

PRETORIA RADIOCARBON DATES II

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This list contains 227 radiocarbon dates pertaining to the western part of southern Africa, between Luanda (9°S) in the north and the Orange R (29°S) in the south.

Unless otherwise stated, all samples are pretreated with hot diluted hydrochloric acid. Most samples were analyzed in two counters described previously (R, 1971, v 13, p 378), but a few dates are included from mini-counter which requires only 60mg carbon (Vogel & Behrens, 1976). Ages are calculated with the conventional half-life of 5568 yr. Corrections for variation in isotope fractionation, based on ¹³C analysis of measured CO₂, are applied to all dates. This is also done for dates on marine shell, but since no correction is made for the apparent age of surface ocean water, these appear about 400 yr too old as listed. Some comparisons between charcoal and shell indicate that apparent age of shell from the west coast of southern Africa is about 440 yr:

	Charcoal	Shell	Difference
Arrisdrift	1200	1590	390 ± 70
Steenbras Bay	2070	2540	470 ± 70
		2440	370 ± 70
Grillenbergl	980	1500	520 ± 70
			<hr/> 440 yr

The most probable historic date for samples with radiocarbon ages of less than 400 yr is deduced from the calibration curve for the Southern Hemisphere (R, 1970, v 12, p 466) and given in comments.

An interesting pattern is emerging in the geographic distribution of the archaeological dates for the region. In figure 1 a histogram of the archaeological dates in this list plus those in Deacon (1966), Vogel (1970) and Vogel & Marais (1971) is presented. As has been pointed out by Wendt (1975) there are no dates between 5100 BP and 2300 BP for the region between the Orange R and Windhoek, while there are several N of Windhoek. This gap must probably be interpreted as a period of sparse or no occupation of the area. It may be noted that, during the preceding period, from 9000 to 5000 BP, no sites are known on the interior plateau of South Africa, while at the same time the coastal region and escarpment were well occupied (Deacon, 1974). Inquiry into the reasons for such patterning will increase our understanding of the human ecology on the sub-continent. For additional dates for sites excavated by W E Wendt, see Freundlich, Schwabedisseu, and Wendt (1980).

The most important result with regard to the geologic section is the accumulation of dates between 36,000 and 28,000 BP and at ca 21,000 yr. The samples represent slightly moister conditions in the Namib desert during these two periods.

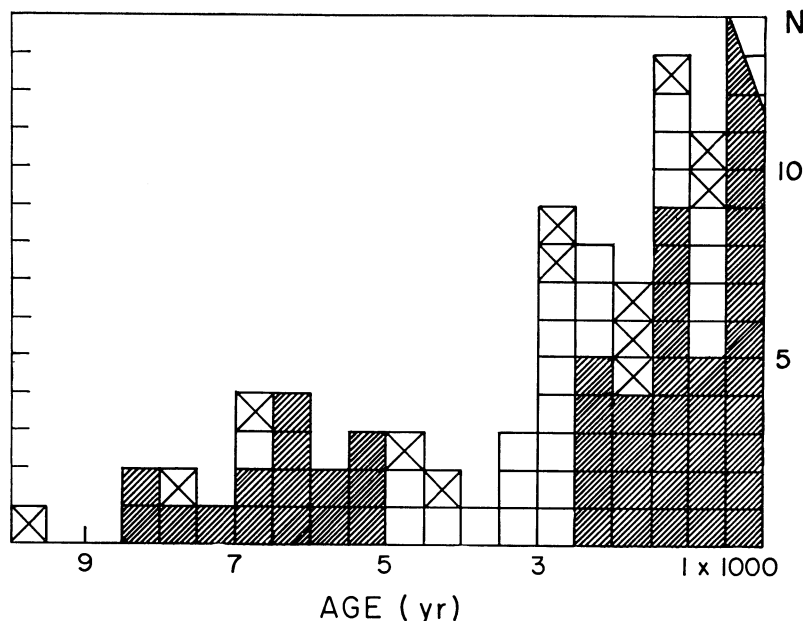


Fig 1. Histogram of the archaeological dates of the region. The hatching indicates dates for sites S of Windhoek showing a marked gap in the period 5100 to 2300 BP. The open squares are for the region between Windhoek and the Kunene R while the crossed squares are the samples from Angola. In these areas there is a more uniform coverage.

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SAMPLE DESCRIPTIONS

I. ARCHAEOLOGIC SAMPLES

Arrisdrift series

At Arrisdrift on right bank of Orange R ($28^{\circ} 28' \text{ S}$, $16^{\circ} 41' \text{ E}$), 30km from Oranjemund, dist Lüderitz, camp site in sand-filled gully between low dunes revealed sea shells, coarse stone flakes, and pottery with unusual decoration. Samples coll 1976; subm 1977 by W E Wendt, Box 3752, Windhoek.

Pta-1933. Arrisdrift 1

1200 ± 50
 $\delta^{13}\text{C} = -27.1\%$

Charcoal from hearth at 5cm depth in Strip B.

Pta-1945. Arrisdrift pot

1250 ± 130
 $\delta^{13}\text{C} = -22.4\%$

Carbonaceous material scraped off potsherd from Strip A at 5cm depth. *Comment*: 190mg from surface produced, after pretreatment with acid, 114ml CO_2 which was measured in small counter (Vogel & Behrens, 1976).

Pta-2089. Arrisdrift 5A **1300 ± 50**
 $\delta^{13}C = -6.0\text{‰}$

Uncharred ostrich eggshell fragments from Strip A at 5cm depth.

Pta-2136. Arrisdrift 5C **1280 ± 40**
 $\delta^{13}C = -6.0\text{‰}$

Uncharred ostrich eggshell fragments from Strip C at 7 to 8cm depth.

Pta-2565. Arrisdrift 4A **1590 ± 50**
 $\delta^{13}C = -0.6\text{‰}$

Patella shell from hearth at 5cm depth in Strip A. *Comment:* outer 10% of carbonate leached with acid and rest analyzed. If apparent age of 400 yr for surface ocean water is subtracted, result agrees with other dates; see Steenbras Bay series, below.

General Comment: different materials give identical results within margin of error indicating occupation at ca 1250 BP.

Fish River Mouth series

On bank of Fish R (28° 04' S, 17° 10' E) near junction with Orange R, dist Lüderitz, open site with evidence of fishing, glass beads, etc. Samples coll 1975; subm 1976 by P T Robertshaw, Albany Mus, Grahams-town, Cape Prov.

Pta-1895. Fish River midden **90 ± 40**
 $\delta^{13}C = -25.3\text{‰}$

Charcoal from 3 to 10cm depth in shallow midden.

Pta-1902. Fish River burial **190 ± 40**
 $\delta^{13}C = -12.9\text{‰}$

Human ribs from burial under stone mound at 1m depth at same site. *Comment:* purified collagen extracted from bone used for analysis.

General Comment: according to calibration curve results suggest date between AD 1750 and 1850 although AD 1690 also possible.

Apollo 11 series

Large cave, called Apollo 11 (27° 45' S, 17° 06' E), in limestone wall of Nuob R valley, W of Hunsberge, ca 35km N of Orange R, dist Lüderitz. Excavations in 1969, 1972, and 1976 revealed succession of deposits containing Middle and Later Stone age assemblages and is especially notable for stratified stone slabs with paintings (Wendt, 1974; 1976). Unless otherwise stated samples coll 1972; subm 1973 by W E Wendt.

Pta-505. Apollo 11. V2 **>50,500**
 $\delta^{13}C = -5.9\text{‰}$

Ostrich eggshell from Sq A11 at 80 to 85cm depth in Layer G with "upper" Middle Stone age assemblage including blades and dorsally re-touched points. Coll 1969; subm 1971. *Comment:* 50% carbonate removed with acid and rest analyzed.

Pta-507. Apollo 11. V1**>49,000** $\delta^{13}C = -5.1\%$

Ostrich eggshell from Sq A10 at 20 to 55cm depth in Layer G with "upper" Middle Stone age assemblage. Coll 1696; subm 1971. *Comment:* 50% carbonate removed with acid and rest dated.

Pta-1415. Apollo 11. V12**>48,400** $\delta^{13}C = -2.4\%$

Ostrich eggshell from Sq B3, in front of cave, at 115 to 120cm depth in Layer F with Middle Stone age blade industry of Howieson's Poort affinity. *Comment:* 37% carbonate removed with acid and rest analyzed.

General Comment: results, as well as several KN-dates from this site (Wendt, 1974), confirm Middle Stone age, including Howieson's Poort industry, beyond range of radiocarbon dating (Vogel & Marais, 1971; Vogel & Beaumont, 1972; Clark, 1975).

Pta-1032. Apollo 11. V11**21,600 ± 300** $\delta^{13}C = -22.3\%$

Twigs from Sq A8X₂ at 65 to 70cm depth in bottom of Layer E which contained indeterminate artifact assemblage. *Comment:* pretreated with acid and alkali. Much younger than overlying samples (Pta-1040, below) and must be rejected as spurious. Contamination cannot explain discrepancy, but one sub-recent twig in sample could.

Pta-1041. Apollo 11. V10**39,800 ± 1700** $\delta^{13}C = -20.3\%$

Twigs from Sq A9X₂ at 49 to 57cm depth in Layer E with indeterminate macrolithic industry directly below 2 painted stone slabs. *Comment:* pretreated with acid and alkali. Comparable to KN-I 869: 33,370 ± 550 and overlying KN-I 847: 46,400 $\begin{matrix} +3500 \\ -2500 \end{matrix}$.

Pta-1040. Apollo 11. V9**26,300 ± 400** $\delta^{13}C = -10.1\%$

Piece of charred wood in Sq A8X₂ at 60cm depth in top of Layer E, same level as painted stones. *Comment:* pretreated with acid and alkali. Sample, together with KN-I 813: 26,700 ± 650, KN-2056: 28,400 ± 450, dates painted stone slabs.

Pta-1039. Apollo 11. V8**18,500 ± 200** $\delta^{13}C = -19.5\%$

Unburnt twigs and fine plant remains from Sq A8X₂ at 51 to 57cm depth at base of Layer D, just overlying painted slabs, assoc with undiagnostic macrolithic early Later Stone age assemblage. *Comment:* pretreated with acid and alkali. Comparable to KN-2057: 18,660 ± 210, KN-I 812: 19,760 ± 175.

Pta-1010. Apollo 11. V7 **13,000 ± 120**
 $\delta^{13}C = -24.5\text{‰}$

Concentration of charcoal from Sq A8X₂ at 36 to 38cm depth in Layer D. *Comment:* pretreated with acid and alkali.

Pta-1021. Apollo 11. V6 **12,500 ± 120**
 $\delta^{13}C = -23.7\text{‰}$

Scattered charcoal from Sq A8X₂ at 25 to 27cm depth in top of Layer D. *Comment:* pretreated with acid and alkali.

Pta-1020. Apollo 11. V4 **7280 ± 80**
 $\delta^{13}C = -23.5\text{‰}$

Scattered charcoal from Sq A7 at 19 to 26cm depth in Layer C with typical microlithic Later Stone age assemblage (Wilton industry). Coll 1969; subm 1973. *Comment:* pretreated with acid and alkali. Stratigraphically between KN-I 610: 9430 ± 90 and KN-I 609: 6200 ± 65 in same layer. KN-I 611: 10,420 ± 80 possibly also belongs to this level.

Pta-1019. Apollo 11. V5 **6480 ± 80**
 $\delta^{13}C = -24.8\text{‰}$

Concentration of charcoal from Sq B9 at 19 to 21cm depth in Layer C where it tapers out. *Comment:* pretreated with acid and alkali. Erroneously given as 6680 BP (Wendt, 1974; 1976).

Pta-1918. Apollo 11. V13 **1960 ± 45**
 $\delta^{13}C = -24.8\text{‰}$

Scattered twigs from Sq A8X₁ at 15 to 20cm depth in base of level with late Later Stone age assemblage including potsherds, glass beads, and iron. This basal level now considered separate layer (Layer B) with pottery Wilton industry. Coll 1976; subm 1977. *Comment:* KN-I 870: 1670 ± 55 and KN-I 846: 1460 ± 55 in similar stratigraphic position. Deposits too thin to accurately determine first occurrence of pottery.

