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RADIOCARBON AGE OF QUATERNARY DEPOSITS, WESTERN ROLLING PLAINS OF TEXAS

by
S. Christopher Caran
Robert W. Baumgardner, Jr.

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Bureau of Economic Geology
W.L. Fisher, Director
The University of Texas at Austin
University Station, P.O. Box X
Austin, Texas 78713

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Four laboratories have made more than fifty finite radiocarbon-age determinations on samples from Quaternary deposits covering a large area of the Rolling Plains. These dates span the period from the late Pleistocene Epoch (23,255 ± 2,335 yr b.p.) virtually to the present.

Caran and Baumgardner (1984) described a previously unrecognized sedimentary sequence covering more than 7,800 km^2 (3,000 mi^2) of northwestern Texas. At the time that report was prepared only a few relevant radiocarbon-age determinations were available. The number of reliable finite dates has now increased to more than fifty, the oldest of which is 23,255 ± 2,335 yr b.p. Older infinite dates and a few questionable finite determinations also have been obtained, some of which were reported previously by other investigators.

A few radiocarbon analyses of bone and mollusk shell and one analysis of caliche (pedogenic calcium carbonate) are included in this summary, but most dates were obtained from organic humates in buried soils and lacustrine deposits. The general reliability of age determinations from analyses of various types of samples is discussed by Stuckenrath (1977), Worsley (1981, p. 277-287), and Meltzer and Mead (1983, p. 131). Wood is the ideal material for radiocarbon dating. Collagen, the principal organic protein in bone, can be satisfactorily dated if the bone is well preserved (Worsley, 1981, p. 283). Rightmire (1967) developed a system of calibration for dating caliche originally considered appropriate for use in northwestern Texas. But more recent findings in other areas such as the southern Strzelecki Desert of South Australia (Callen and others, 1983) indicate that caliches may not provide representative dates. Analyses of caliche appear to have limited value unless they are constrained by an independent chronology.

Other materials also pose analytical difficulties. Shells of mollusks are notoriously unreliable for dating because the organisms may incorporate older carbonate from sediment or aqueous solution (Keith and Anderson, 1963; Goodfriend and Stipp, 1983; Riggs, 1984). Organic matter in soils and lacustrine deposits may be difficult to concentrate, and is subject to contamination through late introduction of humic acids and pedogenic or diagenetic carbonate (Krishnaswami and Lal, 1978, p. 166-168; Birkeland, 1984, p. 150-152). However, careful treatment of these sediments can provide usable dates and organic humates often are relied upon in the absence of available wood or bone collagen (Worsley, 1981, p. 283).

Researchers interested in establishing a practical chronostratigraphy and less concerned with the dating techniques themselves tend to rely on whatever dates are available. This is no less true in our studies although we recognize the limitations of the procedures and have made a reasonable effort to prevent or reduce the intrusion of spurious data or conclusions. The dates summarized in table 1 and figure 1 are compiled from original analyses and the published work of others. Ages have been adjusted for $\delta^{13}C$ values where possible. Samples were collected at sites identified in figure 2. Comparison of dates from correlative deposits, and from strata in superposition, provides a good indication of the reliability of these analyses. And in a few cases, duplicate samples were analyzed by different laboratories. Comparisons among dates should be made at the 2σ (95-percent) level of confidence.

The dates range from a maximum of >38,260 yr b.p. (Beta 8969) to a minimum of <110 yr b.p. (Beta 9602) (table 1). Some of the samples almost certainly were contaminated with younger carbon and their corresponding dates should be ignored: Beta 9606; Beta 9616; UT TX 2880; and perhaps Beta 9587. This is not a failure of the techniques or the laboratories. In each of these instances, the amount of organic matter was a very low percentage of the sample, or there was a distinct possibility of contamination with humic acid. For example, humic acids could not be separated from Beta 9587 because the amount of organic carbon was too small.

Experience elsewhere argues that some dates probably should be rejected out of hand. Included in this category are results of older analyses of mollusk shell (SMOC 1, 2). But these dates are not incompatible with the two infinite dates from this site (TX 4900 and Beta 8969, although they too are highly suspect except as minima) or with the inferred regional stratigraphy. Similarly, the determined age of the one sample of caliche in table 1 (TX 4885) must be questioned on general grounds. In fact, collateral data from the same site appear to indicate the caliche date is a few thousand years too young.

