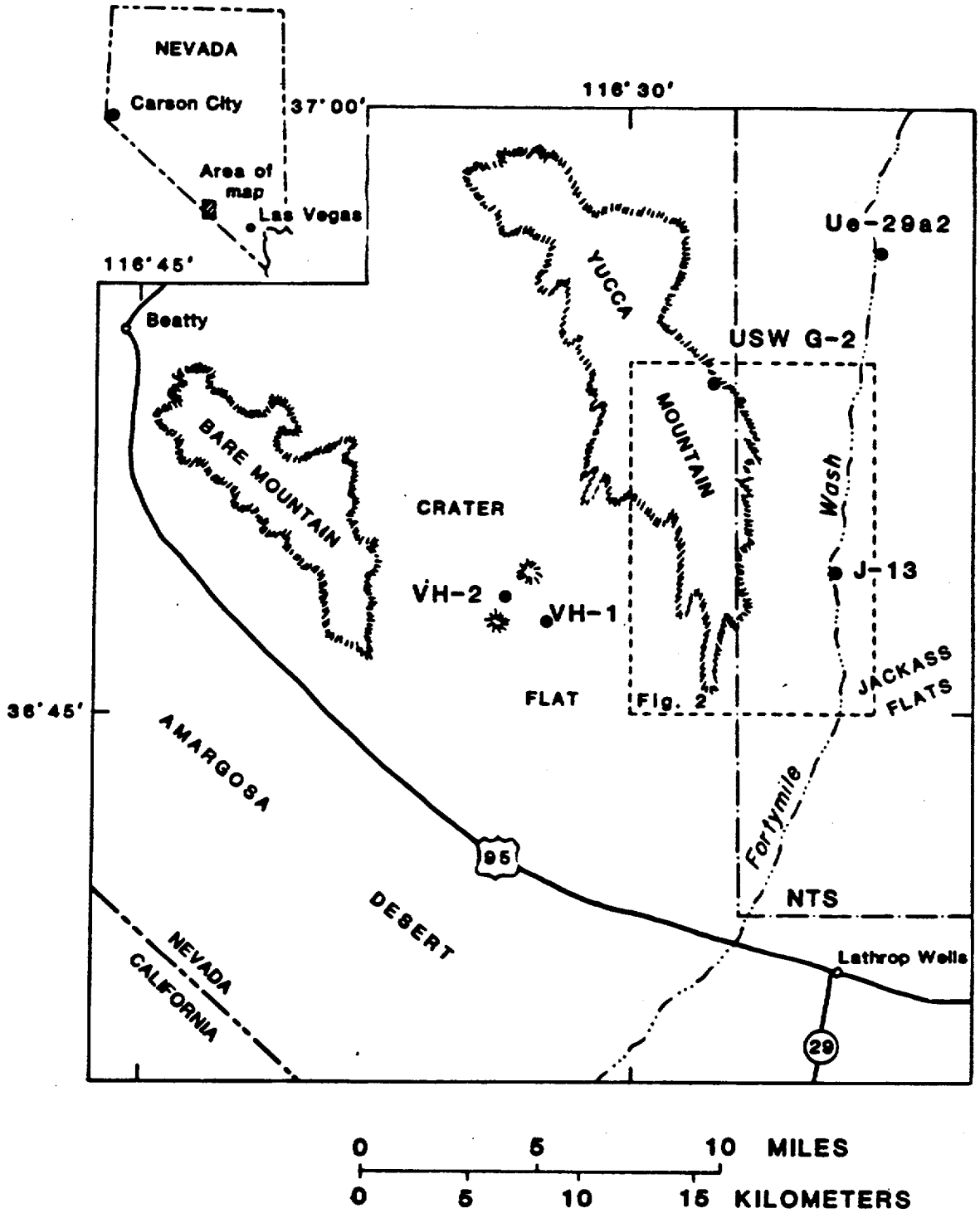
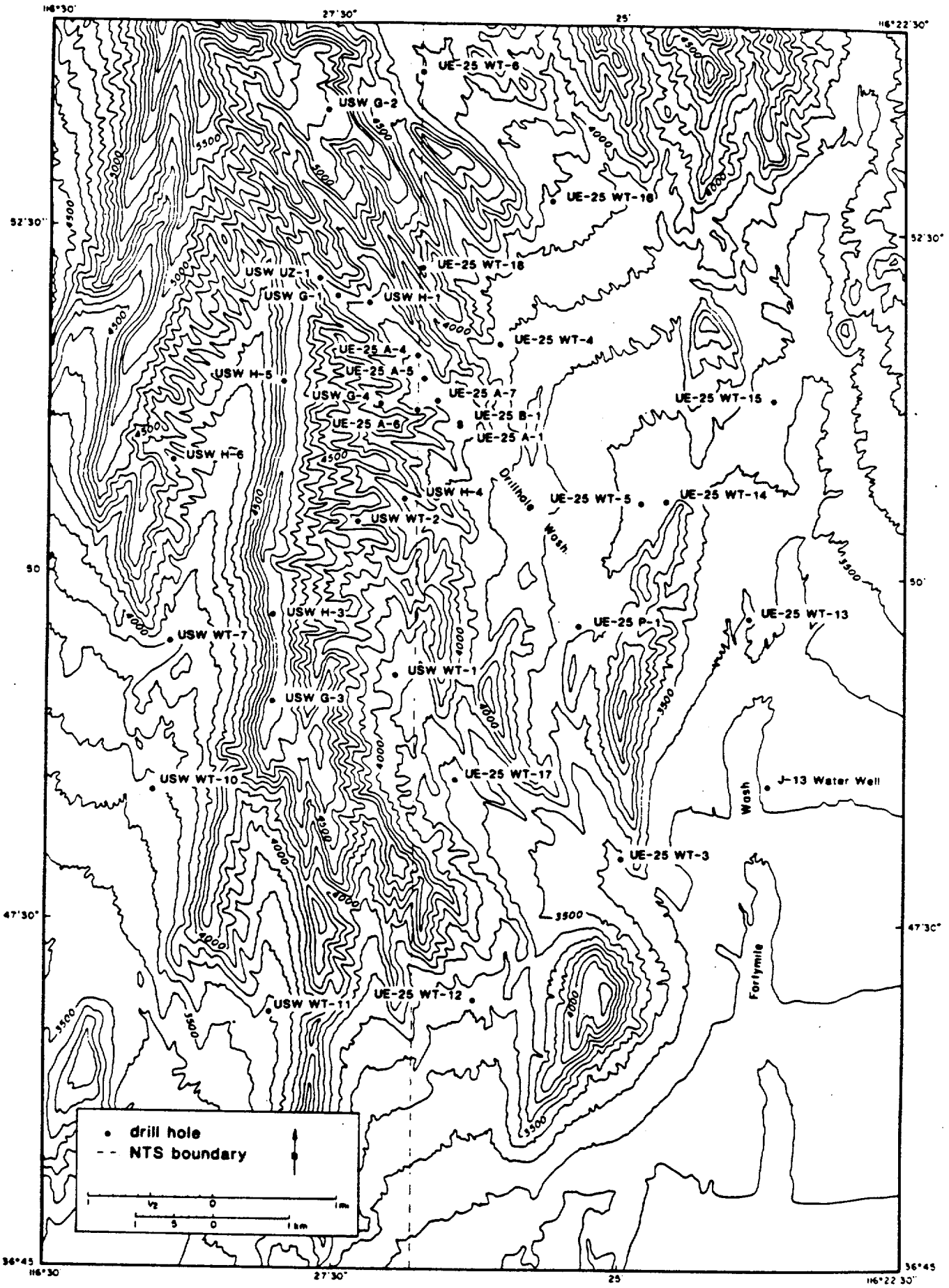


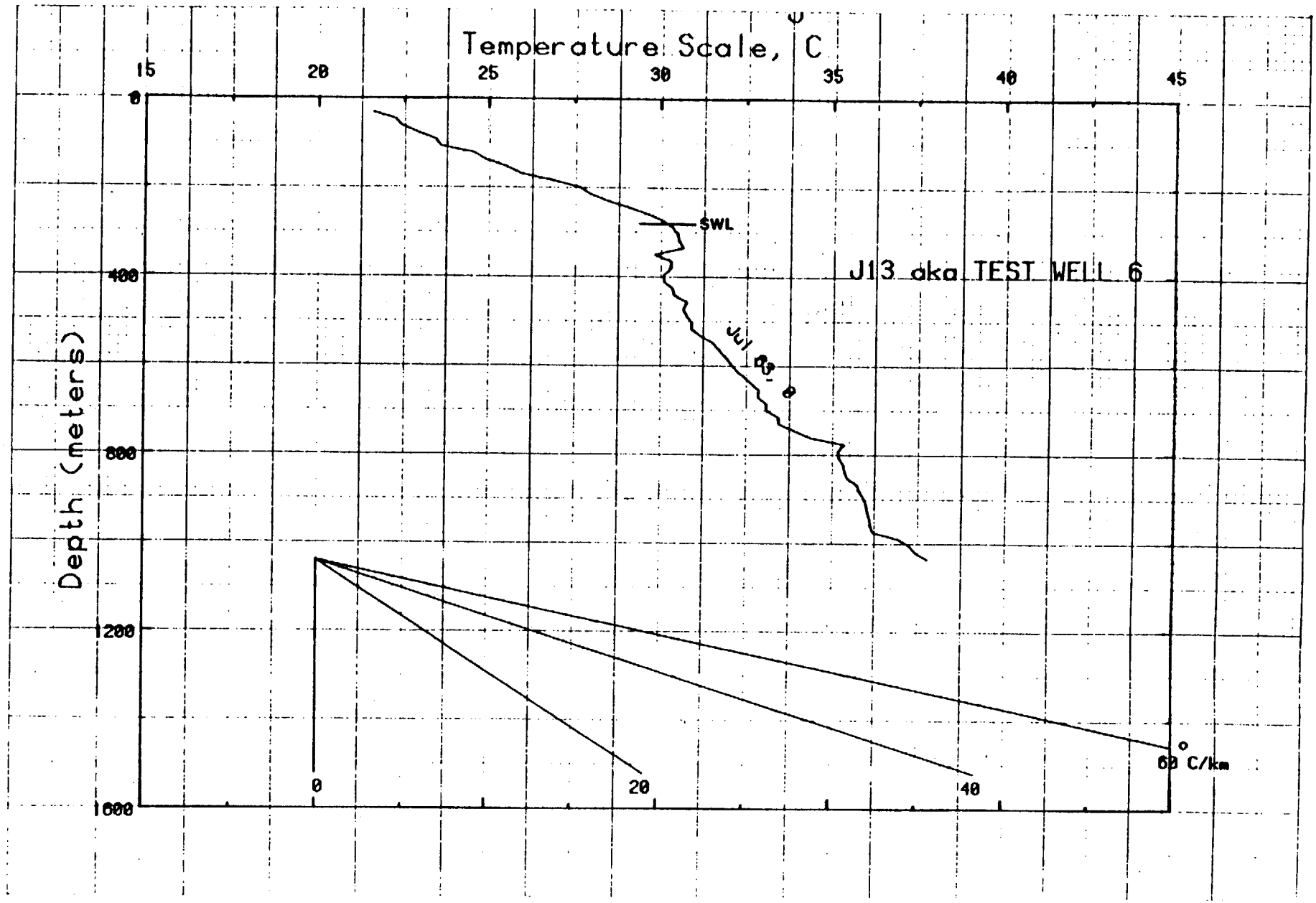
8908030304

Location map - thermal data. Yucca Mountain. From Sass et al., 1987.

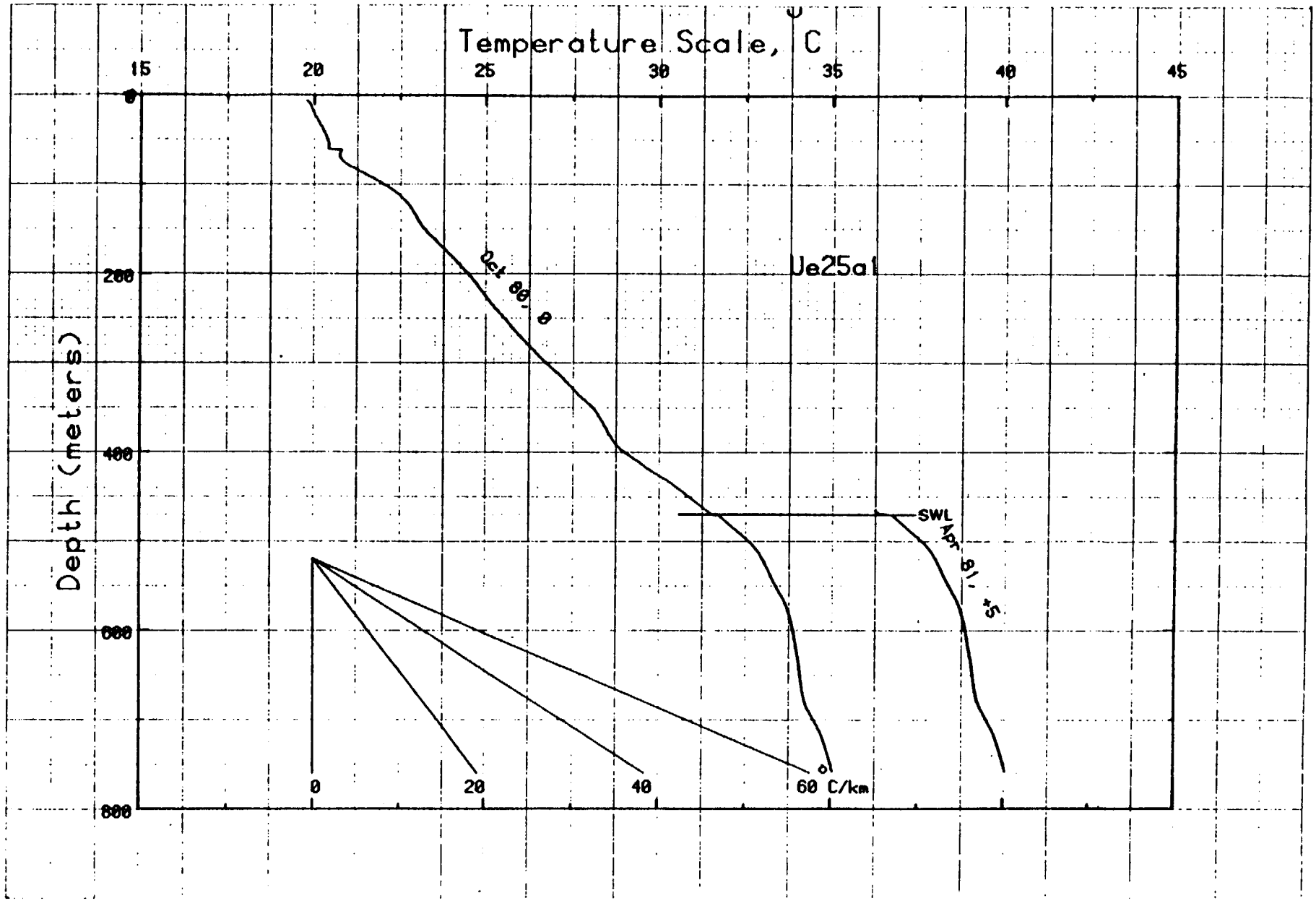
~~8908030304~~ part 6



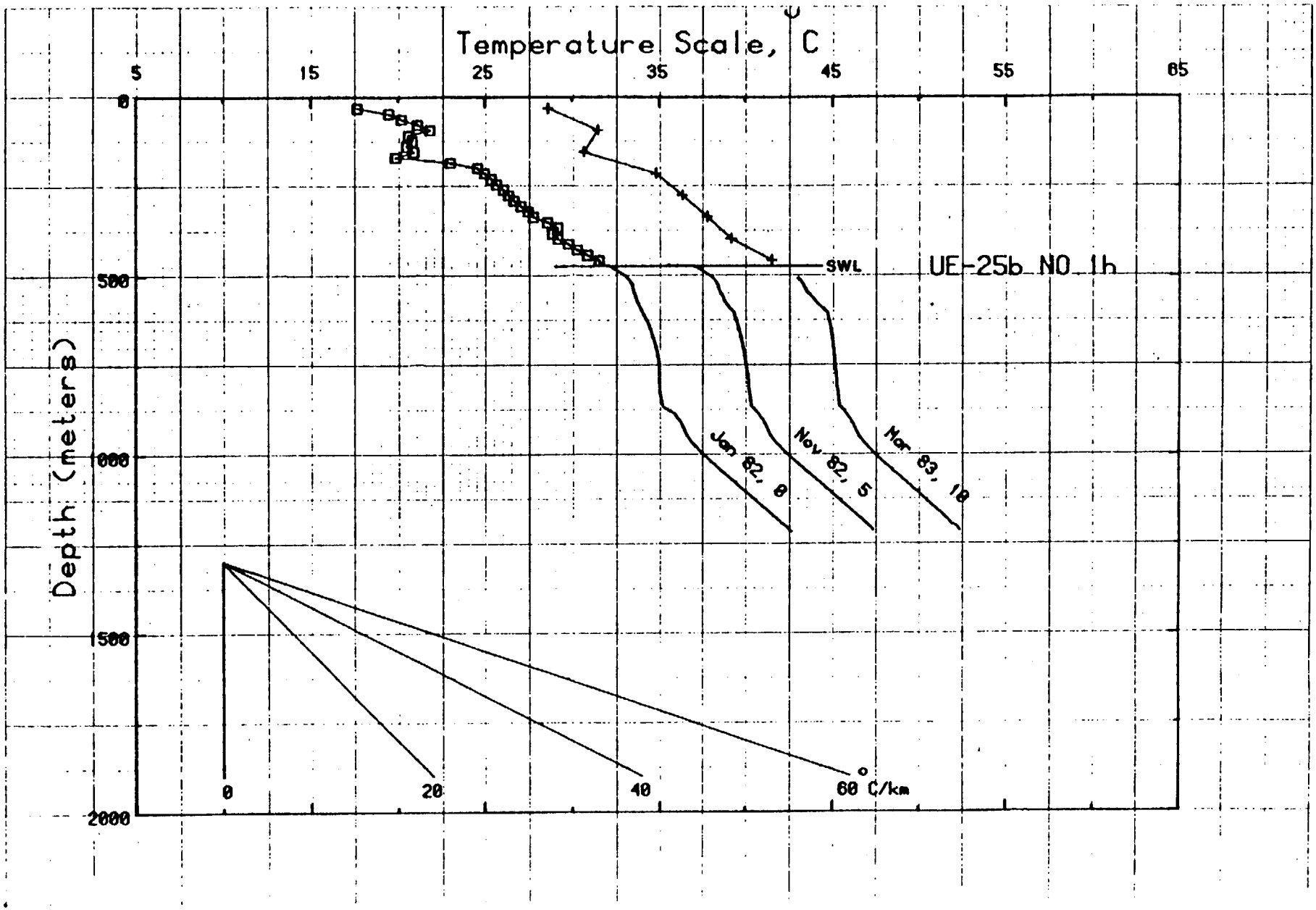
Location map - thermal data. Yucca Mountain. From Sass et al., 1987.



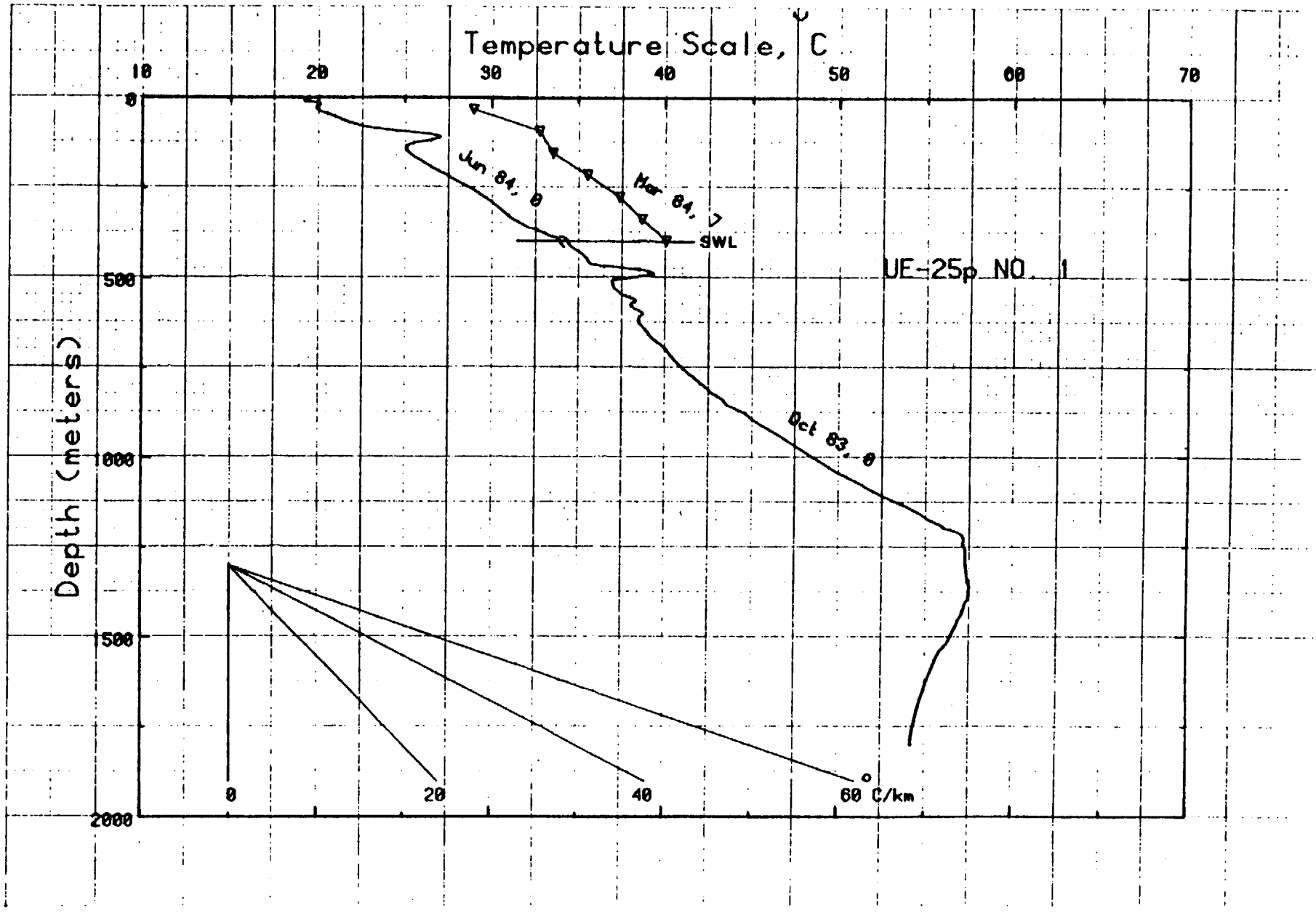
Well J-13. Temperature profile. From Sass et al., 1987.



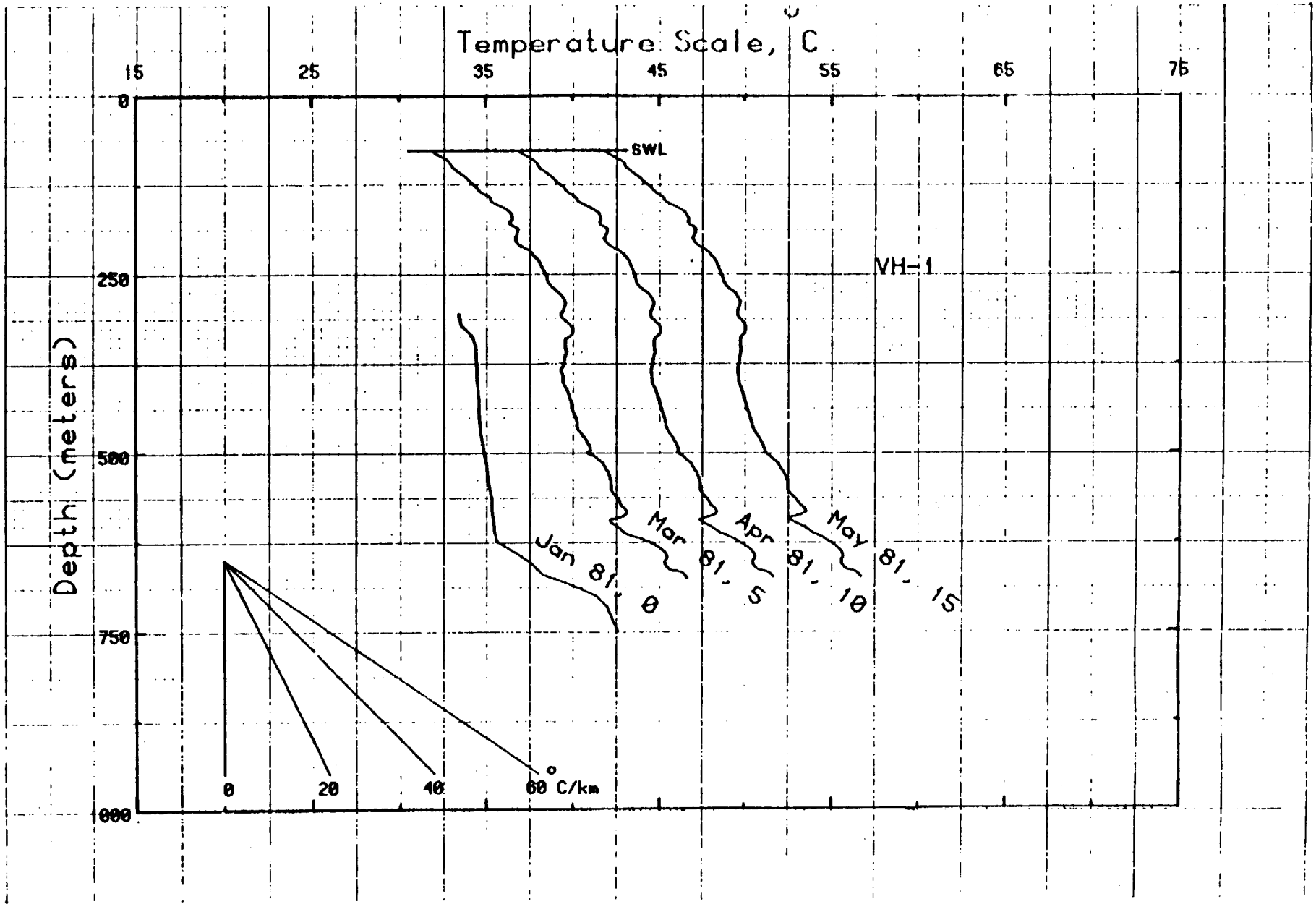
Well UE-25a. Temperature profile. From Sass et al., 1987.



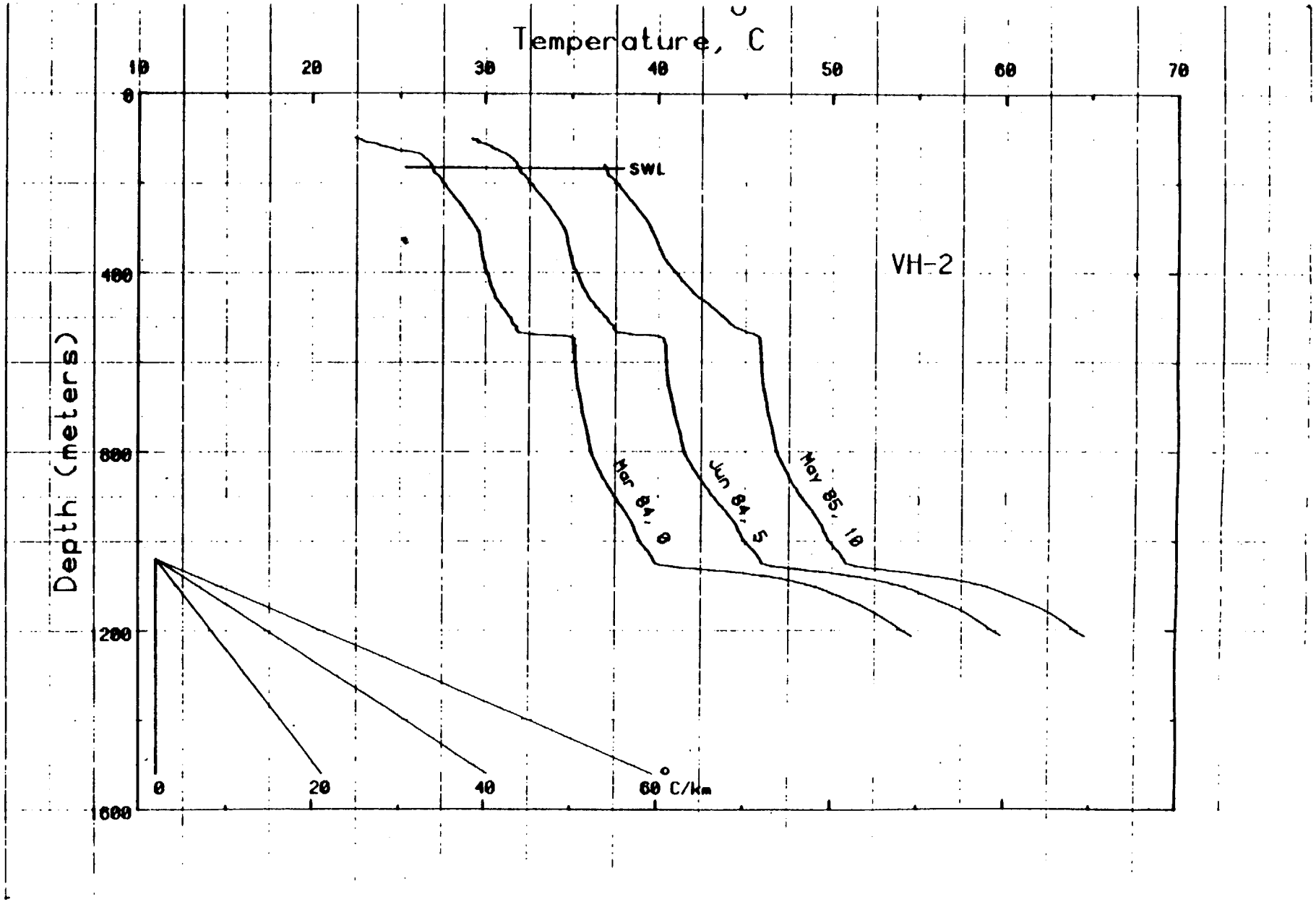
Well UE-25b. Temperature profile. From Sass et al., 1987.



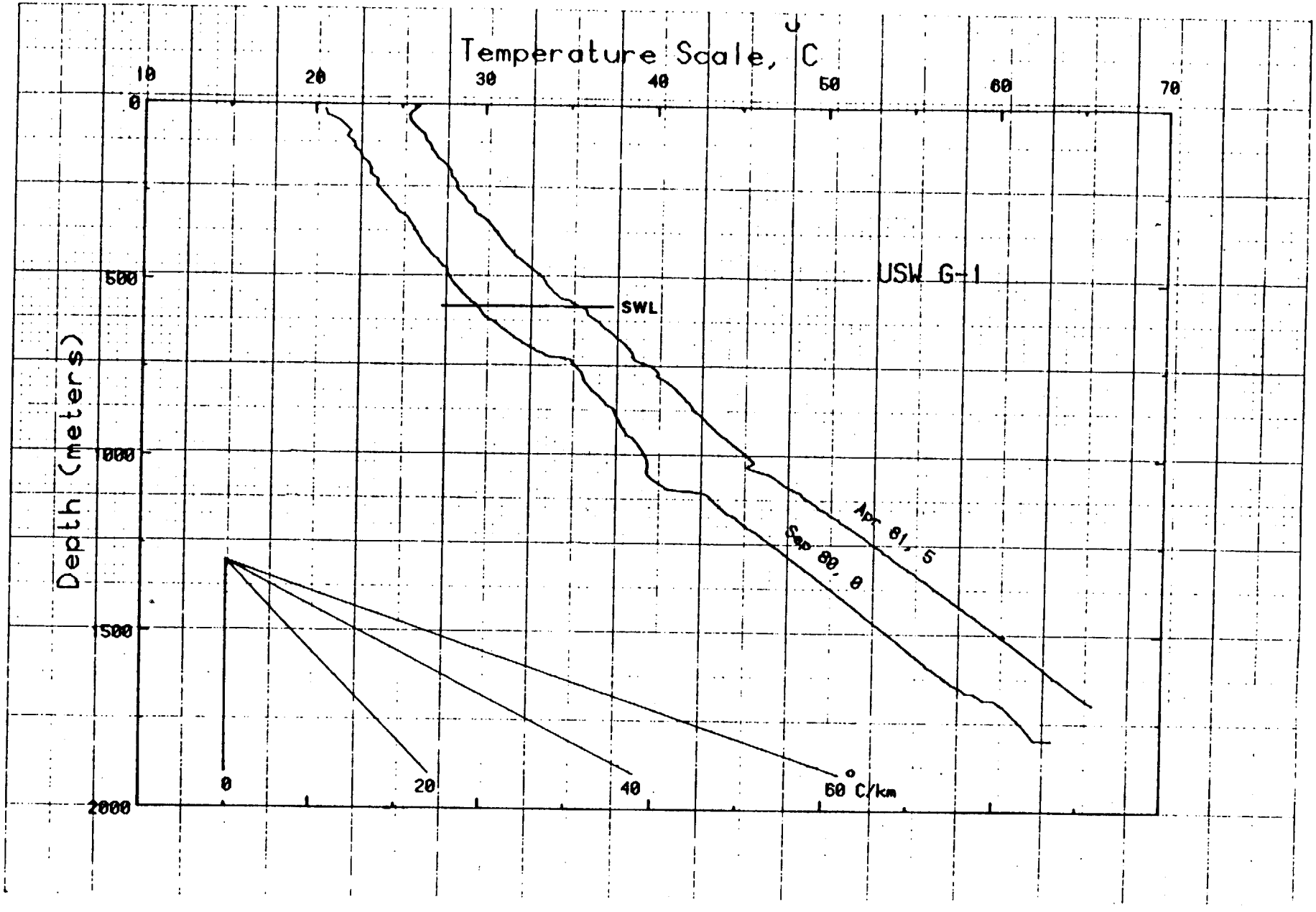
Well UE-25p#1. Temperature profile. From Sass et al., 1987.



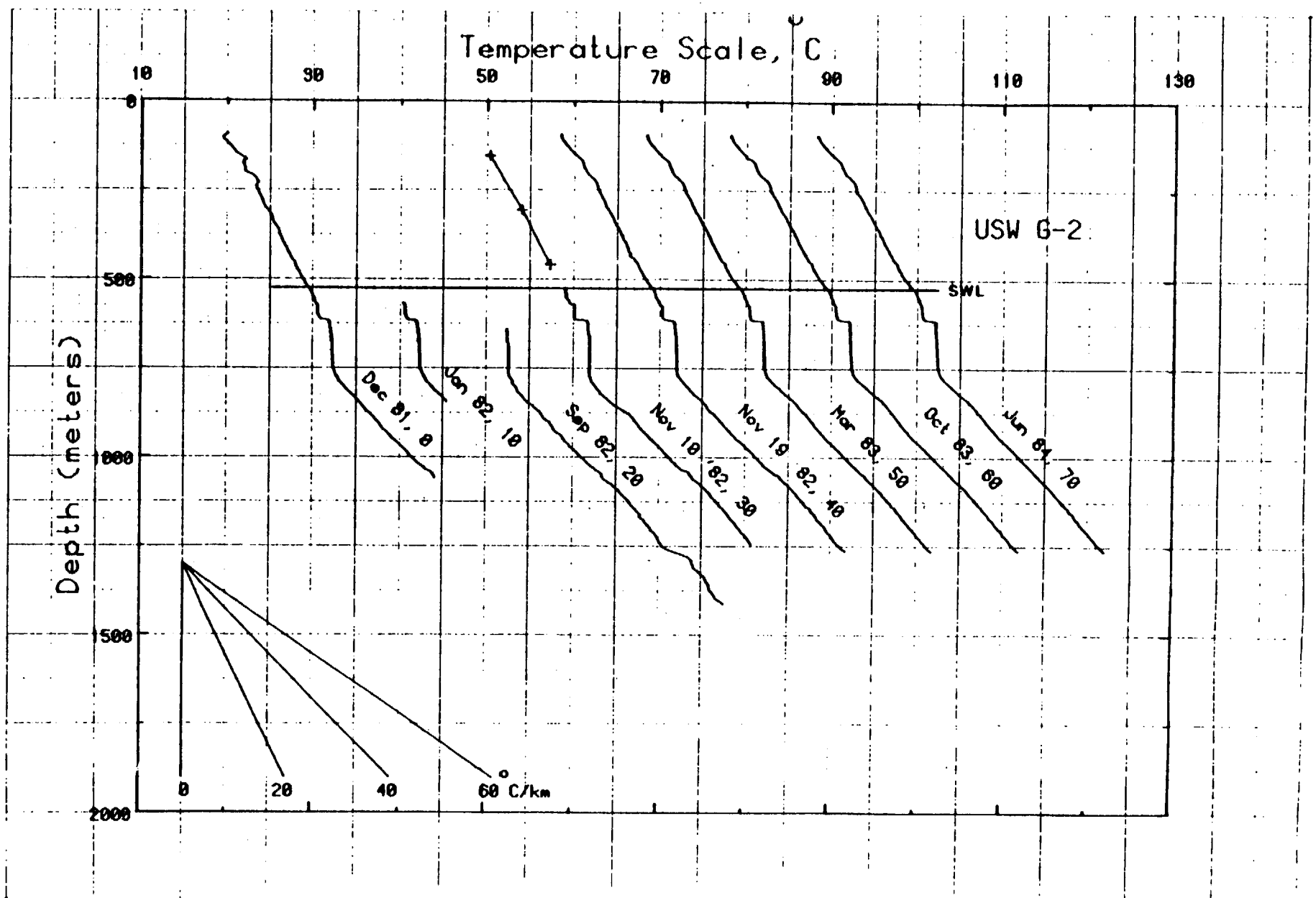
Well USW VH-1. Temperature profile. From Sass et al., 1987.



Well USW VH-2. Temperature profile. From Sass et al., 1987.



Well USW G-1. Temperature profile. From Sass et al., 1987.



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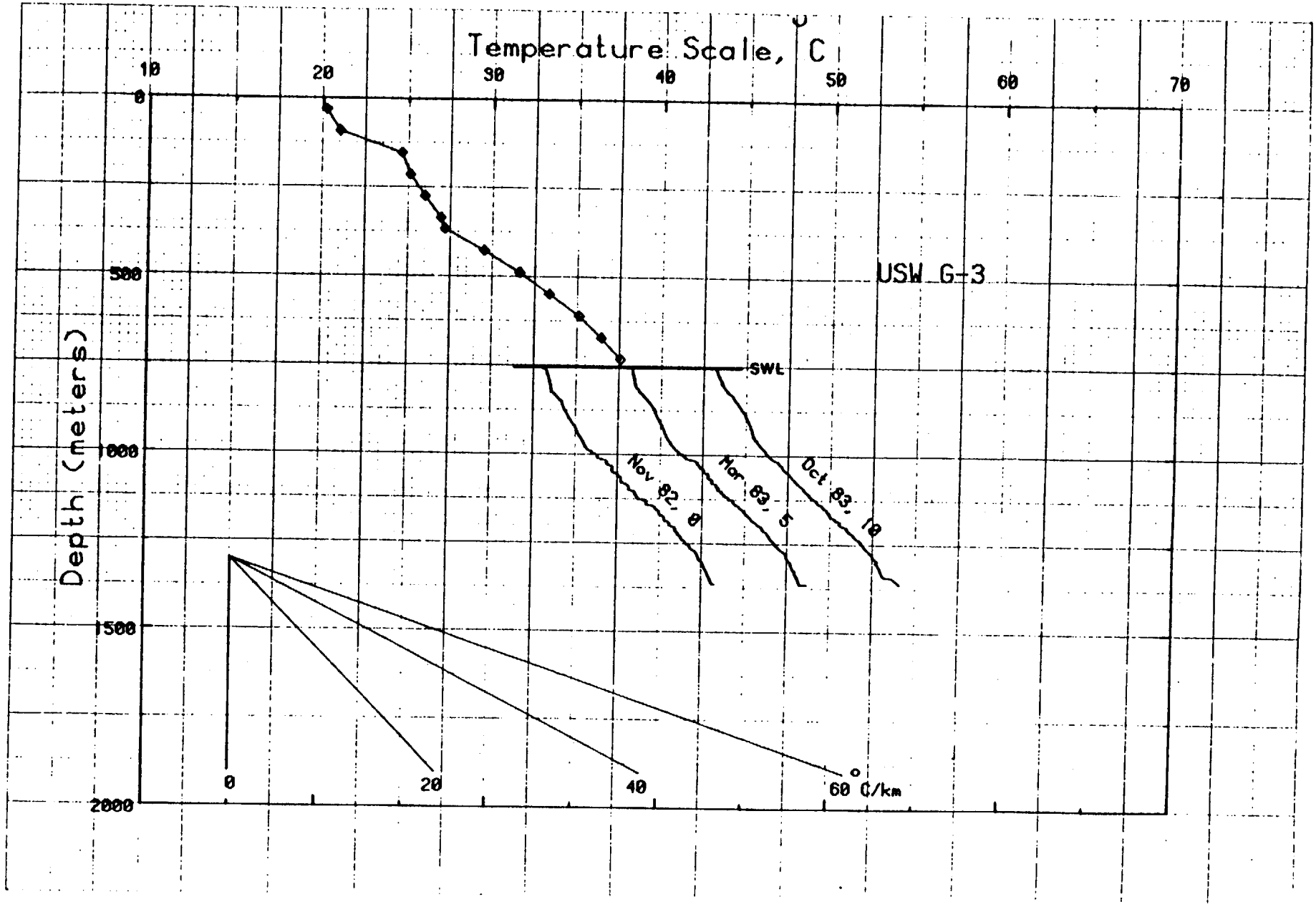
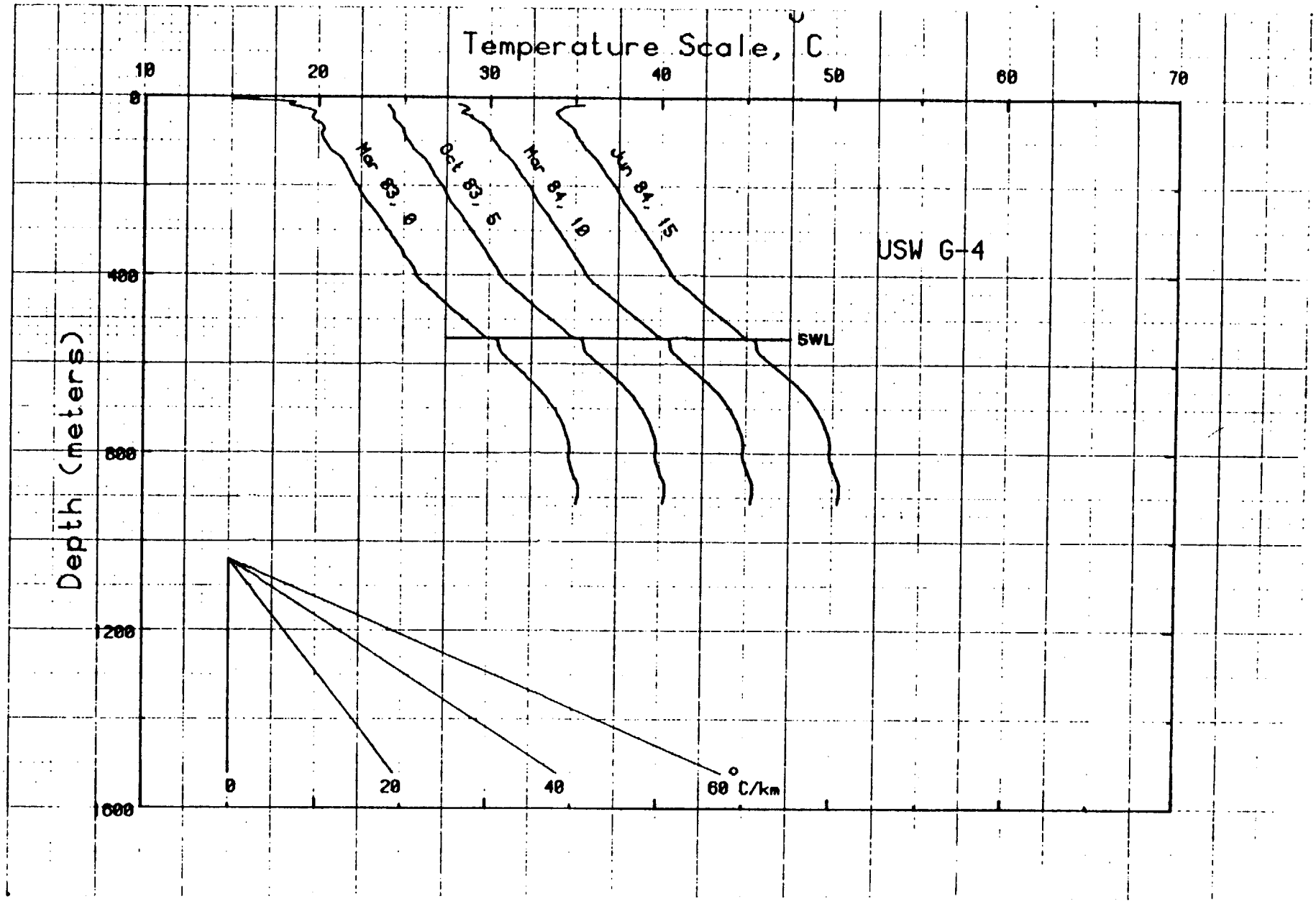
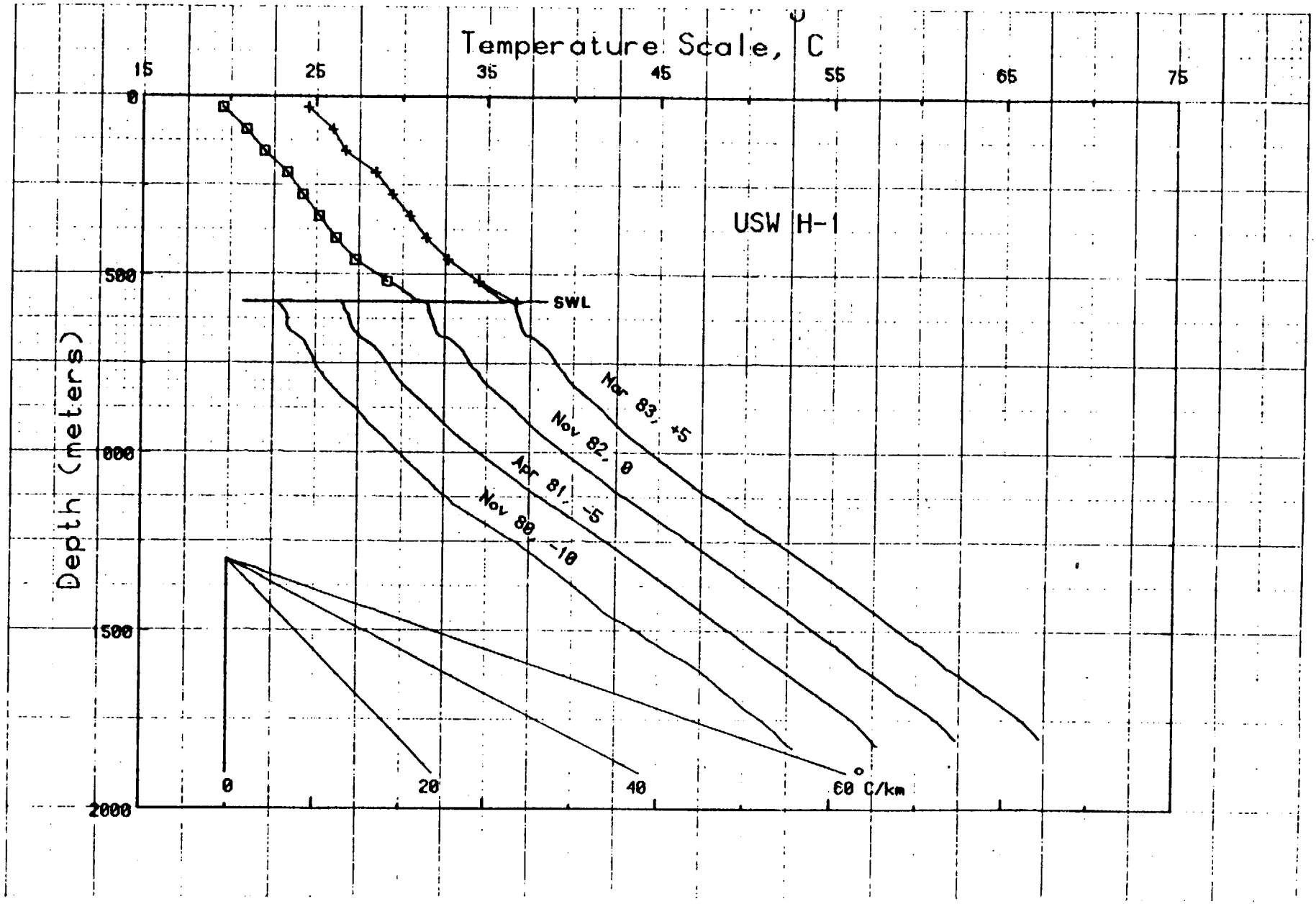


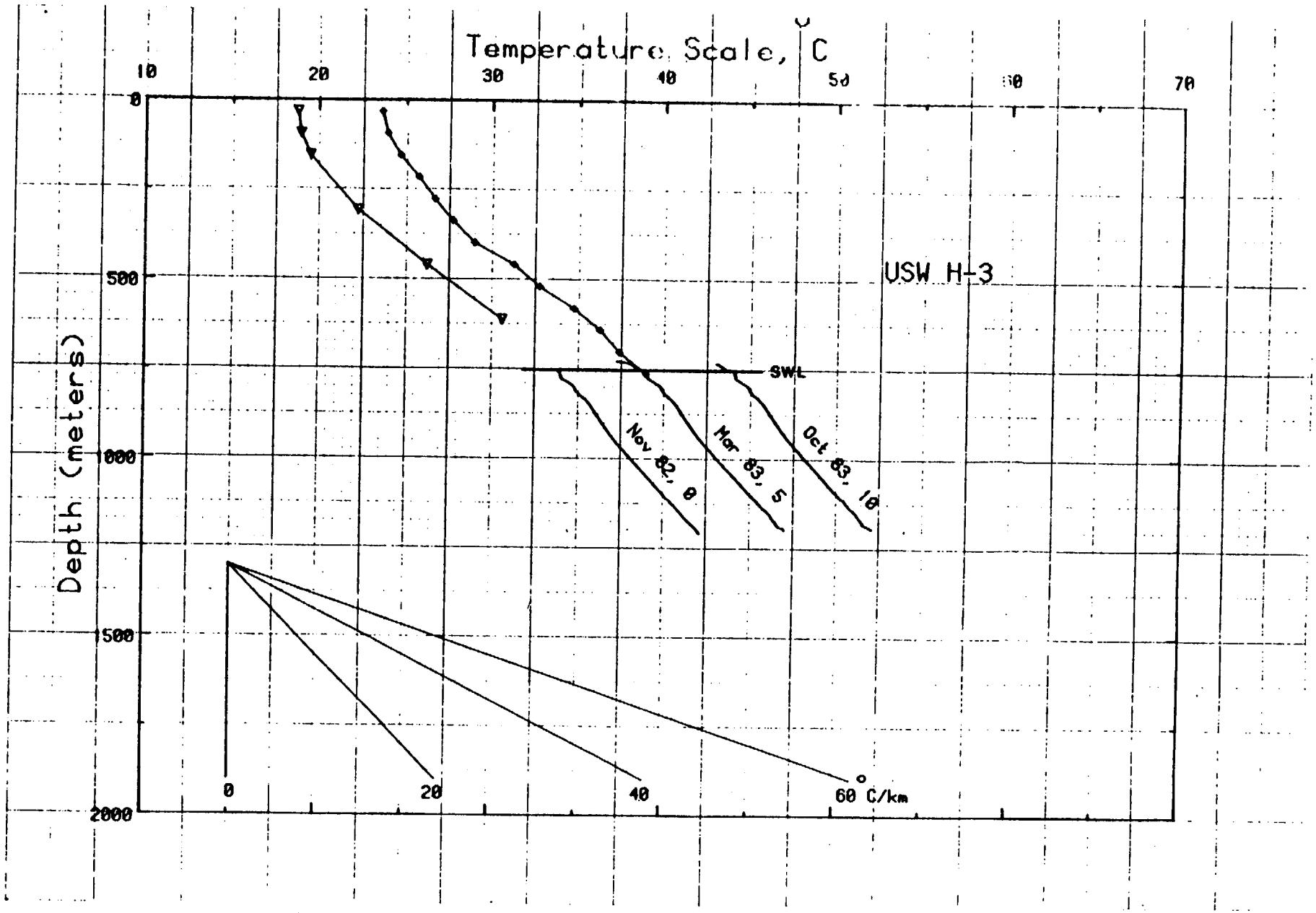
Well USW G-3. Temperature profile. From Sass et al., 1987.



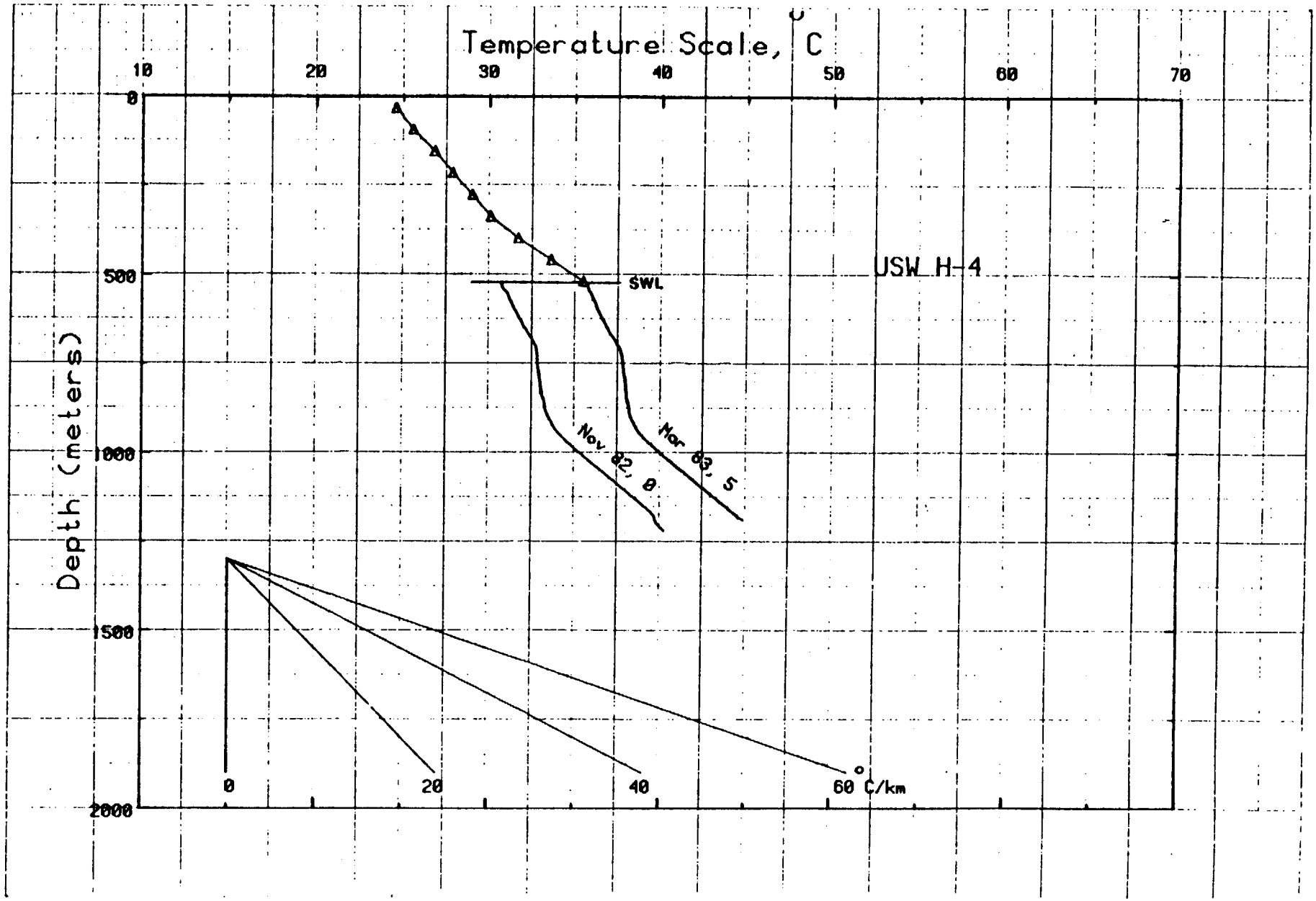
Well USW G-4. Temperature profile. From Sass et al., 1987.