Pta-1009. Apollo 11. V3 **320 ± 40**
 $\delta^{13}C = -25.8\text{‰}$

Concentration of charcoal in Sq B3 under dripline at 5 to 8cm depth in Layer A containing coarse Later Stone age assemblage with potsherds, glass beads, and iron fragments. *Comment:* pretreated with acid and alkali. Compare KN-I 608: 440 ± 45 for same layer. Calibration of result suggests date between AD 1480 and AD 1630.

General Comment: this most complete sequence in SW Africa suggests following dates for different Stone age assemblages.

Layer A.	Final LSA with pottery	— between AD 1480 and 1630
Layer B.	Pottery Wilton (?)	— between 1960 and 1460 BP
Layer C.	Pre-pottery Wilton	— from 9430 to 6200 BP
Layer D.	Early LSA	— from ca 19,000 to 12,500 BP
Layer E.	Undefined industry	— from 39,800 to 26,300 BP
Layer F.	Howieson's Poort MSA	— >48,400 BP
Layer G.	Typical MSA	— >49,000 BP

Pta-2663. Aurus 6

1160 ± 50
 $\delta^{13}C = -21.2\text{‰}$

Cache of nara seeds from deposit in cave at Aurus waterhole (27° 38' S, 16° 13' E), 100km N of Oranjemund, S Namib desert. Subm 1977 by W E Wendt.

Pockenbank I series

Medium-sized cave in limestone wall of small valley on farm Pockenbank (27° 13' S, 16° 31' E) 60km SSE of Aus, dist Lüderitz. Some rock paintings in cave and engravings on bare rock nearby. Below surface dust deposit consists of 10 to 20cm compact lens at rear with pottery Wilton assemblage, then down to ca 40cm depth a poor Later Stone age horizon without microliths, followed by horizon with coarse macrolithic artifacts down to 120cm, and typical Middle Stone age level with flake-blades and retouched points down to 220cm (Wendt, 1972). Excavated 1969; subm 1973 by W E Wendt.

Pta-544. Pockenbank V3

31,200 ± 450
 $\delta^{13}C = -20.1\text{‰}$

Charcoal from Sq A8 at 100 to 104cm depth towards bottom of layer with indeterminate macrolithic artifacts perhaps with some Middle Stone age affinities. *Comment:* pretreated with acid. Since sample all dissolved in alkali, this fraction precipitated and analyzed. Result, thus, only minimum date.

Pta-504. Pockenbank V2

+ 5400
49,500
- 3100
 $\delta^{13}C = -5.5\text{‰}$

Ostrich eggshell from Spit 102 to 112cm in Sq A8. *Comment:* outer 20% carbonate etched off with acid and rest analyzed.

Pta-503. Pockenbank V1

35,600 ± 680
 $\delta^{13}C = -4.9\text{‰}$

Ostrich eggshell from Spit 92 to 102cm in Sq A8. *Comment:* ca 50% carbonate etched off with acid and rest analyzed.

General Comment: since both eggshell dates older than charcoal date (Pta-544), latter must be rejected and lower part of level must be older than 43,300 (Pta-504, 2 σ).

Pta-1203. Pockenbank V4

19,700 ± 220
 $\delta^{13}C = -22.7\text{‰}$

Charcoal from lens, 12 to 16cm depth in Sq A5 in early Later Stone age layer. *Comment:* pretreated with acid and alkali. Compare Pta-1039: 18,500 ± 200, Pta-1010: 13,000 ± 120, Pta-1021: 12,500 ± 120 for similar industry in Apollo 11 cave, above.

Pta-1202. Pockenbank V5

370 ± 50
 $\delta^{13}C = -23.9\text{‰}$

Twigs, grass, and leaves from 3 to 8cm depth in Sq A7 assoc with microlithic Later Stone age (Wilton) with potsherds, glass beads, and iron

objects. *Comment:* calibrated date of AD 1470 (or AD 1590) is reliable result for late Wilton with pottery.

Aar 2 series

Second small cave excavated on farm Aar (26° 43' S, 16° 31' E), 20km E of Aus, dist Lüderitz, contained recent, Late, and Middle Stone age material in ca 1m deposit. Samples coll 1972; subm 1973 by W E Wendt (1972; 1975).

Pta-1751. Aar 2. P3 **6940 ± 80**
 $\delta^{13}C = -6.2\%$

Ostrich eggshell from Sq B4 at 8 to 16cm depth in typical microlithic Late Stone age layer without pottery. *Comment:* pretreated with acid to remove 34% sample and remaining carbonate analyzed.

Pta-1050. Aar 2. P2 **120 ± 45**
 $\delta^{13}C = -24.3\%$

Charcoal from Sq B3 at 23 to 27cm depth in ashy pit of Later Stone age layer with glass beads. *Comment:* pretreated with acid and alkali.

Pta-1046. Aar 2. P1 **100 ± 45**
 $\delta^{13}C = -23.2\%$

Charcoal from Sq A3 at 6 to 9cm depth in same Later Stone age layer as sample P2 above. *Comment:* pretreated with acid and alkali.

General Comment: most probable date for P1 and P2, above, derived from calibration curve is AD 1825, but AD 1690 also possible.

Pta-2265. Aar 1 Pot **80 ± 40**
 $\delta^{13}C = -20.8\%$

Carbonaceous material scraped off pot found in small shelter on farm Aar (26° 43' S, 16° 31' E) in 1967. Subm 1978 by W E Wendt.

Steenbras Bay series

Open shallow shell midden at Steenbras Bay (26° 40' S, 15° 08' E) on Lüderitz peninsula containing typical microlithic Later Stone age artifacts without pottery (Wendt, 1975, p 24). Coll 1972; subm 1973 by W E Wendt.

Pta-1049. Steenbras Bay S3 **2070 ± 50**
 $\delta^{13}C = -24.9\%$

Scattered charcoal fragments from Sq X3 at 10 to 20cm depth in middle level of midden with mainly *Mytilus* shells. *Comment:* pretreated with acid and alkali.

Pta-1045. Steenbras Bay S2 **2540 ± 50**
 $\delta^{13}C = +0.0\%$

Patella shell from Sq X3 at 20cm depth at base of midden. *Comment:* outer 15% carbonate leached with acid and rest analyzed.

Pta-1042. Steenbras Bay S1 **2440 ± 50**
 $\delta^{13}C = +0.3\text{‰}$

Patella shell from Sq X4 at 3 to 5cm depth in surface layer of midden.
Comment: outer 17% carbonate leached with acid and rest analyzed.

General Comment: as expected isotope corrected dates for sea shell here average 420 yr too high. Correction of 400 yr, thus, also applies to this coast with its extensive upwelling.

Pta-2264. Lüderitz potsherd **300 ± 50**
 $\delta^{13}C = -17.7\text{‰}$

Soot scraped from potsherd from vicinity of Lüderitz (26° 38' S, 15° 09' E) now in Lüderitz Mus. Coll by W E Wendt; subm 1977 by Wendt and Vogel. *Comment:* calibrated date between AD 1480 and 1640.

Pta-2296. Nautilus pot **400 ± 50**
 $\delta^{13}C = -19.0\text{‰}$

Soot scraped from pot found at Nautilus/Buschfeld (26° 37' S, 15° 11' E), 3km N of Lüderitz and now in Lüderitz Mus (Cat No. 1192 or 1193). Coll by W E Wendt; subm 1977 by Wendt and Vogel. *Comment:* calibrated date, AD 1460.

Haalenberg series

Small shelter in granite Inselberg near Haalenberg (26° 36' S, 15° 34' E), 40km E of Lüderitzbucht, dist Lüderitz, revealed sequence of Later and Middle Stone age occupation. Excavated 1976; samples subm 1977 by W E Wendt.

Pta-2115. Haalenberg P4 **40,100 ± 1630**
 $\delta^{13}C = -3.8\text{‰}$

Ostrich eggshell fragments from Sq B, Spit 6 at 26 to 28cm depth, near bedrock. Base of early Later Stone age level, but few Middle Stone age artifacts occur on bedrock. *Comment:* outer 34% carbonate removed with acid and rest analyzed. Result earlier than similar assemblages at, eg, Nos, below.

Pta-1927. Haalenberg P3 **2200 ± 50**
 $\delta^{13}C = -26.5\text{‰}$

Charred bark(?) from Sq B, Spit 4 at 20 to 24cm depth at base of Later Stone age level.

Pta-2650. Haalenberg P2 **2300 ± 50**
 $\delta^{13}C = -22.5\text{‰}$

Charcoal from Sq B, Spit 3 at 12 to 18cm depth in Later Stone age level with few microliths.

Pta-1923. Haalenberg P1 **(106.5 ± 0.6)‰**
 $\delta^{13}C = -16.1\text{‰}$

Twigs from Sq B, Spit 1 at 2 to 6cm depth in level without European artifacts, stone microliths or pottery, but with some crude stone flakes.

Comment: sample contains atom bomb ^{14}C and dates to AD 1957 according to calibration curve for post 1950 (Vogel & Marais, 1971, p 392). Obviously recent introduction.

Tiras 5 series

Small shelter in granite hills on farm Tiras (26° 13' S, 16° 34' E), 60km NNE of Aus, dist Bethanie, with white "sailing ship" painting on overhang and 35cm of Later Stone age deposit stratified in two levels. Samples coll 1970; subm 1973 by W E Wendt (1972; 1975).

Pta-1184. Tiras 5. P2 **130 ± 45**
 $\delta^{13}\text{C} = -18.4\text{‰}$

Charcoal from ash lens in Sq A2 at 12 to 14cm depth in top of microlithic Later Stone age level.

Pta-1183. Tiras 5. P1 **100 ± 50**
 $\delta^{13}\text{C} = -16.5\text{‰}$

Twigs from Sq A1 at 5 to 9cm depth in upper Later Stone age level with metal fragments, pottery and some stone artifacts.

General Comment: samples pretreated with acid and alkali. Sample P2 probably does not date bottom Later Stone age level, but belongs to base of upper level. Most probable date from calibration curve is AD 1820 but AD 1690 also possible. Similar to results from Aar 2, above.

Pta-2295. Hottentot Bay Pot **490 ± 50**
 $\delta^{13}\text{C} = -18.4\text{‰}$

Soot scraped from pot found 1969 at Hottentot Bay (26° 09' S, 14° 58' E), 60km N of Lüderitz and now in Lüderitz Mus. Coll by W E Wendt; subm 1977 by Wendt and Vogel. *Comment:* calibrated date AD 1420.

Namtib series

Shelter on small, isolated granite hill on farm Namtib (26° 02' S, 16° 15' E) 85km N of Aus, dist Lüderitz, excavated 1970. Deposit consisted of two Later Stone age layers (Wendt, 1972). Samples coll 1970; subm 1973 by W E Wendt.

Pta-1186. Namtib P2 **5400 ± 70**
 $\delta^{13}\text{C} = -18.9\text{‰}$

Concentrated charcoal fragments from Sq A3 at 31 to 38cm depth in bottom of microlithic Later Stone age layer.

Pta-1185. Namtib P1 **7840 ± 90**
 $\delta^{13}\text{C} = -24.2\text{‰}$

Scattered charcoal fragments from Sq A4 at 21 to 28cm depth in upper, disturbed Later Stone age layer with pottery and nondescript stone artifacts.

General Comment: both samples pretreated with acid and alkali. Sample P1 obviously does not date upper layer and must be derived charcoal. Date for Sample P2 acceptable for Wilton industry; compare Apollo 11, Aar 2, above.

Kumakams series

Small shelter on farm Kumakams (25° 41' S, 16° 59' E), dist Malta-höhe contains shallow deposit with Later Stone age assemblage including microlithic elements and glass. Coll 1972; subm 1977 by W E Wendt.

Pta-1991. Kumakams 1. P2 **50 ± 45**

$$\delta^{13}C = -24.5\text{‰}$$

Charcoal lumps from 8 to 10cm depth.

Pta-2143. Kumakams 1. P1 **30 ± 35**

$$\delta^{13}C = -23.8\text{‰}$$

Charcoal lumps from 15cm depth.

General Comment: together results suggest calibrated date post AD 1850 but deposit may contain older artifacts.

