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CLIMATES OF THE STATES
VOLUME II, WESTERN STATES

by OFFICIALS OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPT. OF COMMERCE, 1974

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COLO. pp 595-613.
UTAH. pp 921-934
NEVADA pp 779-793

Jim Combs { Illinois
Michigan
Iowa

• NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

ARIZONA

STATIONS (By Divisions)	Year	Temp. Jan.	Temp. Feb.	Temp. Mar.	Temp. Apr.	Temp. May	Temp. June	Temp. July	Temp. Aug.	Temp. Sept.	Temp. Oct.	Temp. Nov.	Temp. Dec.	Temp. Annual	Precip. Jan.	Precip. Feb.	Precip. Mar.	Precip. Apr.	Precip. May	Precip. June	Precip. July	Precip. Aug.	Precip. Sept.	Precip. Oct.	Precip. Nov.	Precip. Dec.	Precip. Annual
NORTHWEST																											
MOUNT TRUMBULL		•	•	•	•	•	•	•	•	•	•	•	•	•	.96	1.06	1.04	.73	.53	.40	1.80	2.04	1.08	1.03	.77	1.06	12.50
TRUXTON CANYON		•	•	•	•	•	•	•	•	•	•	•	•	•	.98	1.26	.84	.66	.24	.17	1.37	1.94	1.33	.75	.60	1.17	11.31
WIKIEUP		•	•	•	•	•	•	•	•	•	•	•	•	•	1.15	1.31	.93	.51	.07	.17	1.03	1.70	.90	.63	.57	1.23	10.20
DIVISION		41.9	45.0	50.8	59.0	66.8	75.7	82.2	79.9	74.6	64.2	50.8	44.3	61.3	1.01	1.29	.94	.65	.23	.17	.97	1.63	1.10	.72	.56	1.27	10.54
NORTHEAST																											
ALPINE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.60	1.38	1.24	.78	.54	.80	3.10	3.87	2.10	1.61	.92	1.27	19.21
CIBECUE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.67	1.69	1.68	.94	.41	.56	2.42	3.25	1.74	1.57	1.27	1.62	18.82
FLAGSTAFF WB AIRPORT		27.3	29.6	35.6	43.3	50.9	59.5	65.5	63.9	58.5	47.0	36.1	30.4	45.6	1.83	1.78	1.45	1.18	.51	.69	2.28	2.84	1.58	1.52	1.00	1.65	18.31
FORT VALLEY		24.9	27.2	32.9	40.6	47.4	55.9	62.9	61.3	55.4	44.9	34.1	28.2	43.0	2.32	2.27	1.92	1.52	.69	.76	2.65	3.65	1.83	1.52	1.14	2.07	22.34
GANADO		27.5	32.6	38.6	47.0	55.4	64.3	70.7	68.7	62.0	51.0	37.3	29.5	48.7	.74	.82	.78	.71	.51	.46	1.32	1.90	1.15	1.16	.60	.85	11.00
HOLBROOK		33.4	38.8	45.7	54.3	62.4	71.5	77.6	75.5	69.1	57.1	42.6	34.8	55.2	.47	.54	.46	.45	.28	.33	1.16	1.46	1.01	.68	.41	.49	7.74
PETRIFIED FOREST NP		33.4	38.9	45.0	53.3	61.3	70.8	76.3	74.6	68.7	57.0	42.8	35.1	54.8	.53	.66	.53	.51	.38	.34	1.46	1.71	.97	.80	.53	.51	8.93
PINEDALE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.53	1.36	1.06	.91	.41	.55	2.45	3.11	1.72	1.91	1.26	1.48	17.75
SAINT JOHNS		32.0	36.9	43.2	51.9	59.4	68.3	73.7	71.8	65.7	54.4	40.9	33.4	52.6	.69	.70	.75	.55	.52	.60	2.19	2.11	1.28	.91	.41	.68	11.39
SNOWFLAKE		•	•	•	•	•	•	•	•	•	•	•	•	•	.84	.62	.60	.63	.48	.49	1.87	2.50	1.41	1.02	.58	.65	11.69
SPRINGERVILLE		•	•	•	•	•	•	•	•	•	•	•	•	•	.71	.53	.62	.43	.42	.48	2.49	3.12	1.57	.89	.35	.49	12.10
TUBA CITY		•	•	•	•	•	•	•	•	•	•	•	•	•	.50	.47	.49	.39	.44	.23	.67	1.01	.76	.60	.41	.52	6.49
WILLIAMS		31.0	33.2	38.5	46.9	54.8	63.6	68.7	66.6	61.4	51.0	40.4	34.4	49.2	1.89	2.15	1.85	1.38	.66	.54	2.59	3.73	1.85	1.32	1.06	2.23	21.25
WINSLOW WB AIRPORT		31.0	37.5	45.6	55.6	64.8	74.3	80.2	77.8	70.7	57.4	41.3	32.5	55.7	.43	.48	.39	.45	.32	.26	1.02	1.43	.91	.66	.36	.52	7.23
DIVISION		31.6	35.7	41.7	49.8	57.6	66.7	72.5	70.5	64.6	53.4	40.7	33.9	51.6	1.21	1.25	1.12	.82	.50	.47	1.78	2.34	1.36	1.14	.78	1.18	13.95
NORTH CENTRAL																											
ASH FORK		36.1	39.3	44.5	52.0	59.4	68.1	74.3	72.5	67.1	56.6	45.2	38.8	54.5	1.02	1.15	.97	.87	.35	.47	1.62	2.52	1.42	.85	.57	1.18	12.99
CHILDS		45.1	48.9	54.0	62.1	70.1	78.5	84.6	82.3	77.6	66.6	54.2	47.4	64.3	1.86	1.86	1.38	.88	.33	.53	1.90	2.94	1.45	1.20	1.06	1.93	17.32
CORDES		•	•	•	•	•	•	•	•	•	•	•	•	•	1.25	1.52	.95	.62	.26	.31	1.52	2.21	1.21	.83	.74	1.41	12.83
CROWN KING		•	•	•	•	•	•	•	•	•	•	•	•	•	2.92	2.81	2.14	1.25	.48	.50	3.24	4.75	1.81	1.58	1.43	3.05	25.96
DRAKE RS		•	•	•	•	•	•	•	•	•	•	•	•	•	1.23	1.45	.96	.88	.37	.41	1.56	2.41	1.40	.80	.67	1.57	13.71
DUGAS 2 SE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.52	1.96	1.32	.91	.26	.48	1.90	3.27	1.31	1.21	.93	1.75	16.82
JEROME		41.2	43.4	49.1	57.3	65.4	74.6	79.0	76.3	72.9	62.5	50.9	44.2	59.7	1.64	1.77	1.34	1.13	.49	.45	2.29	2.99	1.30	1.14	.95	1.68	17.17
PRESCOTT FAA AP		37.1	39.6	45.5	53.2	61.3	70.4	76.0	73.4	68.7	57.6	45.7	39.3	55.7	1.01	1.08	.73	.69	.24	.32	2.08	2.66	1.19	.73	.50	1.00	12.23
SELIGMAN		•	•	•	•	•	•	•	•	•	•	•	•	•	.99	1.00	.66	.56	.24	.40	1.36	2.22	1.09	.64	.46	.86	10.48
WALNUT CREEK		•	•	•	•	•	•	•	•	•	•	•	•	•	1.56	1.61	1.14	.76	.32	.48	2.34	3.14	1.70	.94	.66	1.54	16.19
WALNUT GROVE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.62	1.96	1.25	.80	.25	.35	1.90	3.50	1.37	.91	.83	1.77	16.51
DIVISION		40.1	43.2	48.4	55.8	63.4	72.1	78.3	76.2	71.4	60.6	49.0	42.6	58.4	1.43	1.61	1.13	.83	.32	.39	1.86	2.69	1.31	.92	.78	1.48	14.75
EAST CENTRAL																											
GISELA		•	•	•	•	•	•	•	•	•	•	•	•	•	1.90	1.75	1.42	.85	.29	.44	1.88	2.48	1.67	1.22	1.26	1.82	16.98
GLOBE		42.8	46.9	52.4	60.2	68.0	77.0	82.8	80.1	75.1	63.6	50.7	44.6	62.0	1.58	1.36	1.28	.60	.28	.40	2.22	2.86	1.26	1.08	.84	1.61	15.37
MIAMI		44.1	47.9	53.6	61.9	70.4	79.7	83.8	81.3	77.0	65.8	52.6	46.2	63.7	2.07	1.83	1.69	.77	.29	.32	2.34	3.30	1.46	1.14	1.15	2.11	18.47
NATURAL BRIDGE		•	•	•	•	•	•	•	•	•	•	•	•	•	2.45	2.73	2.14	1.36	.48	.53	2.26	3.60	2.09	1.68	1.59	2.66	23.57
PAYSON RANGER STATION		•	•	•	•	•	•	•	•	•	•	•	•	•	2.12	2.19	1.71	1.07	.41	.59	2.39	3.43	1.91	1.48	1.37	1.90	20.57
RENO RANGER STATION		•	•	•	•	•	•	•	•	•	•	•	•	•	1.96	2.08	1.76	.81	.31	.37	1.49	2.82	1.71	1.11	1.15	2.22	17.79
ROOSEVELT 1 WNW		47.5	51.6	57.4	66.2	74.8	84.0	89.0	86.5	82.0	70.5	56.9	49.7	68.0	1.82	1.70	1.54	.70	.25	.38	1.27	1.94	1.41	1.02	1.03	1.95	15.01
SAN CARLOS RESERVOIR		45.8	49.7	55.3	63.8	72.6	82.1	86.7	84.6	79.9	68.2	54.4	47.2	65.9	1.57	1.38	1.32	.60	.23	.41	1.61	2.03	1.09	1.02	.95	1.59	13.80
YOUNG		•	•	•	•	•	•	•	•	•	•	•	•	•	2.00	1.92	1.70	1.07	.41	.48	2.80	3.43	1.87	1.29	1.25	1.95	20.17
DIVISION		42.9	46.3	51.7	59.5	67.4	76.6	82.0	79.9	75.2	64.1	51.3	44.9	61.8	2.00	1.98	1.68	.88	.34	.44	2.03	2.95	1.59	1.28	1.21	2.04	18.42
SOUTHWEST																											
PARKER		51.5	56.3	62.5	70.3	77.8	86.3	93.4	91.7	85.6	73.5	59.9	53.1	71.8	.53	.66	.48	.23	.03	.02	.27	.60	.57	.23	.25	.66	4.53
YUMA CITRUS STATION		53.3	57.0	62.6	69.6	76.5	83.9	91.6	90.8	85.8	74.1	61.7	55.3	71.9	.39	.39	.22	.11	.01	.02	.19	.46	.32	.42	.12	.37	3.02
YUMA WB AIRPORT		55.4	59.1	65.5	72.4	79.6	87.2	94.3	92.5	88.1	76.3	63.9	57.0	74.3	.39	.36	.24	.09	.01	.01	.23	.50	.38	.38	.12	.32	3.03
DIVISION		52.1	56.2	62.2	69.7	76.8	84.8	92.0	90.7	85.5	73.9	60.3	53.9	71.5	.49	.55	.35	.17	.02	.05	.40	.80	.49	.32	.22	.52	4.38
SOUTH CENTRAL																											
AGUILA		•	•	•	•	•	•	•	•	•	•	•	•	•	.91	1.11	.79	.48	.08	.08	.85	1.65	.73	.51	.53	1.05	8.77
CAMELBACK		•	•	•	•	•	•	•	•	•	•	•	•	•	.82	.96	.73	.39	.13	.09	.89	1.09	.78	.58	.52	.94	7.92
CASA GRANDE		50.0	54.1	59.9	68.1	76.1	85.1	91.1	88.8	83.8	71.7	58.5	51.8	69.9	.82	.81	.57	.34	.12	.17	1.11	1.28	.80	.54	.62	.84	8.02
CASA GRANDE RUINS N M		•	•	•	•	•	•	•	•	•	•	•	•	•	.91	.85	.60	.31	.13	.15	1.08	1.20	.89	.58	.66	.95	8.31
FLORENCE		51.2	54.7	59.8	67.4	75.0	83.8	90.2	88.0	83.9	72.4	59.8	53.4	70.0	1.03	1.01	.79	.41	.16	.17	1.11	1.57	.77	.74	.73	1.10	9.59
GILA BEND		52.3	56.4	62.4	70.0	77.7	86.3	93.2	91.6	86.2	74.6	60.9	54.5	72.2	.57	.50	.56	.25	.09	.04	.87	1.09	.40	.32	.35	.58	5.62
GRANITE REEF DAM		•	•	•	•	•	•	•	•	•	•	•	•	•	1.06	.99	.88	.38	.13	.16	.82	1.42	.84	.57	.64	1.12	9.01
LITCHFIELD PARK		50.8	54.7	60.3	68.1	76.0	84.6	91.1	88.9	83.7	71.7	58.9	52.6	70.1	.94	.97	.62	.31	.09	.09	.69	1.28	.78	.48	.54	.98	7.77
MESA EXPERIMENT FARM		49.5	53.1	58.5	66.2	74.0	82.5	88.5	86.8	81.9	70.7	58.1	51.6	68.5	.80	.82	.65	.33	.13	.09	.83	1.20	.72	.51	.51	.94	7.53
MORMON FLAT		52.8	55.5	61.1	69.9	78.1	86.8	92.2	89.6	86.1	75.2	62.5	55.5	72.1	1.54	1.45	1.19	.57	.18	.28	1.22	2.15	1.14	.89	.96	1.48	13.05
PHOENIX INDIAN SCHOOL		•	•	•	•	•	•	•	•	•	•	•	•	•	.81	.89	.64	.34	.13	.05	.83	1.19	.79	.45	.50	.84	7.46
PHOENIX WB AIRPORT		49.7	53.5	59.0	67.2	75.0	83.6	89.8	87.5	82.8	70.7	58.1	51.6	69.0	.73	.85	.66	.32	.13	.09	.77	1.12	.73	.46	.49	.85	7.20
PHOENIX POST OFFICE		52.4	56.0	61.6	69.5	77.7	86.2	91.8	89.8	85.3	73.5	60.8	54.4	71.6	.76	.84	.68	.36	.10	.07	.89	1.16	.81	.52	.47	.76	7.42
PINAL RANCH		•	•	•	•	•	•	•	•	•	•	•	•	•	2.95	2.82	2.53	1.10	.33	.33	2.35	3.63	1.69	1.65	1.67	3.27	24.32
SACATON		49.0	53.0	58.9	66.9	74.9	83.6	89.5	87.3	82.6	70.8	57.3	50.7	68.7	.88	.82	.67	.37	.15	.10	1.20	1.51	.81	.50	.63	.86	8.54
SOUTH PHOENIX		51.5	55.3	60.6	68.1	76.0	84.4	90.7	88.7	84.0	72.4	59.9	53.3	70.4	.73	.87	.70	.32	.12	.10	.77	1.34	.70	.50	.48	.92	7.55
SUPERIOR		•	•	•	•	•	•	•	•	•	•	•	•	•	2.11	1.95	1.69	.81	.29	.28	2.05	2.56	1.33	1.26	1.26	1.95	17.54
TEMPE		50.0	53.7	58.9	66.3	73.6	81.7	88.4	86.8	81.9	70.3	57.9	51.9	68.5	.85	.80	.74	.32	.17	.09	.78	1.24	.63	.52	.51	.93	7.58
WICKENBURG		•	•	•	•	•	•	•	•	•	•	•	•	•	1.11	1.28	.78	.47	.16	.16	1.21	2.40	.90	.58	.65	1.15	10.05
DIVISION		50.1	53.6	59.0	66.8	74.6	83.2	89.5	87.5	82.8	71.2	58.4	52.1	69.1	.97	.96	.77	.39	.14	.14	1.06	1.56	.83	.59	.60	1.01	9.02
SOUTHEAST																											
AJO		52.5	55.9	61.6	69.6	77.2	85.6	90.6	88.3	85.4	74.4	61.7	55.0	71.5	.81	.69	.74	.31	.04	.10	1.32	2.34	.80	.60	.49	.82	9.06
APACHE POWDER COMPANY		•	•	•	•	•	•	•	•	•	•	•	•	•	.70	.79	.43	.26	.12	.68	2.95	3.10	1.27	.66	.47	.81	12.24
BENSON		•	•	•	•	•	•	•	•	•	•	•	•	•	.69	.81	.46	.25	.11	.51	2.60	3.21	1.21	.68	.49	.73	11.75
BISBEE		•	•	•	•	•	•	•	•	•	•	•	•	•	1.32	1.15	.83	.42	.16	.78	3.63	4.43	1.93	.89	.63	1.18	17.34
CANELO 1 NW		•	•	•	•	•	•	•	•	•	•	•	•	•	1.21	1.20	.75	.41	.11	.94	4.21	4.78	1.53	.84	.68	1.23	17.89
CLIFTON		46.6	51.8	58.1	66.2	74.4	83.4	86.6	85.1	80.7	70.3	56.3	48.5	67.3	.91	.91	.72	.37	.25	.39	1.84	2.38	1.64	.91	.53	1.02	11.87
DOUGLAS SMELTER		45.3	48.9	54.0	61.5	68.9	78.1	81.0	79.0	75.2	65.2	53.0	46.9	63.1	.72	.59	.46	.21	.12	.55	3.11	3.10	1.09	.70	.40	.67	11.72
EAGLE CREEK		•	•	•	•	•	•	•	•	•	•	•	•	•	1.32	1.23	1.02	.51	.28	.70	2.63	3.23	1.77	.90	.91	1.21	15.71
ELGIN 5 N		•	•	•	•	•	•	•	•	•	•	•	•	•	.92	.95	.61	.29	.10	.64	3.42	3.61	1.44	.71	.57	.91	14.17
FAIRBANK		•	•	•	•	•	•	•	•	•	•	•	•	•	.65	.66	.38	.25	.11	.58	3.01	3.03	1.23	.61	.46	.67	11.64
PATAGONIA		•	•	•	•	•	•	•	•	•	•	•	•	•	1.29	1.09	.79	.36	.16	.47	4.37	4.26	1.63	.77	.74	1.09	17.02
RUCKER CANYON		•	•	•	•	•	•	•	•	•	•	•	•	•	1.39	1.42	1.04	.52	.18	.89	3.76	4.15	1.73	1.31	.84	1.31	18.54
SAFFORD		44.2	48.8	54.3	62.7	70.8	80.3	85.0	82.2	77.1	65.7	52.3	45.8	64.1	.70	.69	.61	.29	.13	.29	1.70	1.54	1.00	.59	.46	.66	8.66
SAN RAFAEL RANCH		•	•	•	•	•	•	•	•	•	•	•	•	•	1.19	1.08	.85	.42	.08	.60	4.40	4.30	1.49	.75	.61	1.10	16.87
SANTA RITA EXP RANGE		47.5	49.8	54.8	62.4	69.9	78.9	79.9	77.0	75.6	67.2	56.2	50.2	64.1	1.69	1.64	1.13	.58	.14	.75	3.98	4.69	1.88	.91	1.02	1.39	19.80
STEPHENS RANCH		•	•	•	•	•	•	•	•	•	•	•	•	•	1.00	.82	.60	.25	.10	.55	2.60	3.14	1.28	.76	.56	.97	12.63
TOMBSTONE		•	•	•	•	•	•	•	•	•	•	•	•	•	.84	.77	.49	.33	.11	.59	3.67	3.69	1.30	.60	.51	.80	13.70
TUCSON UNIV OF ARIZONA		50.3	53.3	58.4	66.1	73.7	82.5	86.9	84.7	81.0	70.2	58.1	52.2	68.1	.84	.88	.64	.35	.17	.30	1.86	2.24	1.06	.61	.67	.85	10.47
TUCSON WB AIRPORT	R	49.8	52.9	58.0	65.9	73.5	82.7	86.3	83.1	80.4	70.0	58.1	51.9	67.7	.82	.84	.53	.27	.13	.29	2.06	2.88	1.00	.64	.62	.92	11.00
DIVISION		46.0	49.3	54.4	61.9	69.4	78.3	81.6	79.5	75.9	66.1	54.1	48.0	63.7	.98	1.02	.73	.36	.16	.49	2.78	3.14	1.34	.79	.64	.99	13.42

• Normals for the period 1931-1960. Divisional normals may not be the arithmetical average of individual stations published, since additional data for shorter period stations are used to obtain better areal representation.

NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

COLORADO

STATIONS (By Divisions)	TEMPERATURE (°F) Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	PRECIPITATION (In.) Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
ARKANSAS DRAINAGE BASIN																										
BUENA VISTA	24.8	27.3	33.1	41.3	49.8	58.9	63.6	62.1	56.1	47.0	34.2	27.5	43.8	.46	.55	.62	1.16	1.07	.56	1.69	1.37	.70	.70	.45	.36	9.69
CANON CITY	36.6	38.4	42.9	51.7	60.6	70.1	75.8	74.3	67.0	56.7	44.7	39.3	54.8	.49	.45	.82	1.76	2.07	1.12	1.49	1.77	.90	.78	.64	.37	12.66
COLORADO SPRINGS WB AP	28.6	31.5	36.2	45.6	55.0	64.7	70.5	69.2	61.6	50.3	37.5	31.7	48.5	.29	.33	.61	1.31	2.13	1.59	2.37	2.16	1.07	.69	.40	.24	13.19
EADS	•	•	•	•	•	•	•	•	•	•	•	•	•	.39	.42	.71	1.39	2.26	1.92	2.06	2.00	1.00	.84	.49	.30	13.78
HASWELL	•	•	•	•	•	•	•	•	•	•	•	•	•	.34	.37	.53	1.25	2.13	1.69	1.81	1.64	1.07	.73	.45	.23	12.24
LAMAR	29.9	34.9	41.6	52.8	62.9	73.5	79.1	77.4	68.6	56.0	40.4	32.8	54.2	.50	.45	.79	1.30	2.40	2.07	1.85	2.07	1.08	.79	.56	.34	14.20
LAS ANIMAS	30.5	35.1	43.1	54.2	64.4	74.6	79.1	77.2	68.8	56.0	40.6	33.5	54.8	.48	.35	.68	1.20	2.09	1.45	1.83	1.70	.94	.70	.48	.35	12.25
LEADVILLE	17.9	19.3	23.2	32.2	42.0	51.4	56.9	55.6	49.6	39.4	26.4	20.3	36.2	1.32	1.51	1.71	1.83	1.44	1.13	2.73	2.11	1.35	1.11	1.07	1.17	18.48
LIMON 10 SSW	27.7	30.2	35.7	45.9	55.5	65.7	71.7	70.5	62.1	51.0	36.9	30.8	48.6	.41	.42	.95	1.55	2.32	1.79	2.20	2.25	1.32	.79	.56	.38	14.94
NORTH LAKE	•	•	•	•	•	•	•	•	•	•	•	•	•	.92	1.14	1.76	2.30	2.53	1.38	2.95	2.98	1.43	1.26	.92	.77	20.34
ORDWAY	•	•	•	•	•	•	•	•	•	•	•	•	•	.40	.40	.70	1.27	1.92	1.14	1.43	1.51	1.15	.58	.43	.35	11.28
PENROSE 3 NNW	•	•	•	•	•	•	•	•	•	•	•	•	•	.34	.38	.65	1.43	1.97	1.18	1.72	1.67	.87	.80	.47	.31	11.79
PUEBLO WB AIRPORT	30.0	33.9	40.1	50.7	60.6	71.1	76.5	74.6	66.6	54.8	40.0	33.2	52.7	.31	.48	.52	1.18	1.80	1.22	1.82	1.85	.84	.99	.53	.30	11.84
ROCKY FORD 2 ESE	30.0	34.7	41.5	52.3	61.7	71.9	76.8	74.9	66.7	54.5	39.7	32.5	53.1	.43	.35	.72	1.45	2.02	1.26	1.74	1.70	1.07	.79	.46	.32	12.31
RUSH 2 NNE	•	•	•	•	•	•	•	•	•	•	•	•	•	.24	.27	.58	1.33	2.29	1.70	2.07	2.39	1.18	.66	.32	.19	13.22
SALIDA	•	•	•	•	•	•	•	•	•	•	•	•	•	.41	.53	.80	1.32	1.34	.77	1.48	1.47	.77	1.00	.55	.43	10.87
SPRINGFIELD	•	•	•	•	•	•	•	•	•	•	•	•	•	.47	.46	1.05	1.31	2.58	2.01	2.07	1.79	1.16	.85	.55	.43	14.73
TWO BUTTES 1 NW	•	•	•	•	•	•	•	•	•	•	•	•	•	.44	.48	.89	1.36	2.32	1.95	1.69	1.97	1.04	.80	.53	.38	13.85
DIVISION	28.7	31.7	37.2	46.9	56.1	66.1	71.3	69.8	62.4	51.6	37.8	31.5	49.3	.53	.58	.95	1.68	2.25	1.49	2.10	2.10	1.12	.90	.61	.46	14.77
COLORADO DRAINAGE BASIN																										
AMES	•	•	•	•	•	•	•	•	•	•	•	•	•	1.96	2.12	2.34	2.72	1.92	1.32	2.34	3.05	2.25	2.37	1.33	1.69	25.41
CEDAREDGE	27.4	31.8	38.7	48.1	56.9	65.5	71.9	69.6	67.6	51.6	37.5	30.1	49.1?	.93	.98	.95	1.12	.85	.74	.91	1.32	1.04	1.14	.67	.86	11.51
COLLBRAN	22.8	27.6	36.1	46.4	54.8	63.2	69.4	67.2	59.4	48.7	34.4	26.2	[illegible]	1.02	1.22	1.30	1.56	1.10	.74	1.00	1.41	1.28	1.27	.98	.95	13.83
CORTEZ	27.5	31.9	38.5	47.4	55.9	64.7	71.3	69.6	62.2	51.0	37.2	29.5	48.9	1.06	1.10	1.09	1.09	.86	.54	1.21	1.51	1.41	1.46	.75	1.12	13.20
CRESTED BUTTE	13.5	16.3	22.6	33.4	44.2	52.3	56.0	56.9	50.1	40.3	25.7	16.8	[illegible]	2.68	2.56	2.36	1.73	1.31	1.43	1.95	2.27	1.66	1.43	1.52	2.10	23.00
DELTA 1 E	26.4	33.1	41.6	51.6	60.8	68.8	74.8	72.3	64.6	52.9	37.1	28.5	51.0	.53	.49	.50	.72	.62	.52	.62	1.13	.83	.94	.40	.45	7.75
DILLON 1 E	15.2	17.5	22.8	32.3	42.2	49.7	54.9	53.7	47.7	38.3	25.0	18.3	[illegible]	1.43	1.55	2.08	2.17	1.71	1.20	1.89	1.63	1.17	1.11	1.18	1.30	18.42
DURANGO	25.3	29.7	36.7	45.1	52.5	60.6	67.0	66.0	59.0	48.7	36.1	27.9	46.2	1.61	1.30	1.49	1.29	1.13	.85	1.81	2.36	1.73	1.86	.98	1.63	18.04
FORT LEWIS	23.0	25.9	31.7	41.2	49.0	57.2	63.6	61.9	55.7	45.6	33.2	25.9	42.8	1.64	1.71	1.55	1.48	1.19	.90	1.75	2.14	1.80	2.03	.99	1.60	18.78
FRASER	12.7	15.5	21.7	32.5	41.9	49.7	54.8	53.0	46.1	36.3	22.9	15.4	[illegible]	1.52	1.51	1.67	1.90	1.77	1.41	1.64	1.54	1.17	1.03	1.13	1.14	17.43
FRUITA	26.0	32.2	41.3	51.6	61.0	69.4	75.9	73.3	64.9	52.7	37.4	28.5	51.2	.73	.64	.75	.74	.48	.44	.65	1.02	.89	.77	.58	.62	8.31
GLENWOOD SPRINGS 1 N	24.8	29.7	37.9	47.6	56.3	64.3	71.1	69.0	61.6	51.0	36.4	27.4	48.1	1.80	1.75	1.53	1.90	1.36	1.19	1.36	1.67	1.41	1.40	1.21	1.45	18.03
GRAND JUNCTION WB AP	26.0	32.6	41.5	52.3	62.2	71.3	78.2	75.5	67.8	55.0	38.8	29.1	52.5	.64	.69	.75	.75	.60	.42	.57	1.07	.91	.74	.58	.57	8.29
GUNNISON	11.4	15.6	26.2	39.7	48.3	56.6	62.3	60.6	53.3	43.0	28.7	16.4	38.5	.97	.98	.81	.80	.76	.78	1.47	1.46	.89	.72	.60	.76	11.00
HAYDEN	•	•	•	•	•	•	•	•	•	•	•	•	•	1.24	1.14	1.30	1.50	1.47	1.21	1.25	1.19	1.24	1.46	1.09	1.36	15.45
IGNACIO 1 N	23.4	28.4	36.4	45.3	53.4	61.8	68.3	66.8	59.6	48.9	35.2	26.9	46.2	1.30	1.17	1.19	1.07	1.00	.72	1.40	1.77	1.31	1.58	.75	1.19	14.45
MESA VERDE NAT PARK	29.8	33.0	38.6	48.1	57.0	67.4	72.9	70.8	64.4	52.7	39.5	32.1	50.5	1.93	1.95	1.76	1.32	1.05	.70	1.68	2.01	1.53	1.66	.98	1.71	18.28
MONTROSE NO 2	26.5	31.3	39.1	48.8	57.9	67.3	73.3	70.8	63.3	51.5	36.8	28.6	49.6	.65	.60	.65	.98	.74	.49	.70	1.25	.96	.93	.57	.59	9.11
NORTHDALE	22.5	26.6	34.3	43.8	52.0	60.7	68.0	66.2	58.4	47.1	33.5	25.9	44.9	1.07	1.01	1.08	1.10	.91	.58	1.11	1.50	1.49	1.56	.94	1.07	13.42
NORWOOD	•	•	•	•	•	•	•	•	•	•	•	•	•	1.08	1.21	1.31	1.45	1.02	.84	1.59	2.13	1.49	1.61	.93	1.07	15.73
PALISADE	•	•	•	•	•	•	•	•	•	•	•	•	•	.50	.61	.66	.98	.67	.51	.65	.96	1.15	1.01	.60	.46	8.76
PITKIN	•	•	•	•	•	•	•	•	•	•	•	•	•	1.45	1.30	1.41	1.41	1.15	.91	1.86	1.82	1.23	1.00	.89	1.19	15.68
RICO	•	•	•	•	•	•	•	•	•	•	•	•	•	2.46	2.46	2.49	2.23	1.61	1.19	2.39	2.80	2.49	2.40	1.66	2.31	26.49
RIFLE	23.2	29.1	38.3	48.3	56.7	64.5	71.0	68.9	60.6	49.9	35.9	26.7	47.8	.92	.80	.91	1.01	.79	.69	.98	1.20	.92	1.09	.78	.84	10.93
SHOSHONE	•	•	•	•	•	•	•	•	•	•	•	•	•	1.80	1.81	1.67	2.19	1.37	1.22	1.11	1.66	1.32	1.54	1.37	1.73	18.79
SILVERTON	16.7	19.0	23.8	33.2	41.9	49.7	55.1	54.1	48.2	39.0	26.6	19.3	35.6	1.46	1.67	2.08	1.76	1.39	1.41	2.47	2.82	2.28	2.26	1.16	1.50	22.26
STEAMBOAT SPRINGS	15.1	19.6	27.5	39.1	48.5	55.5	62.0	60.6	53.1	43.3	28.7	18.9	39.3	2.41	2.31	2.27	2.35	2.06	1.56	1.40	1.49	1.48	1.79	1.90	2.45	23.47
TELLURIDE	21.5	23.8	28.3	37.5	45.3	53.4	58.6	57.1	51.8	42.8	30.5	23.5	39.5	1.89	2.10	2.30	2.56	1.72	1.22	2.31	2.93	1.90	1.89	1.23	1.74	23.79
DIVISION	21.2	25.3	32.6	42.8	51.7	60.1	66.4	64.5	57.3	46.7	32.7	24.4	43.8	1.38	1.35	1.46	1.46	1.19	.93	1.38	1.69	1.33	1.37	1.01	1.24	15.79
KANSAS DRAINAGE BASIN																										
BURLINGTON	29.7	33.0	38.9	49.7	59.0	69.4	75.5	73.8	65.8	53.9	39.7	33.0	51.8	.42	.48	.99	1.64	2.53	2.52	2.57	2.23	1.23	.88	.43	.43	16.35
CHEYENNE WELLS	29.4	32.5	39.0	50.2	59.8	70.1	76.0	74.6	66.1	54.3	39.9	32.2	52.0	.34	.37	.76	1.45	2.23	2.30	2.43	2.55	1.10	.78	.43	.23	14.97
HOLYOKE	27.3	30.4	36.6	48.2	58.1	68.5	75.6	73.9	64.3	52.2	37.7	30.3	50.3	.31	.35	.99	1.91	3.19	3.37	2.46	2.00	1.48	.92	.44	.39	17.81
LEROY 7 WSW	•	•	•	•	•	•	•	•	•	•	•	•	•	.62	.57	1.40	2.21	2.88	2.75	2.04	1.91	1.28	.92	.73	.66	17.97
WRAY	27.6	31.4	38.1	49.5	59.3	69.4	76.0	73.9	64.4	52.2	38.1	30.8	50.9	.42	.46	.91	2.09	3.08	2.57	2.68	2.22	1.41	.79	.46	.42	17.49
YUMA	•	•	•	•	•	•	•	•	•	•	•	•	•	.42	.46	1.07	1.69	2.83	2.62	2.63	1.95	1.24	.93	.49	.40	16.73
DIVISION	28.1	31.4	37.4	48.5	58.2	68.6	75.1	73.5	64.7	53.0	38.4	31.2	50.7	.40	.43	.94	1.69	2.76	2.53	2.50	2.16	1.32	.88	.48	.40	16.49
PLATTE DRAINAGE BASIN																										
BOULDER	32.7	34.7	39.3	48.7	57.4	67.5	73.6	72.1	64.3	53.7	41.4	35.8	51.8	.72	.83	1.75	2.75	3.36	1.89	1.41	1.64	1.25	1.39	.96	.62	18.57
BYERS	28.8	31.9	37.5	47.2	56.6	67.3	73.7	72.2	63.8	52.4	38.5	31.0	50.2	.43	.47	.87	1.86	2.54	1.58	2.01	1.49	1.14	.72	.54	.40	14.05
CHEESMAN	28.0	30.1	35.1	43.5	52.1	62.1	67.1	65.8	59.3	49.0	37.3	31.6	[illegible]	.45	.57	.95	1.97	2.05	1.13	2.33	2.06	1.13	.85	.59	.40	14.48
DENVER WB AIRPORT	28.5	31.5	36.4	46.4	56.2	66.5	72.8	71.5	63.0	51.4	37.7	31.6	[illegible]	.55	.69	1.21	2.11	2.70	1.44	1.53	1.28	1.13	1.01	.69	.47	14.81
DENVER WB CITY	32.6	34.6	39.2	48.6	57.7	68.1	74.4	73.1	64.6	53.8	41.2	35.8	52.0?	.49	.63	1.07	1.85	2.41	1.27	1.22	1.09	.91	.93	.62	.40	12.89
ESTES PARK	26.3	27.7	31.4	39.6	47.7	56.3	62.2	60.9	54.1	45.3	34.5	29.8	43.0	.53	.82	1.05	2.03	2.22	1.72	2.13	1.86	1.24	1.00	.82	.65	15.37
FORT COLLINS	26.6	29.7	36.2	46.4	55.4	64.9	71.0	69.2	60.7	49.8	36.7	30.4	48.1	.38	.50	.95	1.86	2.90	1.73	1.15	1.53	1.20	1.08	.49	.42	14.19
FORT LUPTON 1 N	•	•	•	•	•	•	•	•	•	•	•	•	•	.49	.48	.70	1.71	2.65	1.42	1.25	1.25	1.02	.84	.46	.35	12.62
FORT MORGAN	24.3	28.8	36.6	47.9	57.7	67.9	73.9	72.0	62.7	51.2	36.2	28.0	48.9	.34	.27	.71	1.51	2.58	1.73	1.76	1.38	1.20	.73	.36	.29	12.86
GREELEY	24.1	28.4	36.0	47.1	57.0	67.3	73.7	71.7	62.1	49.8	35.1	27.6	48.3	.35	.36	.72	1.45	2.49	1.42	1.19	.81	.76	.85	.39	.33	11.12
GREELEY CSC	24.1	28.4	36.0	47.1	57.0	67.3	73.7	71.7	62.1	49.8	35.1	27.6	48.3	.35	.36	.72	1.45	2.49	1.42	1.19	.81	.76	.85	.39	.33	11.12
GROVER 10 W	26.9	29.2	34.7	45.0	54.4	64.6	71.6	70.1	61.5	50.7	37.1	30.8	48.1	.33	.43	.73	1.17	2.61	2.03	2.08	1.51	1.06	.65	.40	.30	13.30
HARTSEL	•	•	•	•	•	•	•	•	•	•	•	•	•	.43	.34	.50	.92	1.09	.88	2.13	2.08	.94	.66	.39	.35	10.71
HAWTHORNE	•	•	•	•	•	•	•	•	•	•	•	•	•	.87	1.03	1.92	3.36	3.74	1.94	1.59	1.54	1.45	1.52	1.11	.75	20.82
IDAHO SPRINGS	26.1	27.8	32.3	40.7	48.5	57.5	62.8	61.6	55.0	45.6	34.4	29.2	43.5	.40	.60	.95	2.05	2.23	1.42	2.19	2.14	1.12	.84	.66	.40	15.00
JULESBURG	27.7	31.2	37.5	49.4	59.3	69.3	76.4	74.5	64.7	52.6	38.2	30.3	50.8	.43	.44	1.00	1.74	2.04	2.38	2.20	1.93	1.23	.73	.50	.42	16.32
KASSLER	32.7	35.0	40.0	49.6	58.2	67.9	74.0	72.7	65.4	55.0	41.9	35.9	52.4	.72	.93	1.62	2.75	2.90	1.51	1.42	1.48	1.22	1.33	.95	.58	17.41
LAKEWOOD	31.5	34.4	39.5	49.1	57.9	68.2	74.0	72.5	63.9	52.7	40.2	35.0	[illegible]	.65	.73	1.20	2.78	2.82	1.42	1.33	1.32	1.03	1.12	.79	.45	15.14
LONGMONT 2 ESE	27.0	30.4	36.9	47.0	56.3	65.6	71.6	70.2	61.7	50.6	37.0	30.8	48.8?	.35	.44	.77	1.63	2.66	1.45	1.09	.88	1.06	.92	.46	.32	12.03
PARKER 9 E	•	•	•	•	•	•	•	•	•	•	•	•	•	.35	.41	.71	1.83	2.38	1.49	1.86	1.71	1.00	.85	.52	.29	13.41
SPICER	•	•	•	•	•	•	•	•	•	•	•	•	•	.93	1.00	1.28	1.52	1.35	1.04	1.33	1.41	1.07	.91	1.02	1.18	14.06
STERLING	24.8	28.9	36.0	47.0	57.4	67.4	73.9	72.2	62.3	50.8	36.4	28.2	48.9	.33	.32	.76	1.50	2.60	2.58	1.84	1.54	1.12	.75	.41	.35	14.10
WATERDALE	28.5	30.8	36.7	46.4	55.0	64.0	70.5	68.9	61.1	50.1	37.6	31.9	48.5	.43	.55	1.11	2.08	2.91	1.88	1.35	1.30	1.45	1.12	.54	.42	15.14
DIVISION	26.5	29.1	34.8	44.6	53.7	63.2	69.4	67.8	59.7	49.0	36.1	29.9	47.0	.50	.60	1.03	1.90	2.53	1.71	1.77	1.56	1.15	.95	.63	.48	14.81
RIO GRANDE DRAINAGE BSN																										
ALAMOSA WB AIRPORT	17.4	23.5	32.1	41.8	50.8	60.0	64.9	63.0	55.7	44.4	29.5	19.2	41.9	.26	.17	.26	.69	.73	.49	1.07	.98	.77	.60	.29	.25	6.56
DEL NORTE	20.8	25.8	33.6	42.7	53.9	59.1	63.6	62.2	56.3	46.5	33.1	23.7	[illegible]	.46	.29	.50	.77	.87	.59	1.19	1.57	.88	.92	.37	.34	8.65
HERMIT 7 ESE	12.7	16.0	23.2	34.4	43.0	50.7	56.4	55.2	48.7	39.2	25.5	15.1	35.0	1.01	.67	.94	1.29	1.18	1.00	1.90	2.73	1.40	1.87	.80	.83	15.07
MANASSA	18.1	24.9	32.8	42.2	50.8	59.2	63.5	61.9	55.8	45.7	31.2	21.5	[illegible]	.37	.23	.31	.58	.81	.48	.83	1.26	.74	.63	.26	.26	6.76
SAGUACHE	•	•	•	•	•	•	•	•	•	•	•	•	•	.36	.27	.42	.69	.77	.61	1.36	1.54	.74	.72	.31	.31	8.10
DIVISION	17.2	22.7	30.5	40.2	48.4	56.9	61.9	60.5	54.1	44.1	29.9	20.2	40.6	.61	.49	.72	.96	.98	.66	1.44	1.65	.99	1.07	.49	.53	10.54

* Normals for the period 1931 - 1960. Divisional normals may not be the arithmetical average of individual stations published, since additional data for shorter period stations are used to obtain better areal representation.

NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

IDAHO — TEMPERATURE (°F) — PRECIPITATION (In.)