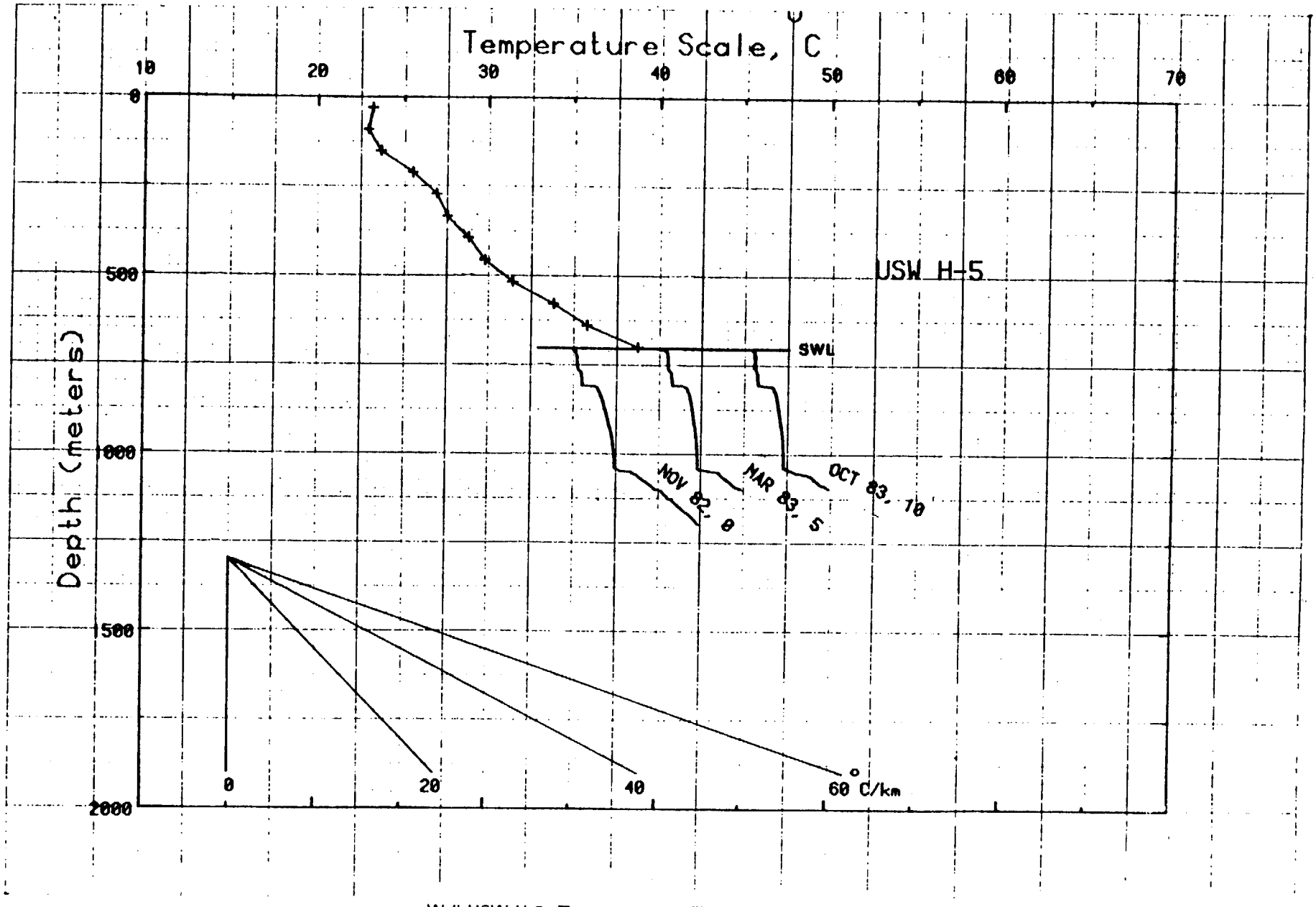
Well USW H-1. Temperature profile. From Sass et al., 1987.



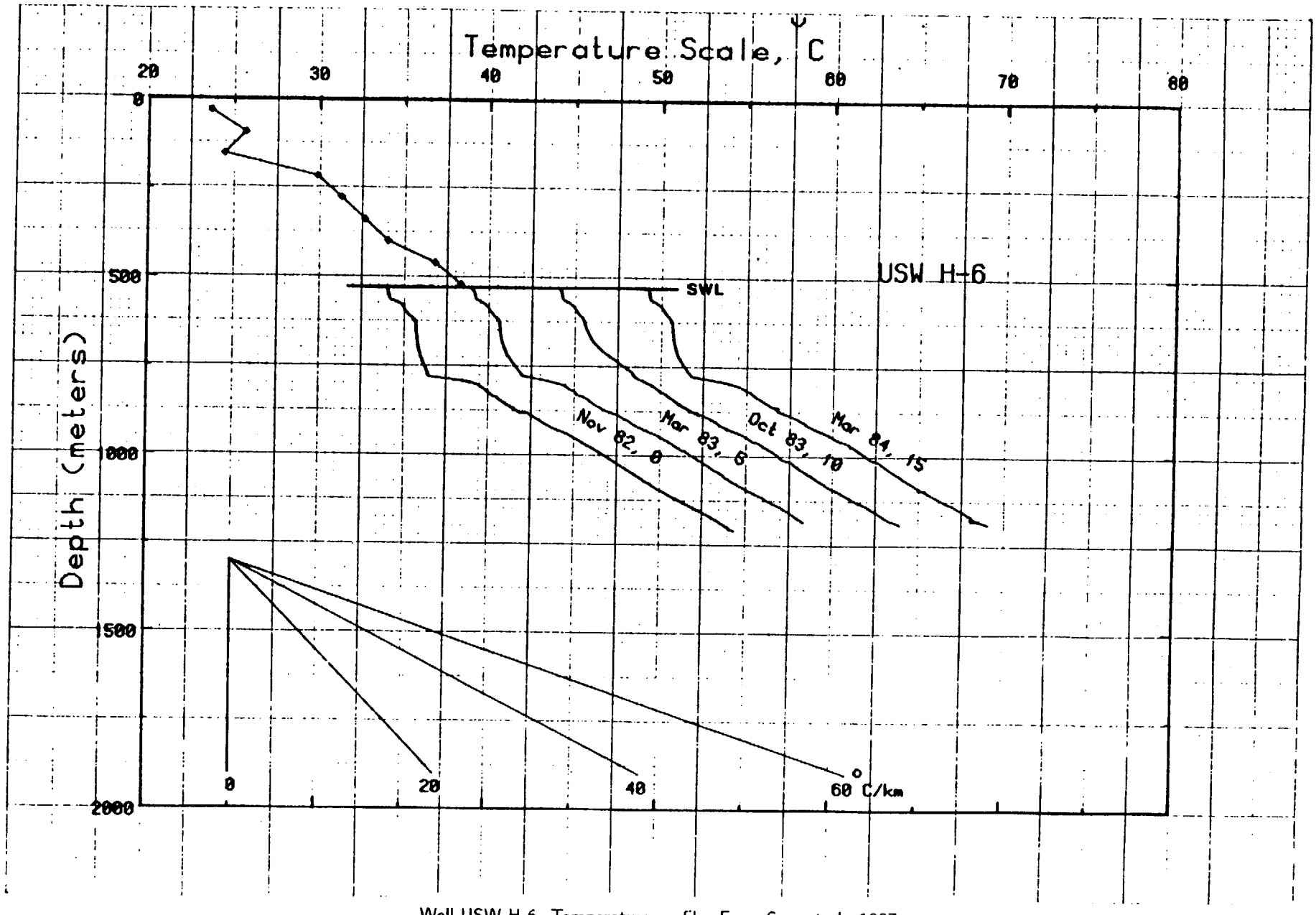
Well USW H-3. Temperature profile. From Sass et al., 1987.



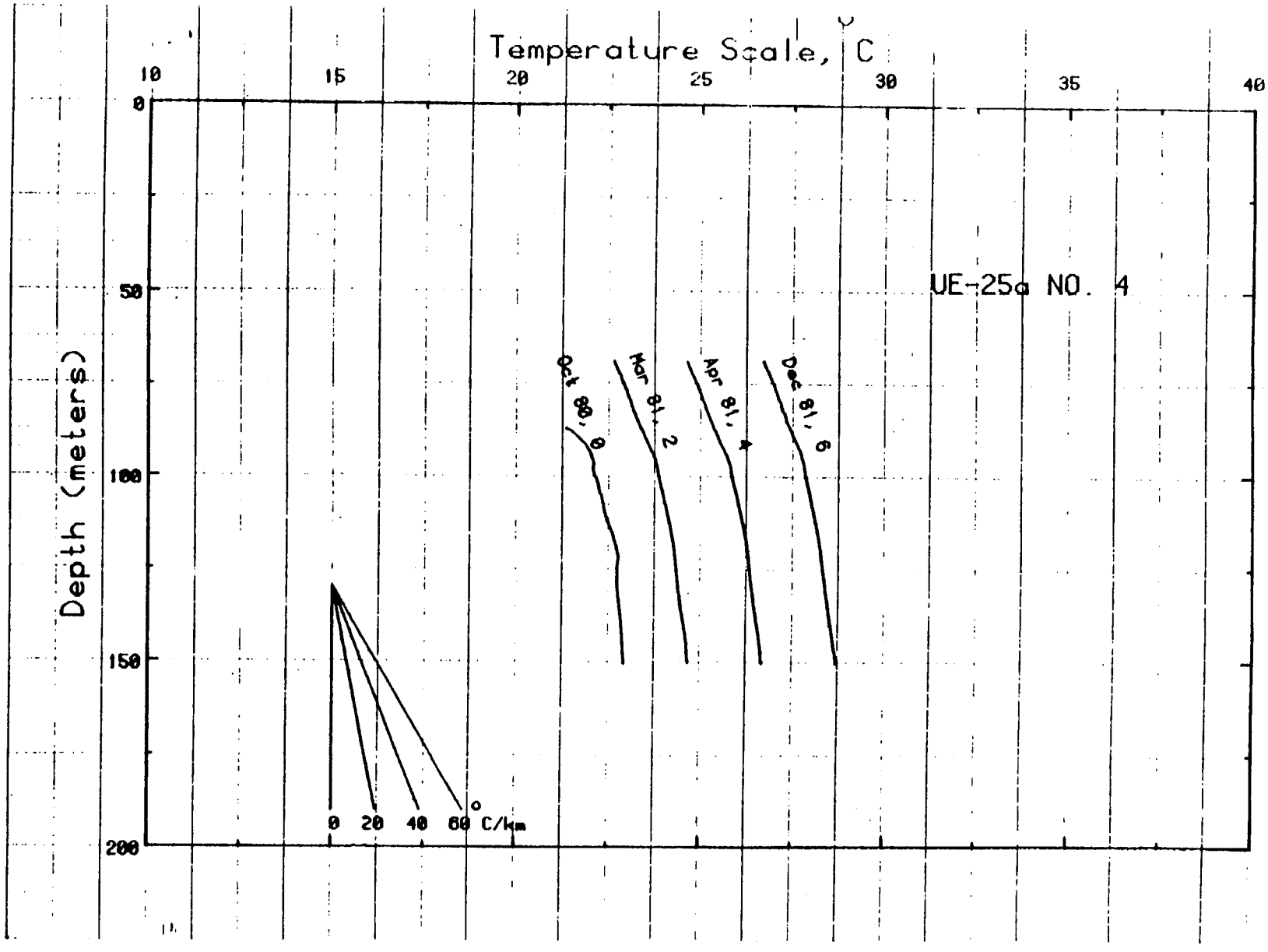
Well USW H-4. Temperature profile. From Sass et al., 1987.



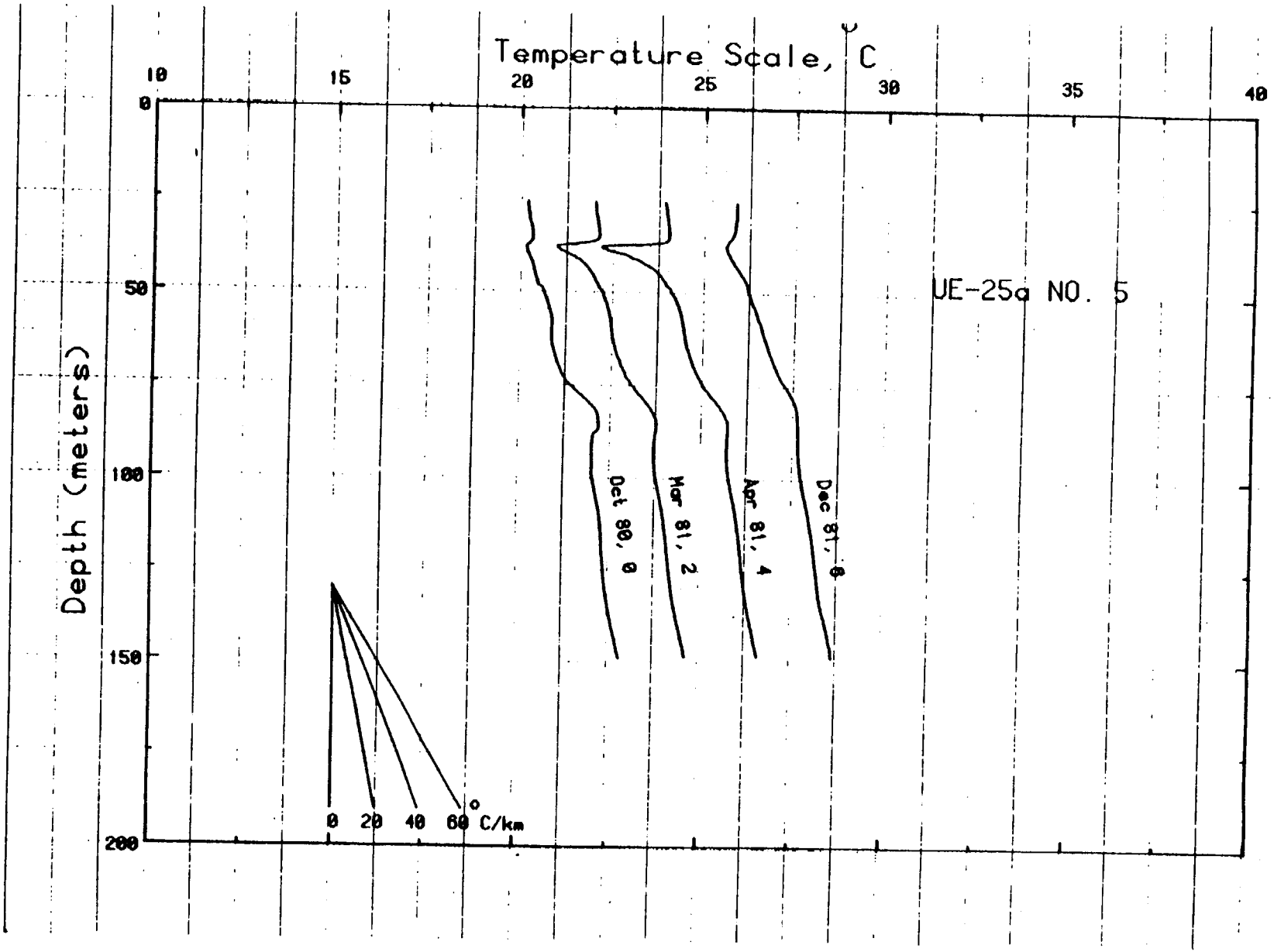
Well USW H-5. Temperature profile. From Sass et al., 1987.



Well USW H-6. Temperature profile. From Sass et al., 1987.



Well UE-25a No.4. Temperature profile. From Sass et al., 1987.



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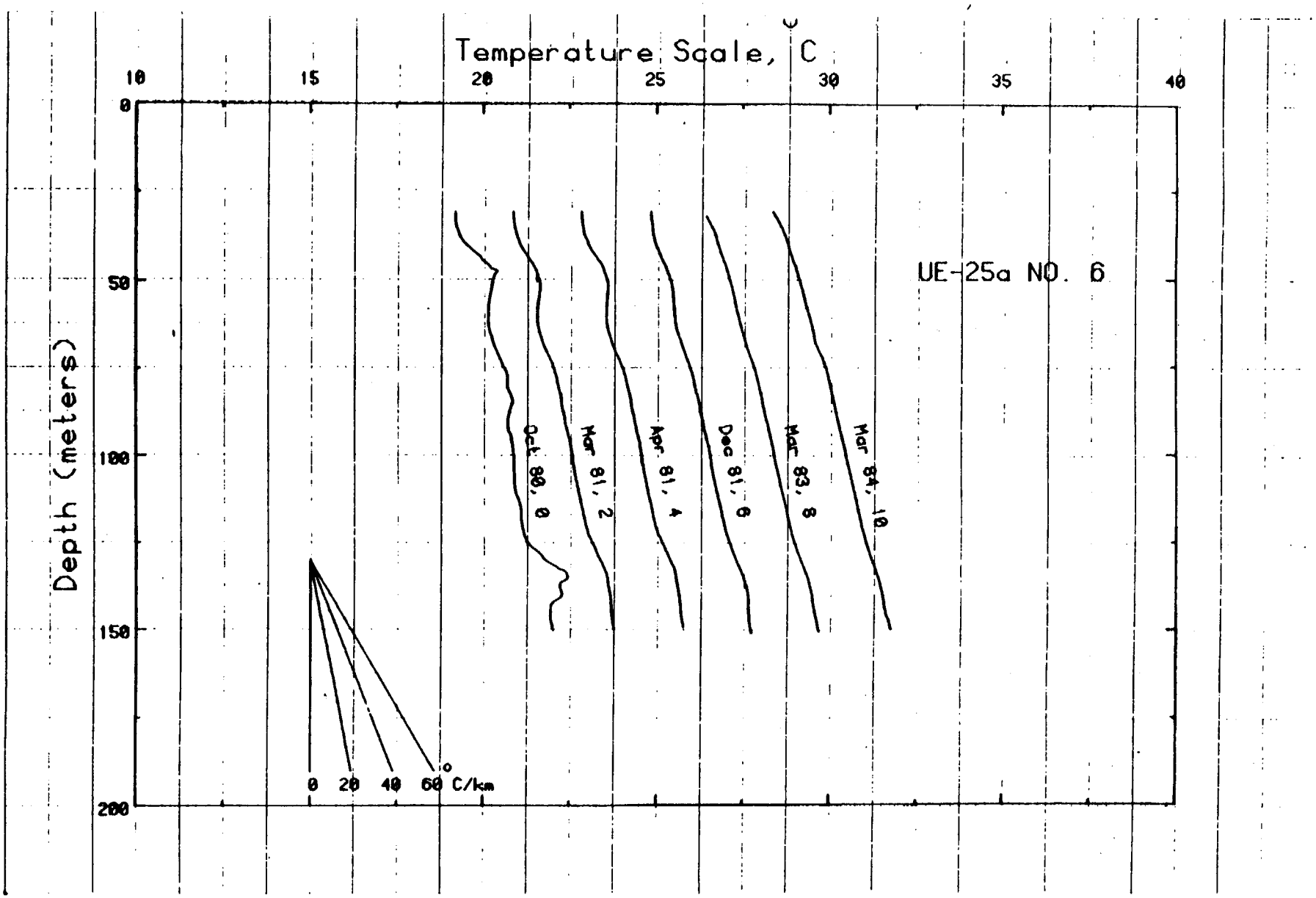

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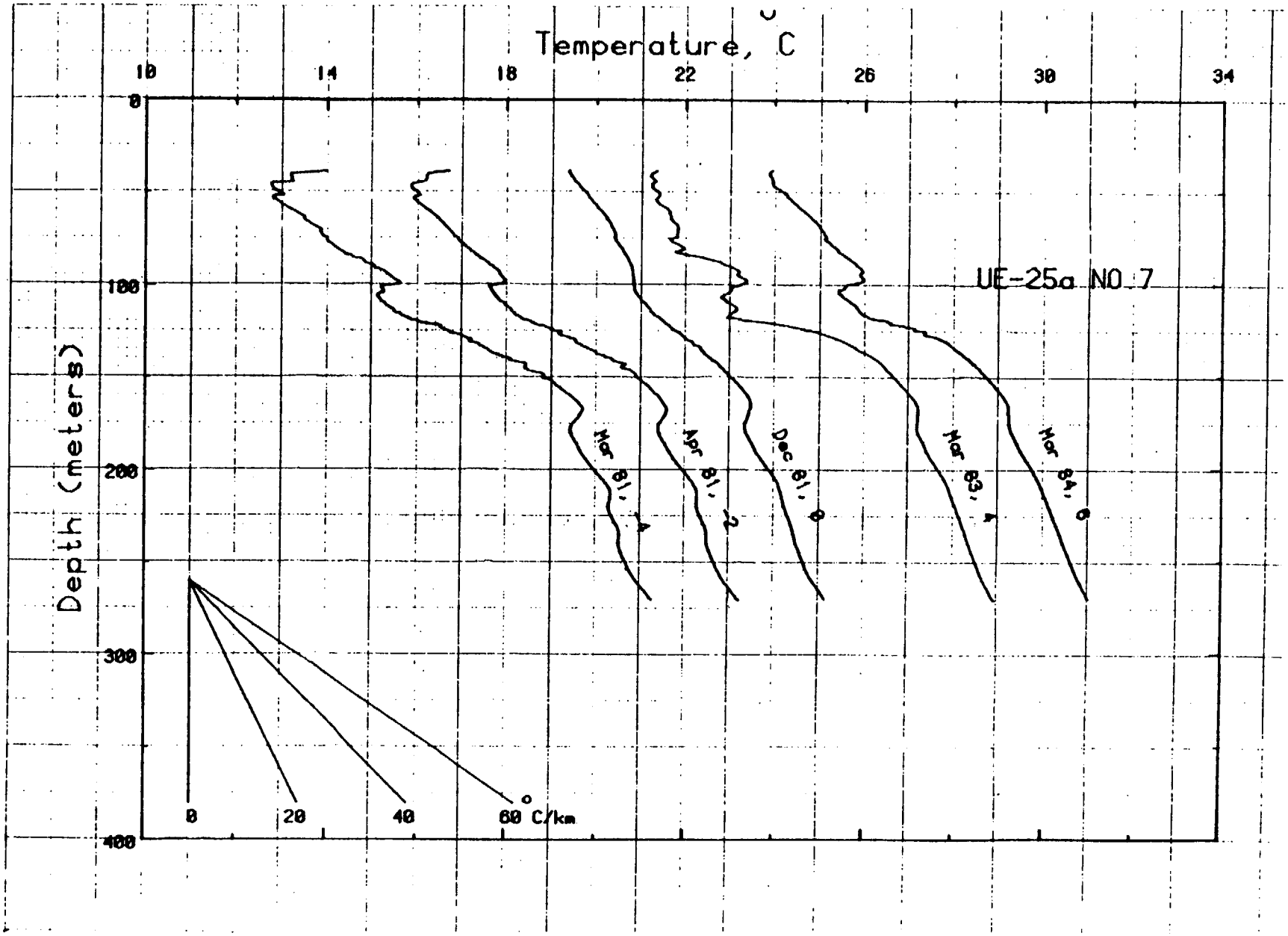
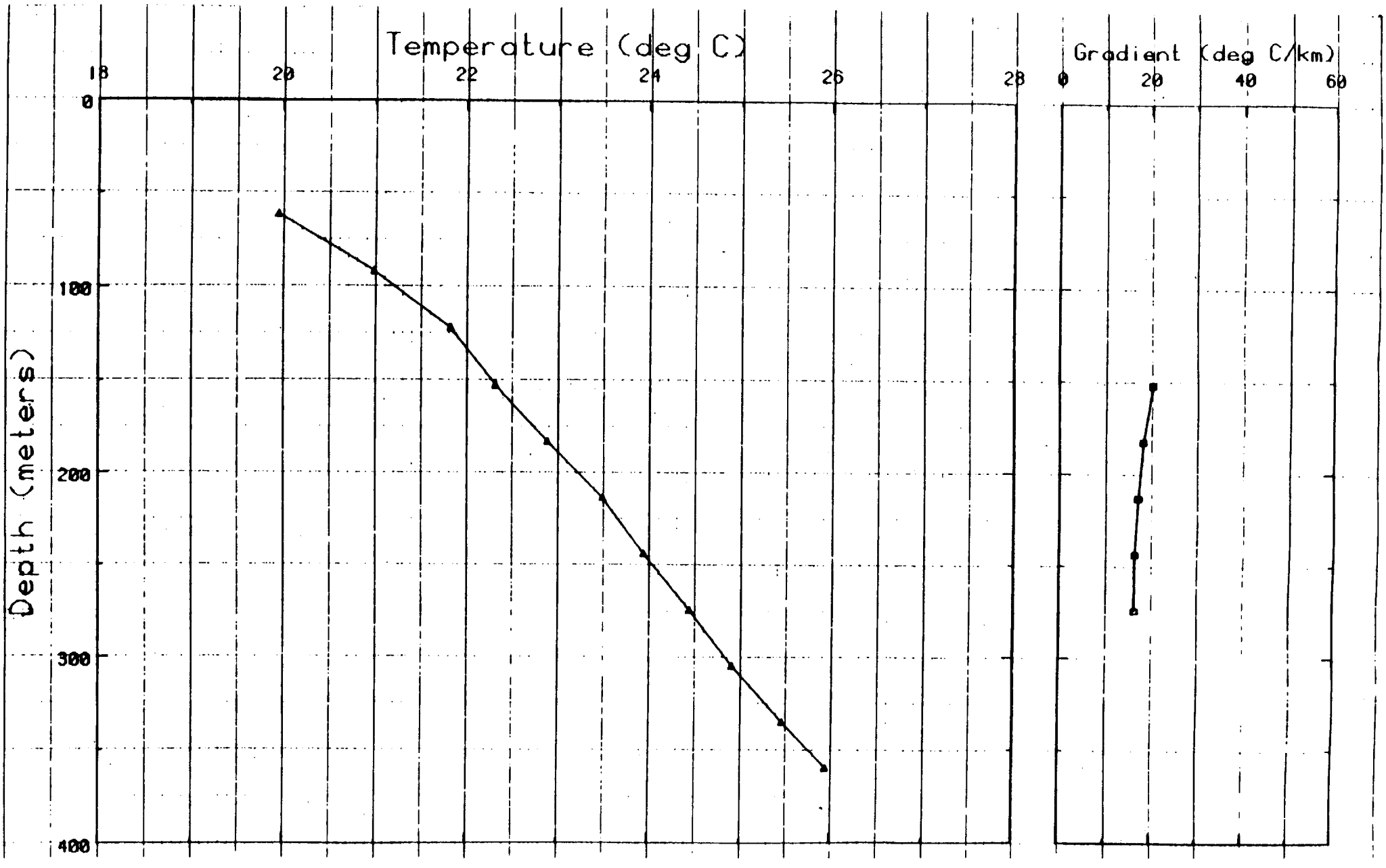
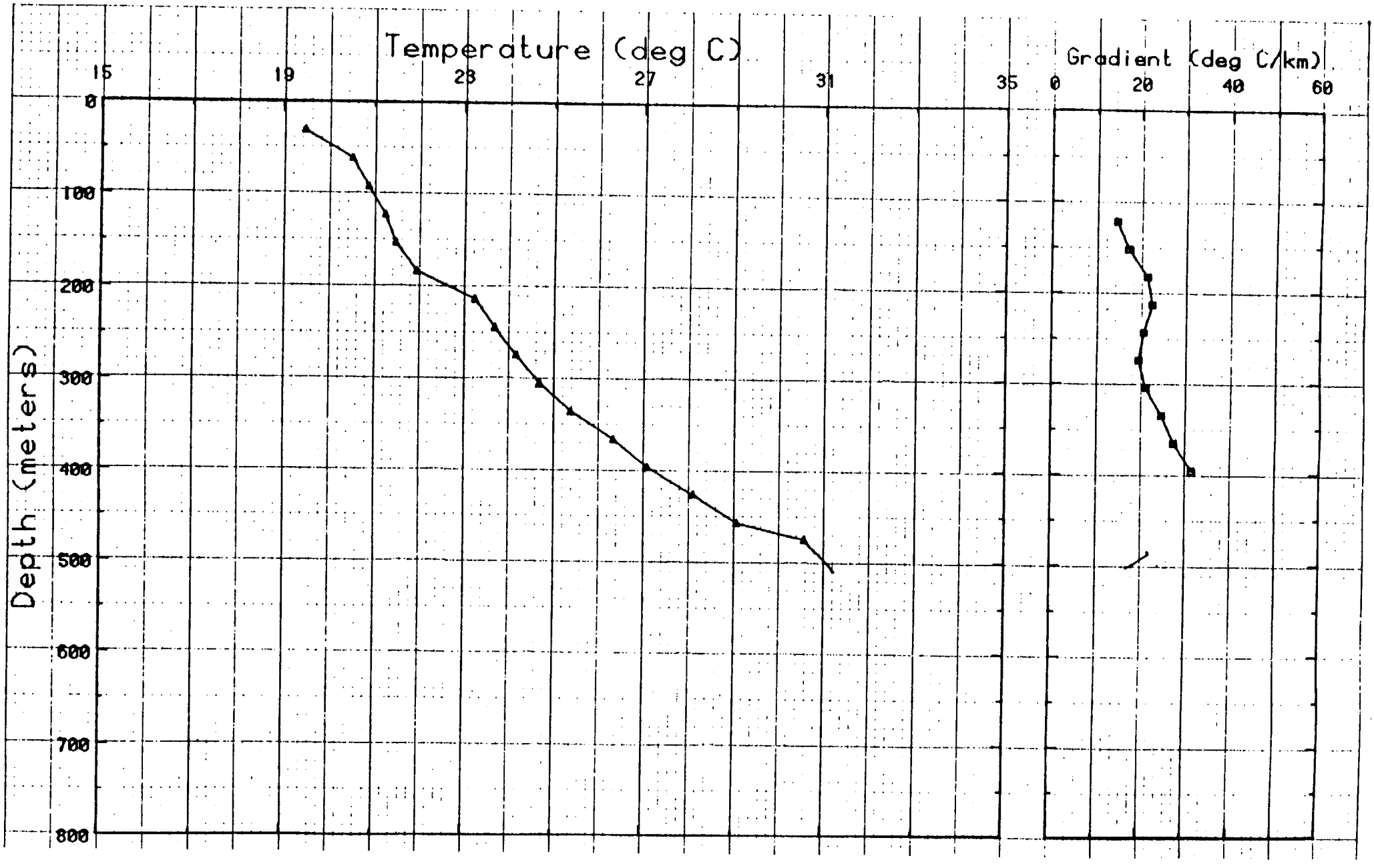


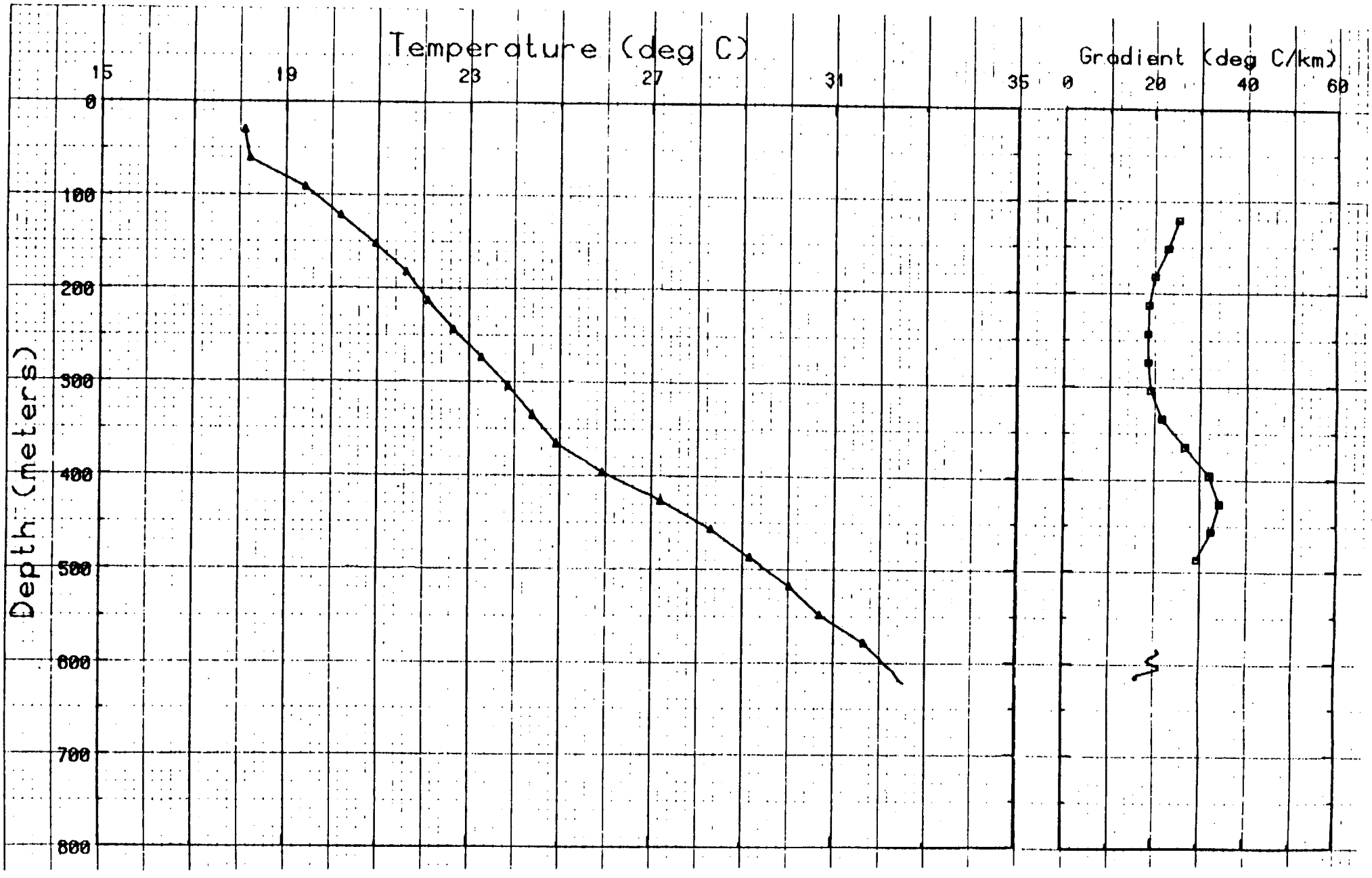
Well UE-25a No.7. Temperature profile. From Sass et al., 1987.



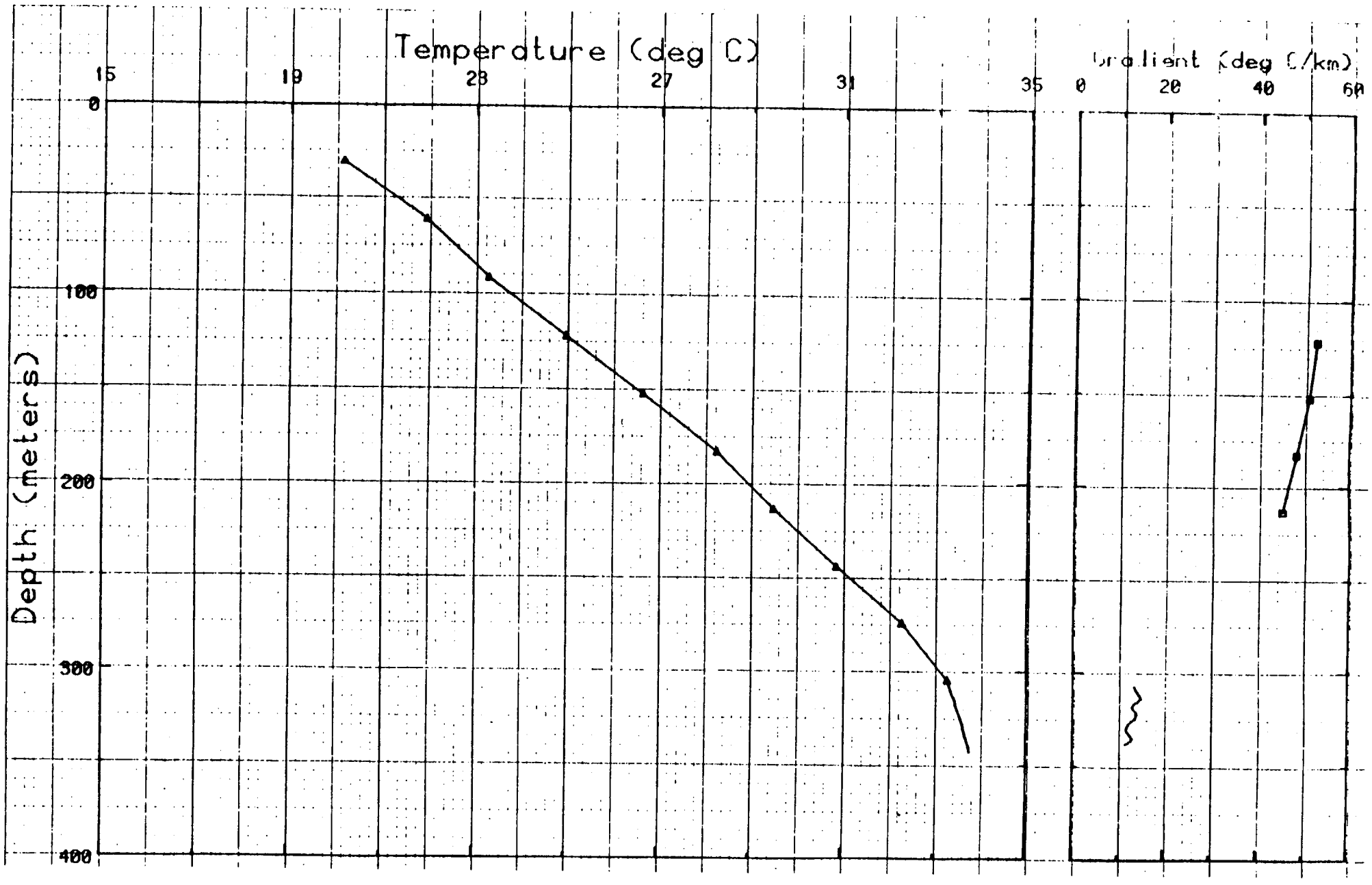
Well UZ-1. Temperature profile. From Sass et al., 1987.



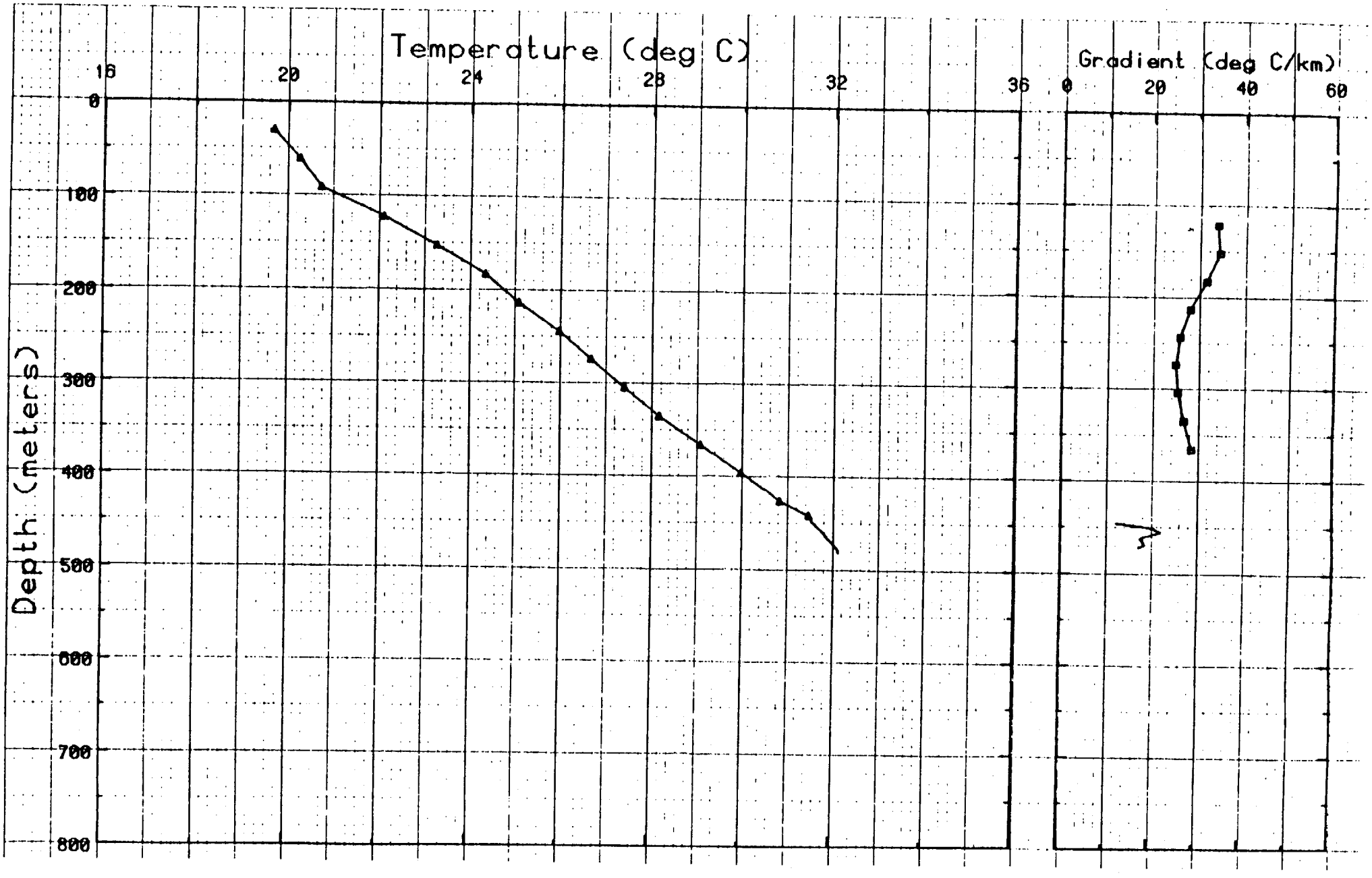
Well USW WT-1. Temperature profile. From Sass et al., 1987.



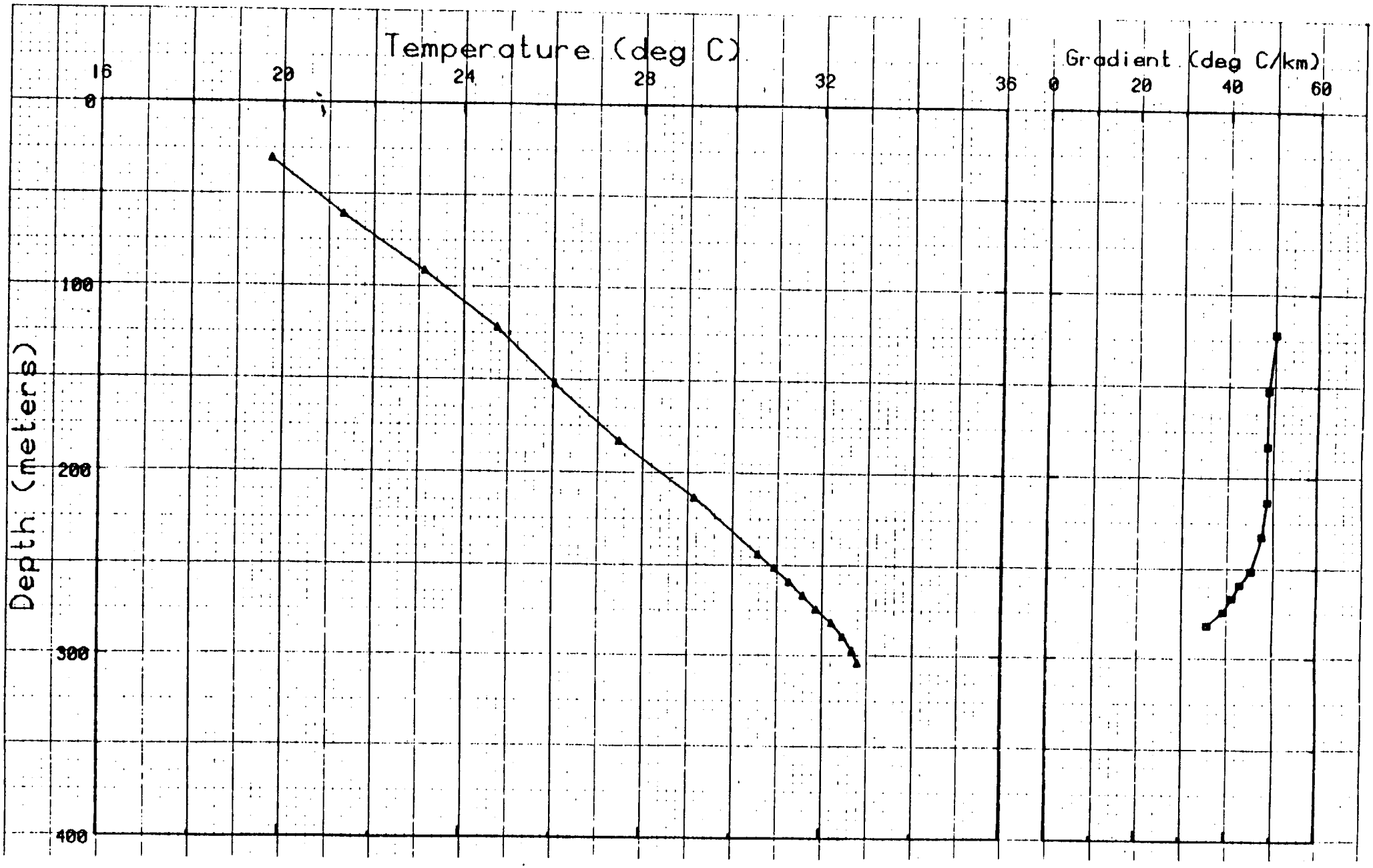
Well USW WT-2. Temperature profile. From Sass et al., 1987.



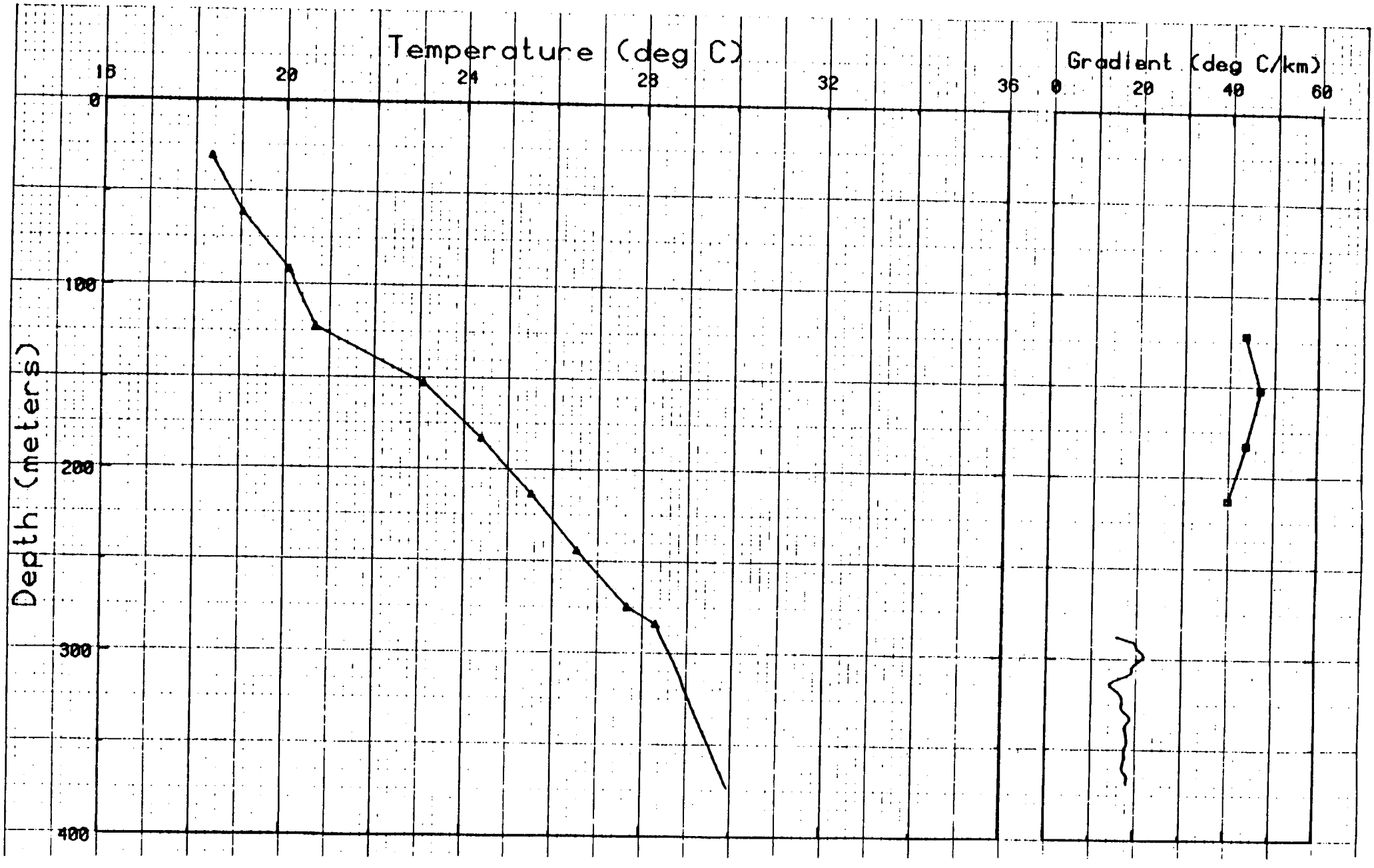
Well UE-25 WT-3. Temperature profile. From Sass et al., 1987.



Well UE-25 WT-4. Temperature profile. From Sass et al., 1987.



Well UE-25 WT-5. Temperature profile. From Sass et al.. 1987.