Pta-2662. Maguams **380 ± 50**

$$\delta^{13}C = -23.0\text{‰}$$

Charcoal from 25cm depth assoc with microlithic Later Stone age assemblage in shelter with rock paintings on farm Maguams (25° 32' S, 16° 52' E), dist Maltahöhe (Wendt, 1972). Coll 1969; subm 1977 by W E Wendt. *Comment:* calibrated date AD 1470, but 1590 also possible.

Nos series

At Nos waterhole (25° 28' S, 15° 30' E) in granite Inselberg halfway between escarpment and coast in Central Namib desert, dist Lüderitz, 30cm cultural deposit with pre-, typical and sub-recent Later Stone age levels, excavated in 1970. Samples coll and subm 1973 by W E Wendt.

Pta-1750. Nos P3 **22,100 ± 220**

$$\delta^{13}C = -4.3\text{‰}$$

Portion of 6.5kg lens of ostrich eggshell in Sq A3 at 15 to 30cm depth in basal "pre-Later Stone age" level with coarse indeterminate stone artifacts. *Comment:* pretreated with acid to remove 35% sample and remaining carbonate analyzed. Compare Apollo 11, Pta-1041: 39,800 ± 1700, Pta-1040: 26,300 ± 400 and Pockenbank Pta-544: 31,200 ± 450, above, for similar artifact assemblages.

Pta-1131. Nos P2 **330 ± 50**

$$\delta^{13}C = -22.1\text{‰}$$

Scattered fragments of charcoal, twigs, and seeds from Sq A2 at 10 to 15cm depth in top of 2nd layer with pottery and typical microlithic Later Stone age tools. *Comment:* pretreated with acid and alkali. Calibrated date between AD 1470 and 1630.

Pta-1132. Nos P1 **40 ± 50**

$$\delta^{13}C = -23.2\text{‰}$$

Scattered charcoal, twigs, and seeds from Sq A3 at 3 to 5cm depth in upper layer with pottery, iron fragments, and nondescript stone artifacts. *Comment:* pretreated with acid and alkali. Calibration curve suggests post AD 1830 date.

Pta-2470. Sossusvlei **270 ± 50**
 $\delta^{13}C = -23.7\text{‰}$

Charcoal from hearth of small camp site with pottery, glass beads, and crude stone flakes in foot of low dune at Sossusvlei (24° 46' S, 15° 21' E), Central Namib desert. Coll 1977 and subm by W E Wendt. *Comment:* possibility that old dead wood was burned. Calibrated date is AD 1520 or 1630. Compare Nos, Tiras 5, Aar 2, Kumakams, above, for related sites.

Zebrarivier series

Test pit A1 in narrow cave about 10m deep into flank of mountain ridge on farm Zebrarivier (24° 29' S, 16° 16' E), dist Maltahöhe revealed Later Stone age level overlying early Later Stone age and Middle Stone age levels down to 120cm (Wendt, 1972). Coll 1970; subm 1977 by W E Wendt.

Pta-1996. Zebrarivier P1 **11,900 ± 90**
 $\delta^{13}C = -23.0\text{‰}$

Twigs and charcoal from 25cm depth at base of level with poor Later Stone age assemblage containing some microlithic elements. *Comment:* very early for microlithic (Wilton) industry, see Apollo 11 series above.

Pta-2142. Zebrarivier P2 **>48,200**
 $\delta^{13}C = -22.9\text{‰}$

Charcoal from 70cm depth in Middle Stone age level.

Grillenberg series

130km S of Walvis Bay and 6km N of abandoned diamond digging settlement, Grillenberg is a complex of hut circles (24° 6' S, 14° 34' E) constructed of thin granite slabs set upright into sand. Site situated between extended barkan dunes in complete desert with no plant in sight. Site 15km from coast and 12km S of nearest water hole at Conception Bay. Coll and subm 1977 by J C Vogel.

Pta-1832. Grillenberg charcoal **980 ± 50**
 $\delta^{13}C = -12.0\text{‰}$

Scattered charcoal in hearth area between hut circles, 3 to 6cm below surface.

Pta-1824. Grillenberg shell **1500 ± 40**
 $\delta^{13}C = +0.7\text{‰}$

Bivalve shells from same hearth area, 3 to 6cm below surface. *Comment:* 34% removed with acid and remaining carbonate dated. If apparent age of sea shells of 400 yr is subtracted, result in accordance with Pta-1832, above.

General Comment: occurrence of well-constructed settlement so far from both fresh water and the sea, and even further from other food resources is strange. No potsherds or other artifacts noticed on site; bones present in hearth.

Conception Bay series

Fresh water available at 3m depth ca 8km SE of old landing place at Conception Bay (24° 01' S, 14° 34' E), 110km S of Walvis Bay. Surroundings dotted with stone artifacts, shallow shell middens and often a human skeleton exposed by shifting sand.

Pta-1863. Conception bone **710 ± 50**
 $\delta^{13}C = -12.9\%$

Collagen from femur of intact adult skeleton buried in sand in crouched position and still covered with hair probably of caross in which corpse was wrapped (Kolb, 1719), some 200m N of German water hole. Coll and subm 1977 by J C Vogel. *Comment*: purified collagen prepared from 50g bone.

Pta-902. Conception pot CPI **620 ± 40**
 $\delta^{13}C = -17.5\%$

Carbonaceous matter scraped from surface of broken bag-shaped pot with pointed base, decorated neck and 2 externally applied, horizontally pierced lugs, found in sand near skeleton CB2. Coll and subm 1973 by J C Vogel (Jacobson & Vogel, 1979).

Pta-1801. Conception pot CP2 **310 ± 20**
 $\delta^{13}C = -19.0\%$

Carbonaceous matter scraped from surface of bag-shaped pot with pointed base and 2 horizontally pierced lugs found 1976 by B Kensley near old house at "windmill" and subm 1976 by L Jacobson, State Mus Windhoek. *Comment*: most probable calibrated date between AD 1490 and 1620.

Pta-1834. Conception midden **220 ± 50**
 $\delta^{13}C = -21.5\%$

Scattered charcoal from shallow shell midden close to CB 1 and 2 on which copper bead was noticed. Coll and subm 1977 by J C Vogel. *Comment*: most probable calibrated date AD 1650.

General Comment: Conception Water Place obviously visited over many centuries in this millennium in connection with utilization of marine resources.

Pta-2361. Hudaob hut circles **70 ± 50**
 $\delta^{13}C = -24.5\%$

Charcoal from near surface between hut circles formed of upright schist slabs ca 1km S of Hudaob on Kuiseb R (23° 43' S, 15° 26' E), 45km upstream from Gobabeb, dist Walvis Bay. Coll and subm 1978 by J C Vogel. *Comment*: calibrated date post AD 1820, but direct assoc with hut circles not certain. Compare Grillenberg, above for similar hut circles.

Cha-ré Shelter series

Cha-ré rock shelter (23° 39' S, 15° 55' E), 35km N of Solitaire, dist Rehoboth, contains 120cm deposit with Later Stone age artifacts. Samples coll and subm 1977 by B H Sandelowsky, Box 11174, Klein Windhoek.

Pta-2077. Cha-ré 3 **6840 ± 70**
 $\delta^{13}C = -23.6\text{‰}$

Charcoal concentration at 70 to 90cm depth in dark brown layer.

Pta-2075. Cha-ré 2 **5740 ± 60**
 $\delta^{13}C = -16.5\text{‰}$

Charcoal from hearth at 25 to 30cm depth in ashy layer.

Pta-2082. Cha-ré 1 **30 ± 50**
 $\delta^{13}C = -20.6\text{‰}$

Organic matter from dung floor at 15cm depth. *Comment:* most probable calibrated date post AD 1870.

General Comment: deeper levels of same age as in Mirabib shelter, below.

Gorob River mouth series

Remains on Kuiseb R terrace at juncture of Gorob R (23° 40' S, 15° 17' E), dist Walvis Bay, indicate previous occupation by herders. Coll and subm 1977 by B Sandelowsky.

Pta-1988. Gorob mouth charcoal **1210 ± 50**
 $\delta^{13}C = -25.2\text{‰}$

Charcoal from ash layer on surface with potsherds, stone artifacts, etc.

Pta-2066. Gorob mouth log **110 ± 50**
 $\delta^{13}C = -26.2\text{‰}$

Wood from collapsed log enclosure on terrace near eight stone cairns.

General Comment: site obviously occupied intermittently over long period. Calibrated date for Pta-2066 is post AD 1800 but 1690 also possible.

Pta-1344. Gorob skeleton **750 ± 80**
 $\delta^{13}C = -14.0\text{‰}$

Collagen from femur of incomplete skeleton found below stone mound on barren desert plain (23° 37' S, 15° 18' E), 5km NE of juncture of Gorob R with Kuiseb R, dist Walvis Bay. Coll and subm 1974 by B H Sandelowsky. *Comment:* 1.3g purified collagen obtained from 150g bone. See Pta-2006, below.

Pta-2596. Gobabeb **12,800 ± 140**
 $\delta^{13}C = -23.7\text{‰}$

Charcoal from hearth covered by 5cm sand and surrounded by scatter of stones and *Oryx* bones on dune overlooking Kuiseb R (23° 33' S, 15° 00' E), 2km W of Gobabeb, dist Walvis Bay (Sandelowsky, 1976). Coll and subm 1979 by J C Vogel. *Comment:* pretreated with acid and alkali. Date shows unexpected stability of dune surface since Upper Pleistocene.

Pta-2006. Narob grave **1720 ± 45**
 $\delta^{13}C = -25.9\text{‰}$

Plant material next to skeleton at 30cm below natural surface under Stone Cairn A, W of Narob (23° 29' S, 14° 57' E), on right bank of Kuiseb

R, 15km downstream from Gobabeb, dist Walvis Bay. Coll and subm 1977 by B H Sandelowsky. *Comment*: sample probably assoc with burial. Earliest date for cairn burial thus far, see Pta-1344, above.

Mirabib Hill Shelter

Excavations by B H Sandelowsky in rock shelter near Mirabib hill (23° 27' 48" S, 15° 19' 30" E), an Inselberg in the Namib desert 22km N of Kuiseb R and 88km inland from Sandwich Bay, revealed stratified deposit to max depth of 85cm with Later Stone age artifacts, plant, and animal remains. Stone artifacts mainly of quartz (Sandelowsky, 1974a; 1977). Samples coll 1973 to 1975 and subm by B H Sandelowsky.

Pta-1368. Mirabib 8 **8410 ± 80**
 $\delta^{13}C = -25.2\text{‰}$

Scattered charcoal from Sqs C/D 34, towards back of shelter, 65cm to bedrock.

Pta-1013. Mirabib 4 **8200 ± 80**
 $\delta^{13}C = -23.9\text{‰}$

Charcoal from Sq C 35 at 35 to 40cm depth.

Pta-1012. Mirabib 3 **6470 ± 80**
 $\delta^{13}C = -24.2\text{‰}$

Charcoal from Sq C 35 at 25 to 30cm depth. *Comment*: pretreated with acid and alkali.

Pta-1011. Mirabib 2 **5190 ± 80**
 $\delta^{13}C = -23.1\text{‰}$

Charcoal from Sq C 35 at 5 to 10cm depth just below patch of dung floor. *Comment*: pretreated with acid and alkali.

Pta-1536. Mirabib 12 **6500 ± 80**
 $\delta^{13}C = -24.1\text{‰}$

Scattered charcoal from Sq F 35, towards front of shelter, 70cm to bedrock.

Pta-1347. Mirabib 7 **6330 ± 60**
 $\delta^{13}C = -23.7\text{‰}$

Scattered charcoal from Sq E 35 at 50 to 55cm depth just above layer of aeolian sand. *Comment*: pretreated with acid and alkali.

Pta-1348. Mirabib 6 **5570 ± 50**
 $\delta^{13}C = -23.6\text{‰}$

Charcoal from hearth in Sq G 35 at 25cm depth. *Comment*: pretreated with acid and alkali.

Pta-1535. Mirabib 9 **1550 ± 50**
 $\delta^{13}C = -21.5\text{‰}$

Dung from lowest of three dung floors in Sqs F/G 34 at 6.5cm depth. Coll 1975 by J C Vogel. Hair coll from sample id. as sheep

(Sandelowsky, van Rooyen, & Vogel, 1979), proving presence of herders in region by AD 400.

