85*), and SI-3381 provides the first acceptable minimum date for that critical Middle Stone Age alluvial complex; earlier dates of about 17,000 years on *Achatina* shell (SI-III2, III3) probably refer to intrusive snails, perhaps contemporary with soil formation (calcification, silicification).
87. Unit 5A represents Member IV, Riverton Formation, also dated 14,670 ± 270 (SI-3563) on carbonaceous soil at Alexandersfontein.
88. Best dated at Alexandersfontein: (i) site MS-D100: 4475 ± 60 years B.P. (SI-2022) on intact ostrich eggshell, 3040 ± 70 (SI-2587) on a mix of eggshell fragments, and 3805 ± 75 (SI-2586) on soil carbonates from the subsequent ACa-horizon; (ii) Uitzigt: 3290 ± 75 years B.P. (SI-2580) on ostrich eggshell, 4075 ± 300 (SI-2232) on organic spring mucks, and (less satisfactorily) 2520 ± 65 (SI-2582) on correlated, seepage slope carbonates; (iii) site BF-2: 3450 ± 60 years B.P. (SI-2049) on organic spring mucks.
89. At Voigtspost near Petrusburg these sands have an ostrich eggshell date of 1220 ± 50 years B.P. (*90*), whereas at Alexandersfontein site MS-D100 they are dated 805 ± 100 (SI-2024) on a wildebeest horn core.
90. A. Horowitz, C. G. Sampson, L. Scott, J. C. Vogel, *S. Afr. Archaeol. Bull.*, in press.
91. Unit 5C represents Member V, Riverton Formation, with a date of 1960 ± 425 (SI-1954) on hippopotamus bone, Harts River.
92. At Riverview, 5 km upstream, where a collection of trimming debris (more than half smaller than 2 cm in length) included four utilized bladelets, nine utilized flakes, two incomplete end- or side-scrapers, a convex side- and end-scraper with steep end retouch and another with steep lateral retouch, and a piece of bored ostrich eggshell. A Smithfield burial downstream at Weltevreden is dated 3360 ± 60 years B [A. J. B. Humphreys, *S. Afr. Archaeol. Bull.* **25**, 104 (1970); (*82*)].
93. This surface site at the car park is now much picked over. It was referred t R. J. Mason [*S. Afr. Archaeol. Bull.* **9**, 134 (1954)], who excavated a burial in unknown context nearby. Our date is on weathered surface eggshell. The persistence of engraving activity to such a late date is verified by a shale slab with incised lines found within a type R settlement upstre [A. J. B. Humphreys and C. Humphreys, *S. Afr. Archaeol. Bull.* **28**, 47 (1973)].
94. The additional presence of Kora at the time of Stow's visit (1873) is suggested by the label "near Bloem's Homestead," on Stow's copies of some of the engravings [(*29*), plate 4]; Jan Bloem the Younger was captain of the Springbok Kora (*74*).
95. G. W. Stow, *The Athenaeum (London)*, 4 August 1877, p. 151.
96. These engravings are comparable to an inscription "J.H.S. DuPlooy C.B. 1889 De 8" found at +5 m on an exposure 1 km downstream.
97. Since bedrock relief on the Riet channel floor is in excess of 2 m today and functional deposits are developed to as much as 3.5 m above mean low water, some higher bedrock surfaces would have been exposed on the channel floor of the +5-m stage. The andesite bedrock continues to undergo geomorphic modification: sediment plucking along a plane of weakness has undetermined some engravings, and one "single ladder" was found split 12 cm apart by a zigzag fissure. A similar situation was noted by Stow (*95*) [also figure 2 in D. M. L. Fock, *S. Afr. J. Sci.* **66**, 247 (1970)] on the Vaal bed at Riverton, a site now submerged behind a dam. Such rock disintegration can occur rapidly, as evidenced by natural fracturing of an engraving on a surface boulder between 1910 and 1930 (*47*).
98. Figure 1 in (*29*).
99. Both waterholes were originally filled with large rocks, now removed to provide open wells; the lower eye may have been enlarged by dynamite blasts, and adjacent engravings have been either taken away or destroyed.
100. Spring discharge remained unaffected by the unusually heavy rains of 1974 through 1976 and is presumably influenced by long-term climatic changes only.
101. The DeBeers Farm management removed most of the rocks from the pond bed to build the retaining wall, so that watering game and cattle now sink 10 to 30 cm into soft, brownish (10 YR) clayey silt-sand.
102. A pollen spectrum from Voigtspost, near Petrusburg, also suggests an expansion of bush at about this time (*90*).
103. K. W. Butzer, R. Stuckenrath, A. J. Bruzewicz, D. M. Helgren, *Quat. Res.* **10**, 310 (1978); K. W. Butzer, *Geogr. Mag.* **51**, 201 (1978).
104. Several cores through the peat accumulation of this thermal spring show cooler, high-altitude or coastal elements (*Stoebe, Cliffortia, Passerina, Ericaceae, Myrica*), well represented in the Pleistocene part of several cores, disappearing between 11,000 and 7500 years B.P. The semitropical Combretaceae became significant at the same time and attained their maximum 5000 years ago; Proteaceae of the slightly cooler, moister "sour" Bushveld (*59*) suddenly assume importance about 1800 years B.P. (L. Scott and J. C. Vogel. *Palaeoecol. Afr.*, in press).
105. Based on study by K. W. Butzer of B. D. Malan's excavated materials from the 1940's. J. C. Vogel (unpublished data) obtained ostrich eggshell dates of 12,380 ± 95 years B.P. (Pta-2141) on the terminal Pleistocene occupation, and 5930 ± 50 B.P. (Pta-2140) on the early Holocene level, supported by our date of 6000 ± 55 B.P. (SI-2030) on a branch found under a large roof block. Repeated occupation is indicated between 12,000 and 6,000 years ago.
106. Site BF-1 (K. W. Butzer, T. P. Volman, D. Nobares, L. Scott, R. Stuckenrath, in preparation). At adjacent site BF-2, Smithfield occupation postdates 3450 years B.P. (*88*).
107. They also lack most of the refined pieces from Sampson's Later Stone Age I lydianite assemblage at Zeekoegat 13, near the Orange River [C. G. Sampson, *Natl. Mus. Bloemfontein Res. Mem.* **2** (No. 6), 211 (1967)], unfortunately undated. They differ from the two aceramic "Wilton" levels at Rose Cottage Cave, where the second level, with backed bladelets and convex scrapers suggestive of Smithfield, has dates of 8640 ± 105 and 6850 ± 45 years B.P. [(*108*); J. C. Vogel, unpublished data].
108. P. B. Beaumont and J. C. Vogel, *Afr. Stud.* **31**, 65 (1972).
109. Local industrial designations include Early Smithfield and Lockshoek.
110. A. J. B. Humphreys, *Ann. Cape Prov. Mus. Nat. Hist.* **11**, 217 (1978).
111. This level is dated 3060 ± 40 B.P. (Pta-2139) (J. C. Vogel, unpublished data).
112. W. H. I. Bleek and L. C. Lloyd, *Specimens of Bushman Folklore* (Struik, Cape Town, 1968) (originally published 1911).
113. D. F. Bleek, Ed., *The Mantis and his Friends* (Maskew Miller, Cape Town, 1923); *Bantu Stud.* **6**, 233 (1932); *ibid.*, p. 321; *ibid.* **7**, 297 (1933); *ibid.*, p. 375; G. W. Stow and D. F. Bleek, *Rock Paintings in South Africa* (Methuen, London, 19 J. Parkington, *S. Afr. J. Sci.* **32**, 150 (19 J. D. Lewis-Williams, *S. Afr. Archaeol. Bull.* **32**, 165 (1977). Although the data base is amplified by travelers' accounts, it is less than satisfactory when compared with the level of resolution attained in recent Botswana Bushman studies [G. B. Silberbauer, in *Hunters and Gatherers Today*, M. G. Bicchieri, Ed. (Holt, Rinehart & Winston, New York, 1972), p. 270; R. B. Lee and I. DeVore, Eds., *Kalahari Hunter-Gatherers: Studies of the Kung San and their Neighbors* (Harvard Univ. Press, Cambridge, Mass., 1976)]. For an older general overview, see I. Schapera [*The Khoisan Peoples of South Africa* (Routledge, London, 1930)].
114. A. M. Duggan-Cronin and D. F. Bleek, *The Bushman Tribes of Southern Africa* (McGregor Museum, Kimberley, 1942).
115. Stow's (*74*) unedited, posthumous work variously refers to C. S. Orpen's information from Kwaha (Toby) of Bethulie, born on the Caledon.
116. C. G. Sampson, *Natl. Mus. Bloemfontein Res. Mem.* **5**, 139 (1970); M. Brooker, "Rescue investigations at the Welbedacht Dam site," unpublished report.