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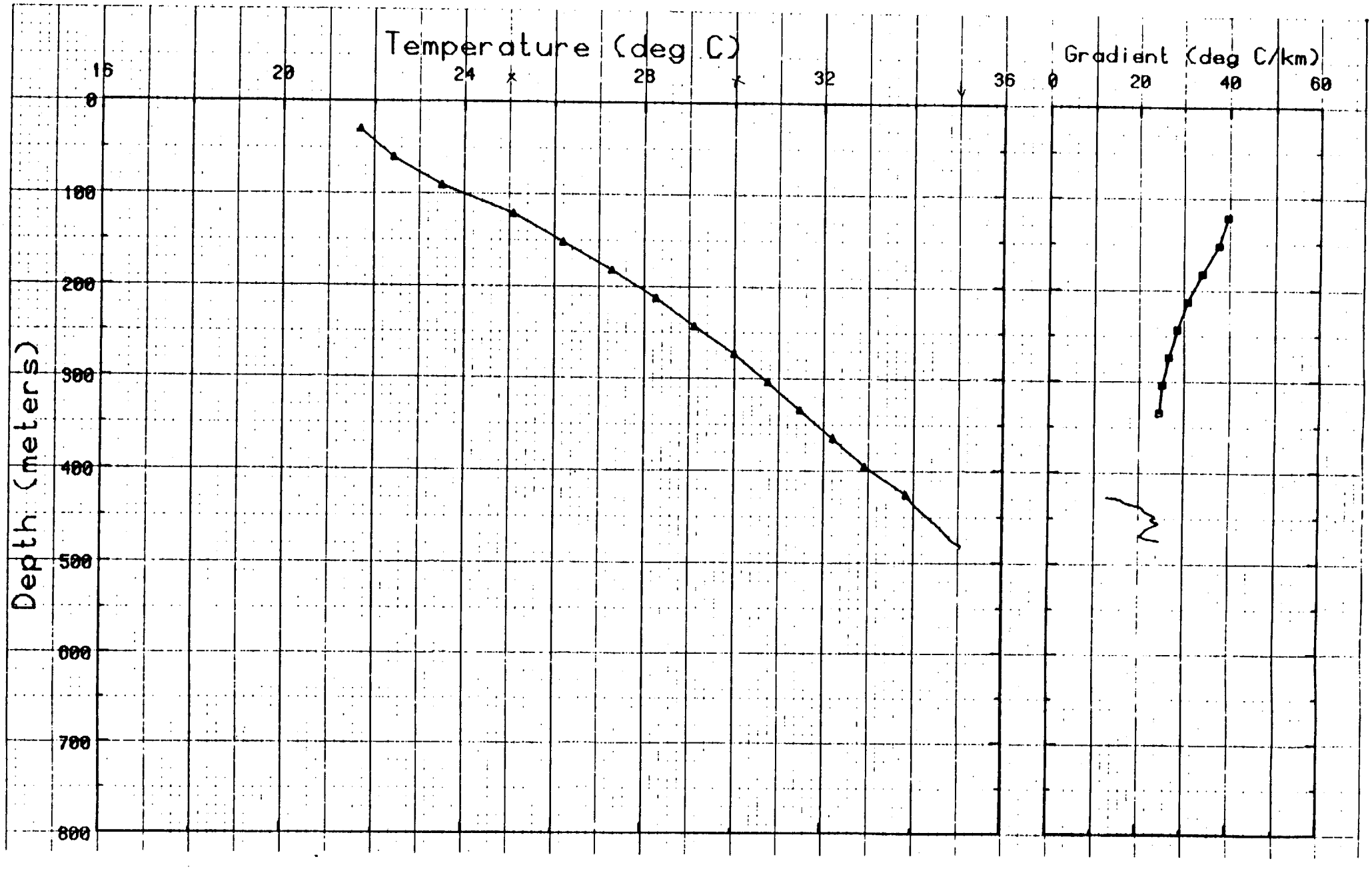

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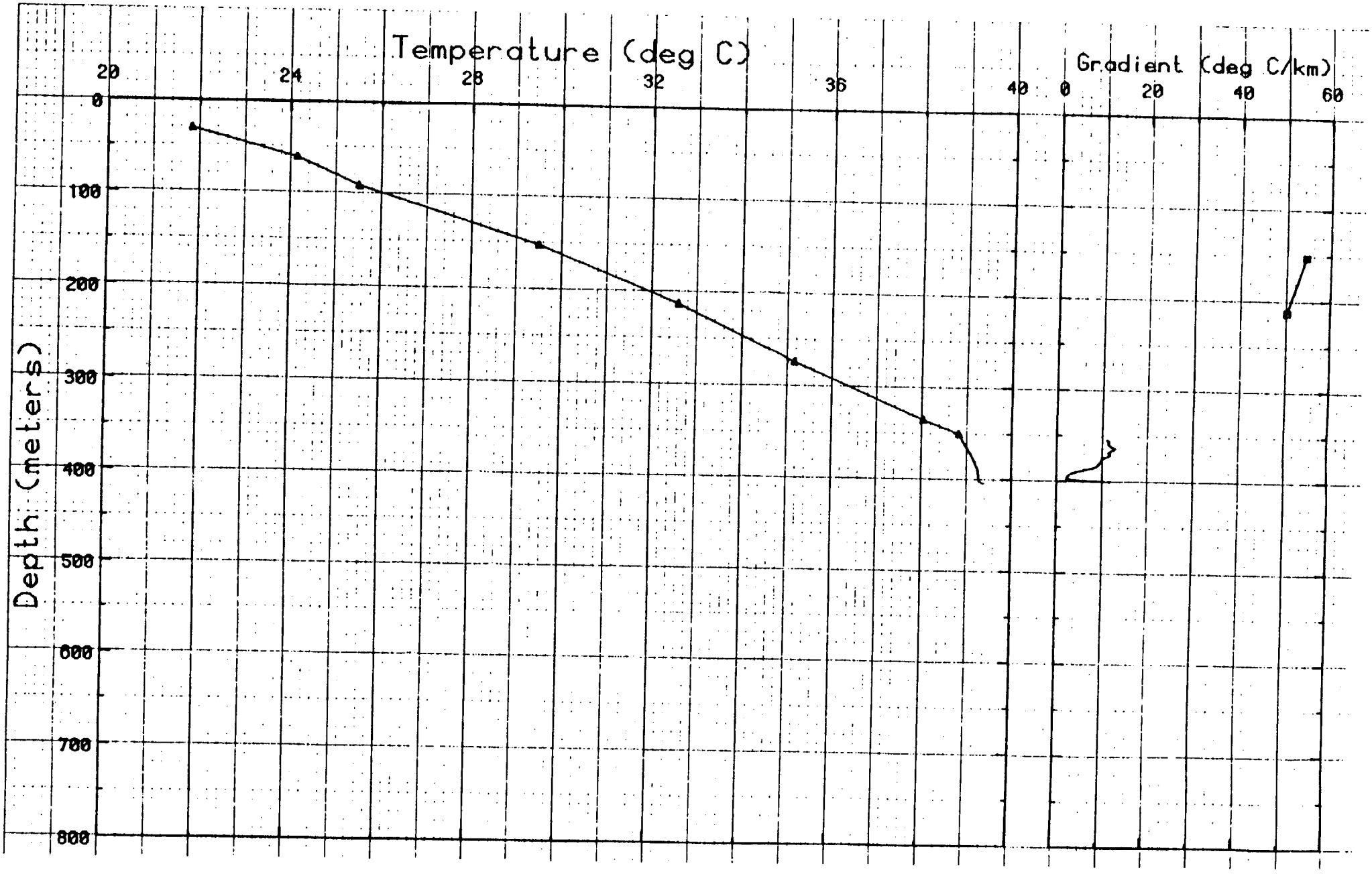
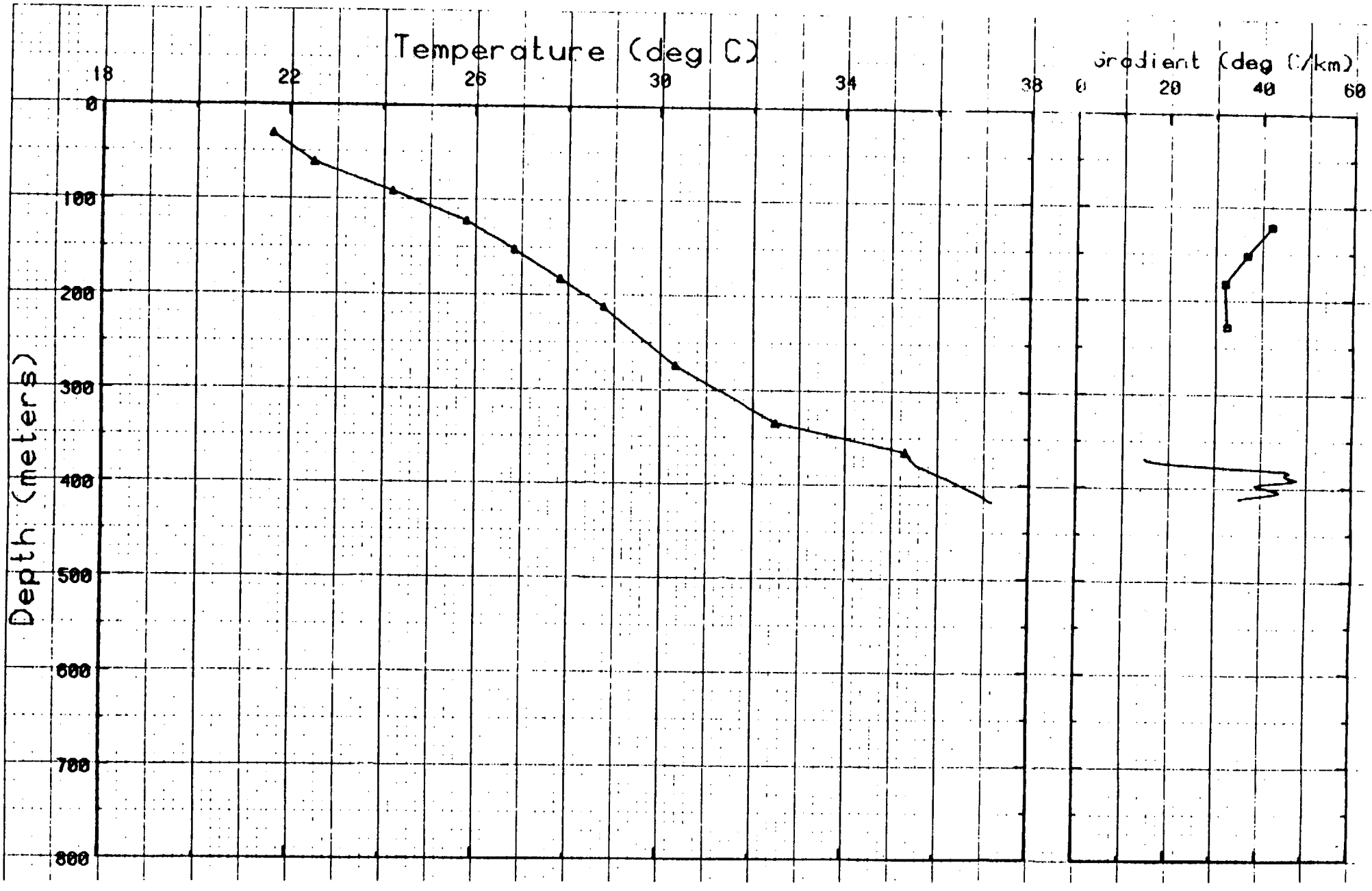
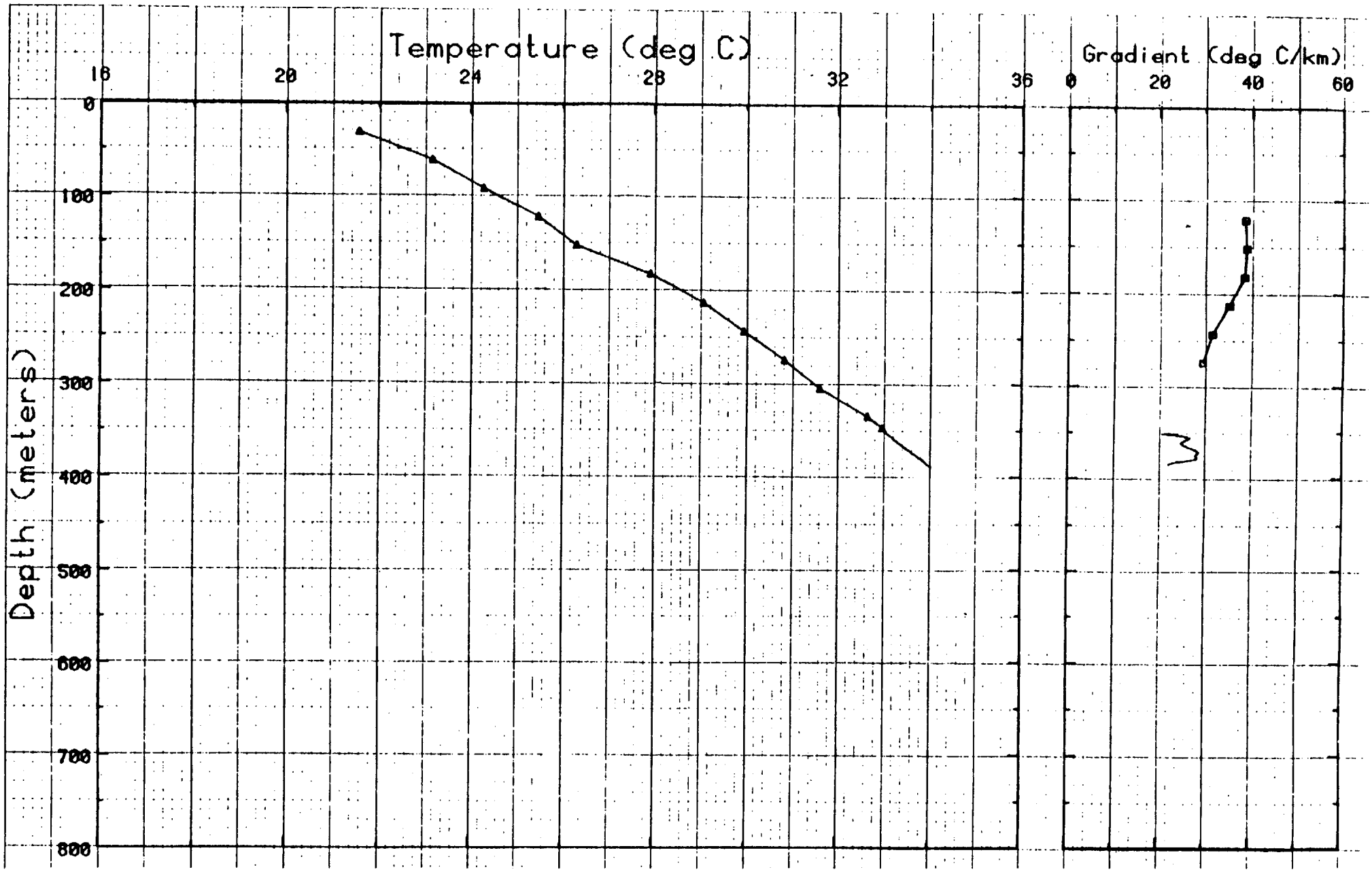


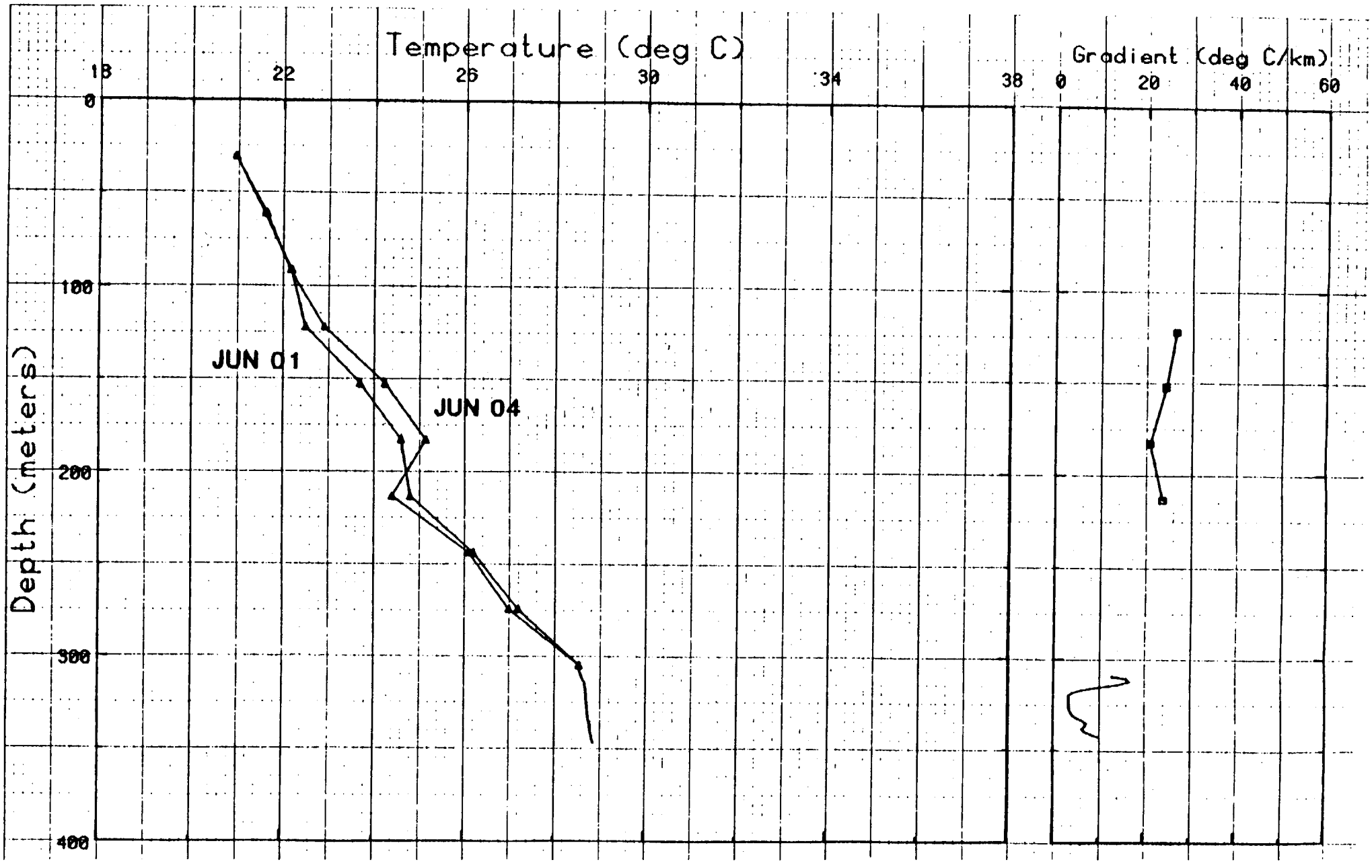
Well USW WT-10. Temperature profile. From Sass et al., 1987.



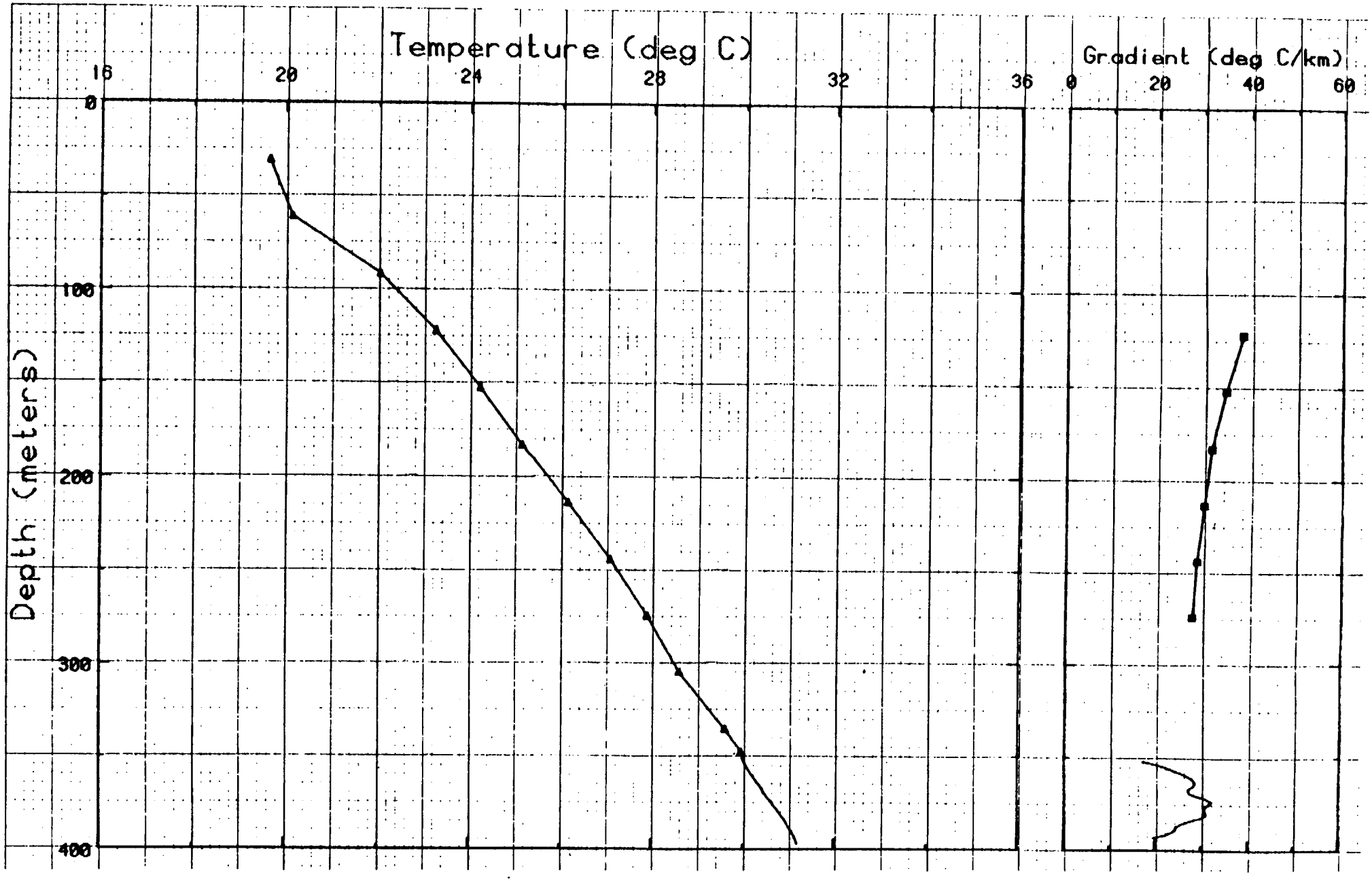
Well USW WT-11. Temperature profile. From Sass et al., 1987.



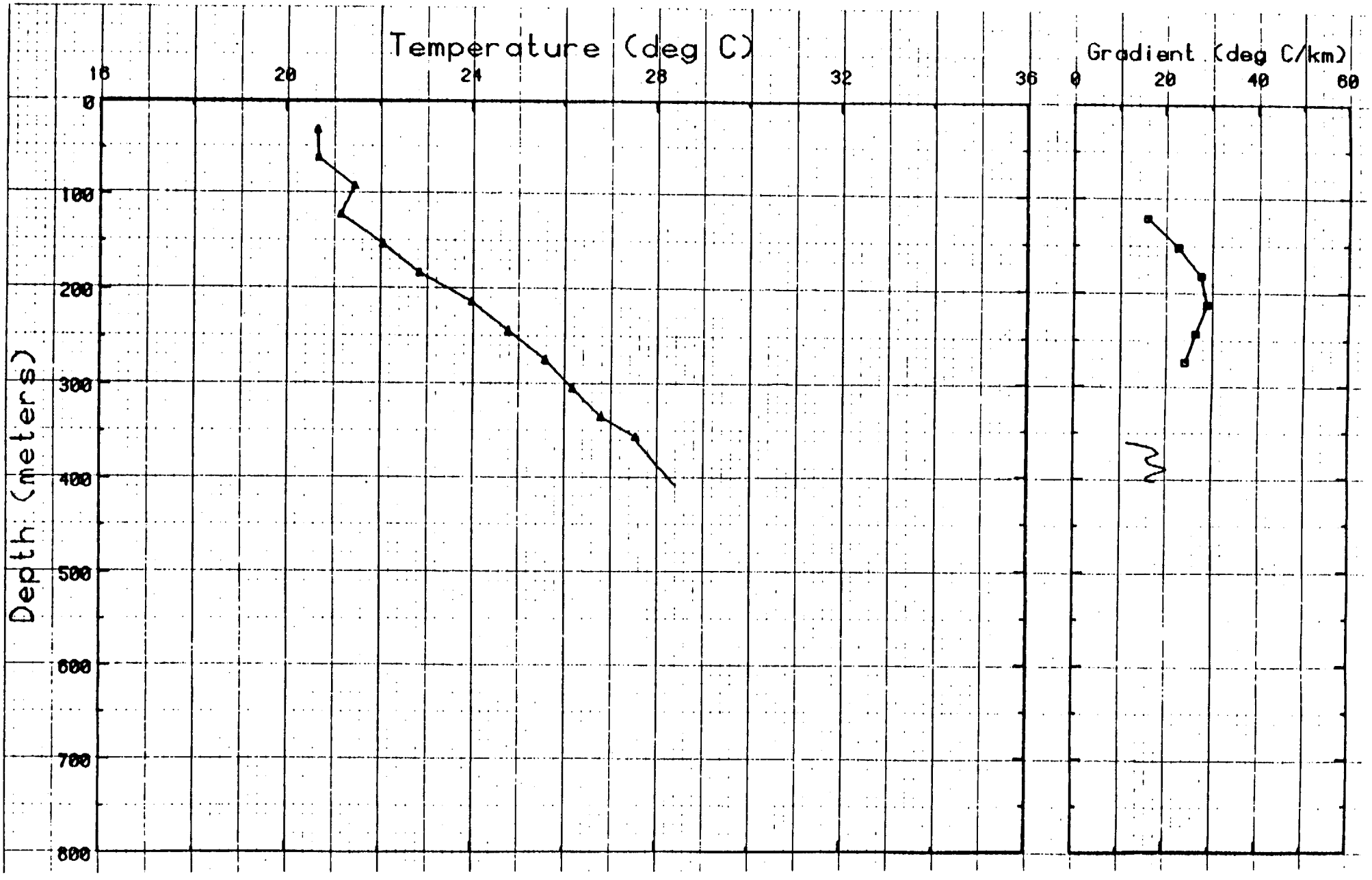
Well UE-25 WT-12. Temperature profile. From Sass et al., 1987.



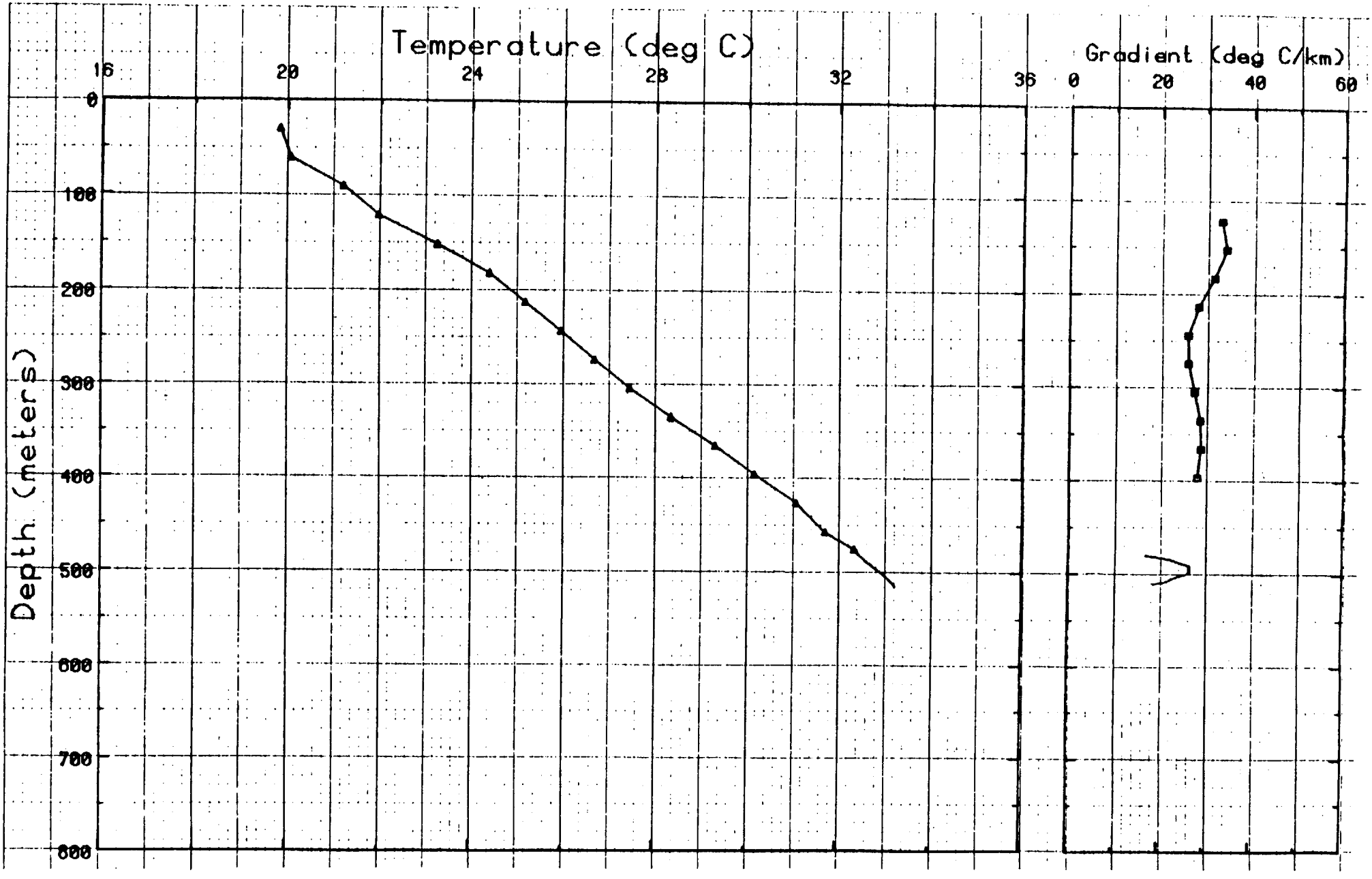
Well UE-25 WT-13. Temperature profile. From Sass et al., 1987.



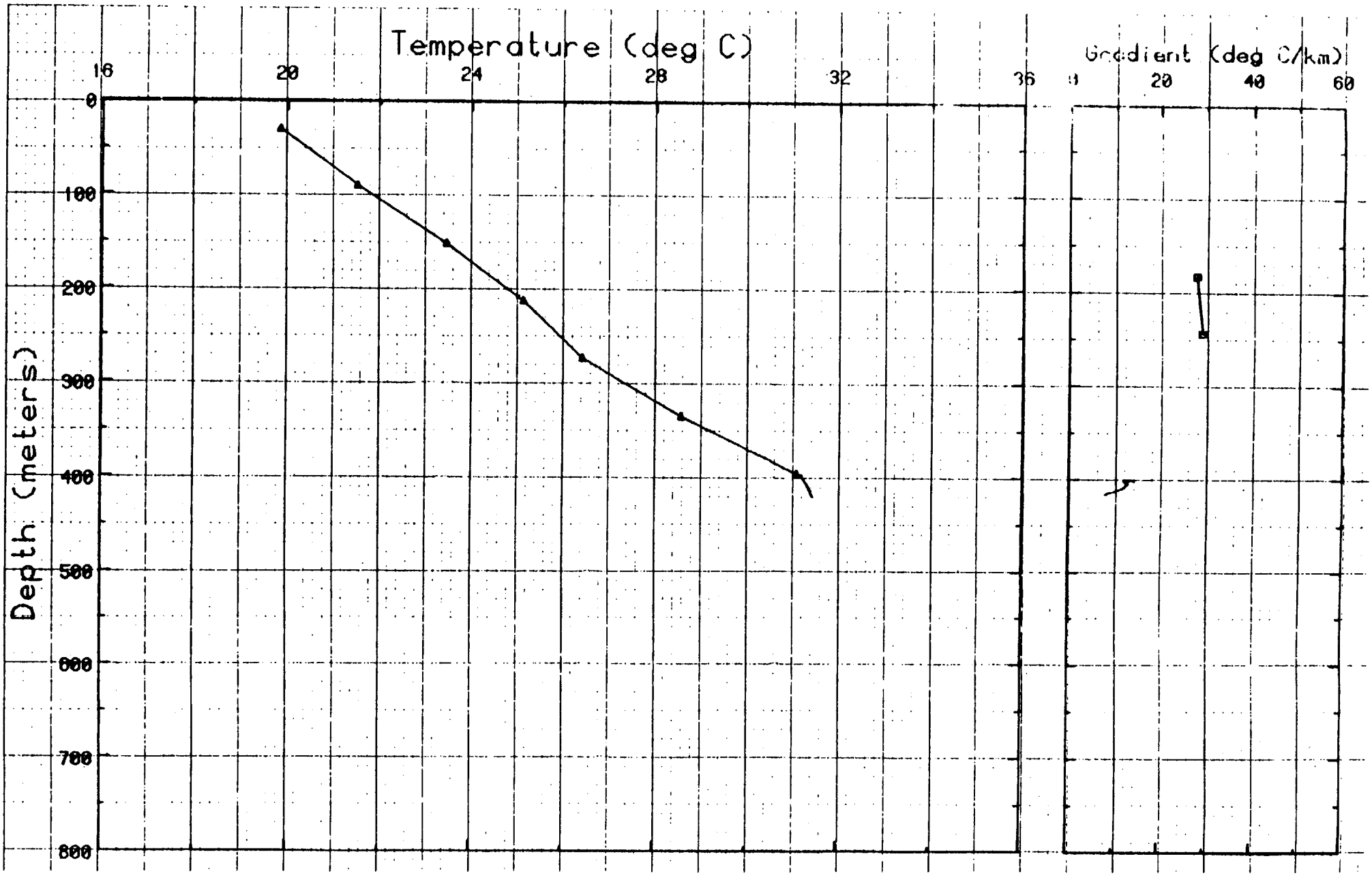
Well UE-25 WT-14. Temperature profile. From Sass et al., 1987.



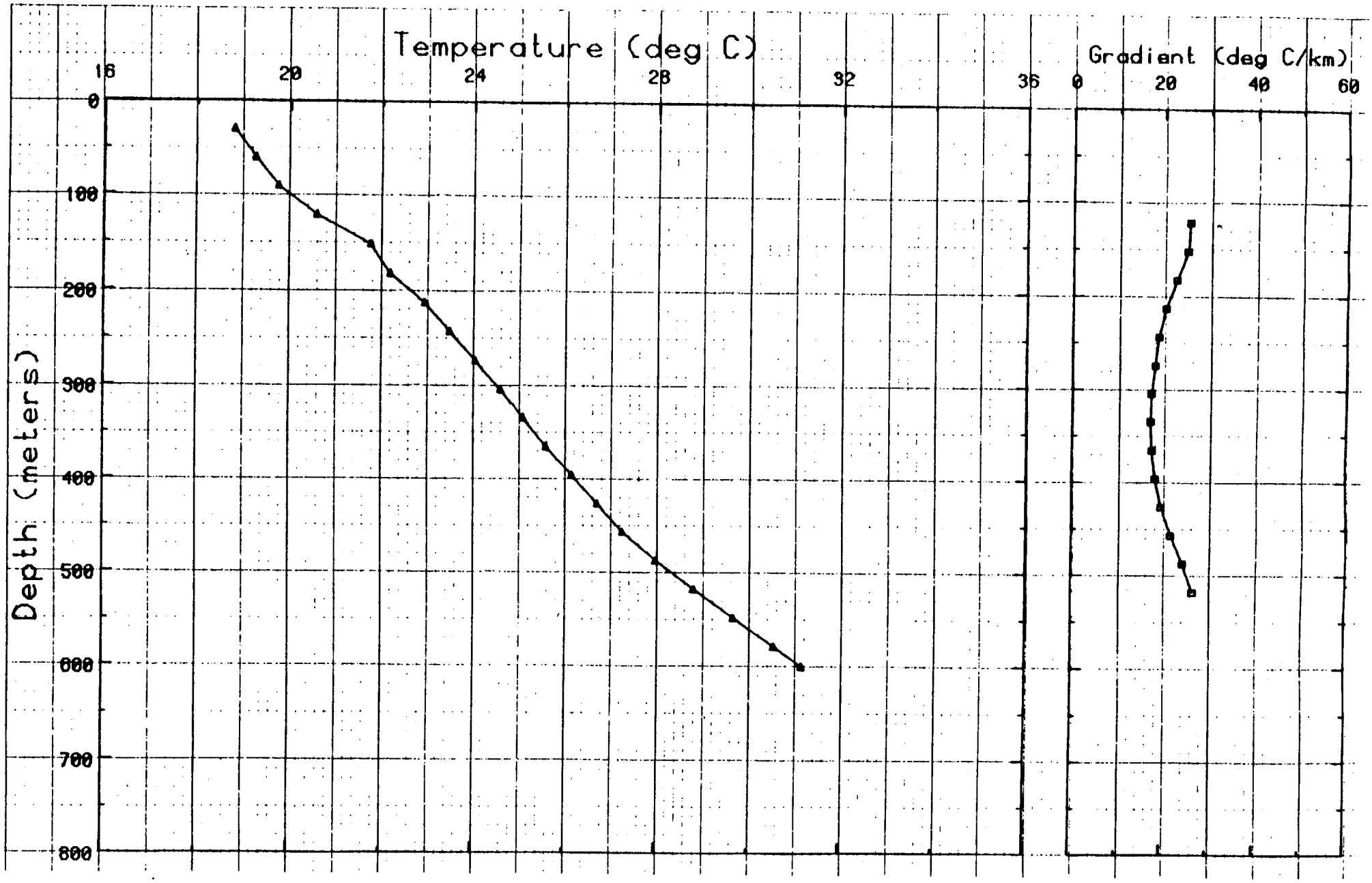
Well UE-25 WT-15. Temperature profile. From Sass et al., 1987.



Well UE-25 WT-16. Temperature profile. From Sass et al., 1987.



Well UE-25 WT-17. Temperature profile. From Sass et al., 1987.



Well USW WT-18. Temperature profile. From Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
242.3	Paintbrush Tuff (Topopah Spring Member)	Densely welded tuff	2.15	U
405.4		Densely welded tuff	1.18	U
458.1	Tuffaceous beds of Calico Hills	Non-welded tuff	1.30	U
520.0		Non-welded tuff	1.17	U
---------- SWL (static water level) ----------				
612.6	Crater Flat Tuff (Prow Pass Member)	Partially welded tuff	1.28	S
630.9		Partially welded tuff	1.33	S
693.1	(Bullfrog Member)	Non- to partially welded tuff	1.37	S
704.2		Non- to partially welded tuff	1.38	S
721.7		Partially welded tuff	1.88	S
753.6		Moderately to densely welded tuff	1.80	S
759.9		Moderately to densely welded tuff	1.88	S
773.0		Moderately to densely welded tuff	1.90	S
782.7		Moderately to densely welded tuff	1.36	S
823.3	Crater Flat Tuff (Tram Unit)	Partially to moderately welded tuff	1.39	S
857.7		Partially to moderately welded tuff	2.26	S
868.1*		Partially to moderately welded tuff	1.80	S
892.5		Partially to moderately welded tuff	2.07	S
892.8*		Partially to moderately welded tuff	1.94	S
892.9*		Partially to moderately welded tuff	1.87	S
895.7		Partially to moderately welded tuff	2.10	S
929.6		Partially to moderately welded tuff	1.95	S
930.2*		Partially to moderately welded tuff	1.42	S
940.4		Moderately welded tuff	1.54	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-1. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
967.3		Partially welded tuff	1.62	S
983.6		Non-welded tuff	1.67	S
1013.8		Vitrophyre	1.67	S
1044.5	Crater Flat Tuff (Tram Unit)	Vitrophyre	2.00	S
1065.6		Vitrophyre	1.80	S
1091.6	Flow breccia	Flow breccia	1.86	S
1123.4		Flow breccia	1.43	S
1157.9		Flow breccia	1.95	S
1187.9		Flow breccia	1.49	S
1219.4	Lithic Ridge Tuff	Partially welded tuff	1.65	S
1253.6		Partially welded tuff	1.80	S
1280.1		Partially welded tuff	1.88	S
1319.9		Partially welded tuff	1.72	S
1349.2		Partially welded tuff	1.77	S
1389.4		Partially welded tuff	1.86	S
1419.3		Partially welded tuff	1.75	S
1450.7	Lithic Ridge Tuff	Partially welded tuff	1.96	S
1477.5		Non-welded tuff	2.10	S
1511.6		Non-welded tuff	1.68	S
1540.0	Older ash flows to bedded tuffs. Units A, B, and C	Densely welded tuff	1.98	S
1573.0		Densely welded tuff	1.98	S
1600.0		Densely welded tuff	2.15	S
1632.6		Bedded tuffs	2.12	S
1675.7		Non-welded tuff	1.70	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-1. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
1716.9		Densely welded tuff	1.94	S
1747.7		Moderately welded tuff	1.91	S
1754.5		Moderately welded tuff	1.85	S
1783.3		Moderately welded tuff	1.97	S
1813.8		Moderately welded tuff	1.89	S
1814.0		Moderately welded tuff	1.86	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-1. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
110.7	(Paintbrush Tuff)	Non-welded tuff	0.88	U
135.6		Non-welded tuff	0.69	U
166.8	(Pah Canyon Member)	Partially welded tuff	0.85	U
196.6		Moderately welded tuff	1.53	U
230.6		Bedded tuff	0.97	U
259.7	(Topopah Spring Member)	Welded tuff	1.67	U
279.4		Densely welded tuff	1.95	U
309.6		Densely welded tuff	2.01	U
337.2		Densely welded tuff	2.13	U
371.1		Densely welded tuff	2.15	U
394.2		Densely welded tuff	1.74	U
422.2		Densely welded tuff	1.71	U
451.6		Densely welded tuff	2.05	U
481.6		Densely welded tuff	2.09	U
495.5		Densely welded tuff	2.11	U
----------		SWL (static water level)	----------	
525.8		Bedded tuff	1.16	S
555.4	(Tuffaceous beds of Calico Hills)	Bedded tuff	1.10	S
579.3		Non-welded tuff	1.14	S
586.6		Non-welded tuff	1.06	S
617.4		Non-welded tuff	1.16	S
644.9		Non-welded tuff	1.16	S
675.7		Non-welded tuff	1.31	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-2. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
700.6		Non-welded tuff	1.28	S
731.6		Non-welded tuff	1.19	S
761.8		Non-welded tuff	1.24	S
793.0		Partially welded tuff	1.37	S
822.4		Moderately welded tuff	1.37	S
852.6	Crater Flat tuff (Prow Pass Member)	Moderately welded tuff	1.89	S
885		Partially welded tuff	1.65	S
916.9		Partially welded tuff	1.51	S
951.5		Partially welded tuff	1.43	S
982.1		Non-welded tuff	1.56	S
1010.8	(Bullfrog Member)	Moderately welded tuff	1.83	S
1013.0		Moderately welded tuff	1.78	S
1028.5		Moderately welded tuff	1.89	S
1041.2		Non-welded tuff	1.81	S
1071.6		Bedded tuff	1.60	S
1101.6	(Tram Unit)	Lithic-rich tuff	1.90	S
1137.2		Partially welded tuff	1.60	S
1166.9		Partially welded tuff	1.92	S
1202.7		Bedded tuff	1.97	S
1234.1		Bedded tuff	1.76	S
1294.5	(Tuff of Lithic Ridge)	Partially welded tuff	1.98	S
1324.4		Partially welded tuff	2.07	S
1355.0		Partially welded tuff	1.98	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-2. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
1385.1		Partially welded tuff	1.84	S
1416.0		Partially welded tuff	2.04	S
1444.8		Partially welded tuff	2.07	S
1461.9		Partially welded tuff	2.31	S
1498.1	(Rhyolitic lava and flow breccia)	Flow breccia	2.46	S
1535.6		Lava	2.16	S
1560.2		Lava	2.13	S
1588.9	(Quartz latitic lava and flow breccia)	Lava	2.40	S
1622.6		Lava	2.14	S
1650.5		Lava	1.77	S
1681.9		Flow breccia	1.92	S
1711.2		Flow breccia	2.11	S
1734.4	(Dacitic lava and flow breccia)	Lava	2.49	S
1765.8		Lava	2.04	S
1796.4		Bedded tuff	2.42	S
1827.0	(older tuffs of USW G-2)	Moderately welded tuff	2.21	S

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-2. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
35.7	Paintbrush tuff (Tiva Canyon Member)	Welded tuff	2.03	U
61.0		Welded tuff	2.20	U
96.0		Welded tuff	1.89	U
133.2		Bedded tuff (non-welded)	1.28	U
152.4	(Topopah Spring Member)	Moderately welded tuff	1.54	U
183.3		Moderately welded tuff	1.95	U
214.0		Welded tuff	2.26	U
253.3		Welded tuff	2.22	U
276.5		Welded tuff	2.23	U
311.6		Welded tuff	2.17	U
335.7		Welded tuff	2.01	U
367.3		Densely welded tuff	1.34	U
396.5		Partially welded tuff	1.08	U
453.0	(Tuffaceous beds of Calico Hills?)	Non-welded tuff	0.84	U
457.3		Non-welded tuff	0.91	U
489.4	Crater Flat Tuff (Prow Pass Member)	Non-welded tuff	2.50	U
519.1		Partially welded tuff	1.61	U
549.9		Partially welded tuff	1.02	U
580.6		Partially welded tuff	1.07	U
608.5		Bedded tuff	1.15	U
640.3	Crater Flat Tuff (Bullfrog Member)	Partially welded tuff	1.90	U
669.4		Welded tuff	1.86	U

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-3. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
704.1		Welded tuff	1.98	U
734.7		Welded tuff	2.01	U
---------- SWL (static water level) ----------				
767.1		Moderately welded	1.91	S
791.2		Partially welded	1.31	S
- End GU-3 -				
795.4		Partially welded	1.20	S
829.7	Crater Flat Tuff (Tram Member)	Non- to partially welded tuff	1.73	S
859.9		Bedded tuff	1.69	S
920.6		Moderately welded	1.77	S
949.2		Partially to moderately welded tuff	1.77	S
986.4		Moderately to partially welded tuff	1.97	S
1011.9		Partially to moderately welded tuff	1.39	S
1042.9		Partially to moderately welded tuff	1.39	S
1074.1		Moderately welded tuff	1.66	S
1103.5		Moderately welded tuff	1.41	S
1134.1		Moderately to partially welded tuff	1.50	S
1162.1		Partially to moderately welded tuff	1.37	S
1194.8	Lithic Ridge Tuff	Moderately welded tuff	1.71	S
1224.7		Partially welded tuff	1.53	S
1255.9		Non- to partially welded tuff	1.60	S
1286,7		Partially to moderately welded tuff	1.64	S
1316.6		Partially welded tuff	1.74	
1347.6		Moderately welded tuff	1.71	

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-3. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
1347.6		Moderately welded tuff	1.71	
1377.6		Partially to moderately welded tuff	1.74	
1407.6		Partially to moderately welded tuff	1.75	
1438.9		Moderately to partially welded tuff	1.85	
1469.6		Moderately to partially welded tuff	1.86	
1499.8	Older tuffs (Unit A?)	Welded tuff	1.92	
1529.5		Welded tuff	1.80	

Thermal conductivities from the Tertiary tuff "pile" in Well USW G-3. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
27.6	Paintbrush Tuff (Tiva Canyon Member)	Densely welded tuff	1.88	U
77.2	(Tonopah Spring Member)	Densely welded tuff	1.33	U
116.1		Moderate to densely welded tuff	1.72	U
151.3		Densely welded tuff	2.03	U
183.8		Densely welded tuff	2.04	U
214.8		Densely welded tuff	2.17	U
253.0		Densely welded tuff	2.11	U
286.5		Densely welded tuff	2.21	U
324.8		Densely welded tuff	1.69	U
376.1		Densely welded tuff	1.87	U
418.5		Non-welded tuff	0.95	U
448.2	Rhyolite lavas and tuffs of Calico Hills (Tuffaceous beds of Calico Hills)	Non-welded tuff	1.11	U
479.6		Non-welded tuff	1.11	U
511.6		Non-welded tuff	1.14	U
---------- SWL (static water level) ----------				
544.3	Crater Flat Tuff (Prow Pass Member)	Non-welded tuff	1.23	S
570.8		Partially welded tuff	1.52	S
603.2		Non- to partially welded tuff	1.23	S
627.5		Partially welded tuff	1.21	S
660.5		Partially welded tuff	1.19	S
694.9	Crater Flat Tuff (Bullfrog Member)	Partially welded tuff	1.71	S
721.5		Partially welded tuff	1.25	S

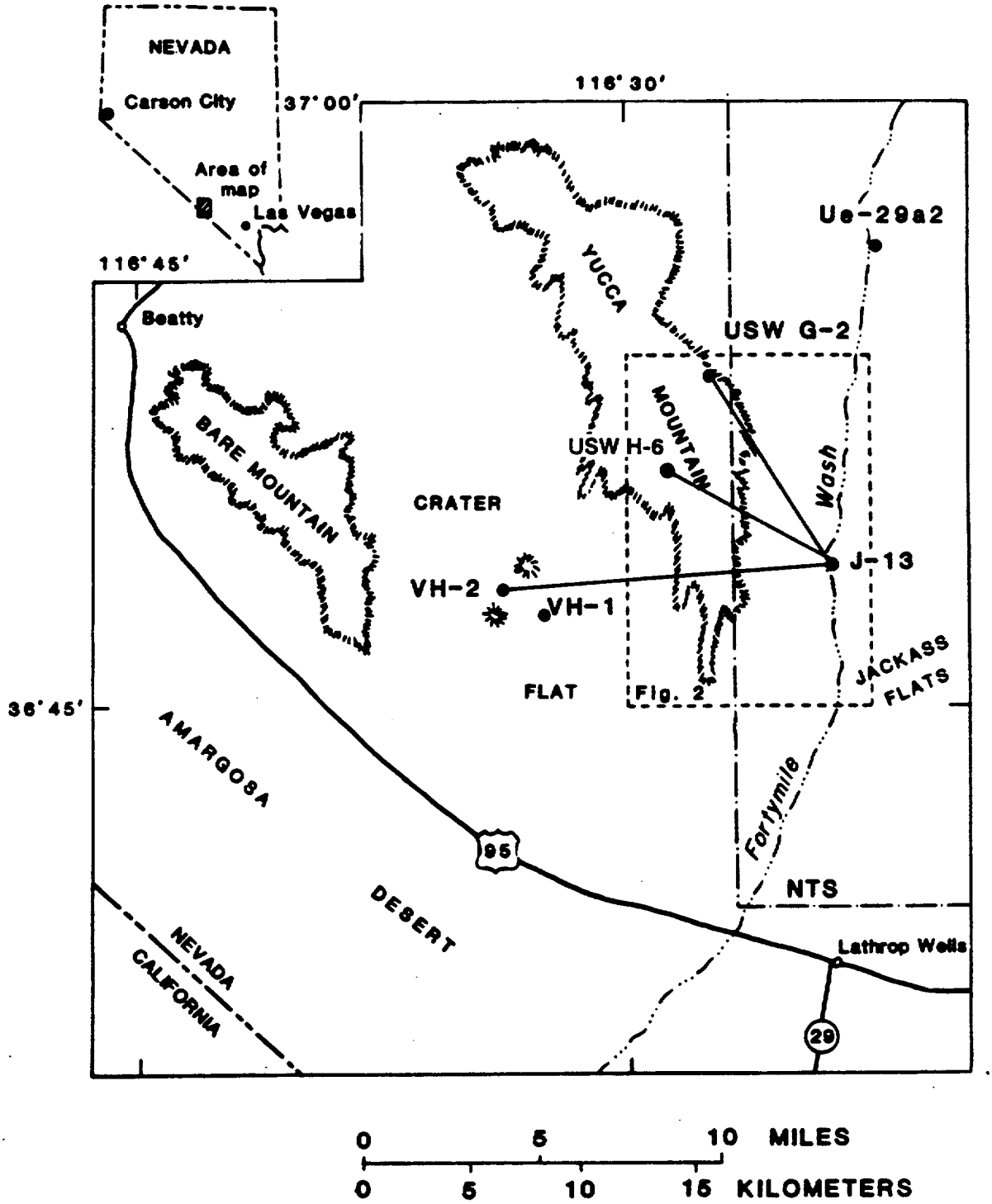
Thermal conductivities from the Tertiary tuff "pile" in Well USW G-4. Sass et al., 1987.

Depth, m	Formation (member)	Lithology	K $Wm^{-1}K^{-1}$	Saturation
752.5		Partially welded tuff	1.36	S
786.1		Partially welded tuff	1.91	S
820.2		Partially welded tuff	1.39	S
849.9	(Tram Member)	Non- to partially welded tuff	1.28	S
873.4		Tuff	1.99	S
905.7		Tuff	1.25	S

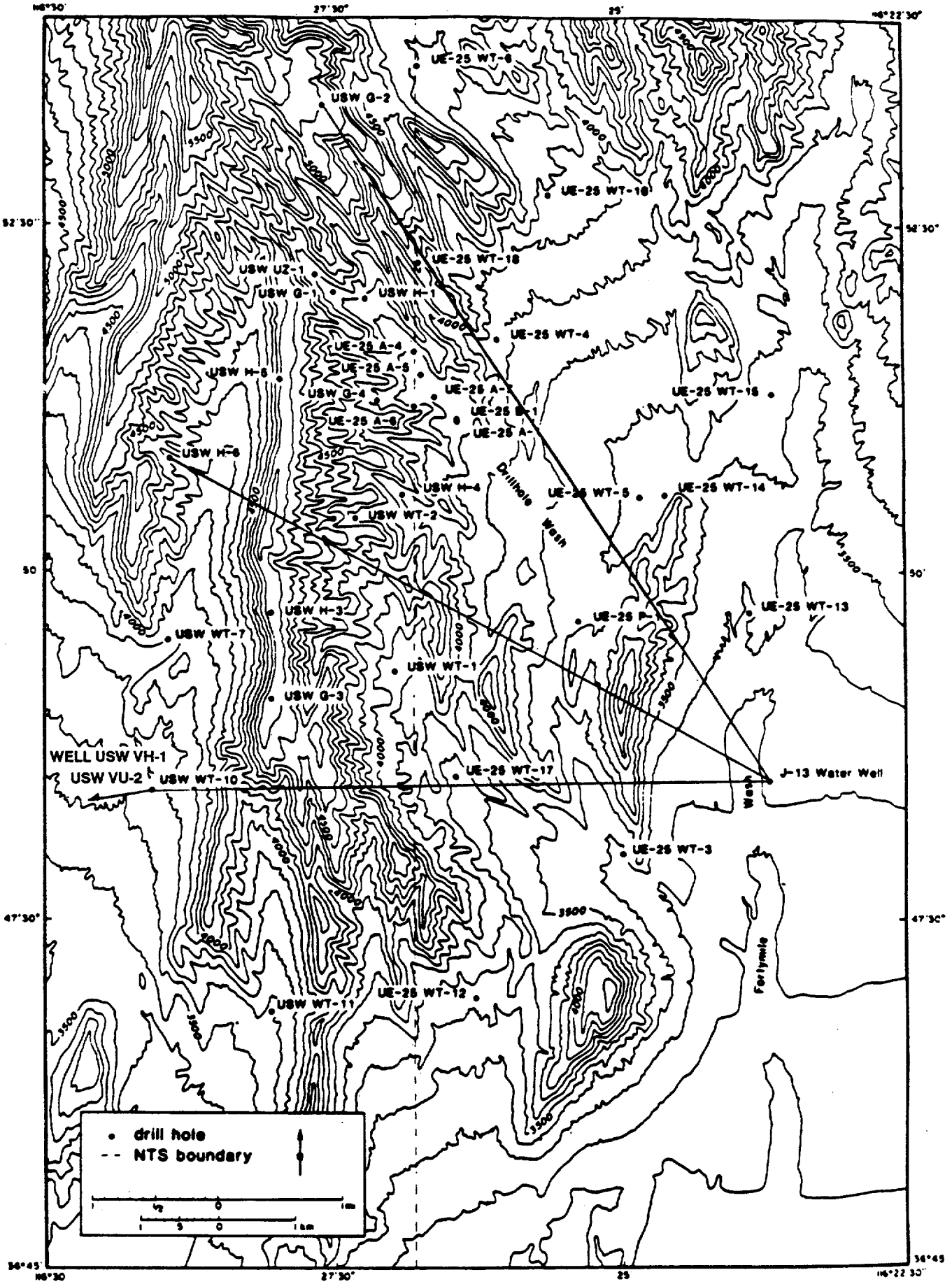
Thermal conductivities from the Tertiary tuff "pile" in Well USW G-4. Sass et al., 1987.

Depth, m	Formation (member)	K $Wm^{-1} K^{-1}$
1310.4	Lone Mtn. Dolomite	5.36
1330.5	Lone Mtn. Dolomite	5.08
1339.9	Lone Mtn. Dolomite	4.67
1351.6	Lone Mtn. Dolomite	4.91
1367.4	Lone Mtn. Dolomite	5.17
1387.0	Lone Mtn. Dolomite	4.71
1399.1	Lone Mtn. Dolomite	4.93
1414.5	Lone Mtn. Dolomite	4.76
1429.0	Lone Mtn. Dolomite	4.45
1454.1	Lone Mtn. Dolomite	5.09
1479.1	Lone Mtn. Dolomite	4.79
1490.5	Lone Mtn. Dolomite	4.94
1801.6	Roberts Mountains Formation	5.47

Thermal conductivities from Paleozoic carbonates. Sass et al., 1987.



Location map. Thermal cross-sections for Yucca Mountain.



Location map. Thermal cross-sections for Yucca Mountain.

J-13
EL. 1011m
WT. 283 m

Temp. °C	Depth (m)
25	135
30	270
35	770

UE-25p#1
EL. 1114m
WT. 384 m

Temp. °C	Depth (m)
20	40
25	100
30	300
35	440
40	700
45	910
50	1050
55	1200
55	1700

UE WT-13
EL. 1031m
WT. 303 m

Temp. °C	Depth (m)
25	175

UE-25 WT-5
EL. 1083m
WT.

Temp. °C	Depth (m)
20	35
25	130
30	230

UE-25b#1
EL. 1200m
WT. 470 m

Temp. °C	Depth (m)
20	60
25	230
30	430
35	700
40	1130

USW H-1
EL. 1302m
WT. 572 m

Temp. °C	Depth (m)
20	50
25	340
30	560
35	820
40	1040
45	1210
50	1390
55	1560
60	1750

USW G-1
EL. 1324m
WT. 572 m

Temp. °C	Depth (m)
20	0
25	330
30	560
35	750
40	980
45	1160
50	1330
55	1500
60	1700

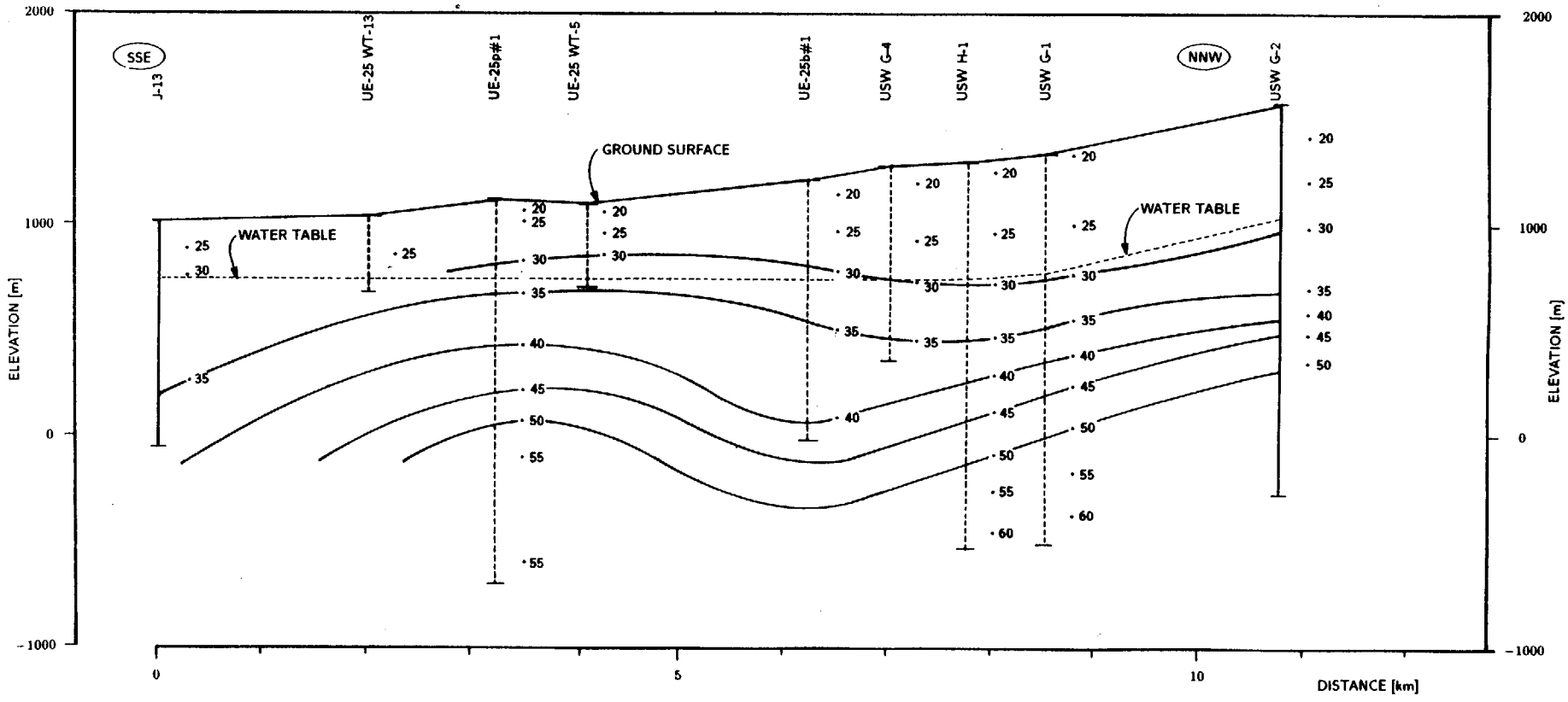
USW G-2
EL. 1552m
WT. 525 m

Temp. °C	Depth (m)
20	150
25	360
30	580
35	870
40	980
45	1080
50	1220

USW G-4
EL. 1269m
WT. 539 m

Temp. °C	Depth (m)
20	80
25	350
30	520
35	800

Summary of thermal data. NNW-SSE cross-section. Yucca Mountain.



NNW-SSE thermal cross-section. Yucca Mountain.