General Comment: results indicate three periods of occupation: at back of cave 35cm deposit dates to 9th millennium BP, followed by level dating to between ca 6500 and 5200 BP and overlain by thin herder layer with dung floors, potsherds, etc, dating to AD 400.

Wortel series, Walvis Bay

Several shell middens at Wortel (23° 03' S, 14° 28' E), inland of coastal dunes in delta of Kuiseb R, 9km S of Walvis Bay were investigated by L Jacobson in 1976 (Jacobson & Vogel, 1977).

Pta-1645. Wortel KM2 **400 ± 50**
 $\delta^{13}C = -24.2\text{‰}$

Charcoal from hearth in midden KM2 at 5cm depth assoc with potsherds, bone points, ostrich eggshell beads, and grindstones. Coll and subm 1976 by L Jacobson. *Comment:* calibrated date AD 1460.

Pta-1651. Wortel KM3 **260 ± 50**
 $\delta^{13}C = -12.0\text{‰}$

Charcoal from hearth in midden KM3 at 25cm depth assoc with potsherds, etc. Coll and subm 1976 by L Jacobson. *Comment:* calibrated date AD 1635 or 1520.

Pta-2554. Wortel WM1 **370 ± 30**
 $\delta^{13}C = -21.1\text{‰}$

Scattered charcoal fragments from midden WM1 assoc with copper fragments and beads. Coll and subm 1979 by J Kinahan, State Mus, Windhoek. *Comment:* calibrated date AD 1470 or 1590.

General Comment: these middens pre-date European colonization of SW African coast.

Rehoboth series

Smelting site for iron and/or copper in townlands of Rehoboth (23° 20' S, 17° 05' E) investigated 1970 by B H Sandelowsky (1974b). Assoc stone tuyères widely distributed in central and S parts of region, from Ovitoto near Okahandja to Warmbad (Sandelowsky & Pendleton, 1969). Samples coll 1970; subm 1971 by B H Sandelowsky.

Pta-434. Rehoboth 3 **250 ± 45**
 $\delta^{13}C = -23.7\text{‰}$

Charcoal assoc with slag in Sq C4/c2 at 25cm depth.

Pta-433. Rehoboth 2 **230 ± 40**
 $\delta^{13}C = -24.2\text{‰}$

Scattered charcoal assoc with slag in Sq A1/b4 at 35cm depth.

Pta-432. Rehoboth 1 **220 ± 50**
 $\delta^{13}C = -24.2\text{‰}$

Scattered charcoal assoc with slag in Sq A2/b1 at 5cm depth.

General Comment: taken together, most probable calibrated date is AD 1645 \pm 5 ($\pm 1\sigma$); only direct date for metal working in territory thus far.

Pta-2573. Friedenau slag

420 \pm 50

$\delta^{13}C = -23.4\text{‰}$

Charred material contained in slag from near Matchless copper deposit on farm Friedenau (22° 42' S, 16° 50' E), dist Windhoek. Coll and subm 1979 by J Kinahan. *Comment:* oldest evidence of copper smelting in region.

Otjompaue series

Copper smelting furnaces formed partly of stone slabs on farm Otjompaue (22° 35' S, 16° 50' E), dist Windhoek. Coll and subm 1979 by J Kinahan.

Pta-2559. Otjompaue furnace 2

280 \pm 40

$\delta^{13}C = -24.0\text{‰}$

Concentration of charcoal from 18cm depth in base of smelting furnace 2.

Pta-2564. Otjompaue furnace 1

130 \pm 50

$\delta^{13}C = -23.4\text{‰}$

Concentration of charcoal from 15cm depth in base of smelting furnace 1.

General Comment: calibrated dates of AD 1620 or 1520 and AD 1690 or 1820, respectively, suggest 17th century date for these furnaces; compare Rehoboth series, above.

Pta-1627. Karamba GK 203

80 \pm 35

$\delta^{13}C = -25.1\text{‰}$

Charcoal from lump of slag found on surface at farm Karamba (21° 57' S, 18° 08' E), dist Gobabis. Coll by R Wadley; subm 1976 by L Jacobson. *Comment:* charcoal extracted from slag and pretreated with acid. Most probable calibrated date is AD 1820 to 1920, but AD 1690 also just within $\pm 1\sigma$ range.

Big Elephant Shelter series

Big Elephant Shelter in S Erongo Mts on farm Ameib (21° 50' S, 15° 40' E), dist Karibib, 20km N of Usakos previously produced dates of 1400 \pm 80 (UCLA-724B) and 2550 \pm 80 (UCLA-724A), apparently on surface material, together with potsherds (Clark & Walton, 1962; Beaumont & Vogel, 1972, p 83). Excavation of NW sec in 1974 by L Wadley yielded apparently homogeneous Later Stone age assemblage with potsherds, glass, copper and iron beads, bones of several antelope and sheep(?), and plant remains (Wadley, 1976; 1979). Samples coll and subm 1975 by L Wadley, Ranfontein, Transvaal.

Pta-1557. Big Elephant Shelter 2

3130 \pm 40

$\delta^{13}C = -24.7\text{‰}$

Accumulation of charcoal in Sq L4 at 35cm depth, near base of deposit.

Pta-1556. Big Elephant Shelter 1 **2600 ± 50**
 $\delta^{13}C = -24.5\text{‰}$

Charcoal from Sq L4 at 5cm depth, just below grass bedding layer.
Comment: similar to UCLA-724A: 2550 ± 80 for probably surface sample from this area.

Pta-1558. Big Elephant Shelter 3 **1080 ± 50**
 $\delta^{13}C = -24.0\text{‰}$

Charcoal from Sq K5 at 31cm depth, near bedrock.
General Comment: Pta-1557 and -1556 unexpectedly old for pottery and sheep but stratigraphy obviously complicated.

Pta-2230. Striped Giraffe Shelter **370 ± 40**
 $\delta^{13}C = -15.8\text{‰}$

Collagen from skull of sheep with horn cores from 15 to 23cm depth in Spit 3, Sq A4 of Striped Giraffe Shelter (21° 48' S, 15° 42' E) in Erongo Mts, dist Karibib. Site excavated 1962 contained micro/macrolithic Later Stone age assemblage with pottery in upper levels (Sandelowsky & Viereck, 1969). Coll 1962 by A Viereck; subm 1977 by L Jacobson and id. as *Ovies aries* by I Plug (1979). *Comment:* 9g purified collagen extracted from 37g bone. Other dates for site are SR-63: 4590 ± 100 close to bedrock and SR-64: 3080 ± 100 15cm higher up.

Pta-2681. Messum 1 **1370 ± 50**
 $\delta^{13}C = -14.3\text{‰}$

Plant fiber from Sq A9 in upper level assoc with pottery and iron in Shelter 1 in Messum Mt (21° 22' S, 14° 17' E), 150km N of Swakopmund, Damaraland. Coll and subm 1977 by W E Wendt. *Comment:* compare Pta-2664, Ururu, below.

Hungarob Schlucht series

Hungarob Schlucht (21° 14' S, 14° 31' E) is one of numerous ravines in S Brandberg Massif, 170km N of Swakopmund and on inland margin of Namib desert. Samples subm by L Jacobson.

Pta-1625. Hungarob pot **50 ± 45**
 $\delta^{13}C = -23.8\text{‰}$

Charcoal scraped from surface of whole pot found in small overhang in Hungarob Schlucht. Vessel bag-shaped with applied lugs and crack repaired with wire. Coll 1974; subm 1976. *Comment:* calibrated date post AD 1830 for last use of vessel.

Pta-2107. Hungarob Site H9 **20 ± 50**
 $\delta^{13}C = -23.5\text{‰}$

Charcoal from stone hut circle of Brandberg industry at Site H9 in Hungarob Schlucht. Coll and subm 1977. *Comment:* most probable calibrated date AD 1890 which is younger than other sites of Brandberg industry, see below.

Orabes Schlucht series

In Orabes Schlucht (21° 13' S, 14° 37' E), Brandberg, both occupied shelters and open hut circle sites occur (Jacobson & Vogel, 1975). Coll and subm 1974 by L Jacobson unless otherwise indicated.

Pta-1296. Upper Orabes Shelter 04.L21 **180 ± 45**
 $\delta^{13}C = -23.2\%$

Charcoal from ash layer Spit 2 at 10 to 20cm depth in Upper Shelter, Site 04 assoc with microlithic Later Stone age artifacts and pottery. *Comment*: most probable calibrated date is AD 1645 to 1830 ($\pm 1\sigma$).

Pta-1380. Lower Orabes Shelter 05.L1 **150 ± 35**
 $\delta^{13}C = -23.3\%$

Charcoal from hearth in Sq E4, Spit 1 at 6cm depth in Lower Shelter. Site 05 assoc with microlithic Later Stone age artifacts and potsherds and overlying burial of Khoikhoi male (de Villiers, 1975). *Comment*: most probable calibrated date is AD 1650 to 1840 ($\pm 1\sigma$).

Pta-1378. Orabes Open Site 01.BH **220 ± 30**
 $\delta^{13}C = -22.6\%$

Charcoal from hearth BH at 2 to 3cm depth in open settlement Site 01 with stone hut circles of Brandberg industry (Rudner, 1957; Jacobson, 1976). *Comment*: most probable calibrated date is AD 1640 to 1650 ($\pm 1\sigma$), but AD 1760 also possible (-1.2σ).

Pta-2106. Orabes Open Site 02.1 **180 ± 40**
 $\delta^{13}C = -25.2\%$

Charcoal from open settlement Site 02 of Brandberg industry. Coll and subm 1977. *Comment*: calibrated date is AD 1645 to 1810.

General Comment: hut circle Sites 01 and 02 have 17th/18th century date as do similar sites in Tsisab Schlucht, and Zerrissene Berge, below.

Pta-1868. Amis Schlucht pot **90 ± 70**
 $\delta^{13}C = -23.5\%$

Charcoal scraped from pot with pointed base and spout found 1968 by W E Wendt under protruding rock in Amis Schlucht (21° 13' S, 14° 28' E), Brandberg, and made available from collection in State Mus, Windhoek, by W Sydow. Subm 1977 by J C Vogel. *Comment*: 1.7g carbonaceous matter scraped from surface and pretreated with acid. Most probable calibrated date is AD 1860, but AD 1690 also within 1σ .

Pta-1377. Grosse Dom Schlucht H4 **360 ± 40**
 $\delta^{13}C = -24.4\%$

Charcoal from hearth against roughly packed stone wall forming one of several hut circles on open site in Grosse Dom Schlucht (21° 11' S, 14° 26' E), Brandberg, Brandberg culture (Jacobson & Vogel, 1975). Coll and subm 1974 by L Jacobson. *Comment*: most probable calibrated date AD 1480 or 1590. Compare Zerrissene Berge series, below.

Numas Schlucht series

Cave in Lower Numas Schlucht (21° 07' S, 14° 25' E), W Brandberg, originally investigated by J Rudner (1973), re-excavated in 1974 by L Jacobson to depth of 80cm (Jacobson & Vogel, 1975), yielded microlithic Later Stone age (Wilton) assemblage. Samples coll and subm 1974 by L Jacobson.

Pta-1620. Lower Numas Cave L70 **4840 ± 50**
 $\delta^{13}C = -5.3\%$

Ostrich eggshell from Sqs B3/4 at 60 to 70cm depth. *Comment:* 36% carbonate removed with acid and rest analyzed.

Pta-1295. Lower Numas Cave L61 **4180 ± 60**
 $\delta^{13}C = -24.0\%$

Charcoal from Sq B4 at 60cm depth.

Pta-1623. Lower Numas Cave L51 **3950 ± 60**
 $\delta^{13}C = -23.9\%$

Charcoal from Sq B3 at 50cm depth. *Comment:* results considerably older than previous dates for shallower samples: Pta-178: 2890 ± 65 at 7cm depth and Pta-179: 2950 ± 65 at 15cm depth (R, 1971, v 13, p 388).

Pta-2645. Numas Schlucht pot **420 ± 140**
 $\delta^{13}C = -23.5\%$

Carbonaceous material scraped from isolated pot found in Lower Numas Schlucht. Coll and subm 1977 by W E Wendt. *Comment:* 55mg carbon analyzed in mini-counter (Vogel & Behrens, 1976). Calibrated date AD 1450.