117. G. J. Fock, *South West Africa Scientific Society (Windhoek), Spec. Publ.* **4**, 1 (1969).
118. B. R. Schulze, *S. Afr. Geogr. J.* **40**, 31 (1958); D. B. Carter, *Drexel Publ. Climatol. (Centerton, N.J.)* 7, 453 (1954).
119. D. F. Bleek, *Comparative Vocabularies of Bushman Languages* (Cambridge Univ. Press, Cambridge, 1929); in *Festschrift Meinhof* (Augustin, Gluckstadt, 1927), p. 55; J. A. Engelbrecht, introduction to D. F. Bleek, *A Bushman Dictionary* (American Oriental Society, New Haven, Conn. 1956); T. Gutsche, *The Microcosm* (Timmins, Cape Town, 1968); C. Meinhof, *Z. Eingeborenen-Sprachen* **19**, 161 (1929); C. F. Wuras, *ibid.* **18**, 81 (1920); T. Arbousset and F. Daumas, *Narrative of an Exploratory Tour of the Northeast of the Colony of the Cape of Good Hope* (Struik, Cape Town, 1968) (originally published, 1846); C. M. Doke, *An Outline of Khomani Bushman Phonetics* (Univ. of the Witwatersrand Press, Johannesburg, 1936); P. L. Breutz, *Afrika and Übersee* **42**, 49 (1958).
120. Supported by grant SOC-74-12223 from the National Science Foundation and the Social Sciences Division, University of Chicago (K.W.B.); the Deutsche Forschungsgemeinschaft (G.J.F.); the Council for Scientific and Industrial Research (L.S.); and the Smithsonian Institution (R.S.). J. C. Vogel kindly dated several samples critical to the project. R. G. Klein and D. M. L. Fock provided discussion and information. Maps and diagrams were drawn by C. Mueller-Wille. Preparation of this article was made possible by a John Simon Guggenheim Fellowship to K.W.B.