J-13	
EL.	1011m
WT.	283 m
Temp.°C	Depth (m)
25	135
30	270
35	770

UE-25p#1	
EL.	1114m
WT.	384 m
Temp.°C	Depth (m)
20	40
25	100
30	300
35	440
40	700
45	910
40	1050
55	1200
55	1700

USW WT-1	
EL.	1201m
WT.	471 m
Temp.°C	Depth (m)
20	50
25	320
30	470

USW H-4	
EL.	1248m
WT.	518 m
Temp.°C	Depth (m)
20	60
25	340
30	520
35	1020
40	1210

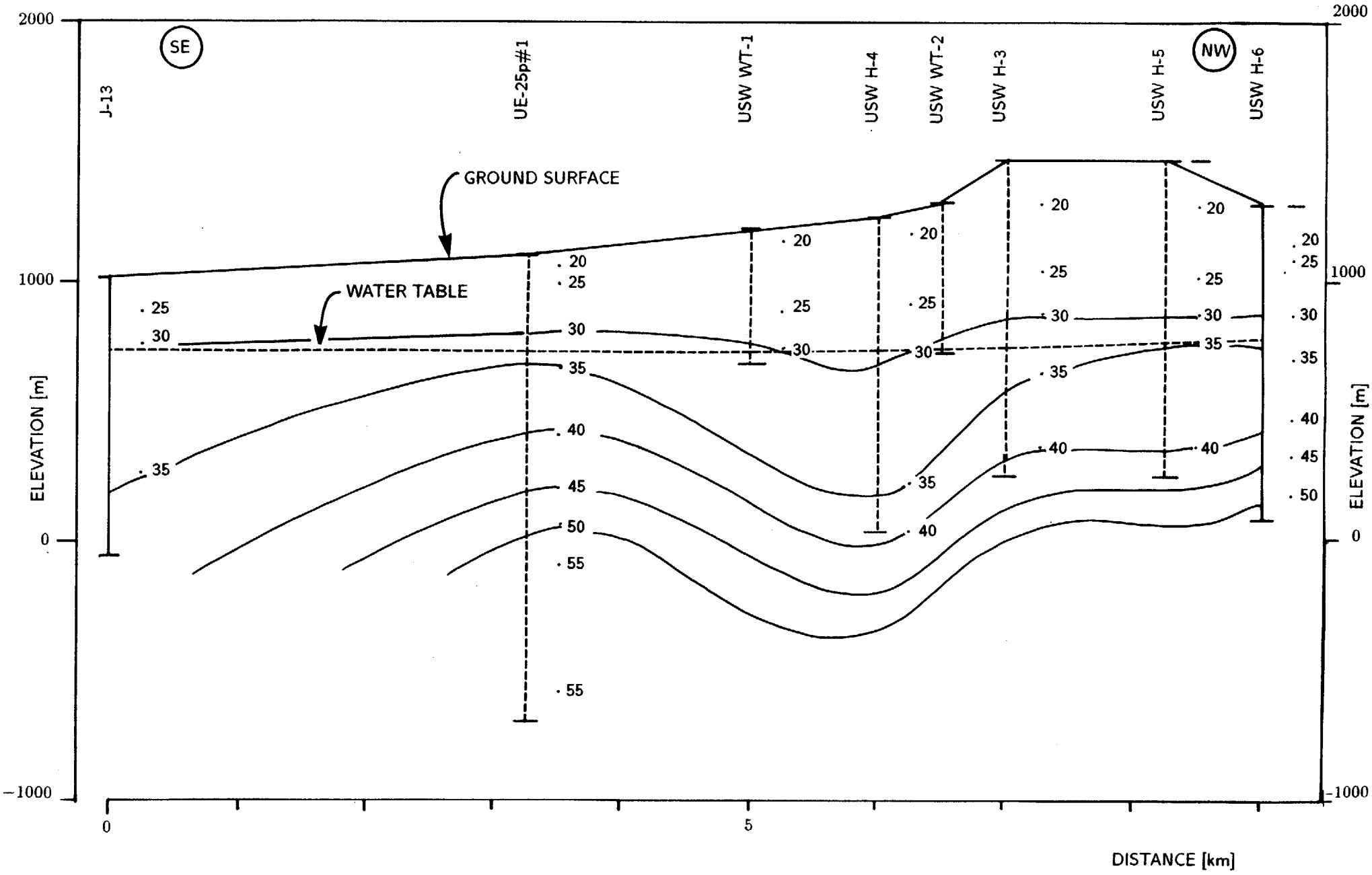
USW WT-2	
EL.	1301m
WT.	571 m
Temp.°C	Depth (m)
20	120
25	370
30	520

USW H-3	
EL.	1483m
WT.	750 m
Temp.°C	Depth (m)
20	180
25	440
30	610
35	830
40	1120

USW H-5	
EL.	1478m
WT.	704 m
Temp.°C	Depth (m)
20	200
25	470
30	620
35	720
40	1130

USW H-6	
EL.	1301m
WT.	526 m
Temp.°C	Depth (m)
20	170
25	220
30	430
35	600
40	840
45	970
50	1120

Summary of thermal data. NW-SE cross-section. Yucca Mountain.



NW-SE thermal cross-section. Yucca Mountain.

plate 4.3.3.-47a

J-13 EL. 1011m WT. 283 m	
Temp.°C	Depth (m)
25	135
30	270
35	770

UE-25 WT-3 EL. 1029m WT. 300 m	
Temp.°C	Depth (m)
20	25
25	125
30	225

USW WT-17 EL. 1124m WT. 394 m	
Temp.°C	Depth (m)
20	30
25	210
30	370

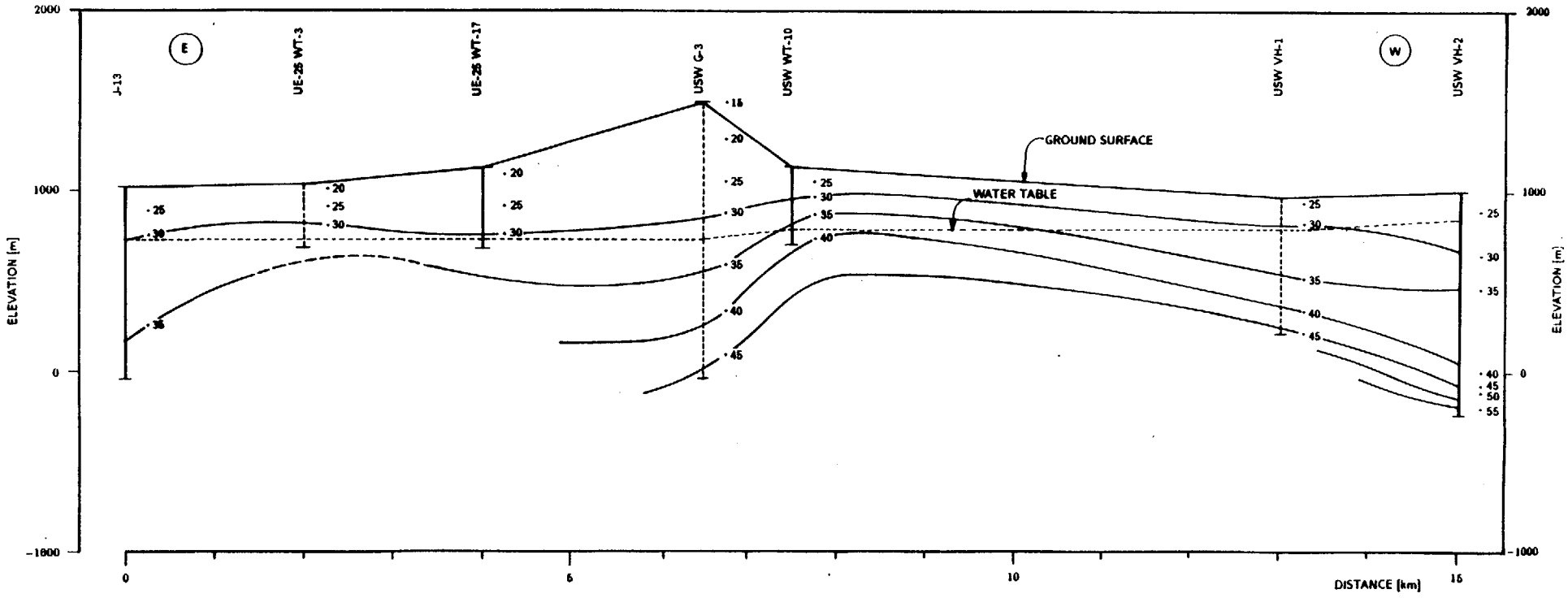
USW G-3 EL. 1480m WT. 750 m	
Temp.°C	Depth (m)
15	0
20	200
25	440
30	620
35	900
40	1160
45	1400

USW WT-10 EL. 1123m WT. 347 m	
Temp.°C	Depth (m)
25	80
30	170
35	270
40	400

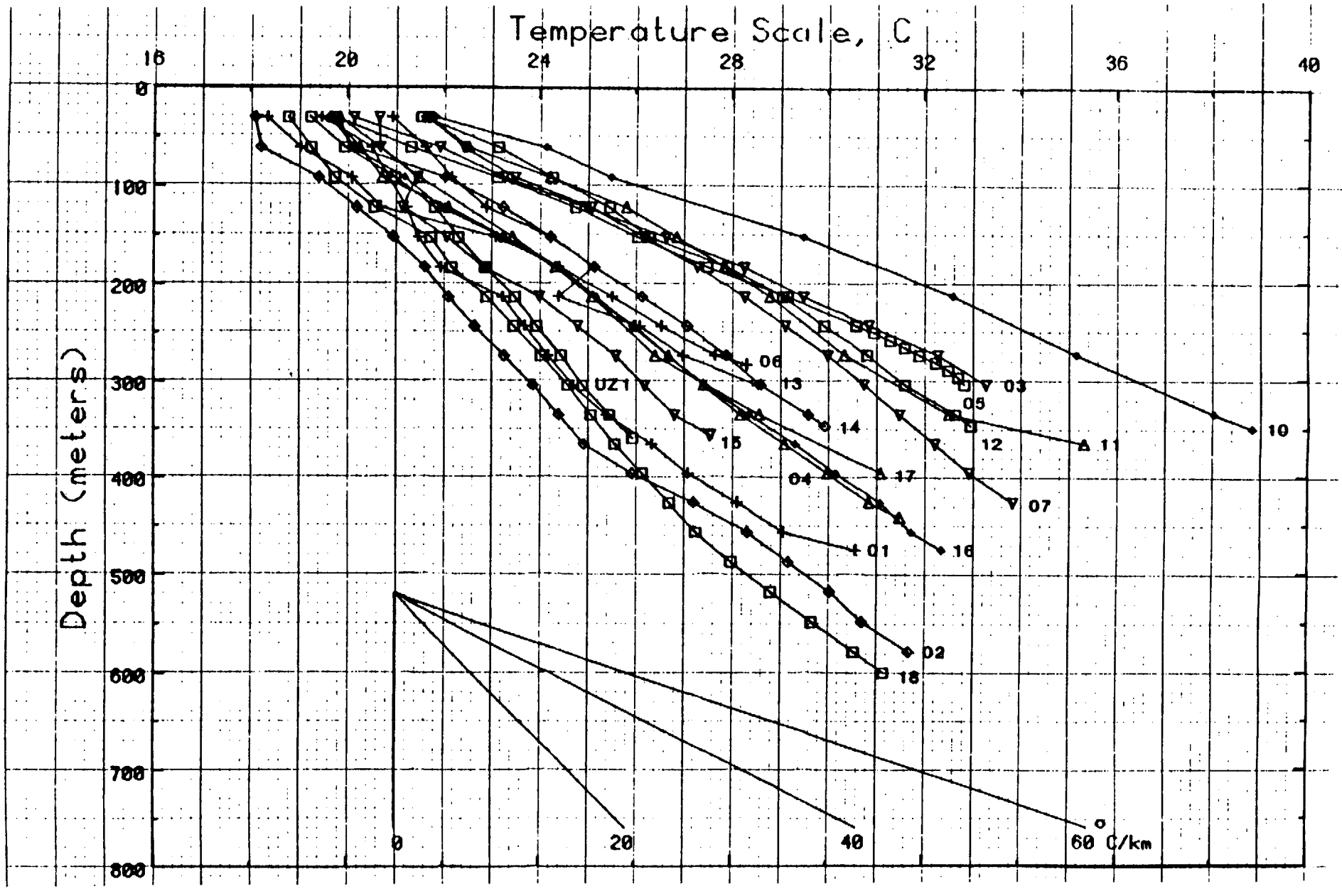
USW UH-1 EL. 963 m WT. 750 m	
Temp.°C	Depth (m)
25	30
30	140
35	450
40	630
45	750

USW UH-2 EL. 974 m WT. 164 m	
Temp.°C	Depth (m)
25	110
30	360
35	540
40	1000
45	1070
50	1110
55	1200

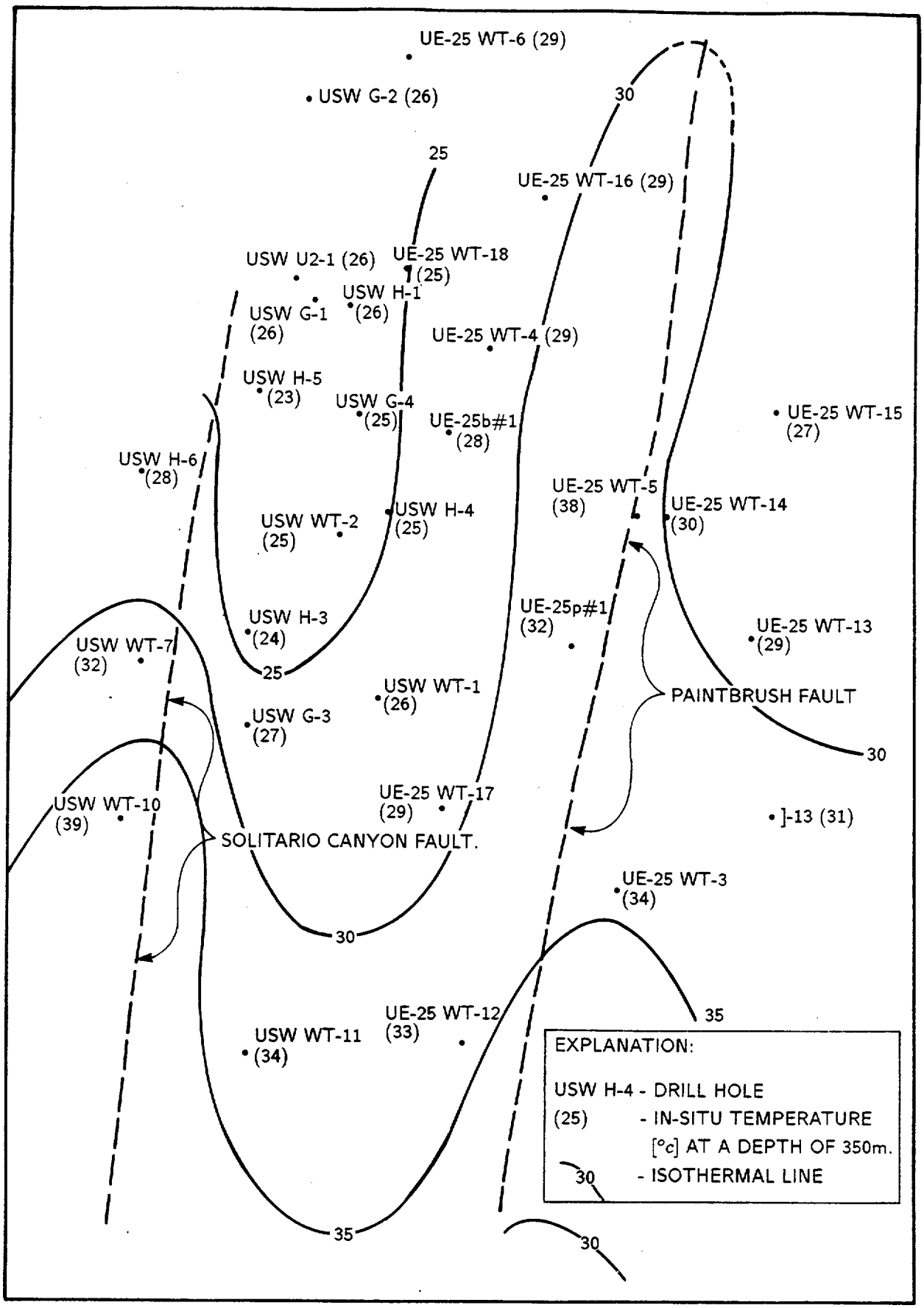
Summary of thermal data. E-W cross-section. Yucca Mountain.



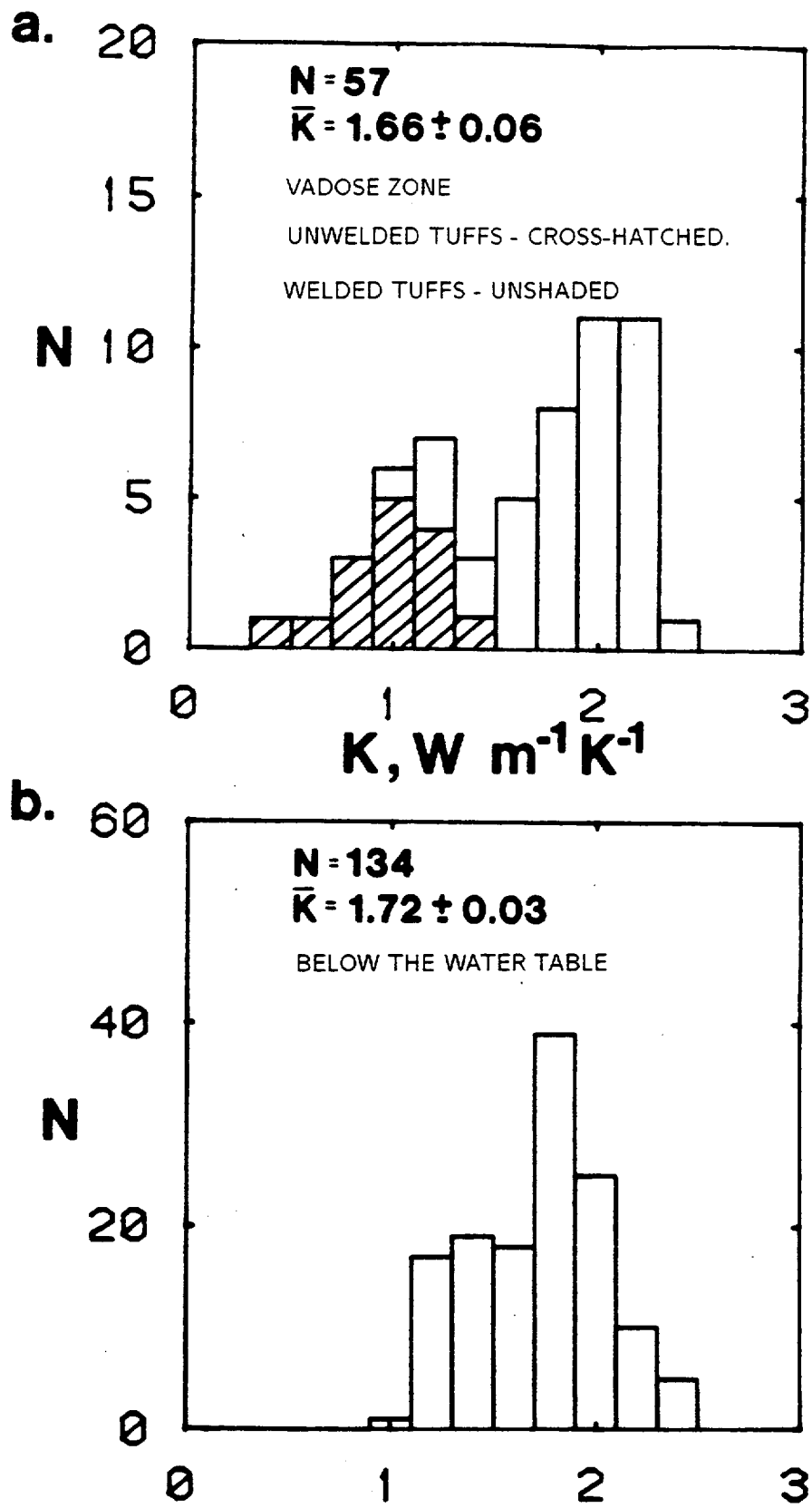
E-W thermal cross-section. Yucca Mountain.



Temperature profiles. Vadose zone at Yucca Mountain. From Sass et al., 1988.



In situ temperatures at a depth of 350 m. Yucca Mountain - vadose zone.



Histogram of thermal conductivities from the Tertiary tuff "pile". Yucca Mountain. From Sass et al., 1987.

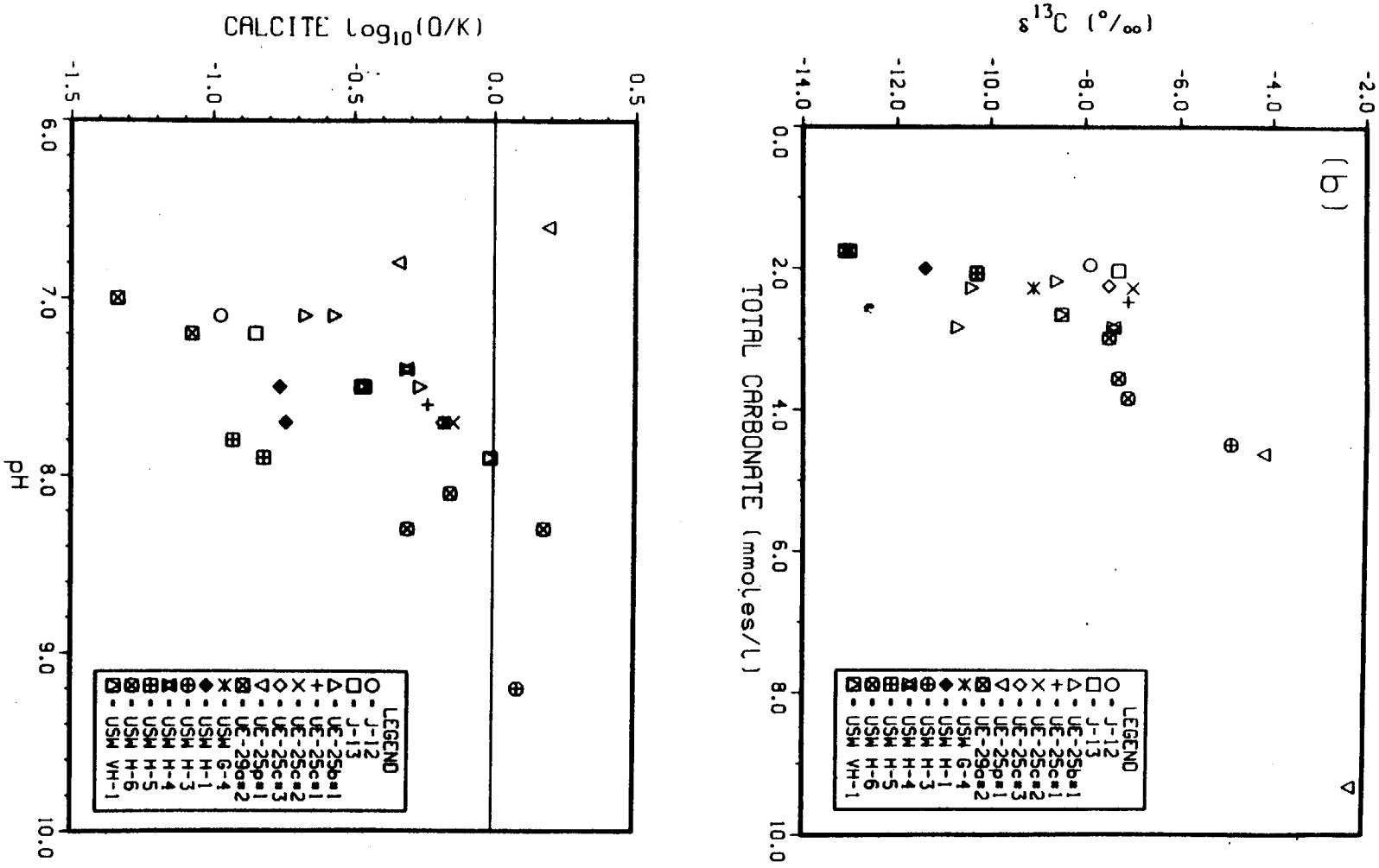
Designation	Unit	Thermal conductivity $Wm^{-1} K^{-1}$							
		N	unsat	S.D.	S.E.	N	sat	S.D.	S.E.
Tpb	Paintbrush Tuff, bedded tuffs	2	0.78	0.13	0.13				
Tpc	Paintbrush Tuff, Tiva Canyon Mem.	5	1.86	0.35	0.15				
Tpp	Paintbrush Tuff, Pah Canyon Mem.	3	1.12	0.36	0.21				
Tpt	Paintbrush Tuff, Topopah Spr. Mem.	31	1.87	0.36	0.07	1	1.16		
Tht	Tuff beds, Calico Hills	7	1.08	0.16	0.06	11	1.22	0.11	0.03
Tcp	Crater Flat Tuff, Prow Pass Mem.	5	1.47	0.62	0.28	12	1.42	0.21	0.06
Tcb	Crater Flat Tuff, Bullfrog Mem.	4	1.94	0.07	0.03	20	1.63	0.26	0.06
Tct	Crater Flat Tuff, Tram Mem.					34	1.72	0.26	0.04
Tfb	Flow breccia					4	1.68	0.26	0.13
Tlr	Lithic Ridge Tuff					27	1.84	0.18	0.03
Tllr	Rhyolitic lava - flow breccia					3	2.25	0.18	0.11
Tllq	Qtz-latitic lava - flow breccia					5	2.07	0.24	0.11
Tlld	Latitic lava - flow breccia					3	2.32	0.24	0.14
Tta	Older ash flows - bedded tuffs. Units A, B, and C.					6	2.01	0.15	0.06
Ttb						1	2.12		
Ttc						7	1.87	0.09	0.03
Slm	Lone Mtn. dolomite					12	4.90	0.25	0.07
Srm	Roberts Mtn. Fm.					1	5.47		
All		57	1.66	0.49	0.06	134*	1.72	0.32	0.03

*Excluding Paleozoic rocks from Ue25-p1

Average thermal conductivities. Yucca Mountain. From Sass et al., 1987.

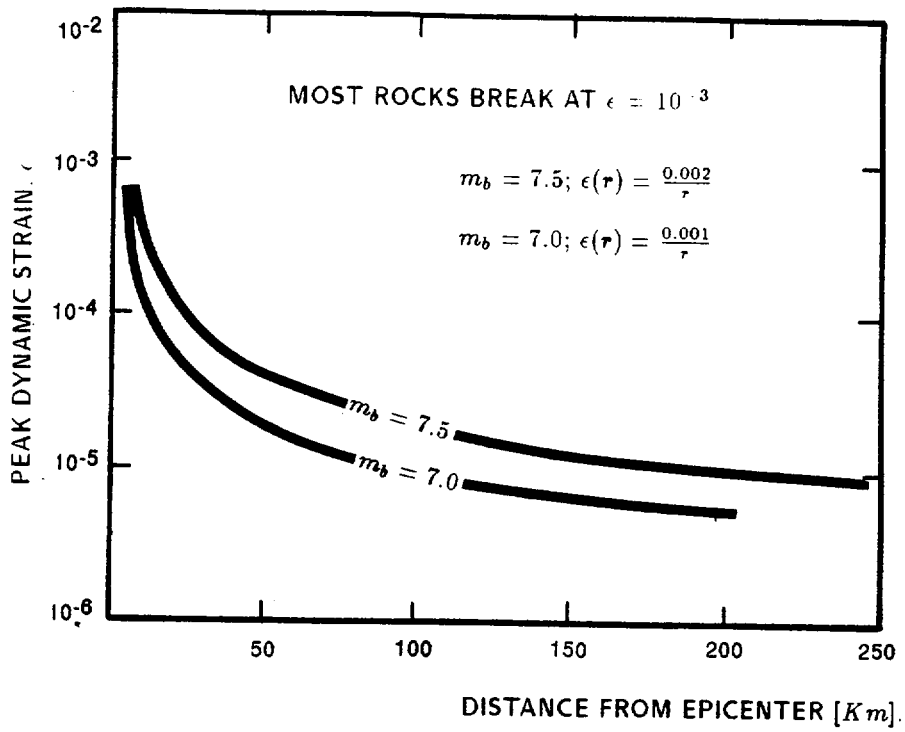
WELL No	DEPTH INTERVAL [m]	GEOTHERMAL GRADIENT [$^{\circ}c/km$]	THERMAL CONDUCTIVITY [$Wm^{-1}K^{-1}$]	HEAT FLOW [mWm^{-2}]
UGW G-1	1000 - 1500	32	1.77	56.6
USW G-2	750 - 1250	41	1.74	71.3
USW H-5	1060 - 1100	40	1.73 (?)	69.2
USW H-6	800 - 1100	40	1.73	69.2
USW VH-1	690 - 860	60	1.73 (?)	103.8
USW VH-2	1055 - 1220	65 (?)	1.73 (?)	112.4

Estimates of heat flow. Yucca Mountain.



$\partial^{13}C$ ratios and calcite saturation indexes for water samples from Yucca Mountain. From Kerrisk, 1987.

PEAK DYNAMIC STRAIN. FROM WOOD (1985).



DURATION OF STRESSING AND WIDTH OF STRESSED INTERVAL.

FREQ. SEISMIC WAVE	WIDTH OF STRESSED INTERVAL $\frac{\lambda}{4}$	TIME OF STRESSING
.5 Hz	3.0 Km	.5 $SEC.$
10 Hz	.15 Km	.025 $SEC.$
100 Hz	.015 Km	.0025 $SEC.$

PORE PRESSURE INCREASE

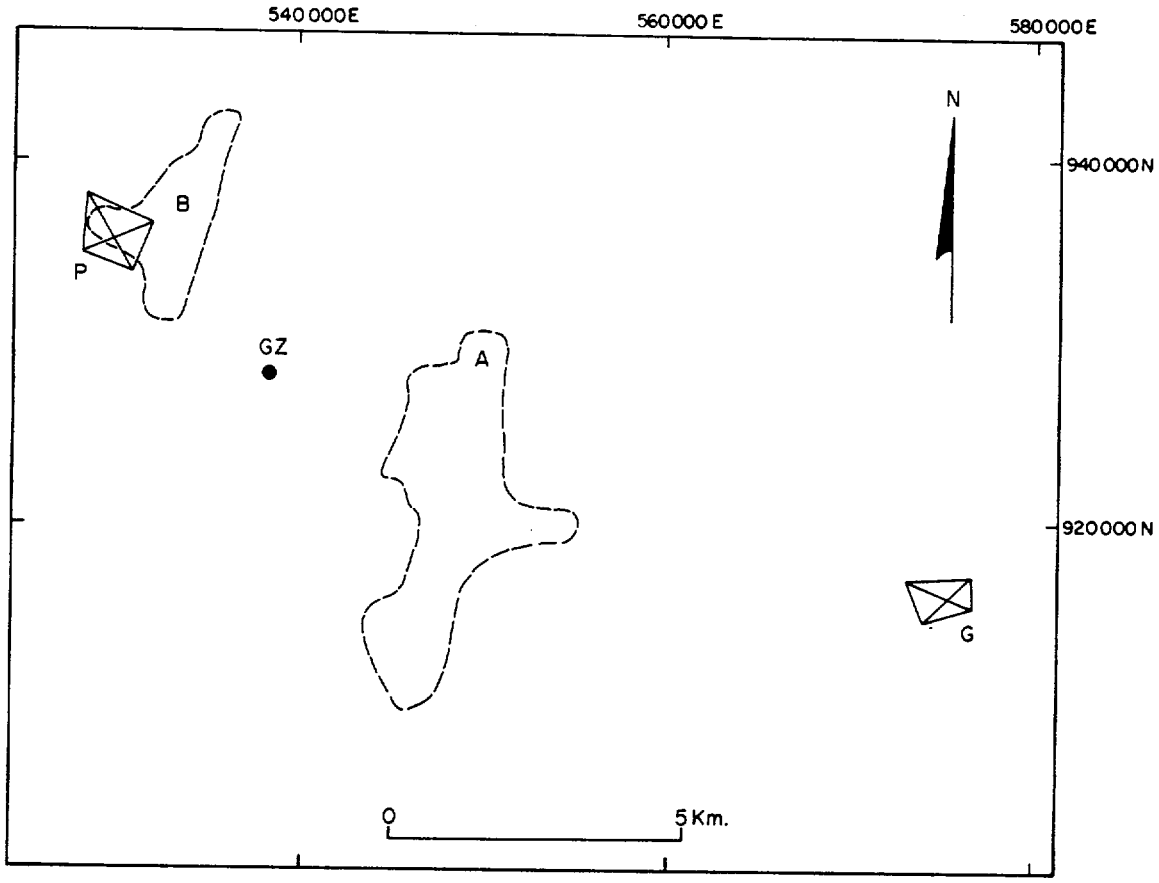
$\Delta p = \frac{1}{\beta} \cdot \frac{\Delta v}{v}$

ASSUME $\epsilon = \frac{\Delta v}{v} = 10^{-4}$

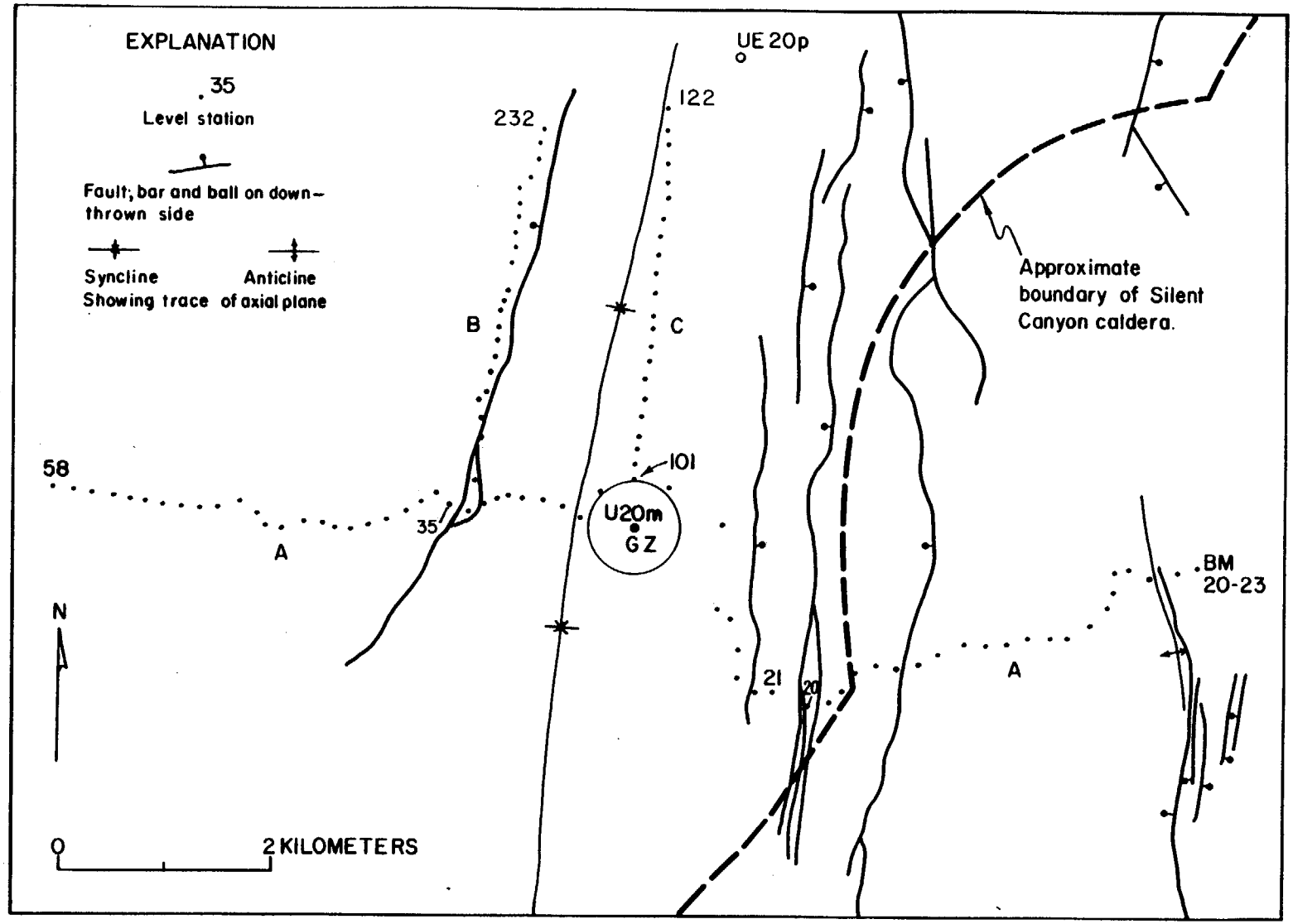
$\beta = 4.5 \times 10^{-5} (Mpa)^{-1}$

$\Delta p = 2.3\ Mpa = 333 psi$

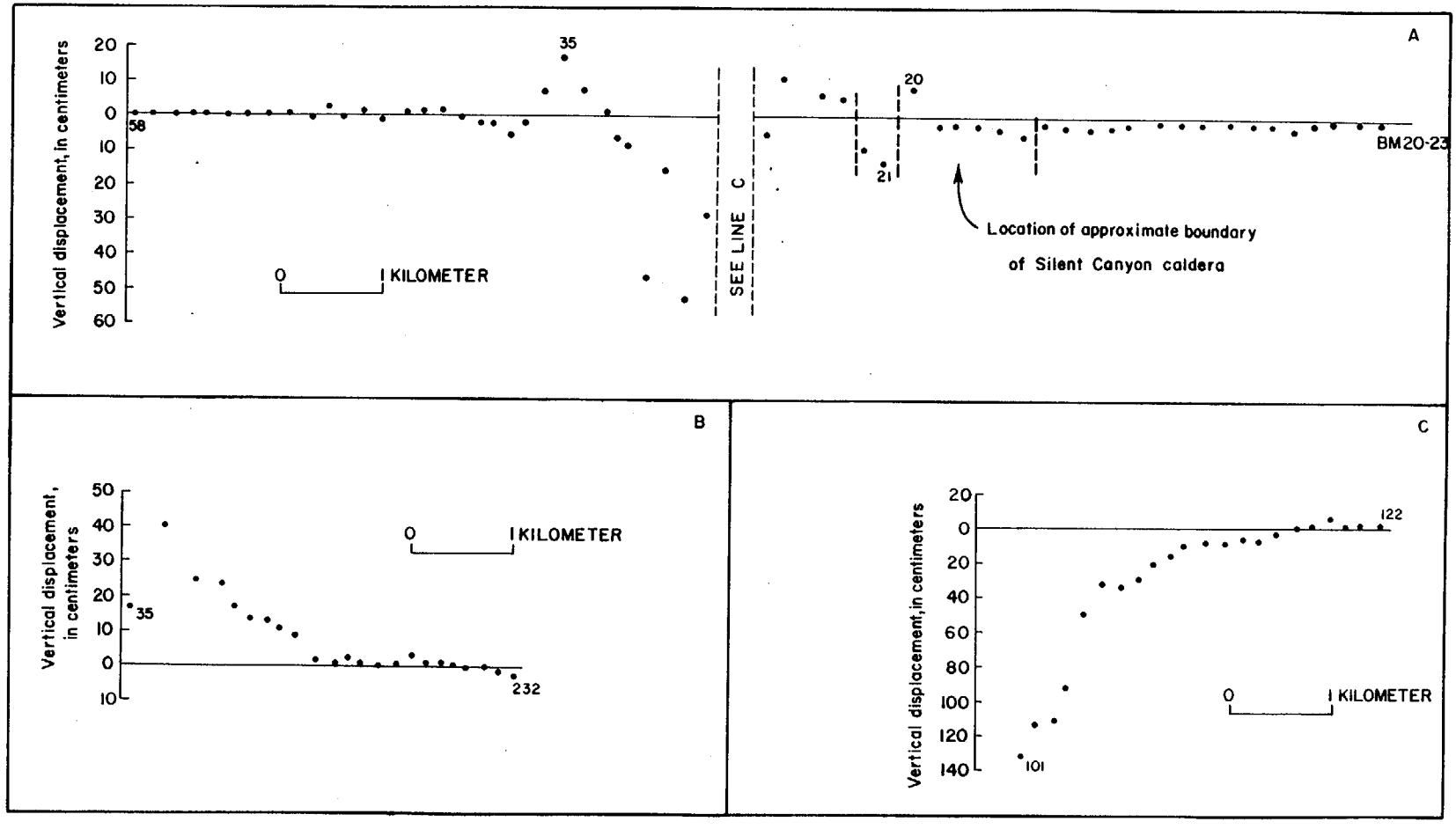
Potential increase of pore pressure caused by vibratory ground motion.



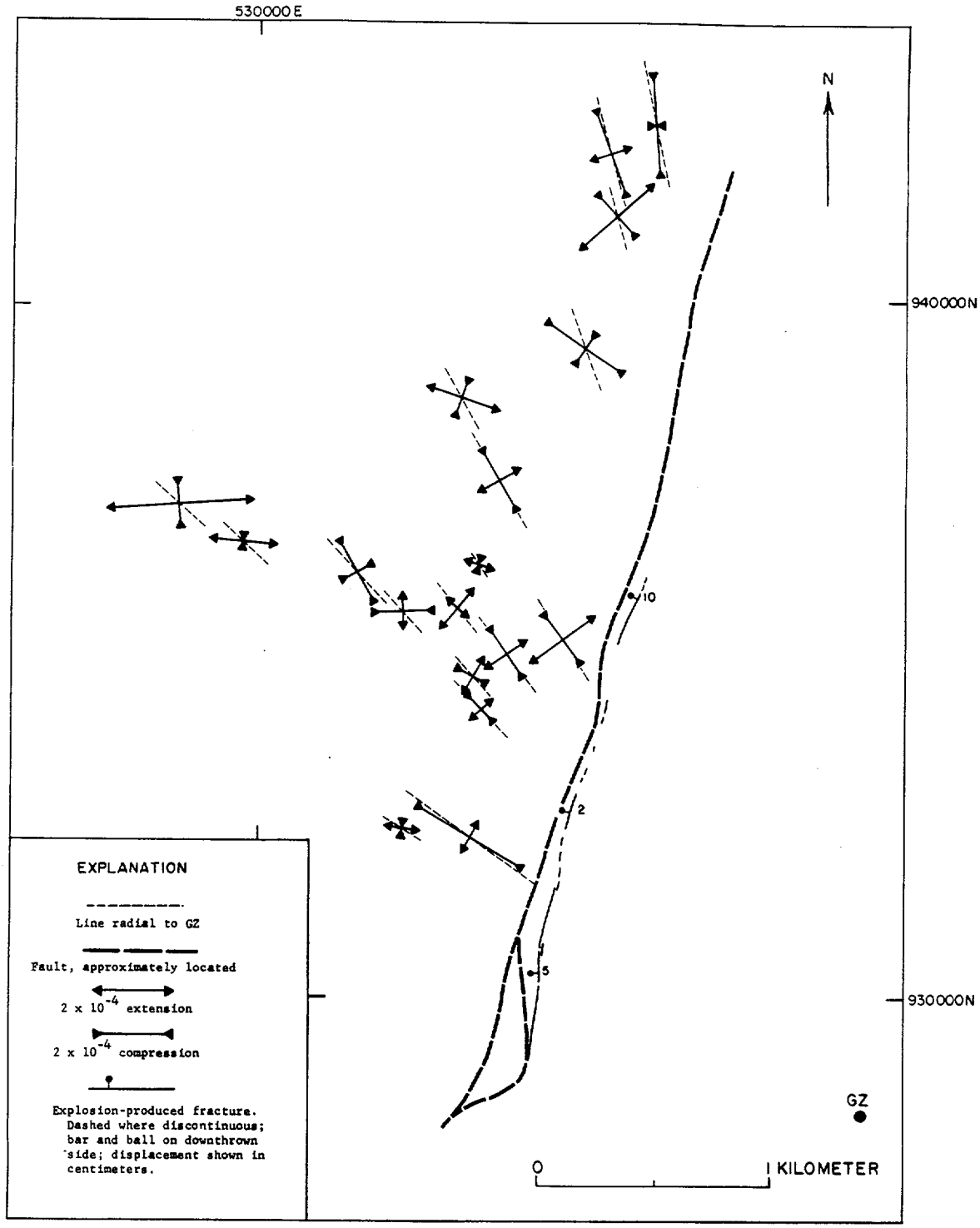
Location of geodetic survey networks. Handley event, Pahute Mesa. From Bucknam and Dickey, 1971.



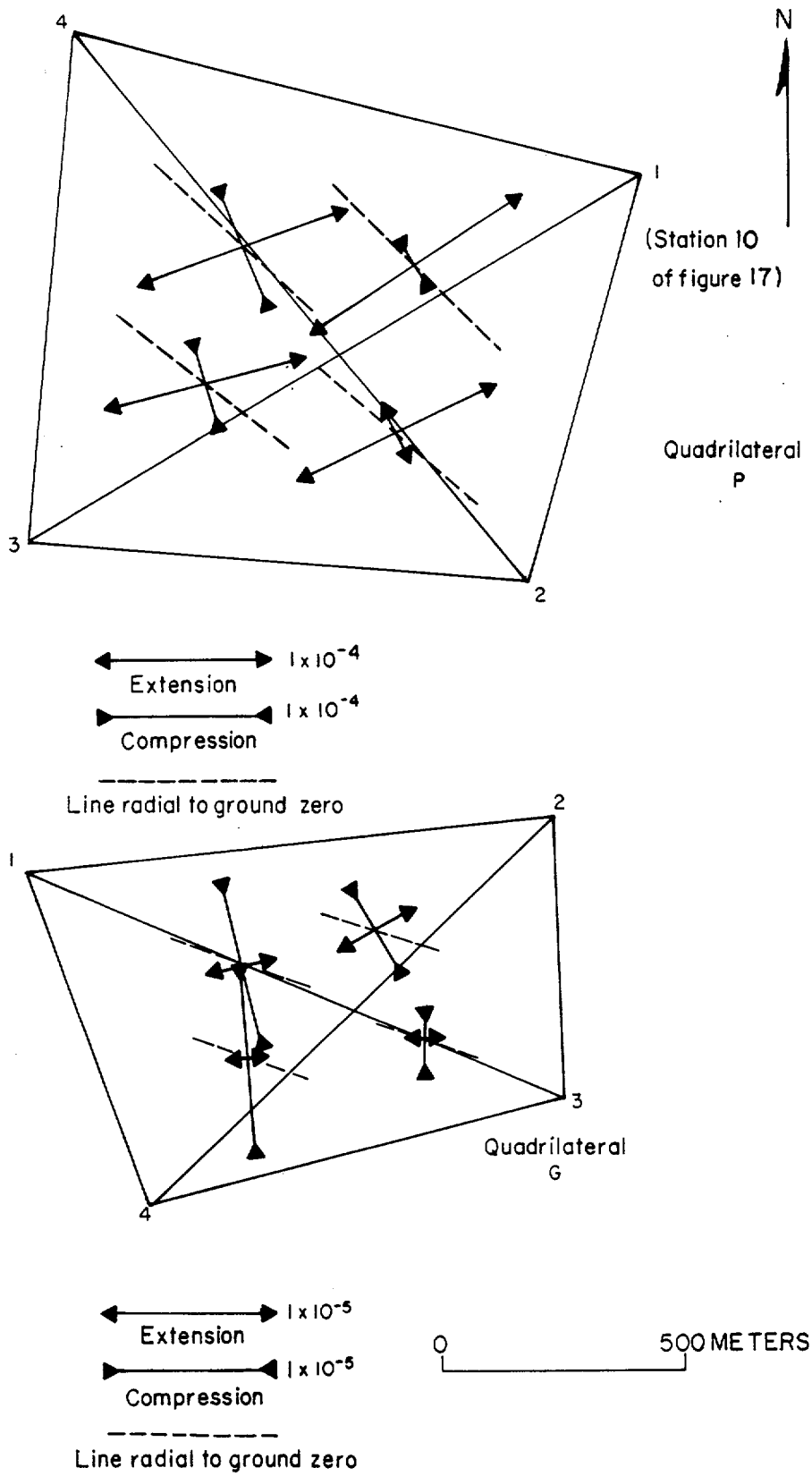
Location of leveling lines. Handley event, Pahute Mesa. From Bucknam and Dickey, 1971.



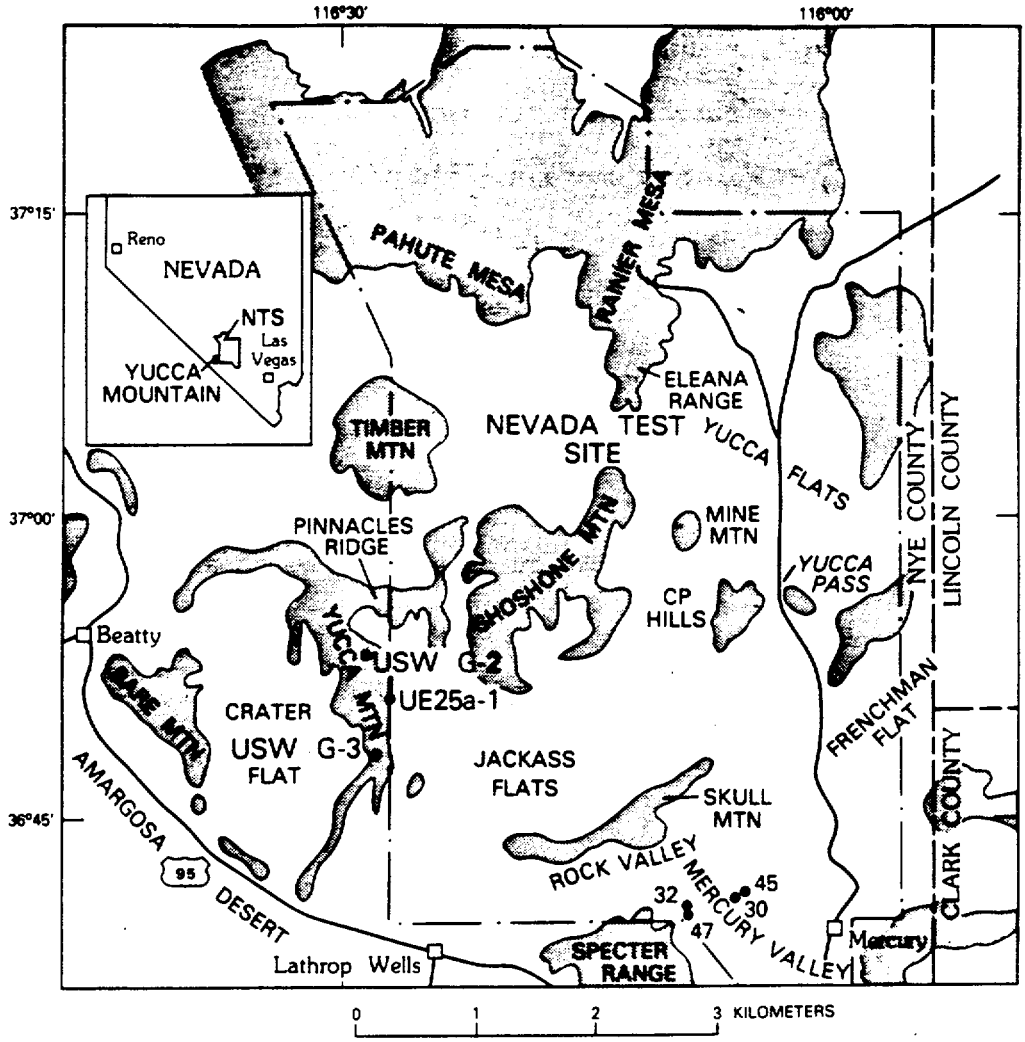
Vertical displacements produced by Handley event. From Bucknam and Dickey, 1971.



Principal horizontal displacements produced by Handley event within triangulation network B. From Bucknam and Dickey, 1971.



Principal horizontal strains produced by Handley event within quadrilateral networks P and G. From Bucknam and Dickey, 1971.



Location of boreholes where calcite samples from Yucca Mountain were collected. From Szabo and Kyser, 1985.

Sample depth (m)	Material	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	$\delta^{13}C$	$\delta^{18}O$
			(activity ratio)			(°/oo)	
34	Calcite	0.767 ±0.015	1.17 ±0.02	2.37 ±0.07	1.02 ±0.04	-4.52	+20.00
283	Calcite	5.03 ±0.10	1.47 ±0.02	22.2 ±0.7	1.04 ±0.04	-6.33	+17.60
611	Calcite	3.43 ±0.07	1.29 ±0.02	72 ±3	1.19 ±0.05	-5.41	+15.60

Sample depth (m)	Fraction	Percent carbonate	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	$\delta^{13}C$	$\delta^{18}O$
				(activity ratio)			(°/oo)	
280	Calcite	>99	0.500 ±0.010	1.032 ±0.015	12.0 ± 2.4	1.023 ±0.041	-8.35	+19.21
302	Calcite	n.d.	n.d.	n.d.	n.d.	n.d.	-7.90	+19.31
346.7	Calcite	64	0.405 ±0.008	1.167 ±0.018	4.29 ±0.21	0.915 ±0.037	-7.43	+18.22
346.8	Calcite	n.d.	n.d.	n.d.	n.d.	n.d.	-7.37	+18.30
348.7	Calcite	>99	0.073 ±0.006	1.02 ±0.03	4.6 ±0.5	0.73 ±0.06	-7.47	+18.19
348.8-A	Calcite	97	0.136 ±0.004	0.937 ±0.028	10.7 ±1.6	1.010 ±0.040	-6.93	+18.13
348.8-B	Calcite	63	33.3 ±0.7	1.026 ±0.015	94 ±15	0.093 ±0.037	n.d.	n.d.
359-A	Calcite	61	1.21 ±0.06	1.020 ±0.015	261 ±80	0.795 ±0.032	-6.82	+17.98
359-B	Calcite	75	0.644 ±0.013	0.965 ±0.014	36 ±11	0.811 ±0.032	n.d.	n.d.

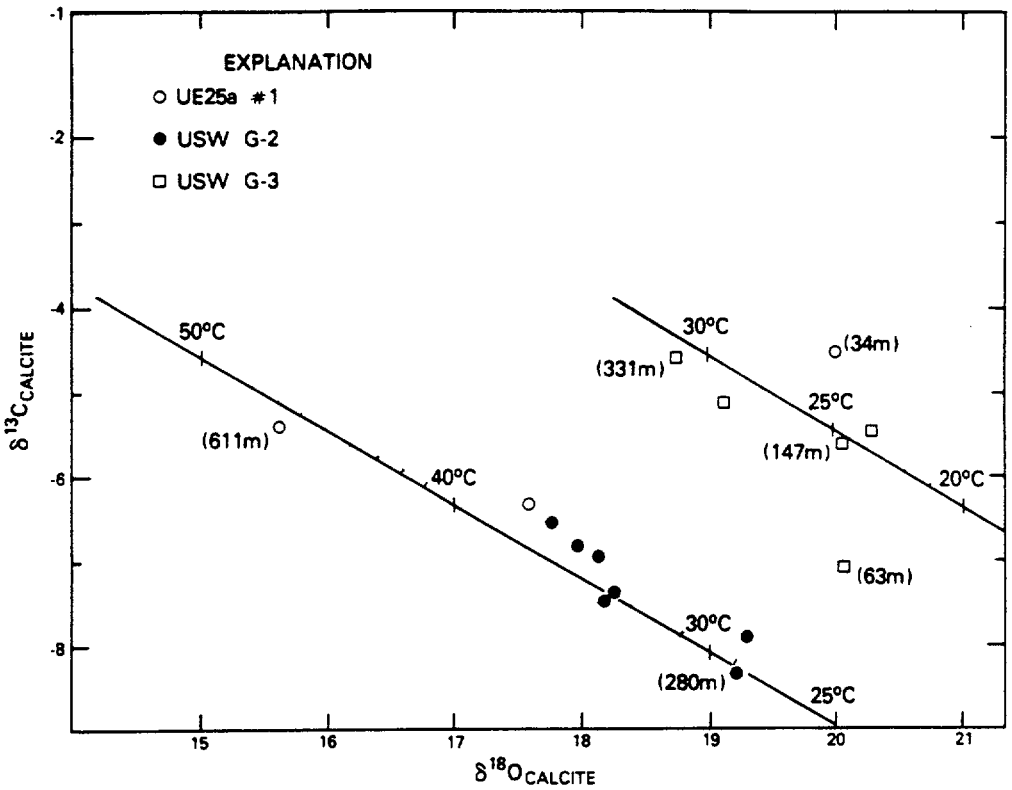
Analytical data from fracture filling calcites from Yucca Mountain. From Szabo and Kyser, 1985.

Sample depth (m)	Fraction	Percent carbonate	Uranium (ppm)	$^{234}U/^{238}U$ (activity ratio)	$^{230}Th/^{232}Th$ (activity ratio)	$^{230}Th/^{234}U$ (activity ratio)	$\delta^{13}C$ (°/oo)	$\delta^{18}O$ (°/oo)
361	Calcite	n.d.	n.d.	n.d.	n.d.	n.d.	-6.56	+17.77
63	Calcite	95	0.558 ±0.011	2.26 ±0.03	35 ±4	1.00 ±0.03	-7.06	+20.23
131	Calcite	52	3.02 ±0.06	1.43 ±0.02	84 ±40	0.216 ±0.009	-5.11	+20.16
147	Calcite	n.d.	n.d.	n.d.	n.d.	n.d.	-5.58	+20.04
159	Calcite	n.d.	n.d.	n.d.	n.d.	n.d.	-5.44	+20.28
318	Calcite	95	0.0836 ±0.0017	0.991 ±0.020	2.58 ±0.13	1.10 ±0.06	-5.10	+19.11
331	Calcite	87	0.36 ±0.01	1.06 ±0.04	10 ±5	0.24 ±0.02	-4.54	+18.73

Analytical data from fracture filling calcites from Yucca Mountain (continued). From Szabo and Kyser, 1985.