Tsisab Schlucht series

Several sites in Tsisab Schlucht (21° 06' S, 14° 41' E), E Brandberg Massif, excavated 1975 and 1976 by L Jacobson. Shelters 3.5km up ravine contain rock paintings, including famous "white lady", and mostly shallow, often disturbed, Later Stone age deposits. Open sites with stone hut circles of Brandberg industry characterized by large informally retouched flakes, pottery and, rarely, iron and smoking pipes (Rudner, 1957; Jacobson, 1976). Samples coll and subm 1975 and 1976 by L Jacobson.

Pta-1547. Girls' School Shelter T6.1 **6510 ± 80**
 $\delta^{13}C = -24.4\%$

Charcoal concentration from Sq B6, Spit 2 at 12 to 16cm depth in level with Later Stone age artifacts, including medium sized scrapers; Girls' School Shelter, Site T6. *Comment:* oldest date thus far from Brandberg.

Pta-1776. Girls' School Shelter T6.4 **2780 ± 60**
 $\delta^{13}C = -23.8\%$

Scattered charcoal from Sq C, Spit 3 at 17 to 22cm depth in Girls' School Shelter, Site T6 with Later Stone age artifacts. *Comment:* pre-

treated with acid and alkali. Compare dates for sites in Numas Schlucht on other side of Brandberg (below).

Pta-1777. Girls' School Shelter T6.2 **910 ± 40**
 $\delta^{13}C = -23.0\text{‰}$

Charcoal clump from Sq B, Spit 1 at 6 to 8cm depth in Girls' School Shelter, Site T6 with Later Stone age artifacts and pottery. *Comment:* pretreated with acid and alkali.

Pta-1773. Girls' School Shelter T6.A2 **720 ± 45**
 $\delta^{13}C = -23.7\text{‰}$

Charcoal from hearth in Sq A, Spit A2 at 4cm depth in Girls' School Shelter, Site T6 assoc with scrapers and overlying potsherds. *Comment:* pretreated with acid and alkali.

Pta-1783. Tsisab Open Site T30.I/1 **420 ± 45**
 $\delta^{13}C = -10.5\text{‰}$

Charcoal from Hearth I amongst stone hut circles and semi-circles at 0 to 5cm depth at open Site T30 of Brandberg industry. *Comment:* most probable calibrated date AD 1450, but AD 1590 also possible (1.2 σ).

Pta-1820. Tsisab T30.R **275 ± 50**
 $\delta^{13}C = -24.1\text{‰}$

Charcoal from Hearth R, 0 to 5cm depth, at Site T30. *Comment:* most probable calibrated date AD 1630 or 1570.

Pta-1821. Tsisab T30.34 **210 ± 50**
 $\delta^{13}C = -23.8\text{‰}$

Charcoal accumulation at Site T30, 0 to 5cm depth. *Comment:* most probable calibrated date AD 1645 or 1760.

Pta-1784. Tsisab Open Site T20 A.1 **200 ± 40**
 $\delta^{13}C = -23.8\text{‰}$

Charcoal from hearth, 0 to 5cm depth, at open Site T20 with stone hut circles, Brandberg industry. *Comment:* most probable calibrated date AD 1650 or 1760.

General Comment: no temporal overlap between occupation of rock shelters (6500 to 720 BP) and open settlement sites with stone hut circles. Latter most probably occupied in first half of 17th century.

Pta-1550. Ostrich Shelter T3.2 **2590 ± 60**
 $\delta^{13}C = -25.3\text{‰}$

Charcoal concentration in Sq D4 at 16cm depth with Later Stone age artifacts at Ostrich Shelter, Site T3.

Pta-1551. Ostrich Shelter T3.1 **2390 ± 50**
 $\delta^{13}C = -24.1\text{‰}$

Charcoal from hearth in Sq D4 at 12cm depth with Later Stone age artifacts at Site T3.

Pta-1546. Tsisab Shelter T2.1 **2240 ± 50**
 $\delta^{13}C = -24.8\%$

Charcoal from hearth complex in Sq C5 at 10cm depth assoc with Later Stone age assemblage at Site T2.

Zerrissene Berge series

Several stone hut circle complexes with walls up to 1.2m high in valleys of Zerrissene Berge (21° 05' 24" S, 13° 59' 16" E), 7km S of Ugab R and 35 km W of Brandberg, dist Swakopmund, discovered by M & A Carr, apparently belong to Brandberg culture (see above) (Carr *et al*, 1976). Coll and subm 1975 by L Jacobson.

Pta-1577. Zerrissene Berge Z10 **340 ± 40**
 $\delta^{13}C = -22.0\%$

Charcoal from ash layer 15cm below surface inside stone structure of Site 10 on Sessob R. *Comment*: most probable calibrated date is AD 1470 to 1620 ($\pm 1\sigma$).

Pta-1610. Zerrissene Berge Z10A **260 ± 30**
 $\delta^{13}C = -11.8\%$

Collagen from dog skeleton buried near marker cairn in apex of side valley to Sessob R above hut circles at Site 10. *Comment*: 3.7g purified collagen extracted from 200g bone. Most probable calibrated date is AD 1620 to 1645 ($\pm 1\sigma$).

Pta-1578. Zerrissene Berge Z11 **220 ± 35**
 $\delta^{13}C = -22.7\%$

Charcoal from stone-lined hearth attached to hut circle at Site Z11 in side arm of Sessob R valley. *Comment*: most probable calibrated date is AD 1640 to 1655 ($\pm 1\sigma$), but AD 1760 also possible.

Pta-1638. Zerrissene Berge Z2 **80 ± 45**
 $\delta^{13}C = -20.3\%$

Dung from floor of storage cairn at Site 2, ca 5km SE of Sites 10 and 11. *Comment*: most probable calibrated date ca AD 1860, apparently related to later occupation of site.

General Comment: results suggest early 17th century date for main occupation of sites as also for similar Brandberg sites.

Pta-2111. Ugab River site BW/1 **400 ± 40**
 $\delta^{13}C = -21.3\%$

Charcoal assoc with dung horizon surrounded by crude stone wall(?) in small cave S of Ugab R (20° 59' S, 14° 00' E), W of Brandberg in completely uninhabited region. Coll and subm 1977 by L Jacobson. *Comment*: calibrated date AD 1460, predating settlements in Zerrissene Berge, above.

Pta-2654. Zwei Schneider**5850 ± 70** $\delta^{13}C = -25.2\text{‰}$

Charcoal from 10cm depth in shallow microlithic Later Stone age deposit of Zwei Schneider shelter with rock paintings at Twyfelfontein (20° 35' S, 14° 23' E), Damaraland. Coll 1968; subm 1977 by W E Wendt.

Pta-2014. Hasenbild T2**180 ± 60** $\delta^{13}C = -23.8\text{‰}$

Charcoal from hearth, 15 to 20cm deep, Sq B3, in upper part of Later Stone age deposit in Hasenbild shelter with rock paintings at Twyfelfontein (20° 35' S, 14° 23' E), Damaraland, 195km W of Outjo. Coll 1968 and subm 1977 by W E Wendt. *Comment:* most probable calibrated date AD 1660 or 1770. Compare KN-I 469: 140 ± 50 (Wendt, 1972) from same shelter.

Pta-2664. Ururu**1000 ± 60** $\delta^{13}C = -25.4\text{‰}$

Bark from 17cm depth in Ururu shelter with crude Later Stone age flakes, ostrich egg shell beads and potsherds on farm Krone (20° 30' S, 14° 03' E), Damaraland, 40km W of Twyfelfontein. Coll 1968; subm 1977 by W E Wendt. *Comment:* compare Pta-2021, Unjab midden and Pta-2681, Messum with similar assemblages.

Pta-2021. Unjab Midden**2690 ± 60** $\delta^{13}C = -23.5\text{‰}$

Dispersed charcoal from shallow shell midden on dune slope at mouth of Unjab R (20° 10' S, 13° 10' E), Skeleton Coast, 315km N of Swakopmund, dist Outjo, assoc with crude stone artifacts. Coll 1968; subm 1977 by W E Wendt.

Pta-1867. Hoanibmund pot**150 ± 70** $\delta^{13}C = -21.1\text{‰}$

Charcoal scraped from broken pot with nose and probably pointed base found 1968 by E Braune at mouth of Hoanib R (19° 27' S, 12° 45' E), Skeleton Coast, and made available by W Sydow from collection in State Mus, Windhoek. Subm 1977 by J C Vogel. *Comment:* ca 2g carbonaceous matter scraped from surface of pot. Most probable calibrated date AD 1690 or 1810.

Pta-2552. Warmquelle**2140 ± 50** $\delta^{13}C = -23.3\text{‰}$

Charcoal from hearth at 8cm depth assoc with ?Khoi pottery in cave 5km N of Warmquelle (19° 10' S, 13° 46' E), N Damaraland. Coll and subm 1979 by J Kinahan. *Comment:* very early for Khoi pottery so far N.

Pta-676. Hoarusibmund**70 ± 45** $\delta^{13}C = -10.5\text{‰}$

Charcoal from shell midden at mouth of Hoarusib R (19° 04' S, 12° 33' E), Skeleton Coast, assoc with stone flakes and potsherds. Coll 1968

and subm 1972 by W Sydow, Windhoek. *Comment*: most probable calibrated date AD 1870.

Pta-1624. Otjinungwa KK/OT 1 **300 ± 50**
 $\delta^{13}C = -24.4\text{‰}$

Charcoal from hearth in stone hut circle in Otjinungwa valley ridge (17° 15' S, 12° 26' E), Kaokoveld, near Kunene R, assoc with iron arrow head and axe, Kavango pottery featuring cross-hatched incisions and occasional stamping. Coll 1966 by R MacCalman; subm 1976 by L Jacobson. *Comment*: most probable calibrated date is AD 1490 to 1635 ($\pm 1\sigma$).

Pta-1399. Berorue 10/75, Angola **130 ± 40**
 $\delta^{13}C = -24.9\text{‰}$

Charcoal and charred bone from hearth at 0 to 5cm depth inside ring of stone hut foundations at Iron age settlement site at foot of Berorue Mts (16° 45' S, 12° 20' E) in Iona National Park, dist Mocamedes, Angola. Coll and subm 1975 by R J Mason, Univ Witwatersrand, Johannesburg. *Comment*: sample boiled with 20% HCl to decompose bone and alkali solubles extracted with dilute NaOH, residue dated. Calibrated date either AD 1690 or 1820 suggesting that site was occupied after Herero-speaking peoples first settled in region but before re-entry of Himba groups at about AD 1870 (Malan, 1974).

Pta-765. Tchitundo-Hulo, Angola **2620 ± 60**
 $\delta^{13}C = -23.6\text{‰}$

Charcoal from 24 to 29cm depth in lowest level of deposit in rock shelter on Tchitundo-Hulo Mulume hill (15° 56' S, 12° 53' E) on inland fringe of desert, 120km SE of Mocamedes, Angola. Assoc with microlithic (Wilton) Later Stone age assemblage (Ervedosa, 1974). Coll 1972; subm 1973 by C M N Ervedosa, Univ Luanda, Luanda, Angola. *Comment*: compare Pta-769, below.

Galanga series, Angola

Excavation on hill, 14km from Galanga (12° 04' S, 15° 09' E), dist Huambo, Angola, revealed 140cm deposit with Later Stone age assemblage. Samples coll and subm 1972 by J R Dos Santos, Jr and C M N Ervedosa.

Pta-772. Galanga 110cm **4140 ± 70**
 $\delta^{13}C = -23.8\text{‰}$

Scattered charcoal from 100 to 120cm depth.

Pta-769. Galanga 70cm **2620 ± 50**
 $\delta^{13}C = -24.6\text{‰}$

Scattered charcoal from 60 to 80cm depth.

General Comment: samples pretreated with acid and alkali. Deposit younger than that of Caninguiri, Mungo (R, 1971, v 13, p 389; Dos Santos, Jr & Ervedosa, 1971, p 136).

Benfica series, Angola

At Benfica (8° 57' S, 13° 09' E), 17km S of Luanda on coast thin shell midden covered by soil contains boldly decorated potsherds and clay smoking pipes (Dos Santos, Jr & Ervedosa, 1970). Two more samples dated because of important implication of previous early dating Pta-212: 1810 ± 50 BP (R, 1971, v 13, p 389) for pottery and pipes. Samples coll and subm 1973 by C M N Ervedosa.