No special circumstances or internal inconsistencies are evident that would eliminate any of the other dates. Several of these are supported by analyses of duplicate samples or by compatible superposition of ages. However, the small percentage of organic matter in many of the samples requires cautious acceptance of these dates. A detailed assessment of each date will be the focus of future studies.

In summary the existing suite of radiocarbon dates provides a reasonably well constrained chronology from which stratigraphic and paleoenvironmental interpretations can be made. Deposits covering the western Rolling Plains range from late Pleistocene to latest Holocene in age. A shift from lacustrine environments to soil-forming drylands was inferred from the stratigraphic sequence (Caran and Baumgardner, 1984). The onset of this transition clearly began in early Holocene time. Additional work is needed to confirm the reliability of dates in other key parts of the section that appear to be widely correlative.

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FIGURE CAPTIONS

Figure 1. Distribution of radiocarbon dates from original or previously reported analyses. All samples were collected at sites in the western Rolling Plains of Texas. Letter designations correspond to those in figure 2, numbers refer to the following laboratory sample numbers (see table 1): (A1) TX 4319; (A2) TX 4320; (B3) TX 4659; (B4) TX 4660; (B5) TX 4661; (B6) TX 4662; (B7) SMU 856; (B8) SMU 866; (B9) TX 2879; (B10) TX 2880; (B11) TX 4663; (B12) TX 4664; (C13) TX 4321; (C14) TX 4322; (D15) TX 4326; (D16) TX 4327; (E17) TX 4324; (E18) TX 4323; (F19) Beta 9586; (F20) Beta 9587; (F21) TX 4325; (F22) Beta 9588; (G23) TX 3906; (H24) Beta 9600; (H25) Beta 9601; (I26) TX 4901; (I27) Beta 9597; (I28) TX 4902; (I29) Beta 9598; (I30) TX 4903; (I31) Beta 9599; (J32) Beta 9595; (J33) Beta 9596; (J34) Beta 9589; (K35) Beta 9591; (K36) Beta 9592; (L37) TX 4898; (L38) Beta 9602; (L39) TX 4899; (L40) Beta 9603; (L41) Beta 9607; (L42) Beta 9606; (L43) Beta 9605; (L44) Beta 9604; (M45) Beta 9615; (M46) Beta 9616; (N47) TX 4900; (N48) Beta 8969; (N49) SMOC 1; (N50) SMOC 2; (O51) TX 4885; (P52) Beta 9594; (Q53) Beta 9610; (Q54) Beta 9611; (Q55) Beta 9612; (Q56) Beta 9613; (R57) Beta 9608; (R58) Beta 9609. No data (insufficient organic carbon in sample): Beta 9590; Beta 9593; Beta 9614; TX 4883; TX 4884.

Figure 2. Geologic map of part of the western Rolling Plains, indicating sites from which radiocarbon samples were collected. Letters designations correspond to those in figure 1.

Table 1. Summary of radiocarbon dates.

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1 σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
[A]	Upper Holmes Creek (031481-1)	2 [upper]	Highly calcareous silty clay (lacustrine deposit)	NR	TX 4319	Within interval 140-180	9,740 ± 160	--	--	--
		2 [middle]	-Same-	NR	TX 4320	Within interval 180-215	11,020 ± 160	--	--	--
[B]	Lake Theo archeological site (82032401, also designated 41B170)	10 [soil horizon A1, 5-10 cm below top]	Calcareous silty clayey sand (modern soil)	1	TX 4659	5-10	950 ± 60	--	--	1.2
		9 [soil horizon IIA1b1, 5-10 cm below top]	Calcareous clayey slightly sandy silt (buried soil)	2	TX 4660	100-105	3,520 ± 470	--	--	1.0
		7 [soil horizon IVA11b2, 4-9 cm below top]	Silty clayey sand (buried soil)	3	TX 4661	190-195	5,660 ± 180	--	--	1.0
		7 [soil horizon IVA11b2, 19-24 cm below top]	-Same-	4	TX 4662	205-210	5,540 ± 180	--	--	1.0
		6 [soil horizon IVA11b3, top]	Calcareous clayey silty sand (buried soil)	NR	SMU 856	Approx. 310-320	9,420 ± 85	--	--	1.2
		6 [soil horizon IVA12b3, bottom]	Calcareous silty slightly sandy clay (buried soil)	NR	SMU 866	Approx. 355-365	9,950 ± 110	--	--	1.8
		6 [bone bed W.T. 7; soil horizon IVB2b3]	Calcareous clayey silty sand (buried soil)	NR (Bones of *Bison antiquus* associ-	TX 2879	Within interval 367-413	9,360 ± 170	--	--	0.50
				ated with Folsom artifacts)	TX 2880	-Same-	8,010 ± 100	--	--	0.50