STATIONS (By Divisions)	TEMP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN	PRECIP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
PANHANDLE																										
BONNERS FERRY 1 SW	•	•	•	•	•	•	•	•	•	•	•	•	•	3.16	2.24	1.76	1.11	1.37	1.62	.78	.78	1.26	2.41	3.08	3.51	23.08
COEUR D ALENE 1 E	27.5	30.8	37.6	46.9	55.4	61.3	69.1	67.8	59.6	48.7	36.8	31.7	47.8	3.42	2.52	2.34	1.71	2.04	1.93	.66	.72	1.35	2.50	3.20	3.74	26.13
PORTHILL	24.0	27.6	35.7	46.3	54.7	60.2	66.8	64.7	56.5	45.6	33.9	28.5	45.4	2.18	1.55	1.42	1.02	1.38	1.94	.74	1.05	1.26	2.03	2.26	2.42	19.25
PRIEST RIVER EXP. STA	23.8	27.6	34.4	43.9	52.5	58.2	64.6	62.5	55.3	44.9	32.9	28.0	44.1	4.31	3.13	2.84	2.03	2.18	2.59	.90	.89	1.60	3.29	3.92	4.78	32.46
SAINT MARIES	27.8	32.2	38.6	47.3	55.2	60.7	67.6	65.8	58.6	48.5	36.6	31.6	47.5	3.79	2.87	2.63	1.99	1.99	2.18	.71	.67	1.43	2.79	3.58	4.08	28.71
SANDPOINT EXP STATION	25.6	29.2	36.0	45.8	53.8	59.3	65.3	63.4	56.1	46.1	34.9	29.7	45.4	4.49	3.30	2.97	1.97	2.05	2.33	.63	.83	1.71	3.37	4.21	4.88	32.74
DIVISION	25.8	29.5	36.5	46.0	54.2	59.9	66.6	64.7	57.1	46.7	35.0	29.9	46.0	3.56	2.60	2.38	1.67	1.85	2.09	.73	.82	1.45	2.82	3.42	3.98	27.37
NORTH CENTRAL PRAIRIE																										
GRANGEVILLE	27.7	31.5	36.9	44.9	52.2	57.9	67.0	65.9	58.1	47.8	36.4	31.3	46.5	1.38	1.52	2.05	2.68	3.30	3.04	.88	.76	1.51	2.20	1.82	1.51	22.65
MOSCOW U OF I	28.2	32.5	38.9	47.1	54.4	60.0	67.3	65.6	59.2	49.5	37.8	32.4	47.7	2.80	2.14	2.12	1.69	1.63	1.74	.51	.52	1.24	2.03	2.64	3.15	22.21
NEZPERCE	26.5	30.7	36.5	44.7	52.1	57.6	65.5	64.5	57.4	47.5	35.7	30.6	45.8	1.53	1.45	1.78	2.13	2.75	2.66	.86	.71	1.35	1.95	1.83	1.70	20.70
POTLATCH 3 NNE	28.7	32.4	38.4	46.5	53.5	59.0	65.6	63.8	57.4	48.5	37.8	32.7	47.0	3.10	2.35	2.28	1.82	1.94	2.06	.55	.52	1.38	2.33	2.80	3.36	24.49
DIVISION	27.4	31.2	37.0	45.1	52.4	57.9	65.9	64.4	57.5	47.9	36.5	31.3	46.2	2.07	1.81	2.00	2.05	2.50	2.48	.73	.68	1.37	2.09	2.17	2.25	22.20
NORTH CENTRAL CANYONS																										
KOOSKIA	30.3	36.0	43.0	50.9	58.5	64.3	71.8	69.6	62.4	51.5	39.0	33.5	50.9	1.93	1.86	2.39	2.82	3.05	2.89	.85	.74	1.50	2.46	2.24	1.99	24.72
LEWISTON WSO	30.7	35.9	42.6	50.8	58.4	64.8	73.8	71.7	63.5	52.0	39.8	34.9	51.6	1.10	.97	1.18	1.14	1.55	1.73	.43	.43	.90	1.21	1.23	1.37	13.24
OROFINO	31.0	36.4	43.2	51.9	59.6	65.8	73.8	71.7	63.5	52.0	39.7	34.1	51.9	2.79	2.61	2.63	2.06	2.27	2.29	.60	.47	1.43	2.36	3.05	3.37	25.93
RIGGINS RANGER STATION	•	•	•	•	•	•	•	•	•	•	•	•	•	.90	1.22	1.49	1.54	2.08	1.91	.62	.56	1.02	1.42	1.37	1.33	15.46
DIVISION	31.4	36.5	43.4	51.7	59.3	65.4	73.7	71.7	63.7	53.1	39.9	34.6	52.0	2.10	2.02	2.35	2.12	2.31	2.30	.62	.59	1.35	2.13	2.38	2.48	22.75
CENTRAL MOUNTAINS																										
ARROWROCK DAM	24.5	29.6	37.8	48.4	56.7	63.8	74.1	72.2	62.7	50.7	36.6	29.3	48.9	2.77	2.60	2.14	1.49	1.42	1.10	.27	.15	.47	1.28	2.32	2.81	18.82
AVERY RANGER STATION	27.9	31.7	37.9	46.6	55.0	60.7	68.0	66.5	59.3	49.1	35.7	30.6	47.4	3.57	3.02	3.20	2.45	2.41	2.51	1.04	.95	1.75	3.36	3.89	4.31	32.46
DEADWOOD DAM	16.9	21.3	26.9	36.3	45.3	52.2	60.4	58.4	51.1	42.2	28.8	20.1	38.3	4.79	4.23	3.51	1.95	2.11	1.83	.61	.60	1.00	2.27	3.64	5.43	31.97
GARDEN VALLEY RS	24.2	30.1	37.5	47.0	55.0	61.6	70.9	68.6	60.5	49.1	34.9	27.4	47.2	3.38	3.02	2.66	1.77	1.75	1.39	.33	.41	.72	1.74	2.89	3.76	23.82
HAILEY RANGER STATION	18.7	23.4	30.8	43.3	52.3	58.8	68.0	66.0	57.5	47.0	32.2	23.6	43.5	2.11	1.88	1.28	1.07	1.33	1.04	.41	.42	.60	.90	1.31	2.18	14.53
HILL CITY	15.3	19.5	26.8	40.5	50.0	56.3	65.8	63.7	54.7	44.3	30.6	21.8	40.8	2.32	1.94	1.41	1.01	1.26	.85	.27	.33	.41	1.00	1.71	2.18	14.69
IDAHO CITY	22.9	27.3	34.2	44.2	52.2	58.4	66.9	64.8	57.1	47.5	34.5	27.0	44.8	3.41	3.20	2.57	1.68	1.86	1.38	.34	.29	.57	1.62	2.64	3.63	23.19
KELLOGG	27.2	31.5	38.1	47.0	55.1	60.8	68.2	66.1	58.6	48.4	36.3	31.2	47.4	3.61	2.92	2.97	2.38	2.41	2.42	.83	.83	1.70	3.18	3.71	4.01	30.97
MC CALL	18.5	21.8	27.6	37.2	47.1	54.1	62.8	60.4	52.6	43.1	30.2	22.9	39.9	3.62	3.15	2.75	1.87	2.35	2.07	.55	.61	1.19	2.28	2.78	3.53	26.75
NEW MEADOWS RANGER STA	19.1	23.9	30.9	41.7	49.5	55.7	62.7	60.3	52.8	43.6	31.2	23.3	41.2	3.30	2.70	2.37	1.94	2.07	1.99	.55	.55	1.15	2.22	2.87	3.58	25.29
WALLACE WOODLAND PARK	25.8	29.4	34.9	43.7	51.4	57.1	64.3	62.6	55.6	46.7	35.1	29.9	44.7	4.30	3.43	3.42	2.47	2.45	2.72	1.01	.87	1.93	3.62	4.45	5.08	35.75
DIVISION	21.0	25.2	31.4	41.4	50.0	56.3	64.6	62.5	54.8	45.1	32.0	25.0	42.4	3.56	3.11	2.78	1.97	2.06	1.93	.66	.63	1.20	2.34	3.16	3.96	27.36
SOUTHWESTERN VALLEYS																										
BOISE WSO	29.1	34.5	41.7	50.4	58.2	65.8	75.2	72.1	62.7	51.6	38.6	32.2	51.0	1.32	1.33	1.32	1.16	1.29	.89	.21	.16	.39	.84	1.20	1.32	11.43
CALDWELL	28.9	34.6	42.5	51.4	58.8	65.2	73.5	70.4	61.5	51.2	38.3	32.3	50.7	1.29	1.26	1.17	1.01	1.08	.78	.24	.11	.41	.79	1.21	1.26	10.61
CAMBRIDGE	22.3	27.5	37.9	49.2	57.3	63.9	74.1	71.0	61.0	49.8	36.0	28.0	48.2	2.88	2.57	1.99	1.43	1.45	1.43	.25	.23	.65	1.45	2.45	2.93	19.71
COUNCIL	24.7	29.2	37.5	48.3	56.6	63.0	72.8	70.4	61.6	50.5	36.9	29.0	48.4	3.82	3.34	2.77	2.09	2.02	1.83	.35	.39	.86	2.14	3.18	4.01	26.80
DEER FLAT DAM	28.6	34.0	41.8	50.8	58.2	64.8	73.5	70.7	61.7	51.2	38.3	32.3	50.5	1.06	.94	1.11	.87	1.06	.73	.18	.16	.36	.69	1.02	1.08	9.26
EMMETT 2 E	29.5	35.1	43.1	51.9	59.5	65.5	73.7	71.1	63.0	52.6	39.4	33.3	51.5	1.55	1.44	1.31	1.07	1.28	1.01	.15	.12	.55	.95	1.37	1.63	12.43
GLENNS FERRY	•	•	•	•	•	•	•	•	•	•	•	•	•	1.25	.94	1.02	.75	.90	.59	.25	.14	.25	.55	1.05	.99	8.68
GRAND VIEW 2 W	29.4	35.4	43.0	52.7	60.8	67.9	76.5	73.4	63.5	52.3	39.0	32.3	52.2	.71	.58	.91	.70	1.09	.83	.16	.11	.33	.47	.68	.69	7.26
KUNA 2 NNE	29.0	34.5	41.8	50.3	57.6	63.7	72.0	69.4	61.3	51.8	38.8	32.4	50.2	1.12	1.03	1.20	1.03	1.37	.88	.19	.14	.40	.79	1.18	1.03	10.36
MOUNTAIN HOME	28.3	33.2	40.4	49.6	57.4	64.4	73.7	71.1	62.2	51.9	38.7	31.9	50.2	1.04	.87	1.10	.84	1.02	.73	.24	.15	.30	.65	.93	.91	8.78
PARMA EXPERIMENT STA	28.3	34.3	42.6	51.5	58.8	65.4	73.6	71.0	62.0	51.5	38.3	32.0	50.8	1.11	.98	.91	.80	1.04	.79	.14	.23	.44	.78	1.00	1.12	9.34
PAYETTE	27.5	33.2	42.4	51.7	59.5	66.3	75.3	72.3	62.5	51.3	38.0	31.5	51.0	1.51	1.26	1.10	.88	1.00	.87	.22	.22	.42	.90	1.21	1.37	10.96
WEISER 2 SE	27.5	33.3	42.8	52.1	60.1	66.8	75.4	72.5	63.1	52.0	38.5	31.6	51.3	1.70	1.45	1.11	.90	.99	.82	.11	.22	.39	.86	1.28	1.48	11.31
DIVISION	28.2	33.6	41.7	51.0	58.8	65.4	74.4	71.6	62.6	52.0	38.7	32.0	50.8	1.54	1.36	1.30	1.04	1.22	.97	.21	.18	.44	.91	1.35	1.48	12.00
SOUTHWESTERN HIGHLAND																										
HOLLISTER	26.6	31.2	37.1	46.0	53.9	60.9	71.3	68.8	59.9	49.9	37.1	30.8	47.8	1.09	.74	1.01	1.09	1.23	1.06	.40	.28	.43	.74	.91	1.01	9.99
DIVISION	26.0	30.2	35.9	44.8	52.6	59.4	69.4	67.0	58.4	50.2	36.5	30.0	46.7	1.11	.80	1.07	1.16	1.44	1.14	.41	.31	.44	.98	.89	1.02	10.77
CENTRAL PLAINS																										
BLISS	•	•	•	•	•	•	•	•	•	•	•	•	•	1.24	.92	.92	.66	.88	.61	.22	.11	.27	.55	1.05	1.11	8.54
BURLEY	26.6	31.5	39.1	48.6	56.9	64.2	73.8	71.4	62.1	51.3	38.0	31.3	49.6	1.11	.92	.84	.79	.87	.72	.26	.28	.40	.63	.85	.94	8.61
HAZELTON	26.3	31.4	39.2	48.7	57.0	64.5	73.6	71.1	61.9	51.2	37.8	30.8	49.5	1.35	1.06	.98	.99	1.09	.83	.25	.19	.39	.79	1.07	1.12	10.11
JEROME	26.5	31.2	39.0	49.1	57.4	64.6	74.1	71.4	62.4	51.5	38.1	30.8	49.7	1.26	.99	.93	.79	.87	.66	.18	.15	.41	.64	.95	1.04	8.87
RICHFIELD	•	•	•	•	•	•	•	•	•	•	•	•	•	1.41	1.13	.88	.70	.85	.64	.26	.30	.39	.71	1.05	1.32	9.64
RUPERT	24.7	29.4	37.5	47.3	55.8	63.2	72.6	69.6	60.3	49.7	36.5	29.7	48.0	1.02	.85	.82	.74	.82	.76	.23	.23	.41	.68	.81	.90	8.27
SHOSHONE 1 WNW	23.1	27.7	36.6	47.5	55.9	63.3	72.9	69.9	60.5	49.7	35.8	28.2	47.6	1.58	1.25	.98	.79	.99	.64	.22	.22	.43	.74	1.09	1.35	10.28
TWIN FALLS 2 NNE	27.3	32.7	39.9	49.2	57.4	64.4	72.9	69.9	61.3	51.0	38.1	31.6	49.6	1.04	.70	.84	.93	1.00	.79	.24	.17	.49	.76	.92	.86	8.74
TWIN FALLS 3 SE	26.9	31.9	38.9	48.3	56.5	63.6	72.3	69.2	60.5	50.3	37.6	31.0	48.9	1.02	.72	.87	.86	1.01	.79	.21	.21	.46	.75	.93	.91	8.74
DIVISION	25.4	30.3	38.2	48.0	56.2	63.4	72.7	69.9	61.0	50.5	37.1	30.1	48.6	1.18	.91	.87	.81	.95	.74	.25	.22	.40	.71	.95	1.01	9.00

* NORMALS BY CLIMATOLOG..AL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

IDAHO, CONT.

TEMPERATURE (°F)

STATIONS (By Divisions)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
NORTHEASTERN VALLEYS													
CHALLIS	18.4	25.0	34.2	44.7	52.9	59.7	68.1	65.9	57.5	47.1	32.4	23.0	44.1
MACKAY RANGER STATION	16.9	21.2	30.0	42.4	51.0	58.1	66.8	64.6	56.3	46.0	30.6	21.6	42.1
SALMON	17.9	24.7	35.1	45.7	53.9	60.2	67.8	65.6	56.6	45.0	31.8	22.5	44.0
DIVISION	16.7	22.6	32.1	43.2	51.6	58.2	66.2	64.1	55.6	45.5	30.8	21.5	42.3
UPPER SNAKE RIVER PLN													
ABERDEEN EXP STATION	21.2	26.2	35.5	46.0	54.4	61.6	70.2	67.8	58.7	48.0	34.3	26.5	45.9
ASHTON 1 S	18.1	21.7	27.9	41.4	51.7	57.6	64.5	62.5	54.8	45.4	30.3	22.1	41.5
BLACKFOOT 2 SSW	.	.	.	.	.	.	.	.	.	.	.	.	.
DUBOIS EXP STATION	17.8	21.2	28.4	42.3	52.2	59.4	69.4	67.4	58.0	46.2	30.7	22.6	43.0
FORT HALL INDIAN AGNCY	22.7	27.6	36.1	46.4	55.1	62.1	70.6	68.2	59.6	49.2	35.0	27.2	46.7
IDAHO FALLS FAA AP	19.3	24.2	33.2	45.2	53.9	60.5	69.2	66.9	58.0	47.3	33.0	24.5	44.6
IDAHO FALLS 42 NW	13.4	18.9	29.3	43.1	52.7	59.8	69.1	66.4	56.1	44.1	28.1	18.8	41.7
IDAHO FALLS 46 W	15.4	20.4	30.0	43.3	52.6	59.8	69.0	66.6	56.5	44.9	29.8	20.8	42.4
POCATELLO WSO	22.3	27.2	35.8	46.5	55.1	62.8	72.4	70.1	60.3	49.1	35.0	27.4	47.0
SUGAR	17.5	21.5	29.9	43.8	52.6	59.3	66.6	63.9	55.6	45.5	31.3	22.7	42.5
DIVISION	19.6	24.1	32.6	44.6	53.5	60.5	69.1	66.7	57.8	47.2	32.6	24.5	44.4
EASTERN HIGHLANDS													
DRIGGS	17.3	21.1	27.1	38.6	47.9	55.0	63.7	62.1	53.7	43.6	29.0	21.9	40.1
GRACE	18.9	22.5	29.4	41.5	50.5	57.4	65.8	64.3	56.1	45.7	31.3	23.5	42.2
LIFTON PUMPING STATION	17.4	19.4	26.7	40.5	51.2	59.0	66.9	64.4	55.6	44.8	31.1	23.3	41.7
MALAD	22.7	27.2	35.4	46.4	54.7	62.1	71.0	69.3	60.4	49.3	35.1	27.3	46.7
MONTPELIER RANGER STA	17.8	20.8	28.0	40.8	50.5	58.0	66.4	64.4	55.6	44.8	30.6	22.6	41.7
OAKLEY	27.5	31.9	38.4	47.2	55.0	62.0	71.3	69.2	60.7	51.0	38.4	31.7	48.7
DIVISION	19.1	23.0	29.9	41.6	50.7	57.8	66.3	64.5	56.0	45.6	31.4	23.7	42.5

PRECIPITATION (In.)

STATIONS (By Divisions)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
NORTHEASTERN VALLEYS													
CHALLIS	.48	.33	.35	.53	1.11	1.18	.58	.53	.60	.46	.31	.47	6.93
MACKAY RANGER STATION	.81	.68	.56	.62	1.09	1.26	.85	.79	.71	.64	.54	.70	9.25
SALMON	.56	.50	.53	.64	1.38	1.35	.81	.56	.72	.66	.63	.59	8.93
DIVISION	.57	.45	.46	.60	1.25	1.28	.91	.67	.70	.66	.46	.58	8.59
UPPER SNAKE RIVER PLN													
ABERDEEN EXP STATION	.78	.60	.70	.76	.91	.81	.31	.36	.46	.72	.67	.79	7.87
ASHTON 1 S	1.82	1.77	1.39	1.04	1.45	1.91	.82	.95	.94	1.35	1.56	1.89	16.89
BLACKFOOT 2 SSW	1.00	.80	.84	.84	1.12	1.13	.40	.51	.64	.82	.88	.92	9.90
DUBOIS EXP STATION	.89	.79	.69	.79	1.42	1.79	.67	.76	.71	.82	.69	.92	10.94
FORT HALL INDIAN AGNCY	.86	.70	.73	.89	1.14	1.22	.42	.57	.70	.88	.81	.76	9.68
IDAHO FALLS FAA AP	.89	.71	.66	.66	.98	1.13	.46	.50	.63	.63	.62	.80	8.67
IDAHO FALLS 42 NW	.55	.49	.46	.49	.88	1.24	.44	.49	.63	.41	.33	.61	7.02
IDAHO FALLS 46 W	.73	.77	.62	.51	1.10	1.09	.26	.48	.35	.66	.41	.59	7.57
POCATELLO WSO	1.21	.92	1.02	1.06	1.13	.96	.51	.55	.61	.89	.99	1.00	10.85
SUGAR	1.12	1.15	.89	.80	1.13	1.42	.51	.62	.73	.78	.88	1.21	11.24
DIVISION	1.03	.89	.82	.85	1.16	1.26	.50	.59	.65	.81	.80	.96	10.31
EASTERN HIGHLANDS													
DRIGGS	1.41	1.40	1.17	1.10	1.74	2.05	.86	1.22	1.11	1.29	1.05	1.39	15.79
GRACE	1.14	1.17	1.13	1.36	1.61	1.46	.78	.91	1.04	1.13	1.14	1.13	14.20
LIFTON PUMPING STATION	.68	.67	.77	1.02	1.16	.94	.58	.75	.78	.91	.68	.68	9.62
MALAD	1.51	1.32	1.11	1.21	1.39	1.25	.74	.79	.90	.98	1.25	1.53	13.97
MONTPELIER RANGER STA	1.15	1.11	1.28	1.38	1.44	1.48	.65	.84	.93	1.16	1.08	1.17	13.67
OAKLEY	.82	.69	.84	1.08	1.37	1.07	.62	.57	.61	.78	.80	.83	10.08
DIVISION	1.37	1.29	1.24	1.27	1.64	1.60	.76	.92	.96	1.16	1.19	1.42	14.82

* Normals for the period 1931-1960. Divisional normals may not be the arithmetical average of individual stations published, since additional data for shorter period stations are used to obtain better areal representation.

CONFIDENCE - LIMITS

In the absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State. Because of the wider variation in mean precipitation, the corresponding monthly means and annual mean must be substituted for "p" in the precipitation table below to obtain mean precipitation confidence limits.

2.1	1.9	1.3	1.1	1.1	1.0	.6	.5	.9	1.1	1.3	1.6	.5	.18$\sqrt{p}$	.20$\sqrt{p}$	.21$\sqrt{p}$	.21$\sqrt{p}$	.28$\sqrt{p}$	.25$\sqrt{p}$	.22$\sqrt{p}$	.24$\sqrt{p}$	.27$\sqrt{p}$	.25$\sqrt{p}$	.25$\sqrt{p}$	.17$\sqrt{p}$	.23$\sqrt{p}$

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for Moscow (University of Idaho), Idaho, for the period 1906-1930 and are included in this publication for comparative purposes.

26.9	31.5	38.3	45.8	52.6	59.4	67.6	66.3	57.7	48.3	37.7	29.3	46.8	3.03	2.20	2.09	1.50	1.71	1.32	0.57	0.74	1.15	1.53	2.91	2.55	21.30

NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

MONTANA — TEMPERATURE (°F) / PRECIPITATION (In.)

STATIONS (By Divisions)	TEMP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN	PRECIP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
WESTERN																										
DARBY	25.3	29.6	35.6	44.5	51.8	57.6	65.1	63.0	55.[illegible]	46.7	34.8	29.1	44.9	1.29	1.29	1.13	1.01	1.75	1.86	.82	.78	1.23	1.24	1.67	1.62	15.69
EAST ANACONDA	22.0	24.9	30.0	40.6	49.9	56.4	66.5	64.7	55.4	45.4	31.9	26.4	42.8	.72	.68	.92	.95	1.67	2.48	1.20	.96	1.17	.87	.84	.76	13.22
FORTINE 1 N	19.9	24.5	32.9	42.8	50.9	56.7	63.0	60.2	52.8	43.1	30.7	24.7	41.9	1.46	1.11	1.15	1.23	1.82	2.42	1.13	1.27	1.32	1.57	1.55	1.60	17.63
HAMILTON	24.8	29.3	36.9	46.7	54.6	60.3	68.2	66.1	57.7	47.4	34.5	28.5	46.3	.86	.88	.67	.74	1.61	1.85	.79	.64	1.04	1.02	1.08	1.04	12.22
HAUGAN 3 E	21.8	26.4	33.0	42.4	51.0	57.0	62.9	60.9	54.1	45.0	32.4	26.1	42.8	4.27	3.43	3.07	1.89	1.70	2.18	.78	.83	1.67	2.84	4.00	4.66	31.32
HERON 2 NW	24.2	28.2	34.4	44.1	52.2	57.5	64.0	61.8	54.8	44.9	33.4	28.4	44.0	4.47	3.77	3.29	2.00	2.23	2.58	.73	.92	1.78	3.18	4.41	4.98	34.34
KALISPELL WSO	19.9	24.5	31.8	43.7	52.2	58.6	65.7	63.1	54.7	43.9	31.0	25.0	42.8	1.37	1.00	.96	1.04	1.57	2.21	1.04	1.09	1.04	1.24	1.43	1.33	15.42
LIBBY 1 NE RANGER STA	.	.	.	.	.	.	.	.	.	.	.	.	.	2.18	1.50	1.41	1.04	1.29	1.66	.62	.90	1.19	1.97	2.34	2.37	18.47
LONEPINE 1 WNW	22.9	26.2	34.7	45.7	54.2	60.3	68.2	65.9	57.3	46.4	33.0	27.8	45.2	1.03	.82	.70	.72	1.12	1.62	.61	.62	.88	1.06	1.20	1.08	11.46
MISSOULA 2 WNW	22.4	27.5	36.0	46.4	54.6	60.5	68.3	66.3	57.4	46.2	33.4	26.8	45.5	.89	.74	.65	.96	1.82	1.99	.91	.75	1.06	.96	.93	1.12	12.78
MISSOULA WSO	19.2	25.0	33.7	44.3	52.6	58.5	67.0	64.8	55.4	44.0	30.5	23.5	43.2	.92	.87	.73	.97	1.87	1.91	.85	.72	1.02	.99	.90	1.08	12.83
OVANDO	15.2	20.4	28.0	41.0	48.6	54.6	61.7	59.3	51.2	42.4	28.6	20.4	39.3	1.50	1.18	1.09	.67	1.79	2.33	1.00	.88	1.13	1.21	1.44	1.73	15.95
PHILIPSBURG RANGER STA	.	.	.	.	.	.	.	.	.	.	.	.	.	.84	.82	1.03	1.17	2.07	2.93	1.26	1.09	1.22	.96	.82	.76	14.97
PLEASANT VALLEY	19.5	23.5	30.1	40.2	48.4	54.2	60.1	57.9	50.9	42.2	30.1	24.2	40.1	1.91	1.52	1.30	1.19	1.54	2.08	1.02	.96	1.20	1.81	2.19	2.12	18.84
POLSON	25.1	27.7	35.1	45.1	53.1	59.7	67.4	65.7	56.9	46.3	34.6	29.7	45.5	1.02	.97	.89	1.16	1.93	2.27	1.00	.94	1.23	1.29	1.17	1.16	15.03
SAINT IGNATIUS	25.1	28.4	36.2	46.3	54.3	60.2	67.6	65.6	57.2	46.9	34.7	29.7	46.0	.84	.85	.99	1.32	2.21	2.51	.98	1.04	1.25	1.20	1.01	.90	15.10
SILVER LAKE	.	.	.	.	.	.	.	.	.	.	.	.	.	.98	1.10	1.52	1.76	2.49	3.18	1.48	1.29	1.61	1.29	1.08	.91	18.69
STEVENSVILLE	23.0	27.8	35.7	45.4	53.2	59.1	66.0	63.7	55.2	45.4	33.2	27.0	44.6	1.07	1.00	.83	.78	1.52	1.73	.93	.69	.92	.94	1.10	1.20	12.71
SUPERIOR	24.6	29.5	36.8	45.7	53.9	60.1	67.5	65.1	57.3	46.8	34.3	28.2	45.8	1.64	1.29	1.17	1.10	1.76	2.04	.78	.77	1.12	1.50	1.58	1.60	16.35
THOMPSON FALLS PH	26.6	30.8	38.1	47.2	55.3	61.3	69.2	67.6	59.8	48.7	36.0	30.9	47.6	2.11	1.70	1.88	1.52	1.79	1.96	.82	.80	1.29	2.07	2.41	2.45	20.80
WEST GLACIER	21.1	24.3	31.4	41.8	51.1	57.0	64.0	62.0	53.3	43.1	30.9	25.7	42.1	3.13	2.42	1.81	1.87	2.36	3.02	1.27	1.33	1.89	2.64	3.06	3.26	28.06
DIVISION	21.8	25.8	33.0	43.2	51.5	57.5	64.9	62.8	54.6	44.7	32.1	26.2	43.2	1.41	1.47	1.35	1.25	1.82	2.26	.99	.96	1.29	1.63	1.87	1.96	18.66
SOUTHWESTERN																										
BOZEMAN MONT ST UNIV	20.3	23.8	30.1	42.2	51.3	57.7	66.4	64.9	55.8	46.0	31.9	25.4	43.0	.90	.74	1.52	1.73	2.34	2.95	1.14	1.17	1.57	1.40	1.05	.87	17.38
BUTTE FAA AIRPORT	15.1	19.5	26.3	38.5	47.3	54.3	62.7	60.3	51.2	41.6	27.7	20.1	38.7	.42	.44	.65	.90	1.74	2.42	1.20	1.03	1.04	.67	.49	.48	11.48
DILLON WMCE	21.9	25.4	32.5	43.0	51.2	58.2	65.9	63.7	55.2	46.1	33.0	26.3	43.5	.44	.47	.71	1.12	1.81	2.14	1.16	.83	1.06	.76	.43	.41	11.34
ENNIS	21.8	25.1	31.6	42.1	50.8	57.3	64.8	62.8	54.4	45.8	33.0	26.9	43.0	.25	.25	.46	.95	1.64	2.47	1.14	.94	1.15	.72	.31	.29	10.57
HEBGEN DAM	11.4	15.4	22.6	34.8	45.8	53.3	61.3	60.0	51.3	40.7	25.0	16.0	36.5	2.76	2.41	2.39	1.67	2.49	2.85	1.53	1.32	1.45	1.86	2.38	2.73	25.84
LIMA	16.0	19.1	26.8	38.7	47.5	54.5	63.1	61.4	53.0	43.2	28.2	20.4	39.3	.33	.29	.55	.93	1.77	2.11	1.08	.93	.96	.87	.35	.33	10.50
NORRIS MADISON PH	25.5	28.4	34.5	45.2	54.4	61.4	70.8	69.2	59.9	49.7	36.5	30.3	47.2	.76	.76	1.34	2.01	2.55	3.14	1.38	1.13	1.66	1.38	.87	.73	17.71
TRIDENT	22.5	27.8	35.4	46.8	55.5	62.3	70.2	68.0	58.5	48.7	34.8	27.8	46.5	.	.	.	.	.	.	.	.	.	.	.	.	.
VIRGINIA CITY	20.8	24.2	30.2	40.7	49.5	56.3	65.7	63.7	54.7	44.8	31.3	25.0	42.2	.65	.51	1.03	1.39	1.86	2.57	1.38	1.11	1.22	.87	.72	.64	13.95
WEST YELLOWSTONE	11.7	16.2	22.5	34.4	44.2	51.5	59.6	57.1	48.3	38.0	22.3	15.0	35.1	2.30	1.81	1.88	1.44	2.14	2.44	1.26	1.18	1.17	1.63	1.79	2.18	21.22
DIVISION	18.1	21.9	28.5	40.0	49.0	55.8	64.1	62.1	53.3	43.7	29.7	22.7	40.7	.83	.73	1.05	1.23	1.93	2.48	1.19	1.06	1.22	1.05	.81	.83	14.41
NORTH CENTRAL																										
BABB 6 NE	19.5	20.9	26.8	38.3	47.6	53.2	60.3	58.5	50.9	42.8	31.3	25.1	39.6	.80	.91	1.06	1.56	2.58	4.04	1.63	1.74	1.98	1.26	1.06	.93	19.55
BIG SANDY	16.2	19.7	30.0	45.4	56.0	62.5	71.3	68.7	58.1	47.2	31.6	22.3	44.1	.31	.35	.59	.80	1.84	3.07	1.30	1.23	1.00	.63	.47	.47	12.06
BROWNING	19.4	21.3	27.6	39.7	48.9	54.8	62.8	60.4	52.5	43.7	31.0	24.8	40.6	.75	.72	.75	1.08	1.93	3.25	1.37	1.18	1.36	.91	.80	.71	14.81
CHINOOK	13.6	16.9	28.2	44.5	55.7	62.4	70.3	67.2	57.0	46.3	30.1	20.4	42.7	.51	.43	.60	.91	1.68	3.04	1.33	1.23	1.06	.71	.51	.51	12.52
CHOTEAU AIRPORT	22.0	24.1	30.6	42.2	52.0	58.4	66.4	64.0	54.9	46.4	33.9	27.4	43.5	.24	.32	.44	.74	2.00	3.07	1.32	1.14	1.07	.57	.31	.23	11.45
CONRAD AIRPORT	19.6	22.1	29.5	42.2	52.6	59.3	67.0	64.8	55.6	46.1	32.7	25.2	43.1	.31	.44	.61	.99	1.73	3.03	1.57	1.15	1.02	.59	.38	.36	12.18
CUT BANK FAA AP	17.4	19.4	26.9	39.9	50.4	56.8	65.3	62.6	53.3	43.7	30.2	23.2	40.8	.37	.38	.46	.79	1.72	2.84	1.35	1.31	1.11	.52	.35	.33	11.53
DUNKIRK 14 NNE	15.1	18.6	27.4	40.8	51.6	58.2	66.6	63.8	54.0	43.4	28.6	20.9	40.8	.37	.45	.48	.82	1.53	2.77	1.39	1.34	1.03	.59	.40	.44	11.61
FAIRFIELD	21.7	24.1	30.8	42.9	52.3	58.3	66.9	64.5	56.2	47.4	34.1	27.1	43.9	.30	.36	.50	.76	1.97	3.14	1.24	1.11	1.08	.64	.36	.24	11.72
FORT ASSINNIBOINE	14.4	16.6	27.2	43.3	54.6	61.3	70.0	67.2	56.6	45.6	29.9	21.0	42.3	.37	.34	.49	.89	1.47	2.76	1.31	1.21	.92	.72	.40	.37	11.25
HARLEM	12.2	15.7	27.3	43.6	55.2	61.7	69.8	66.5	56.2	45.6	29.2	19.3	41.9	.51	.51	.64	.79	1.54	3.10	1.46	1.13	.93	.68	.52	.49	12.30
HAVRE WSO	13.9	16.3	26.9	43.1	54.7	61.0	70.0	67.0	55.6	45.8	29.5	20.9	42.1	.49	.43	.60	.97	1.53	2.73	1.27	1.10	1.01	.79	.50	.47	11.89
MALTA	12.0	15.2	27.7	44.8	56.3	63.2	71.5	68.6	57.9	46.8	30.0	19.4	42.8	.43	.41	.60	.78	1.57	2.91	1.33	1.26	.99	.74	.42	.40	11.84
SIMPSON 6 NW	.	.	.	.	.	.	.	.	.	.	.	.	.	.32	.26	.36	.79	1.42	2.56	1.37	1.12	.90	.54	.31	.25	10.20
TELEGRAPH CREEK	15.3	18.8	29.3	44.3	55.5	62.7	71.8	69.4	58.6	47.4	31.4	22.5	43.9	.38	.29	.47	.81	1.60	2.78	1.21	1.06	1.05	.76	.43	.43	11.27
VALIER	19.8	21.8	28.6	41.3	51.7	57.9	66.3	64.1	55.5	46.0	32.5	25.4	42.6	.28	.35	.50	.93	1.89	3.51	1.57	1.21	1.15	.63	.40	.34	12.76
DIVISION	16.5	19.9	28.1	42.4	53.1	59.5	67.9	65.3	55.7	45.7	31.0	22.7	42.3	.41	.43	.58	.92	1.79	3.06	1.39	1.25	1.11	.70	.49	.44	12.56
CENTRAL																										
AUGUSTA	22.2	24.6	30.4	41.8	51.4	57.6	65.7	63.6	55.2	46.4	33.9	27.5	43.4	.50	.54	.82	1.05	2.05	3.16	1.33	1.24	1.24	.76	.64	.50	13.83
CASCADE 5 S	24.6	26.1	32.8	44.8	53.9	60.3	68.7	66.6	57.8	49.4	36.7	30.3	46.0	.46	.52	.81	1.17	2.39	3.33	1.20	1.00	1.36	.99	.60	.44	14.27
FLATWILLOW 4 ENE	20.8	23.6	30.9	44.2	54.6	61.9	71.5	69.2	58.9	48.0	34.2	26.7	45.4	.31	.38	.64	.85	1.94	3.17	1.40	1.19	.98	.88	.44	.39	12.57
GIBSON DAM	22.7	24.5	29.6	39.7	48.2	54.2	62.4	60.5	52.7	44.8	33.2	27.8	41.7	.75	.63	.93	1.28	2.63	3.53	1.41	1.44	1.72	1.23	1.05	.89	17.49
GREAT FALLS WSO	22.1	23.8	30.7	43.6	53.0	59.9	69.4	66.8	57.4	47.5	34.3	27.3	44.7	.61	.74	.92	.98	2.10	2.90	1.28	1.26	1.20	.73	.75	.60	14.07
HELENA 6 N	.	.	.	.	.	.	.	.	.	.	.	.	.	.34	.29	.37	.72	1.51	2.37	1.07	.89	.88	.49	.39	.36	9.68
HELENA WSO	18.6	23.2	31.4	43.3	52.9	59.5	68.4	66.2	56.0	45.6	31.6	24.2	43.4	.47	.43	.70	.83	1.56	2.23	1.03	.89	.95	.66	.57	.53	10.85
HOLTER DAM	26.0	28.2	34.4	45.8	55.3	62.2	71.3	69.1	59.8	50.5	38.2	31.8	47.7	.54	.47	.68	1.00	2.08	2.89	1.12	.86	1.12	.73	.53	.47	12.49
LEWISTOWN FAA AP	20.2	22.5	28.7	41.2	51.0	57.5	66.3	64.2	54.9	45.9	32.6	26.1	42.6	.57	.61	.85	1.00	2.60	3.87	1.58	1.53	1.44	1.07	.71	.69	16.52
MELSTONE	21.5	24.9	33.0	45.7	56.2	64.0	73.0	70.3	60.1	49.0	35.2	27.5	46.7	.43	.40	.64	.88	1.74	2.93	1.22	.94	.89	.87	.47	.49	11.90
MOCCASIN EXP STATION	20.8	22.8	28.6	40.9	50.8	57.2	66.6	64.8	55.3	46.0	32.7	26.6	42.8	.42	.41	.60	.96	2.21	3.43	1.41	1.41	1.22	.73	.48	.45	13.73
ROUNDUP	23.7	26.5	33.7	45.7	55.8	63.2	72.1	69.8	59.6	49.2	36.1	29.0	47.0	.29	.32	.56	.75	1.80	2.53	1.21	.97	.96	.82	.36	.36	10.93
STANFORD	22.1	23.6	29.5	41.2	51.0	57.3	66.5	64.5	55.5	46.1	33.6	27.6	43.2	.54	.56	.70	.99	2.38	3.39	1.65	1.51	1.27	.80	.60	.57	14.96
WHITE SULPHUR SPRINGS	20.1	22.8	28.6	40.6	50.1	56.7	65.2	63.3	53.6	44.2	31.2	24.8	41.8	.95	1.17	1.68	1.40	2.32	3.28	1.36	1.45	1.38	1.17	1.19	1.11	18.46
WINIFRED	18.4	21.3	29.9	43.7	54.2	60.8	69.8	67.1	56.9	46.2	32.2	24.3	43.7	.47	.42	.76	.77	1.76	3.00	1.46	1.04	1.12	.89	.57	.59	12.85
DIVISION	20.9	23.8	30.2	42.2	51.8	58.4	67.1	65.0	55.7	46.0	32.9	26.4	43.4	.58	.58	.83	1.05	2.08	3.05	1.32	1.17	1.23	.91	.70	.63	14.12

MONT 2

*NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

MONTANA Cont.

STATIONS (By Divisions)	TEMPERATURE (°F) JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN	PRECIPITATION (In.) JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
SOUTH CENTRAL																										
BALLANTINE	21.8	25.5	34.3	46.9	57.3	64.7	73.0	70.6	60.3	49.5	35.1	27.0	47.2	.42	.48	.80	1.01	1.68	2.53	.84	.89	1.04	.89	.52	.48	11.58
BIG TIMBER	27.1	29.7	35.1	45.8	54.9	61.9	70.7	68.7	59.7	50.0	37.9	31.7	47.8	.45	.51	1.05	1.49	2.54	2.55	.99	1.10	1.39	1.09	.69	.51	14.36
BILLINGS WATER PLANT	23.7	27.4	34.9	46.9	56.7	63.9	72.1	69.4	59.6	49.4	36.1	28.9	47.4	.46	.48	.78	1.34	2.12	2.80	.84	1.06	1.27	1.14	.59	.52	13.40
BILLINGS WSO	23.2	25.7	33.7	46.0	56.8	65.1	74.7	71.9	60.4	49.5	35.1	28.4	47.5	.54	.60	1.05	1.31	1.88	2.55	.90	.90	1.19	1.09	.63	.59	13.23
BUSBY	17.9	21.7	31.0	44.0	54.1	62.1	71.0	68.9	58.0	46.9	32.3	23.7	44.3	.36	.33	.62	1.15	1.99	2.42	1.07	1.10	1.08	.90	.57	.44	12.03
COLUMBUS	22.6	26.3	33.7	45.4	55.2	62.0	70.3	68.5	59.0	48.5	34.7	27.3	46.1	.38	.36	.85	1.50	2.34	2.79	.89	.76	1.23	1.12	.60	.44	13.26
CROW AGENCY	19.9	24.3	33.6	46.1	56.5	64.2	72.5	69.7	59.3	48.6	34.1	25.7	46.2	.62	.61	1.18	1.71	1.94	2.59	.84	.95	1.29	1.23	.74	.74	14.44
HUNTLEY EXP STATION	20.3	23.3	32.4	45.1	55.5	63.0	71.2	68.8	58.4	47.8	33.8	25.6	45.4	.38	.45	.77	1.06	1.77	2.47	.76	.86	1.04	.93	.52	.47	11.48
LIVINGSTON	25.5	28.0	33.3	43.7	52.6	59.4	68.6	66.6	57.4	48.2	35.6	30.0	45.7	.51	.49	.92	1.21	1.98	2.25	1.07	1.18	1.40	1.08	.66	.63	13.38
MYSTIC LAKE	23.9	25.1	28.9	38.6	47.5	54.2	63.4	62.0	53.6	45.1	33.0	27.9	41.9	1.25	1.16	2.34	2.64	3.24	3.39	2.00	1.77	2.01	1.53	1.37	1.12	24.02
RAPELJE 4 S	23.5	25.9	32.1	43.4	53.2	60.5	69.9	68.2	58.4	48.0	34.7	28.6	45.5	.45	.47	.82	1.18	2.15	2.72	1.02	1.06	1.12	1.00	.58	.38	12.95
RED LODGE	21.7	23.4	28.4	39.3	48.9	55.8	64.7	62.5	53.7	44.7	32.0	26.7	41.8	.82	.79	1.71	2.85	3.07	3.21	1.39	1.16	1.71	1.42	1.20	.69	20.02
DIVISION	22.2	25.2	32.2	44.0	53.7	61.0	69.7	67.7	57.8	47.9	34.2	27.1	45.2	.59	.59	1.06	1.51	2.16	2.64	1.11	1.04	1.31	1.13	.73	.62	14.49
NORTHEASTERN																										
CIRLE 7 N	13.1	16.5	27.3	42.8	54.1	62.0	70.0	67.8	56.9	45.5	29.6	20.5	42.2	.27	.22	.34	.91	1.45	2.93	1.84	1.22	.93	.63	.34	.25	11.33
CULBERTSON	9.5	13.4	25.5	42.6	54.9	62.6	70.5	68.2	57.2	45.3	27.9	17.5	[illegible]	.34	.29	.42	.94	1.60	3.36	1.79	1.49	1.08	.76	.45	.32	12.84
FRAZER	8.1	12.4	25.8	43.1	55.2	62.8	71.2	68.7	57.5	45.4	27.7	16.7	41.2	.47	.41	.69	1.09	1.48	3.19	1.59	1.35	1.04	.67	.46	.38	12.82
GLASGOW WSO	9.8	13.6	26.7	43.4	55.1	62.3	70.7	67.8	56.7	45.4	28.2	17.7	41.4	.48	.41	.56	1.01	1.49	2.98	1.33	1.49	.96	.64	.47	.45	12.27
GLENDIVE	15.2	18.7	30.5	46.5	58.4	66.3	74.7	72.0	60.8	48.8	32.5	22.6	45.6	.39	.39	.62	1.03	1.60	3.17	1.73	1.48	.90	.71	.41	.30	12.73
HAXBY 18 SW	16.1	19.0	28.9	43.8	55.1	62.7	71.8	69.5	58.5	47.7	31.8	23.0	44.0	.43	.36	.67	1.12	1.62	3.26	1.32	1.37	1.10	.74	.50	.41	12.90
JORDAN	•	•	•	•	•	•	•	•	•	•	•	•	•	.34	.29	.52	.91	1.38	2.46	1.22	1.05	.79	.64	.37	.34	10.31
LUSTRE 4 NNW	•	•	•	•	•	•	•	•	•	•	•	•	•	.28	.24	.37	.81	1.38	2.93	1.74	1.60	.99	.55	.31	.22	11.42
MEDICINE LAKE 3 SE	•	•	•	•	•	•	•	•	•	•	•	•	•	.31	.29	.36	.92	1.55	3.30	2.04	1.48	1.06	.69	.47	.30	12.77
POPLAR	9.4	13.8	26.5	44.2	56.2	63.9	71.6	69.2	58.4	46.3	28.7	17.6	42.2	.30	.30	.46	.87	1.47	3.19	2.21	1.54	.93	.64	.38	.29	12.58
SAVAGE	12.8	16.6	28.2	44.4	56.3	64.3	72.0	69.5	58.7	47.0	30.3	20.4	43.4	.40	.31	.54	1.18	1.61	3.30	2.09	1.54	1.10	.66	.42	.26	13.41
VIDA	12.6	15.8	26.6	43.3	55.2	62.5	71.2	69.2	58.2	46.7	29.7	20.5	42.6	.75	.64	.85	1.32	1.70	3.42	1.91	1.36	1.10	.88	.71	.60	15.24
DIVISION	10.8	15.3	26.2	43.0	55.1	62.7	70.9	68.4	57.5	45.9	28.8	18.5	41.9	.40	.35	.52	.96	1.53	3.09	1.84	1.49	1.00	.68	.43	.35	12.64
SOUTHEASTERN																										
BAKER	•	•	•	•	•	•	•	•	•	•	•	•	•	.38	.33	.59	1.04	1.67	3.24	1.81	1.37	1.04	.72	.37	.29	12.85
COLSTRIP	21.6	24.5	32.4	44.8	55.1	63.5	72.6	70.5	59.8	48.6	34.4	26.8	46.2	.58	.60	1.00	1.64	2.26	2.94	1.23	1.22	1.19	1.22	.66	.59	15.13
EKALAKA	17.9	20.8	29.8	43.1	54.4	62.8	71.6	69.8	58.7	47.0	31.1	23.7	44.1	.40	.35	.62	1.11	1.95	2.96	1.90	1.39	1.01	.74	.45	.34	13.22
MILDRED	15.5	19.0	29.8	44.8	56.4	64.7	73.5	71.1	59.6	47.7	31.7	22.4	44.7	.38	.31	.56	1.05	1.80	2.84	1.64	1.34	.89	.77	.45	.33	12.36
MILES CITY FAA AIRPORT	16.5	20.3	30.9	45.7	57.4	65.6	75.3	72.6	61.0	49.0	32.6	23.2	45.8	.44	.37	.65	1.06	1.73	2.71	1.34	1.24	.96	.87	.43	.37	12.17
PLEVNA	14.7	17.4	27.2	42.7	54.3	62.6	71.5	69.7	58.4	46.4	30.0	21.1	43.0	.39	.39	.58	1.14	1.68	2.95	1.74	1.22	.97	.80	.41	.32	12.60
DIVISION	17.8	21.5	30.4	44.4	55.4	63.6	72.5	70.4	59.2	47.8	32.2	23.8	44.9	.43	.39	.70	1.17	1.88	2.81	1.48	1.17	.95	.88	.52	.41	12.79

* Normals for the period 1931-1960. Divisional normals may not be the arithmetical average of individual stations published, since additional data for shorter period stations are used to obtain better areal representation.