Pta-1025. Benfica shell B **2160 ± 60**
 $\delta^{13}C = -0.8\%$

Shell from thin shell layer covered by 40cm soil and assoc with pottery. *Comment:* due to apparent age of seawater ca 400 yr must be subtracted for true age, viz 1760 BP which compares well with Pta-212 suggesting 2nd century AD date for deposit.

Pta-1026. Benfica shell A **1000 ± 70**
 $\delta^{13}C = -0.0\%$

Shell from 8cm depth in same layer but at some distance from Pta-1025. *Comment:* true age ca 400 yr younger, viz 600 BP or AD 1350. Much younger than other 2 dates but still before European contacts.

General Comment: 20% sample removed with acid and rest of carbonate dated in both cases.

Angra Fria series

Wood from shipwrecks litter beach near Angra Fria, (18° 15' S, 11° 56' E), Skeleton Coast, some of which are heavily eroded by wind. Three such pieces coll by L Ehbrecht. Sampled for dating and subm 1972 by J C Vogel.

Pta-730. Angra Fria 1 **310 ± 50**
 $\delta^{13}C = -26.5\%$

Outer annual rings of heavily eroded part of block and tackle coll 1966. *Comment:* most probable calibrated date, AD 1430 to 1630.

Pta-826. Angra Fria 2 **200 ± 40**
 $\delta^{13}C = -23.6\%$

Outer annual rings of wooden block. *Comment:* most probable calibrated date, AD 1650, but date between AD 1640 and 1800 within ± 1σ.

Pta-722. Angra Fria 3 **80 ± 50**
 $\delta^{13}C = -25.4\%$

Outer annual rings of wooden beam. *Comment:* most probable calibrated date, AD 1860 ± 40, but AD 1690 within 1σ.

General Comment: results (Pta-730) prove that remains of 17th century shipwrecks are still to be found on Skeleton Coast.

II. PALEOENVIRONMENTAL SAMPLES

Oranjemund series

On coast N of Orange R mouth extensive excavations have exposed several fossil beach gravel complexes. In attempt to date these, samples were coll and subm in 1974 by J A Fowler, CDM, Oranjemund.

Pta-1351. Gemsbok, wood **5750 ± 60**
 $\delta^{13}C = -25.9\text{‰}$

Wood from base of gully cut into bedrock and infilled with marine gravel at present Mean Sea Level; overlain by 5m marine beach sands at Gemsbok (28° 34.9' S, 16° 21.9' E). *Comment:* pretreated with acid and alkali. Significantly, marine sands accumulated to + 5m since 6th millennium BP.

Pta-1332. Gemsbok MA 3S **>44,700**
 $\delta^{13}C = -0.2\text{‰}$

Shell fragments from shell bank in marine beach crest at + 3m above MSL and overlain by 3m sand at Gemsbok (28° 30.0' S, 16° 19.3' E). *Comment:* 24% carbonate removed with acid and rest dated.

Pta-1334. Gemsbok MA 5S **42,500 ± 3000**
 $\delta^{13}C = +0.1\text{‰}$

Shell fragments from shell bank at crest of 'B' beach at + 4m above MSL and overlain by 5m sand at Gemsbok (28° 29.9' S, 16° 18.5' E). *Comment:* 32% carbonate removed with acid and rest dated.

Pta-1333. Gemsbok MA 4S **43,200 ± 2800**
 $\delta^{13}C = +1.9\text{‰}$

Shell fragments from shell bank at crest of 'C' beach at + 9m above MSL and overlain by 1m sand at Gemsbok (28° 29.8' S, 18.8' E), 500m inland from previous sample. *Comment:* 21% carbonate removed with acid and rest dated.

Pta-1335. Kerbe Hoek MA 6S **37,400 ± 1330**
 $\delta^{13}C = +0.3\text{‰}$

Shell fragments from shell bank at + 13m above MSL, assoc with gravel bed on + 9m terrace and overlain by 5m sand at Kerbe Hoek (28° 03.0' S, 15° 53.9' E), 75km N of Oranjemund and several km inland from coast. *Comment:* 16% carbonate removed with acid and rest dated.

Pta-1336. Affenrücken MA 7S **37,800 ± 1600**
 $\delta^{13}C = -1.1\text{‰}$

Shell fragments from shell bank in gully at + 10m above MSL on + 9m terrace and overlain by 6m sand at Affenrücken (27° 57.7' S, 15° 47.7' E), 90km NW of Oranjemund and several km inland from coast. *Comment:* 42% carbonate removed with acid and rest dated.

General Comment: compare dates of 38,100 (GrN-4571) and 35,000 (GrN-4572) for shell from 'A' terrace at + 2m near Kerbe Hoek (R, 1970, v 12, p 40). All shell samples contain less than 1% modern carbon which could represent contamination with more recent carbonate precipitation. Dates therefore only minimum ages and all these beach gravels probably pre-glacial.

Continental Shelf series

Numerous cores taken on Continental shelf between Orange R mouth and Lüderitz during exploration for diamonds provided shell for dating

postglacial rise in sea level (table 1). Samples coll by D O'Shea along four traverses perpendicular to coast between 1 and 25km from shore (except for Pta-1166 and -1167, both ca 55km out) and subm 1973 by R H Joynt, Paarden I., Cape Town.

TABLE 1

Lab no.	Locality	Depth in sed (m)	Depth below surf (m)	$\delta^{13}C$ (‰)	Age (yr BP)
Pta-948	28°16.2'S, 15°58.1'E	2.4	66.4	+0.9	5930 ± 80
Pta-955*	28°16.7'S, 15°57.8'E	7.0	76.5	+0.2	13,600 ± 120
Pta-951*	28°17.6'S, 15°57.1'E	4.4	81.2	-0.7	14,300 ± 130
Pta-945	28°20.2'S, 15°54.2'E	1.9	97.9	+1.5	5850 ± 70
Pta-1164	28°20.8'S, 15°54.1'E	3.0	103.6	-0.2	13,600 ± 120
Pta-956	28°21.2'S, 15°53.7'E	1.3	104.6	+1.1	13,000 ± 110
Pta-952	28°22.4'S, 15°52.4'E	1.3	111.9	+0.1	10,300 ± 100
Pta-1165	28°38.0'S, 15°43.6'E	0.5	156.0	+2.9	10,800 ± 90
Pta-1166	28°38.0'S, 15°43.6'E	0.6	156.1	+0.2	14,500 ± 130
Pta-1167	28°42.7'S, 15°45.4'E	1.6	190.6	+2.6	43,600 ± 2800
Pta-1163	28°07.0'S, 15°47.1'E	0.4	58.4	+1.9	4500 ± 80
Pta-947	28°07.4'S, 15°47.2'E	1.0	59.5	(-2.8)	5950 ± 140
Pta-957*	28°07.8'S, 15°46.7'E	1.8	71.3	-0.2	12,900 ± 120
Pta-1162	28°09.9'S, 15°44.8'E	0.3	89.9	+0.2	3130 ± 50
Pta-958	28°11.2'S, 15°43.6'E	4.2	99.3	+0.5	13,000 ± 110
Pta-1099*	27°55.0'S, 15°40.4'E	3.9	20.4	+0.6	7400 ± 90
Pta-1098*	27°56.4'S, 15°40.5'E	5.7	20.3	+0.8	7650 ± 80
Pta-949*	27°57.9'S, 15°37.1'E	1.0	72.2	+0.5	14,000 ± 160
Pta-1104*	27°58.2'S, 15°36.5'E	1.6	78.4	-0.8	27,800 ± 440
Pta-1105*	28°00.3'S, 15°34.6'E	1.2	87.2	-1.0	16,100 ± 160
Pta-1100	27°50.7'S, 15°31.3'E	1.2	77.1	+0.3	3370 ± 60
Pta-1101	27°56.1'S, 15°26.0'E	5.9	112.0	+0.9	14,500 ± 140

* See General Comment below.

General Comment: outer carbonate etched off from most samples and rest used for dating, 400 yr to be subtracted from all dates to account for apparent age of sea water. Since shell can be deposited in deep water but not so readily transported to higher levels, shallowest occurrence of shell of a certain age can tentatively be taken to date sea level at that time. On this basis the following dates for past sea levels are derived (samples marked with asterisk):

7130 BP (Pta-1099, 1098)	-20.4m
13,300 BP (Pta-955, 951, 957, 949)	-75.5m
15,700 BP (Pta-1105)	-87.2m
27,400 BP (Pta-1104)	-78.4m

In addition, see 7650 BP (GrN-4858, R, 1970, v 12, p 450) for -23m; 5750 BP (Pta-1351, Oranjemund series, above) for ± 0m and, possibly, 4940 BP (Pta-419, Lüderitz series, below) for +3.5m.

Pta-2038. Auchas Silt Terrace

180 ± 40
 $\delta^{13}C = -21.7‰$

Bark of dead tree buried in 3m silt deposit on right bank of Orange R at Auchas (28° 18' S, 16° 45' E), 40km upstream from Oranjemund,

dist Lüderitz. Silt deposited by extreme flood apparently killed trees growing on high terrace. Coll 1976; subm 1977 by G Corvinus and W E Wendt. *Comment*: most probable calibrated date for silt deposit AD 1660 or 1770.

Lüderitz series

Low marine platforms above present beach near Lüderitz suggest recent marine transgression along SW coast of Africa. O Davies, Natal Mus, Pietermaritzburg, coll and subm samples in 1970 to establish dates of these high sea levels.

Pta-419. Sturmvogelbucht **5340 ± 60**
 $\delta^{13}C = +0.8\text{‰}$

Patella shells from shell bed on marine platform below cliff base at + 3.6m above MSL, on W side of Sturmvogelbucht (26° 38' 30" S, 15° 07' 20" E), ca 6km W of Lüderitz. *Comment*: 48% sample removed with acid, remaining carbonate dated. True age ca 400 yr younger, ie, 4940 BP.

Pta-417. Grosse Bucht **1580 ± 50**
 $\delta^{13}C = +0.6\text{‰}$

Bullia digitalis shells from shell bed on marine platform 1.2 to 1.8m above MSL bounded landwards by storm ridge of pebbles up to + 3m above MSL at S end of Grosse Bucht (26° 46' 40" S, 15° 06' 40" E), ca 16km SW of Lüderitz. *Comment*: 68% sample removed with acid, rest of carbonate dated. True age ca 400 yr younger, ie, 1180 BP.

General Comment: further evidence for + 3.5m and + 1.5m Holocene transgressions.

Pta-1235. Reutersbrunn Oyster **6750 ± 80**
 $\delta^{13}C = +1.4\text{‰}$

Ostrea atherestonei shell from surface of stormwater beach at Reutersbrunn (24° 43' S, 14° 46' E), 30km S of Meob Bay. Coll and subm 1973 by M K Seely, Namib Desert Research Sta, Box 953, Walvis Bay. *Comment*: 30% sample removed with acid and remaining carbonate dated. True age ca 400 yr younger. Compare Pta-1287, Langewandt Oyster, below.

Meob series

Site 22km SE of Meob Bay (24° 31' S, 14° 37' E), 175km S of Walvis Bay. Fresh water occurs 2m below surface of extensive deflation area. Remnants of flat surface capped with calcrete layer protrude ca 4m above plain near dune field margin. Calcified reed stalks coll from calcrete surface behind first dune ridge on inland side of plain indicate former higher groundwater table. Subm 1977 by J C Vogel.

Pta-1830. Meob reed fr 1 **11,800 ± 90**
 $\delta^{13}C = -9.2\text{‰}$

Pta-1831. Meob reed fr 2 **11,700 ± 120**
 $\delta^{13}C = -9.3\text{‰}$

Calcified reed stalks, probably *phragmites*, from calcrete surface inland from coast. *Comment*: to test for recent contamination of calcium

carbonate sample treated as follows: first 10% carbon dioxide evolved on acidification rejected; next 48% collected as fraction 1; next 10% rejected; final 32% collected as fraction 2. Similarity of results for two fractions exclude significant post-depositional contamination. Date suggests significant lowering of groundwater table and formation of calcrete layer at about 12,000 BP, *ie*, at same time as similar event at Conception Bay, below.