Drill hole	Depth (m)	Uranium (ppm)	Calculated age ($x10^3$ years)
		Calcite	
UE25a#1	34	0.77	310^{+80}_{-50} (a)
GU-3	63	0.56	227±20
GU-3	131	3.0	26±2
USW-G2	280	0.50	>400
UE25a#1	283	5.0	310^{+70}_{-65}
GU-3	318	0.084	>400
GU-3	331	0.36	30±4
USW-G-2	346.7	0.40	190±20 (b)
USW-G-2	348.7	0.073	142±30
USW-G-2	348.8-A	0.14	>400
USW-G-2	348.8-B	33	280±70
USW-G-2	359-A	1.2	170±18
USW-G-2	359-B	0.64	185±18
UE25a#1	611	3.4	>400

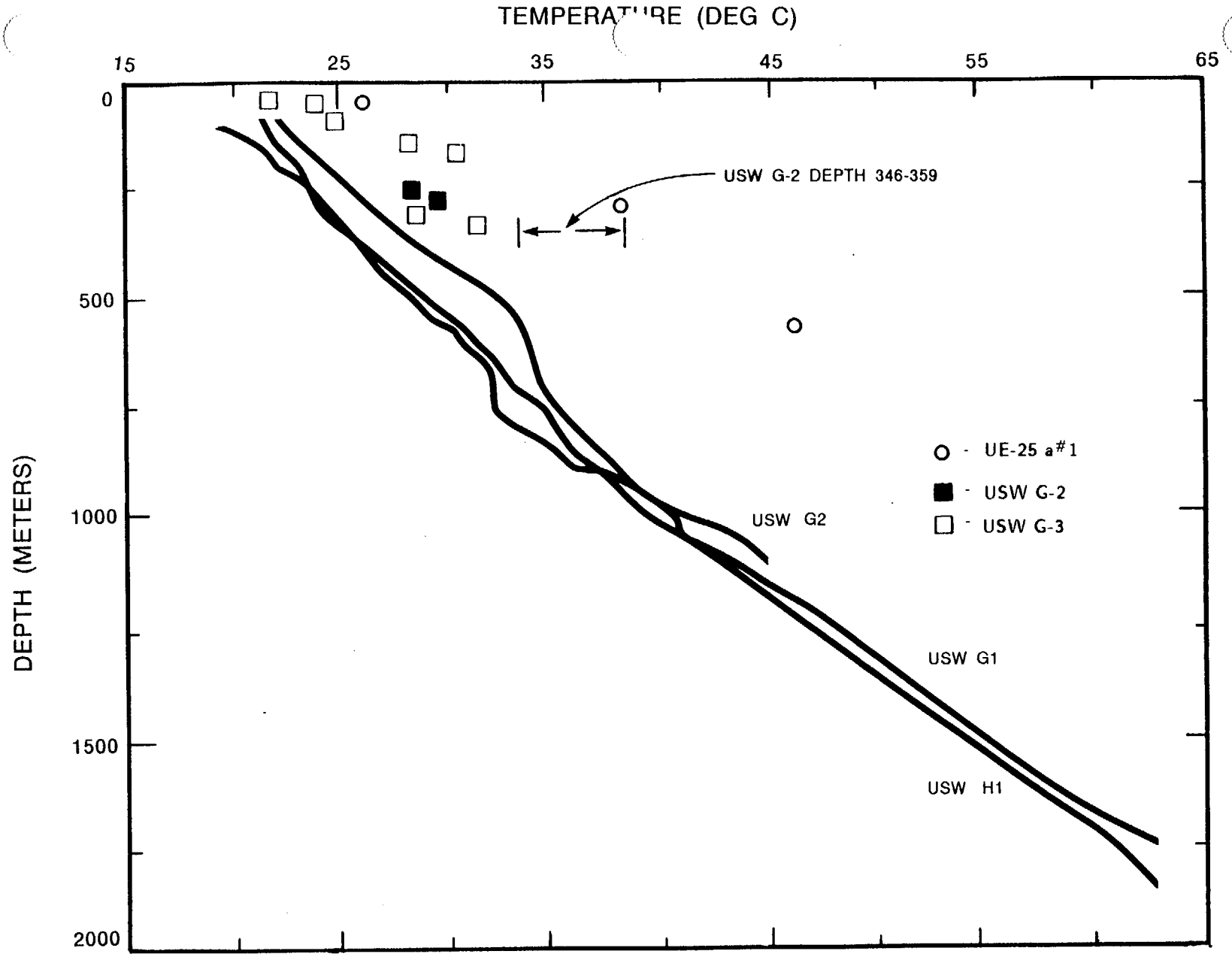
Calculated uranium series ages of fracture filling calcite from Yucca Mountain. From Szabo and Kyser, 1985.



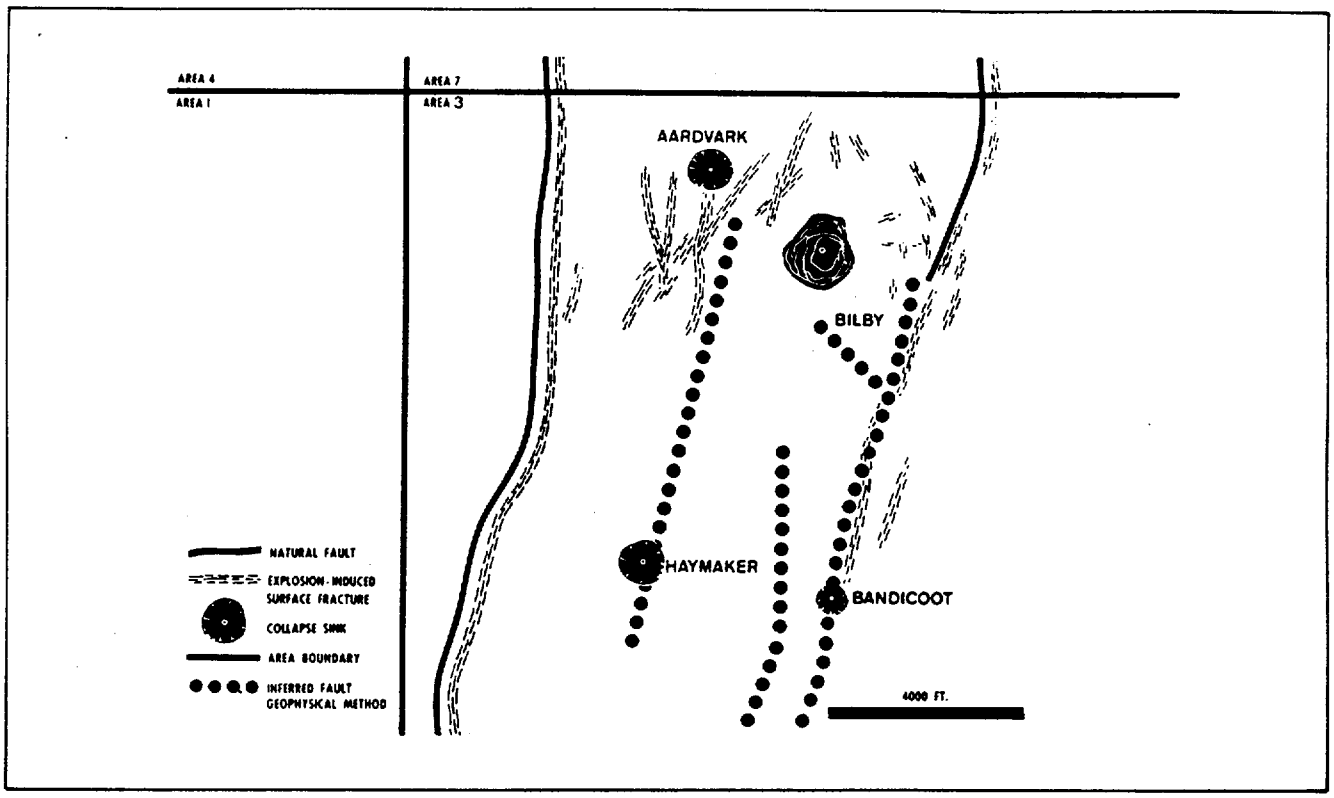
$\delta^{18}O$ versus $\delta^{13}C$ ratios for calcites from Yucca Mountain. From Szabo and Kyser, 1985.

BOREHOLE	DEPTH (m)	TEMPERATURE (°C)
UE-25 a#1	34	26
	283	38
	611	46.5
USW G-3	63	22
	131	24
	147	24.5
	318	28.5
	331	31
USW G-2	280	29
	318	29
	346-359	37-34

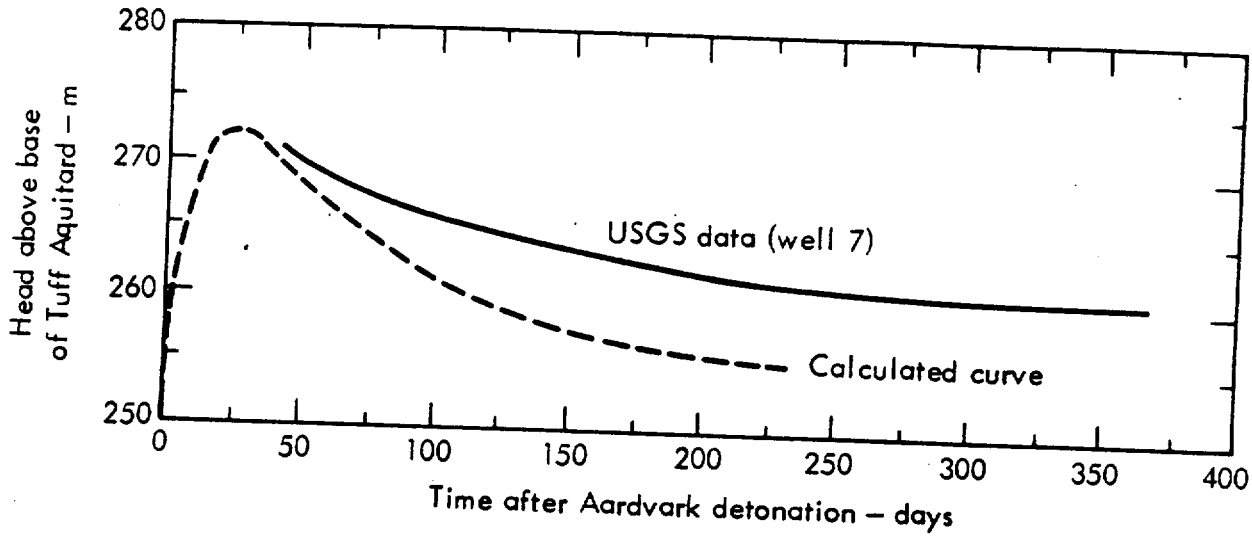
Estimate of paleo-temperatures based on stable isotope content of calcites from Yucca Mountain. Modified from Szabo and Kyser, 1981.



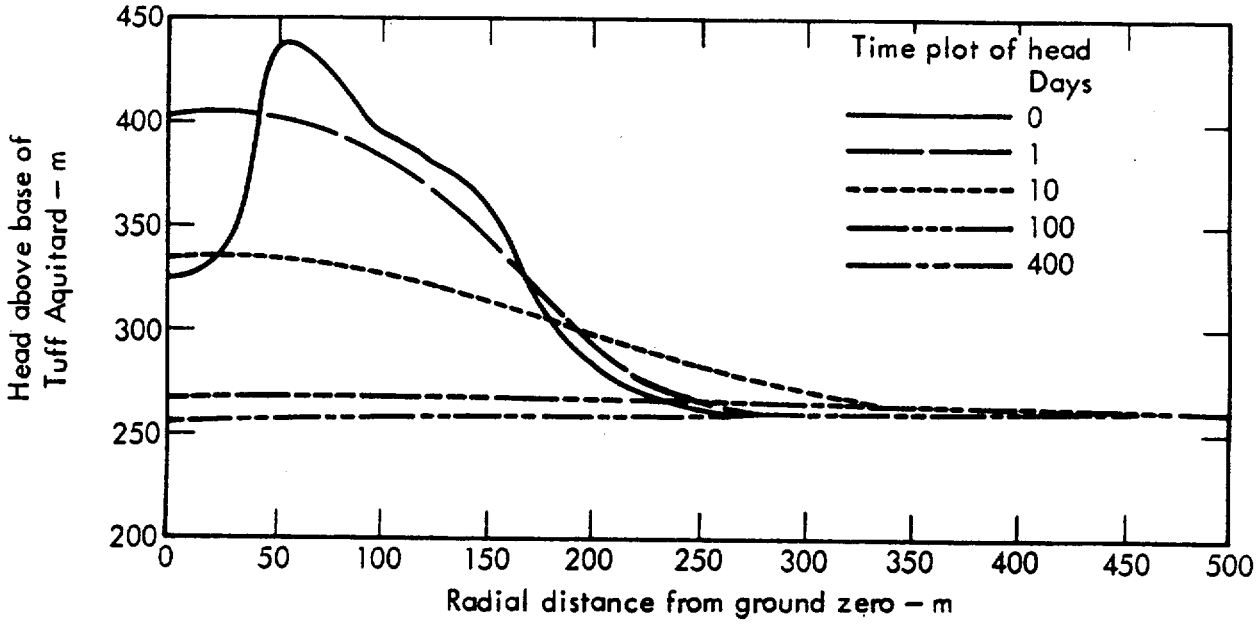
Comparison of contemporary and late Quartenary in situ temperatures at Yucca Mountain.



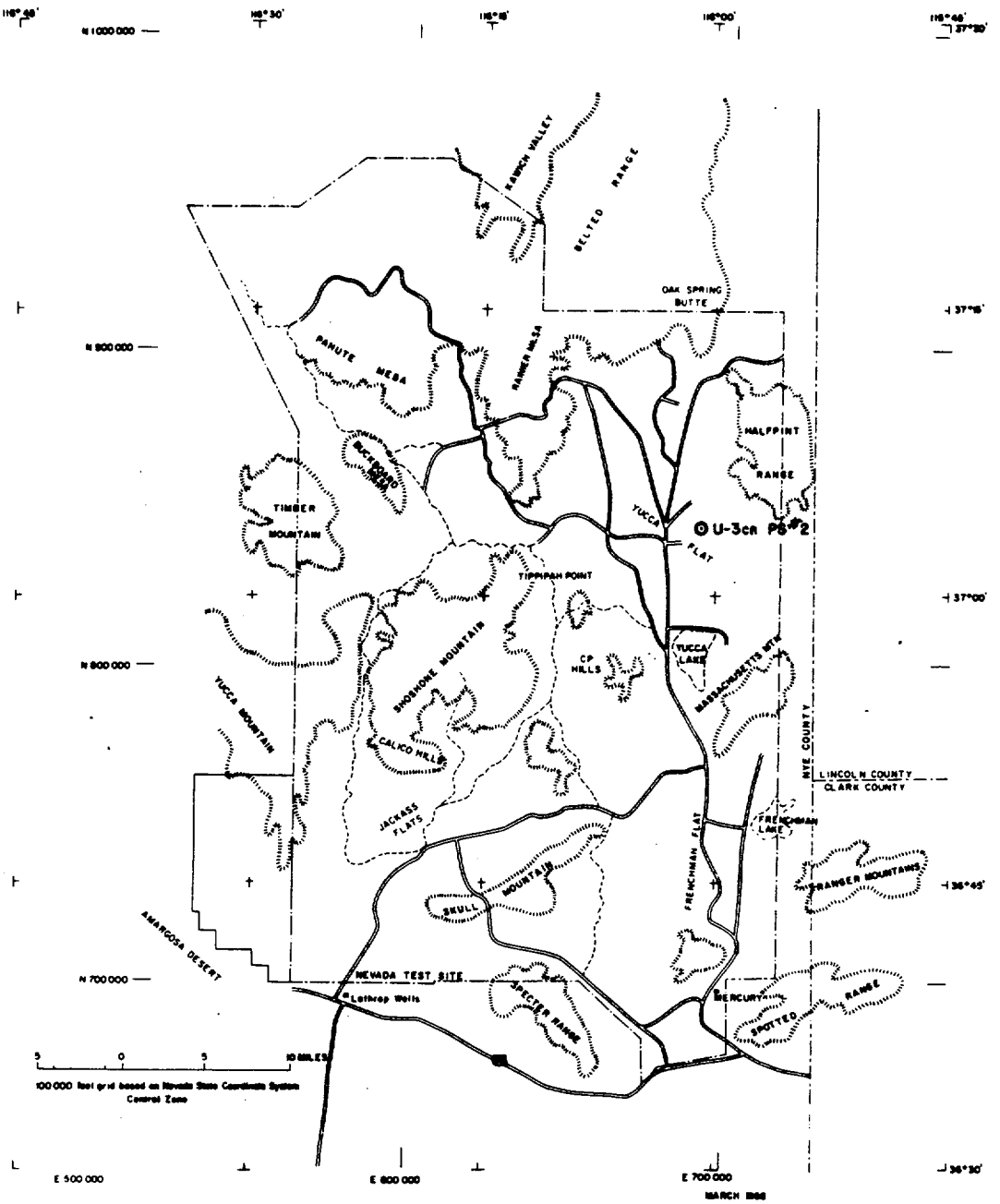
Location of detonation site of the Aardvark event. From Stead, 1969.



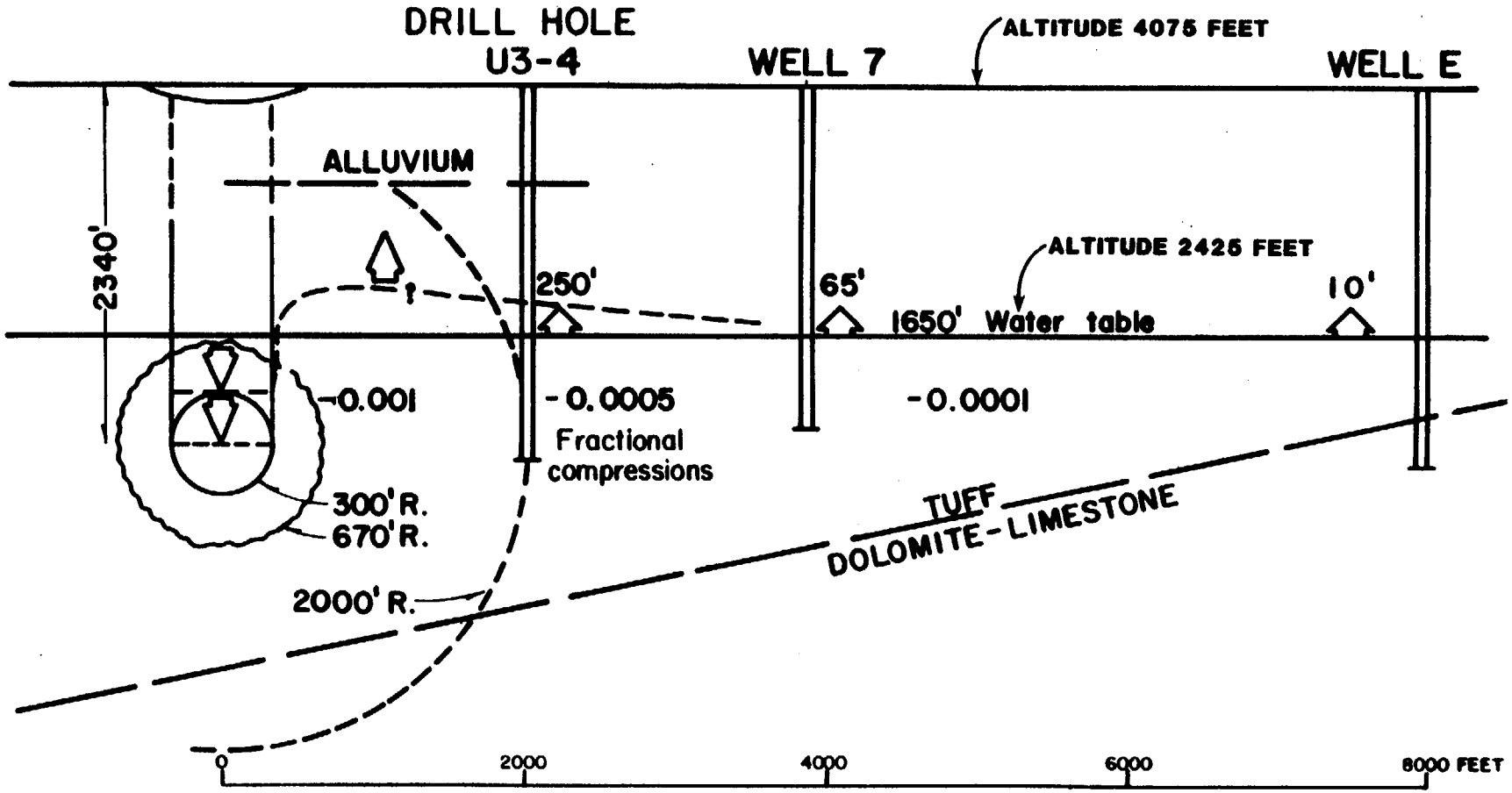
Observed and calculated histories of groundwater levels in test Well #7. Aardvark event. From Borg et al., 1975.



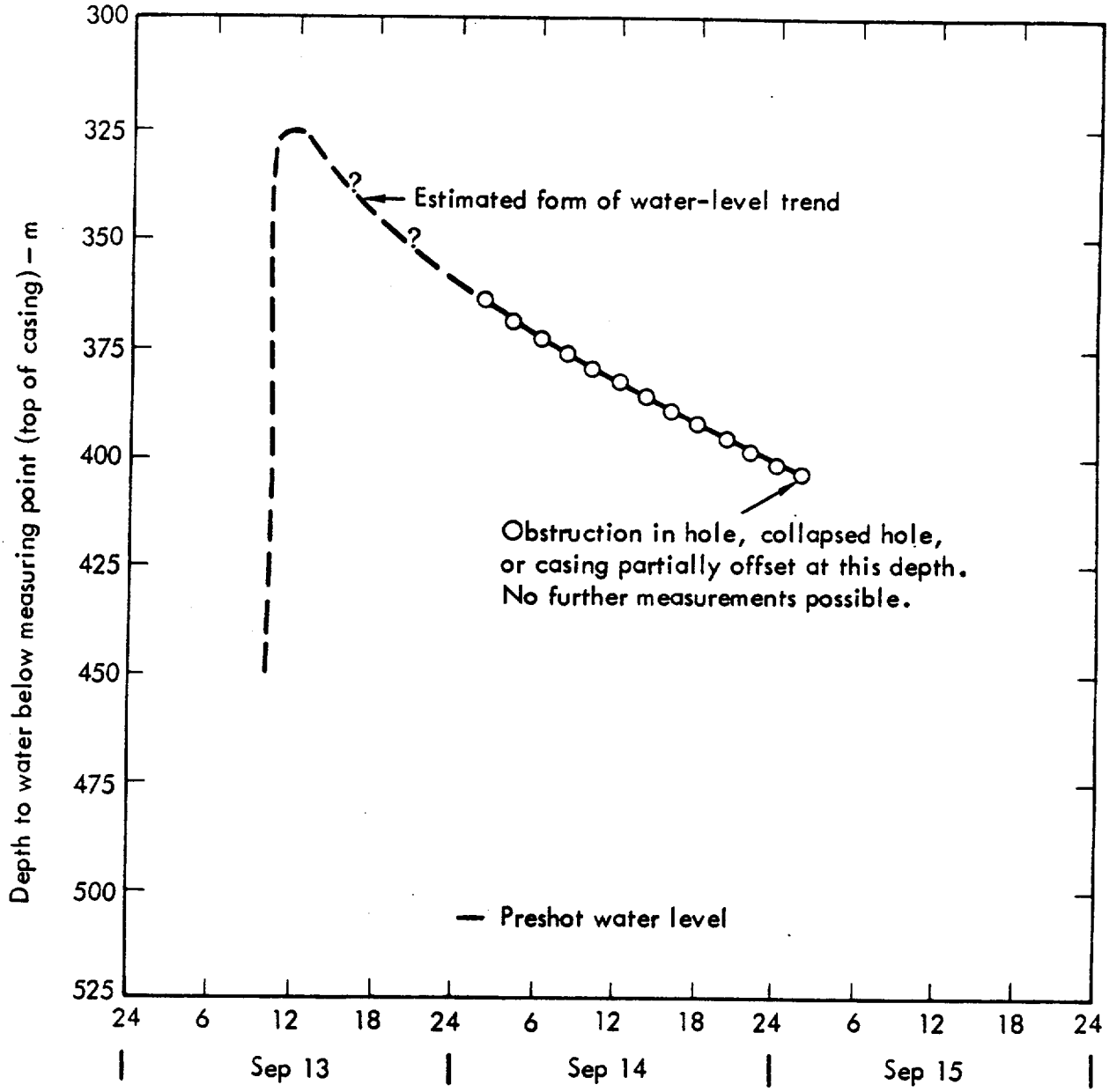
Calculated configuration of the groundwater mound produced by the Aardvark event as a function of time. From Borg et al., 1976.



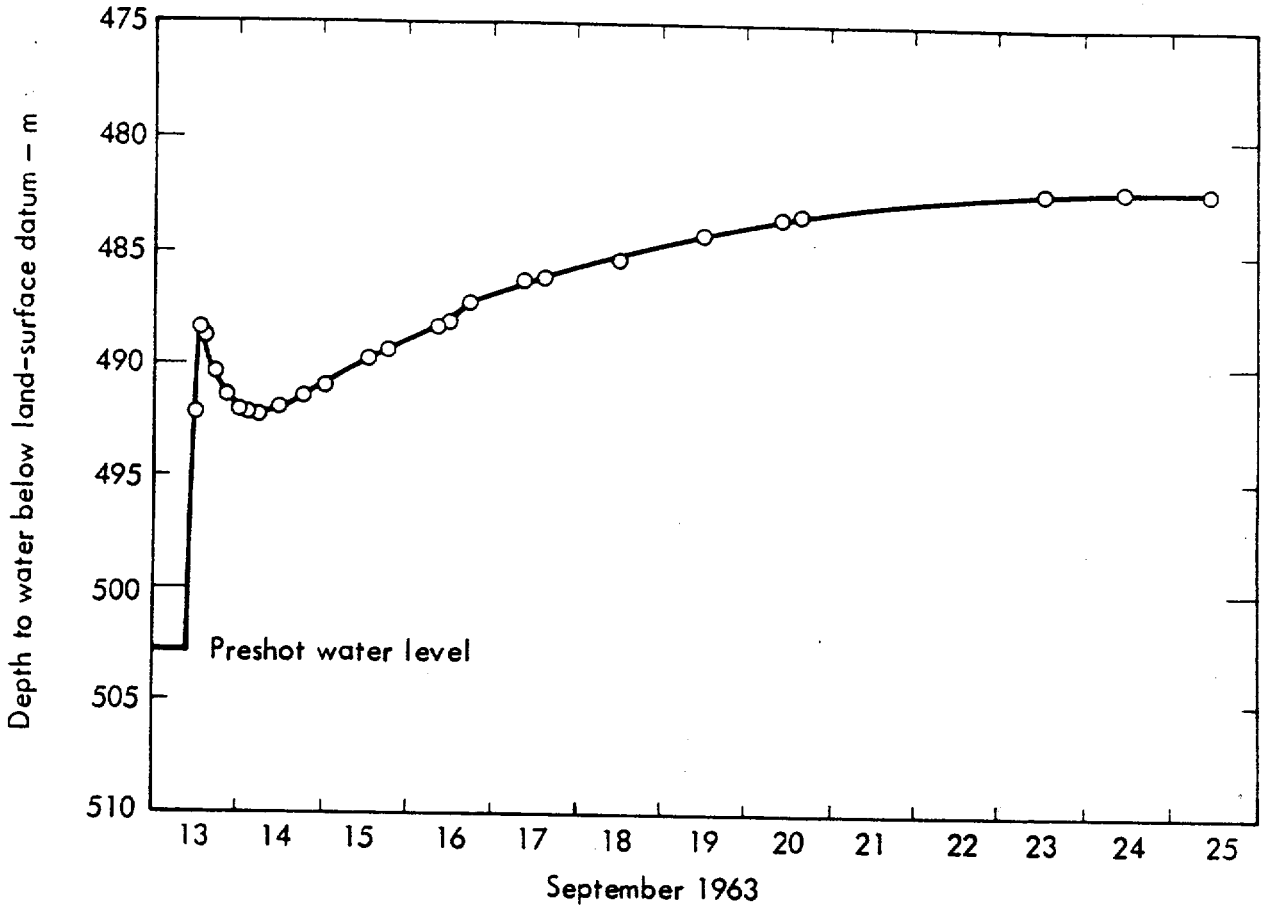
Location of detonation site of the Bilby nuclear device. From Garber, 1971.



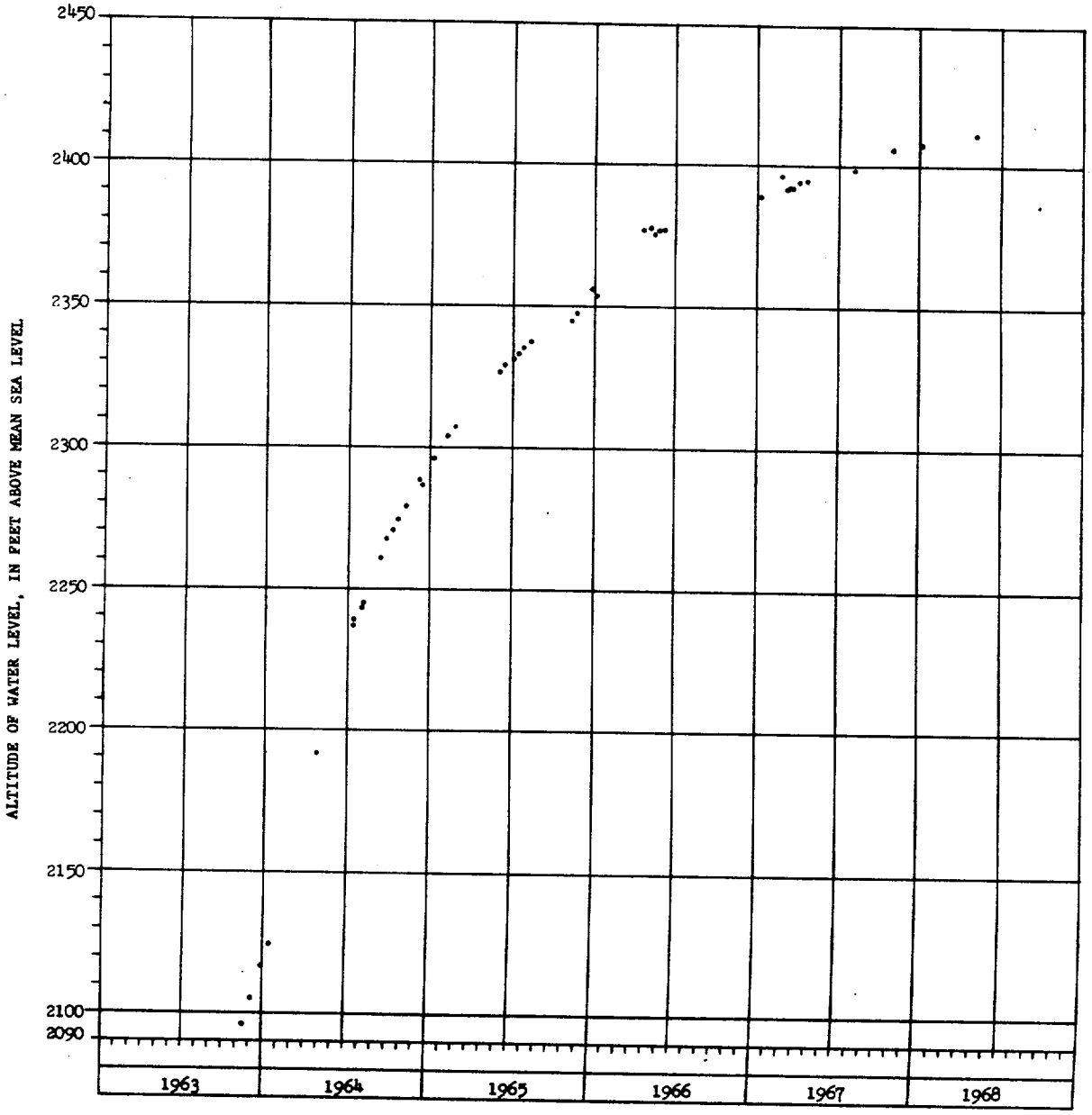
Fluid overpressure caused by the Bilby event. From Corchary and Dinwiddie, 1975.



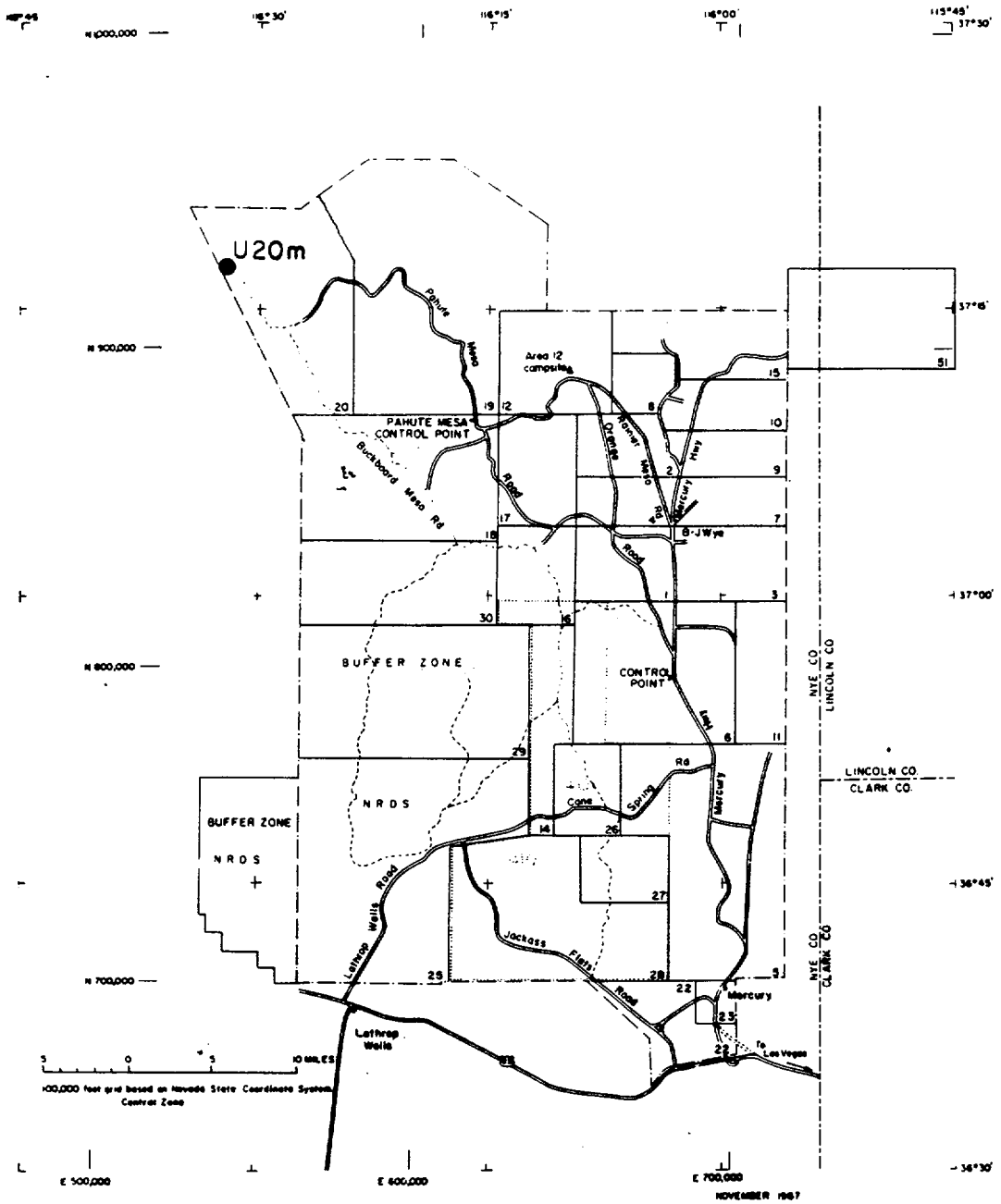
History of groundwater level in test Well #U-3cn-4 after the Bilby event. From Borg et al., 1976.



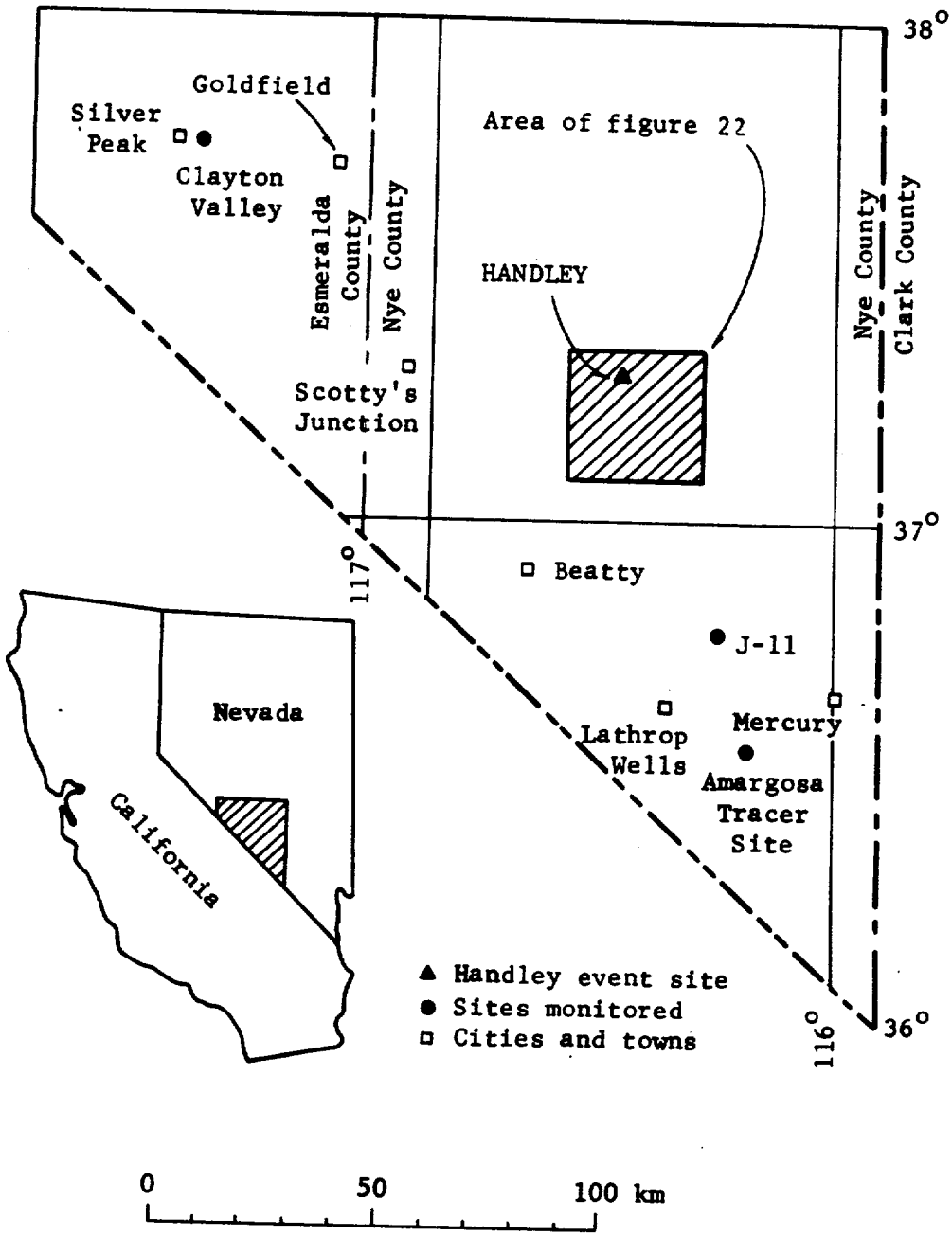
History of groundwater level in Well #7 after the Bilby event. From Borg et al., 1976.



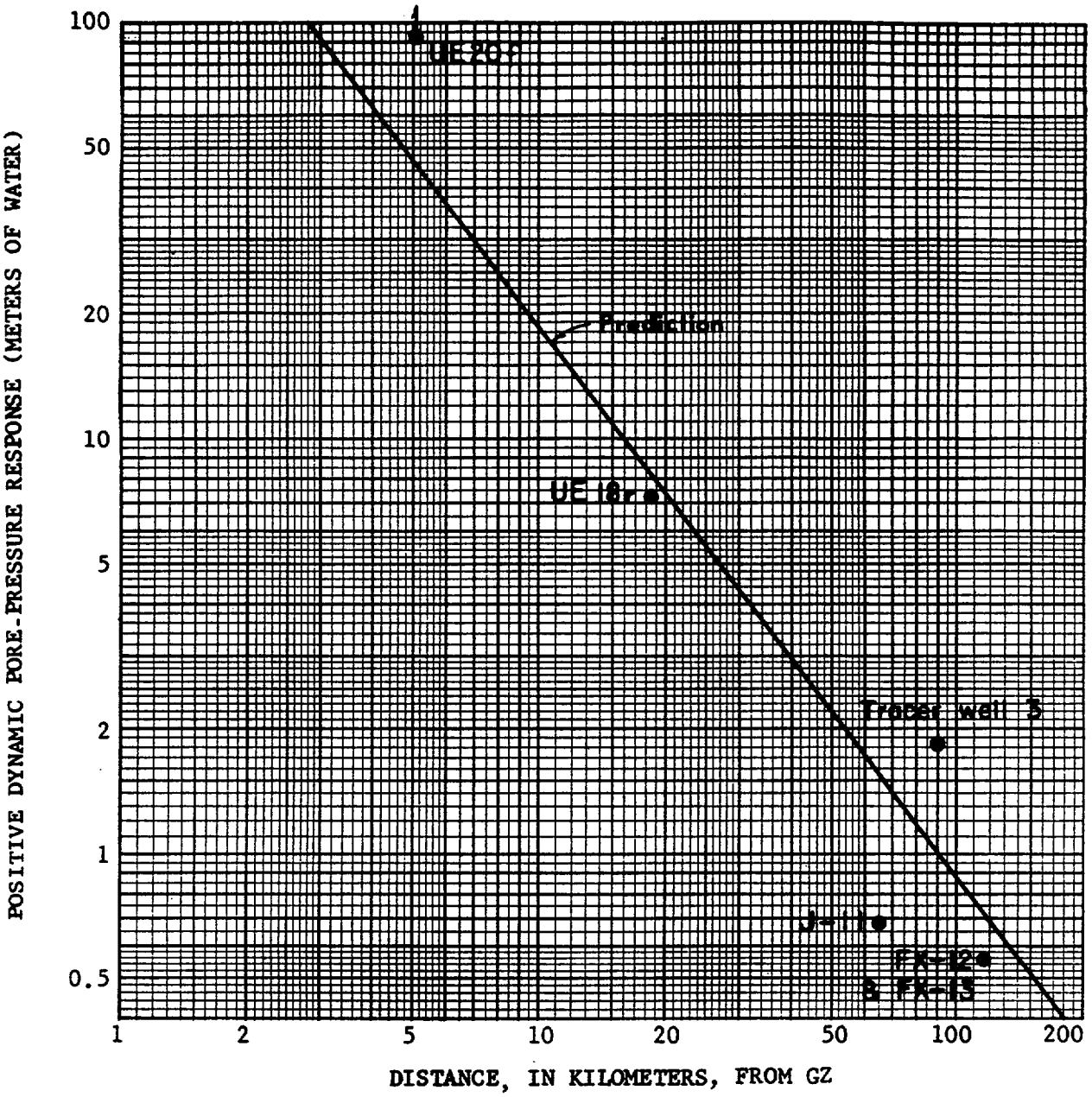
Fluid level rise in U-3cn PS#2. From Garber, 1971.



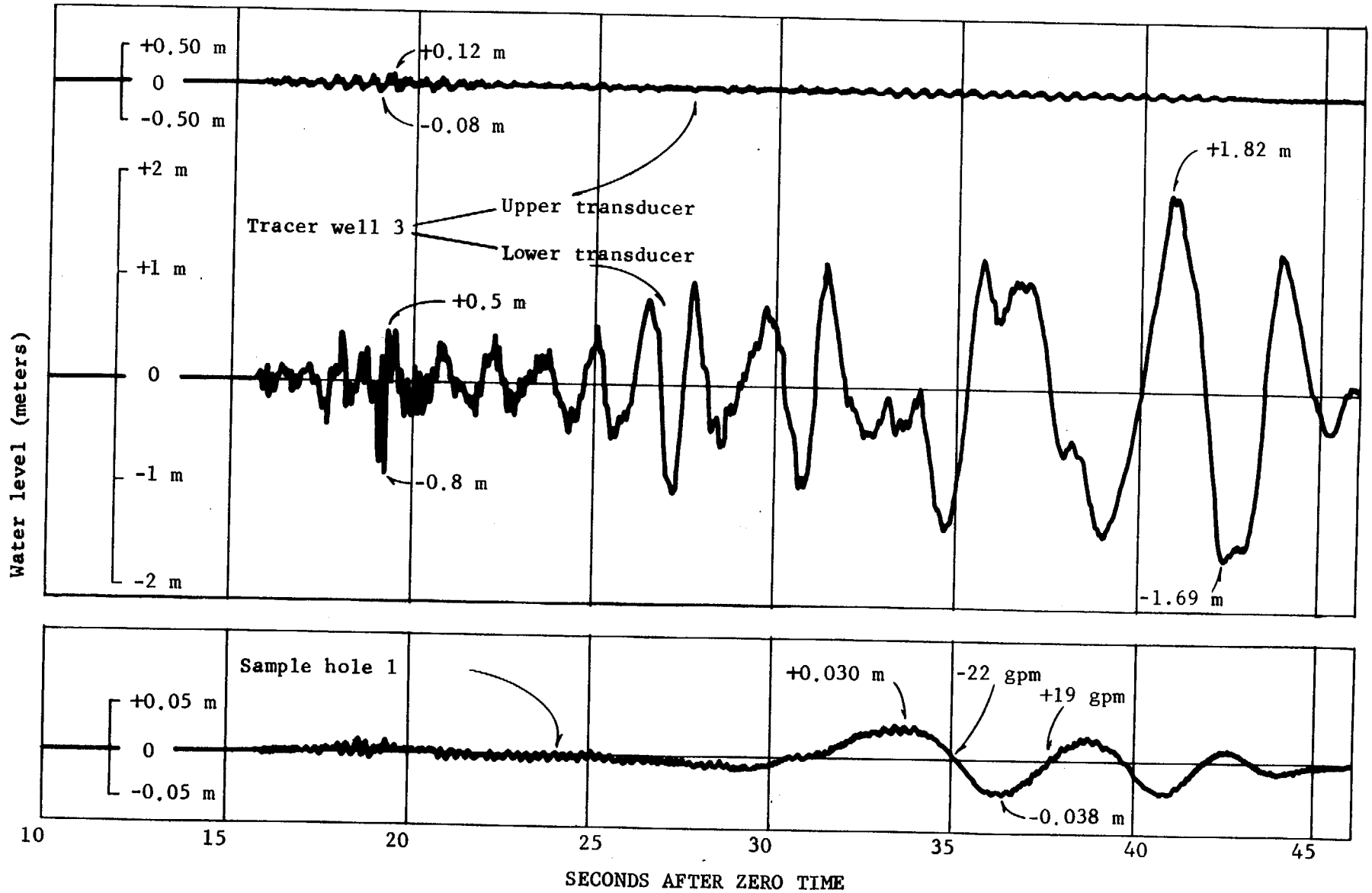
Location of detonation site of the Handley nuclear device. From Morris, 1971.



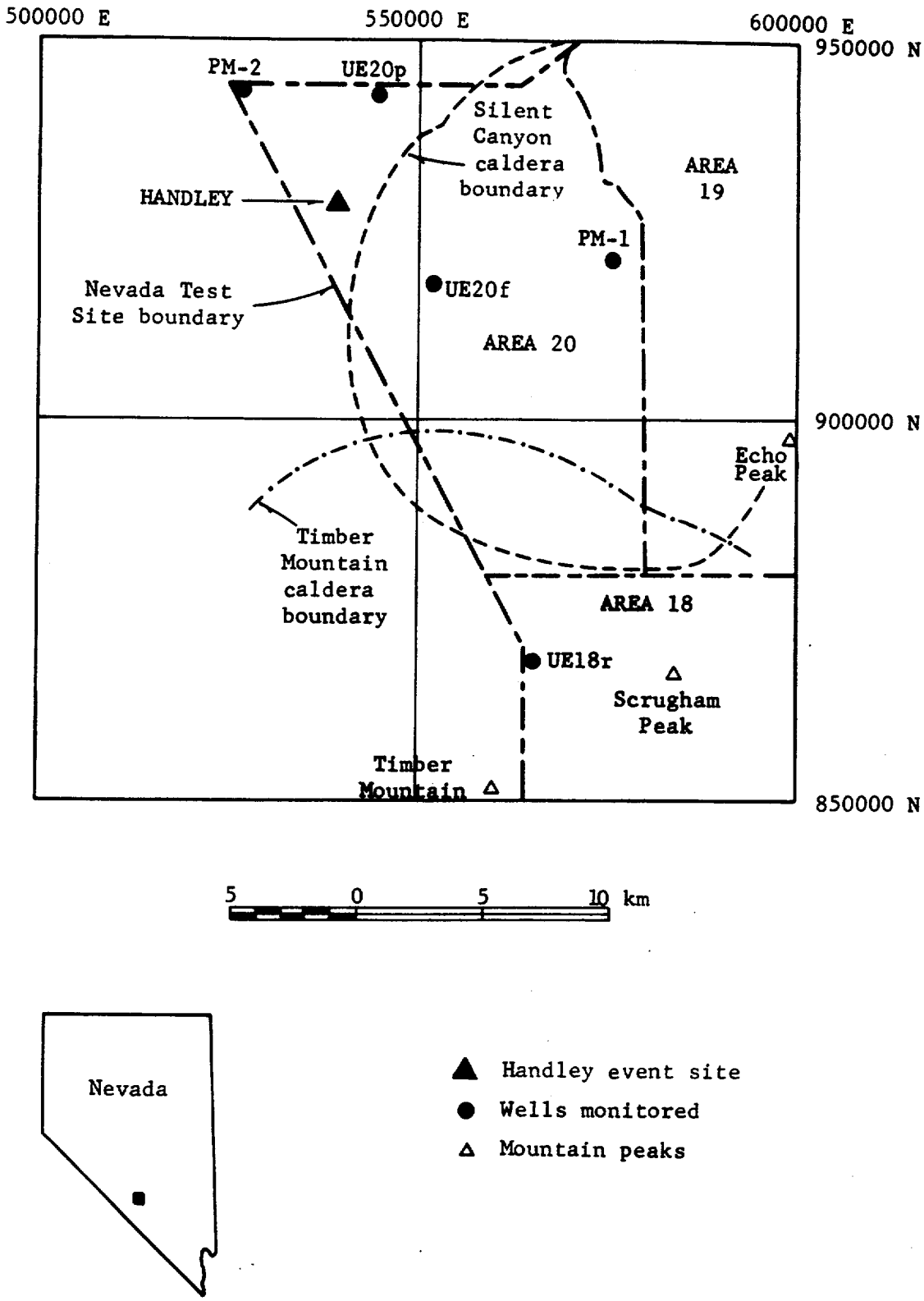
Location of offsite wells monitored during the Handley event. From Dudley et al., 1971.



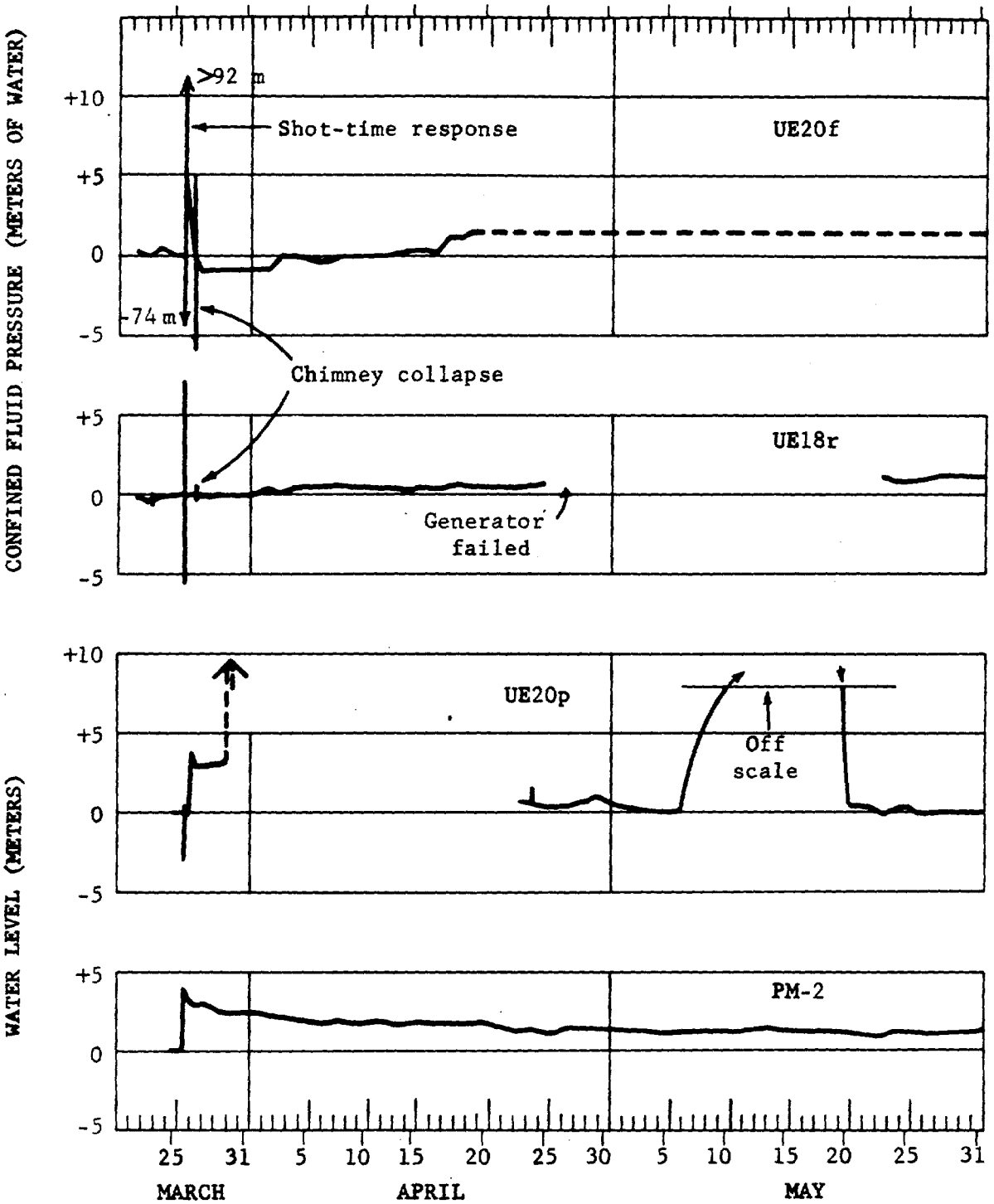
Dynamic fluid overpressure produced by the Handley detonation. From Dudley et al., 1971.



Pressure response observed in two wells at the Amargosa Tracer Site, at a distance of 90 km from the Handley detonation site. From Dudley et al., 1971.



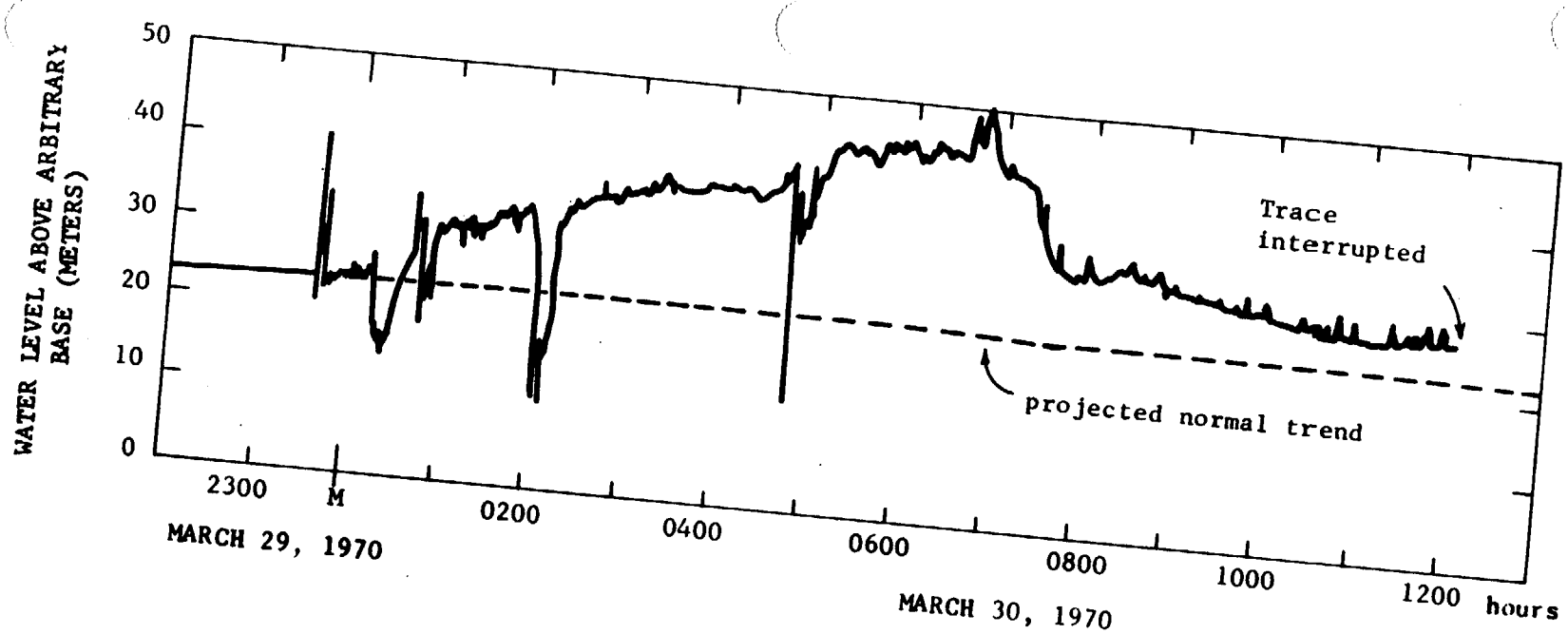
Location of monitoring wells at Pahute Mesa. Handley detonation. Dudley et al., 1971.