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
	Lake Theo archeological site (continued)	3 [soil horizon VIIAlcab4, 5-15 cm below top]	Highly calcareous silty sandy clay (lacustrine deposit)	5	TX 4663	455-460	11,040 ± 270	--	--	1.5
		3 [soil horizon VIIA1cab4, 20-25 cm below top]	-Same-	6	TX 4664	470-475	11,980 ± 320	--	--	1.5

Dates on bones (soil horizon IVB2b3) were reported by Harrison and Killen (1978, Addendum).
Dates from the SMU laboratory (soil horizons IVA11b3 and IVA12b3) and percentages of organic carbon were reported by Johnson and others (1982, table 2 and fig. 4).
Depths of some of the sampled strata do not correspond precisely to the depths of soil horizons given by Johnson and others (1982, table 1) because these samples were not collected from the same profile. However, Holliday (personal communication, March, 1982) extended the original horizon boundaries to the site of sampling to ensure consistent stratigraphic correlation. Descriptions of units do not in every case agree precisely with those of Johnson and others (1982).

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
[C]	Lake Theo: south bank (83082709, previously designated 031581-1)	8 [upper]	Highly calcareous silty sandy clay (lacustrine deposit)	NR	TX 4321	Approx. 700-710	12,470 ± 290	--	--	--
		8 [middle]	-Same-	NR	TX 4322	Approx. 735-745	13,400 ± 300	--	--	--
[D]	Lake Theo: southeast bank (031681-1)	8 [upper]	Highly calcareous silty slightly sandy clay (lacustrine deposit)	NR	TX 4326	Approx. 690-700	8,560 ± 290	--	--	--
		8 [lower]	Highly calcareous sandy silt (lacustrine deposit)	NR	TX 4327	Approx. 760-770	8,640 ± 170	--	--	--
[E]	Lower Holmes Creek (031581-5)	7 [upper]	Highly calcareous silty clay (lacustrine deposit)	NR	TX 4324	Approx. 745-755	12,640 ± 180	--	--	--
		7 [lower]	-Same-	NR	TX 4323	Within interval 800?-830	13,210 ± 210	--	--	--
[F]	Little Red River terrace: measured section (031581-7, previously designated 011580-2)	3 [lowermost 10 cm]	Clayey silty very fine sand (buried soil)	5A,B	Beta 9586	90-100	1,470 ± 130	-25.26	1,465 ± 130	0.08
		8 [5-13 cm below top]	Organic-rich sandy clayey silt (buried soil)	6A,B	Beta 9587	297-305	1,400 ± 70	-19.14	1,495 ± 80	0.13

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1 σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
	Little Red River terrace (continued)	10 [10-17 cm below top]	Silty clay (buried soil)	7	TX 4325	755-762	1,640 ± 70	--	--	--
		10 [10-20 cm below top]	-Same-	NR	Beta 9588	755-765	1,990 ± 100	-15.93	2,140 ± 110	0.13
[G]	Unnamed tributary of Little Red River (110679-B)	Not reported	Alluvial fill in an abandoned stream channel	NR (Bones of *Bison* sp.)	TX 3906	Not reported	920 ± 190	--	--	--
[H]	Henson farm: measured section (83040909)	3 [20-30 cm below top]	Clayey very fine sandy silt (buried soil)	1A,B	Beta 9600	170-180	1,280 ± 60	-15.66	1,435 ± 70	0.15
		6 [10-20 cm below top]	Calcareous silty clay (lacustrine deposit)	2A,B	Beta 9601	340-350	9,580 ± 130	-15.93	9,730 ± 140	0.14
[I]	Henson farm: measured section 15C (83040908)	2 [uppermost 5 cm]	Silty sand (buried soil)	1A	TX 4901	28-33	330 ± 80	--	--	--
				1B (duplicate of 1A)	Beta 9597	28-33	<320	-16.35	--	0.05
		4 [uppermost 10 cm]	Organic-rich sandy silt (buried soil)	2A	TX 4902	250-260	1,670 ± 70	--	--	--
				2B (duplicate of 2A)	Beta 9598	250-260	1,520 ± 80	-13.93	1,700 ± 90	0.09
		5 [53-63 cm below top]	Silty clay (lacustrine deposit)	3A	TX 4903	390-400	6,410 ± 90	--	--	--
				3B (duplicate of 3A)	Beta 9599	390-400	6,120 ± 160	-14.96	6,285 ± 170	0.09