Conception reed series

In surroundings of watering place at Conception Bay (24° 01' S, 14° 34' E), 10km S of landing place, fresh water occurs 3m below surface. Remnants of flat surface capped with calcrete layer containing calcified reed stalks, protrude from extensive deflation area. Samples coll and subm 1973 by J C Vogel.

Pta-1238. Conception reeds 1 **11,900 ± 100**
 $\delta^{13}C = -6.6\%$

Calcified reed stalks, probably *phragmites*, from calcrete surface 4.1m above deflation plain at watering place, Conception Bay. *Comment*: 12% sample removed with acid and remaining carbonate dated.

Pta-1647. Conception reeds 2, fr 1 **12,500 ± 120**
 $\delta^{13}C = -8.6\%$

Pta-1648. Conception reeds 2, fr 2 **12,600 ± 140**
 $\delta^{13}C = -9.0\%$

Two fractions of another sample of calcified reed stalks from same locality as Pta-1238, above. *Comment*: to test for recent contamination of calcium carbonate sample was treated as follows: first 10% carbon dioxide evolved on acidification rejected; next 40% collected—fraction 1; next 10% rejected; remaining 40% collected—fraction 2.

General Comment: fact that fractions 1 and 2 of sample 2 give identical results suggests contamination is insignificant. Three dates together indicate lowering of groundwater table and calcification of extensive reed marsh ca 12,000 BP (see Meob series, above).

Conception saltpan series

Extending S from Conception Bay (23° 56' S, 14° 30' E) is large saltpan separated from beach by sand barrier, now completely dry but with signs of recent submergence. Samples coll and subm 1977 by J C Vogel to date disappearance of coastal lagoon.

Pta-1833. Conception tree **440 ± 50**
 $\delta^{13}C = -25.6\%$

Outer annual rings of large tree trunk lying in middle of saltpan ca 7km W of waterhole. Apparently washed up by sea at time when lagoon still existed. *Comment*: pretreated with acid and alkali.

Pta-1826. Conception small shell **920 ± 50**
 $\delta^{13}C = +0.8\text{‰}$

Donax serra bivalves standing upright in pairs in living position on 50cm shell beds on top of saltpan surface ca 6km W of waterhole. *Comment*: 39% sample removed with acid and remaining carbonate analyzed.

Pta-1827. Conception large shell **940 ± 50**
 $\delta^{13}C = +0.9\text{‰}$

Lutraria capensis bivalves standing upright in pairs on 50cm shell beds on top of saltpan surface in living position near *Donax* colony (Pta-1826, above). *Comment*: 33% sample removed with acid and remaining carbonate analyzed.

General Comment: due to apparent age of surface seawater, ca 400 yr must be subtracted from seashell dates to obtain true date. Thus, shells (520 BP and 540 BP) only insignificantly older than tree (440 BP) suggesting that lagoon still existed in first half of 15th century (calibrated date). *Donax* prefers wave action while *Lutraria* may occur in lagoons (R N Kilburn, 1977, written commun).

Pta-1287. Langewandt oyster **7640 ± 80**
 $\delta^{13}C = +1.3\text{‰}$

Ostrea shell lying on stormwater beach at N end of Langewandt (23° 39' S, 14° 31' E), 28km S of Sandwich Bay together with driftwood, planks, etc, that have been washed up in recent times. Coll and subm 1973 by J C Vogel. *Comment*: 50% sample removed with acid and remaining carbonate dated. True age ca 400 yr younger. Sample collected because occurrence of oysters on this rockless stretch of coast was strange. Probably shells are washed up from fossil submerged oyster bed. Demonstrates danger of using shell to date fossil beaches, compare Reutersbrunn oyster, Pta-1235: 6750 ± 75, above. See also GrN-4858: 7650 ± 70 for *Ostrea* shell from sea bottom, and GrN-4857: 1610 ± 50 for *Donax* shell from above beach in same area (R, 1970, v 12, p 450).

Sossusvlei Silt series

At Sossusvlei (24° 45' S, 15° 21' E), in Central Namib desert, flood waters from the Tsauchab R have left extensive silt deposits. In SW corner lobe of vlei has been cut off by high sand dunes. Small portion is 3m lower than rest of lobe floor. Dating of dead trees in this lobe given below.

Pta-1859. Sossusvlei silt 4 **24,800 ± 320**
 $\delta^{13}C = -1.8\text{‰}$

Calcareous silt from 2.85cm below surface of lower floor in separate lobe of vlei. Coll 1976; subm 1977 by E M van Zinderen Bakker, Inst Environmental Sci, Univ OFS, Bloemfontein. *Comment*: calcium carbonate content 4.4% of which unknown fraction is primary carbonate; 14% carbonate rejected and remaining proportion analyzed.

Pta-1579. Sossusvlei silt 2**9600 ± 90** $\delta^{13}C = -2.0\text{‰}$

Calcareous silt from 5 to 10cm below surface of upper floor of separated lobe of vlei. Coll and subm 1975 by J C Vogel. *Comment:* calcium carbonate content 4.2%. All carbonate used for analysis.

Pta-1503. Sossusvlei silt 1**9460 ± 90** $\delta^{13}C = -2.6\text{‰}$

Calcareous silt from 0 to 5cm below surface of upper floor of separated lobe of vlei. Coll and subm 1975 by J C Vogel. *Comment:* calcium carbonate content 5.4%. All carbonate used for analysis.

General Comment: if Sa 1 and 2 assumed deposited in sub-recent times then 2/3 of carbonate is primary without ^{14}C . Then Sa 4 would be ca 16,000 yr old. Assumption supported by ^{13}C contents. Pollen spectrum in silt similar to that of present vegetation (van Zinderen Bakker, oral commun).

Pta-1646. Sossusvlei silt 3**(106.4 ± 2.5)%** $\delta^{13}C = -21.0\text{‰}$

Organic material separated from large sample of silt from 2.4m depth in active lobe of Sossusvlei, near present endpoint of Tsauchab R. Coll and subm 1975 by E M van Zinderen Bakker. *Comment:* pit dug close to evaporating floodwater pool revealed successive layers of silt and sand. Large sample of silt from bottom of pit digested with hydrofluoric acid and remaining 0.3g organic material analyzed. Comparison with curve for atmospheric ^{14}C content (Vogel & Marais, 1971, p 392) suggests date of AD 1957, *ie*, 17 yr old in 1975.

Pta-1501. Tsondabvlei silt**8640 ± 70** $\delta^{13}C = -2.9\text{‰}$

Slightly calcareous silt from surface near entrance to Tsondabvlei (23° 56' S, 15° 22' E), Central Namib desert. Coll and subm 1975 by J C Vogel. *Comment:* sample contained 4.5% calcium carbonate which was used for analysis. Silt deposits here frequently submerged and possibly reworked by flood waters entering vlei, thus representing a different situation to fossil deposits in Tsondab lower valley and Homeb silts (below) which were apparently deposited in still water and subsequently calcified. Oxygen isotopic composition, $\delta^{18}O = -9.48\text{‰}$, indicates pure fresh water carbonate.

Tsondab Lower Valley series

Tsondab R deriving from escarpment ends in Tsondabvlei, but previously extended much further W into Namib sand desert. Some 6km W of present Tsondabvlei remnants of silt deposits occur on N edge of former lower valley of Tsondab R (23° 53' S, 15° 15' E) (Seely & Sandelowsky, 1974). In upper part of silt several thin calcified layers occur, representing repeated flooding and dessication.

Pta-1502. Tsondab Lower Valley silt **14,300 ± 130**
 $\delta^{13}C = -2.8\text{‰}$

Calcified layer in upper section of silt deposits protruding from underneath dune sand. Coll and subm 1975 by J C Vogel. *Comment:* sample contained 5.3% carbonate which was all used for analysis. Oxygen-18 content, $\delta^{18}O = -6.96\text{‰}$ indicates mainly fresh water carbonate; thus date probably reliable.

Pta-1043. Tsondab Lower Valley snails **13,300 ± 90**
 $\delta^{13}C = -7.1\text{‰}$

Small shells of freshwater snails (*Lymnaea natalensis* and *Biomphalaria pfeifferi*) mostly from slightly lower level than silt sample (Pta-1502, above). *Comment:* 23% carbonate removed with acid and rest analyzed.

General Comment: similarity of results indicates reliability of date from silt and suggests extensive flooding before ca 14,000 BP. Subsequently lower valley was blocked by high sand dunes to E forming present Tsondabvlei.

Pta-1197. Narabeb root cast **28,500 ± 500**
 $\delta^{13}C = -3.2\text{‰}$

Calcified root casts(?) from site called Narabeb (23° 55' S, 14° 55' E), 38km W of Tsondabvlei and 47km from coast in former lower Tsondab R valley, Central Namib desert. Pedotubules originate from above extensive hardpan, but are at lower level than silt deposits along E edge of dune valley (Seely & Sandelowsky, 1974). Coll and subm 1973 by M K Seely. *Comment:* 34% carbonate removed with acid and rest analyzed. Compare similar dates, Pta-1493 and -1494, Homeb series, below.

Pta-2375. Kuiseb silt **(159.1 ± 0.8) %**
 $\delta^{13}C = -30.8\text{‰}$

Thin layer of leaves 1m from top of 3m silt deposit on N bank of Kuiseb R bed (23° 39' S, 15° 16' E), 13km upstream from Homeb. Coll and subm 1978 by J C Vogel. *Comment:* calibrated date (R, 1971, v 13, p 392) AD 1968 ± 1, probably March 1969 flood. Leaf layer slants upward into river bank and postdates trees on terrace. Result shows large movement of silt taking place at present.

Homeb series

At Homeb (23° 38' S, 15° 09' E), 15km upstream from Gobabeb in Kuiseb R gorge, 100km SE of Walvis Bay, remnants of well-stratified lacustrine-like silt sediments occur, possibly deposited in stormwater lake at time when Kuiseb R was blocked by sand dunes (Scholz, 1972). In upper part of ca 27m sedimentary column numerous thin carbonate-cemented layers are present. In lower part small freshwater gastropod shells are found. An attempt was made to date formation by means of these carbonates and shells. In addition, samples of calcrete crust on desert plain between dunes S of river and carbonate cement of coarse gravel ca 40m above river bed on S bank were analyzed. Samples coll and subm by J C Vogel.

Pta-1494. Homeb 9a calcrete **28,900 ± 490**
 $\delta^{13}C = +0.1\text{‰}$

Younger generation of distinctly two-phase hardpan from ca 110m above river bed on top of S bank of Kuiseb R at Homeb. This hardpan crust occurs extensively in dune streets between river and Tsondabvlei. Coll 1975. *Comment:* 19% sample removed with acid and rest analyzed. CaCO₃ content: 32%.

Pta-2419. Homeb 9b calcrete **28,100 ± 480**
 $\delta^{13}C = +0.5\text{‰}$

Another sample of same younger generation calcrete as Pta-1494, above. Coll 1978. *Comment:* 10% carbonate removed with acid and rest analyzed. CaCO₃ content: 46%.

Pta-2426. Homeb 9b nodules fr 1 **30,700 ± 510**
 $\delta^{13}C = -3.6\text{‰}$

Pta-2427. Homeb 9b nodules fr 2 **32,700 ± 600**
 $\delta^{13}C = -3.7\text{‰}$

Two fractions of nodules forming first phase of hardpan formation, same sample as Pta-2419. *Comment:* 6% carbonate removed with acid, then 50% coll as fraction 1, and remaining 44% coll as fraction 2. Small age difference between fractions 1 and 2 show absence of recent contamination. Results suggest calcrete formed between 33,000 and 28,000 BP.

Pta-1493. Homeb 8a conglomerate **29,400 ± 520**
 $\delta^{13}C = -3.3\text{‰}$

Calcium carbonate cement of top of coarse river gravel forming terrace on S bank of Kuiseb R at Homeb ca 40m above river bed. Coll 1975. *Comment:* first 21% sample rejected, remaining carbonate analyzed. CaCO₃ content: 38%.

Pta-2355. Homeb 8b conglomerate **28,900 ± 500**
 $\delta^{13}C = -3.7\text{‰}$

Another sample of same river gravel as Pta-1493, coll 1978. *Comment:* first 36% sample rejected; remaining carbonate analyzed. CaCO₃ content: 80%.