Hydrologic response in Pahute Mesa to the Handley detonation. From Dudley et al., 1971.

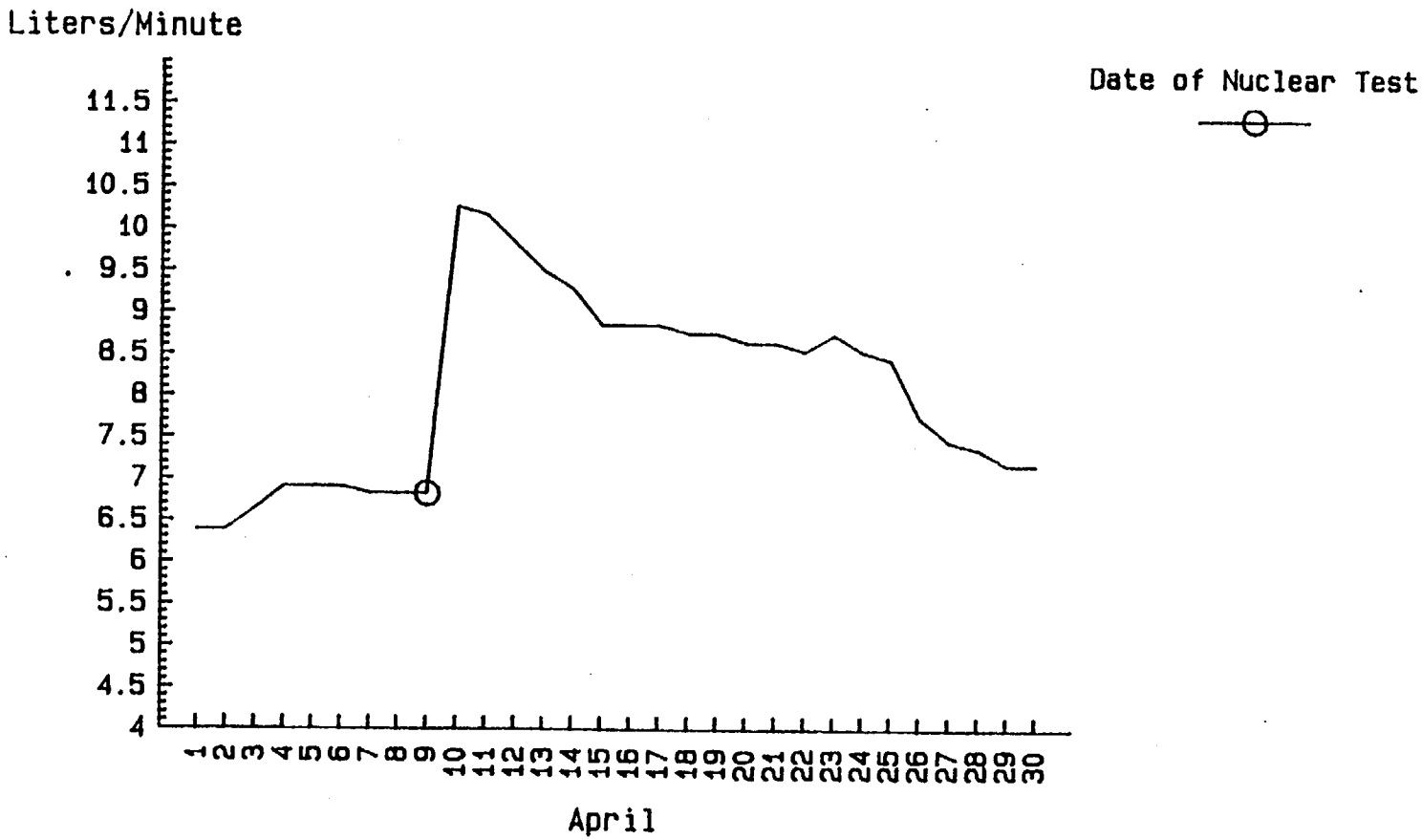
Time postshot (in minutes)	Remarks
3.4	+15.4 m to -28.7 m arrival.
3.4- 5.0	Numerous excursions to ±10 m.
5.0- 7.4	Smooth decay of primary step.
7.4- 12.2	Continuous activity, including excursion of +24.5 m to -28.7 m at 8.7 min.
12.2- 15.3	Smooth decay of primary step.
15.3- 18.8	Continuous activity with prominent peaks at 15.9, 17.5, and 18.2 min.
18.8- 23.0	Smooth decay of primary step.
23.0	Arrival of +9.8 m to -12.2 m excursions and secondary pressure step of +15.4 m.
23.0- 27.1	Erratic and cyclic decay of secondary pressure step to -9.5 m.
27.1- 30.0	Erratic recovery to +4.5 m.
30.0- 31.0	Decline to primary decay curve.
31.0-214.0	Continuous activity, praticularly intense at 74 to 80 min., where excursions of ±7 m occur, and at 85 to 87 minutes. Ends abruptly at 214 minutes postshot (1434 hrs. PST).

Hydrologic response to the Handley event in Well UE-20f. From Dudley et al., 1971.

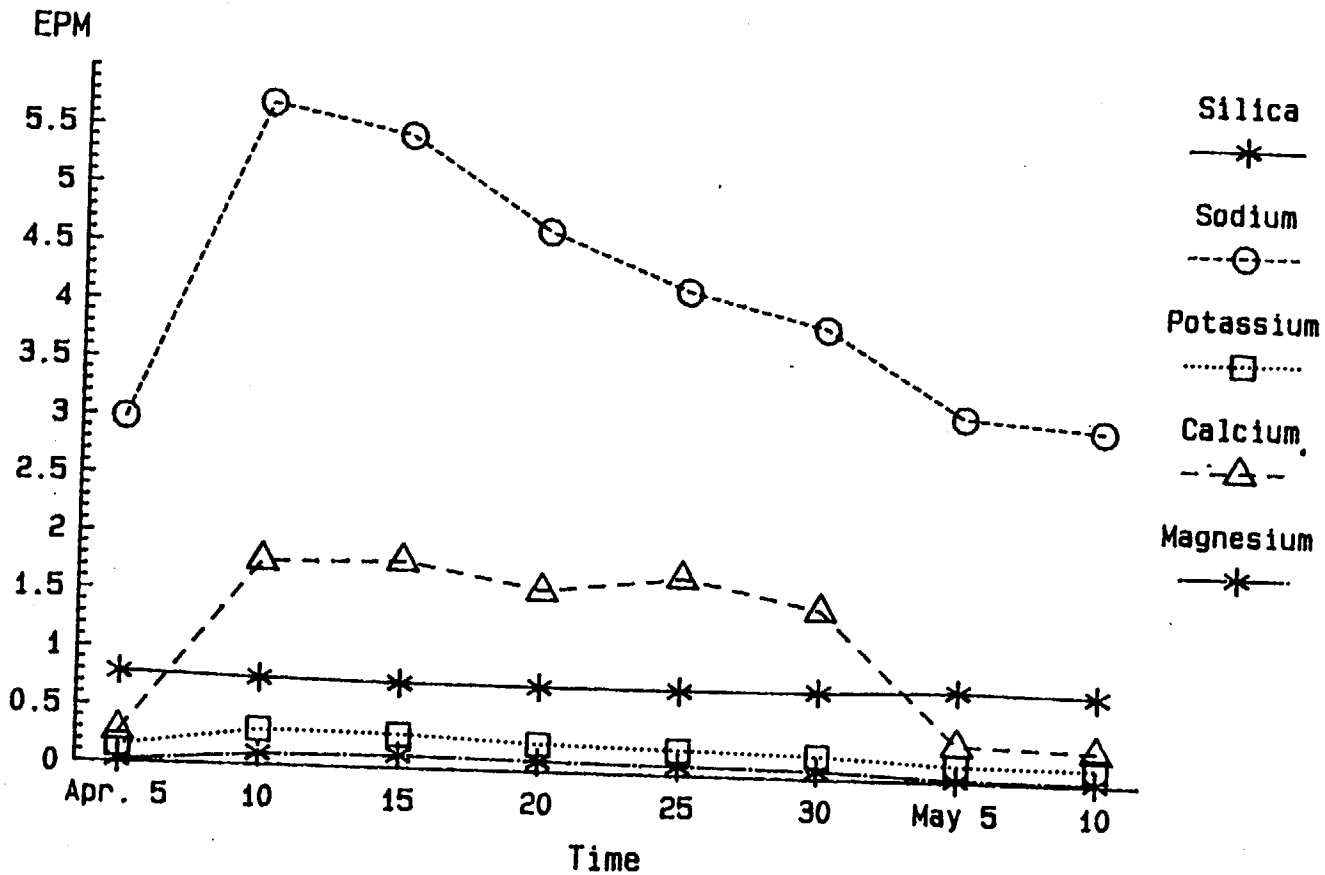


Hydrologic response to the Handley event in Well UE-20p. From Dudley et al., 1971.

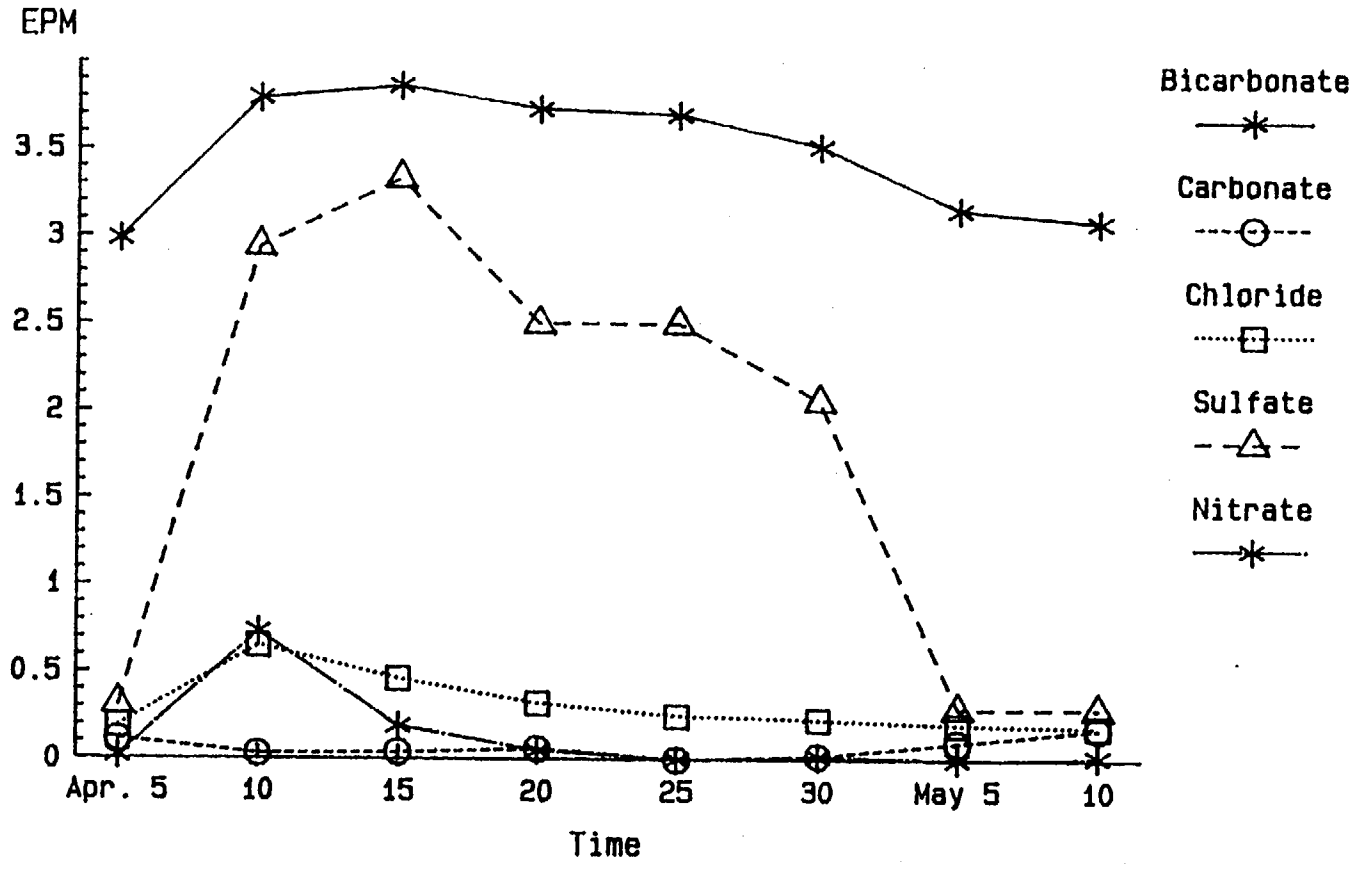
[redacted]



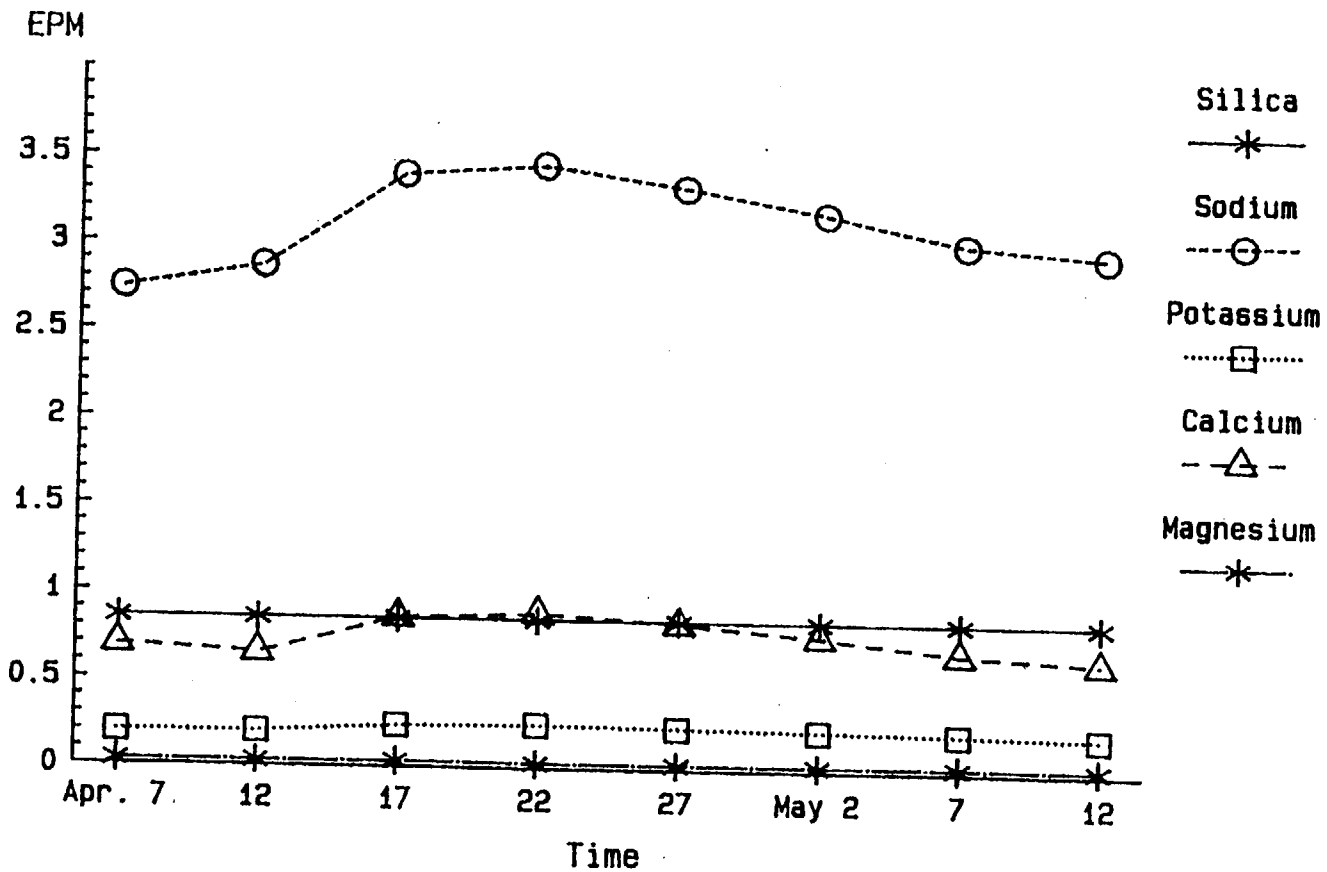
Increased discharge from a seep caused by the April 10, 1986 nuclear detonation. From Russell, 1987.



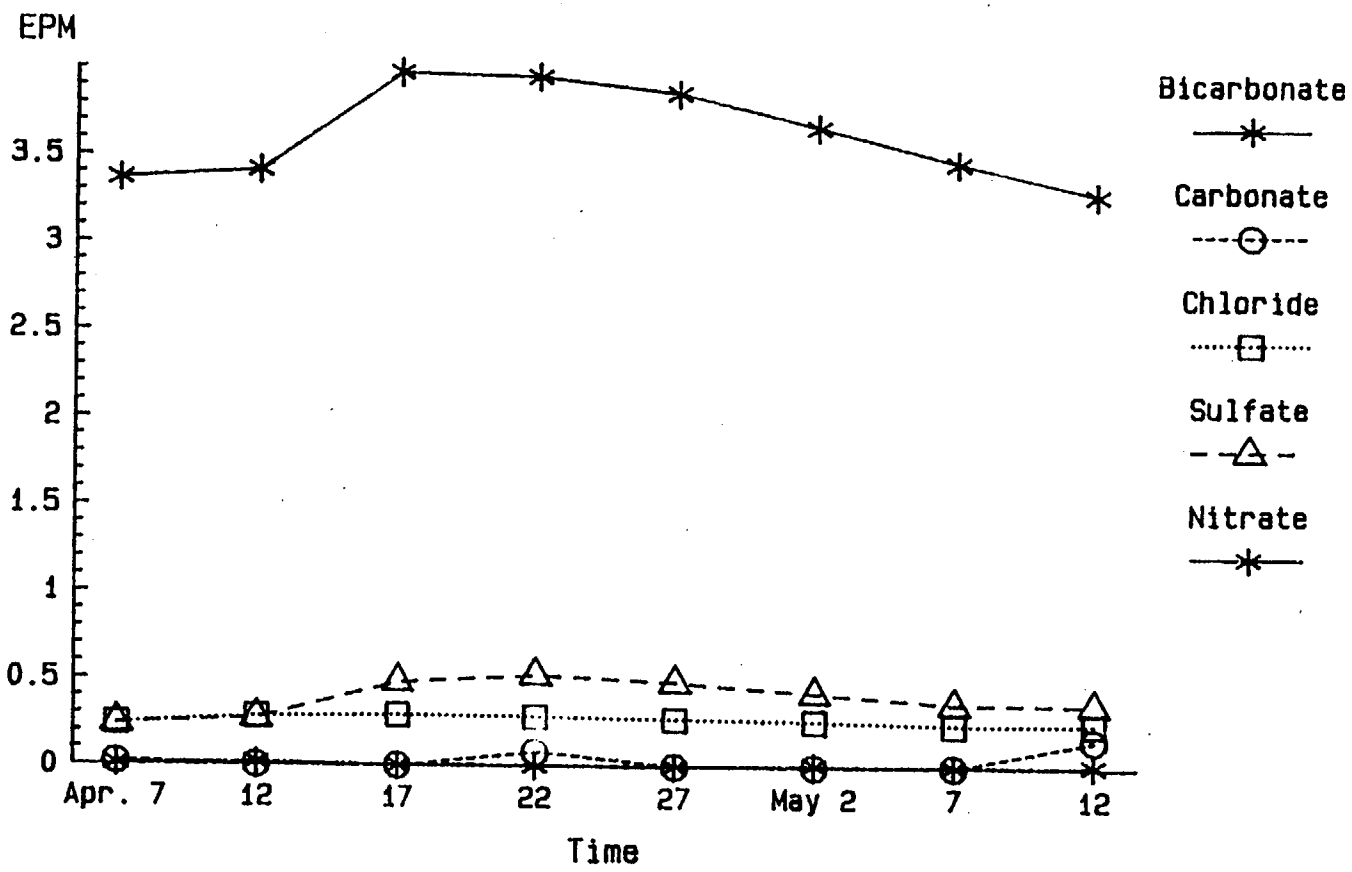
Change in aqueous chemistry caused by the April 6, 1985 nuclear detonation. From Russell, 1987.



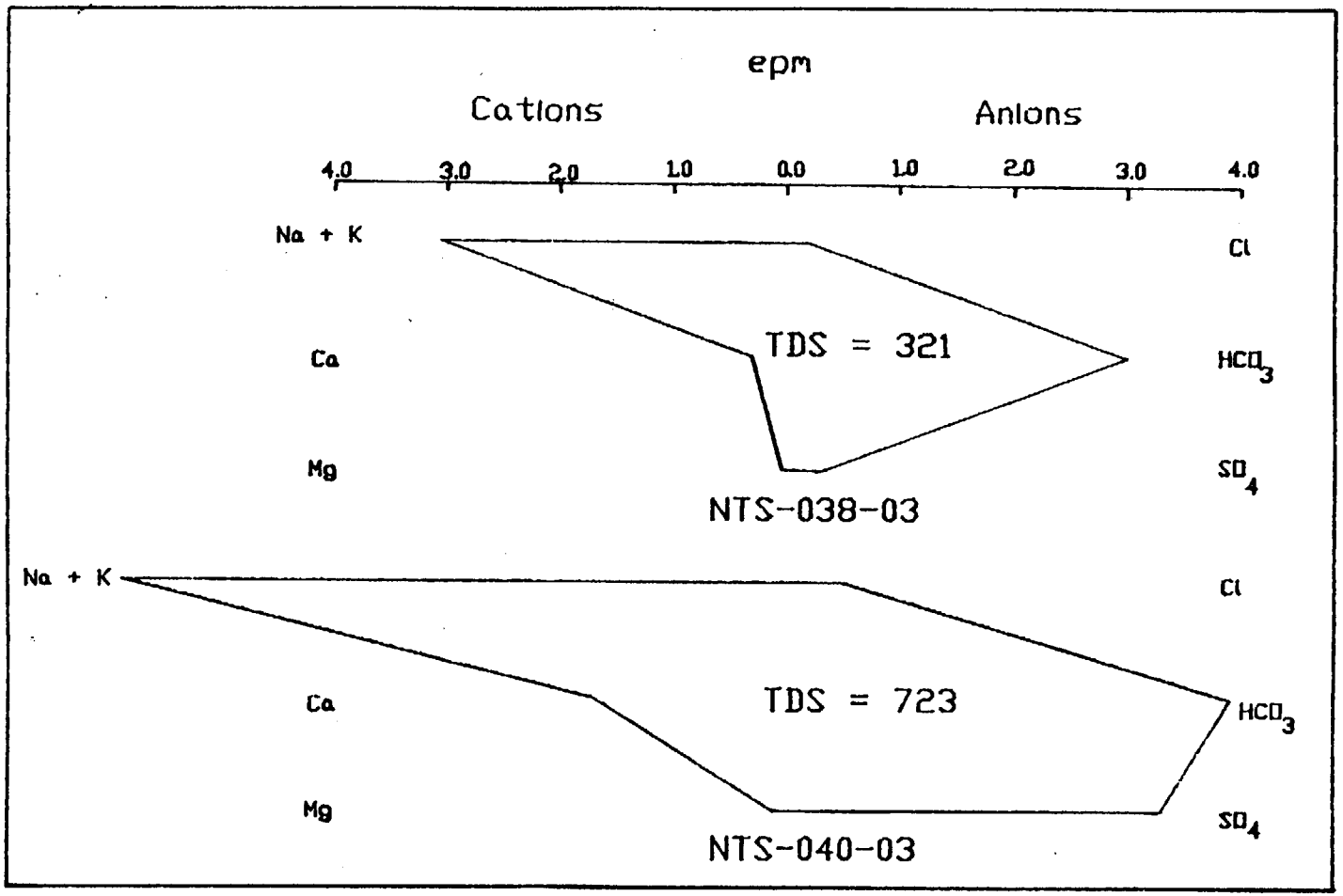
Change in aqueous chemistry caused by the April 6, 1985 nuclear detonation. From Russell, 1987.



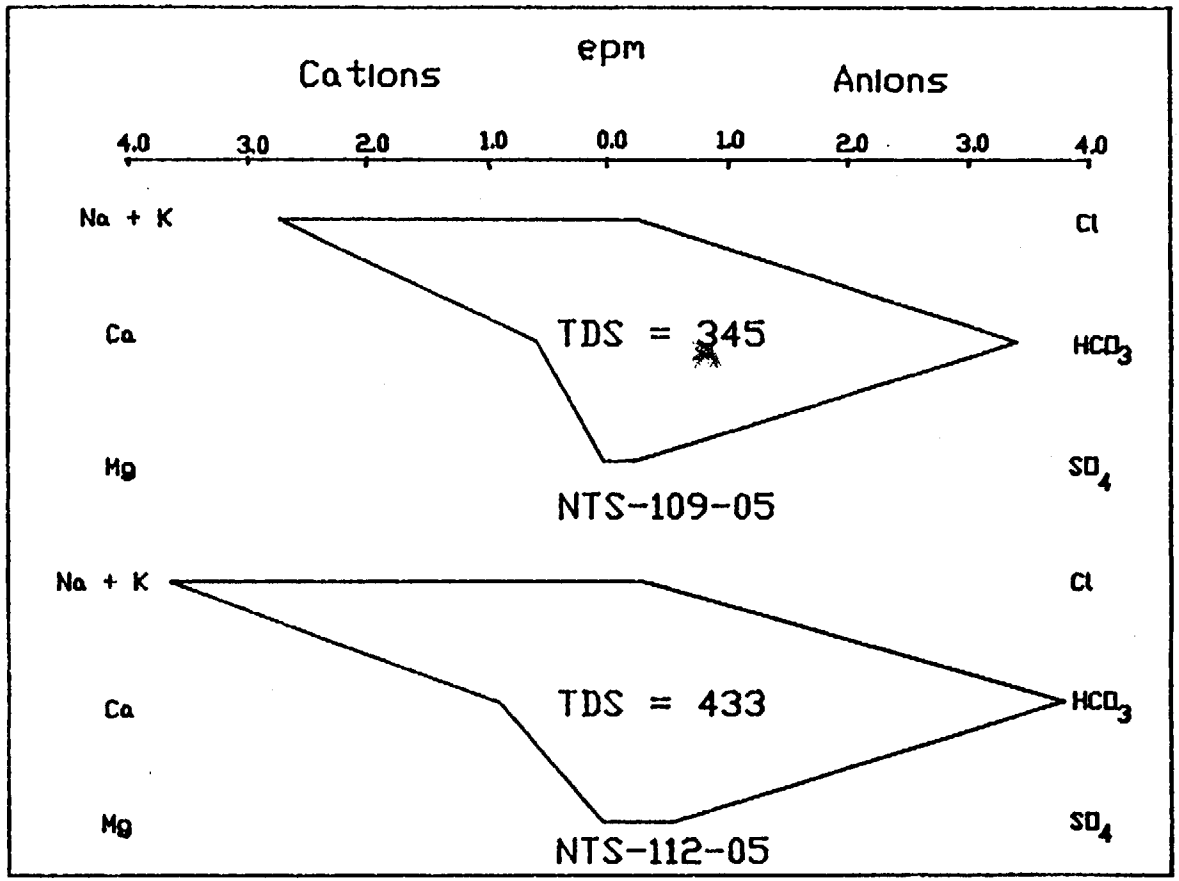
Change in aqueous chemistry caused by the April 10, 1986 nuclear detonation. From Russell, 1987.



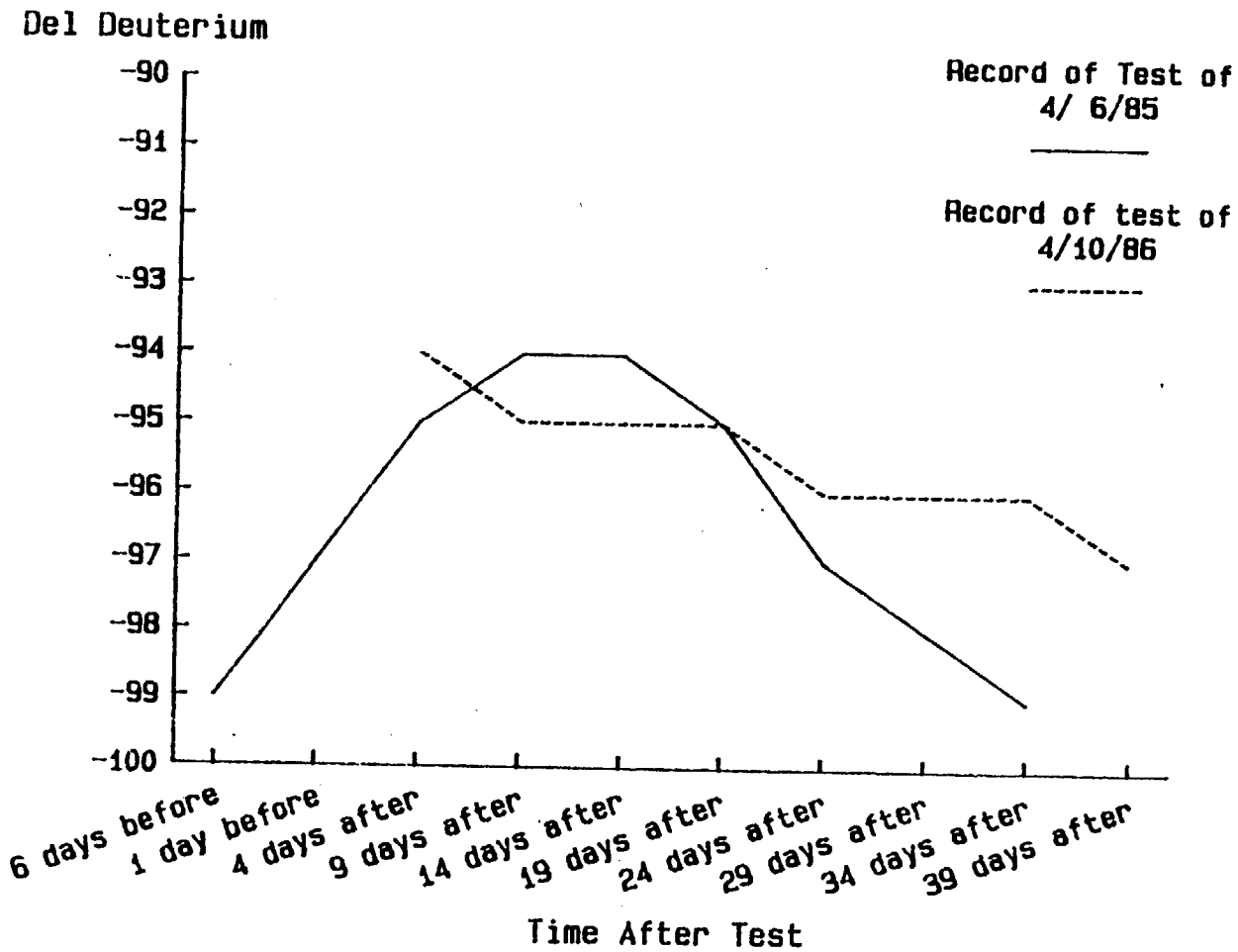
Change in aqueous chemistry caused by the April 10, 1987 nuclear detonation. From Russell, 1987.



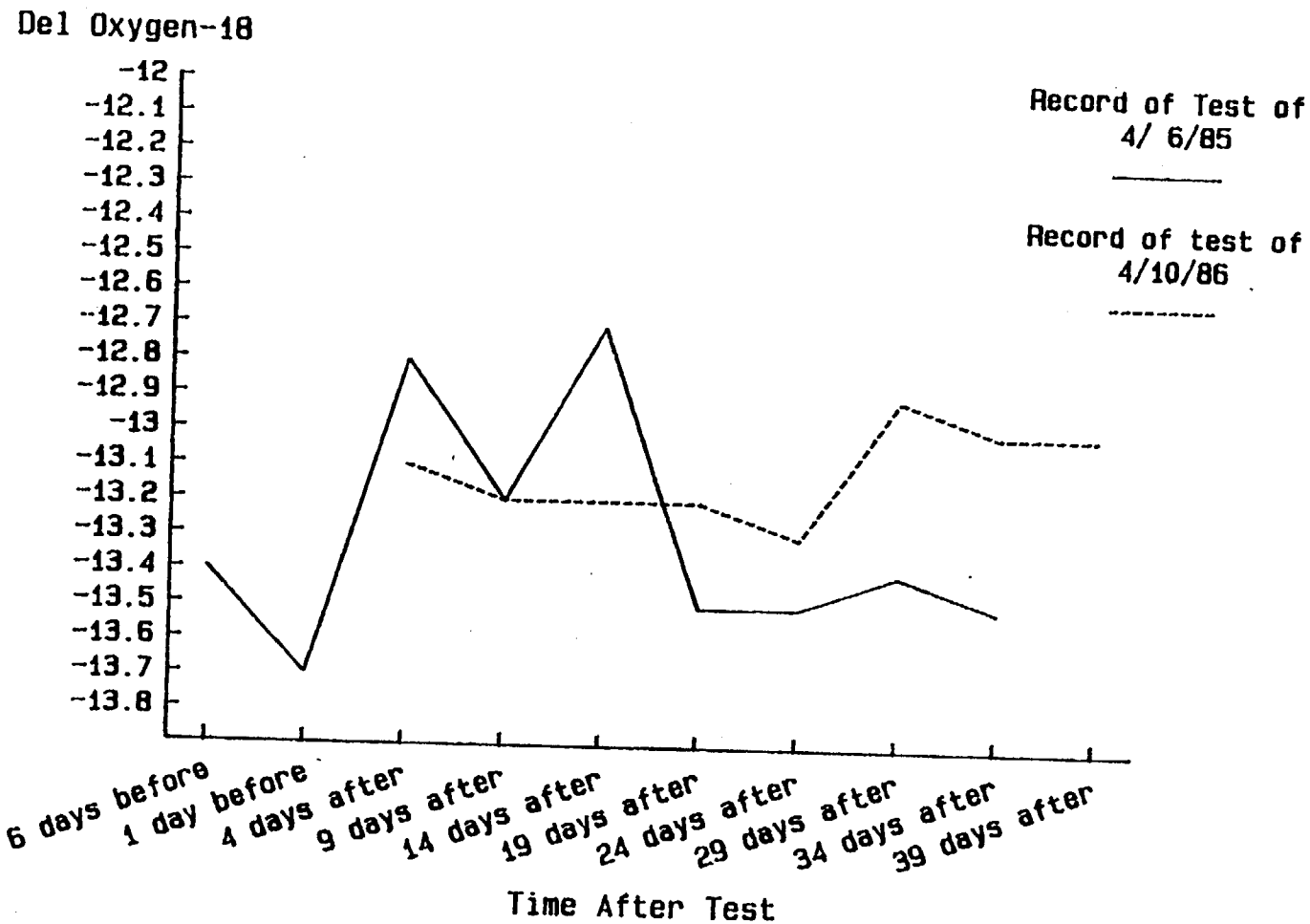
Stiff diagrams of aqueous chemistry before and after the April 6, 1985 nuclear detonation. From Russell, 1987.



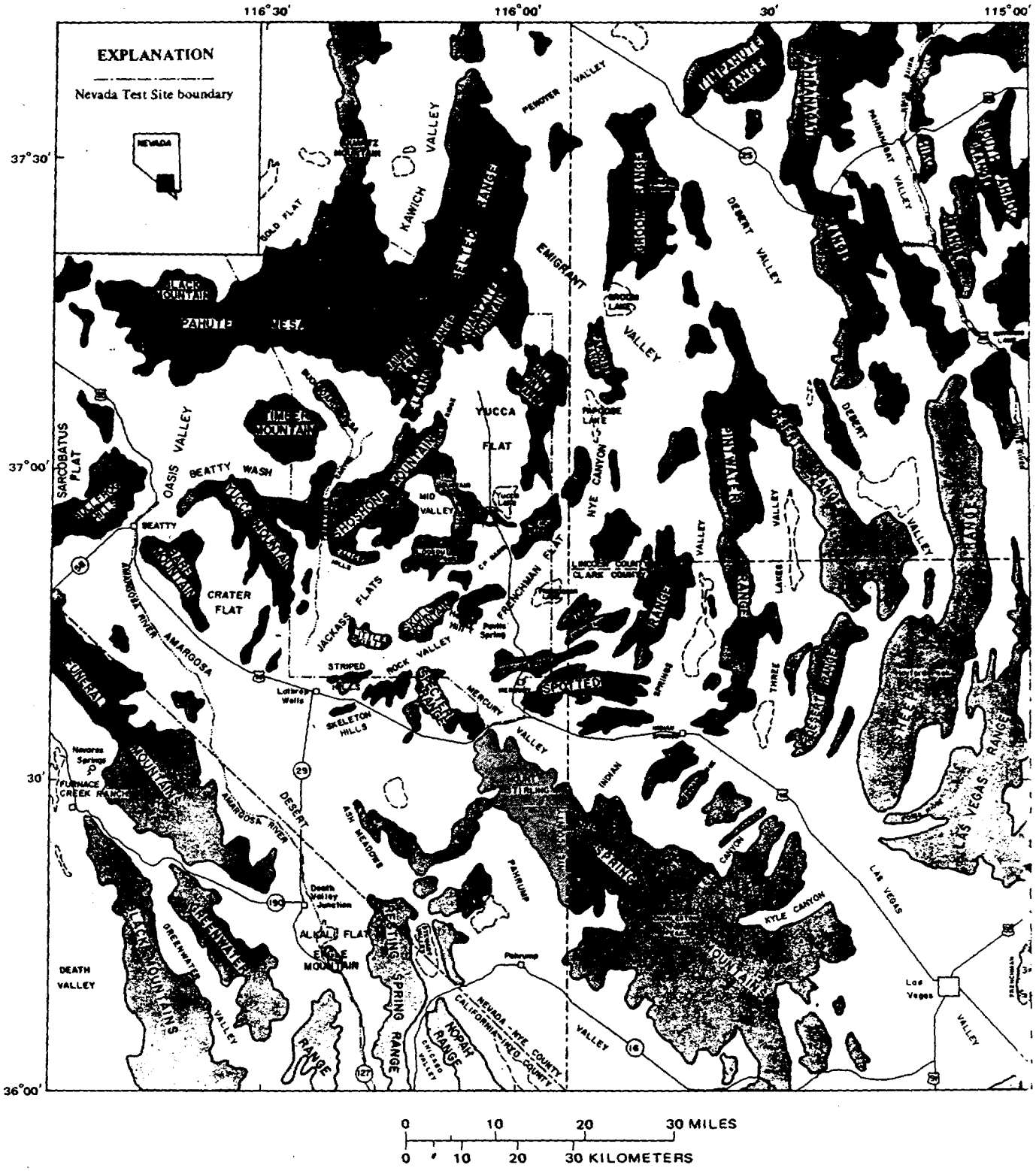
Stiff diagrams of aqueous chemistry before and after the April 10, 1986 nuclear detonation. From Russell, 1987.



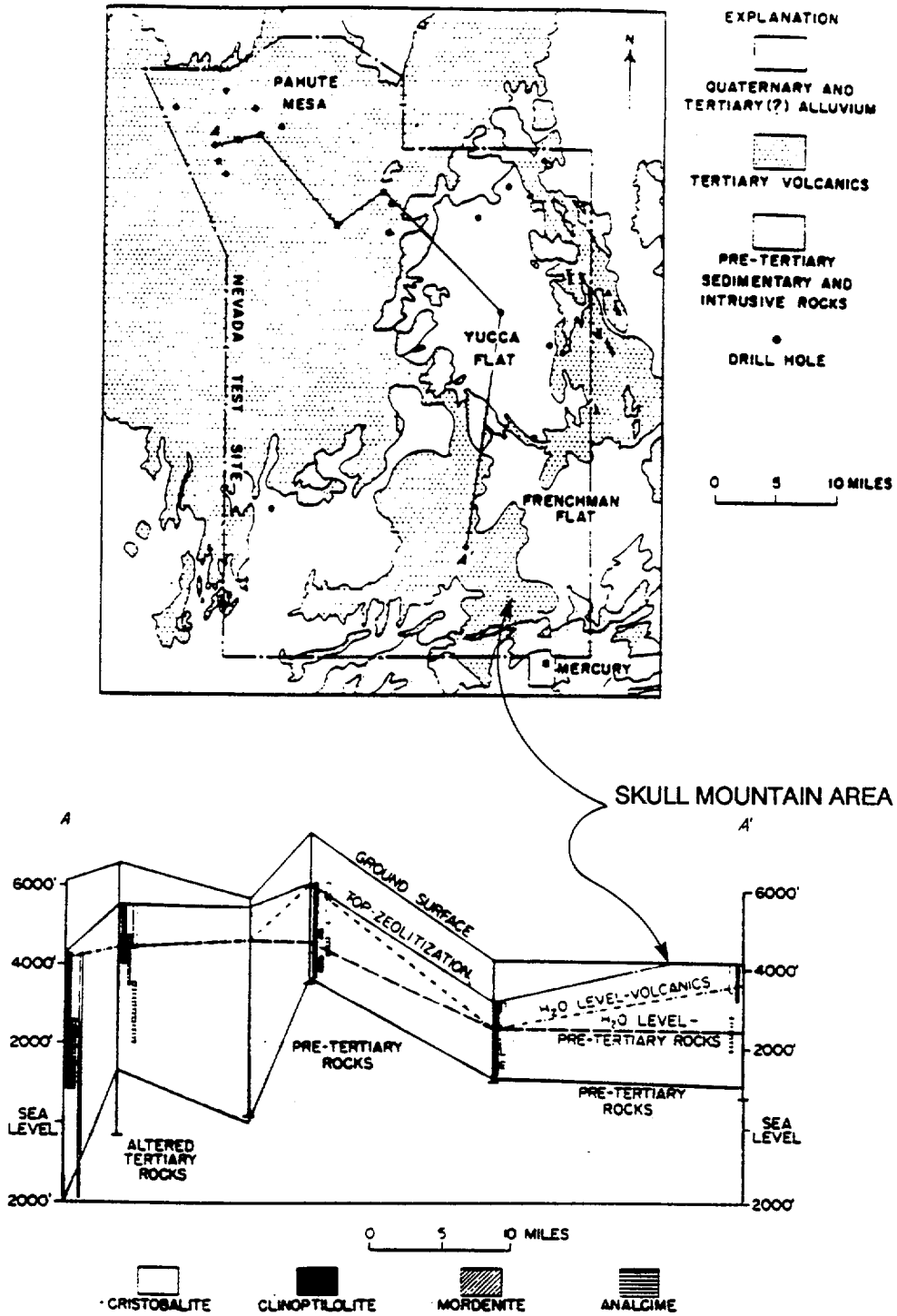
Change in deuterium content caused by two nuclear detonations. From Russell, 1987.



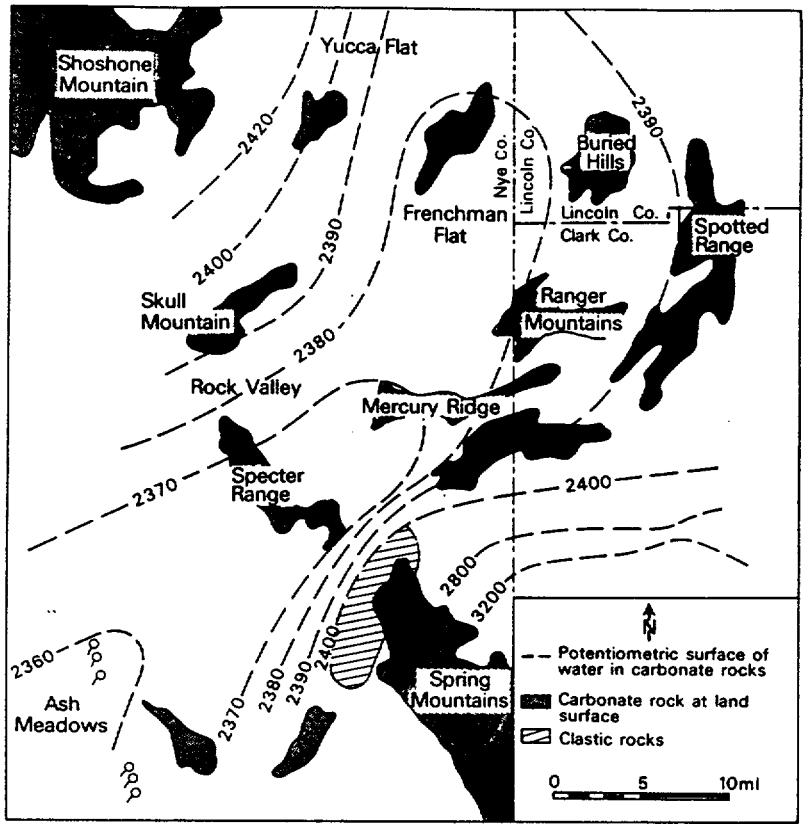
Change in oxygen-18 content caused by two nuclear detonations. From Russell, 1987.



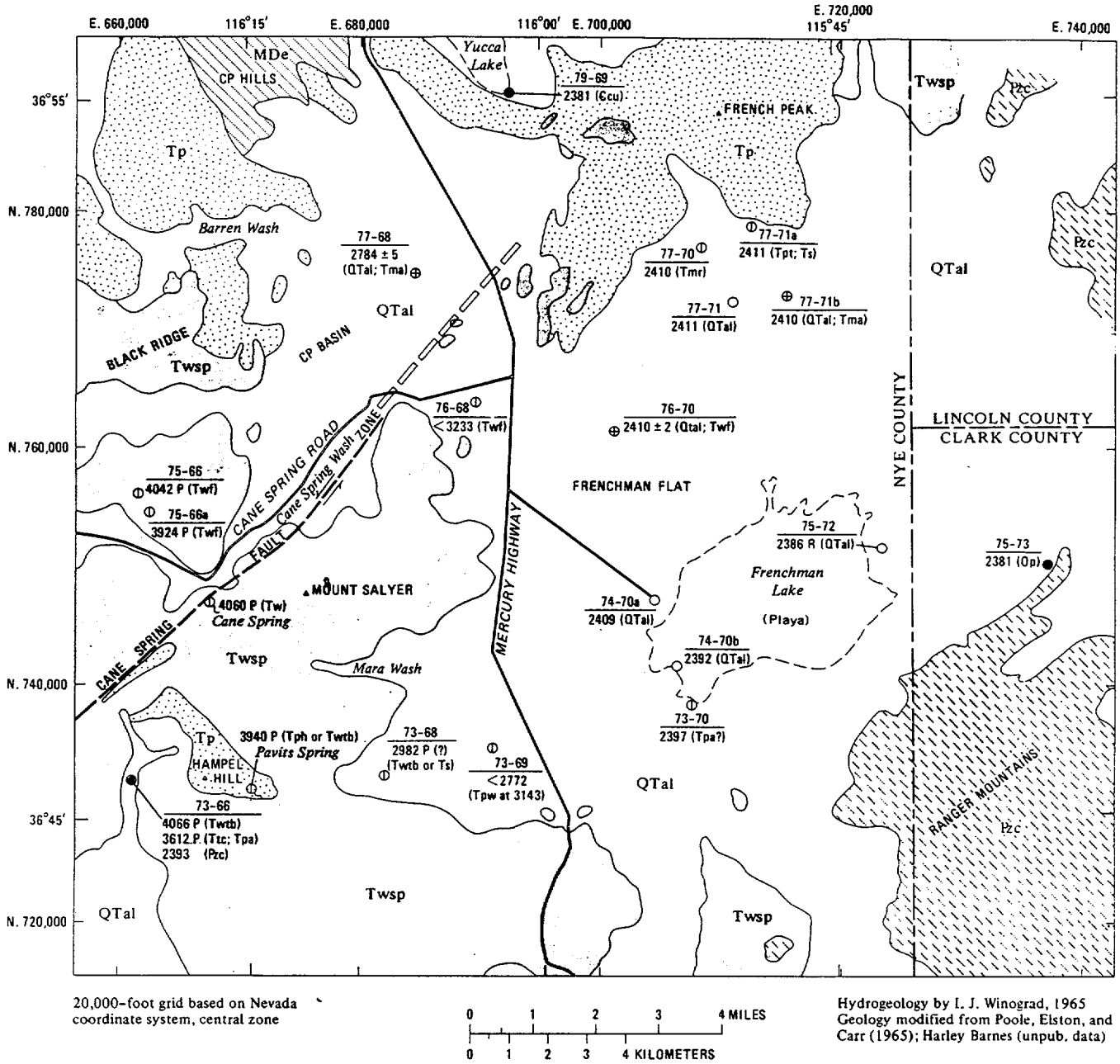
Location of hydrologic features considered in Section 4.5.2. From Winograd and Thordarson, 1975.



General hydrology of Yucca Flat and Frenchman Flat. Nevada Test Site. From Hoover, 1968.



Potentiometric setting of the Skull Mountain area. Nevada Test Site. From Domenico, 1972.



20,000-foot grid based on Nevada coordinate system, central zone

0 1 2 3 4 MILES
0 1 2 3 4 KILOMETERS

Hydrogeology by I. J. Winograd, 1965
Geology modified from Poole, Elston, and Carr (1965); Harley Barnes (unpub. data)

Local hydrologic conditions near Skull Mountain. Nevada Test Site. From Winograd and Thordarson, 1975.

EXPLANATION

QTal — TERTIARY AND QUATERNARY

Valley-fill aquifer
Alluvial fan, fluvial, fanglomerate, lakebed, and mudflow deposits

Tp — TERTIARY

Welded-tuff and bedded-tuff aquifers
Densely to semi-welded tuff of Piapi Canyon Group; interbedded vitric ash-fall tuff is bedded-tuff aquifer

Tuff and lava-flow aquitards
Ash-fall and ash-flow tuff massively altered to zeolite or clay; lava flows; also include tuffaceous and clayey lake deposits; predominantly rocks of Wahmonie, Salyer, and Horse Spring Formations and Rocks of Pavits Spring

MDe — DEVONIAN AND MISSISSIPPIAN

Upper clastic aquitard
Argillite, quartzite, conglomerate, and minor limestone of Eleana Formation; overlain at shallow depth by upper carbonate aquifer and by klippen of lower carbonate aquifer and lower clastic aquitard

Pzc — CAMBRIAN TO DEVONIAN

Lower carbonate aquifer
Dolomite and limestone; minor shale and quartzite

Contact

Fault
Arrows indicate direction of relative movement; dashed where approximately located

HYDROGEOLOGIC AND GEOLOGIC UNITS

SYMBOL	GEOLOGIC UNIT	HYDROGEOLOGIC UNIT
QTal	Valley fill	Valley-fill aquifer
Tma	Ammonia Tanks Member of Timber Mountain Tuff	Tuff aquifers and aquitard and lava-flow aquitard
Tmr	Rainier Mesa Member of Timber Mountain Tuff	
Tpt	Topopah Spring Member of Paintbrush Tuff	
Tph	Sandstone and tuff of Hampel Hill (lower part of Piapi Canyon Group)	
Tpw	Tuff and sandstone of Piapi Canyon Group, and tuff, sandstone, and lithic tuff of Wahmonie Formation undifferentiated	
Tw	Wahmonie Formation undifferentiated	
Twf	Dacite and rhyodacite lava flows of Wahmonie Formation	
Twtb	Tuff, sandstone, and lithic tuff breccia of Wahmonie Formation	
Ts	Salyer Formation undifferentiated	
Ttc	Tuff of Crater Flat	
Tpa	Rocks of Pavits Spring	
Pzc	Paleozoic carbonate rock	Lower carbonate aquifer
Op	Pogonip Group	
Ꞓcu	Carrara Formation, upper half	

HYDRAULIC SYMBOLS

NOTE: All altitudes in feet; datum is mean sea level; potentiometric contours not drawn for reasons outlined in text

75-73 / 2381 (Op)

Test well
Well tapping lower carbonate aquifer; upper number is well number; lower number is altitude of static water level; symbol in parentheses is formation tapped

73-66 / 4066 P (Twtb) / 3612 P (Ttc; Tpa) / 2383 (Pzc)

Test well
Well tapping tuff aquitard and lower carbonate aquifer; upper number is well number; lower numbers are altitude of static water level; P, perched water; symbols in parentheses are formations tapped

73-69 / <2772 (Tpw at 3143)

Test well
Well tapping Tertiary hydrogeologic units; upper number is well number; lower number is altitude of static water level; symbol and number in parentheses are formation tapped and its altitude; symbol < denotes well was dry

75-72 / 2386 R (QTal)

Test well or water well
Well tapping valley-fill aquifer; upper number is well number; lower number is altitude of static water level; R, reported water level; symbol in parentheses is formation tapped

77-71b / 2410 (QTal; Tma)

Test well
Well tapping both valley-fill aquifer and Tertiary hydrogeologic units; upper number is well number; lower number is altitude of static water level; symbols in parentheses are formations tapped

4060 P (Tw)

Spring
Number is altitude; P, perched or semiperched; symbol in parentheses is formation supplying spring

Dry lakebed

Inferred ground-water barrier
Width of symbol not intended to represent width of barrier, which may range from several tens to a few thousand feet

Explanation of symbols used on Plate 4.5.2.3-3. From Winograd and Thordarson, 1975.

Chemical analysis of water from test well 68–69. Mercury Valley, Nye County

	Milligrams per liter[1]	Milliequivalents per liter
Silica (SiO_2)	23	---
Calcium (Ca)	281	14.02
Magnesium (Mg)	90	7.40
Sodium (Na)	1,290	56.12
Bicarbonate (HCO_3)	98	1.61
Carbonate (CO_3)	Tr	---
Sulfate (SO_4)	3,600	74.99
Chloride (Cl)	[2]35	.99
Dissolved solids (sum)	5,420	---
Hardness as $CaCO_3$ (total)	1,070	---
pH	8.1	---

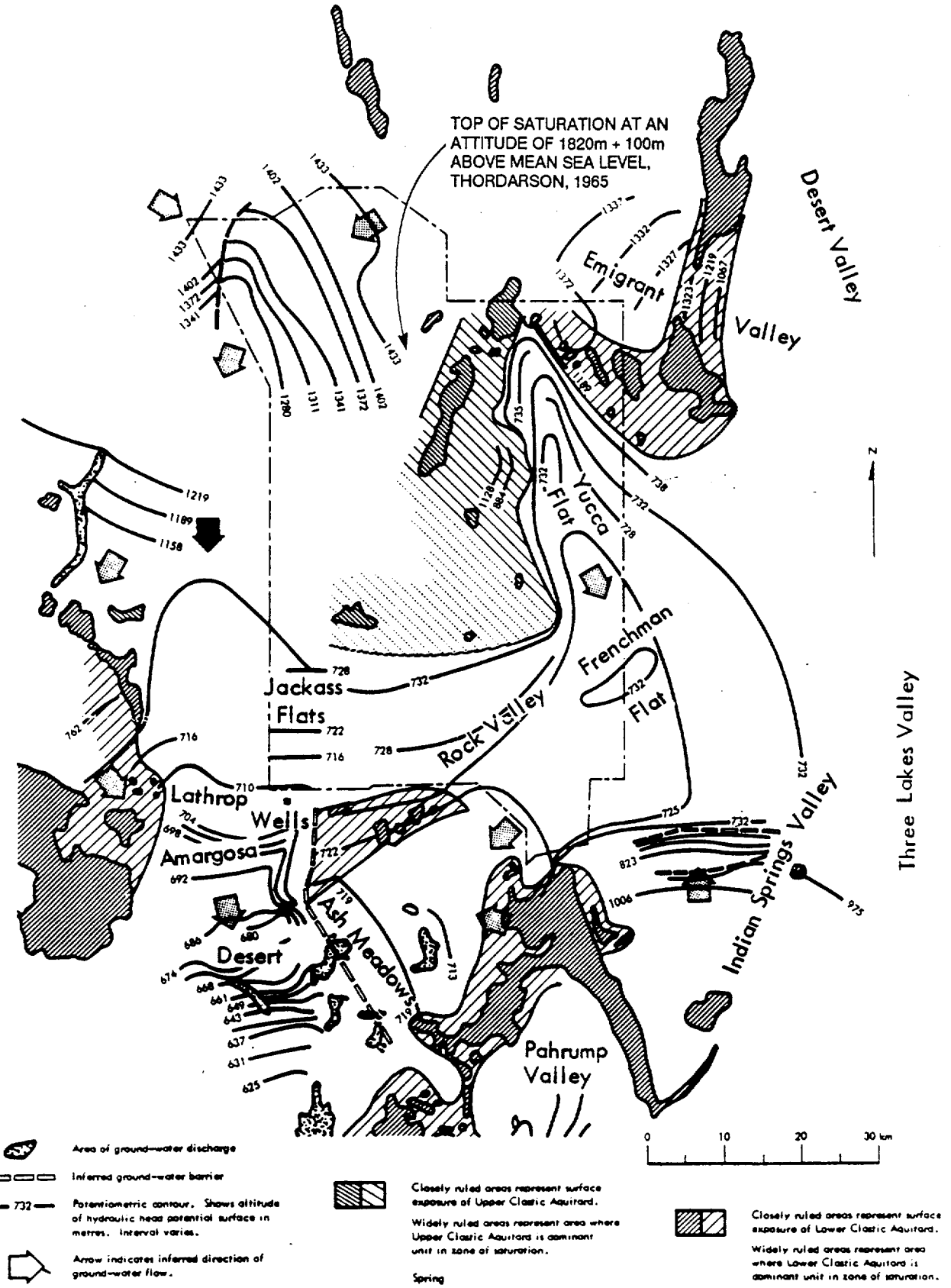
[1]Analysis by Smith-Emery Co. of Los Angeles, Calif., 1951. Sodium, sulfate, dissolved solids, and hardness have been rounded to Survey standards.
[2]Erroneously reported as 98 by Schoff and Moore (1964, p. 27).