CONFIDENCE - LIMITS

In the absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State. Because of the wider variation in mean precipitation, the corresponding monthly means and annual mean must be substituted for "p" in the precipitation table below to obtain mean precipitation confidence limits.

**	2.6	2.1	1.2	1.0	1.0	.9	.5	.6	1.0	1.0	1.2	1.5	.5	$.16\sqrt{p}$	$.15\sqrt{p}$	$.15\sqrt{p}$	$.19\sqrt{p}$	$.25\sqrt{p}$	$.24\sqrt{p}$	$.21\sqrt{p}$	$.26\sqrt{p}$	$.27\sqrt{p}$	$.25\sqrt{p}$	$.20\sqrt{p}$	$.18\sqrt{p}$	$.22\sqrt{p}$
***	3.2	2.8	1.5	1.2	1.2	.9	.8	.7	1.1	1.3	1.7	2.1	.7	$.15\sqrt{p}$	$.14\sqrt{p}$	$.18\sqrt{p}$	$.23\sqrt{p}$	$.27\sqrt{p}$	$.32\sqrt{p}$	$.28\sqrt{p}$	$.25\sqrt{p}$	$.29\sqrt{p}$	$.25\sqrt{p}$	$.19\sqrt{p}$	$.17\sqrt{p}$	$.24\sqrt{p}$

** Western and Southwestern Divisions
*** All Other Divisions

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for Bozeman Agricultural College, Montana, for the period 1906-1930 and are included in this publication for comparative purposes.

19.4	23.0	30.4	40.6	48.6	57.0	64.5	62.5	52.9	42.7	31.4	21.3	41.2	0.93	0.71	1.14	1.69	3.05	2.57	1.56	1.18	1.96	1.67	1.15	0.90	18.51

NEV,

*MEAN TEMPERATURE AND PRECIPITATION

NEVADA

STATION	JANUARY Temperature	JANUARY Precipitation	FEBRUARY Temperature	FEBRUARY Precipitation	MARCH Temperature	MARCH Precipitation	APRIL Temperature	APRIL Precipitation	MAY Temperature	MAY Precipitation	JUNE Temperature	JUNE Precipitation
NORTHWESTERN												
CARSON CITY	31.7	2.21	35.9	1.70	41.2	1.23	48.1	.56	55.1	.46	61.9	.38
EMPIRE	30.2	.82	35.4	.79	42.0	.52	51.0	.44	58.7	.68	66.0	.56
FALLON EXP STATION	29.9	.57	35.5	.66	42.1	.55	50.4	.51	57.5	.61	64.2	.42
GOLCONDA		.66		.60		.70		.53		.60		.63
IMLAY		.72		.66		.60		.61		.83		.67
LAHONTAN DAM	31.8	.47	36.7	.59	43.6	.34	52.4	.37	60.3	.44	67.9	.38
LOVELOCK	30.0	.82	35.6	.71	42.5	.54	51.1	.53	59.0	.46	66.1	.62
MINDEN	30.8	1.36	35.7	1.26	41.0	.91	48.4	.56	55.3	.43	62.0	.48
OROVADA		1.14		1.14		1.04		1.25		1.51		1.21
PARADISE VALLEY 1 NW		1.37		1.00		.70		.66		.85		.82
RENO WB AP	31.2	1.04	38.3	1.05	40.6	.70	47.7	.46	55.3	.48	61.5	.42
SAND PASS	29.7	1.01	35.4	.80	42.4	.53	50.5	.47	57.7	.50	64.7	.49
SMITH		.88		.96		.57		.49		.49		.54
WINNEMUCCA WB AP	27.8	.96	34.5	1.01	39.4	.86	46.8	.83	55.9	.84	64.0	.79
YERINGTON	30.9	.59	35.9	.56	41.7	.41	49.6	.37	56.3	.51	62.6	.50
DIVISION	29.9	1.13	34.8	.98	39.6	.83	48.1	.62	55.3	.75	62.3	.58
NORTHEASTERN												
ARTHUR 5 NW		2.06		1.70		1.67		1.41		1.58		1.24
AUSTIN	27.9	1.21	30.5	1.22	35.4	1.50	43.7	1.55	51.3	1.33	59.2	.85
ELKO WB AP	21.9	1.07	28.4	.95	36.1	.69	44.6	.93	53.0	.95	60.3	.70
ELY WB AP	23.0	.94	28.1	.90	35.3	1.29	43.7	1.20	51.7	1.18	59.6	.50
KIMBERLY	24.3	1.55	27.0	1.58	32.5	1.61	42.6	1.35	50.5	.94	59.1	.87
LAMOILLE PH	25.5	1.46	28.3	1.56	34.8	2.01	43.4	2.67	51.2	2.17	58.5	1.48
MC GILL	26.0	.70	29.6	.64	35.6	.77	44.9	1.02	53.3	.80	61.8	.65
MONTELLO	23.3	.57	28.5	.38	37.2	.28	46.9	.59	55.1	.76	62.9	.65
OWYHEE		1.38		1.19		1.25		1.35		1.64		1.22
DIVISION	24.1	1.13	28.3	.88	34.4	1.03	43.8	1.15	51.3	1.12	58.7	.88
SOUTH CENTRAL												
ADAVEN	28.6	1.54	31.1	1.58	37.0	1.50	46.0	1.13	53.7	.76	61.6	.55
CALIENTE	30.0	.86	35.7	.80	43.6	.92	52.5	.74	60.5	.51	68.2	.38
MINA	31.8	.34	36.6	.26	43.3	.31	52.0	.42	60.5	.40	68.9	.27
SCHURZ	32.5	.56	37.5	.57	43.5	.44	51.3	.48	58.7	.63	65.5	.43
DIVISION	29.5	.57	34.3	.55	39.7	.62	49.0	.64	56.6	.37	64.4	.24
EXTREME SOUTHERN												
ALAMO		.75		.71		.74		.58		.40		.18
BEATTY		.66		.72		.54		.43		.20		.08
BOULDER CITY	45.3	.74	49.5	.60	56.4	.55	65.6	.38	73.9	.13	82.2	.06
LAS VEGAS WB AP	44.2	.44	50.4	.58	56.5	.35	65.6	.24	74.1	.16	83.6	.13
SEARCHLIGHT		.96		.86		.85		.36		.15		.10
DIVISION	42.7	.67	47.2	.51	53.5	.49	62.9	.28	70.7	.14	78.6	.09

STATION	JULY Temperature	JULY Precipitation	AUGUST Temperature	AUGUST Precipitation	SEPTEMBER Temperature	SEPTEMBER Precipitation	OCTOBER Temperature	OCTOBER Precipitation	NOVEMBER Temperature	NOVEMBER Precipitation	DECEMBER Temperature	DECEMBER Precipitation	ANNUAL Temperature	ANNUAL Precipitation
NORTHWESTERN														
CARSON CITY	69.6	.18	67.8	.09	61.2	.29	51.4	.70	40.2	1.34	34.2	2.46	49.9	11.50
EMPIRE	76.1	.17	74.0	.12	65.8	.15	54.2	.50	40.5	.56	33.5	.85	52.3	8.16
FALLON EXP STATION	72.4	.17	69.9	.12	62.0	.20	51.7	.50	39.4	.35	32.6	.68	50.6	5.34
GOLCONDA		.16		.08		.22		.55		.69		.80		6.20
IMLAY		.19		.10		.21		.69		.58		.78		6.64
LAHONTAN DAM	77.9	.11	76.2	.11	67.0	.24	55.6	.40	42.3	.30	34.7	.56	53.9	4.31
LOVELOCK	75.1	.13	72.5	.14	64.7	.20	53.2	.54	40.2	.42	33.2	.65	51.9	5.76
MINDEN	69.5	.32	67.7	.21	60.8	.17	51.2	.56	40.0	.83	33.9	1.87	49.7	8.96
OROVADA		.26		.11		.40		1.05		.96		1.21		11.28
PARADISE VALLEY 1 NW		.22		.14		.31		.66		.90		1.15		8.76
RENO WB AP	69.6	.23	67.4	.33	60.5	.22	50.7	.55	40.2	.64	33.2	.94	49.5	8.98
SAND PASS	73.1	.18	71.0	.07	63.5	.19	52.9	.45	39.8	.61	33.1	1.23	51.2	6.33
SMITH		.34		.26		.15		.49		.75		1.32		7.24
WINNEMUCCA WB AP	74.2	.31	69.7	.18	59.9	.34	48.6	.79	37.6	.84	30.0	1.00	49.1	8.75
YERINGTON	70.3	.23	68.6	.18	61.3	.22	51.3	.49	39.4	.45	32.7	.83	50.1	5.33
DIVISION	71.4	.21	69.2	.14	61.9	.31	51.2	.65	39.6	.81	32.6	1.42	49.7	8.43
NORTHEASTERN														
ARTHUR 5 NW		.57		.43		.55		1.11		1.47		1.65		15.44
AUSTIN	70.0	.57	68.5	.46	60.7	.40	49.5	1.11	37.6	.91	31.7	1.24	47.2	12.35
ELKO WB AP	70.2	.37	67.6	.29	57.8	.39	47.4	.81	34.5	.93	26.9	1.05	45.7	9.13
ELY WB AP	68.4	.55	66.3	.69	57.8	.68	46.9	.82	35.2	.69	26.9	.88	45.2	10.32
KIMBERLY	69.1	.90	66.9	.88	58.6	.71	47.6	.90	35.0	.87	28.0	1.58	45.1	13.34
LAMOILLE PH	69.1	.74	67.4	.50	58.1	.76	48.4	1.48	36.0	1.61	28.7	1.72	45.8	18.18
MC GILL	71.4	.76	69.6	.74	61.1	.52	49.4	.79	36.9	.60	29.9	.70	47.5	8.69
MONTELLO	72.4	.63	69.5	.46	59.9	.37	49.0	.44	34.9	.61	27.0	.60	47.2	8.32
OWYHEE		.36		.25		.40		1.05		1.06		1.38		12.53
DIVISION	68.4	.51	66.2	.41	57.7	.44	47.4	.76	35.1	.94	27.4	1.21	45.2	10.46
SOUTH CENTRAL														
ADAVEN	69.9	1.02	67.9	1.15	61.4	.55	50.1	.98	38.9	.87	31.9	1.39	48.2	13.00
CALIENTE	76.0	.84	74.0	1.06	66.1	.53	54.1	.85	41.7	.63	33.4	.99	53.0	9.11
MINA	78.3	.24	75.7	.25	66.4	.14	54.3	.39	41.6	.21	34.3	.34	53.6	3.57
SCHURZ	73.4	.38	71.7	.19	63.6	.20	53.7	.44	41.5	.40	34.5	.69	52.3	5.39
DIVISION	73.4	.68	71.3	.53	63.6	.38	52.7	.48	40.5	.48	33.5	.71	50.7	6.23
EXTREME SOUTHERN														
ALAMO		.80		.83		.33		.47		.38		.69		6.86
BEATTY		.22		.26		.18		.30		.38		.62		4.39
BOULDER CITY	89.1	.62	87.0	.66	81.2	.52	68.9	.24	55.5	.28	47.6	.61	66.9	5.39
LAS VEGAS WB AP	90.5	.46	88.4	.53	80.7	.34	67.4	.32	53.9	.22	46.8	.58	66.8	4.35
SEARCHLIGHT		1.10		1.07		.77		.41		.41		.95		7.99
DIVISION	86.3	.46	84.2	.46	77.3	.38	65.5	.28	52.4	.32	44.6	.52	63.6	4.56

* Averages for period 1931 - 1955, except for stations marked WB which are "normals" based on period 1921 - 1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.

CONFIDENCE LIMITS

In the absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State. Because of the wider variation in mean precipitation, the corresponding monthly means and annual mean must be substituted for "p" in the precipitation table below to obtain mean precipitation confidence limits.

2.2	$.27\sqrt{p}$	1.9	$.28\sqrt{p}$	1.2	$.24\sqrt{p}$	1.1	$.23\sqrt{p}$	1.1	$.26\sqrt{p}$	1.1	$.24\sqrt{p}$	.8	$.22\sqrt{p}$	.7	$.27\sqrt{p}$	1.0	$.29\sqrt{p}$	1.0	$.28\sqrt{p}$	1.2	$.26\sqrt{p}$	1.5	$.27\sqrt{p}$	.5	$.26\sqrt{p}$

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for Fallon, Nevada for the period 1906-1930 and are included in this publication for comparative purposes:

30.0	.60	36.7	.45	43.3	.42	50.2	.51	57.3	.50	65.5	.32	73.5	.15	71.0	.27	61.0	.33	50.4	.37	39.0	.33	31.4	.53	50.8	4.81

NM-1

NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

NEW MEXICO (1) — TEMPERATURE (°F) — PRECIPITATION (In.)

STATIONS (By Divisions)	TEMP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN	PRECIP JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
NORTHWESTERN PLATEAU																										
AZTEC RUINS NAT MON	29.0	34.4	41.3	50.2	58.6	67.2	73.8	71.9	64.7	53.6	39.2	31.1	51.3	.74	.76	.79	.60	.67	.44	.94	1.32	1.12	1.09	.49	.86	9.82
BLOOMFIELD 3 SE	.	.	.	.	.	.	.	.	.	.	.	.	.	.52	.67	.59	.51	.63	.33	.81	1.32	.87	.93	.44	.60	8.22
ZUNI FAA AIRPORT	29.4	34.1	40.1	48.3	56.2	65.3	70.8	69.2	63.1	52.2	39.1	32.0	50.0	.79	.83	.77	.61	.45	.46	1.68	1.81	1.09	1.03	.62	.77	10.91
DIVISION	27.8	32.6	39.2	48.2	56.8	66.1	71.9	70.0	63.2	52.0	38.0	30.1	49.7	.76	.81	.79	.64	.64	.47	1.42	1.78	1.13	1.01	.60	.79	10.84
NORTHERN MOUNTAINS																										
ABBOTT 2 SE	.	.	.	.	.	.	.	.	.	.	.	.	.	.32	.23	.42	.77	2.19	1.63	2.51	3.23	1.42	1.29	.43	.25	14.69
BANDELIER NAT MON	.	.	.	.	.	.	.	.	.	.	.	.	.	.79	.78	.94	.86	1.36	.86	2.36	2.60	1.62	1.41	.80	.88	15.26
BLACK LAKE	.	.	.	.	.	.	.	.	.	.	.	.	.	.62	.55	.96	1.15	1.89	1.50	2.84	3.28	1.49	1.35	.62	.43	16.68
CERRO 4 NE	.	.	.	.	.	.	.	.	.	.	.	.	.	.64	.60	.58	.97	1.34	.87	1.70	1.92	1.43	1.19	.61	.61	12.46
CHACON	.	.	.	.	.	.	.	.	.	.	.	.	.	1.11	.78	1.07	1.22	1.82	1.46	2.97	3.73	1.75	1.29	.90	.91	19.01
CHAMA	.	.	.	.	.	.	.	.	.	.	.	.	.	1.80	1.67	1.51	1.37	1.40	.92	1.58	2.32	1.86	1.57	.96	1.63	18.59
CIMARRON	32.2	35.4	40.5	48.8	57.0	66.2	69.8	68.4	62.3	52.4	40.1	34.6	50.6	.42	.45	.67	1.20	2.21	1.41	2.22	2.53	1.36	1.24	.60	.34	14.65
DES MOINES	.	.	.	.	.	.	.	.	.	.	.	.	.	.50	.47	.88	1.46	2.55	1.79	3.07	3.36	1.64	1.15	.65	.39	17.91
EAGLE NEST	.	.	.	.	.	.	.	.	.	.	.	.	.	.73	.78	.92	1.06	1.62	1.08	2.48	2.55	1.27	1.14	.75	.59	14.97
EL RITO	.	.	.	.	.	.	.	.	.	.	.	.	.	.74	.67	.77	.75	1.16	.69	1.60	1.99	1.33	1.12	.55	.62	11.99
JEMEZ SPRINGS	32.9	36.4	42.1	50.6	58.2	66.8	70.8	69.3	63.9	53.7	41.8	35.0	51.8	.88	.95	1.05	1.01	1.32	1.33	2.46	3.16	2.02	1.75	.87	.88	17.68
LAS VEGAS 2 NW	32.3	35.8	40.5	48.6	56.5	66.0	69.0	68.1	61.8	52.3	40.3	34.5	50.5	.65	.47	.78	.91	1.82	1.76	2.58	2.74	2.16	1.09	.54	.44	15.94
LOS ALAMOS	.	.	.	.	.	.	.	.	.	.	.	.	.	.78	.64	.88	.92	1.35	1.38	2.73	3.92	1.89	1.65	.70	.83	17.67
PECOS RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	.68	.68	.98	.80	1.26	1.19	2.79	3.07	1.73	1.15	.49	.68	15.50
PENASCO RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	1.04	1.02	1.20	1.14	1.37	.99	1.98	2.10	1.34	1.32	.87	.82	15.19
RED RIVER	19.4	22.2	28.2	37.6	45.1	53.5	58.1	57.3	51.5	42.1	28.9	21.7	38.8	1.07	1.10	1.35	1.60	1.80	1.24	2.56	3.07	1.49	1.47	.98	.93	18.66
SANTA FE	29.9	33.7	39.2	48.1	56.7	66.5	70.5	68.7	62.9	52.0	39.0	32.1	49.9	.69	.69	.79	.83	1.37	1.14	2.19	2.27	1.44	1.05	.60	.70	13.76
TAOS	.	.	.	.	.	.	.	.	.	.	.	.	.	.82	.72	.79	.92	1.20	.76	1.58	1.77	1.11	1.13	.71	.57	12.08
TIERRA AMARILLA 4 NNW	.	.	.	.	.	.	.	.	.	.	.	.	.	1.41	1.06	1.04	1.15	1.10	.91	1.85	2.33	1.64	1.19	.88	1.24	15.80
TRES PIEDRAS	.	.	.	.	.	.	.	.	.	.	.	.	.	.85	.86	.76	.85	1.11	.69	1.93	2.32	1.36	1.05	.59	.80	13.17
VALMORA	30.7	34.0	38.7	47.2	55.3	64.4	68.7	67.4	61.4	51.1	38.6	33.3	49.2	.45	.31	.59	.89	1.93	1.74	2.79	2.89	1.82	1.30	.55	.41	15.67
WOLF CANYON	.	.	.	.	.	.	.	.	.	.	.	.	.	1.64	1.77	1.90	1.50	1.45	1.04	2.91	3.28	2.14	1.62	1.16	1.51	21.92
DIVISION	26.7	30.2	36.0	44.8	53.0	62.1	66.4	65.1	58.9	48.6	36.0	29.2	46.6	.81	.80	.95	1.12	1.65	1.24	2.39	2.76	1.64	1.28	.70	.73	16.07
NORTHEASTERN PLAINS																										
AMISTAD 1 SSW	.	.	.	.	.	.	.	.	.	.	.	.	.	.47	.43	.66	1.25	2.49	1.54	2.46	2.39	1.57	1.04	.44	.60	15.34
BELL RANCH	36.6	40.9	47.1	56.4	64.8	74.9	78.3	77.2	70.4	58.5	44.9	38.0	57.3	.33	.33	.63	1.05	1.81	1.60	2.47	2.78	1.68	1.03	.38	.43	14.52
CLAYTON WSO	33.2	36.0	40.9	50.7	59.8	70.2	74.5	73.3	66.0	55.3	41.7	36.0	53.1	.35	.37	.63	1.19	2.74	1.48	2.33	2.09	1.65	1.00	.33	.35	14.51
CLOVIS	37.4	41.3	47.2	56.7	65.7	75.4	78.5	77.4	70.2	59.3	46.1	39.4	57.9	.55	.41	.49	.92	2.51	2.30	2.64	2.62	2.10	1.89	.46	.59	17.48
ELIDA	.	.	.	.	.	.	.	.	.	.	.	.	.	.41	.35	.50	.77	1.86	1.63	2.64	2.38	2.16	1.47	.39	.53	15.09
MELROSE	.	.	.	.	.	.	.	.	.	.	.	.	.	.43	.36	.46	.77	2.06	1.63	2.64	2.53	1.73	1.63	.36	.53	15.13
MOSQUERO	33.6	37.0	41.9	50.8	59.4	69.1	73.0	71.3	64.6	54.6	42.2	35.4	52.7	.48	.41	.57	1.09	2.36	1.82	2.85	2.94	1.89	.98	.48	.38	16.25
NEWKIRK	.	.	.	.	.	.	.	.	.	.	.	.	.	.43	.48	.62	.88	1.74	1.64	2.13	2.30	1.69	.92	.39	.59	13.81
PASAMONTE	.	.	.	.	.	.	.	.	.	.	.	.	.	.37	.31	.49	1.02	2.12	1.80	2.49	2.54	1.59	1.02	.27	.31	14.33
PORTALES	37.3	41.8	48.2	57.2	65.8	75.1	77.5	76.5	69.5	58.8	45.7	39.1	57.7	.46	.36	.54	.77	2.42	2.38	2.91	2.66	1.91	1.50	.45	.58	16.94
ROY	.	.	.	.	.	.	.	.	.	.	.	.	.	.41	.43	.63	.91	2.50	1.62	2.32	2.22	1.72	1.40	.43	.53	15.12
SAN JON	37.6	42.0	48.1	57.3	65.9	76.1	79.2	78.0	71.3	59.9	46.3	39.5	58.4	.41	.38	.51	.89	2.28	1.67	2.81	2.62	1.33	1.17	.46	.65	15.18
SPRINGER	30.0	34.9	40.9	49.9	58.7	67.7	71.5	70.1	63.3	52.6	39.0	31.3	50.8	.46	.33	.59	1.11	1.96	1.68	2.39	3.00	1.76	1.35	.61	.35	15.59
STEAD	.	.	.	.	.	.	.	.	.	.	.	.	.	.34	.35	.53	1.37	2.77	1.57	2.69	2.33	1.69	1.01	.38	.40	15.43
TUCUMCARI 3 NE	37.7	41.3	47.5	57.0	65.7	75.8	79.1	77.8	71.0	60.0	46.5	39.4	58.2	.42	.43	.59	.89	2.27	1.61	2.75	2.50	1.35	1.13	.49	.64	15.07
DIVISION	35.3	39.1	45.0	54.3	62.9	72.6	76.1	74.9	68.0	57.2	44.0	37.4	55.6	.41	.37	.55	.99	2.29	1.80	2.70	2.53	1.69	1.25	.41	.48	15.47
SOUTHWESTERN MOUNTAIN																										
AUGUSTINE	.	.	.	.	.	.	.	.	.	.	.	.	.	.44	.52	.53	.47	.45	.64	2.06	2.24	1.44	.90	.27	.55	10.51
FORT BAYARD	37.7	41.0	45.5	53.0	60.7	70.2	72.7	70.9	66.4	56.7	45.4	40.1	55.0	.84	.97	.62	.41	.42	.77	2.79	3.23	1.97	1.01	.57	.81	14.41
LUNA RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	1.04	.80	.76	.62	.48	.73	2.59	2.90	1.71	1.36	.59	.95	14.53
MIMBRES RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	1.16	1.15	.87	.54	.45	.93	2.97	3.40	1.95	1.33	.67	1.05	16.47
PINOS ALTOS	.	.	.	.	.	.	.	.	.	.	.	.	.	1.33	1.70	1.16	.70	.46	1.06	3.27	4.17	2.04	1.41	.69	1.29	19.30
QUEMADO RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	.73	.54	.62	.53	.47	.65	1.83	2.18	1.30	.66	.39	.50	10.40
RESERVE RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.	1.11	.85	1.12	.67	.42	.72	2.10	2.69	1.61	1.30	.61	.95	14.15
WINSTON	.	.	.	.	.	.	.	.	.	.	.	.	.	.55	.60	.41	.45	.52	.82	2.25	2.75	1.95	.97	.30	.57	12.14
DIVISION	31.5	35.3	40.6	48.4	56.4	65.6	69.5	67.5	61.9	51.8	39.7	33.5	50.1	.73	.67	.66	.54	.50	.75	2.27	2.71	1.61	.98	.46	.71	12.59

*NORMALS BY CLIMATOLOGICAL DIVISIONS

Taken from "Climatography of the United States No. 81-4, Decennial Census of U. S. Climate"

NEW MEXICO, CONT.

TEMPERATURE (°F)

STATIONS (By Divisions)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
CENTRAL VALLEY													
ALBUQUERQUE WSO	35.0	39.9	45.8	55.7	65.1	74.9	78.5	76.2	70.0	58.0	43.6	37.0	56.6
BOSQUE DEL APACHE	.	.	.	.	.	.	.	.	.	.	.	.	.
CARRIZOZO	37.0	40.9	46.8	55.0	63.6	72.9	75.4	73.8	68.0	57.2	44.0	38.2	56.1
ELEPHANT BUTTE DAM	41.3	46.3	52.3	60.8	69.1	78.3	80.3	78.5	73.0	62.7	49.5	42.5	61.2
SOCORRO	37.5	43.0	49.6	58.5	66.5	75.8	79.0	77.1	70.5	59.2	45.5	38.3	58.4
DIVISION	36.2	41.0	47.4	56.2	64.6	73.8	77.4	75.7	69.0	57.9	44.3	37.3	56.7
CENTRAL HIGHLANDS													
ANCHO	.	.	.	.	.	.	.	.	.	.	.	.	.
CLOUDCROFT LODGE	.	.	.	.	.	.	.	.	.	.	.	.	.
CORONA	33.9	37.0	42.4	50.2	58.4	67.4	69.9	68.6	63.2	53.7	42.0	35.5	51.9
GRAN QUIVIRA NAT MON	.	.	.	.	.	.	.	.	.	.	.	.	.
MAYHILL RANGER STATION	.	.	.	.	.	.	.	.	.	.	.	.	.
MC INTOSH 4 NW	30.2	34.7	40.5	49.0	57.4	66.6	70.1	68.5	62.2	51.6	39.0	32.4	50.2
MESCALERO	.	.	.	.	.	.	.	.	.	.	.	.	.
MOUNTAIN PARK	.	.	.	.	.	.	.	.	.	.	.	.	.
MOUNTAINAIR	.	.	.	.	.	.	.	.	.	.	.	.	.
PROGRESSO	.	.	.	.	.	.	.	.	.	.	.	.	.
DIVISION	31.7	35.3	40.5	48.6	56.7	65.6	68.5	67.1	61.5	51.7	39.8	33.8	50.1
SOUTHEASTERN PLAINS													
ARTESIA 6 S	40.8	44.9	51.8	60.9	69.4	78.4	80.0	79.4	72.7	62.1	48.8	41.8	60.9
CARLSBAD	.	.	.	.	.	.	.	.	.	.	.	.	.
CARLSBAD CAVERNS	45.6	48.8	53.7	62.9	70.5	78.2	78.9	78.4	72.9	64.4	53.6	47.4	62.9
CROSSROADS 2 NE	.	.	.	.	.	.	.	.	.	.	.	.	.
ELK 3 E	38.0	40.5	45.4	52.5	59.9	67.8	69.6	68.7	63.5	54.9	44.6	39.7	53.8
FLYING H	.	.	.	.	.	.	.	.	.	.	.	.	.
FORT SUMNER	.	.	.	.	.	.	.	.	.	.	.	.	.
LAKE AVALON	.	.	.	.	.	.	.	.	.	.	.	.	.
ROSWELL WSO	37.9	42.1	49.5	59.0	68.0	77.1	78.6	76.6	69.7	59.0	45.9	39.0	58.5
SANTA ROSA	38.5	42.3	47.9	56.8	65.2	74.4	77.3	76.1	69.2	58.5	46.4	40.5	57.8
DIVISION	40.2	44.1	50.1	58.7	66.9	76.0	77.9	77.1	70.6	60.6	48.0	41.8	59.3
SOUTHERN DESERT													
ALAMOGORDO	.	.	.	.	.	.	.	.	.	.	.	.	.
ANIMAS	.	.	.	.	.	.	.	.	.	.	.	.	.
DEMING	40.7	45.3	51.0	59.2	67.6	77.4	80.5	78.7	72.8	62.0	49.0	42.2	60.5
GAGE 4 ESE	.	.	.	.	.	.	.	.	.	.	.	.	.
HACHITA 1 N	41.1	45.3	50.8	58.7	66.7	76.1	78.6	76.7	71.5	61.0	48.8	42.4	59.8
HATCH 2 W	.	.	.	.	.	.	.	.	.	.	.	.	.
HILLSBORO	.	.	.	.	.	.	.	.	.	.	.	.	.
JORNADA EXP RANGE	39.3	43.8	49.7	57.9	66.0	75.7	79.3	77.5	71.2	60.0	46.5	39.9	58.9
LATHAM RANCH	.	.	.	.	.	.	.	.	.	.	.	.	.
LORDSBURG 4 SE	.	.	.	.	.	.	.	.	.	.	.	.	.
OROGRANDE	42.3	46.9	53.5	61.7	70.8	80.7	82.4	80.5	74.3	63.7	49.3	43.0	62.4
STATE UNIVERSITY	40.9	45.4	51.1	59.3	67.3	76.6	79.5	77.8	71.5	61.0	47.7	42.0	60.0
DIVISION	41.2	45.4	51.2	59.3	67.4	76.8	79.6	77.8	72.2	61.7	48.6	42.4	60.3

PRECIPITATION (In.)

STATIONS (By Divisions)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
CENTRAL VALLEY													
ALBUQUERQUE WSO	.41	.38	.48	.47	.75	.57	1.20	1.33	.95	.75	.38	.46	8.13
BOSQUE DEL APACHE	.39	.38	.28	.26	.42	.76	1.10	1.46	1.25	.91	.19	.39	7.79
CARRIZOZO	.73	.75	.77	.67	.92	1.20	2.32	2.25	1.95	.99	.53	.77	13.85
ELEPHANT BUTTE DAM	.37	.45	.31	.33	.34	.68	1.50	1.95	1.22	.74	.20	.46	8.55
SOCORRO	.43	.44	.33	.43	.70	.66	1.34	1.48	1.32	.88	.23	.51	8.75
DIVISION	.41	.44	.41	.45	.61	.72	1.46	1.61	1.20	.81	.32	.47	8.91
CENTRAL HIGHLANDS													
ANCHO	.95	.74	.93	.84	1.03	1.14	2.06	2.14	1.75	1.03	.59	.99	14.19
CLOUDCROFT LODGE	1.80	1.70	1.63	.85	1.09	1.86	5.79	4.73	2.37	1.61	.85	1.46	25.74
CORONA	.84	.80	.82	1.04	1.37	1.27	2.59	2.78	2.01	1.09	.56	.70	15.87
GRAN QUIVIRA NAT MON	.67	.65	.69	.61	.91	1.18	2.37	2.98	1.61	1.00	.49	.72	13.98
MAYHILL RANGER STATION	.75	.73	.79	.59	1.23	1.90	3.53	3.81	2.94	1.45	.38	.80	18.99
MC INTOSH 4 NW	.48	.44	.53	.72	1.10	1.03	2.17	2.53	1.46	1.11	.39	.50	12.46
MESCALERO	1.05	1.03	.91	.65	.87	1.42	3.59	3.71	2.13	1.27	.67	1.07	18.37
MOUNTAIN PARK	1.16	1.05	.97	.57	.73	1.28	3.27	3.26	1.89	1.41	.61	.96	17.16
MOUNTAINAIR	.81	.58	.67	.67	.93	1.01	2.69	2.43	1.39	1.15	.55	.88	13.76
PROGRESSO	.55	.55	.58	.65	.88	1.13	2.84	2.51	1.56	.87	.44	.80	13.36
DIVISION	.90	.84	.93	.79	1.10	1.25	2.94	2.95	1.86	1.20	.61	.92	16.29
SOUTHEASTERN PLAINS													
ARTESIA 6 S	.47	.35	.50	.54	1.47	1.32	1.78	1.43	1.62	1.13	.29	.43	11.33
CARLSBAD	.45	.37	.46	.54	1.76	1.33	1.56	1.60	1.94	1.62	.35	.47	12.45
CARLSBAD CAVERNS	.52	.43	.45	.76	1.51	1.55	2.01	1.92	2.51	1.71	.37	.55	14.29
CROSSROADS 2 NE	.44	.42	.47	.77	2.13	1.86	2.39	2.59	2.39	1.76	.45	.52	16.19
ELK 3 E	.61	.50	.61	.59	1.33	1.64	2.53	3.00	2.61	1.36	.42	.64	15.84
FLYING H	.50	.48	.55	.56	1.30	1.31	2.15	2.34	2.52	1.37	.44	.52	14.04
FORT SUMNER	.48	.38	.56	.87	1.64	1.12	2.53	2.30	1.90	1.28	.34	.44	13.74
LAKE AVALON	.40	.33	.37	.47	1.92	1.28	1.47	1.41	1.80	1.54	.34	.40	11.73
ROSWELL WSO	.48	.42	.50	.73	1.28	1.05	1.77	1.62	1.82	1.07	.34	.54	11.62
SANTA ROSA	.43	.42	.63	.72	1.77	1.36	2.47	2.47	1.63	1.17	.34	.51	13.92
DIVISION	.47	.39	.49	.66	1.64	1.33	2.13	2.02	1.97	1.34	.36	.50	13.30
SOUTHERN DESERT													
ALAMOGORDO	.73	.55	.39	.34	.48	.72	1.61	1.66	1.46	.89	.40	.58	9.80
ANIMAS	.61	.62	.53	.22	.23	.49	1.79	2.39	1.25	.85	.41	.60	9.97
DEMING	.46	.59	.32	.30	.25	.50	1.62	1.70	1.46	.90	.30	.54	8.84
GAGE 4 ESE	.58	.75	.42	.26	.20	.41	1.43	1.97	1.49	.82	.38	.66	9.37
HACHITA 1 N	.58	.67	.45	.21	.17	.40	1.76	2.33	1.10	.96	.36	.65	9.54
HATCH 2 W	.45	.40	.28	.37	.29	.53	1.69	1.81	1.37	.98	.23	.54	8.94
HILLSBORO	.62	.58	.46	.41	.42	.71	1.89	2.00	1.87	1.06	.30	.66	10.98
JORNADA EXP RANGE	.54	.42	.27	.24	.29	.53	1.60	1.71	1.44	.91	.36	.55	8.86
LATHAM RANCH	.79	.91	.66	.48	.37	.86	2.66	2.44	1.96	1.06	.47	.79	13.45
LORDSBURG 4 SE	.79	.90	.61	.33	.13	.45	1.51	2.21	1.29	.75	.49	.64	10.10
OROGRANDE	.50	.39	.28	.33	.43	.84	1.52	1.57	1.26	.92	.30	.45	8.79
STATE UNIVERSITY	.47	.51	.30	.17	.31	.53	1.29	1.68	1.22	.75	.30	.48	8.01
DIVISION	.63	.61	.44	.31	.30	.56	1.77	1.95	1.42	.90	.38	.64	9.91

* Normals for the period 1931-1960. Divisional normals may not be the arithmetical average of individual stations published, since additional data for shorter period stations are used to obtain better areal representation.

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for New Mexico State University, New Mexico, for the period 1906-1930 and are included in this publication for comparative purposes.

41.9	46.2	50.0	59.1	66.7	76.5	79.3	77.2	71.5	60.5	48.8	41.1	59.9	.28	.31	.43	.24	.36	.43	1.49	1.65	.93	.71	.55	.55	7.93

CONFIDENCE - LIMITS

In absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State. Because of the wider variation in mean precipitation, the corresponding monthly means and annual mean must be substituted for "p" in the precipitation table below to obtain mean precipitation confidence limits.

1.1	1.1	.8	.9	.7	.6	.5	.5	.5	.7	.9	1.2	.4	$.22\sqrt{p}$	$.19\sqrt{p}$	$.21\sqrt{p}$	$.27\sqrt{p}$	$.35\sqrt{p}$	$.31\sqrt{p}$	$.29\sqrt{p}$	$.26\sqrt{p}$	$.39\sqrt{p}$	$.26\sqrt{p}$	$.22\sqrt{p}$	$.21\sqrt{p}$	$.27\sqrt{p}$

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*MEAN TEMPERATURE AND PRECIPITATION

NORTH DAKOTA ①

STATION	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		ANNUAL	
	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation
NORTHWEST DIVISION																										
CROSBY	6.0	.36	10.3	.34	21.5	.62	39.7	.79	52.9	1.64	60.7	3.29	68.5	2.13	65.7	1.85	55.0	1.09	44.0	.83	25.8	.40	13.8	.41	38.7	13.75
FOXHOLM 7 N	7.3	.50	11.4	.36	22.6	.77	41.0	1.19	54.2	1.84	62.1	3.52	69.6	1.98	67.3	2.10	56.9	1.24	45.5	.78	26.6	.57	14.4	.41	39.9	15.26
KENMARE		.50		.49		.83		1.07		1.86		3.52		2.25		1.90		1.36		.80		.53		.46	—	15.57
MOHALL	5.3	.50	9.4	.47	21.2	.89	40.4	1.31	54.0	2.01	61.9	4.01	69.1	2.55	66.8	2.18	56.4	1.42	44.7	.83	25.5	.58	12.6	.44	38.9	17.19
NEWTOWN	6.0	.50	9.3	.44	20.6	.57	41.3	1.21	53.4	1.66	61.7	3.61	69.4	1.97	67.0	1.68	56.1	1.22	44.6	.74	26.6	.60	14.6	.39	39.2	14.59
PARSHALL		.40		.31		.47		1.15		2.02		3.54		2.41		1.67		1.44		.72		.49		.28		14.90
PORTAL	4.1	.43	8.2	.44	19.4	.67	39.5	.83	52.7	1.88	60.7	3.78	68.2	2.30	65.3	2.27	55.1	1.24	43.3	.75	24.5	.47	11.8	.44	37.7	15.30
WILDROSE		.54		.48		.69		.90		1.63		3.26		1.80		1.85		1.13		.76		.45		.48	—	13.97
WILLISTON WB CITY	10.0	.49	13.5	.46	26.5	.75	42.9	1.07	54.6	1.66	63.0	3.59	70.9	2.13	68.1	1.41	57.2	1.21	45.5	.77	28.3	.58	15.7	.54	41.3	14.66
DIVISION	6.3	.46	10.5	.42	21.4	.67	40.5	1.09	53.2	1.90	61.2	3.59	69.0	2.15	66.5	1.94	56.0	1.28	44.6	.77	26.0	.50	13.6	.40	39.1	15.17
NORTH CENTRAL DIV																										
BOTTINEAU	3.3	.46	7.6	.35	20.1	.74	39.4	.96	53.4	1.97	61.5	3.80	68.9	2.55	66.5	2.57	55.8	1.38	43.6	.78	23.8	.39	10.2	.40	37.8	16.35
DRAKE	6.0	.45	9.9	.38	21.7	.70	40.6	1.21	54.0	1.84	62.6	3.73	70.0	2.63	67.5	2.09	56.9	1.41	44.8	.86	26.0	.63	13.3	.37	39.4	16.30
ECKMAN 2 SE	3.0		7.6		20.1		40.0		53.3		61.4		68.7		65.9		55.5		43.6		24.2		11.2		37.9	
GRANVILLE	6.7	.55	10.9	.37	23.2	.67	41.6	1.22	55.3	2.04	62.4	3.93	70.0	2.42	67.5	2.14	57.4	1.23	45.5	.75	26.5	.51	14.0	.41	40.1	16.24
HADDOCK AGR SCHOOL	5.2	.54	9.6	.46	22.3	.74	41.0	1.08	54.2	2.01	62.6	3.57	69.6	2.79	67.7	2.09	57.5	1.47	45.0	.90	25.7	.50	12.4	.40	39.4	16.55
RUGBY		.58		.39		.78		1.03		1.76		3.37		2.65		2.21		1.31		.81		.53		.53	—	15.95
SAN HAVEN	4.2	.49	8.8	.40	19.7	.58	39.4	.87	53.1	1.92	60.9	3.51	68.5	2.85	66.0	2.38	55.6	1.39	43.6	.72	24.0	.43	11.4	.40	37.9	15.94
TOWNER	5.0	.57	9.3	.45	21.7	.96	41.5	1.35	54.5	1.98	62.5	3.69	69.8	2.26	67.0	2.24	54.3	1.42	44.6	.79	25.6	.63	12.5	.53	39.0	16.87
VELVA C3	8.2	.57	12.6	.43	24.3	.71	42.6	1.29	55.3	2.16	63.2	3.65	70.0	2.56	67.5	2.11	57.6	1.33	46.0	.80	27.3	.69	15.3	.46	40.8	16.76
WESTHOPE B3	3.7		7.7		20.4		40.2		54.3		62.1		69.2		66.9		56.3		43.8		24.3		10.9		38.3	
WILLOW CITY	2.5	.55	6.8	.39	19.8	.70	39.7	1.07	53.1	1.81	61.5	3.70	68.6	2.48	66.0	2.04	55.7	1.26	43.1	.71	23.9	.54	10.0	.51	37.6	15.76
DIVISION	4.5	.54	9.2	.41	21.0	.79	40.3	1.13	53.7	1.97	61.9	3.77	69.1	2.52	66.7	2.26	56.1	1.39	44.3	.79	25.1	.56	11.8	.46	38.7	16.59
NORTHEAST DIVISION																										
DEVILS LAKE WB CITY	4.8	.40	8.7	.41	22.6	.73	40.0	1.44	53.0	2.13	62.4	3.18	69.3	2.67	66.8	2.17	56.3	2.07	43.9	1.26	25.1	.67	11.2	.48	38.7	17.61
GRAFTON	4.7	.72	9.7	.58	22.9	.90	41.6	1.46	55.4	1.86	64.3	3.19	70.9	3.20	68.7	2.65	58.1	2.05	46.2	1.18	26.4	.90	11.3	.60	40.0	19.29
GRAND FORKS UNIVERSITY	4.4	.60	8.9	.55	22.5	.91	41.3	1.51	54.9	2.33	64.0	3.57	70.7	2.96	68.2	3.13	57.4	1.73	45.3	1.22	26.0	.92	11.5	.62	39.6	20.05
HANNAH		.54		.45		.77		1.09		2.06		3.66		2.70		2.89		1.91		1.06		.70		.42		18.25
HANSBORO	2.9	.42	7.4	.26	19.6	.66	38.6	.92	51.9	1.85	60.3	3.73	67.2	2.59	65.0	2.56	55.0	1.37	43.3	.82	23.7	.52	10.5	.33	37.1	16.03
LANGDON EXP FARM	1.9	.79	6.5	.58	19.5	.92	38.7	1.29	52.5	1.95	61.3	3.06	68.0	2.62	65.9	2.63	55.5	2.05	43.0	1.11	22.8	.75	9.3	.56	37.1	18.31
LARIMORE CG	5.3	.45	9.9	.46	23.0	.86	40.8	1.37	54.6	2.21	63.4	3.09	70.4	2.53	68.3	2.61	57.8	1.73	45.7	1.20	26.5	.78	12.5	.67	39.9	17.76
PARK RIVER	4.4	.36	9.0	.36	21.8	.74	40.1	1.32	54.2	1.79	63.1	3.06	69.6	2.89	67.7	2.19	57.2	2.13	45.3	1.11	25.6	.63	11.6	.40	39.3	16.98
PEMBINA 2 N CG.B6		.58		.44		.72		1.21		1.89		3.07		2.92		2.88		2.45		1.18		.72		.40		18.46
PETERSBURG		.42		.43		.69		1.13		2.03		3.15		2.68		2.50		1.78		1.17		.57		.43		16.98
DIVISION	3.3	.56	7.9	.46	20.8	.80	39.9	1.27	53.4	1.99	62.2	3.32	69.0	2.81	66.9	2.71	56.3	1.92	44.4	1.09	24.9	.72	10.6	.49	38.3	18.14
WEST CENTRAL DIVISION																										
DUNN CENTER 2 SW	10.4	.43	14.2	.39	24.1	.65	40.8	1.26	53.1	1.99	61.4	3.85	69.5	2.34	66.5	1.97	55.4	1.24	44.9	.81	27.8	.46	17.7	.27	40.5	15.66
GARRISON D3	8.3	.59	12.4	.54	23.7	.75	41.6	1.27	54.2	2.05	62.8	3.48	70.4	2.35	67.7	1.82	57.4	1.27	45.2	.78	27.0	.62	15.0	.44	40.5	15.96
MAX C3	6.0	.45	10.0	.40	21.3	.73	40.2	1.25	53.2	2.19	62.1	3.98	69.7	2.66	67.1	2.16	56.1	1.30	43.9	.72	25.4	.59	13.2	.36	39.0	16.79
WASHBURN D3	10.2	.40	14.4	.40	25.6	.69	43.6	1.32	55.9	1.75	64.3	3.69	72.0	2.35	69.2	1.78	59.2	1.32	47.1	.82	28.9	.49	16.9	.32	42.3	15.33
WATFORD CITY	11.2	.61	15.5	.55	25.6	.85	43.0	1.33	55.1	1.85	62.9	3.58	71.4	2.36	68.9	1.55	58.0	1.25	46.5	.96	29.0	.56	17.7	.49	42.1	15.94
DIVISION	8.8	.47	12.7	.44	23.6	.75	41.8	1.30	54.1	2.01	62.3	3.79	70.1	2.38	67.7	1.93	57.1	1.36	45.6	.83	27.2	.55	15.7	.36	40.6	16.17
CENTRAL DIVISION																										
CARRINGTON	6.2	.52	10.1	.48	22.2	.74	40.1	1.40	53.2	2.29	62.5	3.64	69.7	2.64	67.2	1.90	56.4	1.46	45.0	1.15	25.8	.58	12.8	.41	39.3	17.21
COURTENAY		.62		.48		.88		1.25		2.15		3.29		2.51		2.28		1.57		1.11		.60		.59		17.33
FESSENDEN D4	6.3	.57	10.8	.51	22.9	.78	41.2	1.34	54.2	2.14	62.8	3.36	70.2	2.82	67.9	1.97	57.5	1.47	45.3	1.04	26.2	.68	13.2	.53	39.9	17.21
HARVEY C4		.36		.39		.71		1.23		1.92		3.48		2.69		1.81		1.43		1.00		.50		.30		15.82
JAMESTOWN STATE HOSP	8.2	.46	12.3	.57	24.9	.88	42.3	1.64	55.2	2.19	64.6	3.32	71.8	2.73	69.2	2.13	58.5	1.32	46.5	1.17	28.0	.67	15.0	.48	41.4	17.56
MC CLUSKY	7.5	.63	11.6	.51	23.4	.84	41.8	1.49	54.3	2.32	62.8	4.07	70.7	2.14	68.3	1.91	58.0	1.48	45.8	1.02	27.0	.65	14.6	.51	40.4	17.57
PETTIBONE	6.5	.47	10.6	.50	22.7	.79	41.2	1.39	54.1	2.11	62.8	3.01	70.5	2.72	68.2	2.15	57.9	1.64	45.2	1.15	26.4	.50	13.4	.38	40.0	16.81
STEELE E4	7.6	.44	11.6	.37	23.8	.60	41.8	1.32	54.3	2.26	63.0	3.86	70.5	2.51	68.3	2.04	58.1	1.71	45.9	1.20	27.4	.45	14.7	.32	40.6	17.10
DIVISION	6.8	.51	11.0	.48	23.0	.78	41.3	1.40	53.8	2.27	62.6	3.57	70.0	2.66	67.9	2.14	57.4	1.57	45.6	1.14	26.7	.59	13.6	.44	40.0	17.35