Pta-2329. Homeb 8c conglomerate fr 1 **34,500 ± 1000**
 $\delta^{13}C = -5.0\text{‰}$

Pta-2330. Homeb 8c conglomerate fr 2 **35,600 ± 1500**
 $\delta^{13}C = -5.2\text{‰}$

Two fractions of carbonate cement of river gravel on S bank of Kuiseb R at Homeb, 14m below top of terrace and underlying Homeb 6 and 7, below. *Comment:* 34% carbonate removed with acid, then 35% coll as fraction 1 and remaining 31% coll as fraction 2. Similar age of two fractions shows absence of recent contamination. Results for terrace sug-

gest cementing took place gradually as gravel bed accumulated and ended ca 28,000 BP.

General Comment: similarity of dates for samples 8 and 9 suggests moist period until 28,000 BP; see also similar date for Narabeb root cast, above and Gobabeb reed casts, below.

Pta-1861. Homeb 11 **20,100 ± 220**
 $\delta^{13}C = -2.4\%$

Thin calcified crust on top of silt deposit ca 38m above river bed inside valley N of Kuiseb R. Coll 1977. *Comment:* first 36% sample rejected and remaining carbonate analyzed. CaCO₃ content: 33%.

Pta-1860. Homeb 13 root casts **19,600 ± 170**
 $\delta^{13}C = -8.5\%$

Carbonate root casts (?) from 1m below top of silt deposit. Coll 1977. *Comment:* first 44% sample rejected and rest analyzed. CaCO₃ content: 56%.

Pta-1492. Homeb 2 **22,300 ± 320**
 $\delta^{13}C = -2.4\%$

Calcified crust ca 6.8m below top of silt. Coll 1975. *Comment:* CaCO₃ content: 1.7%; all carbonate used for analysis.

Pta-2083. Homeb 14 **18,100 ± 160**
 $\delta^{13}C = -1.9\%$

Calcified crust ca 8m below top of silt. Coll 1977. *Comment:* first 7% sample discarded. CaCO₃ content: 10.8%.

Pta-1862. Homeb 15 **25,000 ± 350**
 $\delta^{13}C = -1.5\%$

Calcified crust ca 11.5m below top of silt. Coll 1977. *Comment:* first 38% sample discarded and rest analyzed. CaCO₃ content: 30.6%.

Pta-1822. Homeb snails **23,500 ± 660**
 $\delta^{13}C = -1.8\%$

Small freshwater gastropod shells from lower half of silt deposit. Coll 1974 by B H Sandelowsky and 1975 by J C Vogel. *Comment:* first 15% 7.6g sample discarded and rest analyzed.

General Comment: extremely low carbonate content of silt levels intervening calcified crusts indicates absence of primary carbonate in deposit. Since calcification must have taken place during desiccation of floodwater accumulations in course of silt accumulation and recent contamination by rain or fog seems to be absent in region (see Meob and Conception reeds, above), results expected to date deposition of silt and, thus, damming of Kuiseb R at ca 20,000 BP.

Pta-2008. Homeb 16 **10,600 ± 110**
 $\delta^{13}C = -6.1\%$

At mouth of side valley and closer to present river bed ca 3m silt occurs on top of coarse river gravel at ca 9m above river. 50cm above gravel

calcified crust coll 1977 for analysis. *Comment*: first 15% sample discarded and remainder analyzed. CaCO₃ content: 12.7%. Deposit apparently much more recent than silts described above.

Pta-1548. Homeb 6 **12,700 ± 100**
 $\delta^{13}C = -1.3\text{‰}$

Slightly calcified level on top of silt visible on S bank of Kuiseb R ca 30m above bed and separated from cemented gravel remnant (Homeb 8, above) by ca 10m sand. Coll 1975. *Comment*: CaCO₃ content 7.7%, all carbonate used for analysis.

Pta-1580. Homeb 7 **6830 ± 70**
 $\delta^{13}C = -0.1\text{‰}$

Slightly calcified level just below Homeb 6 in silt. Coll 1975. *Comment*: CaCO₃ content 4.5%; all carbonate used for analysis.

General Comment: carbonate of latter two samples may derive from overlying conglomerate (Homeb 8, above) by agent of water percolating (through sand and accumulating) on top of silts, thus explaining young dates.

Gobabeb series

In two dune valleys S of Kuiseb R and just W of Gobabeb Desert Research Sta, 88km SE of Walvis Bay, calcified features indicate presence of more moisture in past. Rock outcrops presumably caused moist conditions at these sites when water table was high.

Pta-2651. Gobabeb reed cast fr 1 **21,300 ± 260**
 $\delta^{13}C = +1.3\text{‰}$

Pta-2652. Gobabeb reed cast fr 2 **21,500 ± 260**
 $\delta^{13}C = +1.3\text{‰}$

Reed casts near granite outcropping in dune valley (23° 34' S, 15° 00' E) high above S bank of Kuiseb R, opposite Gobabeb. Coll and subm 1979 by J D Ward, Pietermaritzburg. *Comment*: 7% carbonate removed with acid; next 42% analyzed as fraction 1; final 51% analyzed as fraction 2. CaCO₃ content: 82%. Similarity of results indicates absence of recent contamination and reliability of date.

Pta-1091. Gobabeb root cast **20,900 ± 230**
 $\delta^{13}C = -5.2\text{‰}$

Calcified root cast from dune valley (23° 32' S, 14° 58' E), 6.5km W of Gobabeb and 1km S of Kuiseb R, possibly of nara plant that grew when more moisture was available. Coll and subm 1973 by M K Seely. *Comment*: 22% carbonate removed with acid and rest analyzed. CaCO₃ content: 59%.

Pta-2604. Gobabeb termite nest **21,500 ± 190**
 $\delta^{13}C = -3.6\text{‰}$

Pta-2584. Gobabeb worm cast **22,400 ± 210**
 $\delta^{13}C = -2.8\text{‰}$

Calcified termite nest and worm channel on base of dune in same valley as Pta-1091. Coll and subm 1979 by J C Vogel. *Comment:* 29% carbonate removed with acid and rest analyzed. CaCO_3 content: 27% in both cases.

Pta-2590. Gobabeb reed casts fr 1 **27,400 ± 310**
 $\delta^{13}C = -4.5\text{‰}$

Pta-2591. Gobabeb reed casts fr 2 **28,500 ± 370**
 $\delta^{13}C = -4.4\text{‰}$

Reed casts embedded in crust on floor of same dune valley. Coll and subm 1979 by J C Vogel. *Comment:* 7% carbonate removed with acid; next 43% analyzed as fraction 1; final 50% analyzed as fraction 2. CaCO_3 content: 66%. Similarity of results indicates minimal recent contamination and reliability of date.

Pta-2588. Gobabeb reed casts fr 1 **31,900 ± 460**
 $\delta^{13}C = -8.5\text{‰}$

Pta-2589. Gobabeb reed casts fr 2 **31,600 ± 430**
 $\delta^{13}C = -8.6\text{‰}$

Reed casts from same locality as previous sample, but slightly higher elevation. Coll and subm 1979 by J C Vogel. *Comment:* 7% carbonate removed with acid; next 43% analyzed as fraction 1; final 50% analyzed as fraction 2. CaCO_3 content: 71%. Similarity of results indicates absence of recent contamination and reliability of date.

General Comment: repeated occurrences of dates between 39,000 and 28,000 BP (this series, Homeb, Narabeb), and ca 21,000 BP (this series, Homeb), strongly suggest two distinct moist periods during late Pleistocene in Central Namib desert.

Kuiseb Driftwood series

Along lower Kuiseb R logs of driftwood occur high above present river bed in desert. Dating provides information on exceptionally large floods in past.

Pta-2583. Kuiseb wood 2 **940 ± 35**
 $\delta^{13}C = -24.2\text{‰}$

Outer piece of driftwood log 100m above tree line on N bank of Kuiseb R (23° 26' S, 14° 56' E), ca 15km downstream from Gobabeb.

Pta-2582. Kuiseb wood 1 **160 ± 35**
 $\delta^{13}C = -25.8\text{‰}$

Outer piece of driftwood log 300m above tree line at same location as Pta-2583. Samples coll and subm 1979 by M K Seely. *Comment:* calibrated date younger than AD 1660; could also date to AD 1934 flood.

Pta-2632. Kuiseb wood 3**290 ± 35** $\delta^{13}C = -25.6\text{‰}$

Outer piece of driftwood log ca 1000m S of Kuiseb R on silt in dune street today blocked by cross dune from river bed (23° 21' S, 14° 49' E), 3km upstream from Swartbank. *Comment:* calibrated date between AD 1490 and 1630.

Pta-2638. Kuiseb wood 4**140 ± 60** $\delta^{13}C = -25.1\text{‰}$

Outer piece of driftwood log at same location as Pta-2632, but closer to river. Samples coll and subm 1979 by J C Vogel. *Comment:* calibrated date AD 1660 to 1950. ^{14}C variations do not allow closer dating, but show exceptional floods have occurred since AD 1660 and cross dune is younger.

Rooibank series

During construction of production well in sand bed of Kuiseb R (23° 14' S, 14° 43' E), 10km upstream of Rooibank, near Walvis Bay, wood fragments were recovered at depth. Subm 1972 by P F Hamman, Dept Water Affairs, Windhoek.

Pta-689. Rooibank wood 2**60 ± 45** $\delta^{13}C = -25.9\text{‰}$

Stick from 21.4m depth in river sand.

Pta-604. Rooibank wood 1**80 ± 50** $\delta^{13}C = -26.0\text{‰}$

Stick from 13.7m depth in same well as previous sample.

General Comment: results suggest rapid accumulation of 21m sand in river bed in 2nd half of 19th century, possibly following extensive washout by exceptional flood.

Welwitschia series

Famous Gymnosperm (*Welwitschia mirabilis*) endemic to Namib desert is thought to become very old. Radiocarbon determination of life-span, however, only possible by sectioning stunted trunk to obtain oldest wood for dating. Samples taken from center of trunk of living plant can only give min age. Growth rate of the two leaves can be determined by using recent increase in ^{14}C level of atmosphere. Samples from Welwitschia Plain (22° 41' S, 15° 00' E), ca 100km from coast, 4km N of Swakop R, Namib Desert Park. Coll and subm by H Borman and J C Vogel.

Pta-1835. Welwitschia 2**480 ± 45** $\delta^{13}C = -23.1\text{‰}$

Wood from underneath stem of largest *Welwitschia* plant in vicinity; coll 1977. *Comment:* age of plant probably considerably older than 480 yr. Previous date for wood, possibly from same specimen, is M-1885: 920 ± 100 (R, 1970, v 12, p 161).

Pta-889. Welwitschia 1 **260 ± 70**
 $\delta^{13}C = -19.9\text{‰}$

Old wood from *Welwitschia* plant with stem diam ca 60cm. Coll 1972. *Comment*: sample from center of stem sec, thus close to oldest wood. Calibrated date AD 1630, ie, 340 yr old in 1972.

Pta-1907. Welwitschia leaf 3.85m **(128.3 ± 0.5)‰**
 $\delta^{13}C = -21.5\text{‰}$

Pta-1839. Welwitschia leaf 2.85m **(157.3 ± 0.7)‰**
 $\delta^{13}C = -21.6\text{‰}$

Pta-1838. Welwitschia leaf 1.85m **(146.9 ± 0.6)‰**
 $\delta^{13}C = -21.8\text{‰}$

Leaf, 4m long, of medium-sized *Welwitschia* plant growing on Welwitschia Plain, coll Feb 1977. Samples taken at 3.85, 2.85, and 1.85m from stem. To check difference in age of alkali soluble matter and acid and alkali insoluble matter (mainly cellulose) further 20cm sec was pretreated with acid and alkali:

Pta-2155. Welwitschia leaf 3.7m (insol fr) **(125.1 ± 0.5)‰**
 $\delta^{13}C = -20.9\text{‰}$

Pta-2154. Welwitschia leaf 3.7m (alk sol fr) **(137.6 ± 1.1)‰**
 $\delta^{13}C = -23.5\text{‰}$

Comment: alkali soluble fraction, Pta-2154, contains younger carbon than insoluble fraction, Pta-2155, and allowance must be made for this in interpretation of Pta-1907, -1839, and -1838. By matching results to curve for atmospheric CO₂ (R, 1971, v 13, p 392) the tip (3.85m) is dated to growth of AD 1962 and average growth rate is 26cm/yr.

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