Chemical analyses of water from three depth intervals in test well 73–66, Rock Valley, Nye County

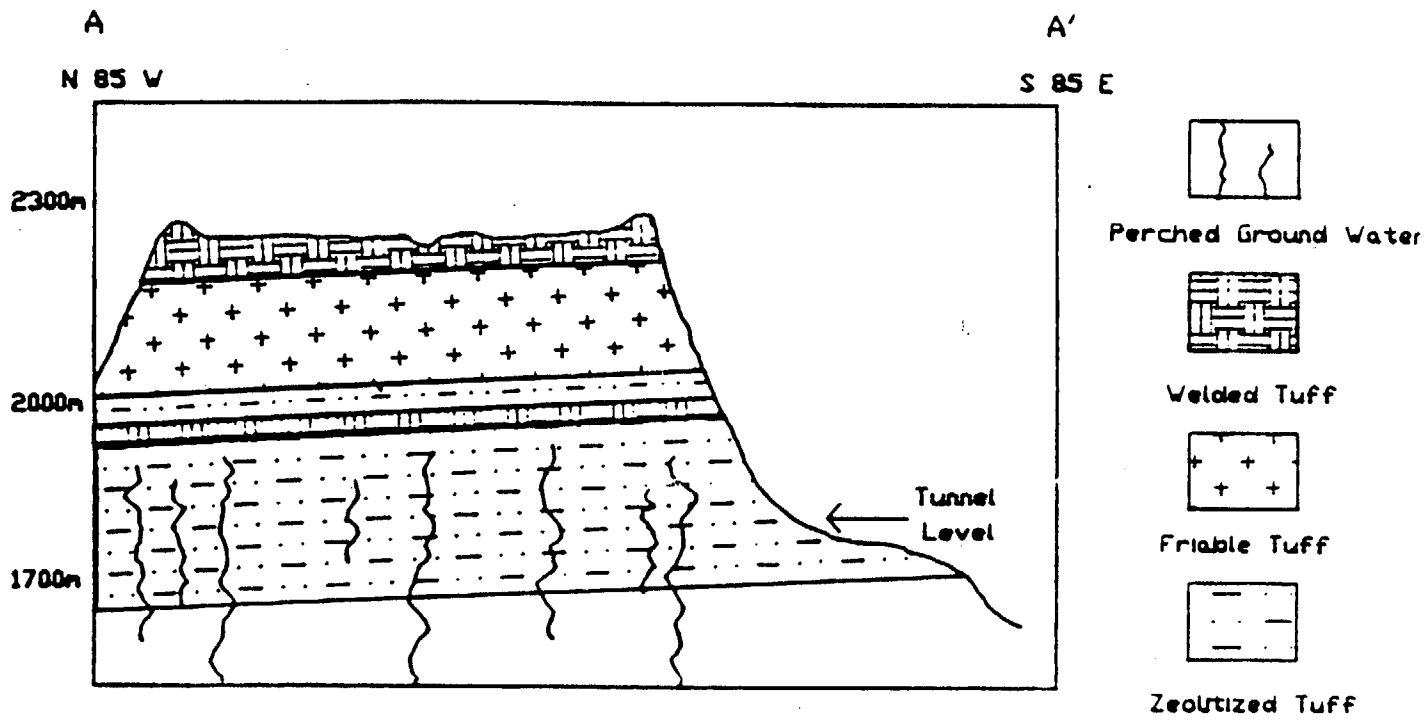
[Analyses by U.S. Geol. Survey, Denver, Colo]

Depth interval (ft)	77–693	1,565–1,695	3,140–3,400
Major constituents, in milligrams per liter			
Silica (SiO_2)	32	14	31
Calcium (Ca)	13	4.0	68
Magnesium (Mg)	1.0	.0	30
Sodium (Na)	99	424	63
Potassium (K)	6.4	4.4	9.6
Bicarbonate (HCO_3)	199	719	273
Carbonate (CO_3)	0	68	0
Sulfate (SO_4)	34	110	181
Chloride (Cl)	32	35	11
Physical characteristics and computed values			
Dissolved solids, in milligrams per liter calculated	327	981	534
Hardness as milligrams per liter $CaCO_3$:			
Total	37	10	293
Noncarbonate	0	0	65
Specific conductance (μmhos per cm at 25°C)	492	1,640	751
pH	7.3	8.8	7.3
Temperature (°C)	22.0	33.5	64.5

Results of chemical analyses of water samples from Well # 68-69 and Well # 73-66. From Winograd and Thordarson, 1975.



Potentiometric setting of Rainier Mesa. From Winograd and Thordarson, 1975.



Schematic diagram illustrating local hydrology of Rainier Mesa. From Russell, 1987.

[Quantities are in millimoles per liter, except as indicated]

Sample No.	Depth (m)	Sodium	Potassium	Calcium	Magnesium	Bicarbonate	Sulfate	Chloride	Silica	pH
1	134.4	1.07	0.26	0.274	0.12	0.95	0.21	0.76	1.02	7.6
2	169.6	1.51	.36	.05	.29	2.25	.38	.90	.98	7.7
3	199.2	1.89	.26	.57	.26	2.25	.42	.76	.95	7.7
4	202.4	1.02	.11	.42	.17	.44	.42	1.07	1.16	7.6
5	257.6	1.30	.12	.40	.20	.43	.40	1.47	1.00	7.2
6	260.0	1.41	.14	.65	.30	.37	.74	1.75	1.25	7.5
7	441.4	2.00	.36	.22	.029	1.09	.54	.56	.82	7.6
8	442.4	2.42	.49	.27	.041	1.07	.87	.56	.88	7.6
9	291.4	1.11	.12	.20	.086	.79	.23	.59	1.25	7.8
10	320.3	1.36	.19	.23	.070	.84	.47	.85	1.25	7.7
11	320.6	1.37	.21	.45	.090	.57	----	.99	.92	7.8
12	321.3	1.54	.21	.70	.18	1.29	.52	.82	1.28	8.2
13	350.8	1.01	.15	.32	.090	.97	.57	.85	1.25	7.9
14	411.2	1.34	.14	.14	.034	.61	.34	.45	.98	7.8
15	470.6	1.74	.038	<.005	<.002	.91	.22	.27	.75	7.9
16	472.4	2.27	.031	.005	.004	1.41	.34	.31	.72	7.9
17	501.7	2.62	.031	.055	.006	1.72	.32	.34	.64	8.1
18	503.2	2.83	.023	.045	.006	1.84	.31	.48	.66	8.1
19	532.8	3.09	.097	.025	.005	1.90	.38	.48	.69	8.0

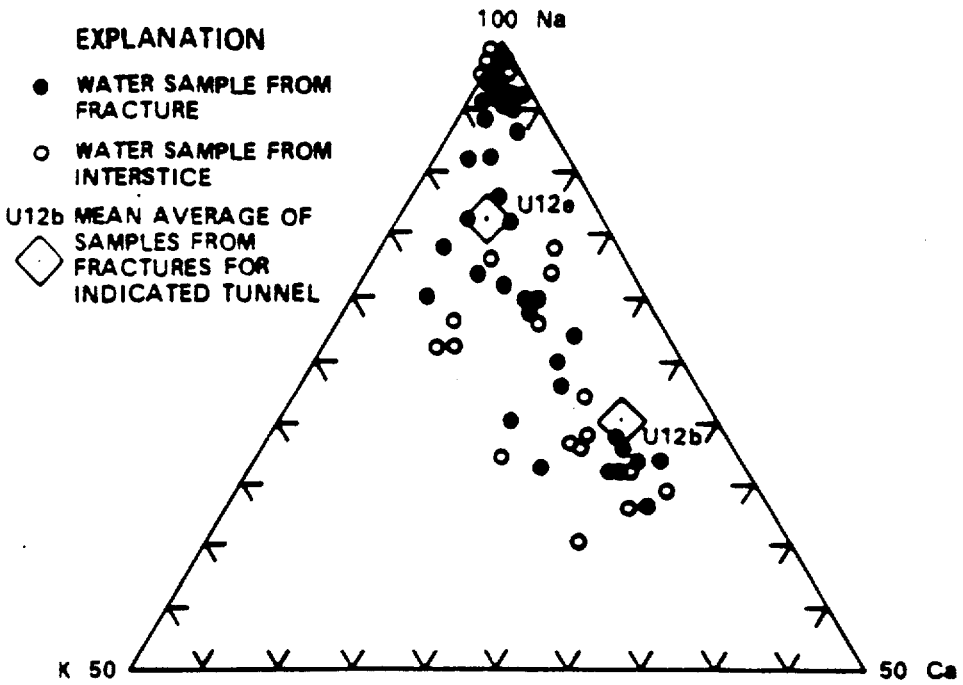
Results of chemical analyses of interstitial water. Core U12T3. Rainier Mesa. From White et al., 1980.

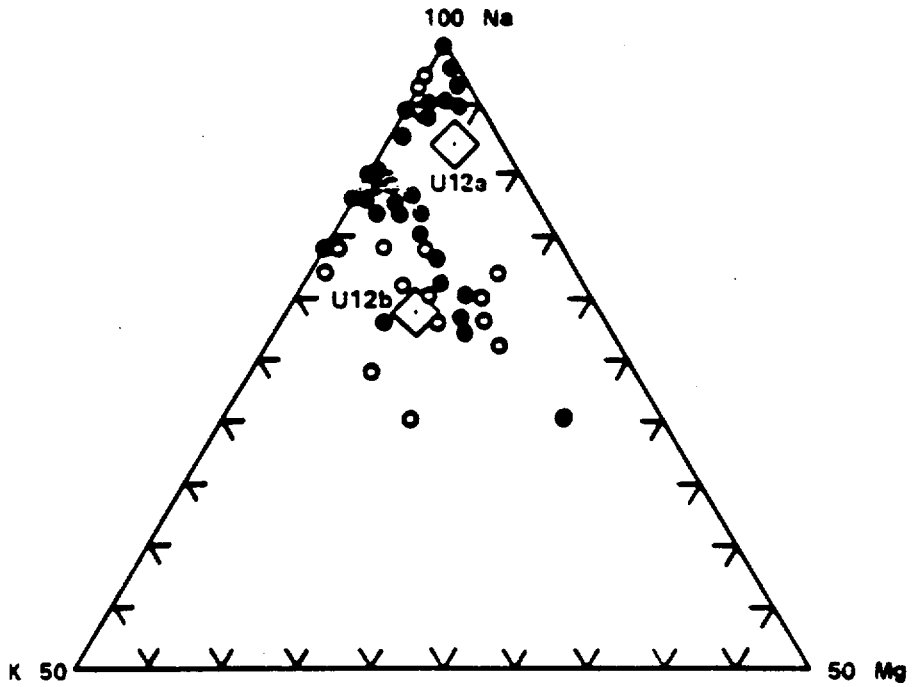
[Quantities are in millimoles per liter, except as indicated]

Sample No.	Tunnel designation	Sodium	Potassium	Calcium	Magnesium	Bicarbonate	Sulfate	Chloride	Fluoride	Silica	pH (units)	Date of collection
1	U12n.05 bypass	1.91	0.24	0.18	0.02	2.29	0.06	0.16	0.01	0.85	8.0	6-02-71
2	U12n.05	2.65	.28	.23	.02	2.85	.15	.37	.01	.72	7.6	9-21-71
3	U12n.05	3.04	.33	.40	.06	3.39	.28	.37	.01	.70	8.3	9-21-71
4	U12n main	2.70	.19	1.15	.28	3.62	.66	.90	.03	.68	8.2	8-03-72
5	U12n.07 bypass	.96	.02	.01	.00	.87	.05	.06	.02	.63	8.04	8-03-72
6	U12n.02	2.04	.14	.18	.01	2.25	.09	.20	.01	.88	7.31	11-14-72
7	U12t.02 bypass	.96	.00	.01	.00	.92	.00	.02	.02	.65	6.9	9-22-71
8	U12t.02	1.09	.01	.03	.01	1.08	.00	.05	.02	.65	7.0	9-22-71
9	U12t.02 bypass	1.13	.02	.07	.00	.82	.18	.05	.01	.63	7.5	9-22-71
10	U12t main	2.83	.09	.02	.01	2.44	.14	.28	.01	.65	7.5	9-22-71
11	U12t.03	1.44	.14	.50	.21	2.23	.18	.27	.02	1.35	---	2-15-73
12	U12t.03	1.39	.14	.22	.06	1.46	.19	.31	.01	.92	---	2-01-73
13	U12t.04	1.44	.13	.24	.08	1.61	.16	.28	.01	.88	---	8-22-73
14	U12t.03	1.30	.17	.50	.17	2.18	.16	.31	.02	1.00	---	3-19-73
15	U12t.03	1.65	.17	.23	.06	1.85	.16	.28	.01	.83	7.18	11-16-72
16	U12t.03	1.13	.14	.51	.19	2.15	.17	.26	.01	1.10	7.4	9-24-74
17	U12e.07	1.13	.15	.43	.17	2.00	.15	.06	.01	.90	7.4	1-11-60
18	U12e.04	1.04	.02	.01	.00	.79	.13	.10	.01	.60	7.1	6-02-59
19	U12e	1.13	.09	.06	.00	.87	.12	.17	.02	.90	7.6	11-22-59
20	U12e	1.04	.20	.06	.00	.93	.10	.11	.01	.87	7.0	11-29-59
21	U12e.04	1.26	.01	.04	.00	.88	.09	.17	.01	.60	6.9	1-07-60
22	U12e.03	1.35	.10	.04	.00	1.15	.09	.06	.02	.67	7.1	12-14-59
23	U12e	.87	.17	.20	.08	.92	.18	.23	.01	.92	7.8	1-29-59
24	U12e.02	1.39	.06	.00	.00	.98	.12	.27	.01	.78	7.4	10-11-58
25	U12e.05	1.44	.08	.06	.00	1.05	.12	.28	.01	1.23	7.4	9-12-58
26	U12e.03	1.74	.03	.06	.00	1.34	.12	.25	.02	.98	7.5	5-27-59
27	U12e.03	1.91	.04	.02	.00	1.34	.12	.28	.01	.63	8.0	5-20-59
28	U12e.03	1.74	.07	.04	.00	1.38	.12	.23	.02	.97	7.5	12-03-59
29	U12e.07	1.13	.15	.43	.12	2.00	.15	.11	.01	.90	7.4	3-18-66
30	U12e	1.48	.16	.33	.00	1.61	.15	.28	.01	1.02	8.0	1-22-59
31	U12e	2.04	.28	.10	.00	1.77	.15	.34	.01	.67	6.8	6-24-59
32	U12e	1.61	.20	.40	.04	2.00	.15	.34	.01	.87	7.9	7-18-59
33	U12e	3.04	.07	.08	.00	2.10	.33	.45	.02	2.10	7.0	7-21-58
34	U12b	.78	.07	.32	.04	1.21	.12	.14	.01	1.11	7.6	6-06-58
35	U12b.03	.65	.07	.24	.06	.79	.09	.21	.01	1.10	6.9	8-22-58
36	U12.04	.96	.08	.20	.34	.98	*	.34	*	*	7.5	9-29-58

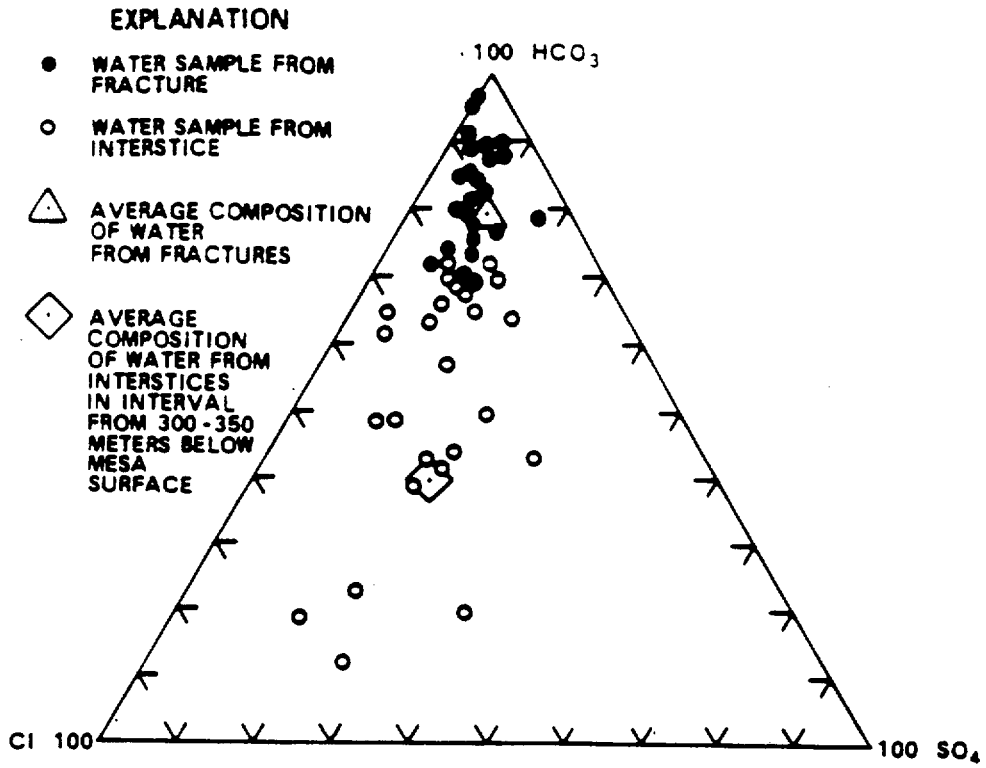
*Not analyzed.

Results of chemical analyses of fracture water. Tunnels in Rainier Mesa. From White et al., 1980.





Comparison of cation ratios in fracture and interstitial waters. Rainier Mesa. From White et al., 1980.



Comparison of anion ratios in fracture and interstitial waters. Rainier Mesa. From White et al., 1980.

Alluvium (quaternay).

Volcanic tuff, undifferentiated (tertiary).

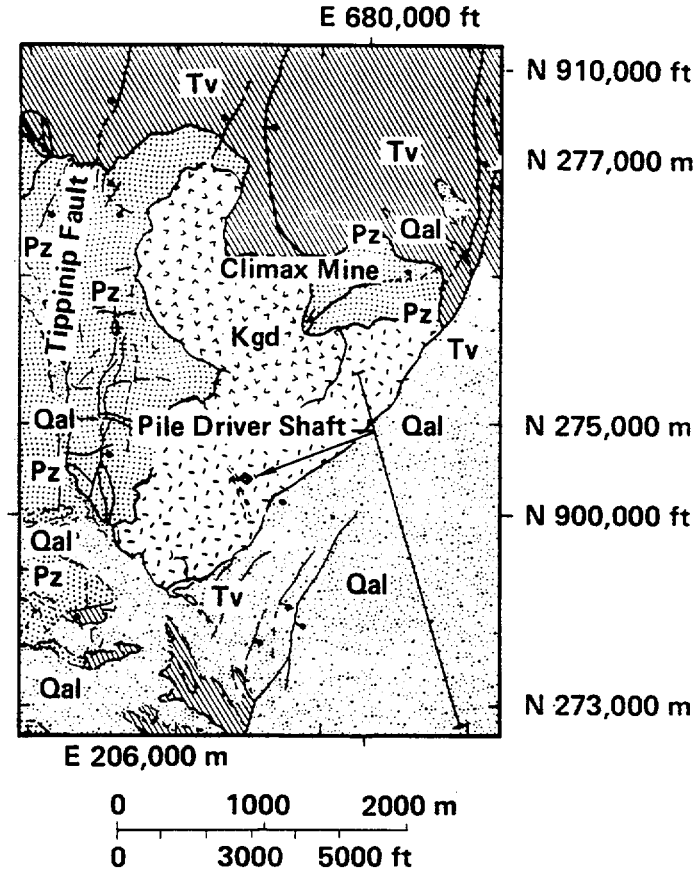
Quartz monzonite, Climax Stock (cretaceous).

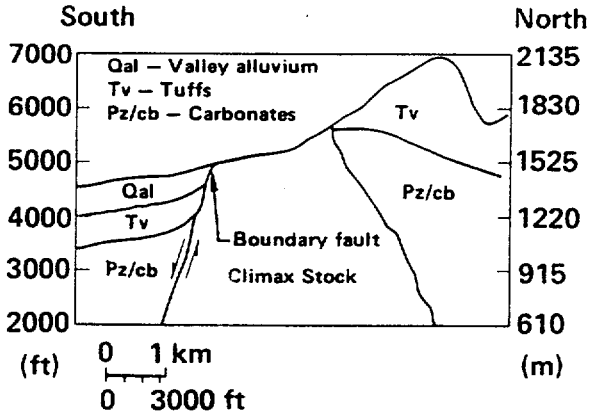
Granodiorite, Climax Stock (cretaceous).

Limestone, dolomite, shale, and quartzite, undivided (paleozoic).

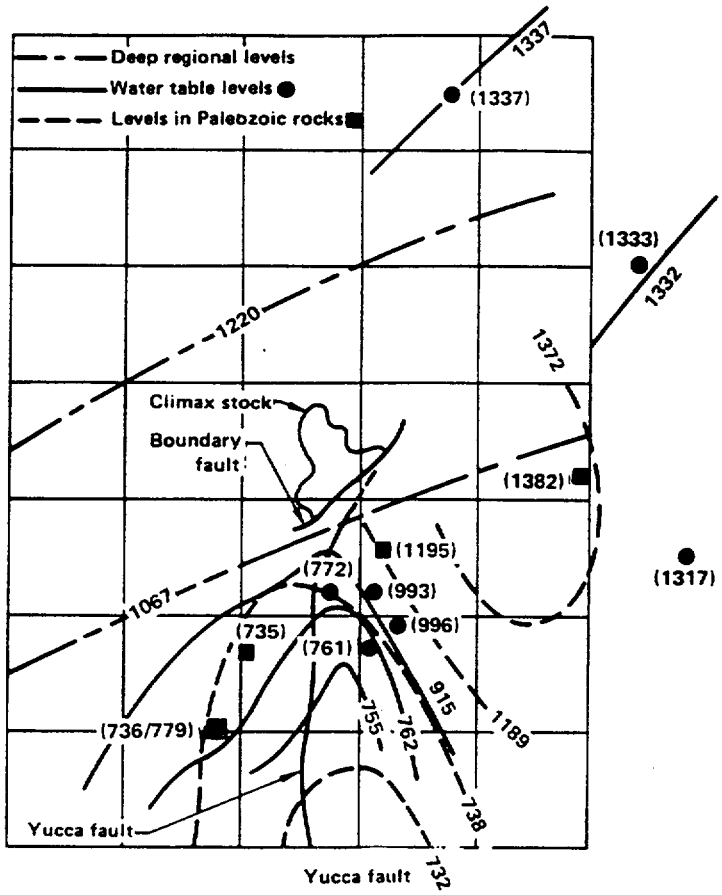
Contact — dashed where location is approximated.

Fault — dashed where location is approximated. Dotted where concealed. Bar and ball on downthrown side.

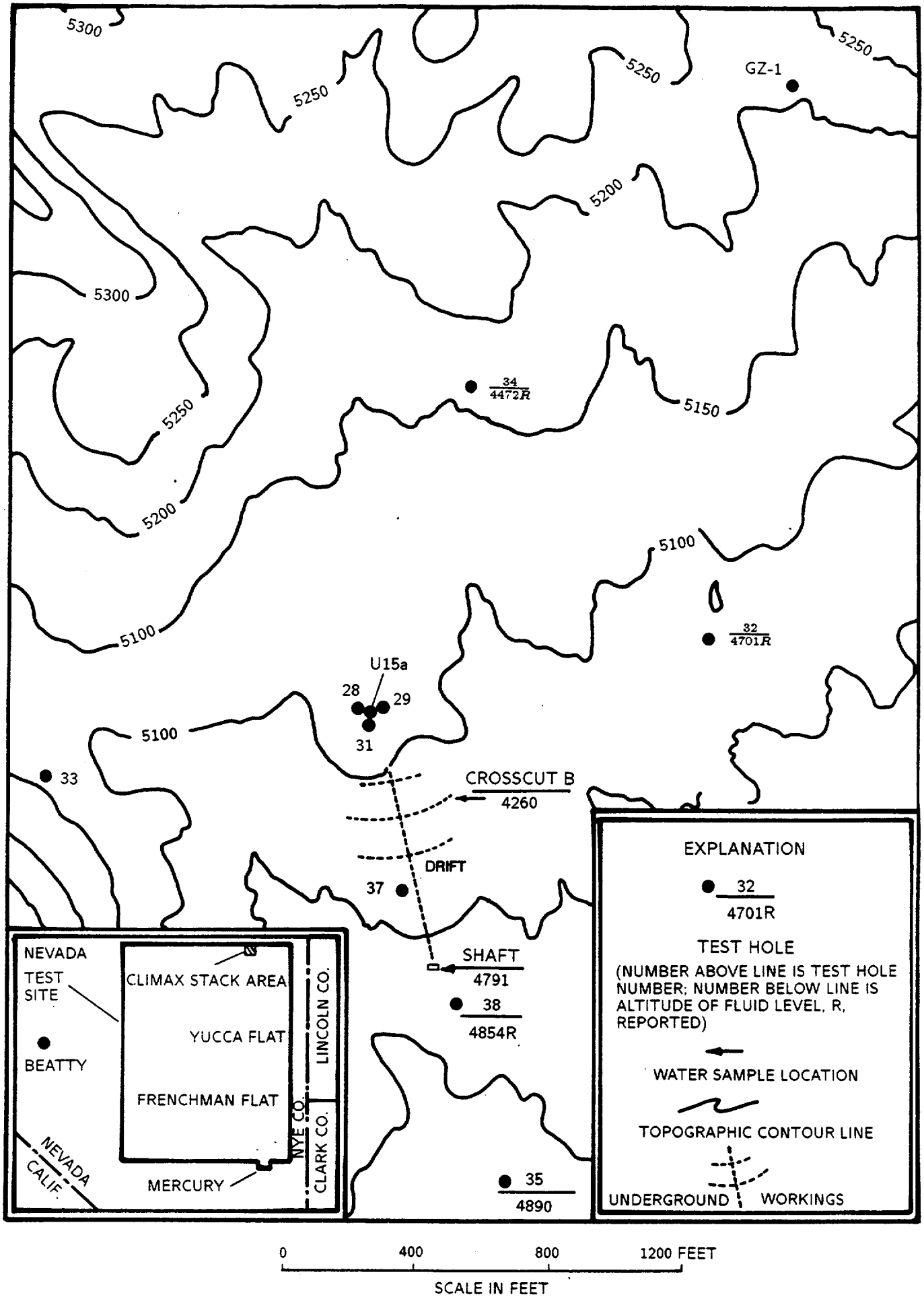




Geologic setting of the Climax Stock area. From Isherwood et al., 1982.



Potentiometric setting of the Climax Stock area. From Murray, 1981.



Location of exploratory boreholes. The area of Climax Stock. From Walker, 1962.

plate 4.5.2.5.-3

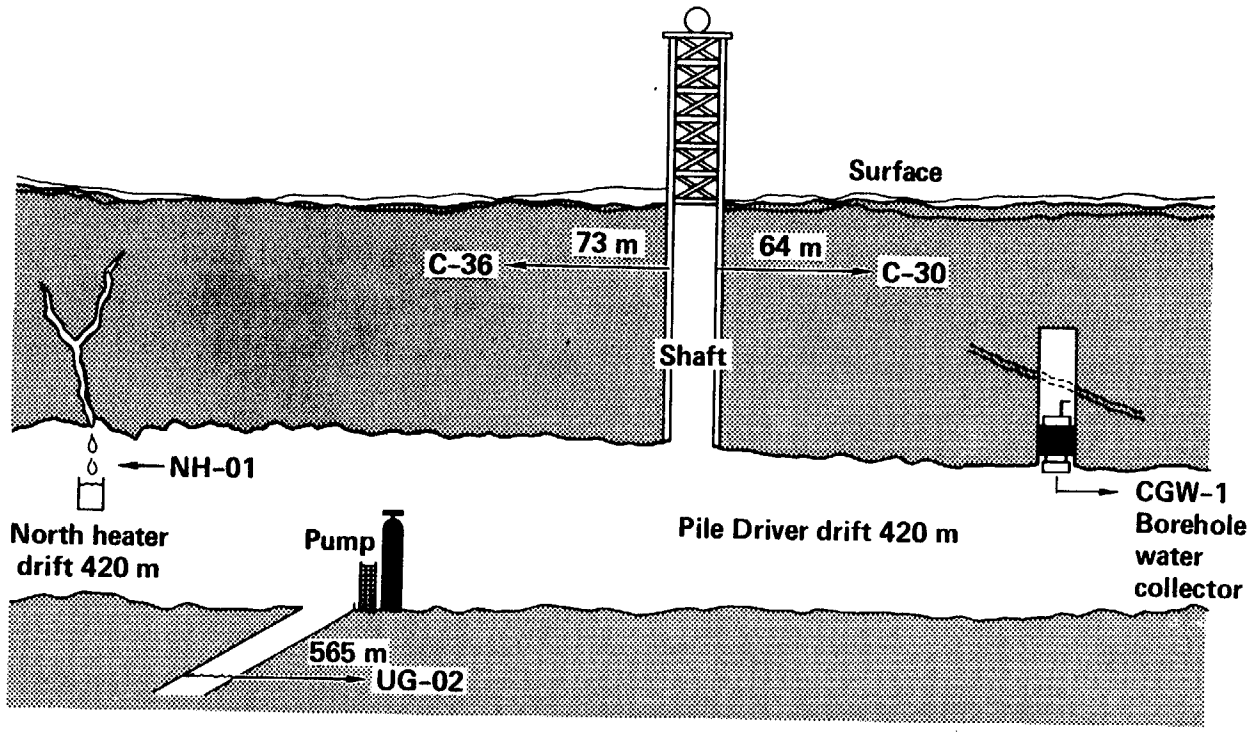
A. Chemical constituents, physical characteristics, and computed values, in parts per million, except as indicated.

Chemical constituents	Well 3	Hole 31	Crosscut	Shaft
Silica	72	19	33	30
Aluminum	.1	.8	.2	.2
Iron	.09	3.8	.21	.35
Manganese	.00	.00	.00	.00
Calcium	19	304	117	118
Magnesium	14	73	18	56
Sodium	37	91	93	50
Potassium	7.4	9.8	3.0	6.4
Bicarbonate	190	168	214	231
Carbonate	0	0	0	0
Sulfate	21	1,050	337	372
Chloride	5	11	32	39
Fluoride	.9	.8	.2	.4
Nitrate	6.1	9.0	.0	.0
Phosphate	.00	.00	.11	.08

Physical characteristics and computed values	Well 3	Hole 31	Crosscut	Shaft
Dissolved solids (res. on evap. at 180°C)	268	1,710	736	846
Hardness as $CaCO_3$				
Total	105	1,060	366	525
Non-carbonate	0	921	190	326
Specific conductance (μmhos at 25°C)	386	2,030	1,050	1,150
pH	7.8	7.5	7.6	7.7
Color	0	0	0	3
Percent sodium	41	16	---	---

Radiochemical constituents				
Alpha activity as uranium equivalent (μg/l)	6.1±3.7	98±83	27±14	52±23
Date	12-15-58	5-18-59	6-29-60	9-23-60
Beta activity, μμc/l	14	41±10	32±5	32±5
Date	12-12-58	4-29-59	6-21-60	9-22-60
Radium (μμc/l)	<0.1	2.4±0.5	5.1±1.0	1.2±0.5
Uranium (μg/l)	2.3±0.2	13±1.3	26±3	12±1
Extractable alpha (net) (μμc/l)	6.8±2.2	4.9±2.4	16±7	8.5±5.6
Strontium 90 (μμc/l)	±/<4	±/<5	±/<0.6	±/<0.6

The results of chemical and radiochemical analyses of water samples from Climax Stock. From Walker, 1962.



Location of water samples. Climax Stock. From Isherwood et al., 1982.

Table 3. Chemical analyses of Climax ground-water samples (concentrations in mg/L except as noted).

Parameter	CGW-1 (10)[a]	NH-01 (1)	UG-02 (3)	C-30 (2)	C-36 (2)
Na	250	229	214	72	56
Ca	283	240	114	161	126
K	3.4	3.8	4.7	6.5	4.8
Mg	0.9	4.8	1.5	118	63
Sr	5.6	7.9	4.2	0.8	1.8
Cs	0.002	ND[b]	ND	ND	ND
Al	0.03	0.05	0.02	<0.05	<0.05
SiO_2	15.8	22.5	23.9	29.3	33.8
U	1.8	18.5	<0.1	<0.1	<0.1
Fe	0.006	0.5[e]	0.8[d]	0.003	<0.004
Zn	0.005	0.03[e]	0.03[d]	0.008	0.004
Mn	0.05	0.008	0.05	0.002	0.03
Li	0.25	0.17	0.17	0.14	0.07
W	0.15	ND	ND	ND	ND
Mo	0.72	0.22	0.09	0.20	0.18
As	0.03	ND	ND	ND	ND
PO_4	<0.5	0.5	<0.3	1.9	1.2
Ti	0.004	0.02	<0.002	0.003	<0.001
Cl	77	160	70	77	52
SO_4	1060	850	480	750	325
S	<0.01	ND	3.0	ND	ND
HCO_3	163	65	165	167	316
NO_3	<0.02	ND	ND	ND	ND
F	0.9	ND	1.4	ND	ND
TDS[c]	1900	1770	1110	1910	1150
Conductivity (µS)	2160	2050	1340	1700	1200
Dissolved O_2 (mg/L)	<0.01	ND	<0.15	ND	ND

The results of chemical analyses of 5 water samples from Climax Stock. From Isherwood et al., 1982.

Parameter	CGW-1 (10)[a]	NH-01 (1)	UG-02 (3)	C-30 (2)	C-36 (2)
Eh (mV)	+410	ND	+86	ND	ND
pH	7.3	8.2	7.5	8.1	7.8
Sample depth (m)	420	420	565	64	73

[a] Nos. in parentheses are No. of samples analyzed.
[b] ND = Not determined.
[c] TDS = Total dissolved solids (mg/L).
[d] Sample contaminated with Fe and Zn from drill bit.
[e] Sample contaminated by wire mesh covering collection site.

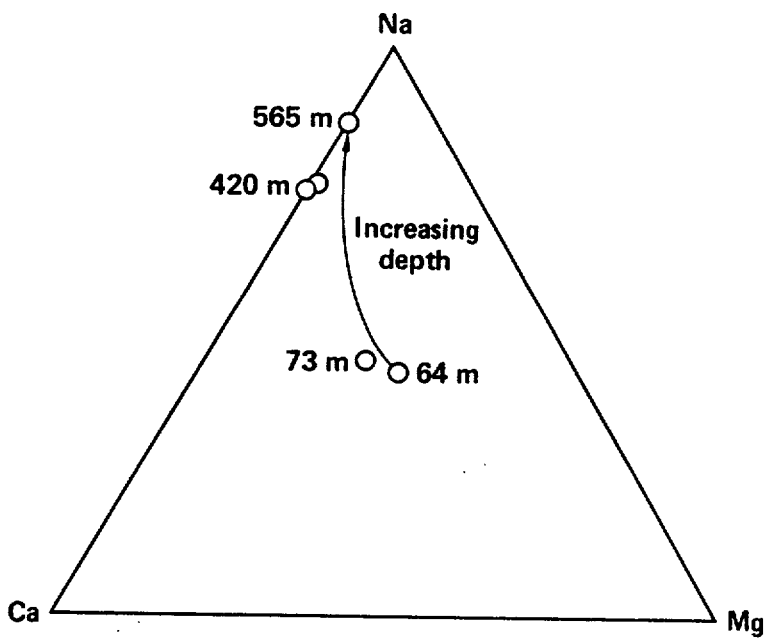


Diagram showing relative percentage of sodium, calcite, and magnesium (equivalents/L) for Climax ground-water samples.

The results of chemical analyses of 5 water samples from Climax Stock. From Isherwood et al., 1982.

Sample	$\delta^{13}C$	$\delta^{2}D$	$\delta^{18}O$	$\delta^{34}S$[b]
Water				
CGW-1a[c]	-4.57	-92	-12.62	+0.98
CGW-1b	-3.54	-94	-12.71	+3.58
UG-02	--	--	--	+6.02
Pyrite from fracture surface	--	--	--	+5.28

[a] Analyses by Global Geochemistry, Canoga Park, CA.

[b] $\delta^{34}S$ from sulfate precipitated from sample with $BaCl_2$.

[c] CGW-1a,b samples were collected from two fractures in the same general location. Their relative orientation suggests they are interconnected.

	CGW-1	NH-01[a]
^{238}U (ppm)	1.827 ± 0.029	18.5 ± 1
^{238}U (dpm/g)	1.363 ± 0.021	--
^{235}U (dpm/g)	0.06073 ± 0.00238	ND
^{234}U (dpm/g)	1.520 ± 0.023	--
$^{234}U/^{238}U$ (AR)	1.115 ± 0.012	1.05 ± 0.02
$^{235}U/^{238}U$ (AR)	0.04455 ± 0.00167	--

[a] Analysis done by M. Michel at Lawrence Berkeley Laboratory, Berkeley, CA.

The results of isotopic analyses of water samples from Climax Stock. From Isherwood et al., 1982.

Mineral	Log Q/K				
	C-30	C-36	NH-01	CGW-1	UG-02
Calcite	0.78	0.80	0.82	0.19	0.17
Dolomite	2.69	2.55	0.76	-0.86	-0.36
Quartz	0.67	0.74	0.55	0.42	0.63
K-feldspar	3.17	3.51	2.80	2.11	3.09
Kaolinite	4.02	5.14	3.92	5.00	5.52
Muscovite	6.80	8.10	6.57	7.23	8.92
Na-beidellite[b]	4.31	5.59	4.26	5.04	5.99
Sat. minerals[c]	58	60	55	38	49

[a] The saturation index was calculated using the EQ3 model.

[b] Na-beidellite is a form of montmorillonite with an average composition of $Na_{0.33}\ Al_{2.17}\ (Al_{3.17}\ Al_{0.83})\ O_{10}(OH)_2$. It is similar to the one used to construct Fig. 8.

[c] The total number of supersaturated minerals (i.e., log Q/K > 0) depends on the data base used in the EQ3 code.

Selected mineral saturation indexes for Climax perched waters. From Isherwood et al., 1982.

Well designation[b]	Collection date	δD (o/oo SMOW)[c]	$\delta^{18}O$ (o/oo SMOW)[c]	$\delta^{13}C$ (o/oo PDB)[d]	^{14}C (pmc)[e]	HTO[f] (TU)
UE-29a#1[g]	01/29/82	-92.0	-12.4	-12.6[h]	75.3	62.0
UE-29a#2[g,i]	01/08/82	-93.5	-13.0	-12.6[h]	62.3	11.0
UE-29a#2[g,i]	01/15/82	-93.0	-13.1	-13.1[h]	60.0	11.0
J-12[j]	03/26/71	-97.5	-12.8	-7.9	32.2	<68.0
J-13[j]	03/26/71	-97.5	-13.0	-7.3	29.2	<68.0
UE-25c#1	09/30/83	-102	-13.5	-7.1	15.0	<0.3
UE-25c#2	03/13/84	-100	-13.4	-7.0	16.6	<0.6
UE-25c#3	05/09/84	-103	-13.5	-7.5	15.7	0.6
USW H-6	10/16/82	-106	-13.8	-7.5	16.3	<3.0
USW H-6	06/20/84	-105	-14.0	-7.3	10.0	1.2
USW H-6	07/06/84	-107	-14.0	-7.1	12.4	0.3
USW VH1[j]	02/11/81	-108	-14.2	-8.5	12.2	6.0
AM-4	03/04/74	-103	-13.2	-7.1	19.3	--
AM-9	03/01/74	-102	-12.6	--[k]	28.4	--
AM-11	03/05/74	-101	-13.1	--	20.8	--
AM-13	03/05/74	-102	-13.0	--	19.3	--
AM-15	03/05/74	-104	-13.0	--	18.4	--
AM-18	03/06/74	-102	-13.0	--	27.8	--
AM-20[l]	03/06/74	-102	-12.4	--	13.8	--
AM-21	06/25/74	-99	-13.2	-8.4	27.4	--
AM-23	03/31/71	-103	-13.4	-7.1	17.1	--
AM-25	03/31/71	-102	-13.4	-5.6	15.6	--
NTS#8[m]	03/24/71	-104	-13.0	-12.1	25.4	--

[a]Sources: Data from Benson and McKinley (1985) and as noted in footnotes. AM-samples from Claassen (1985).

[b]Well locations for UE-, J- and USW-holes are shown in Figure 3-22. Well locations for AM (Amargosa) wells are shown in Figure 3-16.

[c]δ deuterium and δ oxygen-18 are reported in parts per thousand relative to the standard mean ocean water (SMOW) standard.

[d]δ carbon-13 is reported in parts per thousand relative to the Peedee belemnite (PDB) carbonate standard.

[e]Carbon-14 activity is reported as a percent of the modern carbon (pmc) standard.
[f]HTO = tritium; reported in tritium units (TU).
[g]Waddell (1985).
[h]Value reported as positive in reference.
[i]Also reported by Benson and McKinley (1985).
[j]Also reported by Claassen (1985).
[k]-- indicates no data.
[l]Completion in tuffaceous material unsure.
[m]Claassen (1985).

Environmental isotope data for groundwater samples from the tuff and tuffaceous valley fill aquifers in the region near Yucca Mountain. From DOE, 1988.

Well or spring designation	Collection date	δD o/oo SMOW[b]	$\delta^{18}O$ o/oo SMOW[b]	$\delta^{13}C$ o/oo PDB[c]	^{14}C (pmc)[d]	HTO (TU)[e]
			CARBONATE AQUIFER			
UE-25p#1[f,g]	02/09/83	-106	-13.5	-4.2	3.5	<3.1
UE-25p#1[f,h]	05/12/86	-106	-13.8	-2.3	2.3	3.1
16S/51E-23[i]	--[j]	--	-13.6	-4.6	1.8	--
Fairbanks Spring NE[k]	12/13/74	--	--	-5.2	2.2 ± 0.3	0.1 ± 0.2
Fairbanks Spring SW[k]	--	-103	-13.6	-4.9	1.8 ± 0.2	0.0 ± 0.4
Rogers Spring[k]	--	-102	--	-4.6	1.5 ± 0.3	0.0 ± 0.2
Longstreet Spring[k]	--	-103	--	-4.8	2.7 ± 0.4	0.0 ± 0.2
Scruggs Spring[k]	03/10/75[l]	-103	--	-4.7	1.1 ± 0.3	0.2 ± 0.2
Crystal Pool[k,m]	--	-102	-13.7	-5.0	11.6 ± 0.7	0.6 ± 0.4
Devils Hole[k]	--	--	-13.6	-5.0	2.8 ± 0.4	0.3 ± 0.2
King Spring[k,m]	--	-104	--	-4.7	1.7 ± 0.4	0.4 ± 0.2
Big Spring[k,m]	03/09/75	-102	--	-4.6	2.9 ± 0.4	0.3 ± 0.1
			MIXED SYSTEMS			
AM-3[n]	10/20/72	-102	-12.8	--	15.6	--
AM-5[n]	11/17/72	-99.5	-13.2	-6.8	12.4	--
AM-8[n]	03/01/74	-103	-13.4	-7.3	21.9	--
AM-10[n]	06/26/79	-97.5	-13.2	-5.2	24.8	--
AM-16[n]	03/01/74	-104	-12.7	--	10.0	--
AM-17[n]	03/01/74	-105	-12.8	--	18.9	--
AM-19[n]	03/06/74	--	--	--	40.3	--
AM-27[o]	08/18/62	-105	-13.8	-3.6	7.0	--
AM-29[p]	03/31/71	-105	-13.8	-3.4	--	--
AM-30[o]	06/24/79	-104	-13.7	-4.4	10.3	--
AM-47[o]	03/31/71	-102	-13.1	-6.2	31.4	--
AM-50[o]	06/25/79	-104	-13.6	-5.7	--	--
AM-60[p]	12/16/68	--	--	-5.9	28.8	--

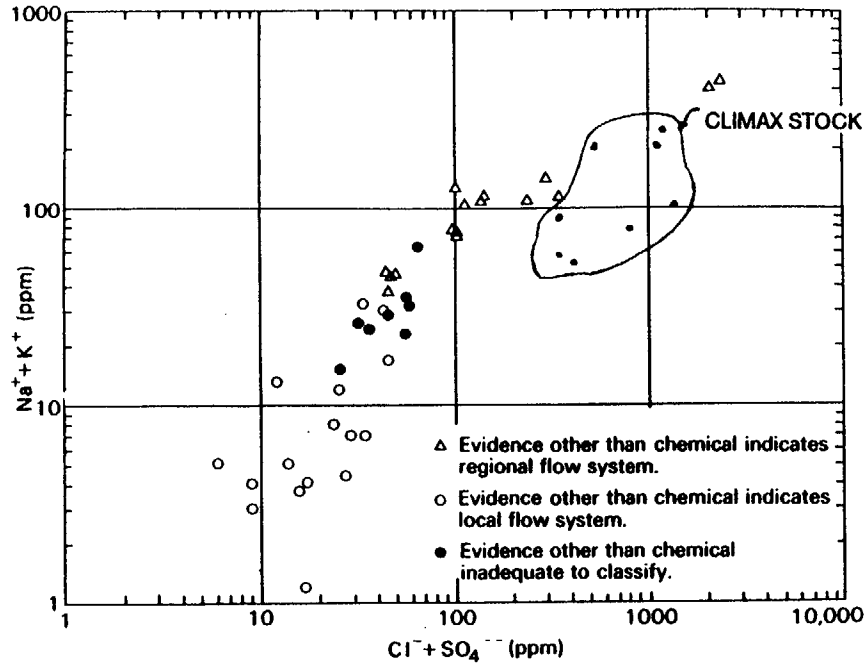
[a]Data from Claassen (1985) unless otherwise indicated.

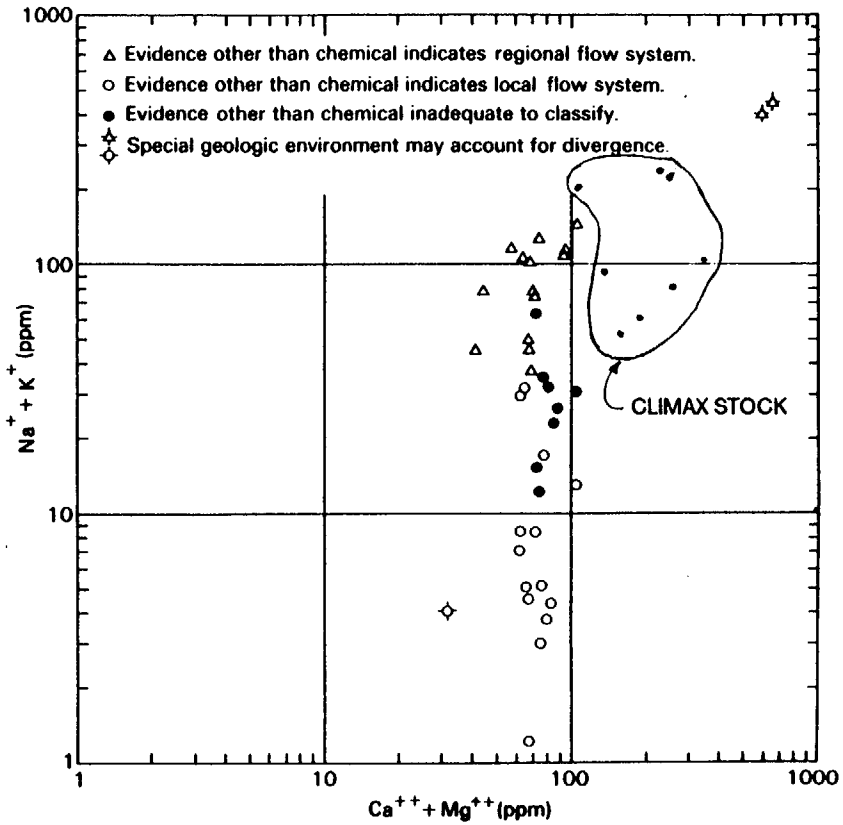
[b]δD and δ oxygen-18 ($\delta^{18}O$) are reported in parts per thousand relative to Standard Mean Ocean Water (SMOW) standard.

[c]Carbon-13 ($\delta^{13}C$) is reported in parts per thousand relative to the Peedee belemnite (PDB) carbonate standard.

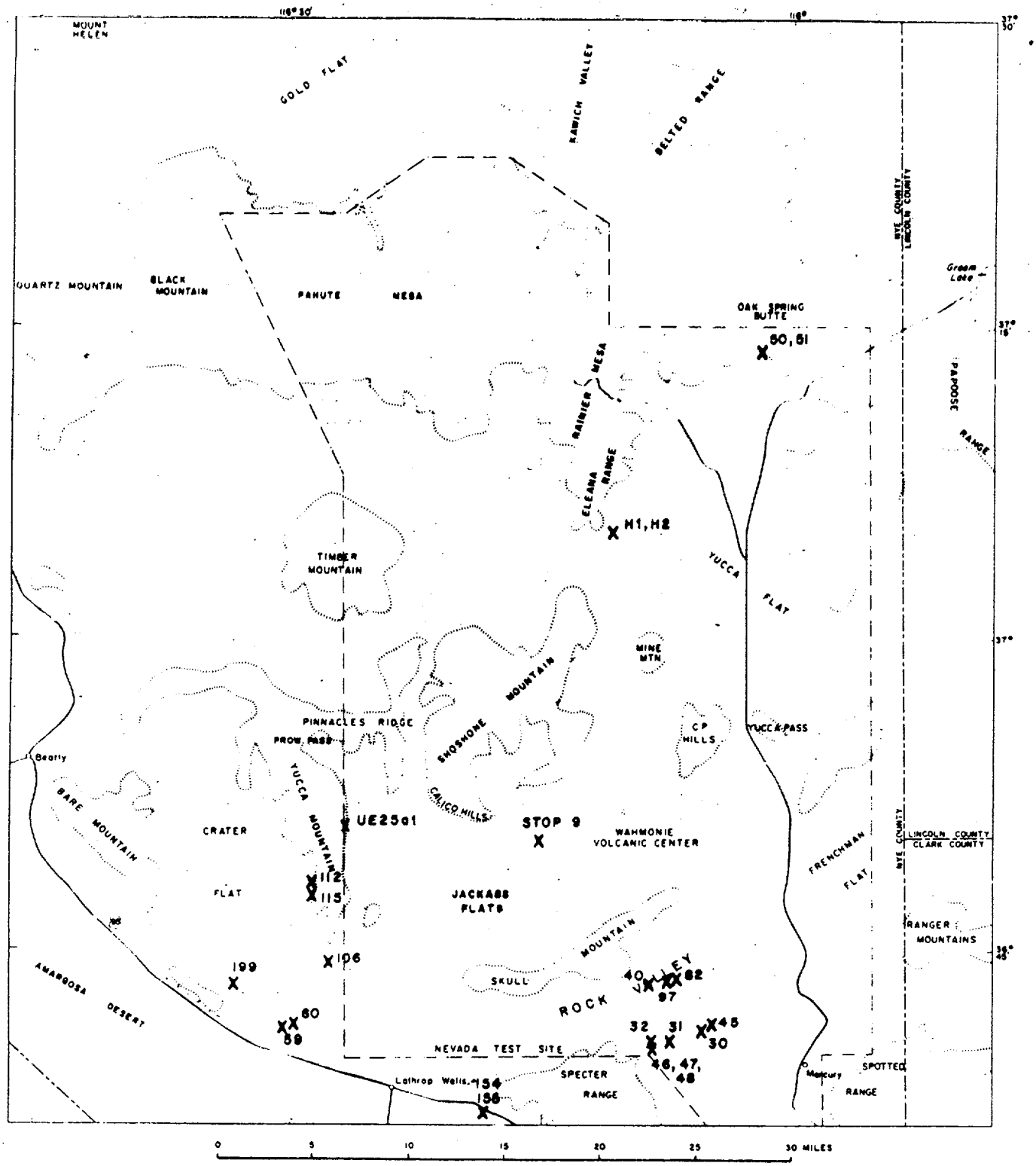
[d]Carbon-14 (^{14}C) activity is reported as a percent of the modern carbon standard (pmc).
[e]HTO = tritium; T is reported in tritium units (TU).
[f]Benson and McKinley (1985).
[g]Sampled from the 381 to 1,197 m interval.
[h]Sampled from 1,297 to 1,805 m interval.
[i]Claassen (1985) reports this well as "Amargosa Tracer Well #2."
[j]Data from multiple collection dates.
[k]Winograd and Pearson (1976).
[l]Representative of multiple samplings.
[m]Similar values reported by Riggs (1984).
[n]Tuffaceous lithology, possible carbonate influence.
[o]Carbonate lithology, possible tuff influence.
[p]In both tuff and carbonate formations.

Environmental isotope data for groundwater samples from the carbonate aquifer and from mixed carbonate - tuff sources. From DOE, 1988.

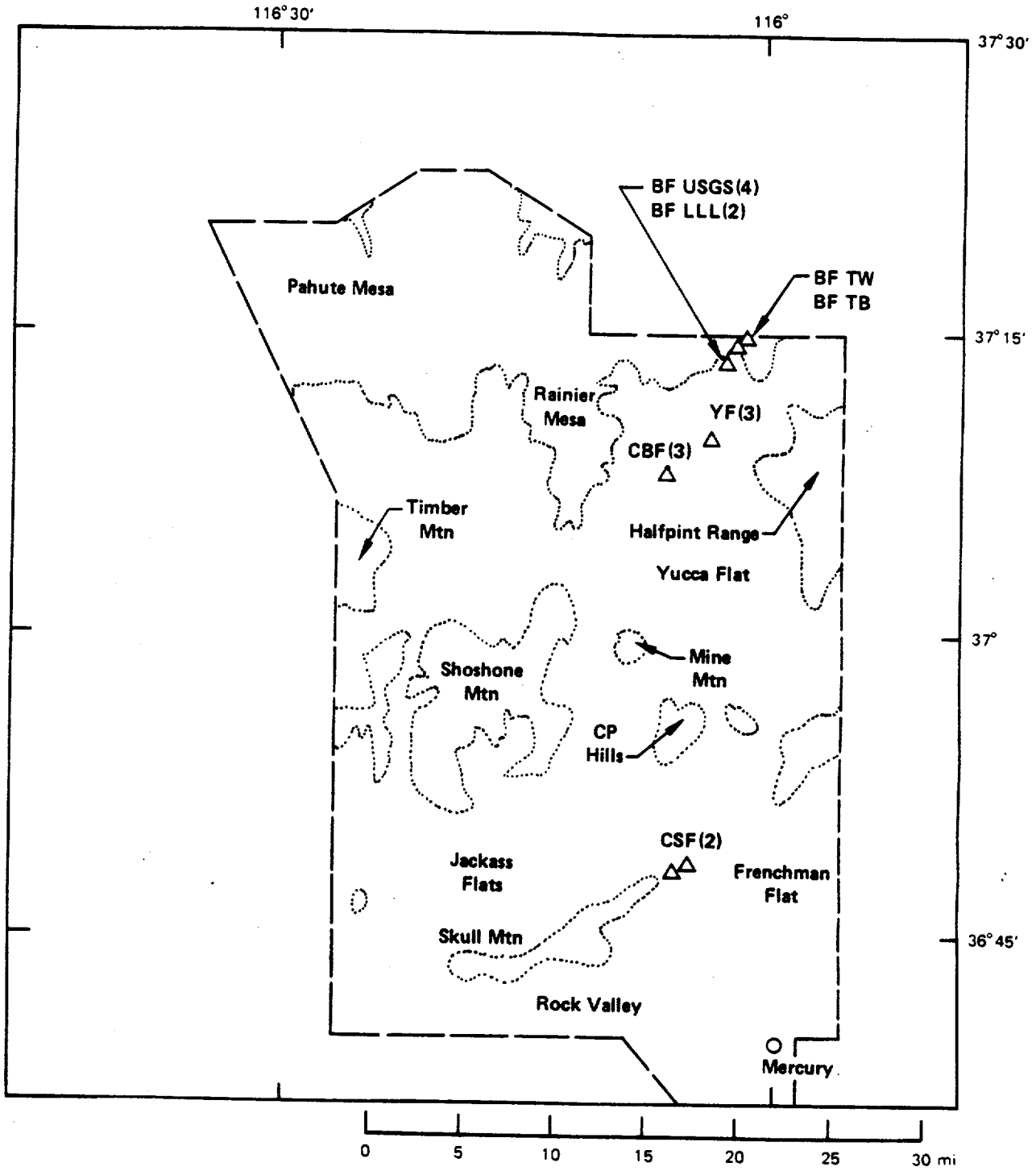




Comparison of chemical composition of Climax Stock perched waters with spring waters discharging from the Paleozoic carbonates. Modified from Domenico, 1972.