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*MEAN TEMPERATURE AND PRECIPITATION

ND-2 STATION	JANUARY Temperature	JANUARY Precipitation	FEBRUARY Temperature	FEBRUARY Precipitation	MARCH Temperature	MARCH Precipitation	APRIL Temperature	APRIL Precipitation	MAY Temperature	MAY Precipitation	JUNE Temperature	JUNE Precipitation	JULY Temperature	JULY Precipitation	AUGUST Temperature	AUGUST Precipitation	SEPTEMBER Temperature	SEPTEMBER Precipitation	OCTOBER Temperature	OCTOBER Precipitation	NOVEMBER Temperature	NOVEMBER Precipitation	DECEMBER Temperature	DECEMBER Precipitation	ANNUAL Temperature	ANNUAL Precipitation
EAST CENTRAL DIVISION																										
COOPERSTOWN		.47		.63		.78		1.17		2.36		3.38		2.51		2.57		1.75		1.14		.65		.57		17.98
FARGO WB AP	7.1	.60	10.8	.66	25.3	.89	42.1	1.88	55.0	2.17	64.6	3.04	71.3	2.31	69.1	2.73	58.9	1.72	46.1	1.26	27.6	.87	12.9	.60	40.9	18.73
HILLSBORO	6.3	.53	10.8	.54	24.1	.83	42.2	1.70	55.4	2.42	64.7	3.77	71.6	3.00	69.0	2.82	58.8	1.88	46.3	1.13	27.3	.76	13.0	.57	40.8	19.95
MAYVILLE	6.8	.53	11.3	.53	24.5	.68	42.4	1.27	55.7	2.27	64.7	3.52	71.8	2.56	69.8	2.69	59.6	1.74	47.1	1.06	27.7	.64	13.5	.49	41.2	17.98
SHARON	4.8	.52	9.5	.47	22.4	.88	40.5	1.44	53.8	2.64	62.7	3.36	70.1	2.66	67.7	2.74	57.1	1.83	44.9	1.25	25.8	.74	11.7	.52	39.3	19.05
VALLEY CITY	8.5	.46	13.1	.49	26.0	.75	43.4	1.42	56.1	2.35	65.1	3.30	71.7	2.81	69.4	2.33	59.1	1.50	47.2	1.18	28.6	.74	15.4	.51	42.0	17.84
DIVISION	5.9	.50	11.0	.52	24.1	.78	41.9	1.42	55.2	2.44	64.2	3.45	71.2	2.67	68.9	2.54	58.5	1.67	46.2	1.13	27.2	.70	13.0	.53	40.6	18.35
SOUTHWEST DIVISION																										
BOWMAN COURT HOUSE	14.8		17.7		26.5		42.7		54.2		62.2		71.1		68.8		60.4		46.5		30.0		21.2		43.0	
DICKINSON EXP STATION	10.7	.48	13.9	.45	23.9	.76	41.3	1.36	53.1	2.01	61.4	3.98	69.8	2.00	67.1	1.76	56.4	1.13	44.8	.88	27.9	.55	17.5	.32	40.7	15.68
HETTINGER	15.2	.37	18.3	.29	27.0	.72	43.5	1.25	55.0	2.11	63.5	3.47	72.0	1.98	72.5	1.82	59.1	1.13	47.1	.83	30.8	.36	21.3	.23	43.8	14.56
MARMARTH	14.9	.56	18.7	.45	28.0	.80	44.4	1.12	55.5	1.92	63.6	3.59	72.1	1.92	69.1	1.65	58.3	1.00	46.6	.92	30.1	.45	20.6	.38	43.5	14.76
MOTT	13.6	.43	17.1	.41	26.6	.79	43.5	1.07	55.0	1.90	63.4	3.65	71.8	1.97	69.1	1.55	58.9	1.27	46.8	.68	29.9	.44	19.8	.30	43.0	14.46
NEW ENGLAND	14.3	.63	17.4	.59	27.0	1.11	43.0	1.51	54.8	1.88	63.4	4.00	72.1	2.39	69.4	1.58	58.7	1.15	46.2	.85	30.2	.52	19.9	.38	43.0	16.59
RICHARDTON ABBEY	12.9	.56	16.1	.55	25.5	1.05	42.7	1.46	54.4	2.02	62.6	3.99	70.8	2.59	68.8	1.79	58.7	1.14	47.2	.83	29.6	.82	19.2	.36	42.4	17.16
TROTTERS 6 SE		.54		.44		.75		1.05		1.84		3.01		2.06		1.68		1.16		.74		.54		.38		14.19
DIVISION	13.7	.50	17.2	.46	26.0	.85	42.8	1.33	54.3	1.95	62.5	3.77	71.0	2.11	68.7	1.76	58.1	1.18	46.5	.86	29.7	.49	19.8	.32	42.5	15.58
SOUTH CENTRAL DIV																										
BISMARCK WB AP	9.2	.36	12.7	.43	26.7	.76	43.1	1.39	54.8	1.94	64.3	3.33	72.1	2.33	69.3	1.50	58.5	1.43	45.7	1.00	28.4	.53	15.5	.40	41.7	15.40
CARSON NO 2	11.8	.53	15.1	.55	25.4	1.11	42.8	1.41	54.8	2.36	63.5	3.87	71.7	2.09	69.4	1.51	59.0	1.34	46.8	1.02	29.3	.55	18.6	.35	42.4	16.69
FORT YATES	12.1	.39	16.5	.45	27.9	.80	44.9	1.37	56.7	2.10	65.4	3.58	73.1	2.01	70.5	1.74	60.4	1.18	48.1	1.12	30.9	.36	19.1	.25	43.8	15.35
LINTON	10.1	.40	14.7	.39	26.7	.72	44.3	1.36	56.6	2.05	65.1	4.09	72.8	2.47	70.9	1.85	60.3	1.43	47.4	1.10	29.3	.40	16.8	.31	42.9	16.57
MANDAN EXP STATION	9.4	.50	13.0	.48	24.6	.90	42.9	1.42	55.2	1.95	63.9	3.78	71.8	2.33	69.2	1.76	58.9	1.34	46.6	.92	28.3	.59	16.2	.37	41.7	16.34
NEW SALEM 1 S	11.0	.45	14.5	.48	25.0	.81	42.6	1.29	54.6	2.02	63.1	3.54	71.1	2.21	68.9	1.80	58.9	1.30	46.7	.76	28.8	.47	17.6	.30	41.9	15.43
DIVISION	10.9	.44	15.2	.47	25.6	.83	43.5	1.32	55.5	2.06	64.0	3.89	71.9	2.26	69.7	1.85	59.4	1.36	47.3	1.01	29.4	.50	17.7	.32	42.5	16.31
SOUTHEAST DIVISION																										
ASHLEY	9.0	.51	12.5	.44	24.7	.77	42.0	1.26	54.4	1.98	63.3	3.83	70.6	2.65	68.4	2.19	58.2	1.23	45.9	.94	28.1	.42	15.6	.28	41.1	16.50
EDGELEY EXP FARM	9.0	.44	13.1	.45	25.4	.76	42.7	1.53	54.9	2.38	63.9	3.76	71.0	2.57	69.0	1.94	58.8	1.43	46.7	.95	28.0	.46	15.1	.34	[illegible]	17.01
ELLENDALE	9.8	.54	13.9	.62	26.6	1.00	43.5	1.94	55.8	2.22	65.0	3.85	71.9	2.84	69.9	2.49	59.8	1.36	47.5	1.08	29.3	.63	16.3	.51	42.4	19.08
FORMAN		.49		.57		.92		1.91		2.55		3.92		3.13		2.19		1.42		1.17		.64		.52		19.43
FULLERTON	10.1	.87	14.1	.95	26.7	1.26	43.7	2.15	56.1	2.51	65.3	3.97	72.2	2.47	70.0	2.21	59.6	1.36	47.4	1.16	29.4	.86	16.5	.78	42.6	20.55
HANKINSON R R STATION	9.2	.56	13.4	.58	25.8	1.10	43.0	1.89	56.5	2.41	65.9	3.91	72.5	2.46	69.7	2.43	59.3	1.69	46.9	1.04	28.7	.69	15.6	.59	42.2	19.35
LISBON	8.7	.51	13.1	.58	26.2	.90	42.4	1.92	55.6	2.35	65.0	3.86	71.7	2.53	69.0	2.87	58.3	1.47	47.3	1.19	29.0	.67	15.2	.51	41.8	19.36
MC LEOD 3 E	8.5	.53	13.0	.47	26.3	.99	43.4	1.67	56.6	2.51	65.2	3.44	72.0	2.85	69.8	2.65	59.9	1.54	47.7	1.12	29.2	.70	14.9	.47	42.2	18.94
NAPOLEON	8.4	.54	12.2	.45	24.0	.95	42.2	1.37	54.7	2.31	63.4	3.72	70.8	2.89	69.1	1.95	58.8	1.40	46.3	1.20	27.8	.63	15.3	.37	41.1	17.78
OAKES	8.4	.49	12.6	.59	25.9	.93	42.7	1.73	55.6	2.32	65.1	3.68	72.0	2.49	69.7	2.04	59.0	1.25	46.8	1.09	28.6	.63	15.0	.50	41.8	17.74
WAHPETON STATE SCHOOL	9.6	.60	13.8	.57	26.9	.86	44.6	1.99	57.5	2.64	66.8	3.57	73.1	3.04	71.2	3.03	61.3	1.61	49.0	1.15	30.1	.71	16.0	.61	43.3	20.36
WISHEK	7.7	.45	11.6	.38	23.5	.71	41.4	1.38	53.8	2.16	63.0	3.76	70.1	2.76	67.6	1.76	59.5	1.30	44.7	.96	27.2	.41	15.2	.28	40.4	16.33
DIVISION	8.8	.53	13.1	.55	25.5	.92	42.9	1.70	55.6	2.37	64.6	3.79	71.6	2.73	69.4	2.29	59.1	1.42	47.0	1.08	28.7	.61	15.6	.47	41.8	18.46

* Averages for period 1931-1955, except for stations marked WB which are "normals" based on period 1921-1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.

CONFIDENCE LIMITS

In the absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State.

3.1	.11	3.1	.11	1.6	.17	1.4	.31	1.5	.49	1.2	.69	1.1	.50	.8	.36	1.1	.39	1.4	.29	1.7	.17	2.2	.09	.7	1.27

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for Dickinson Experiment Station, North Dakota for the period 1906-1930 and are included in this publication for comparative purposes:

10.2	.46	14.1	.40	26.0	.66	41.8	1.21	51.4	2.50	61.9	3.49	68.1	2.21	65.7	1.82	55.9	1.32	43.5	1.02	29.2	.48	14.8	.50	40.2	16.07

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*MEAN TEMPERATURE AND PRECIPITATION

SOUTH DAKOTA

STATION	JANUARY Temperature	JANUARY Precipitation	FEBRUARY Temperature	FEBRUARY Precipitation	MARCH Temperature	MARCH Precipitation	APRIL Temperature	APRIL Precipitation	MAY Temperature	MAY Precipitation	JUNE Temperature	JUNE Precipitation
CENTRAL DIVISION												
HIGHMORE 1 W H5	14.8	.42	18.4	.53	29.2	1.20	45.8	1.71	57.2	2.18	66.7	3.71
KENNEBEC	19.0	.52	22.7	.56	32.2	1.08	48.0	1.69	59.0	2.36	68.7	3.28
MURDO	21.1	.60	24.4	.52	33.1	1.30	48.7	1.79	59.4	2.75	68.8	3.34
PIERRE CAA AP	17.5	.43	21.0	.63	31.3	1.15	47.7	1.49	59.1	2.45	68.8	3.15
OKWANA 3 W	18.2		22.3		32.7		48.5		59.6		69.3	
VIVIAN	19.0	.46	22.5	.56	33.2	1.30	47.8	1.76	59.1	2.79	68.2	3.60
DIVISION	17.9	.45	21.6	.54	31.2	1.15	47.5	1.63	58.5	2.46	67.9	3.53
EAST CENTRAL DIVISION												
ARLINGTON		.59		.66		1.49		2.33		2.76		3.98
BROOKINGS 1 NE	13.9	.40	18.3	.50	29.7	1.07	45.4	1.81	57.6	2.65	67.4	3.99
CASTLEWOOD	12.4	.50	16.9	.48	28.6	1.04	44.3	2.09	56.3	2.60	65.9	4.14
CLARK	12.2		16.5		28.1		44.4		56.7		65.9	
DE SMET	13.8		18.5		29.5		45.4		57.4		67.3	
FLANDREAU	14.3	.58	18.6	.78	29.5	1.32	45.5	2.03	57.6	2.93	67.2	4.31
FORESTBURG 3 NE	15.9	.48	20.3	.55	31.2	1.44	47.0	2.38	58.4	2.61	67.8	3.90
HOWARD	15.5	.50	19.9	.58	30.7	1.27	46.8	2.18	58.6	2.80	68.4	4.05
HURON WB AP	13.5	.57	17.6	.49	31.7	1.09	46.4	1.92	58.0	2.25	68.2	3.06
LA DELLE 7 NE	13.0	.47	17.8	.44	29.8	1.03	45.8	1.88	57.6	2.28	67.2	3.85
MILLER	16.0	.56	19.9	.50	30.5	1.13	46.9	2.13	58.4	2.40	67.9	4.07
REDFIELD	13.8	.50	18.3	.47	30.4	.99	46.5	1.82	58.8	2.19	68.4	3.71
WATERTOWN CAA AP	11.3	.51	15.7	.65	27.3	1.08	43.4	2.06	56.1	2.80	65.8	3.81
WENTWORTH		.55		.68		1.50		2.21		3.00		4.04
DIVISION	14.2	.52	18.5	.57	29.7	1.21	45.7	2.09	57.6	2.65	67.2	4.05
SOUTH CENTRAL DIV												
ACADEMY	20.3	.52	23.6	.67	33.1	1.23	47.9	2.35	58.8	2.95	69.0	4.11
GREGORY	21.5	.50	24.8	.74	33.3	1.40	47.9	2.22	59.0	3.01	68.7	4.24
WINNER	21.8	.49	25.6	.58	33.4	1.24	48.5	2.00	59.4	2.71	68.9	3.67
WOOD	23.0	.59	26.1	.67	34.0	1.39	49.0	1.73	59.2	2.96	68.5	3.60
DIVISION	21.6	.52	25.0	.66	33.4	1.32	48.3	2.08	59.1	2.91	68.8	3.90
SOUTHEAST DIVISION												
ALEXANDRIA	17.2	.42	21.3	.60	32.3	1.28	48.4	2.18	59.9	2.72	69.6	3.90
ARMOUR	19.6	.53	23.3	.70	33.7	1.45	49.2	2.05	60.7	2.70	70.7	4.18
BONESTEEL	20.5	.58	23.9	.77	33.1	1.75	48.1	2.29	59.1	3.30	68.7	3.90
CANISTOTA 2 N		.60		.84		1.55		2.06		2.87		4.36
CANTON	17.6		21.8		32.8		48.5		60.1		69.9	
MARION	17.3	.53	21.4	.91	32.4	1.63	48.2	2.02	60.1	3.15	69.6	4.34
MENNO	18.4	.66	22.5	.88	33.3	1.62	49.2	2.08	60.0	3.24	70.1	4.28
MITCHELL 2 SE	18.2	.47	22.0	.60	32.9	1.41	48.8	2.24	60.1	2.73	69.4	3.93
PARKSTON 5 E		.52		.68		1.34		1.99		2.65		4.17
SIOUX FALLS WB AP	14.2	.72	19.5	.74	32.0	1.35	46.4	2.35	58.1	3.38	68.0	4.25
TYNDALL	19.6	.54	23.2	.81	33.6	1.52	48.8	2.09	60.0	3.16	70.0	4.02
VERMILLION 2 N	20.8	.51	24.5	.84	35.0	1.23	50.4	2.26	61.7	3.09	71.5	4.34
WHITE LAKE	18.1		22.0		32.4		48.0		59.3		69.1	
YANKTON 3 NNW	18.6	.46	22.0	.69	32.2	1.22	47.5	2.08	59.5	3.23	69.6	4.56
DIVISION	18.8	.54	22.8	.80	33.1	1.45	48.7	2.17	60.2	3.04	69.9	4.22

STATION	JULY Temperature	JULY Precipitation	AUGUST Temperature	AUGUST Precipitation	SEPTEMBER Temperature	SEPTEMBER Precipitation	OCTOBER Temperature	OCTOBER Precipitation	NOVEMBER Temperature	NOVEMBER Precipitation	DECEMBER Temperature	DECEMBER Precipitation	ANNUAL Temperature	ANNUAL Precipitation
CENTRAL DIVISION														
HIGHMORE 1 W H5	74.9	1.80	72.8	1.99	62.8	1.21	50.1	1.13	32.4	.49	20.1	.40	45.4	16.77
KENNEBEC	77.3	1.54	75.1	2.03	64.8	1.38	51.5	1.04	34.9	.55	23.5	.43	[illegible]	16.46
MURDO	77.7	1.19	75.7	1.95	65.5	1.22	53.0	1.14	36.4	.47	25.8	.36	[illegible]	16.63
PIERRE CAA AP	77.6	1.69	75.2	2.03	64.3	1.13	51.6	.90	34.4	.46	22.7	.47	47.6	15.98
OKWANA 3 W	77.4		74.8		64.7		51.3		34.3		22.6		48.0	
VIVIAN	77.3	1.60	74.9	1.93	64.6	1.17	51.7	.91	34.5	.55	23.5	.43	48.0	17.06
DIVISION	76.7	1.62	74.5	1.94	64.1	1.22	51.2	1.01	34.3	.47	22.8	.39	47.4	16.41
EAST CENTRAL DIVISION														
ARLINGTON		2.31		2.67		2.15		1.33		.80		.59		21.66
BROOKINGS 1 NE	73.7	2.06	71.3	2.90	61.6	2.10	49.6	1.24	31.7	.67	19.2	.47	45.0	19.86
CASTLEWOOD	72.2	2.69	70.1	2.57	60.5	1.98	48.3	1.31	30.5	.69	18.0	.48	43.7	20.57
CLARK	73.0		70.8		60.9		48.6		30.4		17.9		43.8	
DE SMET	74.1		71.8		61.2		49.2		31.3		18.7		44.9	
FLANDREAU	73.3	2.60	71.0	2.99	61.6	2.63	49.7	1.32	32.1	.86	19.4	.57	45.0	22.92
FORESTBURG 3 NE	75.0	2.26	72.9	2.37	63.1	1.64	50.7	1.29	33.4	.70	21.0	.69	46.4	20.31
HOWARD	75.6	2.43	73.1	2.72	63.2	2.20	50.9	1.19	33.0	.73	20.6	.54	46.4	21.19
HURON WB AP	75.4	2.08	72.9	1.98	62.8	1.73	50.0	1.26	32.5	.66	19.6	.45	45.7	17.54
LA DELLE 7 NE	74.4	2.54	71.9	2.21	62.1	1.64	49.4	1.14	31.4	.57	18.5	.50	44.9	18.55
MILLER	75.5	2.02	73.1	1.83	63.2	1.28	50.5	1.25	33.4	.57	21.3	.47	46.4	18.21
REDFIELD	75.7	2.04	73.3	2.03	63.1	1.34	50.3	1.22	32.4	.56	19.8	.48	45.9	17.35
WATERTOWN CAA AP	72.6	2.84	70.1	2.65	60.1	1.93	47.7	1.16	29.7	.72	17.4	.51	43.1	20.67
WENTWORTH		2.79		3.16		2.48		1.36		.89		.61		23.27
DIVISION	74.2	2.51	71.9	2.57	62.0	1.92	49.7	1.27	32.0	.72	19.5	.53	45.2	20.61
SOUTH CENTRAL DIV														
ACADEMY	77.2	2.23	74.7	2.56	64.6	1.52	52.0	1.24	36.0	.56	24.6	.46	48.5	20.40
GREGORY	76.7	2.08	74.4	2.48	65.0	1.66	52.8	1.29	36.5	.78	26.0	.60	48.9	21.00
WINNER	77.5	1.77	75.1	2.55	65.1	1.41	52.5	1.11	36.3	.52	26.0	.46	49.2	18.51
WOOD	77.6	1.80	76.0	1.75	66.0	1.44	53.6	1.13	37.4	.61	27.4	.45	49.8	18.12
DIVISION	77.2	1.97	75.0	2.33	65.2	1.51	52.7	1.19	36.6	.62	26.0	.49	49.1	19.50
SOUTHEAST DIVISION														
ALEXANDRIA	76.7	2.24	74.3	2.64	64.6	2.11	52.4	1.24	34.9	.66	22.3	.46	47.8	20.45
ARMOUR	78.2	1.98	75.7	3.33	65.8	1.95	53.1	1.22	35.5	.74	24.0	.58	49.1	21.41
BONESTEEL	76.3	2.34	74.2	3.00	64.3	2.09	52.3	1.37	35.9	.72	25.0	.54	48.5	22.65
CANISTOTA 2 N		2.64		3.13		2.48		1.26		.78		.59		23.16
CANTON	75.9		73.7		64.3		52.2		34.9		22.3		47.8	
MARION	76.3	2.80	74.0	2.87	64.4	2.34	52.0	1.42	34.2	.82	21.9	.63	47.7	23.46
MENNO	76.7	2.38	74.0	3.06	64.8	1.98	52.6	1.26	34.9	.79	23.0	.63	48.3	22.86
MITCHELL 2 SE	76.8	2.26	74.3	2.71	64.5	2.16	52.3	1.25	35.1	.69	22.9	.50	48.1	20.95
PARKSTON 5 E		2.35		2.91		2.31		1.13		.69		.55		21.29
SIOUX FALLS WB AP	74.8	3.00	72.4	3.28	62.4	2.93	50.0	1.46	32.2	1.11	19.4	.67	45.8	25.24
TYNDALL	77.1	2.42	74.8	3.10	64.9	2.20	52.9	1.17	35.8	.78	24.1	.53	48.7	22.34
VERMILLION 2 N	77.5	3.14	75.3	3.13	66.2	2.68	54.6	1.30	37.2	.96	25.6	.60	50.0	24.08
WHITE LAKE	76.8		74.5		64.6		52.2		35.0		22.8		47.9	
YANKTON 3 NNW	76.5	2.50	73.8	3.05	64.0	2.29	52.1	1.36	34.9	.77	23.6	.49	47.9	22.72
DIVISION	76.9	2.47	74.6	3.02	64.9	2.18	52.7	1.26	35.4	.78	23.5	.57	48.5	22.50

* Averages for period 1931-1955, except for stations marked WB which are "normals" based on period 1921-1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.

Central Div 47.4
E Central " 45.2
S Central " 49.1
S.E " 48.5
NW " 45.0
N Central " 44.1
Black Hills 46.1
SW Div. 47.7

SD-2

*MEAN TEMPERATURE AND PRECIPITATION

SD.-2

STATION	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		ANNUAL	
	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation
NORTHWEST DIVISION																										
BELLE FOURCHE 2 NE	22.1	.26	24.5	.23	31.4	.64	45.9	1.86	56.1	2.10	64.5	3.15	73.1	1.33	70.5	1.21	60.3	1.18	49.1	.77	35.0	.42	26.1	.22	46.6	13.31
CAMP CROOK	17.4	.50	20.3	.31	28.6	.79	43.5	1.27	54.6	2.03	63.5	2.85	73.0	1.80	70.1	1.39	59.5	.95	46.9	.69	31.4	.30	22.7	.24	44.3	13.12
DUPREE	16.7	.59	20.1	.59	29.1	1.15	45.8	1.48	57.0	1.92	66.1	3.46	75.5	1.52	73.0	1.58	62.4	.94	49.8	.99	32.9	.53	22.4	.35	45.8	15.10
LEMMON	13.7	.47	16.7	.52	26.3	.98	42.7	1.24	54.3	2.05	63.1	3.91	72.0	1.78	69.6	1.76	59.0	1.18	46.8	.81	30.0	.48	19.9	.26	42.8	15.44
LUDLOW 2 NW	17.2	.33	19.5	.31	27.2	.51	42.7	1.15	53.8	1.83	62.4	3.59	71.1	1.98	68.8	1.40	58.4	.94	46.9	.77	31.4	.41	22.5	.20	43.5	13.47
NEWELL 2 NW	18.5	.44	21.6	.39	29.2	.92	44.6	1.75	55.4	2.58	64.2	3.23	73.5	1.75	71.2	1.27	60.6	1.13	48.5	.87	33.1	.53	23.3	.32	45.3	15.18
ORMAN DAM	21.4	.32	24.3	.29	31.1	.82	46.2	1.87	56.8	2.42	65.3	3.44	74.8	1.60	72.5	1.17	62.1	1.15	50.4	.80	35.5	.52	26.0	.26	47.2	14.66
REDIG 9 NE	16.9	.44	19.9	.33	27.7	.75	43.4	1.29	54.1	1.80	62.9	2.93	72.1	1.58	69.6	1.17	58.9	.99	47.0	.74	31.7	.39	22.1	.26	43.9	12.67
VALE	20.4	.35	23.7	.37	31.5	.93	46.3	1.81	56.6	2.69	65.2	3.48	74.0	1.88	71.4	1.27	60.9	1.17	49.2	.99	34.3	.50	24.7	.32	46.3	15.76
DIVISION	17.9	.41	21.0	.38	29.0	.85	44.5	1.48	55.4	2.18	64.0	3.39	73.2	1.67	70.8	1.38	60.2	1.09	48.3	.85	32.5	.44	23.1	.26	45.0	14.38
NORTH CENTRAL DIV																										
BOWDLE		.58		.50		.95		1.72		2.45		4.03		2.09		1.93		1.25		1.01		.53		.30		17.34
EUREKA	10.6	.38	14.8	.39	26.7	.69	43.9	1.38	56.3	2.40	65.1	4.02	72.8	2.37	70.6	2.20	60.2	1.30	47.6	.99	29.9	.38	17.1	.25	43.0	16.35
FAULKTON 1 NW	13.7	.48	17.8	.45	29.3	.97	45.5	1.86	57.2	2.41	66.4	3.55	73.9	2.10	71.6	2.09	61.5	1.38	49.3	1.10	32.3	.52	19.7	.36	44.9	17.27
GETTYSBURG		.38		.48		.95		1.58		2.22		3.65		1.92		1.72		1.19		.90		.42		.34		15.75
MOBRIDGE	13.3	.42	17.4	.47	29.0	.94	46.0	1.29	58.0	2.22	67.0	3.51	75.1	2.17	73.0	1.87	62.1	1.12	49.1	1.13	31.7	.38	19.6	.31	45.1	15.83
ONAKA		.38		.45		.88		1.57		2.13		3.65		2.03		1.97		1.28		.93		.40		.49		16.16
POLLOCK	10.2	.37	14.5	.37	26.9	.61	44.0	1.21	56.1	1.96	64.8	3.61	72.5	2.05	70.5	1.73	59.8	1.12	47.1	1.04	29.4	.34	17.3	.20	42.8	14.61
TIMBER LAKE f.3	13.9		17.3		27.6		44.6		56.5		65.8		74.2		71.5		60.8		48.1		31.0		20.0		44.3	
DIVISION	12.7	.48	16.6	.49	28.0	.92	44.9	1.49	56.8	2.20	65.7	3.81	73.8	2.08	71.1	1.90	61.0	1.23	48.5	1.03	31.1	.45	19.0	.32	44.1	16.40
NORTHEAST DIVISION																										
ABERDEEN CAA AP	11.0	.68	15.8	.63	28.5	1.20	45.2	2.12	57.5	2.24	66.8	4.04	73.9	2.61	71.6	2.16	61.0	1.43	48.4	1.18	30.5	.71	17.6	.63	44.0	19.63
BRITTON	10.4	.44	14.8	.56	27.6	.79	44.8	1.77	57.3	2.22	66.4	3.95	73.4	2.47	71.4	2.82	61.4	1.50	49.0	1.01	30.0	.55	17.0	.41	43.6	18.49
LEOLA		.44		.43		.92		1.72		2.05		3.89		2.73		2.14		1.41		.92		.49		.35		17.49
MELLETTE	12.5	.60	17.0	.63	29.8	1.18	46.0	1.97	57.9	2.33	67.2	4.04	74.5	2.07	72.4	2.04	62.0	1.42	49.4	1.17	31.5	.87	18.4	.48	44.9	18.60
MILBANK	13.5	.57	17.9	.55	29.4	1.19	45.7	2.22	58.7	2.78	68.0	4.25	74.7	2.43	72.3	2.63	62.5	1.87	50.7	1.33	32.3	.78	19.6	.58	45.4	21.18
VICTOR 5 NE		.62		.74		1.34		2.01		2.69		4.31		3.02		2.40		1.69		1.21		.90		.61		21.34
DIVISION	11.7	.58	16.3	.63	28.6	1.08	45.3	2.11	57.5	2.47	66.7	4.19	73.6	2.53	71.6	2.45	61.3	1.59	49.3	1.18	31.1	.70	18.1	.53	44.3	20.04
BLACK HILLS DIVISION																										
BUSKALA RANCH		1.27		.87		1.76		3.11		4.01		4.25		2.59		1.80		1.48		1.26		1.11		.98		24.49
CUSTER		.41		.38		1.00		1.88		3.09		3.09		1.97		2.52		1.05		1.05		.39		.36		17.19
DUMONT 2 ENE		1.39		.87		1.74		2.53		3.31		3.56		2.12		1.76		1.38		1.13		1.23		.98		22.00
HOT SPRINGS	25.1	.41	27.8	.52	34.3	1.12	46.8	1.91	56.8	3.04	66.3	3.01	75.3	2.12	73.2	1.71	62.9	1.33	51.0	.77	36.9	.37	29.0	.36	48.8	16.67
LEAD	24.3	1.11	25.7	.87	29.7	1.70	41.4	2.96	51.1	3.90	60.2	4.09	69.7	2.08	67.9	1.68	58.4	1.57	48.0	1.32	34.4	1.14	28.1	.95	44.9	23.37
SPEARFISH 9 WNW		.60		.51		.98		2.25		2.74		3.61		1.66		1.41		1.57		.95		.74		.50		17.32
DIVISION	24.6	.76	26.7	.67	31.2	1.43	43.9	2.28	53.1	3.49	62.1	3.70	71.3	1.98	69.4	1.90	59.6	1.45	48.9	1.11	35.2	.86	27.5	.64	46.1	20.21
SOUTHWEST DIVISION																										
COTTONWOOD 2 E	20.0	.51	23.3	.40	31.8	.95	46.8	1.62	57.3	2.57	66.8	2.90	75.9	1.39	73.7	1.25	63.0	.99	50.3	.89	34.8	.36	24.3	.36	47.3	14.19
LONGVALLEY		.45		.47		1.14		1.85		2.91		3.24		1.40		1.75		1.17		1.05		.45		.28		16.16
OELRICHS	23.4	.33	26.7	.29	33.8	1.02	46.6	1.79	56.6	3.09	66.1	2.69	75.6	1.98	73.5	1.30	63.0	1.16	50.8	.78	35.9	.39	26.8	.36	48.3	15.18
RAPID CITY WB AP	21.1	.48	23.9	.32	31.3	1.06	44.5	2.01	54.7	3.05	63.7	3.36	72.3	2.06	70.9	1.56	60.5	1.18	49.1	1.13	35.3	.55	25.7	.36	46.1	17.10
RAPID CITY	24.4	.42	26.7	.43	32.1	1.08	45.7	2.00	56.2	2.77	65.1	3.45	74.3	1.85	72.0	1.67	62.2	.98	51.2	.95	37.3	.39	29.0	.31	48.0	16.31
DIVISION	21.8	.40	23.5	.40	32.5	.95	46.4	1.73	56.7	2.76	66.0	3.11	75.5	1.66	73.2	1.60	62.9	1.17	50.8	.94	35.4	.40	25.9	.32	47.7	15.44

* Averages for period 1931-1955, except for stations marked WB which are "normals" based on period 1921-1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.

CONFIDENCE LIMITS

In the absence of trend or record changes, the chances are 9 out of 10 that the true mean will lie in the interval formed by adding and subtracting the values in the following table from the means for any station in the State. Because of the wider variation in mean precipitation, the corresponding monthly means and annual mean must be substituted for "p" in the precipitation table below to obtain mean precipitation confidence limits.

2.8	$.22\sqrt{p}$	2.8	$.18\sqrt{p}$	1.6	$.27\sqrt{p}$	1.3	$.39\sqrt{p}$	1.5	$.41\sqrt{p}$	1.2	$.32\sqrt{p}$	1.2	$.29\sqrt{p}$	1.0	$.32\sqrt{p}$	1.2	$.31\sqrt{p}$	1.4	$.31\sqrt{p}$	1.4	$.24\sqrt{p}$	1.8	$.18\sqrt{p}$	.9	$.30\sqrt{p}$

COMPARATIVE DATA

Data in the following table are the mean temperature and average precipitation for Redfield, South Dakota for the period 1906-1930 and are included in this publication for comparative purposes.