Economic Feasibility of Solar Water and Space Heating

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Direct use of the sun's energy is of interest as a means of alleviating U.S. energy problems. The expected response of consumers to the financial incentives contained in the National Energy Conservation Policy Act (NECPA) of 1978 is of particular concern to energy policy-makers. These incentives are primarily directed toward solar applications for supplying domestic hot water and for space heating, which together represent 20 percent of annual U.S. energy consumption.

Summary. The economic feasibility in 1977 and 1978 of solar water and combined water and space heating is analyzed for single-family detached residences and multifamily apartment buildings in four representative U.S. cities: Boston, Massachusetts; Washington, D.C.; Grand Junction, Colorado; and Los Angeles, California. Three economic decision criteria are utilized: payback period, years to recovery of down payment, and years to net positive cash flow. The cost competitiveness of the solar systems compared to heating systems based on electricity, fuel oil, and natural gas is then discussed for each city, and the impact of the federal tax credit for solar energy systems is assessed. It is found that even without federal incentives some solar water and space heating systems are competitive. Enactment of the solar tax credit, however, greatly enhances their competitiveness. The implications of these findings for government tax and energy pricing policies are discussed.

The ability of solar energy systems to contribute to this large market depends on the current economic feasibility of solar water and space heating systems and the effectiveness of the financial incentives in enhancing their attractiveness. In this article we discuss the economic feasibility for 1977 and 1978 of solar water and combined water and space heating for single-family and multifamily dwellings for four representative U.S. cities. Three economic decision criteria are utilized to determine economic feasibility: payback period, years to recovery of down payment, and years to net positive cash flow. Solar system performance is compared in each city with the performance of heating systems based on electricity, fuel oil, and natural gas. The impact on solar economic feasibility of the federal tax credit in the NECPA is also assessed.

Solar System Description

Solar water heating refers to the use of solar radiation to heat water for domestic use—for showers, washing dishes, and so on. Solar space heating refers to the use of solar radiation to heat the building space. For technological as well as economic reasons, solar space heating systems are often designed to provide domestic hot water; thus the solar space heating systems analyzed here are in reality combined solar water and space heating systems. Typical systems of both types are shown in Figs. 1 and 2.

The solar domestic hot water system (Fig. 1) consists essentially of solar energy collectors, a water storage tank, a heat exchanger, a drain down tank, a circulating pump, a tempering valve, and a differential thermostat. In this example the backup system is a conventional electric resistance domestic water heater.

Whenever the temperature of the solar collectors is higher than the storage tank temperature, the differential thermostat energizes the circulating pump. Water is circulated between the solar collectors and the storage tank, thereby heating the storage water. Cold city water is introduced into the bottom of the storage tank, where it is heated by solar-heated water. Heated water is supplied to faucets after passing through the conventional water heater and a tempering valve. The tempering valve mixes solar-heated water with cold city water, if necessary, to provide the desired water temperature. However, if solar-heated water is not available, the conventional water heater is energized. Whenever solar energy is not available and the solar collector temperature is lower than the storage tank temperature, the differential thermostat de-energizes the circulating pump and causes the water contained in the collectors to drain into the drain down tank, thus preventing energy losses from the collectors and freezing of components.

The combined solar water and space heating system (Fig. 2) consists essentially of solar energy collectors, a water storage tank, a heat exchanger, two circulating pumps, a water heating coil, and a differential thermostat. The backup systems are an electric resistance do-

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