Location of samples analyzed and dated by Szabo et al., 1981. From Szabo et al., 1981.



Location map of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

Sample No.	Material description and locality	Interpretation	Age, years
31	Massive calcrete, overlapping fault scarp, head of Mercury Valley.	Fault has not moved after about 100,000 years ago. Agrees well in age with similar sample 48.	[1]99,000 ± 8,000
48	Massive calcrete, head of Mercury Valley. Is cut by adjacent faults containing dated travertine samples 46 and 47.	Agrees with field relations; that is, gives age slightly older than material in faults that displace it. Minimum age for old alluviam (QTa).	100,000 - 150,000
51	Laminar caliche, similar to samples 82 and 97. In trench on Boundary fault that displaces samples material.	Fault may have moved a little as recently as 8,000 years ago, but calcrete in fault (sample 50) gives age of ≥24,000 years.	>8,000
59	Caliche from base of loess overlying basalt cinder cone near Highway 95 northwest of Lathrop Wells.	Caliche is derived from leaching of loess layer. Age represents minimum for loess and cinder cone. Gives same as as caliche of sample Stop 9, which it may correlate (unit Q2).	25,000 ± 10,000
60	Stalactitic laminated calcrete in cavities between boulders, immediately beneath basalt flow.	Agrees nicely with age of 290,000 years obtained by K-Ar dating on overlying basalt lava.	[2]345,000
82	Laminar caliche, base of soil zone in older alluvium (QTa) trench No. 2 across Rock Valley fault (fig. 9).	Zone of dated caliche is offset several inches to possibly as much as a foot by Rock Valley fault. Age does not agree with obviously mature age of fault scarp, nor with apparent ages of associated soil. See fig. 9.	>5,000
97	Same material as 82, but from trench No. 1.	See remarks for sample 82.	>5,000

Description of samples analyzed and dated by Szabo et al., 1981. From Szabo et al., 1981.

Sample No	Material description and locality	Interpretation	Age, years
106	Seep-deposited tufa or calcrete intercalated in Q2 alluvium. Shows some evidence of spring-water deposition.	Gives approximate minimum age of Q2 alluvium.	78,000 ± 5,000
199	Nodular tufa spring deposit, south end of Crater Flat.	Suggested spring activity was at altitude of about 838 m as late as 30,000 yrs ago. Present water table is about 120 m lower (Winograd and Thordarson, 1975, pl. 1)	~30,000
H-1	Caliche possibly deposited by seepage. East flank Eleana Range.	Age predates adjacent valley; minimum age of alluvium (Qta).	128,000 ± 20,000
H-2	Laminar caliche formed by redeposition at top of zone represented by H-1 sample.	Age postdates adjacent valley	>5,000
Stop 9	Soil caliche in trench, northeast Jackass Flats, Unit #2.	Age is in general agreement with estimated soil age; represents probably a minimum age.	~24,000

[1] Average of two sample splits.

[2] Samples of inner and outer parts of caliche "stalactite" gave the same age (table 1).

Description of samples dated and analyzed by Szabo et al., 1981. From Szabo et al., 1981.

Sample No.	Material description and locality	Interpretation	Age, years
30	Calcite vein, head of Mercury Valley, in limestone bedrock.	Little or no movement has occurred on fault within last 700,000 years.	>700,000
32	Unbroken calcite crystal filling in fault between alluvium and limestone bedrock; ridge between Mercury and Rock Valleys.	No movement has occurred within last 700,000 years.	>700,000
40	Calcrete in fracture in tuff breccia, Rock Valley. Fills fracture adjacent to Rock Valley fault.	Age suggests minor fault movement and reopening of fracture no later than about 20,000 years ago.	<20,000
45	Undisturbed travertine vein in limestone ridge between Mercury Valley and Rock Valley.	Essentially unfractured fault filling indicates no significant movement post-700,000 years.	>700,000
46	Undisturbed travertine vein in alluvium, head of Mercury Valley.	Sample is unfractured filling in fault near, and parallel to, fault sampled by No. 47. Ages of 46 and 47 are in general agreement and indicate no opening of fault after about 70,000 years ago.	<70,000
47A	Undisturbed travertine; represents one-third of total vein width.	Sample is unfractured filling in fault near and parallel to fault sampled by No. 46. Ages agree with sampling; that is, two-thirds vein width is slightly younger.	104,000 ± 8,000
47B	Same, but represents two-thirds of total vein width.		97,000 ± 8,000
50	Calcrete in Boundary fault, northwest edge Yucca Flat.	Sample fills opening in fault; slightly crushed and some slippage evident. Gives an older age than caliche (sample 51) offset by fault.	<24,000
113	Calcrete in fault between welded tuff and alluvium, west side of Yucca Mountain.	Sample was unfractured by fault, so last movement is greater than about 5,000 years ago.	>5,000

Description of samples analyzed and dated by Szabo et al., 1981. From Szabo et al., 1981.

Sample No.	Material description and locality	Interpretation	Age, years
115	Same as 113.	Sample was unfractured by fault; last movement on fault is greater than about 20,000 years ago.	>20,000
154	Nodular calcrete in fault where Rock Valley Wash crosses U.S. 95.		Did not yield an age.
155	Same locality as 154, but from a parallel branch of the fault. Slip surfaces are present within dated calcrete.	Fault has moved a little after about 100,000 years.	70,000 - 110,000
UE25a-1, -34, -283, and -611 meter depths.	Drill hole at Yucca Mountain; calcite in filled fractures in core.	Fractures have probably not been reopened in last 400,000 years.	[1] >400,000

[1]All three sample exceeded the age of resolution of the method.

Description of samples dated and analyzed by Szabo et al., 1981. From Szabo et al., 1981.

CARPETBAG FAULT

CBF 1: The sample point is located on the Carpetbag Fault approximately 465 ft south of Road 2-04. At this point, the fault strikes due north and dips 80°W, although the dip locally is quite variable and may be considered essentially vertical. The east side is down approximately 3 ft relative to the west. Calcrete occurs as a massive carbonate, cementing pebbles in a sandy matrix exposed on the west block. The calcrete appears to be a relatively mature Stage IV K horizon. In later stages of K horizon development, carbonate deposition on solids eventually plugs all voids, and water percolation down through the horizon is greatly restricted. Subsequently, water tends to collect periodically over the plugged horizon. The resulting solution and re-precipitation produces laminations in the upper part of mature K horizons. These laminations are present on top of the calcrete horizon at this location. The calcrete is subparallel to the present surface, is about 1 ft thick, and occurs beneath 1.5 ft of light brown, uncemented, younger alluvium. The present surface on both blocks consists of partially varnished Quaternary alluvium. Sample CBF 1 was taken from the upper 2 in. of the calcrete but excluded the uppermost, laminated surface. This sample should provide a maximum age for the last natural movement.

CBF 1T: The sample point is identical to CBF 1. Sample CBF 1T consisted of the uppermost, laminated surface from this calcrete. This sample should also predate last natural movement but should be younger than sample CBF 1.

CBF 3: The sample point is located approximately 35 ft south of Road 2-04 on the Carpetbag Fault. Locally the fault strikes N07°E and dips 80°W. The east side is down approximately 4 ft relative to the west. Case hardening of the fault has produced a carbonate cement oriented vertically and that coats the fault plane on the exposed (west) block. The carbonate does not extend to the surface. The top is about 3 ft below present surface. It is overlain by a 1-ft-thick water-deposited (layered) pebble horizon which is, in turn,

Description of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

overlain by 2 ft of unconsolidated sand/gravel alluvium. The carbonate coats the lower 1 ft of the exposed face of the west block. At this point the face consists of a sandy matrix containing cobble sized clasts which are cemented to form a layer of calcrete similar in appearance to sample CBF 1. The case hardened material consists of calcium carbonate cementing a sandy silt matrix. The carbonate displays no evidence of faulting (slickensides) and probably postdates the last natural movement. This last episode of faulting breeched the well indurated K horizon. This allowed silt, clay, and carbonate-bearing waters to percolate downward along the fault plane.

CANE SPRING FAULT

CSF 1: The sample point is located approximately 0.5 mi southwest of Cane Spring on a normal fault within the Tertiary volcanics. At this point, the normal fault is subparallel to the Cane Spring Fault and strikes N50°E and dips 83° to the northwest. The faulting has produced a small outcrop of a grey-white pumice agglomerate (Twtb) which underlies a reddish-brown rhyodacite flow (Twf). Both of these volcanic units are part of the Tertiary Wahmonie Formation. The laminar tuffaceous travertine occurs as thick, flow-like layers of very white carbonate, coating the exposed face (fault scarp) of the pumice agglomerate outcrop. The travertine is hard and relatively brittle on the outer surface, appearing similar to solution/precipitation lamination, but is very powdery underneath. There appears to be a rind of altered material between this caliche and the underlying pumice. The travertine is definitely related to the fault producing this scarp, but the relationship between the age of this carbonate and the last movement on the normal fault is unclear. No slickensides are present on the travertine, which suggests that it postdates the last movement. The fault is terminated in the southwest by overlying (unfaulted) Tertiary alluvium and colluvium (Tac) and in the northeast by the Cane Spring Fault. Allowing for the possibility of minor movement along this small fault block in response to left-lateral motion on the Cane Spring Fault, the travertine could be as young as Quaternary in age, although the bulk of the normal faulting in this area undoubtedly occurred in late Tertiary times.

Description of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

CSF 2: The sample point is located on the Cane Spring Fault approximately 0.5 mi southwest of Cane Spring. The fault strikes N60°E and locally dips 80° to the northwest. It separates Quaternary alluvium and colluvium (Qac) on the downthrown (NW) block from Tertiary alluvium and colluvium (Tac). The Qac consists of loose, partly caliche-cemented sand and gravel, whereas the Tac is a well indurated sandy gravel consisting of rhyodacite, dacite, and rhyolitic tuff clasts, some up to 2 ft in diameter cemented in place. Near the base of the scarp, which is well exposed in an arroyo, platy tuffaceous travertine is present only within 0.5 ft of the fault filling fractures between blocks of Tac parallel to the scarp face. The travertine is white and relatively hard although somewhat thin (<1/8 in.). There are no slickensides present, indicating formation certainly postdates the last movement on the Cane Spring Fault, although the exact relationship remains unclear.

YUCCA FAULT

YF SL 1: The sample point is located on the Yucca Fault approximately 400 ft south of the sanitary landfill turnoff on the Mercury Highway. Here a trench has been dug across the Yucca Fault immediately to the south of a skid trail that approaches hole U10c that borders to the east. Locally, the fault strikes N10°E and dips 71° to the east. The fault inclination was estimated from a vertical zone of soil caliche within the trench and is approximate only. The east block has been dropped approximately 5 ft relative to the west, inferred from the offset in a pebble horizon visible about 2 ft below present surface on both blocks. The carbonate occurs in a dirty, sandy gravel cemented into a relatively porous, friable soil caliche. The caliche is located in a zone 1 ft thick at the base of the upthrown block, about 4 ft below present surface. It is now exposed by the fault; hence, the caliche predates the last movement. However, it is unclear whether it occurs only in the fault zone. It cannot be clearly traced away from the fault in the wall of the trench on the west (upthrown) block.

YF SL 2: The sample location is identical to YF SL 1 above. Here, the pebbles in the pebble horizon mentioned above were coated with caliche on the

Description of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

bottom. Several pebbles were collected from a point on the west block about 3 ft west of the fault. The caliche coatings were about 1 mm thick and very hard. Since the pebble horizon is offset by the fault, the caliche definitely predates faulting.

YF SL 3: The sample location is identical to YF SL 1. On the south wall of the trench, the upthrown (west) block contains a nearly vertical case hardened layer where well indurated carbonate is cementing a sandy gravel. The carbonate completely fills a fracture about 2 in. wide that parallels the scarp face 1 ft to the west on the upthrown block. The carbonate cross cuts all sub-horizontal soil caliches exposed in the trench and extends from the bottom to within almost 6 in. of the surface. Here it thins greatly and degrades to thin filaments of carbonate that approach the surface at a very shallow angle.

BOUNDARY FAULT

USGS Trench 5: Four samples were taken from this trench across the Boundary Fault. The trench is located about 1 mi north of the intersection of the road to the Climax Stock and the Boundary Fault. It was placed at the extreme northeast edge of the Climax Stock quartz monzonite. The trench is about 260 ft long overall and strikes N24°W. Starting at the top (NW) of the trench, there is progression from a yellow-brown weathered but competent quartz monzonite (Kq - Climax Stock) into a soft, highly altered, weathered granite (Unit 1) containing a large amount of carbonate and clay. The granite has a red and white mottled appearance and is highly brecciated. It contains slickensides throughout its entire length. Abundant laminar caliche and clay veins run in many orientations throughout Unit 1. The contact between the quartz monzonite and Unit 1 is gradational, but it occurs within a few feet. It does not appear to be a fault contact. Unit 1, however, is in fault contact with Unit 2. The fault strikes N47°E and dips 45° to the southeast. At the Unit 1-Unit 2 contact there are slickensides evident on the granite face and in the caliche present on the contact, which indicates some movement. Unit 2 consists of a badly weathered, highly brecciated white bedded tuff (Tabl). The tuff contains slickensides subparallel to both the

Description of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

Unit 1-Unit 2 contact and Unit 2-Unit 3 contact. Unit 2 is in fault contact with Unit 3. The fault strikes N42°E and dips 70° to the southeast. The Unit 2-Unit 3 contact is well cemented by a powdery white caliche, and no slickensides are apparent on the face of either unit. Unit 3 resembles a pull apart feature that has filled chaotically with large cobble-boulder debris. This debris contains granite and quartzite derived from both the Wood Canyon Formation and the Stirling Quartzite (EpEw) which crops out a short distance up-slope. Unit 3 also contains what appears to be spring-deposited travertine at the top of the trench, right at the Unit 2-Unit 3 contact. The Unit 3-Unit 4 contact is well defined for the bottom 6 ft, but it is indistinct above this point. The dip of the contact is about 75° to the southeast, but the strike may not be stated because the contact is not exposed in the opposing trench wall which is only a few feet high at this point. There are no slickensides present either in Unit 3 or Unit 4 nor along the sharp contact. Pebbles and cobbles are aligned and display drag in the pull apart feature (Unit 3) at the Unit 3-Unit 4 fault, suggesting that it is a normal fault. Unit 4 consists of Quaternary alluvium and colluvium (Qac) cemented with abundant disseminated caliche. There are several pebble horizons that are densely cemented into a calcrete. One such horizon is present about 5 ft above the trench bottom and ends abruptly at the more distinct (lower) Unit 3-Unit 4 contact. The horizon is subparallel to present surface. The four samples listed below were taken from the upper 100 ft of the trench just described; therefore, the remainder of the trench will not be described here.

BF USGS5 1: The sample consists of soft, powdery carbonate on the surface of the tuff face at the Unit 1-Unit 2 fault. The tuff itself is badly fractured and contains abundant disseminated caliche. The faulting apparently brecciated the tuff, which then weathered in place with carbonate precipitated in voids created by both fracturing and weathering. Slickensides are evident. Caliche probably predates the last motion.

BF USGS5 2: The sample consists of caliche cementing a sandy gravel. Adjacent to one large (6 in.) cobble, relatively clean caliche was cementing the cobble to a gravelly matrix, and this was sampled. The sample was essentially on the Unit 2-Unit 3 fault but from within Unit 3. The age

Description of samples analyzed and dated by Knauss, 1981. From Knauss, 1981.

relationship with last fault movement is unclear, but the caliche probably predates the last motion.

BF USGS5 3: The sample consists of a massive calcrete, cementing pebbles of tuff, Paleozoic shale, and quartzite. There are no slickensides present, but the caliche definitely predates the last motion because the pebble horizon is terminated by the sharp lower Unit 3-Unit 4 contact (fault).

BF USGS5 5a: A sample was taken near the top of the trench just below (SE) the Unit 2-Unit 3 fault. A large mass of dense, hard carbonate has cemented tuffaceous gravel/sand containing large clasts of volcanics and Paleozoic noncarbonates. The entire mass was white in color. The outer-most layer was grey-brown and possessed an oolitic texture. There were stringers of soft, white more pure carbonate within the cemented mass. These were also present immediately below the outermost 2-mm-thick oolitic travertine layer. The age relationship with time of the last motion on the Unit 2-Unit 3 fault is unknown.

LLL Trench 1: Two samples were taken from this trench across the Boundary Fault. This trench is located just north of the intersection of the road to the Climax Stock and the Boundary Fault. It is the second trench encountered when going north on the jeep trail which parallels the Boundary Fault. The trench is approximately 190 ft long and strikes N26°W. Starting at the top (NW) of the trench there is progression from weathered but competent granite (Unit 1) that is red in color below and yellow-brown above to a softer, highly altered, brecciated, weathered granite (Unit 2) that is a mottled purple-white color because of abundant clay and carbonate. The Unit 1-Unit 2 contact is a fault displaying obvious slickensides indicating motion. The fault strikes N62°E and dips 53° to the southeast. Unit 2 goes from being brittle and brecciated at the Unit 1-Unit 2 contact to being more clayey, with powdery (more caliche) grus-like material at the Unit 2-Unit 3 contact. This contact is also a fault with laminar caliche present which has become hardened and brittle, displaying slickensides which indicate motion. The fault strikes N65°E and dips 56° to the southeast. The intense brecciation of Unit 2 is undoubtedly a result of differential motion on the two bordering faults.

Description of samples dated and analyzed by Knauss, 1981. From Knauss, 1981.

Unit 3 consists of Quaternary alluvium and colluvium (Qac) which appears relatively uniform throughout the remainder of the trench.

BF LLL1 1: A sample was taken on the Unit 1-Unit 2 contact about 4 ft off the bottom. It consists of brittle laminar caliche displaying slickensides that coat the highly brecciated purple granite (Unit 2). The entire granite is mottled in color because of complete brecciation. Each surface is coated with caliche. This caliche has become hard and brittle and itself displays slickensides; hence, the caliche predates latest faulting.

BF LLL1 2: A sample was taken on the Unit 2-Unit 3 contact approximately 2 ft off the trench bottom. It consists of dry, more friable caliche cementing a sandy gravel matrix (Unit 2). Where this material has been faulted (i.e., as the Unit 2-Unit 3 contact is approached), it becomes laminar, harder, and more clayey and the slickensides are plainly visible. It suggests that this caliche also predates the last movement.

BUTTE FAULT

BF-TW: The sample point is located on the Butte Fault immediately east of Tub Spring. The fault strikes N26°E and is vertical. It juxtaposes the Tertiary Tuff of White Rock Spring (Tw) on the west (upthrown) block and Tertiary Bedded Tuff (Tabl). The Tw consists of brown to orange-brown devitrified partially to densely welded quartz-latite ash-flow tuff. The fault scarp exposed in a drainage displays vertical slickensides. Coating the scarp and within fractures near the scarp, abundant opal and quartz have precipitated. A sample of this material was taken for analysis. The opal is present, coating slickensides on Tw. This indicates that the opal postdates the last movement on the Butte Fault.

BF TB: The sample point is located 0.3 mi NNE of the previous site. At this location, an east-dipping normal fault subparallel to the Butte Fault (and possibly offset by it) crosses a stream channel at right angles. Within the fault zone, a wedge of fault breccia remains as an erosional high. It is considerably harder than either of the Tertiary bedded tuffs (Tba, Tabl)

Description of samples dated and analyzed by Knauss, 1981. From Knauss, 1981.

juxtaposed by the fault. The brecciated material is dark in color and contains euhedral quartz. No slickensides were evident. In several locations, opal was deposited on fracture (fault) surfaces near the outer edge of the breccia. A sample of this material was taken for analysis. The opal is very thick (up to 0.5 in.) and has an oolitic texture. Unlike the BF TW opal, no euhedral quartz was present on the surface of this opal.

Description of samples dated and analyzed by Knauss, 1981. From Knauss, 1981.

Sample No.	Material	Percent residue	Fraction	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	Uranium-series age (years)
				MERCURY VALLEY AREA				
30-A[1]	Trav	0	S	0.038 ± 0.001	1.00 ±0.02	43. ±10.	0.844 ±0.042	>700,000
30-B[2]	Trav	0	S	0.066 ± 0.001	0.987 ±0.030	77. ±15.	0.992 ±0.040	>700,000
32	Trav	0	S	0.016 ± 0.002	1.00 ±0.05	4.05 ± 0.41	1.12 ±0.11	>700,000
45-A[3]	Trav	0	S	0.495 ± 0.007	0.981 ±0.015	6.92 ± 0.21	1.00 ±0.03	>700,000
45-C[4]	Trav	5	S	1.10 ± 0.17	0.999 ±0.015	10.2 ± 0.3	1.06 ±0.03	>700,000
			R	0.52 ± 0.05	0.95 ±0.09	5.5 ± 0.6	1.21 ±0.18	
47-A[5]	Trav	20	S	4.71 ± 0.07	1.12 ±0.02	5.08 ± 0.15	0.846 ±0.025	104,000 ± 8,000
			R	2.84 ± 0.09	0.980 ±0.015	2.20 ± 0.07	1.58 ±0.05	
47-B[6]	Trav	22	S	3.16 ± 0.05	1.17 ±0.02	5.37 ± 0.16	0.957 ±0.029	97,000 ± 8,000
			R	2.51 ± 0.05	1.00 ±0.05	3.42 ± 0.10	1.42 ±0.07	
48	Calcr	18	S	3.17 ± 0.05	1.06 ±0.02	7.65 ± 0.23	0.730 ±0.022	100,000 - 150,000
			R	21.1 ± 0.3	1.01 ±0.02	16.7 ± 0.5	1.08 ±0.03	
46	TTrav	23	S	5.19 ± 0.08	1.04 ±0.02	38.2 ± 1.5	0.999 ±0.030	>70,000
			R	10.6 ± 0.9	1.05 ±0.02	34.0 ± 1.4	1.15 ±0.12	
31-A[7]	Calcr	70	S	19.7 ± 0.03	1.45 ±0.02	13.1 ± 0.4	0.750 ±0.030	102,000 ± 8,000
			R	5.61 ± 0.08	1.37 ±0.02	4.38 ± 0.13	1.16 ±0.05	

Analytical data and uranium series ages of carbonates at the Nevada Test Site [Trave, travertine; TTrav, tuffaceous travertine; Calcr, calcrete; SC, soil caliche; S, acid soluble solution; R, acid insoluble residue]. From Szabo et al., 1981.

Sample No.	Material	Percent Residue	Fraction	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	Uranium-series age (years)
31-B[7]	Calcr	75	S	2.21 ± 0.03	1.10 ±0.02	4.66 ±0.14	0.751 ±0.030	96,000 ± 8,000
			R	1.86 ± 0.03	1.07 ±0.02	1.45 ±0.04	1.79 ±0.07	
ROCK VALLEY FAULT AREA								
154	TTrav	55	S	2.23 ± 0.03	1.17 ±0.02	5.03 ±0.13	1.72 ±0.09	([8])
			R	0.630 ± 0.010	1.03 ±0.02	2.48 ±0.07	1.98 ±0.10	
155	TTrav	80	S	4.96 ± 0.07	1.27 ±0.02	9.73 ±0.29	0.650 ±0.033	70,000 - 110,000
			R	18.8 ± 0.3	1.31 ±0.02	23.4 ±0.7	0.790 ±0.040	
40	Calcr	45	S	6.90 ± 0.10	1.13 ±0.02	16.4 ±0.7	0.435 ±0.013	≥20,000
			R	12.3 ± 0.2	1.13 ±0.02	11.8 ±0.4	0.824 ±0.025	
82	SC	62	S	3.79 ± 0.06	1.41 ±0.02	1.81 ±0.07	0.0747 ±0.0022	>5,000
			R	3.02 ± 0.05	1.24 ±0.02	1.10 ±0.04	1.06 ±0.04	
97	SC	48	S	1.19 ± 0.02	1.35 ±0.02	1.33 ±0.05	0.119 ±0.004	>5,000
			R	2.91 ± 0.04	1.20 ±0.02	1.22 ±0.05	1.44 ±0.06	
JACKASS FLATS								
Stop-9	SC	90	S	4.75 ± 0.06	1.34 ±0.02	3.28 ±0.10	0.240 ±0.010	~24,000
			R	2.79 ± 0.04	1.17 ±0.02	0.961 ±0.029	1.14 ±0.05	

Analytical data and uranium series ages of carbonates at the Nevada Test Site [Trave, travertine; TTrav, tuffaceous travertine; Calcr, calcrete; SC, soil caliche; S, acid soluble solution; R, acid insoluble residue]. From Szabo et al., 1981.

Sample No.	Material	Percent Residue	Fraction	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	Uranium-series age (years)
				LATHROP WELLS AREA				
60-A	Calcr	35	S	5.32 ± 0.08	1.23 ±0.21	6.98 ±0.21	1.05 ±0.03	345,000 + 180,000 - 71,000
			R	3.73 ± 0.06	1.06 ±0.02	1.46 ±0.04	1.14 ±0.03	
60-B	Calcr	46	S	5.37 ± 0.08	1.20 ±0.02	5.62 ±0.17	1.09 ±0.03	345,000 + 180,000 - 70,000
			S	5.03 ± 0.10	1.20 ±0.02	5.53 ±0.17	1.03 ±0.05	
			R	6.11 ± 0.09	1.10 ±0.02	1.62 ±0.05	1.04 ±0.03	
59	SC	47	S	2.14 ± 0.03	1.53 ±0.02	1.99 ±0.06	0.425 ±0.013	25,000 ± 10,000
			R	1.94 ± 0.03	1.21 ±0.02	1.13 ±0.03	1.72 ±0.05	
				YUCCA MOUNTAIN AREA				
113	Calcr	75	S	2.78 ± 0.04	1.03 ±0.02	0.687 ±0.027	0.146 ±0.006	>5,000
			R	4.17 ± 0.06	0.986 ±0.015	0.620 ±0.002	0.837 ±0.025	
115	Calcr	80	S	10.6 ± 0.2	1.46 ±0.03	16.7 ±1.7	0.422 ±0.017	>20,000
			R	9.44 ± 0.14	1.51 ±0.02	22.4 ±0.9	1.19 ±0.04	
106	Ttrav	70	S	9.53 ± 0.14	1.26 ±0.19	4.53 ±0.14	0.660 ±0.026	78,000 ± 5,000
			R	3.66 ± 0.05	1.33 ±0.02	2.43 ±0.07	0.860 ±0.034	
				CRATER FLAT				
199	TTrav	30	S	1.81 ± 0.03	2.16 ±0.03	2.57 ±0.08	0.290 ±0.012	~30,000
			R	1.58 ± 0.02	1.17 ±0.02	2.81 ±0.08	1.47 ±0.06	

Analytical data and uranium series ages of carbonates at the Nevada Test Site [Trave, travertine; TTrav, tuffaceous travertine; Calcr, calcrete; SC, soil caliche; S, acid soluble solution; R, acid insoluble residue]. From Szabo et al., 1981.

Sample No.	Material	Percent Residue	Fraction	Uranium (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	Uranium-series age (years)
				ELEANA RANGE				
H-1	SC	45	S	6.51 ± 0.10	1.21 ±0.02	2.95 ±0.09	0.877 ±0.026	128,000 ± 20,000
			R	4.09 ± 0.06	1.10 ±0.02	1.37 ±0.04	1.18 ±0.04	
H-2	SC	40	S	16.8 ± 0.3	1.34 ±0.02	2.90 ±0.09	0.0806 ±0.0024	>5,000
			R	11.4 ± 0.2	1.35 ±0.02	1.82 ±0.06	0.331 ±0.010	
				BOUNDARY FAULT AREA				
50	SC	40	S	6.21 ± 0.09	1.37 ±0.02	11.2 ±0.5	0.242 ±0.007	≥24,000
			R	4.36 ± 0.07	1.34 ±0.02	4.56 ±0.14	0.279 ±0.008	
51	SC	31	S	4.77 ± 0.07	1.37 ±0.02	1.62 ±0.05	0.164 ±0.005	>8,000
			R	3.50 ± 0.50	1.20 ±0.02	1.07 ±0.03	0.587 ±0.018	

[1]The outside, oldest part of travertine vein TSV-30.

[2]The center, youngest part of travertine vein TSV-30.

[3]The outside, oldest part of travertine vein TSV-45.

[4]The center, youngest part of travertine vein TSV-45.

[5]Sample represents 1/3 of full vein width of sample TSV-47.

[6]Sample represents 2/3 of full vein width of sample TSV-47.

[7]Different aliquots of calcrete cement sample TSV-31.

[8]Age cannot be calculated.

[9]Inner part of dense carbonate rind growing on cobbles.

[10]The softer and porous outer part of the same rind as 9 (above).

Analytical data and uranium series ages of carbonates at the Nevada Test Site [Trave, travertine; TTrav, tuffaceous travertine; Calcr, calcrete; SC, soil caliche; S, acid soluble solution; R, acid insoluble residue]. From Szabo et al., 1981.

Sample No.	Fraction	Activity (dpm/g) ^{232}Th	^{230}Th	^{238}U	^{234}U	Concentration (ppm) Th	U	Activity ratio $^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	$^{234}U/^{238}U$	$CaCO_3$ (%)
CBF 1	Leach	1.73	2.11	2.22	2.83	7.16	2.98	.74	1.21	1.27	39.44
		±.06	±.07	±.08	±.09	±.25	±.11	±.04	±.04	±.05	
	Residue	4.07	2.66	3.06	3.67	16.8	4.10	.72	.65	1.20	-
		±.24	±.16	±.12	±.13	±.9	±.16	±.05	±.03	±.04	
CBF 1T	Leach	1.48	1.47	1.67	2.47	6.13	2.24	.60	.99	1.47	44.33
		±.05	±.05	±.05	±.07	±.20	±.07	±.03	±.04	±.05	
	Residue	3.74	2.69	4.24	5.44	15.4	5.69	.49	.72	1.28	-
		±.15	±.12	±.13	±.15	±.6	±.17	±.03	±.03	±.04	
CBF 3	Leach	.47	1.06	2.20	3.20	1.94	2.94	.33	2.25	1.45	67.31
		±.02	±.03	±.06	±.08	±.09	±.08	±.01	±.12	±.04	
	Residue	2.71	2.93	5.47	7.49	11.2	7.33	.39	1.08	1.37	-
		±.08	±.08	±.19	±.23	±.3	±.25	±.02	±.04	±.05	
CSF 1	Leach	.021	.79	1.99	2.87	.09	2.67	.27	37.7	1.44	78.04
		±.003	±.02	±.05	±.06	±.01	±.06	±.01	±5.7	±.04	
	Residue	.11	2.18	5.87	8.94	.45	7.87	.24	19.8	1.52	-
		±.01	±.07	±.15	±.19	±.06	±.20	±.01	±2.7	±.04	
CSF 2	Leach	.24	.25	4.61	5.68	.97	6.18	.043	1.04	1.23	68.31
		±.01	±.01	±.14	±.17	±.03	±.19	±.002	±.04	±.03	
	Residue	1.80	1.29	9.60	10.8	7.41	12.9	.119	.72	1.13	-
		±.05	±.04	±.38	±.4	±.20	±.5	±.006	±.03	±.04	

Analytical data for carbonates from the Nevada Test Site. From Knauss, 1981.

Sample No.	Fraction	Activity (dpm/g) ^{232}Th	^{230}Th	^{238}U	^{234}U	Concentration (ppm) Th	U	Activity ratio $^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	$^{234}U/^{238}U$	$CaCO_3$ (%)
YF SL1	Leach	.44	2.95	2.59	4.06	1.81	3.47	.72	6.70	1.57	56.14
		±.03	±.10	±.10	±.13	±.13	±.13	±.03	±.50	±.06	
	Residue	2.15	8.00	8.53	13.4	8.84	11.4	.60	3.73	1.57	-
		±.10	±.28	±.29	±.4	±.43	±.4	±.03	±.17	±.05	
YF SL2	Leach	.29	2.48	2.66	3.85	1.23	3.56	.64	8.28	1.45	61.10
		±.02	±.05	±.06	±.08	±.06	±.08	±.02	±.42	±.03	
	Residue	2.77	9.64	10.9	15.4	11.4	14.7	.62	3.48	1.41	-
		±.08	±.23	±.2	±.3	±.3	±.3	±.02	±.09	±.02	
YF SL3	Leach	.10	1.52	3.07	4.88	.42	4.11	.31	14.9	1.59	60.49
		±.01	±.05	±.09	±.13	±.04	±.12	±.01	±1.6	±.05	
	Residue	.33	3.12	5.95	9.44	1.38	7.98	.33	9.34	1.59	-
		±.02	±.08	±.14	±.20	±.09	±.19	±.01	±.61	±.04	
BF 1	Leach	.26	.69	.60	.71	1.06	.80	.97	2.69	1.20	94.56
USGS 5		±.01	±.02	±.02	±.02	±.05	±.02	±.04	±.14	±.04	
	Residue	5.49	2.60	2.20	1.88	22.6	2.94	1.38	.47	.86	
		±.20	±.13	±.14	±.13	±.8	±.19	±.12	±.03	±.08	
BF 2	Leach	.35	2.40	1.69	2.43	1.45	2.27	.99	6.80	1.44	74.76
USGS 5		±.02	±.08	±.06	±.08	±.10	±.08	±.04	±.47	±.06	
	Residue	2.42	7.44	6.94	7.96	9.99	9.29	.94	3.07	1.14	-
		±.12	±.25	±.22	±.24	±.51	±.29	±.04	±.16	±.04	

Analytical data for carbonates from the Nevada Test Site. From Knauss, 1981.

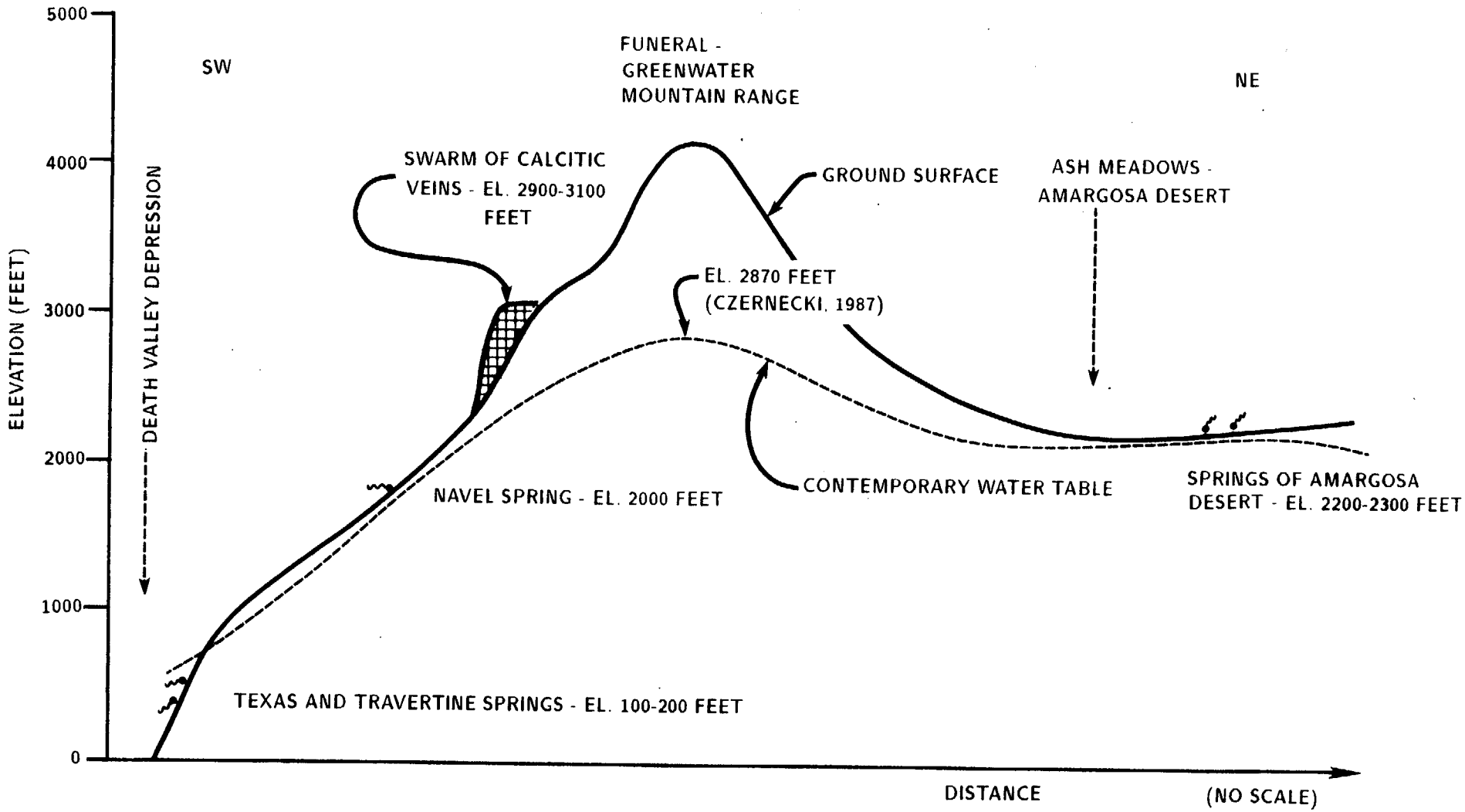
Sample No.	Fraction	Activity (dpm/g) ^{232}Th	^{230}Th	^{238}U	^{234}U	Concentration (ppm) Th	U	Activity ratio $\frac{^{230}Th}{^{234}U}$	$\frac{^{230}Th}{^{232}Th}$	$\frac{^{234}U}{^{238}U}$	$CaCO_3$ (%)
BF 3	Leach	.25	1.95	1.58	1.91	1.05	2.11	1.02	7.67	1.21	65.44
USGS5		±.01	±.05	±.05	±.06	±.06	±.07	±.04	±.43	±.04	
	Residue	1.65	4.69	4.47	5.10	6.82	5.98	.92	2.84	1.14	-
		±.08	±.15	±.17	±.18	±.32	±.23	±.04	±.14	±.05	
BF 5A	Leach	.47	2.31	1.71	2.12	1.95	2.30	1.09	4.87	1.24	69.84
USGS5		±.02	±.07	±.06	±.07	±.10	±.08	±.05	±.24	±.04	
	Residue	2.93	4.54	4.14	4.40	12.1	5.54	1.03	1.55	1.06	-
		±.08	±.11	±.09	±.10	±.3	±.12	±.03	±.05	±.03	
BF 1	Leach	.25	1.76	1.17	1.52	1.04	1.56	1.15	7.01	1.31	61.80
LLL 1		±.02	±.06	±.03	±.09	±.08	±.04	±.05	±.59	±.04	
	Residue	.99	2.57	2.61	2.86	4.06	3.50	.90	2.61	1.09	-
		±.04	±.07	±.09	±.09	±.17	±.12	±.04	±.12	±.04	
BF 2	Leach	.43	1.99	.45	1.85	1.77	1.95	1.08	4.63	1.27	59.59
LLL 1		±.02	±.05	±.03	±.04	±.09	±.04	±.03	±.24	±.03	
	Residue	1.36	2.88	3.14	3.46	5.61	4.21	.83	2.11	1.10	-
		±.04	±.06	±.08	±.09	±.17	±.11	±.03	±.07	±.03	
BF	Total	.077	18.9	18.8	18.8	.31	25.1	1.00	245.	1.00	1.75
TW		±.006	±.4	±.4	±.4	±.02	±.5	±.03	±18.	±.01	
BF	Total	.082	9.76	10.1	10.1	.34	13.6	.97	120	1.00	2.12
TB		±.003	±.13	±.2	±.2	±.01	±.2	±.02	±5.	±.01	

Analytical data for carbonates from the Nevada Test Site. From Knauss, 1981.

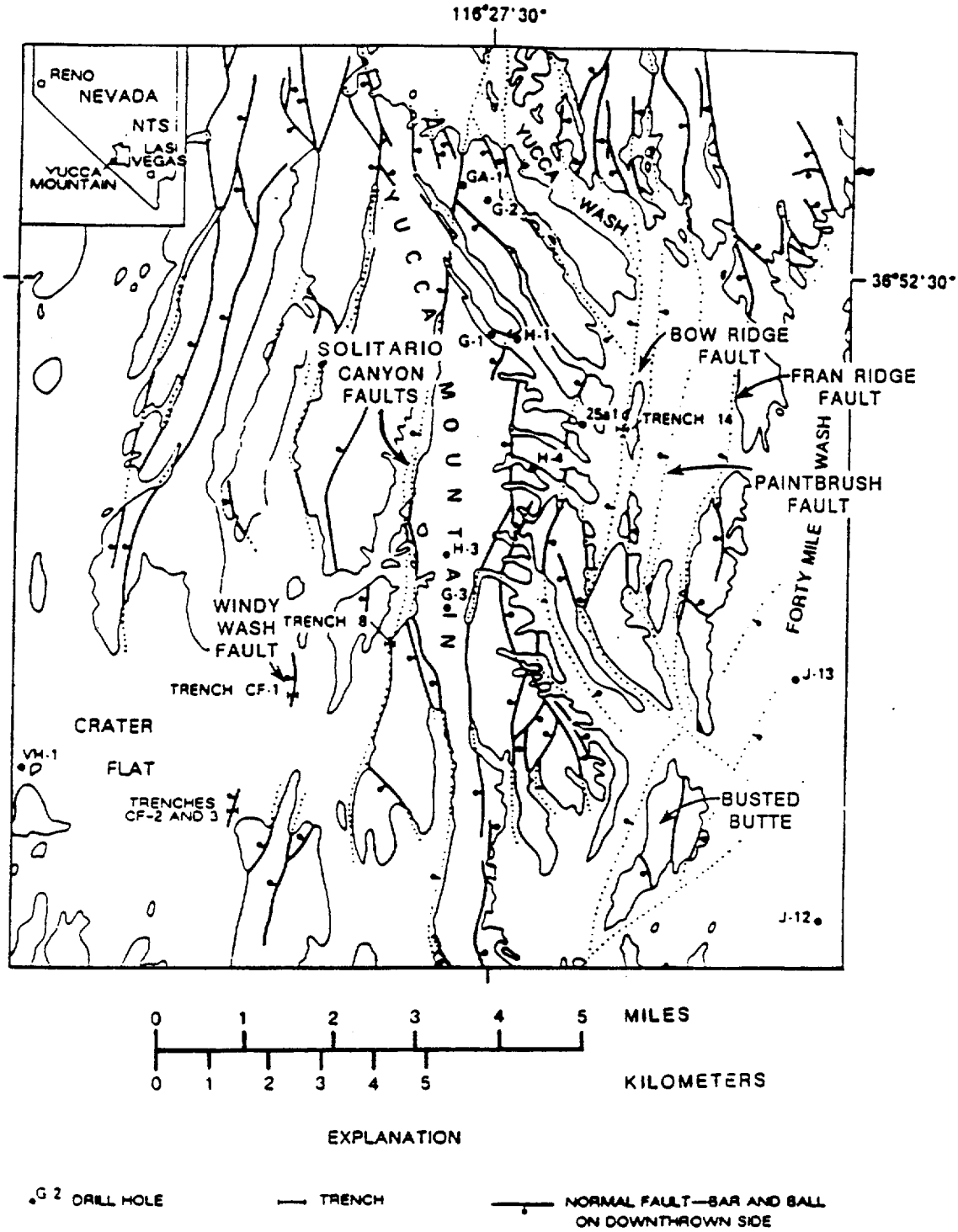
Sample No.	Uncorrected ($\times 10^3$ yr)	Isochron plot ($\times 10^3$ yr)
CBF 1	138	145
CBF 1T	93	a
CBF 3	43	37
CSF 1	34	41
CSF 2	4.8	2
YF SL 1	126	260
YF SL 2	104	108
YF SL 3	39	35
BF USGS5 1	278	217
BF USGS5 2	259	263
BF USGS5 3	278	$\geq$400
BF USGS5 5a	$\geq$400	$\geq$400
BF LLL1 1	$\geq$400	$\geq$400
BF LLL1 2	$\geq$400	$\geq$400
BF TW	$\geq$700	-
BF TB	$\geq$700	-

[a]Not able to calculate.

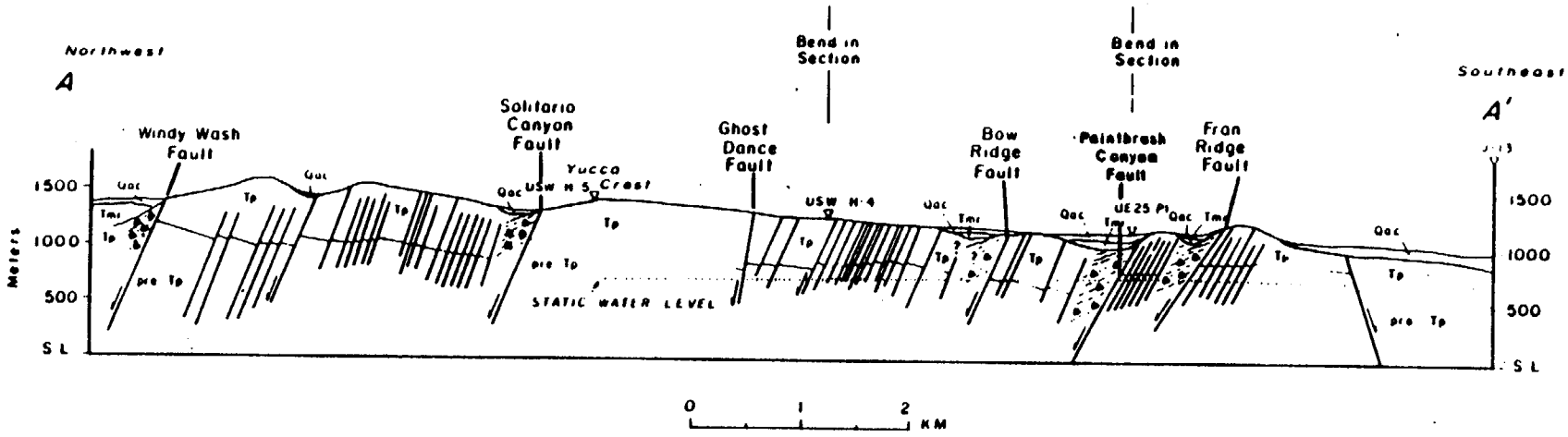
Ages of carbonates from the Nevada Test Site. From Knauss, 1981.



Idealization of contemporary and paleo-hydrologic conditions between Death Valley and Amargosa Desert.

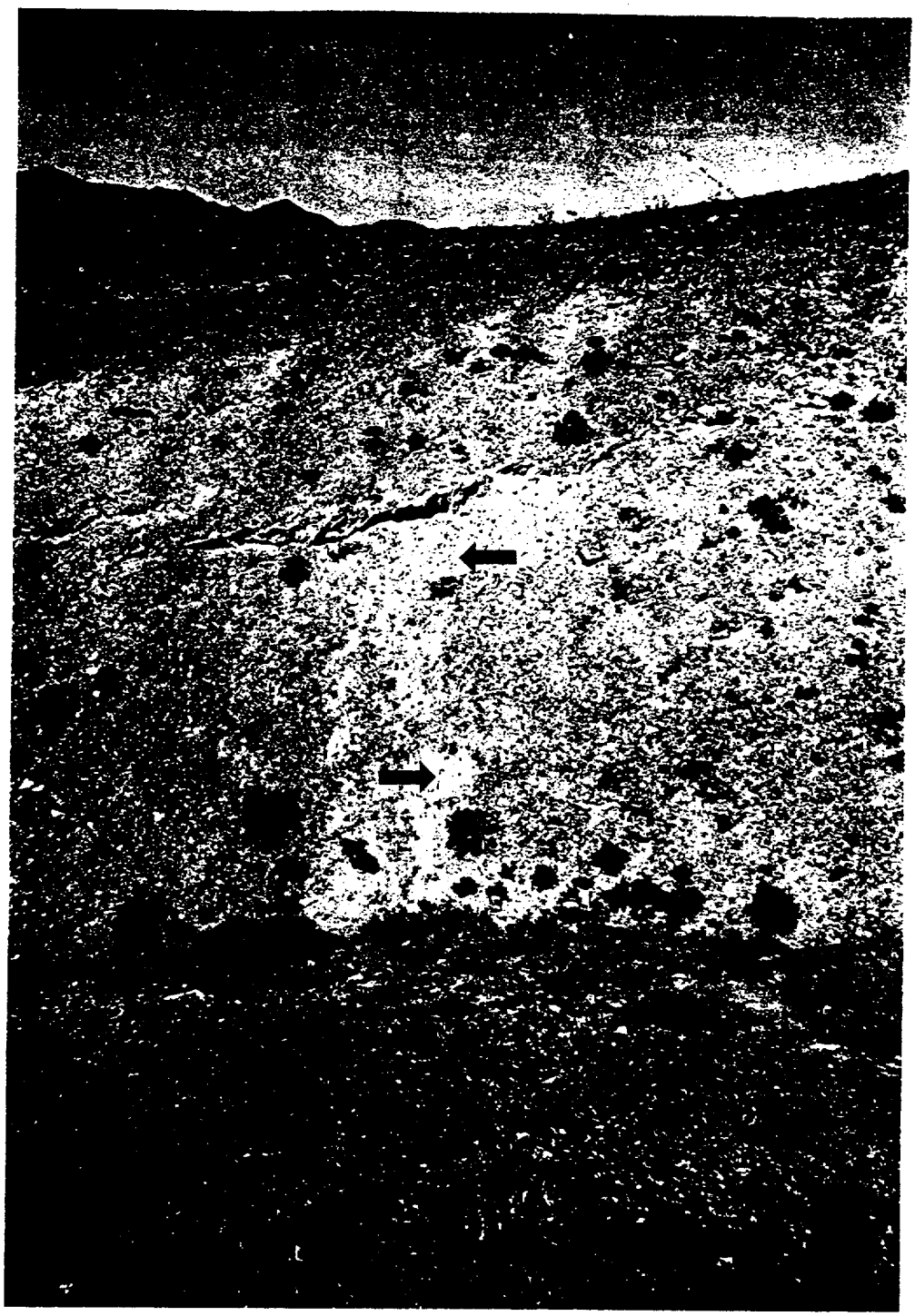


Location of faults containing calcite-silica veins of Quaternary age. Yucca Mountain.

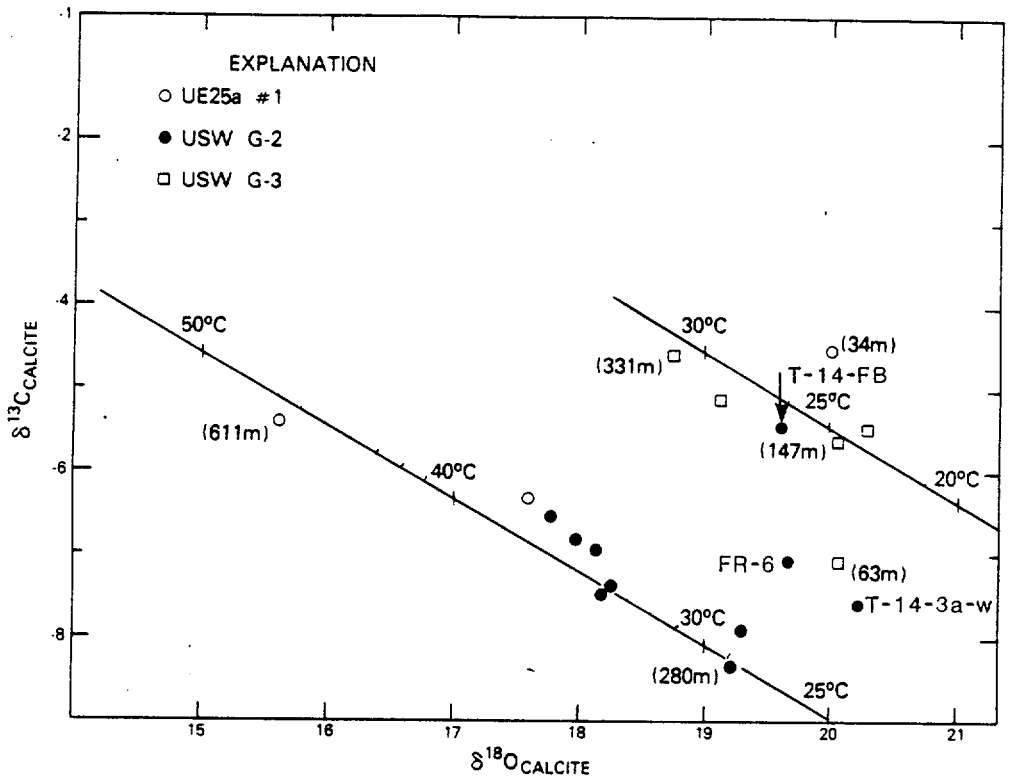


Geologic section across Yucca Mountain showing location and thickness of breccias. From Scott and Bonk, 1984.

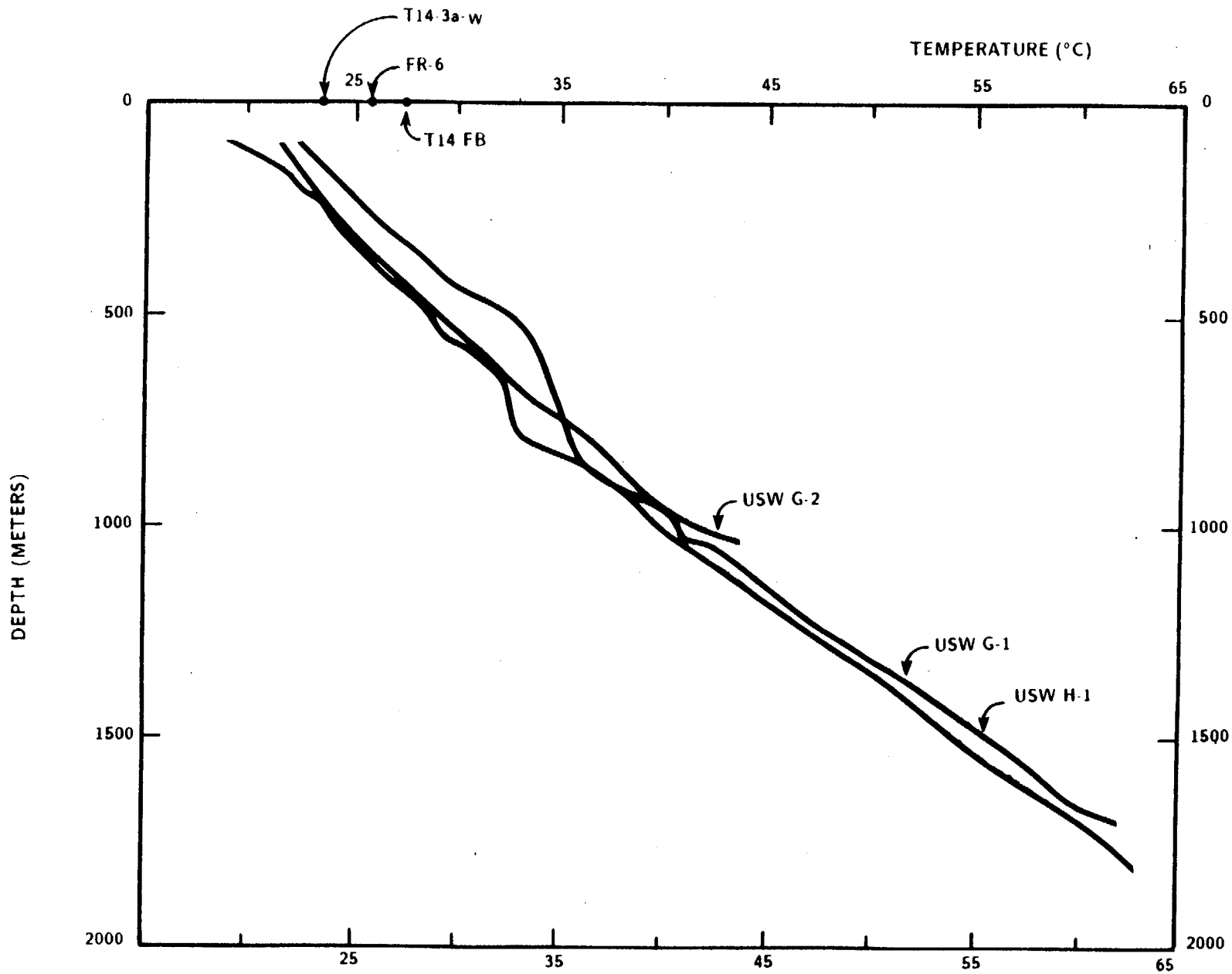
Photograph of the calcite-silica veins emplaced in the Late Miocene bedrock. Yucca Mountain. From Vaniman et al., 1988.



Photograph of the calcite-silica veins and aprons emplaced within Late Quaternary eolian sediments. Yucca Mountain area. From Vaniman et al., 1988.



Comparison of stable isotope composition of three surface samples of calcite-silica veins with isotopic composition of calcite veins from subsurface. Modified from Szabo and Kyser, 1985.



Comparison of temperature of formation of calciate-silica deposits, based on isotopic composition of three samples, with contemporary temperature at Yucca Mountain.