11.3	0.57	16.7	0.64	30.5	0.89	45.8	2.00	56.4	2.78	66.6	3.21	72.3	2.51	70.4	2.33	61.1	1.68	47.6	1.39	33.1	0.74	17.9	0.53	44.1	19.25

UTAH

*MEAN TEMPERATURE AND PRECIPITATION

STATION	JANUARY Temperature	JANUARY Precipitation	FEBRUARY Temperature	FEBRUARY Precipitation	MARCH Temperature	MARCH Precipitation	APRIL Temperature	APRIL Precipitation	MAY Temperature	MAY Precipitation	JUNE Temperature	JUNE Precipitation	JULY Temperature	JULY Precipitation	AUGUST Temperature	AUGUST Precipitation	SEPTEMBER Temperature	SEPTEMBER Precipitation	OCTOBER Temperature	OCTOBER Precipitation	NOVEMBER Temperature	NOVEMBER Precipitation	DECEMBER Temperature	DECEMBER Precipitation	ANNUAL Temperature	ANNUAL Precipitation
UTAH																										
WESTERN																										
DESERET	25.4	.42	31.6	.40	39.8	.63	48.7	.79	56.9	.75	65.0	.47	74.1	.47	72.3	.54	63.2	.34	51.4	.64	37.1	.45	29.3	.59	49.5	6.49
MILFORD WB AP	23.8	.57	30.9	.71	39.2	1.06	47.8	.76	56.8	.74	65.8	.45	74.0	.77	71.7	.81	62.6	.40	50.1	.88	37.4	.54	28.0	.75	49.0	8.44
MODENA	25.8	.81	31.1	.74	38.3	.98	48.8	.73	55.2	.62	63.4	.44	71.9	.98	69.9	1.46	62.2	.64	50.3	1.03	37.5	.55	29.4	.87	48.7	9.85
PARK VALLEY	23.9	1.05	27.4	.86	34.9	.75	44.8	1.00	53.5	.98	61.2	.90	72.1	.93	70.5	.78	61.2	.85	49.8	.64	35.2	.84	27.5	1.05	48.8	10.43
WENDOVER CAA AP	27.1	.31	32.7	.30	41.7	.38	52.2	.58	61.7	.58	70.1	.49	80.0	.34	77.8	.40	66.8	.35	53.5	.51	38.1	.27	30.3	.31	52.7	4.82
DIVISION	25.7	.72	30.2	.53	37.9	.80	48.1	.85	56.0	.82	64.4	.58	74.2	.67	72.3	.75	63.2	.46	51.1	.71	37.2	.62	28.9	.71	49.1	8.22
DIXIE																										
GUNLOCK PH		1.34		1.26		1.53		.82		.50		.27		1.06		1.16		.78		.84		.69		1.48		11.73
ST GEORGE PH	38.7	.99	44.2	1.01	51.5	.92	60.4	.51	68.1	.33	75.9	.22	83.5	.62	81.8	.67	74.5	.64	61.9	.61	48.0	.56	40.5	1.14	60.8	8.22
ZION NP	39.4	1.59	43.7	1.70	50.0	1.72	59.1	1.21	67.8	.73	77.0	.58	84.3	.86	82.2	1.31	76.3	1.08	64.0	1.06	50.5	.98	41.9	1.80	61.4	14.60
DIVISION	38.9	1.15	43.1	.99	49.5	1.31	59.5	.86	67.1	.47	75.6	.34	83.4	.81	81.3	.92	74.7	.75	62.9	.63	48.9	.61	40.5	1.23	60.5	10.07
NORTH CENTRAL																										
ALPINE		1.42		1.29		1.23		1.56		1.29		1.02		.61		.95		.51		1.36		1.16		1.61		14.01
BRIGHAM CITY	25.9	1.98	31.0	1.60	39.0	1.81	50.2	2.13	59.1	1.74	67.0	1.41	76.3	.46	73.8	.58	64.2	.97	53.0	1.59	38.6	1.86	30.8	1.80	50.7	17.93
CORINNE	23.8	1.32	29.1	1.34	38.1	1.55	48.8	1.75	57.1	1.72	65.0	1.12	74.2	.50	72.2	.46	62.8	.81	51.6	1.19	37.3	1.55	29.3	1.72	49.1	15.23
COTTONWOOD WEIR		2.10		1.92		2.56		2.49		2.10		1.40		.76		1.23		.79		1.85		2.03		1.97		21.20
ELBERTA	26.3	.72	32.0	.77	39.6	.92	49.4	.89	57.6	1.02	65.7	.78	74.7	.84	73.3	.80	63.9	.48	51.9	1.03	38.1	.78	30.4	.89	50.2	9.92
EUREKA		1.47		1.36		1.55		1.28		1.19		.92		1.07		1.15		.58		1.31		.97		1.65		14.48
FARMINGTON	28.1	2.28	33.5	1.79	41.0	2.03	50.9	2.32	59.0	1.76	66.4	1.41	75.6	.45	73.9	1.02	64.7	.69	53.7	1.69	39.6	1.89	32.4	2.04	51.6	19.39
LEWISTON	20.6	1.85	26.1	1.49	34.8	1.83	48.3	2.18	54.3	2.12	61.3	1.51	69.9	.54	68.1	.89	59.0	.97	48.1	1.54	34.6	1.53	26.4	1.82	45.8	18.25
LOGAN UTAH STATE UNIV	23.6	1.68	28.4	1.37	36.8	1.86	51.4	2.16	56.5	1.89	63.8	1.35	73.5	.43	72.1	.71	63.1	.92	51.5	1.54	36.4	1.55	28.5	1.60	48.8	17.03
LOWER AMERICAN FORK PH	28.9	1.59	33.6	1.47	40.9	1.61	50.9	1.75	59.4	1.48	67.4	1.23	76.8	.79	75.4	1.11	67.3	.64	55.4	1.61	40.5	1.43	32.6	1.78	52.4	16.49
MIDVALE	27.8	1.23	33.1	1.26	40.5	1.64	50.3	1.61	58.4	1.33	66.5	1.00	76.2	.74	74.4	.98	64.7	.51	53.3	1.26	39.3	1.41	32.0	1.28	51.4	14.23
OGDEN SUGAR FACTORY	26.2	1.70	31.5	1.45	39.5	1.69	50.0	2.16	58.5	1.55	66.0	1.31	75.4	.56	73.4	.79	64.2	.83	53.0	1.67	38.7	1.64	31.3	1.82	50.6	17.07
PAYSON		1.47		1.23		1.52		1.42		1.39		.93		.82		.91		.77		1.38		1.37		1.63		14.84
PROVO RADIO KOVO		1.42		1.22		1.27		1.21		1.12		.84		.65		.86		.58		1.43		1.20		1.40		13.20
RICHMOND		1.96		1.62		1.90		2.26		2.06		1.51		.60		.69		.95		1.64		1.75		1.91		18.65
RIVERDALE PH	26.2	1.78	31.2	1.51	39.3	1.65	49.6	2.04	57.7	1.58	65.6	1.31	74.5	.54	72.7	.78	63.4	.79	52.3	1.64	38.4	1.57	30.8	1.76	50.2	16.95
SALT LAKE CITY WB AP	26.5	1.20	33.4	1.23	41.1	1.66	50.1	1.76	58.9	1.56	67.1	.91	76.6	.61	74.4	.97	64.2	.74	52.9	1.34	39.3	1.42	31.5	1.34	51.3	14.74
SANTAQUIN PH	27.3	1.67	31.6	1.77	38.8	2.22	49.0	2.10	57.1	1.80	65.4	1.13	74.9	.87	73.4	1.08	64.7	.77	52.4	1.87	38.3	1.79	31.1	1.82	50.3	18.89
SPANISH FORK PH	28.3	1.74	33.1	1.49	40.9	1.96	51.2	1.85	59.3	1.41	68.0	1.07	76.6	.78	74.8	.85	66.2	.72	54.4	1.57	40.3	1.62	32.4	1.81	52.1	16.87
TOOELE	28.2	1.28	32.4	1.54	40.1	1.80	50.3	1.81	58.8	1.47	67.1	1.07	76.7	.81	74.9	.94	65.5	.62	53.2	1.37	39.1	1.56	32.0	1.45	51.5	15.72
UTAH LAKE LEHI	25.0	.85	30.7	.84	38.3	.93	48.1	.91	56.3	.68	64.0	.75	72.3	.71	70.7	.96	61.3	.43	50.0	.98	36.7	.83	29.4	1.05	48.6	10.12
DIVISION	26.6	1.57	30.8	1.23	38.1	1.59	49.1	1.70	57.3	1.49	65.1	1.15	74.6	.70	73.0	.85	64.3	.68	52.4	1.29	38.4	1.44	30.2	1.55	50.0	15.24
SOUTH CENTRAL																										
ALTON	25.6	1.67	28.1	1.64	33.4	1.53	42.9	1.13	50.6	.70	58.1	.68	65.5	1.43	64.1	1.62	58.1	1.39	47.9	1.27	36.7	.85	29.2	1.93	45.0	15.82
BEAVER	26.2	.84	30.5	.98	37.3	1.11	46.0	.99	53.8	.94	61.5	.71	69.2	1.39	67.6	1.56	60.3	.76	48.7	1.00	36.3	.60	29.5	.89	47.2	11.77
CEDAR CITY PH	28.5	.88	32.6	.84	39.6	1.16	49.0	.94	56.9	.82	65.8	.50	73.3	1.03	71.7	1.04	64.4	.63	52.7	1.14	39.8	.88	32.2	.93	50.5	10.81
ESCALANTE	26.0	1.20	31.1	.86	38.9	.91	47.3	.58	55.2	.67	63.1	.58	70.3	1.35	67.9	1.95	61.4	1.11	50.5	1.11	37.4	.64	29.0	1.23	48.2	12.19
FILLMORE	28.6	1.38	33.4	1.48	41.3	1.83	51.0	1.39	59.3	1.32	68.2	.88	77.3	.79	75.6	.91	67.0	.52	54.9	1.15	40.4	1.26	32.3	1.35	52.4	14.26
KANAB PH	34.2	1.50	38.0	1.53	44.6	1.24	53.2	.84	60.9	.48	69.1	.40	76.6	.89	74.7	1.50	68.7	.95	57.5	.92	45.0	.72	36.8	1.65	54.9	12.62
KANOSH		1.25		1.51		1.73		1.23		1.46		.78		.77		.99		.47		1.02		1.29		1.29		13.79
LEVAN	25.4	1.16	30.6	1.20	39.0	1.58	48.7	1.35	56.0	1.26	64.0	.88	72.9	.74	71.6	.92	63.7	.61	52.0	1.29	38.4	1.09	29.9	1.38	49.4	13.46
LOA	22.4	.36	26.1	.26	33.0	.48	41.7	.33	50.0	.52	57.7	.61	64.5	1.15	62.6	1.33	55.7	.69	45.3	.77	32.6	.30	24.3	.40	43.0	7.20
MANTI	24.9	1.02	29.2	1.11	37.6	1.34	47.1	1.15	54.7	1.07	62.5	.91	69.8	.80	68.4	.83	60.9	.57	50.2	1.14	36.8	.93	28.8	1.14	47.6	12.01
MORONI		.88		.87		.88		.77		.76		.74		.69		.94		.61		.91		.74		1.09		9.88
OAK CITY	28.2	.98	33.4	1.06	41.1	1.31	50.6	1.24	59.0	1.20	68.2	.81	78.0	.54	76.2	.88	67.1	.56	55.2	1.17	39.5	1.02	31.7	1.10	52.4	11.87
ORDERVILLE		1.77		1.65		1.49		1.07		.66		.47		.80		1.24		1.16		1.14		.98		1.96		14.59
PANGUITCH	22.1	.56	26.4	.51	33.8	.75	43.0	.60	50.1	.56	57.1	.57	63.9	1.50	62.4	1.57	55.6	.81	45.4	.85	33.5	.39	25.2	.66	43.2	9.33
PAROWAN		.88		.96		1.39		.99		.96		.54		1.17		1.17		.68		1.00		.85		1.00		11.59
PIUTE DAM	26.8	.57	31.2	.49	38.0	.76	47.3	.58	55.1	.65	63.5	.62	71.4	.91	69.9	.97	62.2	.75	51.3	.76	38.1	.54	30.2	.59	48.7	8.19
RICHFIELD RADIO KSVC	28.0	.61	32.6	.62	40.2	.87	48.5	.68	56.7	.80	64.5	.62	71.8	.84	70.0	.83	61.9	.49	51.0	.61	38.0	.56	30.6	.64	49.5	8.19
SALINA		.90		.86		1.08		.89		.97		.77		.72		.74		.47		.71		.78		.77		9.66
SCIPIO	24.3	1.10	29.6	1.18	38.0	1.28	47.4	1.00	55.3	.97	63.3	.84	71.4	.75	69.5	.90	60.7	.53	49.7	1.14	36.1	.97	28.5	1.21	47.8	11.87
DIVISION	26.6	1.18	29.9	1.09	37.3	1.37	46.5	1.00	54.2	.87	62.5	.70	70.0	1.12	68.0	1.27	60.9	.75	50.3	.98	37.6	.90	29.6	1.18	47.8	12.41
NORTHERN MOUNTAINS																										
CITY CREEK WATER PLT		2.83		2.64		3.22		3.13		2.35		1.69		.84		1.06		.71		2.21		2.48		2.78		25.93
COALVILLE	22.3	1.27	27.1	1.23	33.9	1.57	43.6	1.19	51.3	1.28	58.0	1.07	66.0	.92	63.9	1.17	56.1	.64	46.7	1.17	33.5	1.27	26.1	1.20	44.0	13.98
HEBER	20.3	1.82	25.3	1.64	34.0	1.40	44.3	1.16	52.1	1.07	59.0	.93	66.9	.83	65.5	1.08	57.6	.72	47.9	1.31	34.7	1.44	25.7	1.98	44.4	15.38
HIAWATHA	23.1	1.00	26.6	.85	33.5	1.03	45.7	.83	52.6	1.04	61.6	1.02	69.4	1.27	67.2	1.88	60.3	.99	48.6	1.27	34.1	.73	26.1	1.07	45.7	12.98
LAKETOWN	20.4	.87	21.9	.83	29.2	.91	42.9	1.03	50.1	1.23	57.0	1.05	65.2	.55	63.4	.86	55.4	.77	45.5	1.05	32.6	.85	25.6	.78	42.4	10.78
MORGAN	22.5	1.81	27.7	1.54	35.3	1.89	45.9	1.40	53.8	1.28	61.0	1.04	68.9	.53	66.8	.88	58.0	.58	48.0	1.28	34.2	1.42	26.4	1.70	45.7	14.95
MOUNTAIN DELL DAM		2.16		2.18		2.48		2.40		2.17		1.43		.84		.97		.89		2.05		2.22		2.29		22.06
SILVER LAKE BRIGHTON		5.17		5.19		5.47		3.75		2.66		2.13		1.52		1.76		1.36		2.98		4.38		5.49		41.86
SNAKE CREEK PH	20.9	3.24	24.8	2.76	32.0	2.57	42.6	1.70	50.5	1.47	57.9	1.11	65.6	.92	63.8	1.16	56.0	.85	46.1	1.62	32.5	2.17	25.5	3.23	43.2	22.80
SOLDIER SUMMIT	17.4	1.69	20.3	1.54	27.6	1.47	37.6	1.11	46.1	1.04	53.3	.97	61.4	1.36	59.9	1.65	52.3	.98	42.0	1.24	28.6	1.20	21.0	1.67	39.0	15.92
WOODRUFF	14.2	.52	17.8	.61	26.4	.71	38.6	.76	47.2	1.09	54.2	.96	62.1	.86	60.1	1.01	51.9	.70	41.9	1.02	27.8	.56	19.7	.55	38.5	9.35
DIVISION	20.3	2.11	23.6	1.79	30.2	2.21	41.3	1.63	49.5	1.42	56.5	1.19	65.0	1.00	63.3	1.38	55.5	1.04	45.2	1.58	32.1	1.75	24.6	2.22	42.3	19.32
UINTA BASIN																										
DUCHESNE	16.7	.58	22.9	.54	34.8	.73	46.1	.61	54.5	.87	61.8	.81	69.2	.97	67.1	1.27	59.0	.84	47.6	.97	32.5	.42	22.5	.67	44.6	9.28
FORT DUCHESNE	14.7	.41	21.0	.36	34.5	.40	47.1	.60	56.0	.70	63.9	.71	70.9	.52	68.7	.73	60.6	.71	48.6	.86	32.7	.42	21.5	.59	45.0	7.01
JENSEN		.53		.44		.64		.81		.61		.73		.50		.76		.69		.96		.45		.76		7.88
MYTON	15.3	.30	22.3	.32	35.5	.42	47.9	.54	56.8	.64	64.4	.61	72.0	.64	70.1	.88	62.1	.60	49.8	.70	33.3	.34	21.8	.50	45.9	6.39
VERNAL AP	15.4	.65	22.1	.49	34.2	.65	45.9	.93	54.6	.73	61.9	.72	69.5	.54	67.2	.80	59.4	.67	47.9	.88	32.6	.50	21.4	.76	44.3	8.22
DIVISION	16.7	.53	22.9	.46	34.4	.58	46.7	.71	55.6	.66	63.4	.70	71.1	.65	68.6	.99	60.7	.74	48.8	.95	33.5	.47	22.7	.68	45.4	8.12
SOUTHEAST																										
BLANDING	28.6	1.05	32.4	1.20	39.2	1.08	48.0	.94	56.7	.76	65.7	.58	72.3	.99	70.5	1.24	62.7	1.47	51.8	1.29	38.6	.82	30.2	1.35	49.6	12.77
BLUFF	30.9	.85	37.8	.72	46.2	.88	56.0	.52	64.5	.37	73.8	.31	80.7	.57	78.5	.84	70.0	1.00	57.3	.72	42.1	.51	33.3	.82	55.9	7.69
EMERY	24.0	.51	28.2	.38	36.3	.47	45.6	.36	53.7	.50	61.3	.55	68.4	.60	66.2	1.26	59.3	.73	48.7	.76	35.5	.88	27.0	.58	46.2	7.22
GREENRIVER AWY	22.7	.37	32.0	.38	42.7	.46	53.7	.46	63.0	.36	71.5	.52	79.8	.54	77.1	.61	67.7	.53	54.0	.68	37.5	.35	28.2	.47	52.5	5.91
HANKSVILLE CAA AP	25.6	.32	33.1	.26	43.3	.30	53.7	.28	62.5	.36	71.8	.35	79.0	.73	76.7	.87	67.8	.47	54.6	.62	39.0	.30	29.7	.35	53.1	5.21
LA SAL		1.07		.89		.98		1.09		.79		.74		1.41		1.67		1.24		1.32		.77		.93		12.90
MOAB	29.7	.57	38.3	.62	46.1	.76	56.7	.78	65.4	.57	73.8	.47	80.7	.55	77.6	.87	69.4	.78	56.8	1.05	41.6	.67	33.0	.71	55.6	8.40
MONTICELLO	25.4	1.10	29.2	.92	35.4	1.04	45.2	.91	53.5	.78	61.9	.63	69.2	1.38	67.0	2.00	60.4	1.47	49.8	1.63	36.5	.80	28.5	1.15	46.8	13.81
PRICE	23.3	.74	29.6	.50	39.2	.69	49.5	.61	58.6	.66	66.9	.73	74.3	.95	72.2	1.10	64.4	.83	52.1	.91	37.0	.48	27.6	.96	49.6	9.23
THOMPSONS	26.1	.73	32.5	.61	41.6	.72	52.3	.75	61.5	.55	70.9	.52	78.6	.60	76.1	.98	68.0	.79	55.4	1.01	39.5	.47	30.0	.81	52.7	8.54
DIVISION	25.9	.68	31.1	.58	40.5	.64	51.4	.59	60.0	.54	68.7	.50	76.4	.75	73.8	1.10	64.8	.78	53.6	.91	38.7	.53	29.2	.72	51.2	8.32

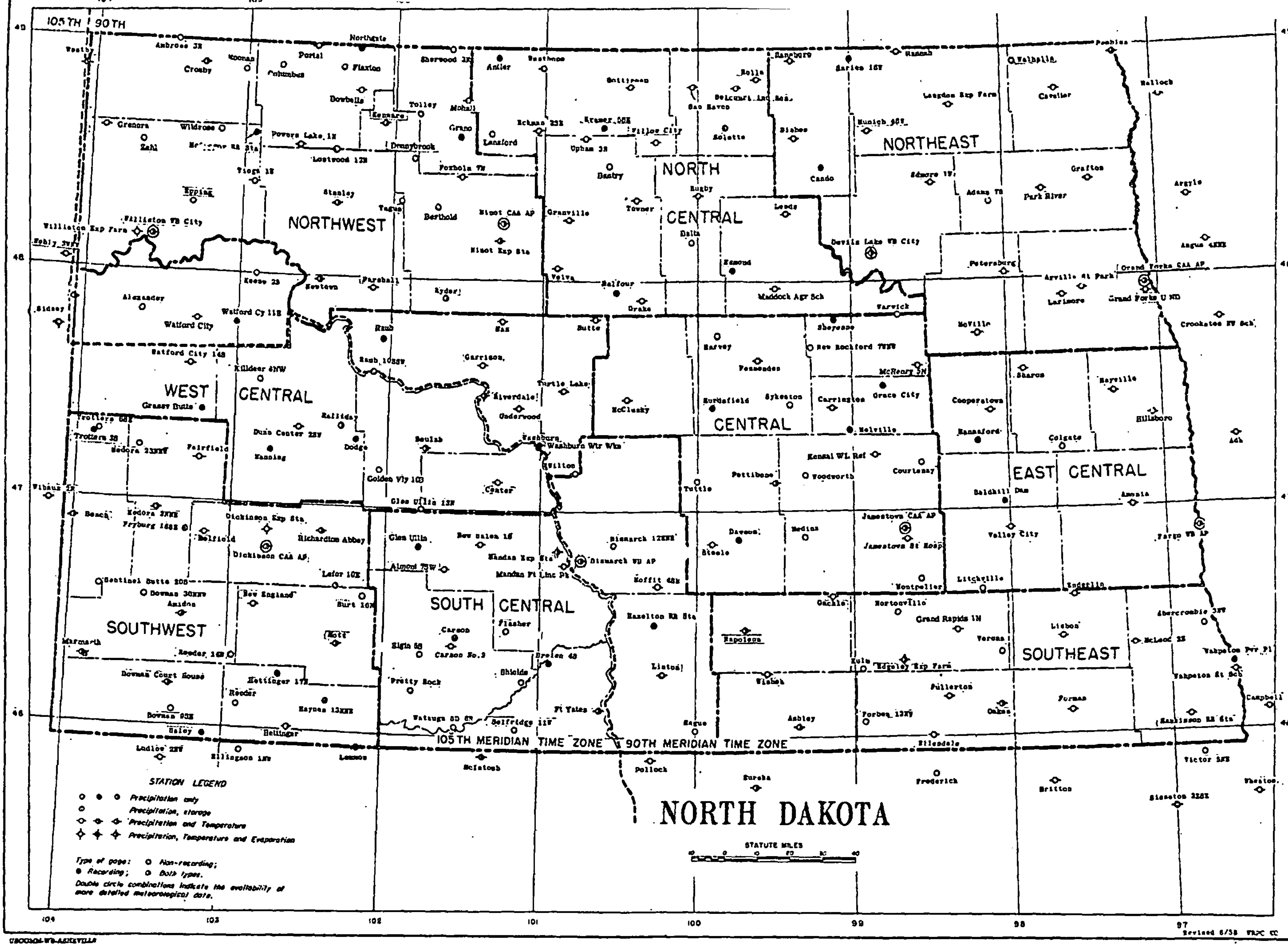
* Averages for period 1931 - 1955, except for stations marked WB and Blanding which are "normals" based on period 1921 - 1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.

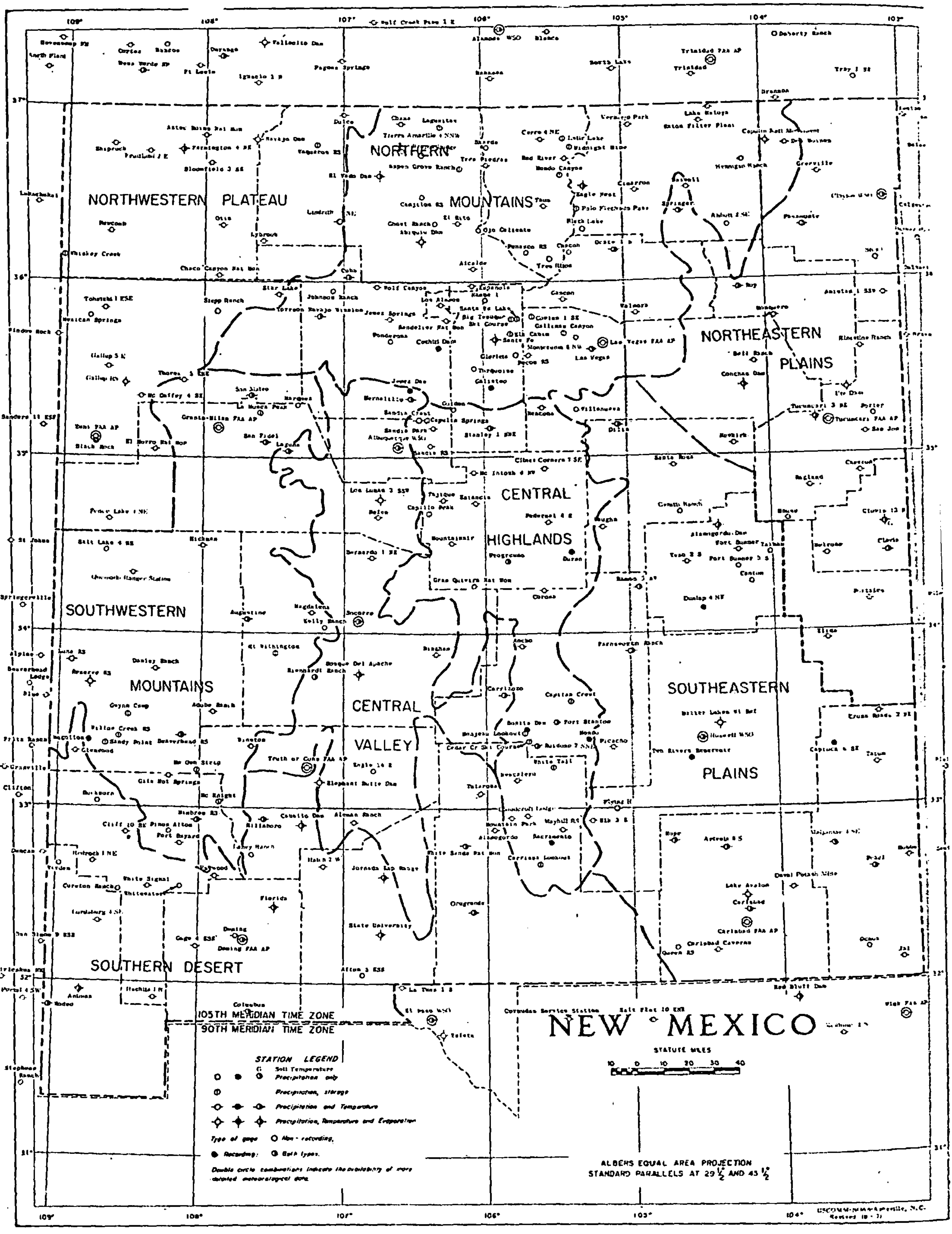
WYO

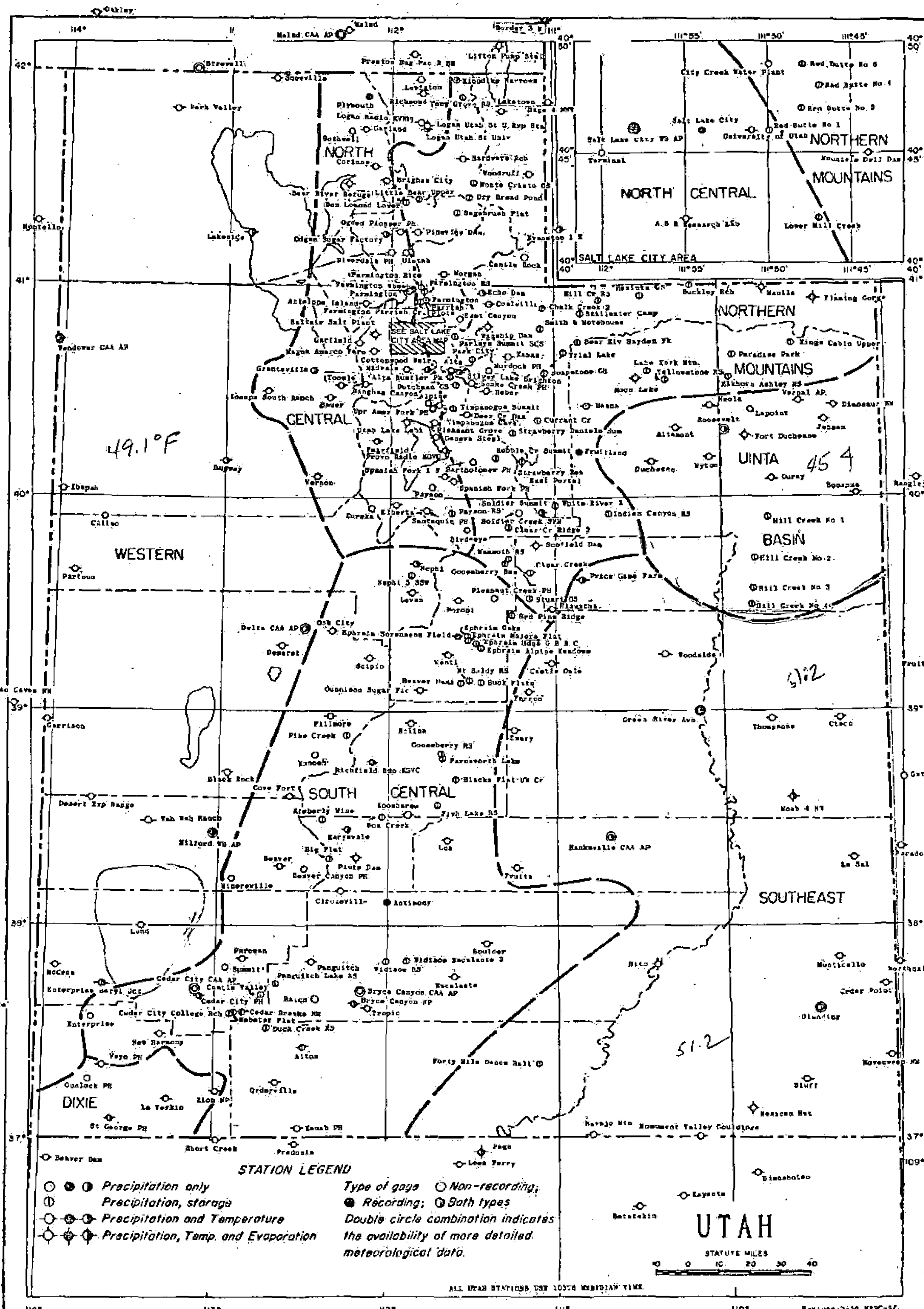
*MEAN TEMPERATURE AND PRECIPITATION

STATION	JANUARY Temperature	JANUARY Precipitation	FEBRUARY Temperature	FEBRUARY Precipitation	MARCH Temperature	MARCH Precipitation	APRIL Temperature	APRIL Precipitation	MAY Temperature	MAY Precipitation	JUNE Temperature	JUNE Precipitation	JULY Temperature	JULY Precipitation	AUGUST Temperature	AUGUST Precipitation	SEPTEMBER Temperature	SEPTEMBER Precipitation	OCTOBER Temperature	OCTOBER Precipitation	NOVEMBER Temperature	NOVEMBER Precipitation	DECEMBER Temperature	DECEMBER Precipitation	ANNUAL Temperature	ANNUAL Precipitation
WYOMING																										
YELLOWSTONE DRAINAGE																										
LAKE YELLOWSTONE		1.87		1.64		1.58		1.46		1.64		2.18		1.48		1.38		1.39		1.21		1.48		1.79		19.00
LAMAR RS	18.3	.95	17.0	.76	23.6	.89	35.6	1.00	45.1	1.52	51.5	2.13	58.6	1.30	56.6	1.29	49.0	1.21	39.6	.99	25.3	.82	16.6	.87	35.9	13.73
TOWER FALLS		1.29		.95		1.30		1.19		1.77		2.29		1.43		1.30		1.29		1.25		1.11		1.17		16.34
YELLOWSTONE PARK	18.3	1.12	21.6	.91	26.9	1.31	38.1	1.20	46.9	1.71	53.8	2.26	62.9	1.18	61.1	1.19	52.4	1.25	42.6	1.17	29.1	1.02	22.2	1.18	39.7	15.50
DIVISION	16.7	1.13	20.0	.92	25.9	1.26	37.1	1.25	45.9	1.54	52.8	2.03	60.9	1.38	58.9	1.20	50.8	1.24	41.2	1.09	27.9	.95	20.8	1.04	38.2	15.03
SNAKE DRAINAGE																										
ALTA 1 NNW	18.1	1.81	21.5	1.43	27.0	1.51	37.9	1.37	47.1	2.07	53.9	2.34	63.0	1.04	61.4	1.19	53.2	1.29	43.7	1.53	29.5	1.37	22.3	1.56	39.9	18.21
BEDFORD 2 SE	10.7	2.14	21.2	1.87	27.1	2.00	38.1	1.56	47.3	2.00	53.5	2.27	61.6	.93	60.4	1.05	52.8	1.25	43.2	1.58	28.9	1.73	20.7	2.24	39.3	20.52
GROVER 2 S	13.1	1.52	17.8	1.44	24.6	1.61	37.0	1.49	47.3	1.85	53.0	2.14	60.4	1.10	58.7	1.10	51.3	1.21	42.1	1.61	27.5	1.50	17.0	1.82	37.5	18.19
JACKSON	14.1	1.47	18.2	1.41	26.0	1.28	38.4	1.18	46.3	1.51	53.6	1.59	61.0	.78	58.9	1.19	51.4	1.08	41.8	1.09	27.1	1.10	17.9	1.67	37.9	15.33
MORAN	10.3	2.24	14.0	2.18	20.2	2.05	32.8	1.69	43.2	1.89	50.4	1.86	57.6	1.02	55.3	1.33	48.0	1.32	38.7	1.43	24.8	1.80	15.2	2.40	34.2	21.21
SNAKE RIVER	13.0	3.76	16.8	3.55	22.4	3.63	33.5	2.20	42.7	2.44	50.5	2.58	58.6	1.43	56.5	1.39	48.2	1.65	38.6	1.91	24.1	2.91	18.2	4.10	35.1	31.53
DIVISION	13.4	2.78	17.5	2.56	24.0	2.45	33.8	1.68	45.2	2.15	51.9	2.44	59.8	1.06	58.0	1.29	50.3	1.44	40.8	1.72	26.6	2.07	17.6	2.74	36.7	24.38
GREEN AND BEAR DRAINAGE																										
BORDER 3 N	11.4	1.23	15.4	1.05	24.1	1.09	38.5	1.11	48.4	1.25	55.1	1.33	62.9	.80	61.0	.80	52.9	.62	42.7	1.24	28.0	1.07	17.4	1.25	38.2	13.04
DIXON	17.3	.93	22.1	.69	30.3	1.20	41.8	1.36	50.4	1.34	58.2	.98	65.4	1.23	63.2	1.19	54.9	.82	44.5	1.34	30.8	.82	22.5	1.03	41.8	12.95
EVANSTON 1 E	17.1	.75	20.5	.85	26.7	.94	38.5	1.02	47.3	1.09	54.4	1.07	62.5	.74	60.9	.98	52.9	.64	42.7	.98	28.8	.85	21.3	.74	39.5	10.85
GREEN RIVER	19.3	.48	24.3	.54	32.6	.70	43.9	1.04	53.3	1.19	61.6	.92	69.7	.60	67.4	.87	58.1	.64	46.6	1.00	32.0	.49	23.4	.40	44.4	8.87
KENDALL		1.77		1.44		1.54		1.21		1.96		1.94		1.21		1.23		1.12		1.13		1.32		1.69		17.56
ROCK SPRINGS CAA AP	18.0	.46	22.8	.60	29.2	.66	40.5	1.10	50.9	1.07	59.8	.79	68.8	.68	66.9	.76	56.4	.75	44.1	1.00	30.4	.54	21.5	.41	42.5	8.82
SAGE 4 NNW		.68		.61		.67		.75		1.17		1.04		.69		.83		.63		.90		.65		.58		9.20
DIVISION	15.4	.74	19.1	.88	26.7	.81	38.9	.93	48.2	1.21	56.5	1.08	64.1	.85	61.8	.89	53.3	.70	42.6	1.00	28.2	.68	19.7	.72	39.5	10.29
BIG HORN AND WIND RIVER DRAINAGE																										
BASIN	16.4	.26	23.2	.18	34.9	.36	48.1	.75	58.0	1.07	66.2	1.13	74.5	.61	71.7	.29	61.1	.68	49.3	.47	32.6	.34	21.5	.22	[illegible]	6.36
BUFFALO BILL DAM	27.9	.44	29.8	.49	34.4	.82	44.9	1.36	52.9	1.96	60.2	1.97	68.9	1.08	68.2	.79	60.4	1.03	51.2	.72	38.9	.45	32.1	.33	[illegible]	11.44
CODY AP	24.8	.36	27.8	.38	33.8	.66	45.0	1.11	53.7	1.54	60.9	1.71	69.9	1.01	67.5	.71	58.1	.88	48.8	.62	35.3	.43	28.5	.28	[illegible]	9.69
DEAVER	16.7	.20	22.7	.13	31.9	.22	45.3	.49	55.2	.89	63.3	1.18	72.0	.55	68.8	.34	57.9	.54	46.3	.36	31.2	.18	21.5	.23	44.4	5.31
DIVERSION DAM	20.5	.23	24.2	.23	32.1	.49	43.1	1.30	52.0	1.85	60.1	1.49	68.6	.78	66.1	.66	57.1	1.00	46.5	.91	31.9	.38	24.0	.19	43.8	9.51
DUBOIS	21.9	.39	24.0	.35	29.1	.58	38.4	1.10	46.9	1.42	54.0	1.37	61.5	.96	59.4	.70	51.8	1.01	43.1	.83	31.3	.41	25.0	.33	40.5	9.45
FORT WASHAKIE 2 S		.34		.47		.90		1.92		2.30		1.53		.68		.49		1.08		1.11		.64		.30		11.76
LANDER WB AP	16.8	.50	22.9	.61	31.3	1.14	42.1	2.41	52.4	2.57	61.5	1.35	70.4	.88	68.4	.60	57.5	1.23	44.6	1.53	30.0	.87	20.4	.49	43.2	14.18
LOVELL	17.8	.32	23.3	.27	32.6	.47	45.8	.59	55.8	1.10	63.6	1.53	72.1	.63	68.8	.42	57.5	.66	46.8	.60	32.6	.32	22.8	.28	45.0	7.19
PAVILLION	19.6	.21	25.1	.19	33.9	.47	45.3	1.25	54.6	1.72	62.8	1.31	71.1	.75	68.5	.56	59.4	.84	47.6	.90	31.6	.36	23.0	.18	45.2	8.74
POWELL	19.8	.15	24.9	.12	33.0	.22	45.4	.41	54.9	1.02	62.8	1.31	71.0	.59	68.7	.47	58.8	.65	47.9	.37	32.5	.19	24.2	.10	45.3	5.60
RIVERTON	15.4	.22	22.0	.27	32.9	.52	44.5	1.37	53.9	1.73	62.4	1.31	70.3	.67	67.7	.47	58.0	.78	46.4	.88	29.6	.47	19.4	.21	43.5	8.90
SUNSHINE 3 SW	21.7	.38	22.8	.33	28.8	1.17	37.8	2.35	48.0	3.04	52.8	2.78	60.8	1.90	59.2	1.25	51.5	1.44	43.1	1.13	31.0	.81	24.5	.47	39.8	17.43
THERMOPOLIS	20.2	.45	25.4	.36	34.3	.67	46.3	1.72	55.4	1.98	63.7	1.68	72.1	.71	70.0	.57	59.8	1.03	48.0	1.06	32.9	.62	24.3	.30	46.1	11.15
WORLAND	15.5	.29	21.8	.23	33.1	.41	46.0	1.05	56.0	1.44	64.3	1.47	72.4	.81	69.5	.42	58.8	.74	47.1	.65	31.4	.39	20.0	.25	44.7	8.15
DIVISION	20.0	.35	24.6	.36	32.2	.64	43.8	1.39	53.1	1.79	61.1	1.55	69.8	.93	67.5	.66	58.0	.91	47.2	.82	32.6	.47	24.2	.29	44.5	10.16
POWDER, LITTLE MISSOURI, & TONGUE DRAINAGE																										
MIDWEST	24.0	.59	27.3	.58	33.9	1.07	45.2	1.65	54.6	2.23	64.0	1.67	73.3	1.18	71.2	.70	61.1	1.00	49.9	.97	35.3	.65	27.8	.55	47.3	12.84
NINE MILE CREEK	21.8	.52	25.2	.43	31.4	.93	43.2	1.63	52.2	2.07	60.9	1.77	70.6	1.06	69.1	.69	58.8	.99	47.7	.78	33.0	.74	25.8	.56	45.0	12.17
ROCKYPOINT 2 NE	19.2	.89	22.1	.75	28.7	1.33	42.5	1.94	52.7	2.59	61.4	3.39	71.4	1.38	69.7	1.09	58.9	1.34	47.3	.95	31.7	.84	23.3	.72	44.1	17.21
SHERIDAN WB AP	20.1	.75	23.2	.61	31.6	1.37	43.5	2.26	52.9	2.64	61.4	2.60	70.6	1.38	68.6	.82	57.9	1.45	46.6	1.27	33.1	.93	24.0	.67	44.5	16.75
SHERIDAN FLD STA	19.6	.55	22.4	.62	30.2	1.22	44.1	2.00	54.1	2.81	62.0	2.86	71.8	1.41	69.8	.89	58.9	1.43	47.7	1.18	32.7	.70	24.1	.51	44.8	16.18
DIVISION	20.3	.62	23.5	.55	29.5	1.18	40.4	1.89	51.1	2.41	59.5	2.56	68.9	1.34	67.0	.92	56.8	1.29	46.3	1.01	32.4	.77	24.7	.57	43.4	15.11
BELLE FOURCHE DRAINAGE																										
COLONY	21.7	.55	24.3	.45	30.7	.93	45.0	1.66	55.3	2.23	64.2	3.29	74.2	1.41	72.0	1.15	61.4	1.26	49.6	.83	34.6	.67	26.1	.47	46.6	14.90
GILLETTE 2 E	21.9	.70	25.0	.50	30.9	1.15	43.3	1.71	52.9	2.31	61.3	2.51	72.2	1.27	70.2	.86	59.9	1.17	48.7	.72	33.8	.73	26.1	.64	45.5	14.27
SUNDANCE		.74		.62		1.14		1.70		2.55		3.38		1.66		1.09		1.38		.99		.78		.69		16.72
DIVISION	20.6	.64	24.1	.56	29.4	1.03	42.7	1.80	52.5	2.56	61.2	2.96	71.0	1.58	69.2	1.15	58.6	1.33	47.7	.89	32.7	.73	24.5	.59	44.5	15.82
CHEYENNE AND NIOBRARA DRAINAGE																										
DULL CENTER 1 SE	23.6	.27	26.5	.27	32.8	.55	44.7	1.55	54.3	2.37	63.7	2.24	73.4	1.45	70.7	1.47	60.4	.98	48.6	.88	34.5	.42	26.3	.29	46.6	12.74
KIRTLEY	22.7	.58	25.1	.63	30.5	.99	42.3	2.41	51.9	3.02	60.8	3.12	70.5	1.55	68.9	1.37	59.2	1.33	47.6	1.16	33.7	.59	26.0	.54	44.9	17.29
LUSK	24.1	.54	26.9	.52	32.8	.80	43.6	1.95	52.8	2.71	62.3	2.86	70.9	1.62	68.9	1.19	59.1	1.18	48.0	.96	34.4	.63	27.0	.50	45.9	15.46
NEWCASTLE	23.2	.45	26.4	.36	32.2	.81	44.8	1.48	55.0	2.32	64.5	2.57	74.4	1.56	71.9	1.70	61.2	.90	49.4	.83	34.8	.47	27.2	.41	47.1	13.82
ROCHELLE 3 E		.29		.28		.78		1.72		2.06		2.25		1.30		1.38		.91		.82		.38		.35		12.52
SPENCER 10 NE		.45		.49		.94		1.66		2.27		2.46		1.57		1.40		.91		.88		.43		.40		13.86
DIVISION	22.2	.41	25.8	.41	31.5	.79	44.1	1.58	53.4	2.37	62.5	2.45	72.3	1.32	70.4	1.24	58.9	1.00	48.2	.81	33.8	.47	25.7	.37	45.7	13.22
PLATTE DRAINAGE																										
ARCHER		.39		.33		.74		1.63		2.60		2.68		1.78		1.71		1.26		.87		.44		.28		14.69
CASPER WB AP	22.3	.69	25.9	.72	32.4	1.13	43.0	1.92	53.1	2.32	62.0	1.48	71.1	1.17	68.9	.86	58.1	1.22	46.4	1.11	33.3	.82	25.5	.65	45.1	14.09
CHEYENNE WB AP	25.5	.58	27.7	.65	31.8	1.22	41.1	2.14	50.1	2.46	60.3	2.10	68.1	1.96	66.8	1.61	57.4	1.20	46.4	1.13	35.1	.70	28.7	.52	44.9	16.25
CHUGWATER	27.5	.55	29.3	.57	33.9	1.05	43.8	2.14	52.5	2.42	61.8	2.47	69.7	1.85	68.0	1.11	58.8	1.14	48.4	.90	36.1	.62	30.1	.66	46.7	15.48
ELK MOUNTAIN		.75		.90		1.38		1.71		1.31		.93		.73		.92		.94		.81		.70		.64		11.72
ENCAMPMENT 10 ESE	21.7	.86	23.4	.81	28.9	1.57	39.8	1.60	48.8	1.65	57.0	1.35	64.8	1.19	63.3	1.34	55.3	1.13	45.2	1.25	32.3	.91	25.4	.87	42.2	14.73
FORT LARAMIE 11 NNW		.44		.50		.82		2.04		2.50		2.48		1.49		1.29		1.29		.97		.48		.54		14.84
FOXPARK	15.1	1.38	16.9	1.39	21.5	1.84	30.6	1.81	39.5	1.59	48.3	1.63	55.1	1.61	54.0	1.51	46.5	1.22	37.4	1.00	24.3	1.20	18.6	1.06	34.0	17.24
HECLA		.47		.36		1.18		2.13		2.50		1.91		1.88		1.35		1.11		.89		.62		.47		15.07
LARAMIE	22.6	.38	25.2	.40	29.8	.75	39.5	1.36	48.5	1.46	58.0	1.50	65.6	1.75	63.8	1.25	55.4	.81	45.2	.65	32.3	.44	26.2	.41	42.7	11.16
LEO 6 SW		.66		.64		.98		1.37		1.40		1.08		.91		.96		.83		1.02		.72		.57		11.14
MARSHALL 7 SW	14.6	.63	18.4	.56	25.2	.87	37.1	1.17	46.3	1.49	55.7	1.25	63.9	1.27	61.4	1.11	52.1	.78	41.2	.71	26.3	.47	19.1	.50	38.4	10.81
PATHFINDER DAM	22.5	.30	25.2	.38	32.1	.58	43.6	1.20	53.2	1.66	62.8	1.18	72.2	1.07	70.2	.86	60.4	.85	49.2	.90	34.9	.48	27.3	.31	46.1	9.77
PINE BLUFFS	26.4	.29	29.5	.31	34.8	.70	45.6	1.63	54.6	2.45	64.4	2.55	72.4	1.78	70.6	1.70	61.3	1.25	49.6	.59	36.0	.41	29.1	.36	47.9	14.02
SARATOGA	20.4	.47	23.3	.41	29.6	.73	40.1	1.04	49.1	1.24	57.8	1.06	65.8	.87	63.9	.96	55.2	.80	44.5	.91	30.9	.54	24.1	.50	42.1	9.33
SOUTH PASS CITY		.98		.98		1.22		1.58		1.26		1.44		.83		.92		.79		1.00		.91		.84		12.75
TORRINGTON EXP FARM	26.5	.29	29.6	.42	35.6	.76	46.4	1.86	55.8	2.44	65.3	2.85	72.9	1.43	70.5	.98	60.7	1.04	49.7	.72	36.3	.47	29.1	.42	48.2	13.68
WHEATLAND 1 N	29.1	.28	31.1	.39	36.3	.67	46.9	1.69	55.9	2.18	65.3	2.08	73.8	1.17	71.9	1.04	62.2	1.19	51.3	.79	38.5	.42	32.2	.36	49.5	12.46
YODER		.32		.39		.74		1.84		2.23		2.63		1.54		1.07		1.09		.77		.41		.37		13.40
DIVISION	23.2	.57	25.9	.57	30.8	.95	42.1	1.63	50.9	2.04	60.1	2.00	68.4	1.37	66.7	1.10	57.5	1.04	46.7	.90	33.3	.63	26.6	.53	44.4	13.33

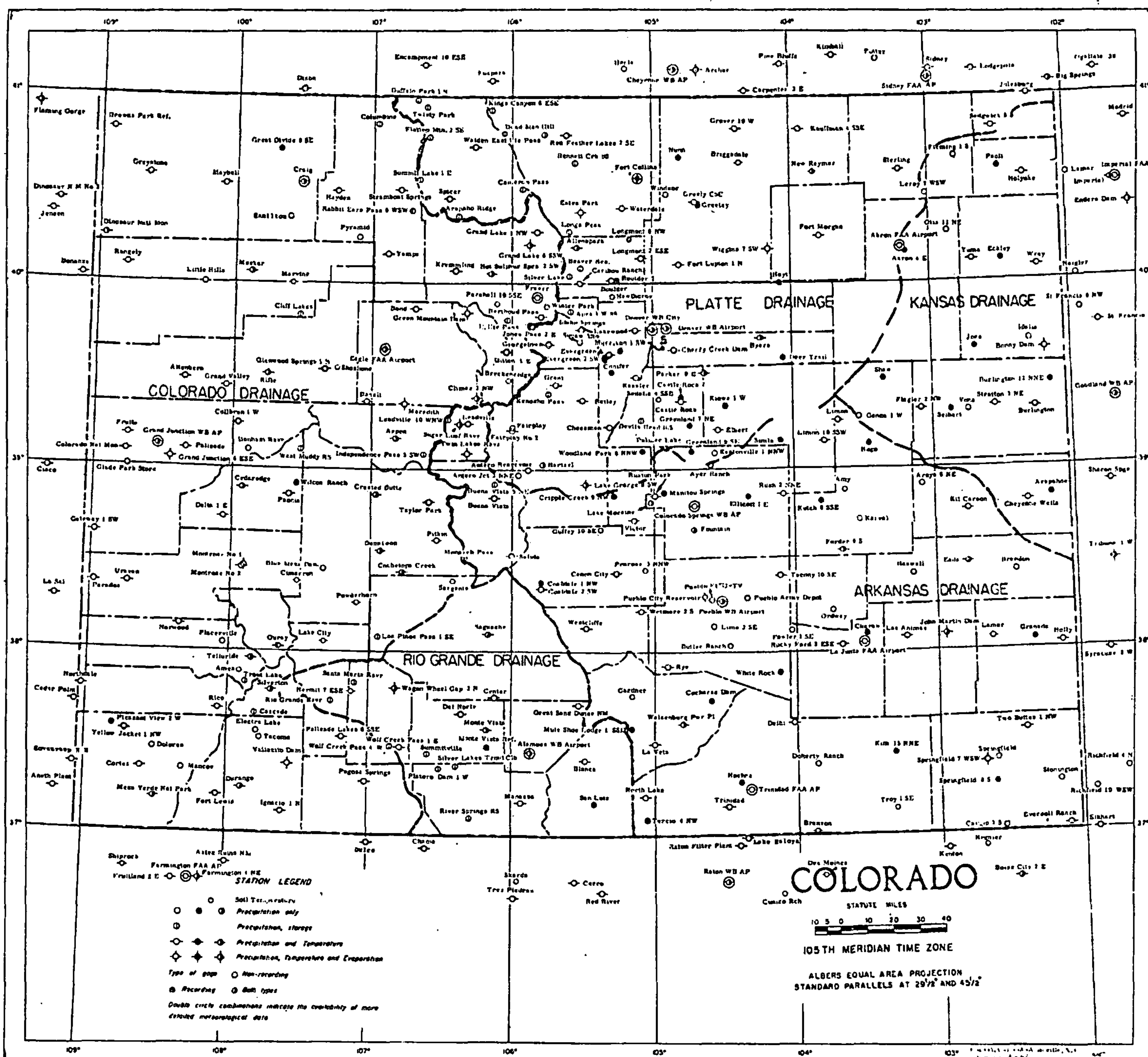
* Averages for period 1931 - 1955, except for stations marked WB and Rock Springs CAA AP which are "normals" based on period 1921 - 1950. Divisional means may not be the arithmetical average of individual stations published, since additional data from shorter period stations are used to obtain better areal representation.