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
[J]	Henson farm: measured section 15B (83040601)	2 [uppermost 3 cm]	Silty clay (buried soil)	1	Beta 9595	37-40	<180	-16.93	--	0.12
		2 [lowermost 6 cm]	Fine sandy silt (buried soil)	2	Beta 9596	66-72	850 ± 60	-15.38	1,010 ± 70	0.17
		4 (originally designated unit 7) [2-6 cm below top]	Silty sandy clay (lacustrine ? deposit)	3	Beta 9589	325-329	1,880 ± 70	-21.20	1,950 ± 80	0.12
		4 (originally designated unit 7) [14-18 cm above base]	-Same-	5	Beta 9590	440-444	Insufficient organic carbon	--	--	--
[K]	Henson farm: measured section 15A (83040701)	1 (originally designated unit 4) [2-4 cm below top]	Slightly gravelly sandy silt (exhumed soil)	1	Beta 9591	2-4	360 ± 80	-17.90	480 ± 75	0.16
			Silty sand (exhumed soil)	2	Beta 9592	36-38	630 ± 70	-17.12	765 ± 75	0.15
	Henson farm: 15 m north of measured section 15A (83040701)	4 (originally designated unit 1) [85-105 cm below top]	Lens of fine to medium sandy clay within silty fine to medium sand (lacustrine deposit)	10A,B	Beta 9593	1,125-1,145	Insufficient organic carbon	--	--	--
[L]	Smith farm: measured section (83062401)	2 [uppermost 5 cm]	Silty sandy clay (buried soil)	1A	TX 4898	130-135	1,000 ± 70	--	--	--
				1B (duplicate of 1A)	Beta 9602	130-135	<110	-16.00	--	0.31
		2 [10-20 cm above base]	-Same-	2A	TX 4899	160-170	2,970 ± 70	--	--	--
				2B (duplicate of 2A	Beta 9603	160-170	1,160 ± 70	-13.03	1,355 ± 80	0.56
		5 [10-45 cm below top]	Silty fine sandy clay (lacustrine deposit)	25A,B	Beta 9607	540-575	14,920 ± 490	-19.44	15,110 ± 500 (cf. Beta 9606)	0.16

Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
Smith farm (continued)	6 [5-20 cm below top]	Silty clayey very fine sand (lacustrine deposit)	24A,B	Beta 9606	590-605	11,560 ± 990	-20.97	11,625 ± 1,000 (cf. Beta 9607)	0.03
	8 [25-55 cm above base]	Calcareous clay (lacustrine deposit)	22A,B	Beta 9605	1,175-1,205	18,650 ± 1,350	-23.99	18,665 ± 1,355	0.19
	9 [20-45 cm below top]	-Same-	21A,B	Beta 9604	1,250-1,275	23,240 ± 2,330	-26.23	23,255 ± 2,335	0.08
[M] Blair farm: measured section (83050802)	3 [10-20 cm below top]	Slightly clayey fine sand (buried soil)	21A,B (originally designated 5 and 6)	Beta 9615	90-100	1,230 ± 90	-17.39	1,350 ± 100 (cf. Beta 9616)	0.06
	3 [20-30 cm below top]	-Same-	22A,B (originally designated 7 and 8)	Beta 9616	100-110	140 ± 100	-16.40	280 ± 110 (cf. Beta 9615)	0.04
	5 [90-110 cm below top]	Clayey sandy silt (lacustrine ? deposit)	9A,B	Beta 9614	390-410	Insufficient organic carbon	--	--	--
[N] Edwards farm: Quitaque Local Fauna type locality (83062302)	3 [55-60 cm above base]	Calcareous clay (lacustrine deposit)	5A	TX 4900	735-745	>35,000	--	--	--
			5B (duplicate of 5A)	Beta 8969	-Same-	>38,260	-20.44	--	0.30
	Probably 3	Shell of pelecypod	NR	SMOC (analysis 1)	Probably within interval 375-795	31,400 ± 5,600	--	--	--
		-Same- (same shell ?)	NR	SMOC (analysis 2)	-Same-	31,400 ± 3,200	--	--	--