NORTH DAKOTA
105TH
90TH
NORTHWEST
NORTH CENTRAL
NORTHEAST
WEST CENTRAL
CENTRAL
EAST CENTRAL
SOUTHWEST
SOUTH CENTRAL
SOUTHEAST
105TH MERIDIAN TIME ZONE
90TH MERIDIAN TIME ZONE
STATION LEGEND
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage: Non-recording; Recording; Both types.
Double circle combinations indicate the availability of more detailed meteorological data.
STATUTE MILES
104
103
102
101
100
99
98
97
Williston WB City
Minot CAA AP
Devils Lake WB City
Grand Forks CAA AP
Dickinson CAA AP
Bismarck WB AP
Jamestown CAA AP
Fargo WB AP
USCOMM-WB-ASHEVILLE

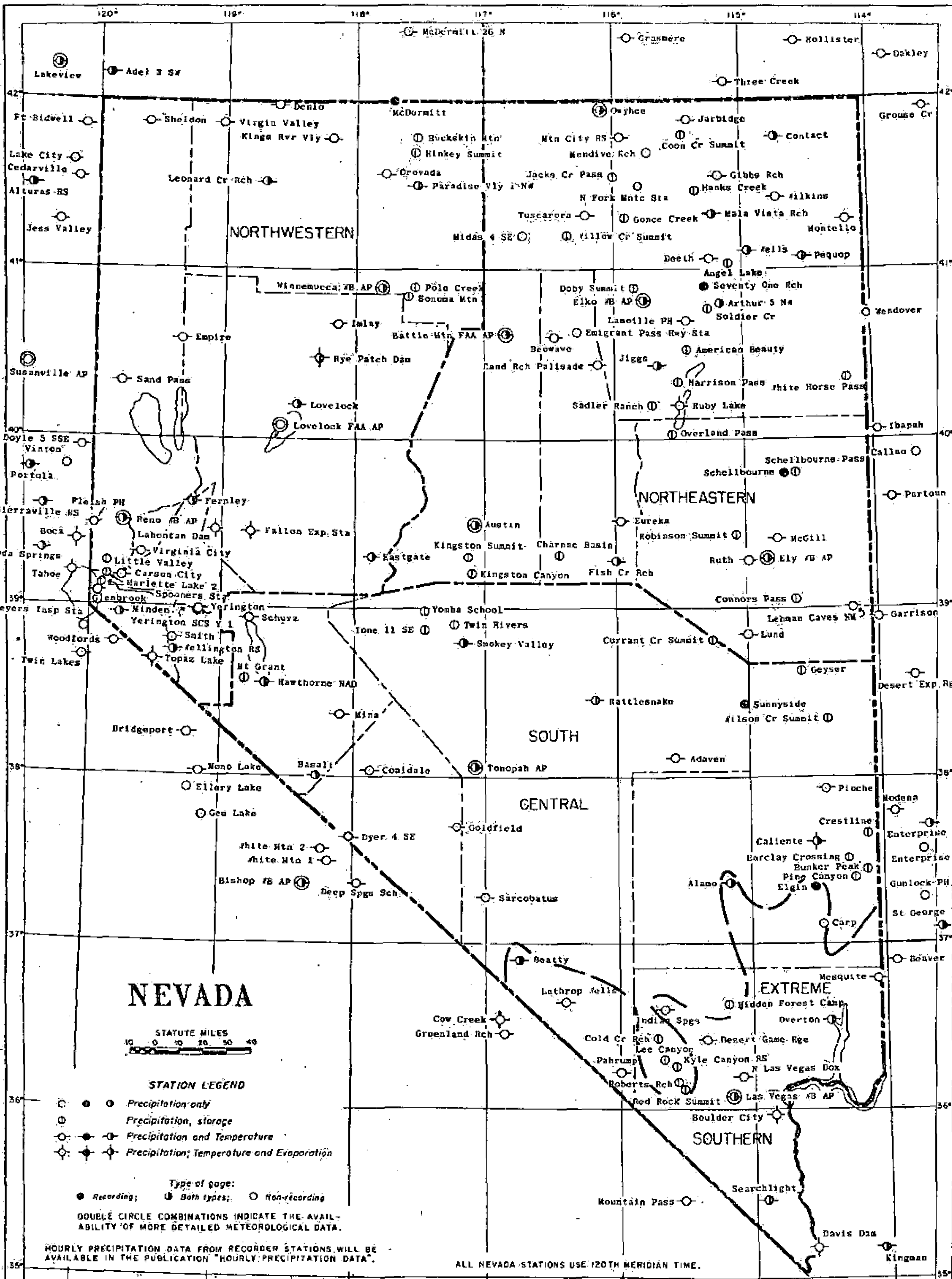

NORTHWESTERN PLATEAU
NORTHERN MOUNTAINS
NORTHEASTERN PLAINS
CENTRAL HIGHLANDS
SOUTHWESTERN MOUNTAINS
CENTRAL VALLEY
SOUTHEASTERN PLAINS
SOUTHERN DESERT
105TH MERIDIAN TIME ZONE
90TH MERIDIAN TIME ZONE
NEW MEXICO
STATUTE MILES
10 0 10 20 30 40
STATION LEGEND
Soil Temperature
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage: Non-recording, Recording, Both types.
Double circle combinations indicate the availability of more detailed meteorological data.
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½° AND 45½°
109° 108° 107° 106° 105° 104° 103°
37° 36° 35° 34° 33° 32° 31°

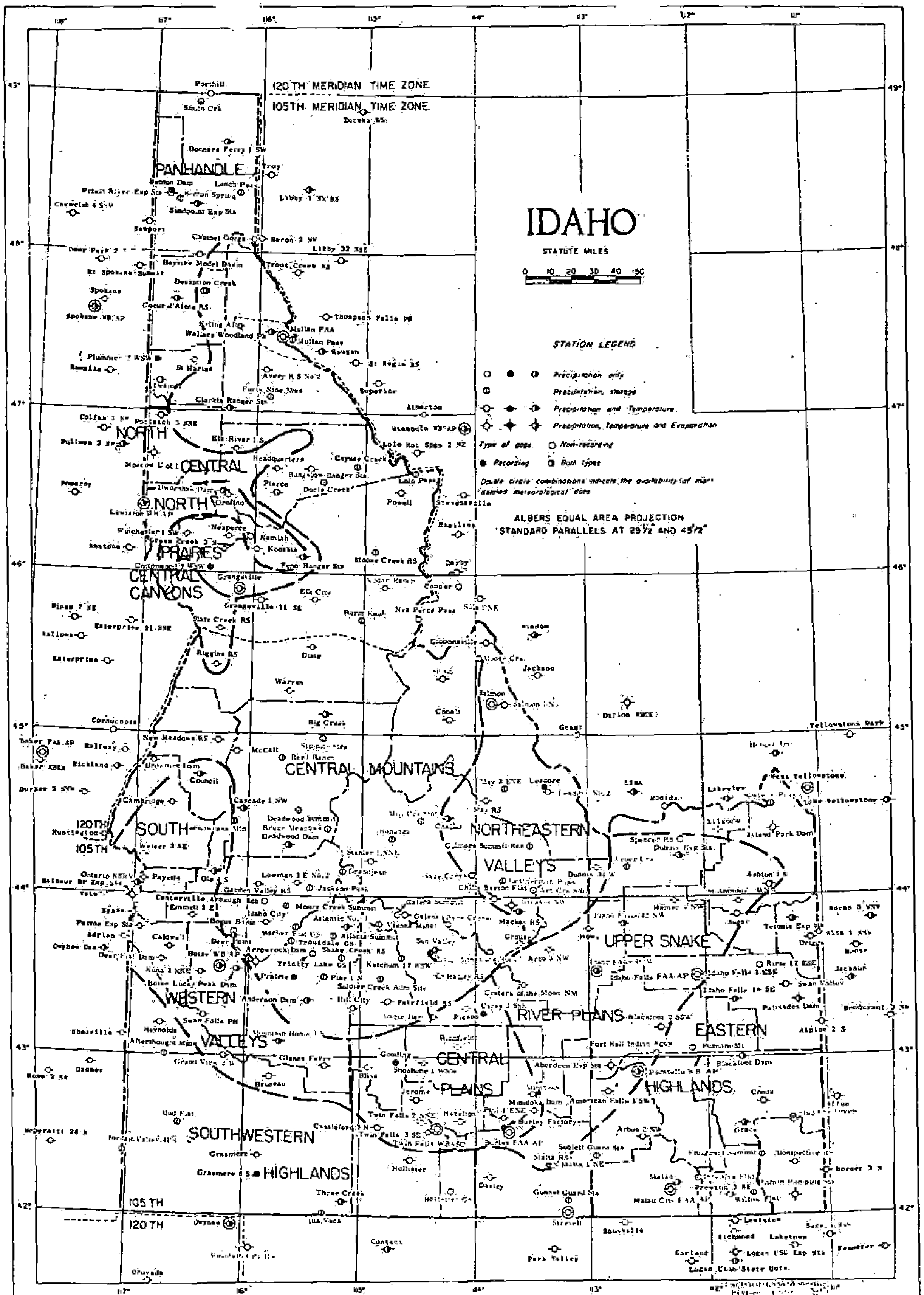


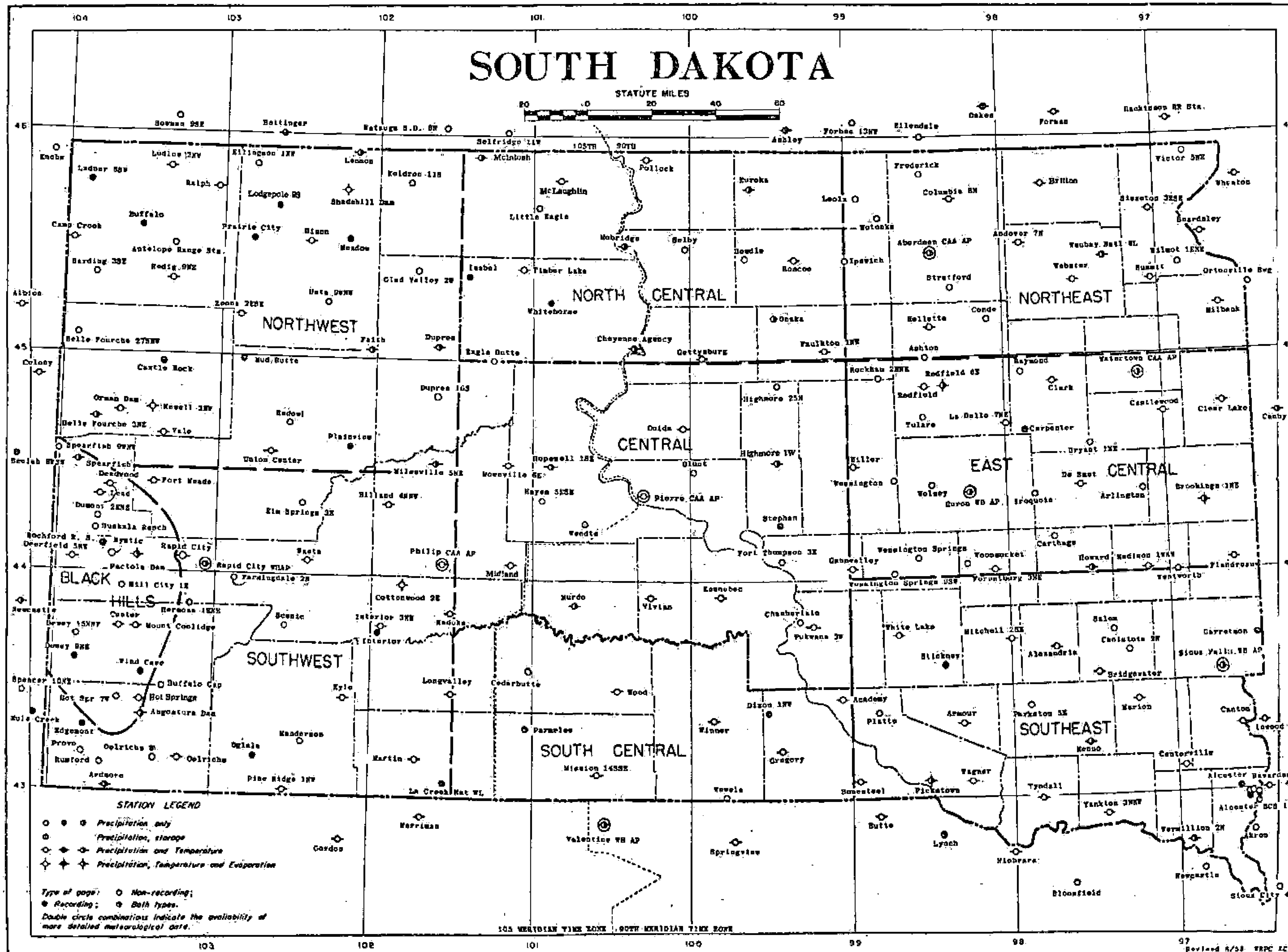
USCOMM-WB-ASHEVILLE



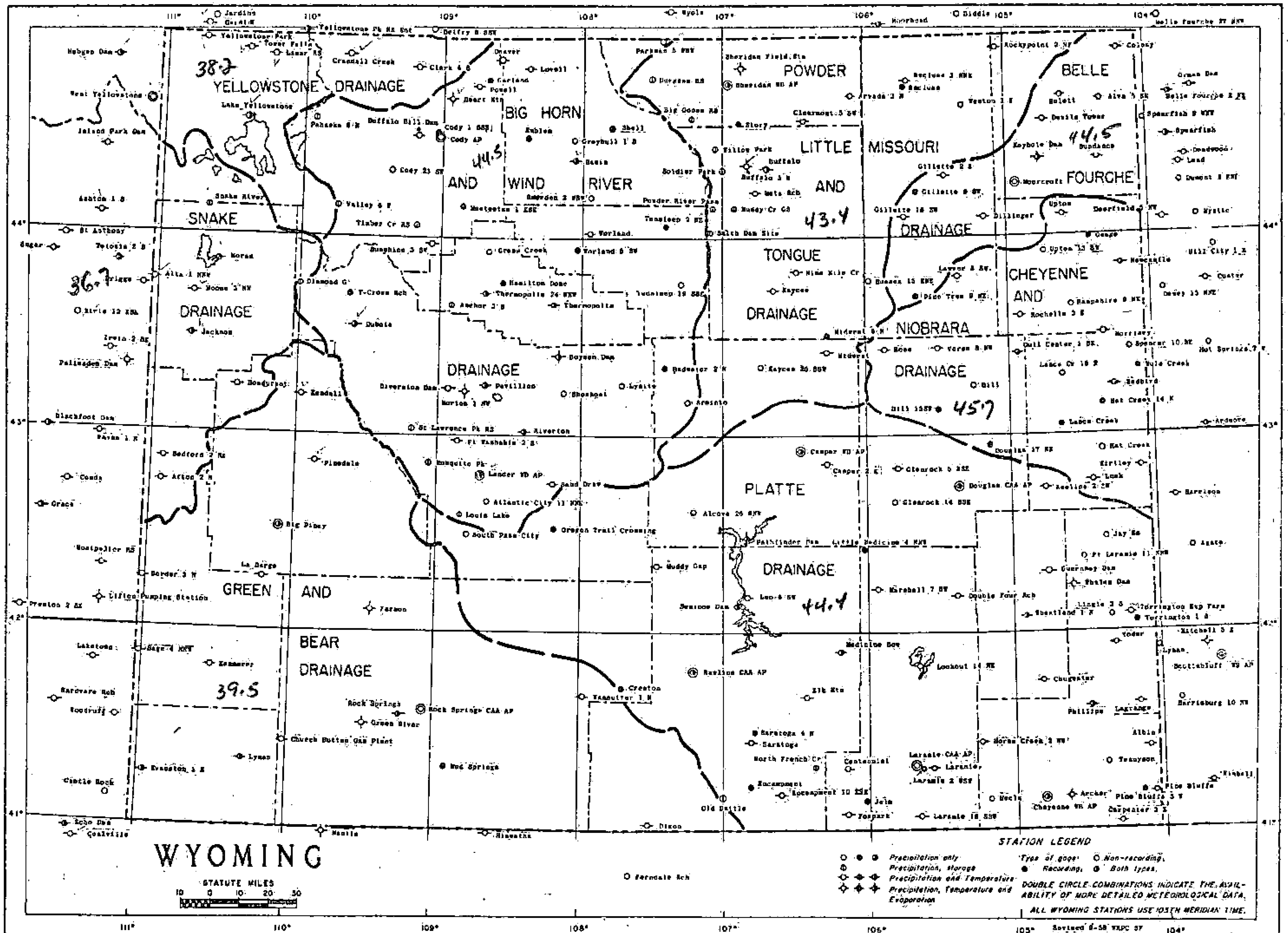
COLORADO
PLATTE DRAINAGE
KANSAS DRAINAGE
COLORADO DRAINAGE
ARKANSAS DRAINAGE
RIO GRANDE DRAINAGE
STATION LEGEND
Soil Temperature
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage
Non-recording
Recording
Both types
Double circle combinations indicate the availability of more detailed meteorological data
STATUTE MILES
105TH MERIDIAN TIME ZONE
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½° AND 45½°


NEVADA
NORTHWESTERN
NORTHEASTERN
SOUTH
CENTRAL
EXTREME
SOUTHERN
STATUTE MILES
STATION LEGEND
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage:
Recording; Both types; Non-recording
DOUBLE CIRCLE COMBINATIONS INDICATE THE AVAILABILITY OF MORE DETAILED METEOROLOGICAL DATA.
HOURLY PRECIPITATION DATA FROM RECORDER STATIONS WILL BE AVAILABLE IN THE PUBLICATION "HOURLY PRECIPITATION DATA".
ALL NEVADA STATIONS USE 120TH MERIDIAN TIME.
Revised 6/59 WRPC-SF
Lakeview
Adel 3 SW
Denio
McDermitt
Owyhee
Jarbidge
Contact
Sheldon
Virgin Valley
Kings Rvr Vly
Orovada
Paradise Vly
Tuscarora
Winnemucca WB AP
Elko WB AP
Wendover
Empire
Rye Patch Dam
Lovelock
Lovelock FAA AP
Battle Mtn FAA AP
Beowawe
Palisade
Jiggs
Ruby Lake
Overland Pass
Ibapah
Susanville AP
Sand Pass
Portola
Fernley
Reno WB AP
Lahontan Dam
Virginia City
Fallon Exp Sta
Carson City
Minden
Yerington
Schurz
Austin
Eureka
McGill
Ely WB AP
Eastgate
Kingston Canyon
Fish Cr Rch
Garrison
Lund
Smokey Valley
Hawthorne NAD
Rattlesnake
Sunnyside
Bridgeport
Mina
Tonopah AP
Adaven
Pioche
Mono Lake
Coaldale
Basalt
Goldfield
Dyer 4 SE
Caliente
Bishop WB AP
Sarcobatus
Alamo
Elgin
Caselton
Beatty
Hidden Forest Camp
Overton
Indian Spgs
Desert Game Rge
Pahrump
Las Vegas WB AP
Boulder City
Searchlight
Mountain Pass
Davis Dam
Kingman
Beaver Dam
St George PH

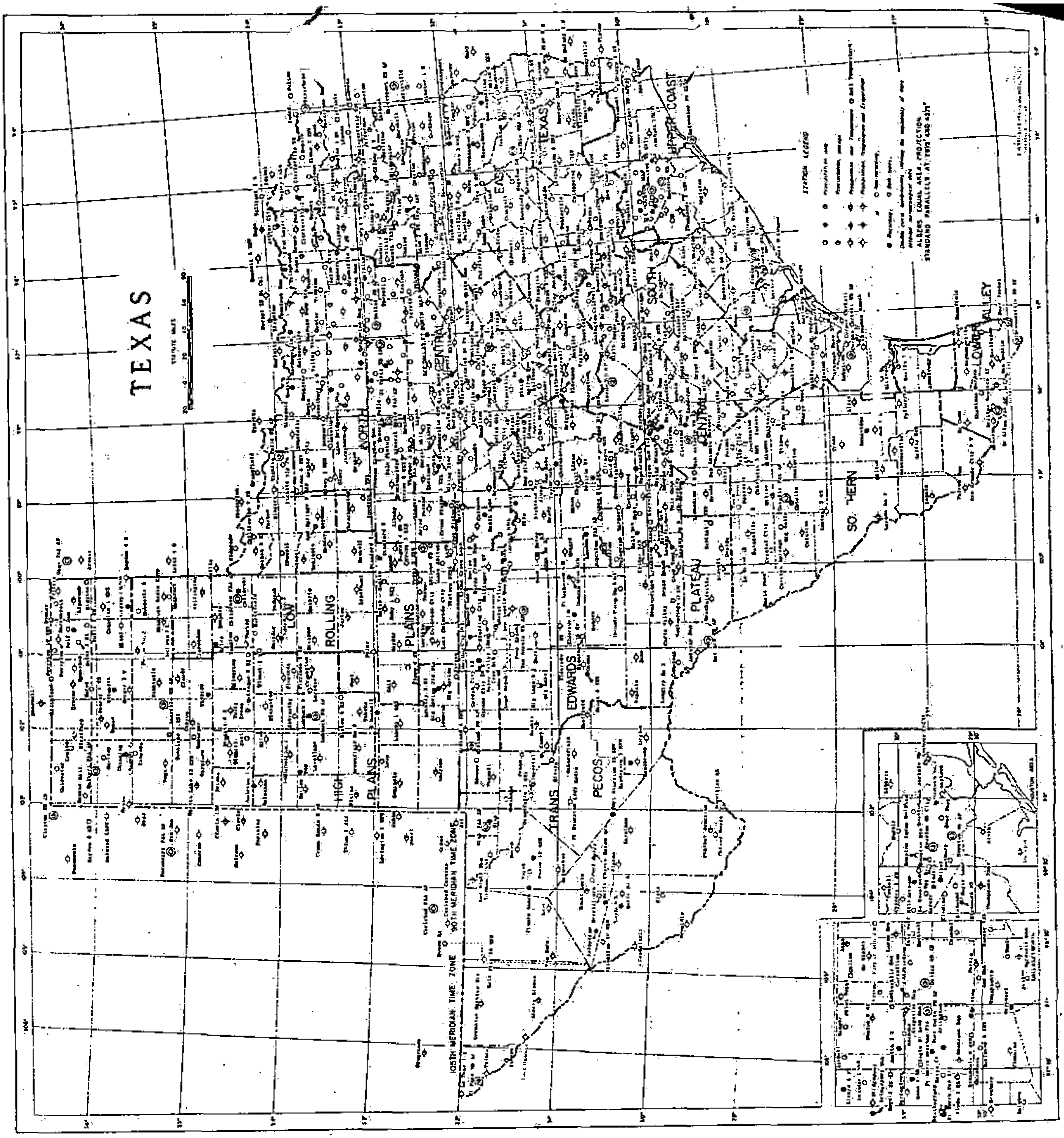

IDAHO
STATUTE MILES
0 10 20 30 40 50
STATION LEGEND
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage: Non-recording
Recording
Both types
Double circle combinations indicate the availability of more detailed meteorological data
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½° AND 45½°
120TH MERIDIAN TIME ZONE
105TH MERIDIAN TIME ZONE
PANHANDLE
NORTH CENTRAL
NORTH CENTRAL PRAIRIES
CENTRAL CANYONS
CENTRAL MOUNTAINS
SOUTH WESTERN VALLEYS
NORTHEASTERN VALLEYS
UPPER SNAKE RIVER PLAINS
EASTERN HIGHLANDS
CENTRAL PLAINS
SOUTHWESTERN HIGHLANDS
120TH
105TH
105 TH
120 TH



USCOMM-WB-ASHEVILLE



YELLOWSTONE DRAINAGE
BIG HORN
AND
WIND
RIVER
DRAINAGE
POWDER
LITTLE MISSOURI
AND
DRAINAGE
BELLE
FOURCHE
SNAKE
DRAINAGE
TONGUE
DRAINAGE
CHEYENNE
AND
NIOBRARA
DRAINAGE
PLATTE
DRAINAGE
GREEN
AND
BEAR
DRAINAGE
WYOMING
STATUTE MILES
10 0 10 20 30
STATION LEGEND
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature and Evaporation
Type of gage: Non-recording, Recording, Both types.
DOUBLE CIRCLE COMBINATIONS INDICATE THE AVAILABILITY OF MORE DETAILED METEOROLOGICAL DATA.
ALL WYOMING STATIONS USE 105TH MERIDIAN TIME.


TEXAS
HIGH PLAINS
LOW ROLLING PLAINS
NORTH CENTRAL
EAST TEXAS
UPPER COAST
TRANS PECOS
EDWARDS PLATEAU
SOUTH CENTRAL
SOUTHERN
LOWER VALLEY
105TH MERIDIAN TIME ZONE
90TH MERIDIAN TIME ZONE

Geothermics (1970) - SPECIAL ISSUE 2
U. N. Symposium on the Development and Utilization of Geothermal Resources. Pisa 1970. Vol. 2. Part 1

AREA
US
GTHM

The AAPG Geothermal Survey of North America

R. O. KEHLE *, R. J. SCHOEPPEL ** AND R. K. DEFORD *

ABSTRACT

Modern data enhancement techniques allow the AAPG geothermal survey of North America to use temperature data from oil, gas, and water wells in determining the thermal regimes of the continent. Without treatment these data would not be usable. Individual well bore temperature measurements may be highly inaccurate. Valid and invalid data are indistinguishable. Yet temperature measurements in well bores are the only data supply large enough to permit a continent-wide geothermal survey. A technique for making these data usable had to be developed.

A two dimensional smoothing or filtering operation will be used in areas of high data density. The method is similar to those employed in improving the quality of satellite transmitted photographic data. Typically a weighted average of data in the neighborhood of a datum point is used for the value at that point. If the central datum differs too much from its neighbours, it is discarded. This precludes spreading a noise burst and thus eliminates one source of false regional anomalies. Because this procedure may also eliminate strong local anomalies, all discorded points will be designated on the final maps. The weights used to average neighboring data points are determined theoretically via communications theory. This theory also provides reliable estimates of error magnitude.

Computed error magnitudes will be used to select contour intervals on all final maps. The validity of these data enhancement techniques will be checked by comparing the final maps against all known reliable geothermal gradient determinations in North America. Some of these have been made by scientists under controlled conditions specifically to determine geothermal gradients. Most are simply accurate measurements of steady state temperature in deep oil and gas reservoirs. Preliminary results indicate excellent agreement.

In sparse data areas, standard smoothing and filtering techniques are of questionable value and are not used in the survey. Instead trend surfaces are fitted to the data. The nature of the surface used to depict geothermal gradient in any given area depends on both the internal consistency of the data and on its density.

A completed geothermal survey of North America is the first step in assessing the thermal resources of the continent. It also provides scientists with information essential to the study of hydrocarbon maturation, sediment diagenesis and many other important geologic processes. Thanks to modern techniques of communications theory, the survey is feasible and should be completed on schedule by the end of 1974.

Knowledge of earth temperature is vital

Geologists are especially interested in earth temperature data. The diagenesis of sediments, the conversion of organic matter to hydrocarbons, the genesis and emplacement of magmas, the formation of mineral deposits, and crustal deformation are some of the many processes that depend directly on heat flow and temperature within the earth's crust. Any attempt to understand and evaluate these geologic processes must be predicated on an adequate knowledge of the temperature regime of the earth. Engineers are also keenly aware of the importance of a comprehensive study of subsurface temperature. Potential sites for exploitation of geothermal resources is of primary interest. In addition, petroleum engineers require knowledge of subsurface temperature to properly design drilling and logging programs and to facilitate accurate log interpretation. Mining engineers need this information to properly assess the economics of deep mine recovery of earth resources. Yet our knowledge of the heat balance of the earth is insufficient for these purposes. We possess only a few careful measurements made at widely scattered locations. Little is known about the distribution and variation of the temperature regime from one province to another across the continents.

Of almost 3000 heat flow measurements reported at this date, only 300 are on the continents. Many large areas have no measurements at all. The nearly 2700 measurements made on the deep sea floor provide us with a much better picture of the thermal regime of the ocean basins than what we have of the continents.

Over prominent topographic features of the ocean floors — the mid-oceanic ridges — heat flow is much higher then normal. This recently acquired information has provided considerable support to the hypothesis that the axes of the mid-oceanic ridges act as loci of sea floor spreading. The high heat flows are purportedly due to the convective transport of thermal energy by mantle materials that rise into the central parts of the mid-oceanic ridges.

The only other areas of the sea floor that have heat flows that are systematically different from the average are the island-arc oceanic-trench system. High heat flow in island arcs is attributed to the rising volcanic materials generated deep below the surface of the earth. Low heat flow in adjacent oceanic trenches is attributed to the deflection into the mantle of the cold oceanic crust, which thereby acts as both a shield and a sponge for heat that normally would have escaped to the surface.

The lack of comparable information on the continents prohibits us from making similar observations

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regarding crustal processes there. The geothermal survey of North America will partly fill this gap. In analogy to the ocean basins, the major folded mountain chains of the earth should possess heat flow considerably higher than the average flow from the ocean basins. If confirmed, this concept would have far reaching consequences to the petroleum and mineral industries. High heat flows signify higher than average temperatures for any given depth in the subsurface. Thus, processes of diagenesis, maturation of hydrocarbons, redistribution of silica in the form of cement, the destruction of porosity, and the metamorphosis of minerals should take place more readily and at shallower depths than over the stable cratons. Definite knowledge regarding the thermal history of such regions might prompt industry to completely reformulate its ideas regarding mineral exploration of such regions. These same regions are the most likely sites for geothermal resources, many of which may not possess surface expressions of thermal abnormality. The potential for discovering economic thermal resources is great. Thus, knowledge of the thermal regimes of the continent would provide substantial economic and scientific benefits.

The survey objective - a geothermal map of North America

The optimum survey would provide temperature data from about one hole per township over all of North America, including the offshore continental shelves. Although temperature measurements have not been made in every township across the continent — some counties have no measurements at all — the density is sufficient to provide a useful representation of the temperature regime. The reasons for selecting a closely spaced uniform grid of values arise from sampling theory. BLACKMAN and TUKEY (1958, p. 31) show that the highest frequency event whose presence can be detected on a map has a wave length of not less than two times the sampling interval. All events that exhibit more rapid spatial variation than this critical (Nyquist) frequency appear as false (aliased) additions to low frequency events that are otherwise adequately sampled. This type of error is unavoidable in any presentation of sampled data. The commonly held assumption that only a few accurate values are needed to construct good regional maps is fallacious.

Initially these data will be organized in the form of a geothermal-gradient map with isogradient contours at intervals of about 0.1°C per 100 feet. Figure 1 is an example of such a map published by SCHOEPPEL and GILARRANZ (1966). The GSNA map will show the form and distribution of regional hot spots and cold spots in North America and will provide a basis for more accurate estimates of heat flow in the earth's crust. In addition to presenting maps of and reports on geothermal data, the AAPG Geothermal Survey of North America intends to maintain a library of basic data on magnetic tapes and punched cards. This library will be available to scientists and engineers throughout the world for any additional studies that they may wish to undertake.

Geothermal gradient is the rate of subsurface increase of temperature with depth below a thin layer of soil and rock that is affected by changes in weather and by seasonal temperature variation. The gradient varies from place to place, both on land and beneath the ocean floor. Geothermal gradient depends on two things: (1) the heat flow from the interior of the earth and (2) the thermal conductivity of the rocks through which heat flows. Regional variation in geothermal gradient may be due to either regional variation in heat flow or variation in the type of near-surface rocks. Because the gradient depends on rock conductivity, it is not necessarily constant from the near surface to bottom hole, even in the same test well. Thus the geothermal map prepared by this survey will reflect not only heat flow variations from place to place across the continent but also variation in composition on the upper few thousand feet of rocks.

A good map from nonequilibrium data

The approach of the AAPG Geothermal Survey of North America to temperature data is quite different from and for a different purpose than that employed by most students of the earth's temperature regime. Recognizing the need for expanded areal coverage of geothermal data for the North American continent in order to compare one province with another, the AAPG Research Committee considered alternative methods for reaching this goal. Usually very accurate temperature measurements are made in deep mines or boreholes that have reached thermal equilibrium. Most of these temperature measurements are made over an interval characterized by one rock type. The thermal conductivity of this rock is measured in the laboratory. From these two measurements the heat flow is accurately calculated. Normal procedure of collecting information only from wells and mines in thermal equilibrium from which representative rock samples could be obtained was judged too time consuming and costly. Rather it was felt that gross relationships could be determined through the immediate use of the vast storehouse of data contained in the log files of the petroleum industry in a continent-wide reconnaissance survey.

Unfortunately, the temperatures recorded on log headings are not in equilibrium and in some cases are not reliable. Most measurements are made in wells immediately after completion of the drilling operation. In such wells, bottom-hole temperatures are lower than equilibrium temperatures for that locality and depth. A second source of error resides in the temperature measurements themselves. Oil-field equipment is not extremely accurate and is subject to breakdown. Measurements are rarely carried out under scientific conditions

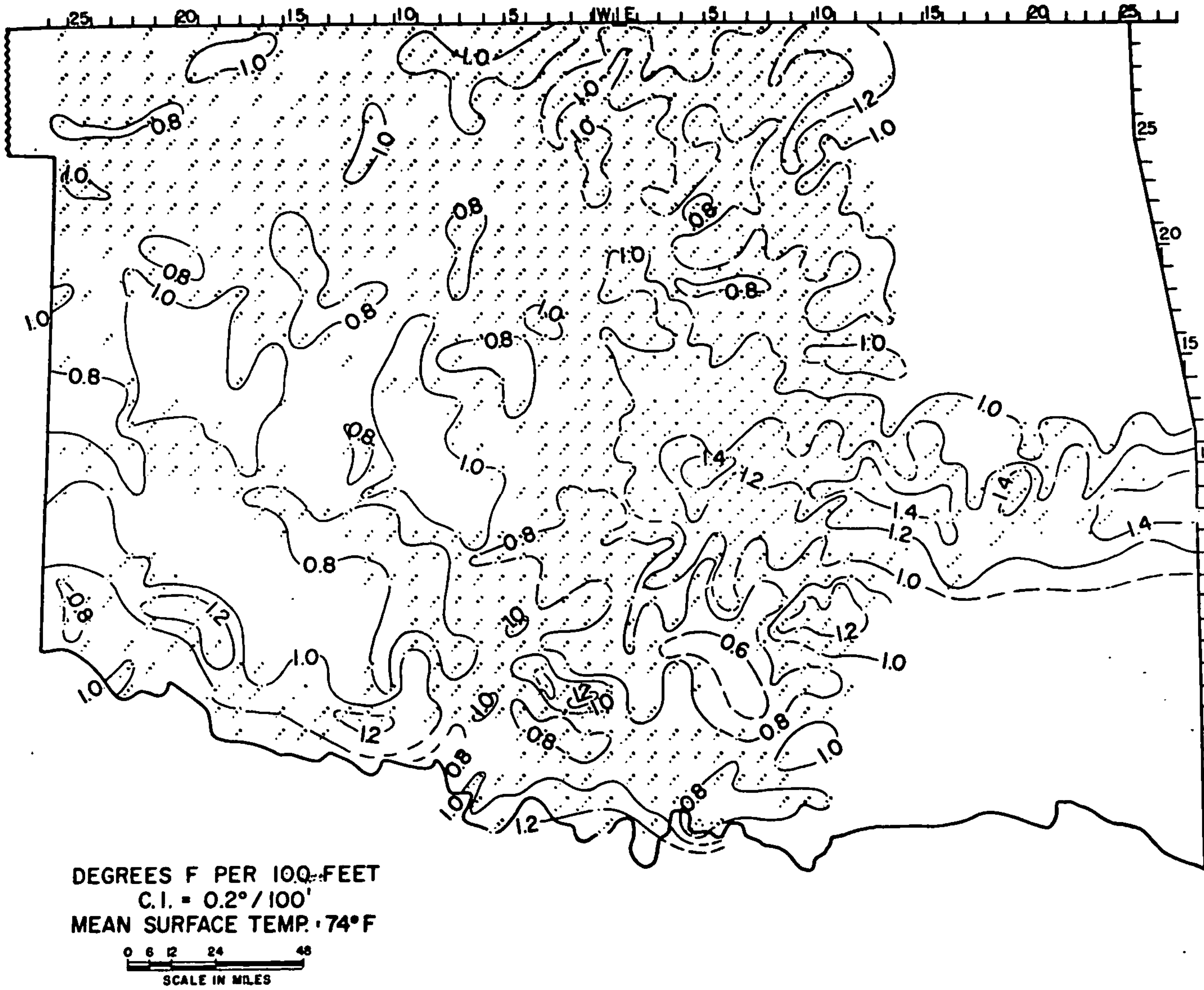

FIG. 1. — *Oklahoma geothermal gradient map based on well logs (After* SCHOEPPEL, GILARRANZ *1966).*

guaranteed to yield the highest precision and accuracy. Aside from these problems, the temperature recorded on the log heading for some wells was not measured at all. Rather, the field engineer assumed a geothermal gradient for the area and used this to calculate « an anticipated » bottom-hole temperature. Clearly this is unacceptable.

Embarrassingly we are faced with the fact that even if the temperature recorded on the log heading was actually recorded and not calculated, the measurement might well be inaccurate. Even if it is accurate, it will likely be different from the desired equilibrium temperature. We are faced with a double task. The first is to systematically adjust all temperature data so as to correct for the fact that the measured temperature represents a nonequilibrium thermal state. Then all bad data, that is, all inaccurate measurements and the calculated values, must be recognized and eliminated. Only then can we reliably use the data. Let us consider the two correction procedures separately.

CORRECTING NONEQUILIBRIUM TEMPERATURE MEASUREMENTS

Borehole measurements of temperature made shortly after drilling ceases can be corrected to true equilibrium temperature if (1) a relationship between transient borehole temperature and equilibrium temperature is known, and (2) the value of the several factors affecting the relationship are known to acceptable accuracy. At present, we believe our knowledge on both points is adequate to proceed with the survey.

The relationship between the transient state and equilibrium temperature is arrived at by describing mathematically the heat exchange processes associated with drilling. Although no one has completely described this process, several investigators have constructed close approximations to it. Analyses by SCHOEPPEL, GILARRANZ (1966) and RAYMOND (1969) both may provide sufficient accuracy for our purposes, although both analyses neglect fluid convection in the borehole after circulation stops (Appendix A). This process could play an important role in determining the manner in which subsurface temperatures return to equilibrium. If further study shows this factor to be important, the existing analyses can be readily modified to include the effect.

Whether or not a correction to existing models is required, it is evident that the models themselves are in good shape compared with our ability to apply them. The models assume that everything about the system is known except either the temperature of the drilling fluids or the geothermal gradient. The supposedly known factors include the temperature of the mud in the mud pit, the pipe size, the circulation rate, the size of the annulus, the heat capacity and thermal conductivity of the drilling fluid, the drill pipe and the country rock, and the time interval between circulation and logging. Because these factors are not generally recorded on log headings, direct application of the results of the mathematical models is not possible unless reasonable approximations of these variables yield acceptable results.

A sensitivity study of the heat exchange processes shows that surface temperature and time since circulation are the only important factors in determining the difference between measured bottom-hole temperature and true equilibrium temperature (Appendix A). Rough estimates of the remaining factors yield adequate corrections, provided that surface temperature and time since circulation are known. Because this information is needed but not available, additional assumptions are required. Surface temperature might be accurately estimated from weather bureau data if logging dates and well locations were known. Time since circulation is more difficult to ascertain. Our first effort will be to test the assumption that for most wells this time interval is proportional to logging depth. For those wells where long delays were experienced before logging, corrections based on average times since circulation will yield temperatures higher than normal for that location. Such data should be removed by the filtering process, as are other types of bad data.

REMOVING BAD DATA

The argument most vigorously and persistently presented against the use of logging temperatures in the geothermal survey of North America is that individual temperature measurements recorded on log headings may be badly in error or may be calculated rather than measured (NICHOLS 1947; MOSES 1961; VAN ORSTRAND 1934 a, b). Results based on such unreliable data would be at best of little value, at worst they would be misleading. Consequently, it is argued that the use of log temperatures should not be condoned in a regional geothermal survey sponsored by responsible scientists and scientific organizations.

This argument has considerable appeal, but it is not really valid. True, when faced with the need of using data of unknown quality one cannot proceed blithely as if the data were impeccable. Consider the seeming validity of the same argument regarding the use of reflection seismograph data to determine subsurface structure. Taken one trace at a time this information is totally unintelligible. In fact a single seismic event is more likely to represent noise than infomation. The odds seem to be less favorable than those we face with geothermal data. Yet when seismic data are corrected to account for topography, surface weathering, geophone moveout, and variations in subsurface seismic velocity and *then are combined with hundreds of additional traces in cross-section form,* they provide explorers with a remarkably reliable picture of the subsurface.

A direct analogy may be drawn between the treatment and presentation of seismic data and the presentation of geothermal information. Correcting temperatures recorded while logging is considered equivalent to static and moveout corrections of seismic data. Preparing a map of a large number of closely spaced geothermal data is equivalent to constructing seismic cross sections. Interpretation of the two types of data is also similar. One skilled earth scientist correlates seismic sections to obtain a picture of subsurface structure. Another contours geothermal data to obtain a picture of geothermal gradient and heat flow. Figure 1 is an example of such an interpretation of geothermal data.

The field of seismic exploration has advanced considerably beyond the mere presentation of corrected but still noisy data. Digital recording of field data has permitted sophisticated computer processing designed to eliminate or at least reduce the more objectionable forms of noise and thereby to enhance the signal quality. This markedly increases the usefulness of the data. The same basic theories used to devise schemes for improving seismic data apply to many other fields as well. Of special interest to us are the applications to mapped data. The work of BHATTACHARYYA (1965); DARBY, DAVIS (1967); DEAN (1958); FULLER (1967); HENDERSON (1960) and SPECTOR (1968) on improving the quality of map presentations of magnetic field surveys, and that of CLARKE (1969); GRANT, WEST (1965); MESKÓ (1960, 1965); NAIDU (1966, 1967, 1968); ODEGARD, BERG (1965); ROSENBACH (1953); SAX (1966) and SWARTZ (1954) in the interpretation and presentation of gravity data are of special interest. Many of these methods may be applied to geothermal data without modification. When used to process data presented in map form, these data-enhancement schemes are called spatial filters.

The simplest type of filters smooth data by computing running averages. Techniques of this type are

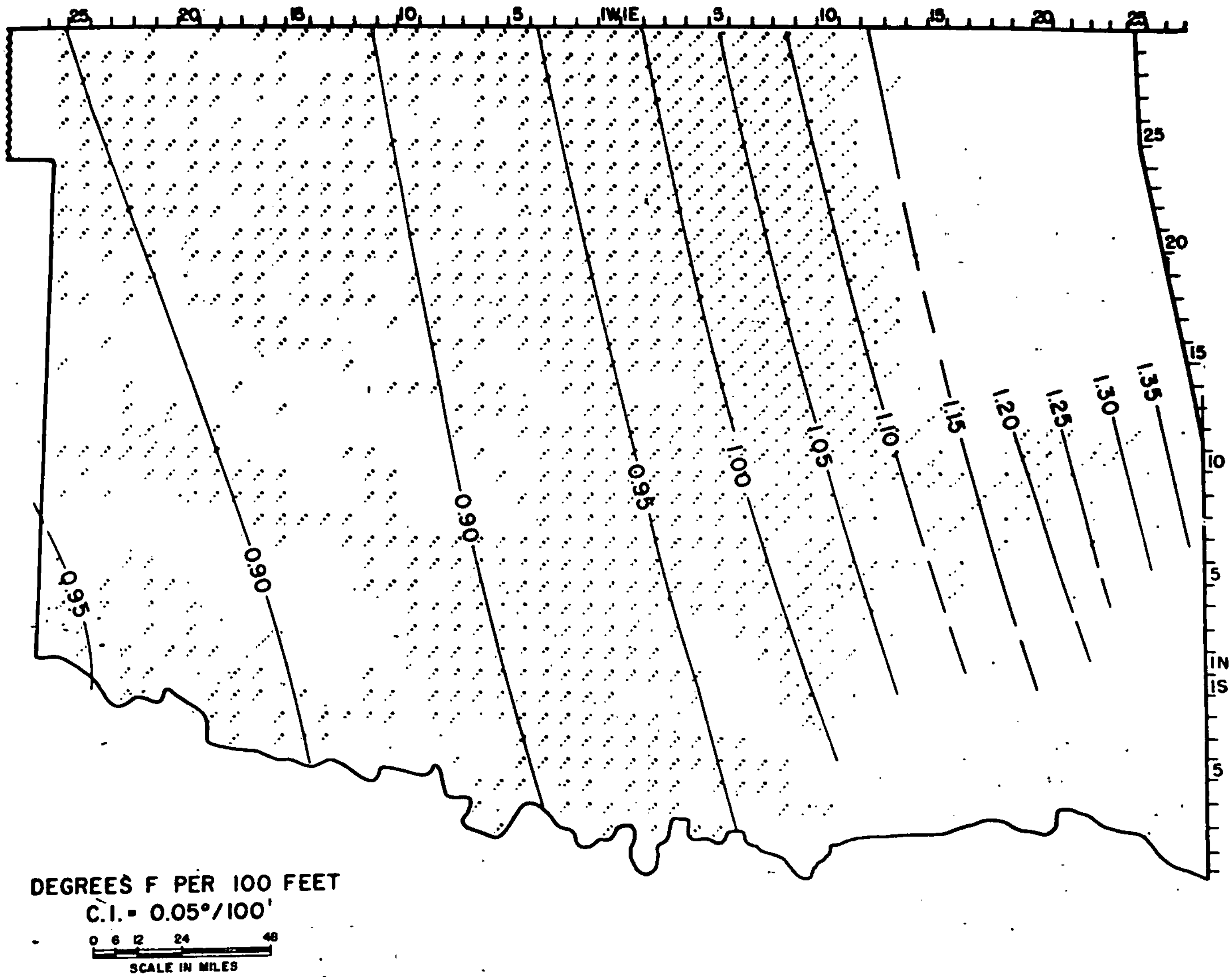

FIG. 2. — *Second-order regional surface of Oklahoma geothermal gradient map (After* SCHOEPPEL, GILARRANZ *1966).*

employed by most computerized methods for establishing trend surfaces. As an example of such a procedure applied to geothermal data, Figure 2 shows a second-order trend surface that has been computed from geothermal gradients in Oklahoma. More highly sophisticated smoothing filters are also in common use. They can be designed to accomplish varied objectives such as the removal of high frequency « noise », the removal of regional trends, or the emphasis of information with intermediate wavelength characteristics. ZURFLUEH (1967) has designed a remarkably efficient set of such filters which we may use in treating geothermal data.

Simple smoothing techniques work well if the maximum expected error for any one data point is relatively small. In the vocabulary of communications theory, this means that the signal-to-noise ratio is relatively large. If some individual errors are large, i.e., if noise bursts occur, simple smoothing techniques are inapplicable. Because many data points are averaged, a noise burst does not remain confined to a single data point but contributes to the averaged values of many surrounding locations. The result is a false regional anomaly. Because potentially large errors exist in the temperatures recorded on log headings, the use of a single smoothing technique is not only insufficient but undesirable unless all large errors are removed beforehand.

Data points possessing large errors can be removed by a process of filtering that compares each data point with a preset number of nearby data points. Two very different types of processes can be employed to this end; one is based on linear programming theory (DOUGHERTY, SMITH 1966), and the other on optimum filter theory (CLARK 1969; ROBINSON 1967; SAX 1966). Both methods may be used to predict expected values of a mapped variable over a selected region. Each mapped datum is considered valid if it does not deviate from its neighbors by more than a certain amount. This cutoff value is not arbitrary, but depends on established local data variations. Either theory will reject grossly deviant data. Differences in rejection criteria are evident where subtler variations are encountered. Procedures of this type eliminate not only data possessing large errors but also valid data from strong local anomalies. This does not detract from their use. Valid data eliminated by a properly designed filter are data associated with an anomaly so local that it could not be properly represented on a regional map anyway. A more detailed account of this material is presented in Appendix B.

Because small local anomalies may be of exceptional interest in certain studies, we plan also to prepare a map of all data removed by the filtering operation.

Once the strongly anomalous data have been removed, the remaining data set is amenable to standard smoothing procedures. We plan to experiment with a variety of these in areas of better data to ascertain which provide the most useful and reliable presentations.

More sophisticated filtering techniques can be envisioned. Usually, these require some knowledge of the end product. For our problem we would need prior knowledge of the distribution of the true geothermal gradient around the continent. At present it is not possible to say whether the application of these more sophisticated techniques is possible or even desirable. As data collection progresses, we shall have more corrected data to experiment with, and we shall investigate the question of suitable filtering techniques more thoroughly.

A FINAL CHECK

We are making a special effort to collect as many equilibrium-temperature data from the North American continent as possible. In addition to those measurements made by heat flow scientists, data collected during pressure-buildup tests in wells at thermal equilibrium and from other special temperature surveys will be added to the data pool. These data will represent only a small fraction of the total temperature information handled during the geothermal survey. Consequently, they need not be used in presenting the normal data. Rather these equilibrium data can be used as an external check on the reliability of the correction procedure and filtering processes applied to the principal data source; that is, to temperatures recorded on log headings. The theories that are used to correct these temperatures also provide us with a method for predicting the expected maximum errors. A comparison of the regional map derived from log temperatures with true equilibrium temperatures at scattered localities over the continent will serve as a final check on the reliability of the map.

Before endorsing publication of the geothermal map, the Project Steering Committee will insist that the map agree with the true data points to within the accuracy prediced by theory. No map will be published unless it can be used with complete confidence by all interested scientists and engineers.

Appendix A

MATHEMATICAL APPROACH

Physical model

Down-hole measurements of drilling mud temperature while circulating have shown that, at a certain depth, there is no thermal transfer between the mud and the formation. Below this depth, the annulus mud acts as a heat sink, a portion of the heat received from the formation being transmitted to the drill pipe and inflowing mud. The degree to which the static formation temperature has been disturbed at any particular drilled level depends on the duration and the rate of heat transfer from the formation. Temperature disturbance is minimized if fluid circulation is stopped immediately upon drilling the interval, as is often the case for the bottom of a drilled hole.

The usual practice prior to logging a freshly drilled interval is to clean the hole by circulating mud for at least one complete displacement, pull the pipe and then run the logging sonde into the hole. This sequence exposes the formations surrounding the bottom of the hole to two periods of unsteady-state heat transfer: circulating mud period and quiescent mud period.

Circulating mud period

Heat transfer during this period can be predicted by the diffusivity equation:

$$\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r} = \frac{\rho C_F}{k_f}\frac{\partial T}{\partial \theta} \qquad (1)$$

which governs unsteady-state heat conduction in an infinite radial system. Basic assumptions in the derivation of the diffusivity equation include (1) homogeneous and isotropic medium, (2) a constant temperature at all radii before the disturbance, and (3) heat flow by conduction only.

By defining a dimensionless time variable as

$$t = \frac{k_f \theta}{\rho C_f r_w^2} \qquad (2)$$

and dimensionless radius as

$$r_D = \frac{r}{r_w} \qquad (3)$$

the diffusivity equation takes the form:

$$\frac{\partial^2 T}{\partial r_D^2} + \frac{1}{r_D}\frac{\partial T}{\partial r_D} = \frac{\partial T}{\partial t} \qquad (4)$$

Eq. (4) can be solved for the total heat influx during the circulating period if the circulating mud temperature remains constant giving:

$$Q(\theta) = 2\pi C_f \rho r_w^2 h \ \Delta T Q(t) \ , \qquad (5)$$

where $Q(\theta)$ is the total heat influx into the wellbore due to a temperature difference ΔT, and $Q(t)$ is a time dependent dimensionless heat flow rate defined by:

$$Q(t) = \int_0^t \left(\frac{\partial T}{\partial r_D}\right)_{r_D = 1} dt \qquad (6)$$

Quiescent mud period

The thermal build-up of the well fluid after circulation is stopped can be determined by using a superposition approach similar to that used in pressure build-up for fluid flow. In this method, the temperature history is represented by a series of temperature plateaus (Figure 3). Each plateau corresponds to a constant terminal temperature case predicted by Eq. (5). By superposition of the temperature increments, the total heat influx during the quiescent mud period can be expressed as

$$Q(\theta) = 2\pi C_f \rho r_w^2 h[(\Delta T)_0 Q(t) + (\Delta T)_1 Q(t-t_1) + + (\Delta T_2)Q(t-t_2) + \cdots] \qquad (7)$$

Eq. (7) also gives the total heat flow during the combined circulating and static mud period if $(\Delta T)_0$ is defined as the temperature difference and $Q(t)$ as the cumulative heat flow during the circulating period.

Temperature build-up

In applying Eq. (7) a means must be provided to solve Eq. (6). This is accomplished by application of the Laplace transformation to the diffusivity equation for an infinite medium yielding:

$$Q(t) = \frac{2}{\pi}\int_0^a \frac{(1-e^{-u^2 t})du}{u^3[J_o^2(u) + Y_o^2(u)]}, \qquad (8)$$

where J_o and Y_o are Bessel functions of the first and second kind, respectively, and u is a function of a complex variable.

Calculation of the temperature build-up of drilling fluid by this method assumes that the mud will warm at the same rate as the wall of the hole. The difference between the heat flow into the bottom of the hole and that into the overlying mud is considered negligible in this approach.

Example

The mathematical analysis predicts an exponential increase in mud temperature after circulation ceases as illustrated by Figure 4. The shape of the curve is a function of hole size, initial temperature difference, circulation time and specific heat of the drilling fluid. A significant temperature increase may be seen to occur

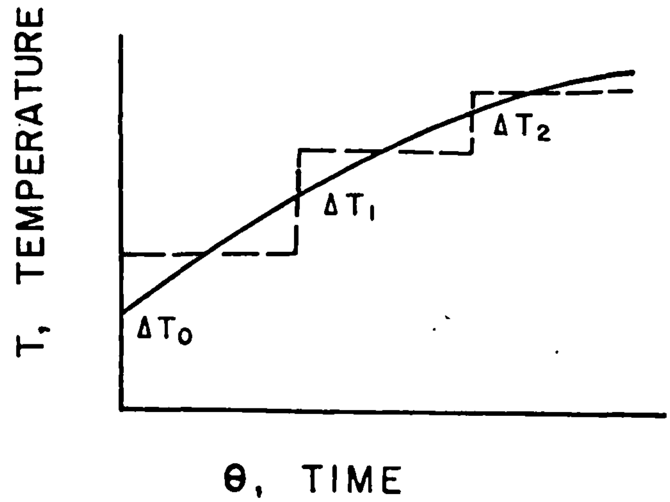

FIG. 3. — *Step function approximation to temperature build-up*

from the time circulation ceases to the commencement of logging operations. The analysis may be extended to allow a more accurate estimation of undisturbed formation temperature if desired. For example, the analysis by RAYMOND (1969) may be used to account for the influence of mud circulation on the temperature build-up after circulation ceases. The important factors to be considered in this case are the inlet surface mud temperature and the time since circulation.

Nomenclature

C_f = specific heat of formation
h = formation thickness
J_o = Bessel function of second kind and order 0
k_f = thermal conductivity
$Q(\theta)$ = cumulative heat flow
$Q(t)$ = dimensionless heat flow
r_D = dimensionless radius
r = radius
r_w = well radius
t = dimensionless time
T = temperature
u = function of complex variable
Y_o = Bessel function of second kind and order 0
θ = time, time since circulation
ρ = formation density

Appendix B

DATA ENHANCEMENT

The advent of high speed digital computers has stimulated considerable work in the development of « non-realizable » filters, filters that cannot be constructed from mechanical or electronic devices because they operate on « future » information. Digital filters can be designed so perfectly that the principal con-

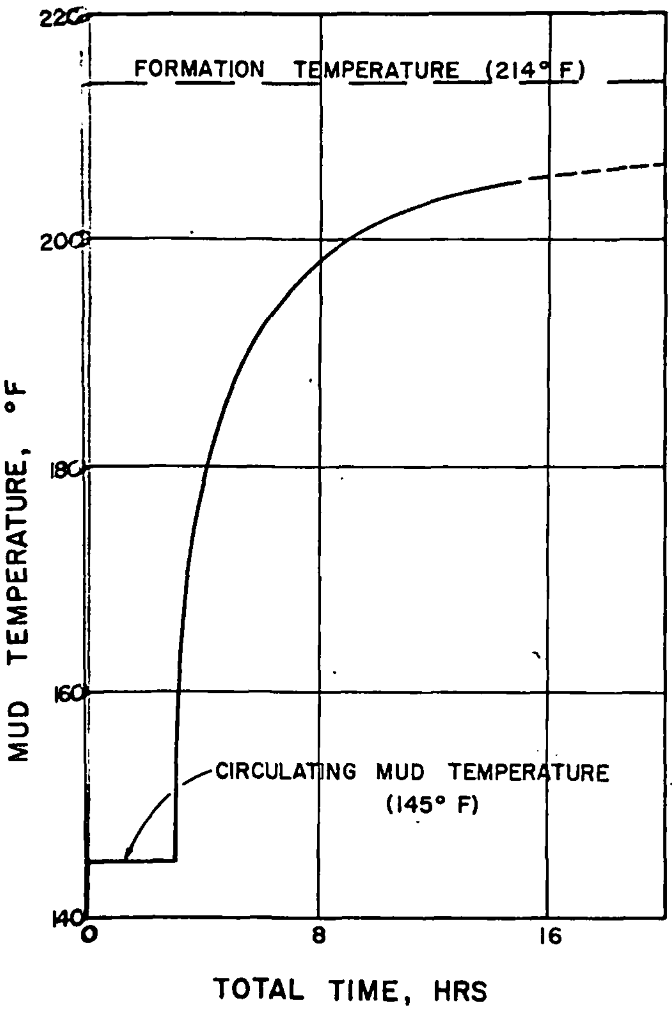

FIG. 4. — *Temperature build-up behaviour predicted by mathematical model (After* SCHOEPPEL, GILARRANZ *1966).*

sideration is not simply achieving a technological goal but rather achieving it at low cost. A large literature on this subject is found in the professional journals of the exploration geophysical industry. The purpose of this appendix is to briefly review the existing technology as it applies to the problem of enhancing the quality of mapped data, specifically regional maps of geothermal gradients and other earth temperature data.

Digital filters

A filter is any collection of linear functions f(t) that operate on an input signal and thereby change it into an output signal. Telephones, radios, and phonographs are filters under this definition. Similarly, the earth is a filter that operates on seismic waves, heat flow, the earth's magnetic and gravity field with the result that the original « signal » is altered by passing through the « filter », i.e. the earth. A filter operates on a signal through the mathematical operation known as convolution. If the input signal is designated $I(t)$, the output signal $O(t)$, and the filter $f(t)$, then the convolution operation is given by

$$O(t) = \int_{-\infty}^{\infty} f(\tau)I(t-\tau)d\tau \qquad \text{B-1}$$

The digital (discrete) equivalent to the convolution integral B-1 is written

$$O_n = \sum_{i=0}^{k} f_i I_{n-i} \qquad \text{B-2}$$

where (I_0, I_1, I_2, ..., I_k) are the $k+1$ samples of the input function, (f_0, f_1, f_2, ..., f_n) are the $n+1$ samples of the filter function, and (O_0, O_1, O_2, ..., O_{k+n}) are the $k+n+1$ samples of the output function.

The Fourier or Laplace transform of the convolution integral is simply the product of the convolution variables, and thus eq. B-1 becomes

$$\hat{O}(s) = \hat{f}(s)\hat{I}(s) \qquad \text{B-3}$$

where $\hat{O}(s)$, $\hat{f}(s)$, and $\hat{I}(s)$ are the transforms of the output, filter, and input functions respectively. Equation B-3 applies to the discrete or digital form eq. B-2 as well. In this case the transform are given by

$$\begin{aligned} \hat{O}(s) &= O_0 + O_1 s + O_2 s^2 + ... + O_{k+n} s^{k+n} \\ \hat{f}(s) &= f_0 + f_1 s + f_2 s^2 + ... + f_n s^n \qquad \text{B-4} \\ \hat{I}(s) &= I_0 + I_1 s + I_2 s^2 + ... + I_k s^k \end{aligned}$$

where each power of the transform variable s represents a delay of one time unit (sample interval). As is typical of most analysis, operations are simplified if carried out with transform functions and variables rather than the original functions and variables. For this reason most filter design is accomplished using transformed variables. Once a filter has been designed it is a simple matter to invert it into its untransformed state. In communications theory, the transformed state is typically called the frequency domain, whereas the untransformed state is called the time domain. In mapped data, the real state is the space domain and the transformed state the wavenumber domain.

Optimum filters

Many filters are designed to enhance signals that have been corrupted by gaussian noise, that is random white noise. Usually the object is to design a filter that gives an output that differs as little as possible from the true (noise free) signal. If the definition for « as little as possible » is taken to mean minimizing the root-mean-square-error between the output and the true or desired output, the optimum filter is called a Wiener filter (WIENER 1949). There is no universally applicable Wiener filter, each must be designed for the problem at hand. Specifically, the discrete or digital Wiener filter is obtained by solving the discrete form of the Wiener-Hopf equation for the problem at hand. This is written

$$\sum_{n=-\infty}^{\infty} f_n \Phi^{II}_{n-\tau} = \Phi^{ID}_{\tau} \qquad \text{B-5}$$

(WIENER 1949) where f_n are the sample sequence of the optimum filter, $\Phi^{II}_{n-\tau}$ is the collection of values representing the discrete autocorrelation function of the input with lag values $i = n - \tau$, which is defined as

$$\Phi^{II}_{n-\tau} = \Phi^{II}_{i} = \lim_{k \to \infty} \frac{1}{2k} \sum_{t=-k}^{k} I_t I_{t+\tau} \qquad \text{B-6}$$

and Φ^{ID}_{τ} is the collection of values representing the discrete form of the cross-correlation function of the input with lag values $i = n - \tau$, which is defined ascording to the formula

$$\Phi^{ID}_{\tau} = \lim_{k \to \infty} \frac{1}{2k} \sum_{t=-k}^{k} I_t D_{t+\tau} \qquad \text{B-7}$$

The transform of the discrete Wiener-Hopf equation B-5 is given by

$$\hat{f}(s)\, \hat{\Phi}_{II}(s) = \hat{\Phi}_{ID}(s) \qquad \text{B-8}$$

where $\hat{\Phi}_{II}$ is the transform of the autocorrelation function and $\hat{\Phi}_{ID}$ is the transform of the cross-correlation function. It is easy to solve the transformed equation B-8 for the transform of the optimum filter $f(s)$. Thus, we have

$$\hat{f}(s) = \frac{\hat{\Phi}_{ID}(s)}{\hat{\Phi}_{II}(s)} \qquad \text{B-9}$$

that is, the transform of optimum filter is given by the ratio of the transforms of the cross-correlation function of the input-desired-output and the autocorrelation function of the input.

A substantial problem exists in the practical application of eq. B-9. Computation of the cross-correlation function depends on knowledge of the desired output, that is, a specification of the signal without additive noise. In communications applications, it is commonly possible to specify the desired output as a random ensemble of wavelets of a specified type. This very general specification, which does not actually represent any given coherent signal, is all that is needed to permit computation of the desired cross-correlation function Φ^{ID}_{τ} or its transform $\hat{\Phi}_{ID}(s)$. In other applications, such as in mapping geothermal data, no such representation of the desired signal may be called upon. Thus it is necessary to estimate the desired output from the input signal even though it possesses many undesirable characteristics. Two possible methods for making this estimate are considered below.

Estimating the desired output

In the absence of *a priori* information regards the true or desired output, an estimate of the output may be made by one of two principal methods: (1) by fitting a surface to the data with a collection of orthogonal functions by minimizing the mean square error between the data and the surface; and (2) by filtering the data with a zero-phase low-pass filter. Especially bad data can often be eliminated by comparing the approximate desired output with the untreated input and discarding those data that exceed a prescribed maximum deviation.

Surface fitting with orthogonal polynomials involves minimizing the mean square error between all the data and the resulting surface. The procedure is identical regardless of whether a simple polynomial (trend) surface or a more complicated function-set surface is to be constructed. Several undesirable factors are characteristic of this method. Each data point influences the nature of the surface over its entire extent. If large deviations from the norm occur, they exert undue influence on the final surface. DOUGHERTY and SMITH (1966) recognized this and have replaced the least squares criterion with one based on minimizing the sum of the absolute values of the errors. This results in a linear programming problem which is readily solved for modest data sets. The fitted surface that results from this method appears to single out bad data much more readily than normal trend surface analysis. Residual maps constructed with this method are especially useful for this task. Regardless of whether the least squares or absolute values of the differences are used to construct the fitted surface, the surface residuals may be used to detect and eliminate bad data. Once eliminated, a new surface may be fitted. Provided sufficient high frequency information remains in the resulting map, this fitted surface can be used as an estimate of the desired output.

Additional difficulties with surface fitting are recognized by ZURFLUEH (1967). These include:

(1) trend surfaces are decidedly unreliable near the edges of a fitted map; and

(2) to adequately represent complicated surfaces that are invariably encountered in regional maps, very high order surfaces are required. Even with the largest of todays computers, it is generally not possible to generate surfaces of high enough order for even the simpler regional maps encountered in the earth sciences. Thus the map must be segmented. Because of the aforementioned lack of reliability near map edges, considerable overlap must be used. This substantially increases the computing effort and results in a patch work map.

These problems do not effect the regional zero-phase low-pass filters designed by ZURFLUEH (1967). With these filters, noise bursts do spread to surrounding grid points, but the sphere of influence is only one-half the breadth of the filter. Filter residuals may be constructed in much the same manner as are residuals of trend surfaces. Similarly, they can be used to identify and eliminate grossly deviant data. An estimate of the desired signal can then be constructed by filtering the restructured data set.

The methods of both ZURFLUEH (1967), and DOUGHERTY, SMITH (1966) are partly empirical. For this reason they cannot be compared purely on theoretical grounds. Both methods will be applied to a variety of synthetic and real geothermal data and their relative success compared. The best method will be then used on the data collected by the AAPG Geothermal Survey of North America. The final optimum filter will be designed in much the same way as CLARKE (1969) developed optimum-second-derivative and downward-continuation filters for gravity data. Interestingly, this type of filter will vary from one geographic region to another as both the sample density and the data quality vary. This is typical of Wiener filters (see for example SHANKS 1967), which always contain a term in the final expression that depends on signal-to-noise ratio.

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PALEOGEOGRAPHIC AND PLATE TECTONIC EVOLUTION OF THE EARLY MESOZOIC MARINE PROVINCE OF THE WESTERN GREAT BASIN

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ABSTRACT

A marine province existed in the northwestern Great Basin in which sedimentary and volcanic rocks accumulated from Early Trassic to late Early Jurassic time. Strata of the province comprise three paleogeographic terranes: shelf, basinal, and volcanic arc. They overlie late Paleozoic rocks which are thought to have chiefly constituted a magmatic arc that collided in Early Triassic time with the margin of the North American continent. The early Mesozoic marine province originated as a successor basin to the accreted late Paleozoic arc. Deposition in the marine province was extinguished by major mid-Jurassic deformation during which quartz arenite, evaporite, and volcanogenic rocks were deposited in an orogenic terrane.

The early Mesozoic volcanic arc terrane includes siliceous igneous rocks of Middle (?) and Late Triassic age which were probably comagmatic with the earliest Sierran plutonism and with a postulated belt of subaerial volcanism that extended far southeast of the marine province. Transition of the volcanic arc terrane from mainly igneous to sedimentary deposition within the Triassic suggests the Triassic magmatic event was fairly shortlived. The early Mesozoic shelf terrane occupies a narrow belt that is generally coincident with the relict Paleozoic continental margin. The basinal terrane represents a more subsident, probably generally deep-water region that lay offshore of the shelf terrane in northwestern Nevada. The enormous volume of mud that accumulated in the basinal terrane may have been fluvially transported to the marine province from the subaerial southeasterly prolongation of the Triassic volcanic arc.

The lateral and vertical distribution of strata of the early Mesozoic marine province of the western Great Basin records the transition of the western edge of the continent from its Paleozoic locus within the Great Basin to a Jurassic position as a continental arc in the Sierra Nevada. Plate models suggest that the orientation of convergent motion may have rotated from northwesterly at the beginning of the Mesozoic through westerly to south-southwesterly by mid-Jurassic time.

INTRODUCTION

Marine deposition occurred widely during the early Mesozoic in both the western and eastern Great Basin according to the record of preserved strata. The western marine province, the subject of this paper, includes an extensive region that underwent pronounced subsidence in the Triassic relative to areas east of 117°W and south of 38°N. The eastern and southern hinge lines of the subsident region are approximately coincident with the Paleozoic margin of the North American continent (Speed, 1977a). Rocks that accumulated in the western marine province comprise three regional terranes which are named shelf, basinal, and volcanic arc, according to their principal paliogeographic settings. The evolution of these terranes and the western marine province as a whole provide a record of the reorganization of the continental margin from its Paleozoic locus within the northern Great Basin to a Middle Jurassic position entirely west of Great Basin. The early Mesozoic shift of the margin to the west of the Great Basin is equivalent to the continental accretion of Rogers and others (1974), although the processes involved are different from what they envisioned.

The present paper summarizes the character, history, and origin of the three terranes that accumulated within the western marine province. It also considers two other lithic groups that are closely associated with the province: 1) the Koipato rhyolites which were apparently extruded in a restricted area at about the onset of subsidence and, 2) rocks here grouped as an orogenic terrane whose deposition was generally synchronous with the mid-Jurassic deformation that eliminated the marine province. Table 1 is a menu of the various Mesozoic and pre-Mesozoic terranes discussed herein. Descriptive sections are followed by models of the paleogeographic and plate-boundary tectonic evolutions of the western Great Basin and adjacent parts of the Sierra Nevada. This study has benefited greatly from the 15 years of work by many geologists in the western Great Basin since the first regional synthesis was presented by Silberling and Roberts (1962). It will show, however, that much still remains to be learned before models graduate from the infantile stage.

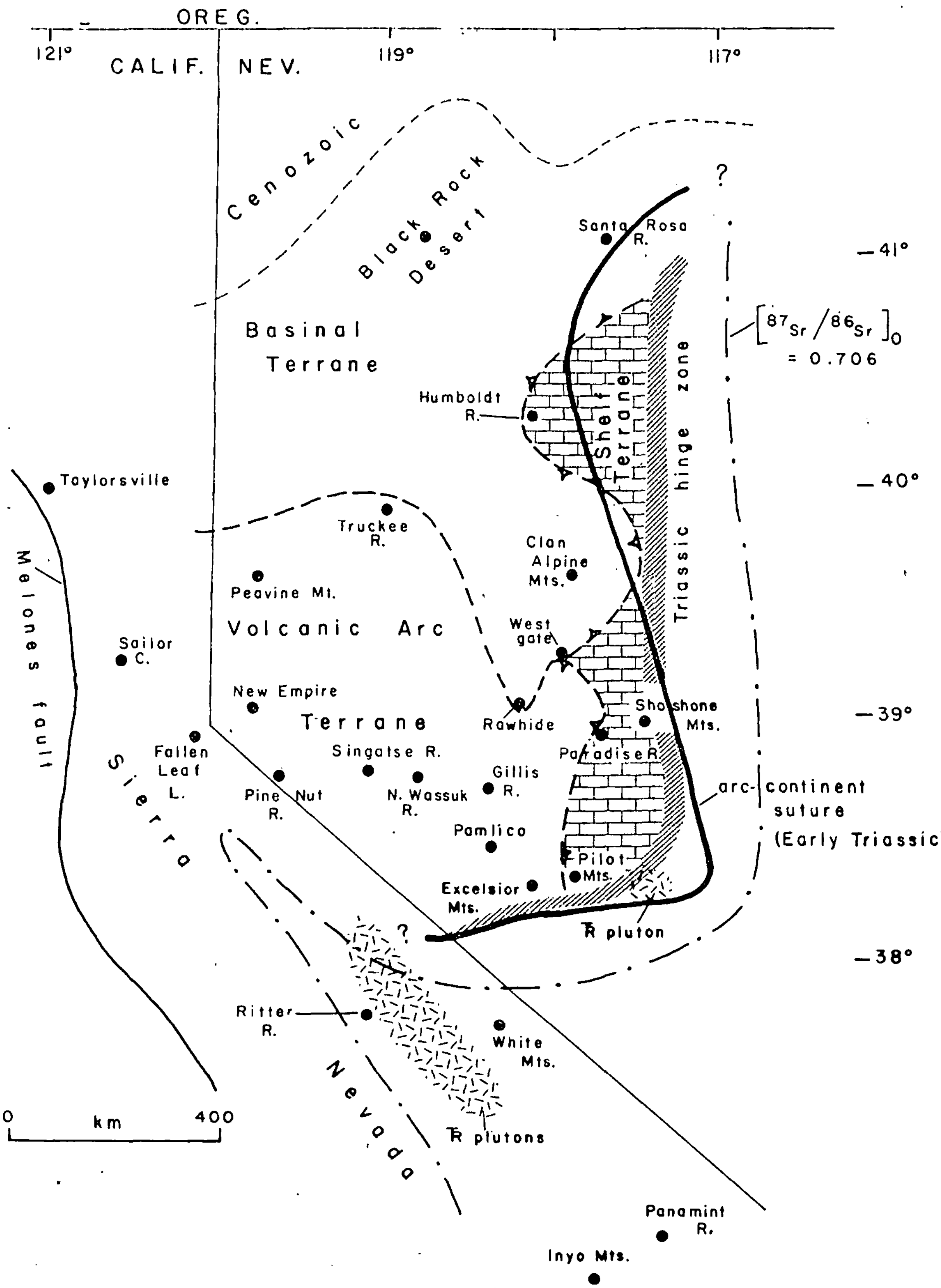


Figure 1: Map showing paleogeographic terranes of early Mesozoic marine province of the western Great Basin and other features referred to in text.

Table 1: Sequence of terranes in the western Great Basin discussed in text

Age	Terrane			
late Early and Middle Jurassic	orogenic terrane			
late Late Triassic to late Early Jurassic	terranes of the early Mesozoic western marine province: volcanic arc terrane	basinal terrane	shelf terrane: southern	shelf terrane: northern
				Koipato rhyolite (Early Triassic)
late Paleozoic	late Paleozoic volcanic arc terrane			late Paleozoic ocean floor terrane (Havallah sequence)

WESTERN MARINE PROVINCE

Lateral stratigraphic variations of marine Mesozoic strata of the Great Basin indicate two main depositional provinces existed in Triassic time. The western province (Fig. 1) was the site of variable but pronounced subsidence adjacent to and offshore from the general locus of the late Paleozoic continental margin of North America. Exposed strata of the western province range in age from late Early Triassic to late Early Jurassic. The eastern province occupied an intracontinental region in eastern and southern Nevada and western Utah; its marine contents are chiefly Early Triassic, and succeeding Upper Triassic and Jurassic deposits are variably of subaerial and marine (?) origin (Stewart, 1969; Stanley and others, 1971; Bissell, 1972; Stewart and others, 1972; Stewart, written comm. 1978).

The region of the central Great Basin between the two depositional provinces is devoid of early Mesozoic strata and was certainly less subsident if not an upland during much of the Triassic. Eastward onlap of the central zone from the western province is indicated by remnants of Middle and Upper Triassic beds in contact with Paleozoic rocks within 50 km east of the hinge zone (Fig. 1) (Nichols, 1971; Stewart and McKee, 1978). Moreover, rocks of both basinal and shelf terranes of the western province indicate that a region to the east of the hinge was at least partly subaerial during Late Triassic time. The basinal terrane includes deep water conglomerate containing probable Paleozoic pebbles from a nearby easterly source (Speed, this vol.) and the shelf terrane contains at least one major tongue of deposits (Grass Valley Formation) of a fluvial system (Silberling and Wallace 1969). Both contain woody fragments.

In the depositional province of the eastern Great Basin, there is a westward onlap of Lower Triassic beds (Collinson, 1976), and such strata contain conglomerates of probable westerly provenance (Koch, 1971; Stewart, written commun., 1978). The existence of 300 m or more of Chinle-like beds in the eastern province (Clark, 1957; Stewart and others, 1972) implies a subaerial environment in Late Triassic time. Thus, sediment transfer from the eastern to the western province conceivably occurred at that time.

It is difficult to prove whether the central Great Basin was a positive region in the Jurassic. The similarity of the distribution of preserved Jurassic sedimentary rocks in the Great Basin with that of Triassic implies that the two Triassic depositional provinces continued as relatively subsident regions into the Jurassic. The intervening region may or may not have been submerged. Stanley and others (1971) inferred on meager evidence that a sea crossed the Early Jurassic Great Basin. The open marine character of beds and absence of evident strandline deposits of Early Jurassic age in the western province may be the best testimony for marine continuity.

The eastern boundary of the western marine province (Fig. 1) is drawn east of the outcrop belt of the shelf terrane which includes strata over 2 km thick deposited at a subsiding margin and west of the region that contains only scattered outcrops of thin Triassic rocks judged to have been stable platform accumulations. Thus, the boundary approximates the hinge zone between regions of significatly different rates of subsidence. Owing to the absence of an exposed complete platform to basin transition, it is impossible to locate an inflection of the shelf-platform margin any closer than about 50 km. Further, because the basinal and volcanic terranes are thrust over the shelf terrane, the width of the subsiding shelf is uncertain.

The hinge zone appears to be approximately coincident with regional geologic features (Fig. 1) that are believed to mark the long-standing Paleozoic continental margin (Speed, 1977a). One is a proposed suture of Early Triassic age between a late Paleozoic magmatic arc and the continent. Another is the 0.706 initial strontium isotope contour (Kistler and Peterman, 1973). Both features are located with imprecision at least as great as that of the hinge zone of the early Mesozoic western marine province.

A southern boundary of the western marine province can be defined on some of the same criteria as the eastern boundary: circumscription of early Mesozoic marine outcrops and essential coincidence with the continental margin, Early Triassic suture, and 0.706 Sr contour (Speed, 1977a). Southernmost autochthonous Lower Mesozoic rocks in this region (Gold Range Formation of Speed, 1977b) are partly subaerial accumulations of ignimbrite and volcanic sedimentary rocks; their nature provides no evidence that deposition was confined to the regions of preserved rocks. In fact, it is possible that isolated tracts of volcanogenic rocks of probable Triassic age in Inyo County (Fig. 1 White Mountains, Inyo Mountains, Panamint Range) are remnants of an originally extensive subaerial belt that was contiguous with the volcanic terrane of the marine province.

An original western boundary of the western marine province cannot be defined. Layered rocks of demonstrable Middle and Late Triassic age apparently do not occur in the Sierra Nevada (east of the Melones fault) in the region south of Taylorsville (Fig. 1) (Clark and others, 1962; Kistler, this vol. and oral commun., 1978). On the other hand, Triassic successions of the marine province in westernmost Nevada do not contain strong westerly facies gradients. Thus, the apparent absence of such rocks in the high Sierra implies erosional and(or) tectonic removal. In the same region of the Sierra, however, Lower and Middle Jurassic deposits are apparently thick and widespread, and evidence presented later indicates they may have been partly contiguous with Jurassic rocks of the western Great Basin (see also Noble, 1962; Stanley and others, 1971). Thus, it may be inferred that this region of the Sierra was active tectonically during the early Mesozoic.

The northern Sierra Nevada near Taylorsville and the Shasta region, however, contain marine Triassic rocks that were conceivably contiguous with those of the western Great Basin (Sanborn, 1960; Albers and Robertson, 1961; McMath, 1966; D'Allura and others, 1977). The thick Jurassic strata of this region are probably correlatives in part with successions of the Ritter pendant, Sailor Canyon Formation, and westernmost Great Basin, as discussed later.

It should be noted that the present shape of the western marine province (Fig. 1) is not necessarily the original one. Deformation is particularly severe in the southern half of the province (Oldow, 1977; Wetterauer, 1977; Speed, this vol.). Moreover, it has been proposed (Albers, 1967) that extensive territory including the southern half of the province has been thrown into sigmoidal Mesozoic bends of crustal dimensions about vertical axes called oroflexes. Although the oroflex concept is kinematically dubious, there is clearly evidence for deformation on a gross scale in that region.

Early Mesozoic rocks of the western marine province are widely underlain by mafic and intermediate volcanic rocks that are known or suspected to be Permian (Speed, 1977a). Several lines of evidence suggest that such volcanic rocks are the basement to all but the easternmost beds of the marine province which lie above an early Triassic allochthon of late Paleozoic ocean floor strata, also known as the Havallah sequence. It has been proposed that the Permian volcanic rocks are the upper layers of a late Paleozoic island arc that migrated east or southeast toward the North American continent and propelled before it an accretionary arc of late Paleozoic ocean floor sediments. The volcanic arc collided with the continental slope at about the beginning of the Mesozoic or at least, before late Early Triassic. The accretionary arc was underthrust by the continental slope and perhaps, partly extruded east across the shelf-slope break. Following its collision, the late Paleozoic arc terrane was welded to the continent, and relative motion of the continent was taken up on a new boundary somewhere west of the Great Basin (Speed, 1977a).

Koipato rhyolite

The Koipato Group (Wallace and others, 1969; Silberling; 1973) was named for a succession of volcanic rocks whose outcrops are coextensive with succeeding strata of the lobate northern tract of the early Mesozoic shelf terrane (Fig. 1). Rhyolitic magmatism of the Koipato Group seems to have retarded basin subsidence in the Koipato outcrop area. It is uncertain, however, whether the Koipato widely underlies strata of the western marine province or is restricted to the area of existing outcrop. I tentatively interpret that it is restricted by arguments given below.

The Koipato Group comprises the Limerick Greenstone and succeeding rhyolitic units according to Wallace and others (1969). A different interpretation indicates that the Limerick Greenstone in its type area of the Humboldt Range belongs to the late Paleozoic arc terrane and that the rhyolitic formations are younger and separated by unconformity from the greenstone (Speed, 1977a). The rhyolitic units constitute about 2 km of remarkably siliceous and alkali-rich ash flow tuff and volcanogenic sedimentary rocks. Associated intrusive and protrusive masses indicate that rhyolite sources existed in the Humboldt and Tobin Ranges (Wallace and others, 1969; Burke, 1973). A faunal age near the top the rhyolite succession in mid-Spathian, only slightly older than the succeeding and nearly conformable beds of the Star Peak Group, according to Silberling (1973). Rb-Sr data from samples throughout the rhyolite units suggest that the approximate age of extrusion is 235-240 my and that partial chemical homogenization occurred later in the Mesozoic (R. W. Kistler and R. C. Speed, in prep.). The initial strontium isotopic composition suggests the rhyolitic magmas were not generated in continental lithoshpere.

The Koipato ash-flow tuffs lap east over deformed beds of the late Paleozoic Havallah sequence, indicating that eruptions probably did not occur before collision of the late Paleozoic arc and the North American continent. The environment of deposition of at least the upper rhyolite succession was variably subaerial and shallow marine. Block faulting occurred during and (or) shortly after accumulation of Koipato rhyolite in the Tobin and New Pass Ranges (Burke, 1973; MacMillan, 1972). Although such faults may have been volcanotectonic, their probable existence in the pre-Koipato basement beyond the area of thick rhyolite accumulation suggests the faults were more likely products of crustal extension.

Siliceous volcanic rocks of approximately similar age to the Koipato rhyolites in Nevada and California are known only in the Ritter pendant of the Sierra Nevada (Koip sequence of Kistler, 1966; this vol.), but those rhyolites are chemically dissimilar to the Koipato rocks. The Bully Hill rhyolite of the Klamath province (Albers and Robertson, 1961) could be contemporaneous with the Koipato but could also be as young as Late Triassic. The base of strata deposited in early Mesozoic basin is exposed at four places (Fig. 1) beside the area of Koipato outcrop: central Humboldt County (Willden, 1964), New Pass Range (MacMillan, 1972; Willden and Speed, 1974), Union district (Silberling, 1959), and Excelsior Mountains (Speed, 1977c). In none of these areas does rhyolite lie between the early Mesozoic sedimentary rocks and the subjacent terrane considered to the the basement of the basin. In the Union district however, volcanic rocks here called basement are poorly dated, and it cannot be demonstrated that such rocks are not underlain by a hidden succession of Middle and Lower Triassic strata. Similarly, undated rhyolites occur in the Gold Range Formation (Table 1) of the Excelsior Mountains above basal clastic strata and could conceivably be Koipato equivalents.