Dates obtained on shell were reported by Dalquest (1964, p. 505).
Dalquest (personal communication, April 1984) agreed that the shell that was analyzed probably had been collected from the outcrop of unit 3.

Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
[O] Turkey railroad cut: measured section, eastern wall (83040901)	1D [5-15 cm below top]	Caliche developed in sandy gravel (buried soil)	12A,B	TX 4885	170-180	18,680 ± 260 (Note: large adjustment required)	-1.73	480-1,650 (older date based on 50% CO_2 exchange with air)	-- --
	2A [15-15 cm below top]	Calcareous silty clay (lacustrine deposit)	11A,B,C,D	TX 4884	225-235	Insufficient organic carbon	--	--	--
	2C [5-15 cm below top]	-Same-	10A,B,C,D	TX 4883	365-375	Insufficient organic carbon	--	--	--
[P] Turkey railroad cut: measured section, eastern wall, 10 m south of previous measured section (83040901)	1B [10-20 cm below top]	Clayey silty sand (buried soil)	21A,B	Beta 9594	35-45	1,120 ± 90	-18.24	1,235 ± 100	0.13
[Q] Turkey railroad cut: measured section, eastern wall, 180 m south of bridge (83040802)	2 [uppermost 5 cm]	Clayey fine sandy silt (buried soil)	1	Beta 9610	38-43	660 ± 70	-14.46	830 ± 80	0.29
	2 [lowermost 3 cm]	-Same-	2	Beta 9611	47-50	1,070 ± 60	-13.35	1,260 ± 70	0.29
	4 [uppermost 5 cm]	Silty sandy clay (buried soil)	3	Beta 9612	85-90	4,070 ± 110	-15.29	4,230 ± 120	0.31
	4 [23-28 cm above base]	-Same-	4	Beta 9613	110-115	6,490 ± 130	-15.93	6,640 ± 150	0.18

	Site name (number)[1]	Unit number	Unit description	BEG sample number[2]	Lab name, sample number[3]	Sample depth (cm)	^{14}C age ± 1 σ (yr)[4]	$\delta^{13}C$[5]	Adjusted age (yr)[6]	Sample % C
[R]	Turkey railroad cut: measured section, western wall (84050901)	3 [95-120 cm below top]	Silty sandy clay (buried soil?)	1A,B	Beta 9608	150-175	9,470 ± 120	-16.79	9,510 ± 130	0.43
		4 [55-80 cm below top]	Silty sandy clay (lacustrine ? deposit)	2A,B	Beta 9609	350-375	12,710 ± 140	-18.90	12,810 ± 150	0.2

1 Letter in brackets corresponds to site designations in figures 1 and 2.
2 BEG = Bureau of Economic Geology; NR = sample number not reported.
3 Radiocarbon laboratories: Beta = Beta Analytic, Inc., P.O. Box 248113, Coral Gables, Florida 33124; SMOC = Sacony Mobile Oil Company, formerly in Dallas, Texas, now inactive; SMU = Southern Methodist University, Institute for the Study of Earth and Man, Radiocarbon Laboratory, Dallas, Texas 75275; TX = The University of Texas at Austin, Radiocarbon Laboratory, Balcones Research Center, Austin, Texas 78758.
4 Radiocarbon age, expressed as years before 1950 ("present") plus and minus one standard statistical deviation (±1 σ) which defines the 68-percent confidence interval of the analysis. For some purposes dates should be compared over the 95-confidence interval (±2 σ). See figure 1.
5 Stable-isotope composition of the sample, conventionally expressed as a ratio. The $\delta^{13}C$ value serves as a correction factor and as a check on the initial determination of radiocarbon age.
6 Age after adjustment for $\delta^{13}C$ value, if the stable-isotope composition of the sample was determined. Adjusted age is expressed as years before 1950 plus and minus one standard deviation.

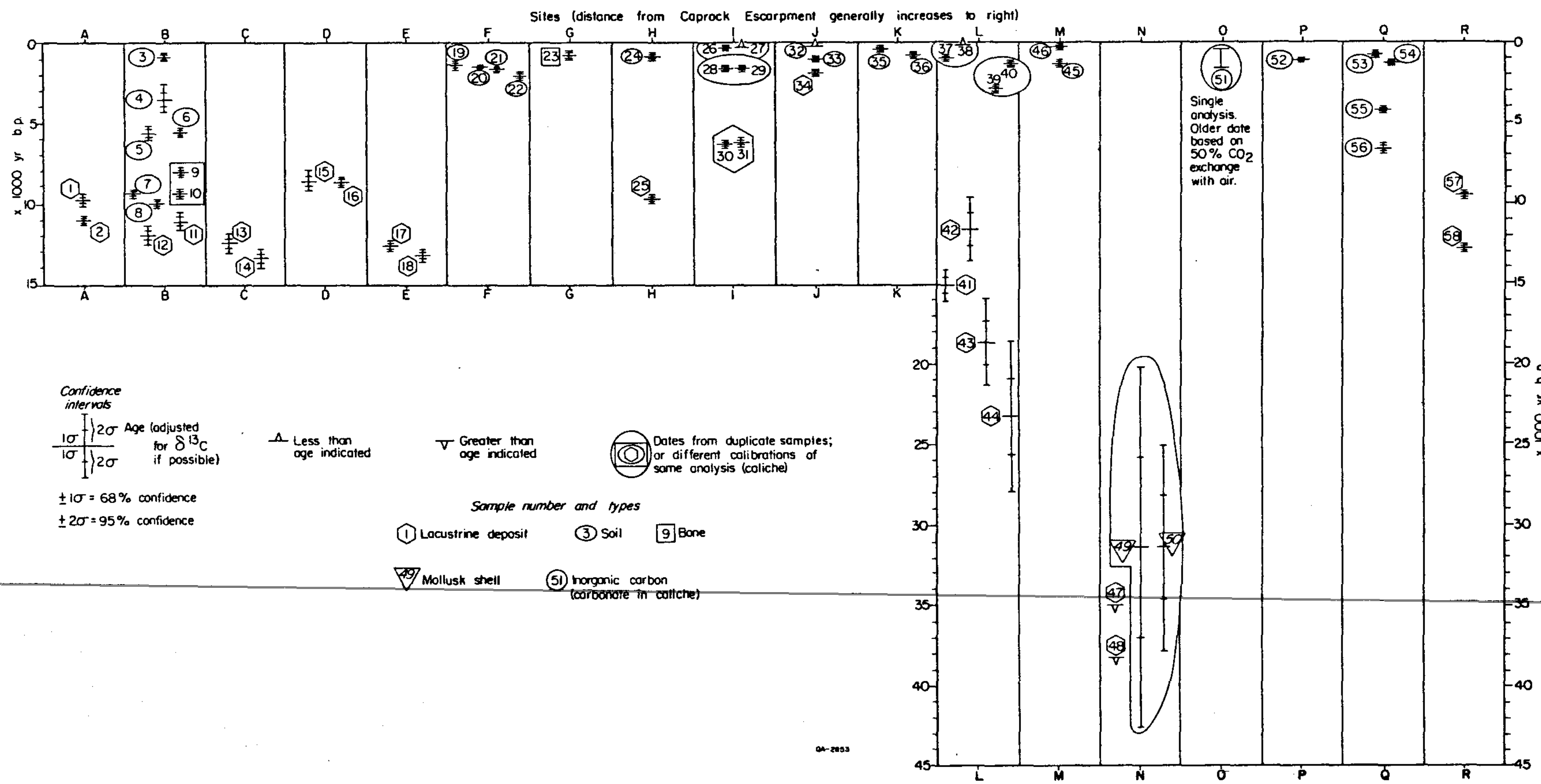

Figure 1. Distribution of radiocarbon dates from original or previously reported analyses. All samples were collected at sites in the western Rolling Plains of Texas. Letter designations correspond to those in figure 2; numbers refer to the laboratory sample numbers (see table 1.)

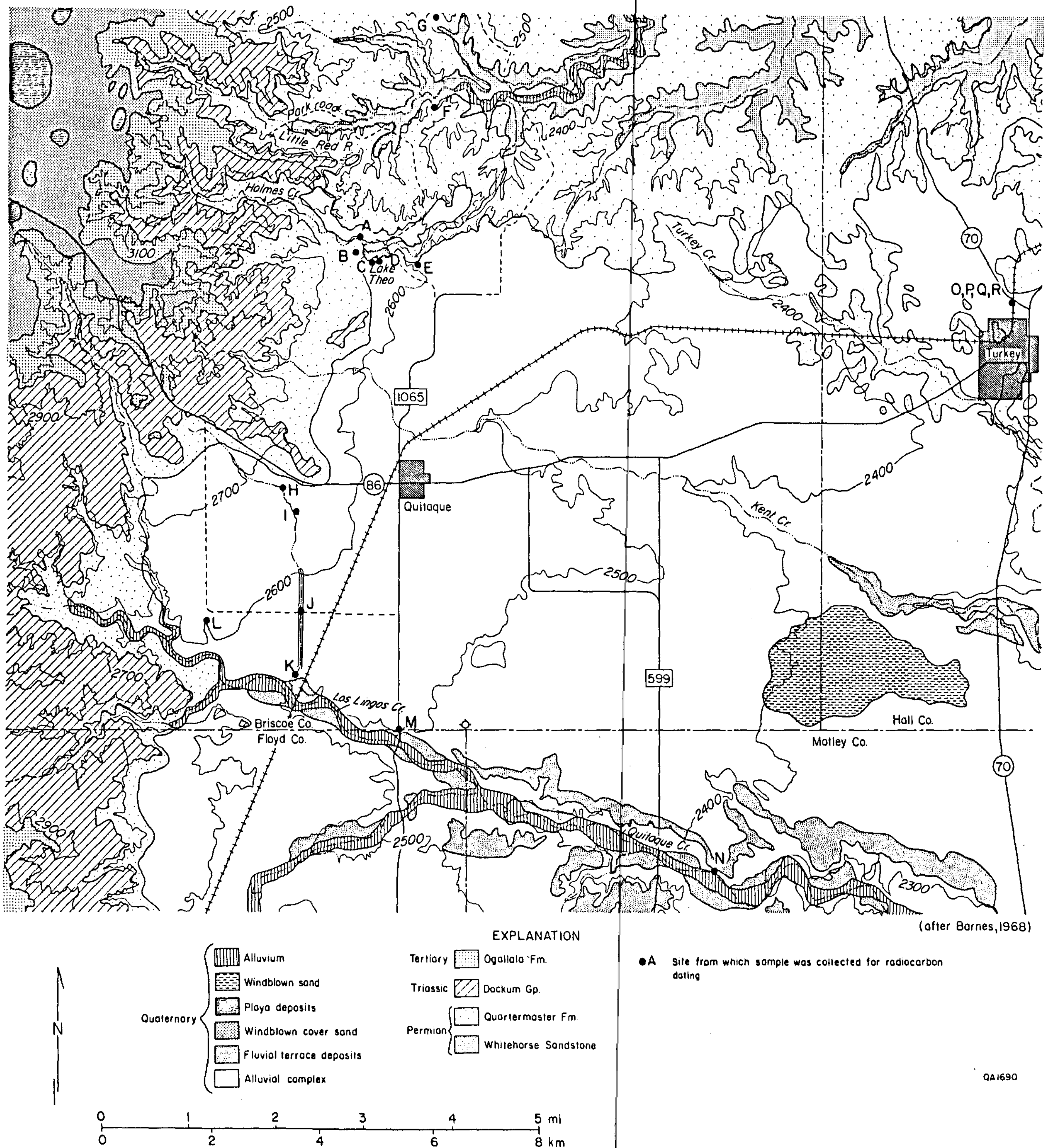

Figure 2. Geologic map of part of the western Rolling Plains, indicating sites from which radiocarbon samples were collected. Letter designations correspond to those in figure 1.