To conclude, there seem to be no evident equivalents of the Koipato rhyolites in the southern cordillera except for the Koip sequence. The rhyolitic magmas emerged chiefly through the late Paleozoic volcanic arc lithospere. Such rocks must represent local magmatism, and in a later section, this inference is used to explain the form and existence of the wide northern shelf of the early Mesozoic basin.

Shelf Terrane

Strata included in the shelf terrane are mainly carbonate and less abundant silicaclastic rocks that were deposited on generally (but not uniformly) shallow subsiding shelves at the east flank of the western marine province. Carbonate platform or bank accumulations also occur at places in the other two early Mesozoic terranes, but they are dominant only in the shelf terrane. This terrane consists of two main regions, a northern one which is lobate to the west and in probable thrust contact with the basinal terrane (Speed, this vol.) and a southern one which occupies a narrow belt and which is in thrust contact with the volcanic arc terrane.

The northern region includes the Star Peak Group, a carbonate platform complex about 1 km thick of late Early Triassic (mid-Spathian) to middle Late Triassic (Karnian) age (Silberling and Wallace, 1969; Nichols, 1972; MacMillan, 1972; Burke, 1973; Nichols and Silberling, 1977). The Star Peak is overlain by Upper Triassic silicaclastic and carbonate rocks about 1 km thick of the Grass Valley, Dun Glen, and Winnemucca Formations* (Silberling and Wallace, 1969; Burke and Silberling, 1973).

Nichols and Silberling (1977) have shown that the Star Peak Group is a carbonate platform complex that prograded generally west from Middle to early Late Triassic (late Anisian to late Karnian) time. Mafic volcanic rocks occur widely at Ladinian horizons of the Star Peak. The succeeding silicaclastic accumulations of the Grass Valley Formation grade west (Silberling and Wallace, 1969) across the shelf terrane from quartz arenite and carbonate rocks with increasing proportions of mudstone and channel-filling subarenite. The formation constitutes a substantially thicker mudstone-rich accumulation in the Humboldt Range (Fig. 1) at the westernmost exposure of the shelf terrane. Silberling and Wallace (1969) interpreted the Grass Valley as a westerly-prograding fluvial-deltaic complex. Their paleocurrent data from outcrops of Grass Valley that are structurally continuous with Star Peak beds indicate generally westerly sediment transport. The succeeding Dun Glen Formation represents a return of carbonate bank deposits on the shelf, and the Winnemucca, a general recursion of muddy silicaclastic debris. Rocks younger than Middle Norian are unrecognized in the northern tract of the shelf terrane.

Strata of the northern shelf terrane indicate generally continuing subsidence for much of Triassic, but facies and unconformities within the succession (Nichols and Silberling, 1977) indicate the rate was nonsteady and that the terrane was variably emergent during its deposition. Moreover, they believe there is evidence for upwarping during the Middle Triassic. The rate of subsidence of the northern shelf terrane appears to have increased generally west and perhaps south. Silicaclastic sediments (Tobin and Dixie Valley Formations) accumulated at the base of the terrane near the basin margin whereas carbonates constitute almost the entire section in the more offshore zone of the shelf that was underlain by thick Koipato rhyolite. The existence of mafic volcanic rocks in the Star Peak Group may suggest that crustal extension accompanied subsidence as does the interpretation of Nichols and Silberling (1977) that local relative uplifts during Star Peak deposition were products of tensional differential subsidence.

The Grass Valley Formation records an abrupt change of lithology and transport mode from the carbonate platform deposits (Silberling and Wallace, 1969). Their interpretation indicates that at the beginning of Norian time, alien mud and sand prograded west across the basin margin and carbonate platform as a deltaic complex. It implies further that a shelf to deep basin transition probably lay just west of the Humboldt Range at the beginning of the Norian and that the transport system of the Grass Valley Formation was one conduit of pelitic debris to the basinal terrane (Speed, this vol.).

The southern region of the shelf terrane consists predominantly of carbonate rocks 2-3 km thick. It includes the Luning, Gabbs, and Sunrise Formations of the Pilot Mountains, Paradise Range, Shoshone Mountian, Gabbs Valley Range, and scattered outcrops east of the latter range, as mapped by Ferguson and Muller (1949). It also includes the late Middle Triassic (Ladinian) Grantsville Formation (Silberling, 1959) of the Shoshone Mountians which is seemingly the oldest among those assigned. The actual maximum age of rocks of the southern shelf is uncertain. The Grantsville lies on poorly dated mafic volcanic rocks that may belong to the late Paleozoic basement of the western marine province or may simply be Triassic eruptives in a shelf sequence that extends to depth (Speed, 1977a). Elsewhere the shelf succession is either allochthonous (Oldow, 1977), or it has a buried base. Unlike the northern region of the shelf, the southern terrane includes rocks of late Late Triassic and Early Jurassic age.

Much of the southern shelf terrane is cut by thrusts, and it is possible that the whole southern terrane is allochthonous. Oldow (1977) found in the Pilot Mountains (Fig. 1), the southernmost outcrop area of the shelf terrane, that strata of the shelf terrane are piled up in a series of 13 thrust nappes; by structural and facies analyses, he interpreted the principal direction of motion of nappes to have been southeast and the magnitude of telescoping to

*Auld Lang Syne was assigned as a group name by Burke and Silberling (1973) for formations above the Star Peak Group and for thick terrigeneous successions with unexposed base north of the Star Peak exposure region. Though the euphony of the group name is appealing, I have not used that terminology because rocks north of the Star Peak outcrop area are included in the basinal terrane (Speed, this vol.).

have been perhaps as great as 100 km. Further, the general north-south boundary between the volcanic and southern shelf terranes (Fig. 1) is probably tectonic along its entire length. In the Paradise Range, the volcanic terrane is thrust over the shelf terrane, but in the Pilot Mountains, the shelf terrane is overthrust. In the Garfield Hills and northern Gabbs Valley Range, it is not clear which terrane is structurally higher at the tectonic boundary. It is reasonable to conclude from preceding paragraphs that the original configuration of the southern shelf terrane and the age range of its strata are in some doubt. It seems likely, however, that as in the northern, rocks of the southern shelf terrane accumulated in proximity to the relict Paleozoic continental margin.

Triassic rocks of the southern shelf terrane are largely shallow marine carbonate together with coarse terrigenous clastic rocks whose debris was probably derived from short distances east of the basin margin. The middle member of the Luning Formation of Norian age (N. J. Silberling, oral commun., 1972) is particularly interesting because it contains abundant pelite together with coarser rocks interpreted by Oldow (1977) as a deltaic complex. In the Pilot Mountain, the upper half of the 1 km thick middle member contains feldspathic siliceous tuff and copious euhedral feldspar sand of evident volcanic origin (Nielsen, 1963; Oldow, 1977). Moreover, the middle member locally contains chert-boulder conglomerate, implying accumulation within several kilometers of basement prominences.

The upper member of the Luning Formation is a conspicuous massive Norian carbonate unit of about 700 m thickness that occurs with remarkable lithologic consistency throughout the southern shelf terrane (Silberling and Roberts, 1962). It is succeeded by several hundred meters of marine limy mudstone and thin bedded limestone of late Norian and Early Jurassic age. The upper member of the Luning and higher units suggest lateral continuity of depositional environments as compared to the heterogeneous middle member of the Luning Formation.

Basinal Terrane

Exposed rocks of the basinal terrane are chiefly Triassic pelites and interstratified quartz sandstone of known or suspected deep water origin. Thick successions of such rocks occupy an arcuate belt that circumscribes the western margin of the lobate northern shelf terrane (Fig. 1). Within this belt, the pelite-sandstone successions are of late Late Triassic (Norian) age, but their depositional base is not exposed. Moreover, outcrops of older strata are absent in the area of the belt so that the total thickness and age range of hidden successions of the basinal terrane are unknown. In the southern half of the belt, strata of the basinal terrane grade up to more calcareous rocks of latest Triassic and Early Jurassic age. In contrast, rocks of known Jurassic age are absent from the northern half of the belt, and Triassic pelites may be the last marine deposits of that area. West of the arcuate belt of abundant exposure of the basinal terrane, outcrops of similar rocks are scattered throughout northwestern Nevada (Fig. 1)

Specific map units of northwestern Nevada included in the basinal terrane are listed in Speed (this vol.). Early Mesozoic pelitic rocks of the northern Sierra Nevada and Shasta regions are perhaps correlative with the basinal terrane. The upper Arlington ("Cedar") and Swearingen Formation (D'Allura and others, 1977) and the Pit Formation and succeeding Triassic units (Sanborn, 1960) may have been originally contiguous.

The arcuate boundary between the basinal and shelf terranes (Fig. 1) is a variably certain or probable thrust zone on which the basinal terrane is allochthonous (Speed, 1976; this vol.). The zone of dislocation is interpreted to lie close to the Triassic declevity that separated the shelf and basinal despositional realms. The magnitude of displacement of rocks of the basinal terrane near the thrust zone is probably small (few km ?). The strong deformation and general shelfward vergence of folds of strata within the basinal terrane, however, imply that lateral shortening of the terrane during shelfward thrusting was probably large. The time of thrusting and first tectonic deformation of the basinal terrane was approximately mid-Jurassic. Conceptually, the mid-Jurassic orogeny seems to have caused the basinal terrane to flatten against and squeeze out over the shelf edge.

The boundary between basinal and volcanic arc terrane is depositional at Rawhide Summit (Fig. 1), the only place the contact is exposed. There, distal turbidites of the basinal terrane are succeeded by proximal volcanogenic turbidite and Upper (?) Triassic carbonate rocks and at higher levels, by volcanic and carbonate rocks typical of the volcanic arc terrane. This one locality indicates northward progradation of rocks of the volcanic terrane over those apparently allied with the basinal terrane and ultimate shoaling of the depositional site. The pelitic rocks could, of course, be a tongue in an otherwise continuous succession of volcanogenic rock.

The Clan Alpine Mountains (Fig. 1) probably provide the greatest depth of exposure of strata within the southern part of the basinal terrane (Speed, this vol.). The Clan Alpine succession is about 5.8 km thick and spans Norian time; the upper 400 m could be Jurassic. The lower 4 km are predominantly distal turbidite and hemipelagite of which the mud fraction is composed of quartz, illite, chlorite, and plagioclase. The directions of currents that deposited the distal turbidites are unknown. Interstratified with the muddy rocks are deep water quartz arenite, chert-quartzite-limestone pebble conglomerate, and carbonate-particle deposits whose debris moved generally down and accumulated at the base of a northwesterly-facing slope (in modern geography). The sources of such particles were littoral regimes which included exposures of older rocks, biogenic and inorganic carbonate particle accumulations, and quartz sand beaches or bars.

The upper 1.5 km of the sequence in the Clan Alpine Mountains contains only fine silicate sediment of hemipelagic (?) origin and upward increasing proportions of carbonate rock, culminating in about 600 m of massive platform carbonate at the top of the section. The upper part of the section records either by-passing or elimination of sources of the coarse debris that occurs in the lower strata. Moreover, it indicates ultimate shoaling of the former deep basin floor.

West of the Clan Alpine Mountains, the basinal terrane includes Lower Jurassic beds as thick as 1 km (Speed, 1974) which are generally organic limy pelites. Such rocks were evidently deposited under open marine conditions, perhaps below wavebase.

Their carbonate debris was conceivably derived from the carbonate platform that forms of the upper strata of the basinal terrane in the Clan Alpine Mountains. Given that the Early Jurassic and Late Triassic subperiods were equally long, the mean rate of accumulation of sediment was more than 5x greater in the Late Triassic in the southern region of the basinal terrane.

The only other succession of the basinal terrane where a stratigraphy has been worked out is in the Santa Rosa Mountains (Fig. 1). There, Compton (1960) found a succession over 6 km thick of pelite, quartzose sandstone, and minor carbonate rocks of Norian and Norian (?) age. Unfortunately, data leading to interpretation of depositional environments of the basinal terrane are unavailable outside the Clan Alpine Mountains. The uniformity of mineral composition of the Triassic pelites and their widespread association with quartz sandstone, however, suggests that the entire basinal terrane had the same general sediment source.

Contemporaneous deposition of nearly identical sediment occurred in the northern shelf and basinal terranes in early and Middle Norian time. Comparison of thicknesses of approximately coeval intervals in the Clan Alpine sequence (Byers Canyon, Dyer Canyon, and lower half of Bernice Formations) with that of the Grass Valley, Dun Glen, and Winnemucca Formations of the central part of the northern shelf terrane (Silberling and Wallace, 1969) indicates the basinal succession accumulated about 3x more rapidly. A similar comparison with the Santa Rosa succession cannot be made because age equivalence is unknown. The differences in Norian accumulation rates between shelf and basinal terranes and the evidence for deep water deposition in at least the southern region of the basinal terrane indicate large differential subsidence between areas of the two terranes. The differential subsidence could have been either pre- or syn-Norian; if the latter case is true, the rate of basinal subsidence exceeded the impressive rate of sediment accumulation of roughly 10^2cm/10^3yr for about 5 m y. Later evidence will suggest that pre-Norian differential subsidence is more likely.

Interpretations of the direction of sediment transport in the Grass Valley Formation (Silberling and Wallace, 1969) and in lower formations of the Clan Alpine sequence (Speed, this vol.) imply easterly sources, surely for sand and coarser debris and at least part for the silicate mud. The eastern quartz sandrich part of the Grass Valley ("Osobb Formation") may be a preserved deposit of the same beach zone that supplied clean quartz sand to the deep water deposits in the Clan Alpine sequence.

To ascertain the histories of differential subsidence and accumulation of silicate mud of the basinal terrane, the character and age of the concealed rocks of the terrane must be inferred from exposures of the base of the terrane and subjacent rocks in the Black Rock Desert of northwestern Nevada (Fig. 1). Based largely on Willden's (1964) reconnaissence, the sequence in the Black Rock Desert is interpreted as follows (Speed, 1977a; this vol.): late Paleozoic volcanic arc and related sedimentary rocks are overlain by about 500 m of carbonaceous limestone and interbedded black mudstone and chert of early Mesozoic age; these beds are conformably succeeded by pelite and quartz sandstone that are typical of Triassic rocks of the basinal terrane. The best estimate of the age of the lowest horizons of the pelitic succession is late Middle Triassic (Ladinian), as diagnosed by N. J. Silberling (in Willden, 1964) for the Quinn River Formation.

The depositional environment of the Triassic rocks below the pelitic succession is uncertain. However, their content of chert and dark mudstone may imply that the region was basinal for an unknown duration before the onset of major influx of silicate mud and sand, probably in late Middle Triassic (Ladinian) time. It follows that if the earliest mud of the thick pelites of the basinal terrane was dumped into a preexisting deep water basin, the basal accumulations of the pelites are probably isochronous and everywhere Ladinian. Thus, it appears that the pelitic sediment entered the deeper marine region for a significantly longer duration than the early and middle Norian times during which it also spread over the northern shelf (to form the Grass Valley and Winnemucca Formations). A further implication is that a copious supply of mud and sand suddenly became available near the end of Middle Triassic time.

The volume of exposed rocks of the basinal terrane is estimated to be $10^5 km^3$, close to the value given by Burke and Silberling (1973). Of this, probably 70 percent is mudstone. It is reasonable to assume that concealed deposits might double the figure.

The pelitic rocks are seemingly homogeneous according to x-ray studies and density measurements and Compton's (1960) petrographic, chemical, and density data. They contain abundant quartz and lesser white mica and plagioclase as silt and perhaps finer particles. K-feldspar is apparently absent. Illite and chlorite compose the clay fraction. Compton's chemical analyses indicate the clay fraction is somewhat ferrugenous, and calculations with his data indicate about 10 percent total iron oxide as Fe_2O_3 in the clays. This value is somewhat higher than the 5-7 percent given for modern terrigenous clays by Garrels and Mackenzie (1973). Volcanogenic particles are not evident in the Clan Alpine sequence nor in the Santa Rosa succession, but in the latter, some detrital mica is biotite in various stages of alteration to white mica (Compton, 1960). Beyond the implication of an igneous source for biotite in the Santa Rosa sequence, the lithology of the mud fraction provides no direct indication of its origin. Later regional considerations suggest, however, that a volcanogenic origin of the pelitic debris was perhaps likely.

Volcanic Arc Terrane

The volcanic arc terrane contains intermediate and siliceous extrusive and related sedimentary rocks, interstratified carbonate rocks, and higher beds of generally less volcanogenic sedimentary rocks. The environment of volcanism and sedimentation was generally marine. The volcanic terrane of the marine province and its probable original subaerial prolongation to the south are arc-related because they form a belt that is parallel and adjacent to a Triassic tectonic boundary, as discussed later.

Table 2 summarizes stratigraphic relationships at major localities in this terrane. The data show how meager the age control is. The lower contact of most of these successions is buried or faulted. The only locality where a depositional base above regional basement is exposed is in the Excelsior Mountains; there, the early Mesozoic strata (Gold Range Formation) lie unconformably over 250-260 my old mafic rocks of the late Paleozoic arc at a position just north of the Paleozoic continental margin. (Speed, 1977b). Unfortunately, the lower part of the Gold Range Formation is undated. The depositional base of the early Mesozoic arc terrane at Rawhide Summit cannot be regarded as a regional contact because the subjacent mudstone may be only a tongue in a volcanic section that continues to depth.

Triassic and Jurassic strata of the volcanic arc terrane are widely overlain by quartz sandstone and volcanogenic rocks of the Dunlap Formation (Muller and Ferguson, 1939) and related units. In this paper, these suprajacent units are grouped in an orogenic terrane (Table 1) and discussed separately in a later secton.

The oldest dated rock in the early Mesozoic volcanic arc terrane appears to be andesite at the base of the exposed section in the Singatse Range (Table 2). The dated rocks give a Rb-Sr age of 215 m y (Einaudi, 1977), and they lie some distance below beds that contain faunas at the Karnian-Norian transition (J. C. Proffett, oral commun., 1976; fossils identified by N. J. Silberling). Assuming that Permian rocks are a ubiquitous basement to the early Mesozoic volcanic terrane, the onset of early Mesozoic volcanism was between 250 and 215 mybp. I infer below that igneous rocks of the early Mesozoic volcanic arc terrane were products of the earliest epoch of plutonism of the Sierra batholith. Intrusions generated in that epoch (Fig. 1) have an apparent age range of 215-200 mybp (Evernden and Kistler, 1970; Kistler, this vol.). Thus, andesite of the Singatse Range was among the first eruptions of the Mesozoic volcanic terrane.

The thickness of the volcanic arc terrane is poorly known except in the Singatse and Pine Nut Ranges where exposed sections are about 3 km (Einaudi, 1977) and 2 km thick (Noble, 1962), respectively. Most of the localities, however, give the impression of substantial thickness.

There seems to be a general concentration of volcanic rocks in lower parts of the successions where a stratigraphy can be recognized. At most places, increasing proportions of carbonate rocks occur upsection, commonly culminating in a thick massive carbonate unit of known or presumed Norian age. The massive carbonate rocks are succeeded by thin-bedded limy pelitic rocks that are latest Norian and Early Jurassic. Except for the region from the Singatse Range west, rocks of known Early Jurassic (and pre-Dunlap) age have little or no volcanogenic material. Moreover, Lower Jurassic rocks in the Singatse and Pine Nut Range are less volcanogenic than the Triassic parts of the section.

Lateral variations in the volcanic terrane are less evident and have been complicated by thrusting within the terrane and between the volcanic and southern shelf terranes. A significant difference, however, seems to exist between the early Mesozoic volcanic terrane of the Excelsior Mountains and that in areas farther north. The Gold Range Formation of the Excelsior Mountains contains high proportions of ash-flow tuff and fluvial terrigenous and volcanogenic sedimentary rocks, suggesting a prevailingly subaerial environment. In contrast, the volcanic terrane in the Gillis Range contains much massive flow foliated rhyolite and breccia that is irregularly associated with thin bedded volcanic sedimentary rocks and, at places, with marine carbonate rocks. The Gillis volcanic rocks and those of the Pamlico district (Oldow, this vol.) are perhaps more generally marine than those of the Gold Range. The volcanic terrane near Rawhide Summit seems to have an even higher proportion of marine volcanic and carbonate sedimentary rocks. Thus, the southern strandline of the marine province may have lain generally north of the Excelsior Mountains in the Triassic. The existence of volcanic conglomerate in the Gillis and Sand Springs successions, however, implies that volcanic shoals existed within the marine region.

The widespread occurrence of massive carbonate rocks in the region of early Mesozoic volcanic rocks has been observed by many geologists and first documented by Muller and Ferguson (1939). They correlated almost all the carbonate rocks in the Hawthorne and Tonopah (1:125,000) quadrangle with the Luning Formation which is here restricted to the shelf terrane. In order to maintain the integrity of the Luning Formation, they were forced to envision that thrust faults separate volcanic and carbonate units which are in fact interbedded. It may be correct that the upper member of the Luning Formation and massive carbonate strata of the volcanic terrane were at least partly contiguous. Muller and Ferguson (1939) also correlated Lower Jurassic rocks that lie above Triassic volcanic sections with the Sunrise Formation that lies above the nonvolcanogenic Luning Formation. The lateral homogeneity of the beds of known and presumed Early Jurassic age makes Sunrise an applicable name.

Chemical analyses of Triassic volcanic rocks of the volcanic terrane are presented in great number by Rogers and others (1974), and a few more are in Ross (1961) and Speed (1977c). The data indicate that the rocks are calc-alkaline and range widely in composition. They include mafic as well as strongly siliceous (SiO_2 > 75 percent) types; alkali contents are markedly variable and occasionally as great as 10 percent. There is no evident spatial trend of the chemical data. As noted by Rogers and others (1974), the Triassic volcanic rocks are significantly more siliceous than the subjacent late Paleozoic rocks (their Excelsior Formation).

Uncertainty in ages of rocks exists at many places in the volcanic arc terrane, but it seems that volcanism generally waned within late Triassic time. The region of Triassic volcanism, which contained sites of carbonate production and accumulation during magmatism, was then covered pervasively by a shallow marine carbonate regime within the Norian. Subsidence of the region continued and could even have increased during widespread carbonate accumulation relative to that of the earlier volcanic stage.

East of the Singatse Range, the Lower Jurassic deposits (Sunrise) record a generally offshore, plane-floored marine environment, considered by Stanley (1971) to be generally subtidal. Like the probably contiguous Lower Jurassic rocks of the basinal terrane, these rocks suggest that the rate of subsidence in the Early Jurassic marine province exceeded the rate of carbonate production such that deepening of the province increased with time. The only Sunrise facies indicating nonmarine conditions or nearby terrigenous sources are the Jurassic red beds of the Gold Range Formation (Table 2).

From the Singatse Range west, the Lower Jurassic deposits (Gardnerville Fm.) indicate probably a west-

Table 2: Lithic Successions Within the Volcanic Arc Terrane

Location (Fig. 1)	Lithic Succession (older to younger)	References
Excelsior and Pilot Mountains	Gold Range Fm.: unconformable on Permian arc rocks; includes >3 km(?) of coarse terrigenous and volcanic rocks interlayered with siliceous ash-flow tuff and breccia (undated) and upper 100 m of Lower Jurassic red beds and marine carbonate rocks	Speed (1977b)
Garfield Hills	Pamlico Fm.: allochthonous; Triassic intermediate and siliceous lava, breccia, and sediment interlayered with carbonate rocks; increasing proportions of carbonate upward; conformably overlain by Lower Jurassic limy pelite of Sunrise Fm.	Oldow, this vol.
Gillis Range	thick succession of intermediate and siliceous lava, breccia, protrusions, and volcanic sediment, probably chiefly marine; thin carbonate interbeds with Late Triassic fossils (N. J. Silberling, written commun., 1972); succeeded by massive (>300 m?) carbonate unit and higher, by dark shaly limestone and mudstone of Norian age	Ferguson and Muller (1949) Ross (1961) Speed (1977b and unpubl. data)
Paradise Range	undated laterally variable intermediate massive volcanic rocks, volcanic sediments, and carbonate rocks, all probably allochthonous; assemblage of quartz porphyry, Kfeldspar porphyry, quartz sandstone, and dolomite of the orogenic terrane is locally associated	Vitaliano and Callaghan (1963) Speed (1977c)
Westgate	undated andesite, volcanic conglomerate, quartz porphyry; allochthonous	Corvalán (1962) Willden and Speed (1974)
Rawhide Summit	Late Triassic volcanic sediments overlying mudstone (of basinal terrane) and interbedded with carbonate rocks; increasing proportions of andesite, welded tuff, and carbonate rocks; (probably Late Triassic) upsection, massive carbonate unit (>500 m, locally conglomeratic) at top	Ross (1961) Willden and Speed (1974)
Truckee Range	undated andesite and siliceous rocks	Willden and Speed (1974)
Peavine Mtn.	intermediate breccia and tuff, volcanic sediments; Late Triassic(?)	Bonham (1969)
Singatse Range	thick succession of Karnian(?) andesite and rhyolite, upper Karnian-lower Norian carbonate and silicaclastic strata, massive limestone, Lower Jurassic limy pelitic rocks (tuffaceous)	John C. Proffett (oral commun., 1976) Einaudi (1977)
Pine Nut Range	Norian intermediate and siliceous volcanic breccia, lava, tuff, and ash-flow tuff interstratified with marine limestone (1000 m) of the Oreana Peak Fm.; Norian and Lower Jurassic mudstone, volcanogenic sediments, and limestone as young as late Toarcian (1000 m) of the Gardnerville Fm.; succeeded by rocks of orogenic terrane	Noble (1962)
northern Wassuk Range	andesite and siliceous volcanic rocks overlain by massive Triassic(?) limestone; siliceous argillite and siltstone, at least partly of Early Jurassic age, with limestone interbeds in upper horizons	E. C. Bingler (written commun., 1978)
New Empire quadrangle	andesite overlain by dacite flows and ash-flow tuff; interbedded Upper Triassic limestone and marine pyroclastic rocks correlated with Oreana Peak Fm.; calcareous and tuffaceous pelitic rocks correlated with Gardnerville Fm.; succeeded by siliceous volcanic rocks of probable affiliation with orogenic terrane	E. C. Bingler (written commun., 1978)
Fallen Leaf Lake	over 2 km of graded thin-bedded calcareous turbidites of at least partly Early Jurassic age; overlain by thick conglomerate and andesite of probable affiliation with orogenic terrane	Loomis (1961)

erly increasing rate of subsidence, influx of more silicate and volcanogenic debris than in the Sunrise rocks, and at least occasional turbidity current transport (Noble, 1962; E. C. Bingler, written comm., 1977; R. C. Speed, unpubl.). As first proposed by Noble (1962), the Gardnerville strata (here extended east to the Singatse Range) seem to be transitional between contemporaneous subsiding shelf deposits of the Sunrise and largely volcanogenic trough accumulations of the Sailor Canyon (Milton) Formation in the central Sierra Nevada (Fig. 1). In fact, the Sailor Canyon trough probably included the Early Jurassic rocks of the Ritter pendant (Kistler, 1966; Stanley and others, 1971; Kistler, this vol.) and the Mt. Jura section of the northern Sierra (McMath, 1966).

Although the correlation of sections containing massive Norian carbonate rocks and "Sunrise" beds between the volcanic and southern shelf terranes seems reasonable, there is little basis for alliance of lower parts of the two successions. The existence of volcanogenic material in the middle member of the Luning Formation of one of the thrust nappes of the Pilot Mountains is the only evidence for intergradation (Nielsen, 1963) between volcanic and shelf terranes. Thus, one must appeal either to an abrupt transition (for example, volcanism restricted to the west of a shelf edge) or to a broader zone of intergradation that is overthrust by rocks of the volcanic terrane.

Contact relationships among the three early Mesozoic terranes suggest that the basinal terrane and the volcanic arc terrane (except for the Gold Range Formation, Table 2) could be companions in a giant allochthon that moved continentward over the shelf terrane. It is noteworthy that if a continuous thrust zone actually underlies the basinal and volcanic arc terranes, the surface trace of thrust would roughly parallel and be coextensive with the Permo-Triassic Golconda thrust as drawn by Speed (1977a).

Facies provide no certain indication that the southernmost outcrops (the Gold Range Formation, Table 2) of the volcanic terrane represent the southern limit of its deposition. The bulk of the Gold Range was probably deposited subaerially, and lithic equivalents may have extended untold distances to the south. In fact, scattered tracts of poorly dated volcanogenic rocks that are possibly correlative with the volcanic arc terrane of the western marine province occur to the south of the Gold Range Formation (Fig. 2) in the Inyo, White, and Panamint Ranges of Inyo County, California (Johnson, 1957; Merriam, 1963; Ross, 1967; Abbott, 1972; Crowder and Ross, 1973; Stevens and Olson, 1972). Successions in each tract may be Late Triassic (age brackets vary from as close as Middle Triassic-Early Jurassic to as open as pre-Cretaceous), and Abbott's (1972) study indicates that those of the Inyo and Panamint Ranges are compositionally like the Triassic volcanic rocks of the Gillis Range (Rogers and others, 1974). The depositonal environment of Inyo County volcanic rocks is not certain, but there is no evidence for marine environments. Thus, I propose that the realm of deposition of Triassic volcanic rocks extended southward of the marine province in western Nevada on emergent ground as far as Death Valley, and perhaps, beyond.

The paucity of outcrop of Triassic volcanic rocks south of the marine province is due partly to massive erosion because the well known southeastward increase in average age of rocks exposed between the Excelsior Mountains and Death Valley implies progressively greater post-Triassic uplift to the south. The volcanic rocks may also have undergone tectonic covering by thrust sheets of Lower Paleozoic rocks, as inferred in the White Mountains by Stevens and Olson, 1972.

Intrusions of the Lee Vining epoch, the earliest phase of the Sierra Nevada batholith, crop out just south of the western marine province (Fig. 1) (Evernden and Kistler, 1970). Such plutons have an apparent age range of 215-200 mybp (Kistler, this vol.; oral commun., 1978) according to concordant hornblende (K-Ar), zircon, and Rb-Sr dates. A small pluton with a hornblende age of 210 my occurs within the southern volcanic arc terrane (Fig. 1) (Speed and Armstrong, 1971), and other scattered bodies with ages in the same range seem to occur in a belt that trends southeast at least 500 km from the area of Triassic plutons in Figure 1 (Burchfiel and Davis, 1972). The probable overlap in age of Triassic volcanic rocks of the marine province and the Triassic plutons of the Sierra batholith strongly implies the two suites of igneous rocks were comagmatic. Moreover, the postulated southeasterly subaerial prolongation of the early Mesozoic volcanic terrane and generally coextensive Triassic plutons provide a glimpse of the locus of an elongate magmatic belt that was the first Phanerozoic arc developed on the continent in the southern cordillera (Hamilton, 1969).

OROGENIC TERRANE AND DESTRUCTION OF THE MARINE PROVINCE

The early Mesozoic marine province of the western Great Basin underwent major deformation and final effacement as a site of marine deposition in late Early Jurassic and Middle Jurassic time (late Toarcian and Bajocian). During this interval, sediments of the orogenic terrane accumulated at local sites within the region of the marine province south of about 40°N. Most sites were created by tectonic subsidence (Ferguson and Muller, 1949; Speed and Jones, 1969; Wetterauer, 1977) but a few seem to be relics of the earlier open marine environment.

This terrane contains the following rock units: Boyer Ranch Formation (Speed and Jones, 1969); Lovelock Formation (Speed, 1974); Muttlebury Formation (Speed, 1975); Humboldt lopolith (Speed, 1976); Middle Jurassic rocks at Westgate (Corvalán, 1962; Willden and Speed, 1974); association of quartz porphyry-quartz arenite-limestone conglomerate in the southern Stillwater Range (Willden and Speed, 1974), Paradise Range, and Quartz Mountain (R. C. Speed, unpubl.); Dunlap Formation (Ferguson and Muller, 1949; Nielsen, 1963; Stanley, 1971; Wetterauer, 1977); gypsum, quartz sandstone, contiguous volcanogenic strata at Ludvig, Singatse Range in the western Excelsior Mountains, and in the Pine Grove Hills (R. C. Speed, unpubl.), and the Preachers, Veta Grande, and Gold Bug Formations of Noble (1962).

Rocks of the orogenic terrane lie variably with conformity or unconformity above strata of the three Mesozoic terranes and in the Pilot Mountains, above pre-Mesozoic rocks. Basal strata of the orogenic terrane are almost uniformly quartz sandstone which may be interstratified with carbonate-evaporite rocks or include quantities of coarse terrigenous sediment. These rocks are commonly overlain by volcanogenic sedimentary rocks and minor volumes of andesite and siliceous volcanic rocks. Major exceptions to this theme occur at two places. Marine carbonate rocks that are late Early Jurassic and interstratified with quartz sandstone at Westgate (Fig. 1) are continuous with early Middle Jurassic limestone (Corvalán, 1962). In the Pine Nut Range (Noble, 1962) and nearby areas, quartz sandstone is overlain by several kilometers of volcanogenic rocks of which welded tuff is the predominant constituent.

Dating of the quartz sandstone of the orogenic terrane is meager but permissive of isochronous deposition in late Early Jurassic (late Toarcian) time. Some overlap in times of depostion of Sunrise rocks and the orogenic terrane is conceivable, but Stanley's (1971) contention they are facies is totally unsupported. Deposition of volcanogenic debris of the orogenic terrane is dated at one place in the Dunlap Formation, there also probably late Early Jurassic. Evidence from the Humboldt lopolith indicates quartz sandstone was accumulating (or perhaps, reaccumulating) at about 165 mybp.

Deformation of the Mesozoic strata of the marine province occurred by the creation of folds and thrust nappes at the free surface (Ferguson and Muller, 1949, Speed and Jones, 1969; Speed, 1975; Oldow, 1977). These surface phenomena were probably synchronous with deep-seated movements that culminated in the major thrust faults between terranes. The thrusts are apparently of great trace length, but their magnitude and direction of displacement are poorly known in a regional sense. For example, the southeastern part of the basinal terrane (Clan Alpine sequence) probably moved northeast relative to the northern shelf terrane (Speed, this vol.) whereas rocks of the southern shelf terrane in the Pilot Mountains moved southeast relative to an autochthon of the volcanic arc terrane (Oldow, 1977). If a uniform displacement originally occurred on the major thrusts of the province, progressive deformation during the mid-Jurassic orogeny and rotation by subsequent tectonic events have made it hard to decipher.

At the onset of regional deformation in the Jurassic, the marine province south of 40°N was an open marine region with probably greatly diminished subsidence relative to its average Triassic rate except near the western boundary. The eastern shoreline may have been within the western Great Basin (Speed and Jones, 1969), or the sea may have extended east into Utah (Stanley and others, 1971). Deformation caused mountains along what is now the southern margin of the marine province (Ferguson and Muller, 1949; Wetterauer, 1977) and warps of free surface at other places. Quartz sand from the same sources that fed the Jurassic Nugget-Navajo-Aztec sand accumulations in the eastern Great Basin migrated into the tectonic lows that developed in the western marine province (Speed and Jones, 1969; Stanley, 1971). The thicknesses of quartz sand trapped in these lows varies from a few tens of meters to nearly 2 km. Evaporites were deposited with or without quartz sandstone in those basins with restricted circulation. Quartz sand that entered basins near the mountainous regions was comingled with deluges of coarse terrigenous debris. Quartz sand in units of possible Early Jurassic age in the southern Sierra Nevada (Jones and Moore, 1973; Schweikert and others, 1977) may have been derived from the same sources.

Cessation of deposition of quartz sand north of about 39°N was apparently caused by increased uplift and deformation (Speed and Jones, 1969), although marine deposition occurred as late as Bajocian time at Westgate (Corvalán, 1962). South of 39°N, the source of debris in the volcanogenic rocks which abruptly succeed the quartz sandstone is inferential. The thick succession of volcanic rocks above the quartz sandstone in the Pine Nut Range (Noble, 1962), however, indicates that volcanic sources existed in what is now a westerly direction. There is also a general southward thickening of the volcanic sedimentary rocks (in the Dunlap Formation), but this probably reflects the direction of increased subsidence of a tectonic trough. Minor magmatism occurred within the areas of the marine province during accumulation of the orogenic terrane, but such igneous activity seems not to have been a major sediment contributor.

Conditions in the western Great Basin before and after the onset of orogeny at the end of Early Jurassic time indicate change from general quiesence to tectonic disruption and encroachment of a major quantities of volcanic sediment toward the southern region of the province. The absence of marine beds younger than Bajocian in the western Great Basin suggests that the western Great Basin has remained high and dry ever since the mid-Jurassic orogeny.

ORIGIN OF SUBSIDENCE OF THE WESTERN MARINE PROVINCE

The remarkable proximity of the continentward margin of the subsident region of the early Mesozoic marine province and the proposed Early Triassic collisional boundary between a late Paleozoic volcanic arc and the North American continent (Speed, 1977a) provides a ready explanation for the subsidence of the marine province. The marine province represents a successor basin to the collided late Paleozoic arc, and its subsidence was caused by thermal contraction of the late Paleozoic arc lithosphere.

After collison, the convergent boundary jumped west to an unknown, perhaps distant, location. Near its continental suture, at least, the lithosphere of the late Paleozoic arc cooled and contracted because pre-collison subduction-related heating was eliminated.

The rate of contraction, hence subsidence, was not evidently uniform throughout the successor basin. The basinal terrane presumably records the zone of maximum subsidence rate. The subsiding shelves sank apparently less rapidly even though parts of the shelf terrane lie above the late Paleozoic volcanic arc. The lower rate of subsidence close to the suture may be explained by the flexural rigidity of the volcanic arc and its weld at the suture. This effect does not, however, account for the wide and lobate form of the northern shelf terrane and the seemingly coextensive Early Triassic Koipato magmatism. A relatively simple hypothesis holds that local melting of subducted sediment added volume and water to the arc lithosphere at about the time of collision. Such events perhaps locally cooled and thickened the arc lithosphere and created a region of lower subsidence rate. Preliminary strontium isotopic studies (R. W. Kistler and R. C. Speed, in prep.), however, suggest the Koipato rhyolite was not a product of melting of continental or continentally-derived material. Perhaps upleaking of subduction-related water alone into a part of the colliding lithosphere could have provided the same results.

Subsidence of the part of the marine province in which the early Mesozoic volcanic arc terrane accumulated was evidently affected by heating that caused Triassic magmatism. If the hypothesis is correct that Triassic volcanism started at about 215 mybp, reheating in the lithosphere below the volcanic terrane presumably started sometime earlier, perhaps at 220 mybp. If collison of the late Paleozoic lithosphere was complete at about 235 mybp (approximate time of Koipato rhyolitic volcanism), a gap of some 15 m y intervened between the onset of cooling and reheating. Thus, the general hypothesis predicts that early subsidence occurred in the region of the volcanic arc terrane and that the later Triassic volcanism either filled the basin or accompanied uplift that caused regionally shallow marine conditions. The later Triassic magmatic event was fairly short-lived as here inferred from stratigraphic successions and more general, as interpreted by Kistler (1974) from chronologic studies of plutonic rocks of the Sierra batholith. Cessation of Late Triassic igneous activity in the volcanic terrane thus allowed resumption of lithospheric contraction, subsidence of the surface, and the development of a regional carbonate bank. It may be inferred that carbonate production could not keep pace with subsidence and that by latest Triassic time, the region became a more continuous offshore marine regime that accumulated the fines of the Sunrise type.

ORIGIN OF SILICATE MUD IN THE BASINAL TERRANE

An important factor in paleogeographic models of the Late Triassic of the cordillera is the origin of the copious silicate mud that accumulated in the basinal terrane and to a lesser degree, in the shelf terrane. As discussed earlier, the pelitic constituents of these terranes have no characteristics that evince their provenance. It would appear that some at least of the mud was transported by fluvial means west across the continental margin into the marine province starting approximately in late Middle Triassic and waning in late Late Triassic times. With these constraints, two source regions can be envisioned: 1) the subaerial region of the Triassic continental magmatic arc that extended southeast of the western marine province, and 2) a continental region east of the northern Colorado Plateau, as suggested by Silberling and Wallace (1969).

Although the existence of a major source east of the northern Colorado Plateau cannot be discounted, the arc source seems likely to have been a major contributor. The timing of onset and cessation of Triassic volcanism may be harmonious with that of mud influx to the marine province (within the uncertainty of absolute and relative time scales in the Triassic). The spottiness of thick remnants of volcanic successions of postulated Late Triassic age in Inyo County argues that an original belt of such rocks was severely eroded. The abundance of detrital mica that may have originally been biotite in rocks of the basinal terrane supports a volcanic source. Finally, sediment patterns in the subaerial Upper Triassic rocks of the southern Colorado Plateau support the idea that a volcanic source existed in southeastern California and Arizona and that fluvial transport was northerly to northwesterly (Stewart, 1969; Stewart and others, 1972). Thus, the marine province of northwestern Nevada and subaerial realms further east may have shared this sediment supply (J. H. Stewart, oral commun., 1978). The absence of evident volcanic particles in the basinal terrane and in Upper Triassic rocks of the northern plateau requires that such material was comminuted during long (300 km) transport and(or) altered during diagenesis.

SUMMARY: MODEL OF PALEOGEOGRAPHIC EVOLUTION OF EARLY MESOZOIC WESTERN MARINE PROVINCE AND RELATED AREAS

The long standing Paleozoic continental margin in what is now central and western Nevada (Fig. 1) was the locus of collision with an easterly to southeasterly migrating late Paleozoic volcanic arc. The collsion occurred in the Early Triassic perhaps at about 235 mybp but not necessarily everywhere at the same time. The late Paleozoic arc welded to the continental margin, and the convergent boundary that had previously dipped below the arc jumped far west to an unknown site (Speed, 1977a). Loss of subduction-related heating caused thermal contraction of the arc and created the subsident region of the early Mesozoic western marine provice of the Great Basin. A perturbation of unspecified nature, perhaps creating massive influx of subduction-related water may have caused local late stage Koipato magmatism in the collided (or colliding) edge of the arc lithosphere. Such magmatism was associated with processes that caused a lobate tract of the arc lithosphere to subside less rapidly than adjacent regions.

In the early phase of subsidence (235-215 mybp), the offshelf realm of the province was probably a deep water basin in which shelf-derived hemipelagic(?) carbonate and silicaclastic muds accumulated over the late Paleozoic basement (Fig. 2a).

Widespread magmatism began at about 215 mybp and caused volcanism in the southern half of the marine province (Fig. 2b) and probably in a contiguous belt of emergent territory at least as far south as Death Valley. Plutons of the Lee Vining intrusive epoch (Evernden and Kistler, 1970) in the Mono region and a Triassic intrusion in the southern marine province were comagmatic with the volcanic rocks. Together, these Triassic igneous rocks were the products of the construction of a new volcanic arc whose prolongation south of the marine province records the first Phanerozoic magmatism within the continental realm of the southern cordillera.

Magmatism in the southern part of the marine province filled the basin with volcanic rocks and (or) caused uplift of the seafloor so that shallow marine conditions existed there through most of the Norian. The volcanic terrane may have prograded north over the basinal terrane.

The subaerial Triassic volcanic pile which lay south of the marine province (Fig. 2b) was the source of the enormous volume of finegrained silicaclastic sediment that exists in the basinal terrane. Such sediment was apparently transported by fluvial systems 100 to 300 km north to the eastern margin of the subsident region. There, one or more fluvial-deltaic conduits, like that documented by Silberling and Wallace (1969) for the Grass Valley Formation, delivered sediment across the subsiding shelf to the upper slope break. From there, turbidity currents were the principal mode of transport of sediment to the basin floor, at least in the southern part of the deep basin. The subsiding shelf which occurred along the eastern margin of the deep basin was chiefly the site of carbonate regimes and of quartz sand beaches except where and when they were overrun by deltaic deposits (Grass Valley and Winnemucca Formations of Silberling and Wallace, 1969; facies

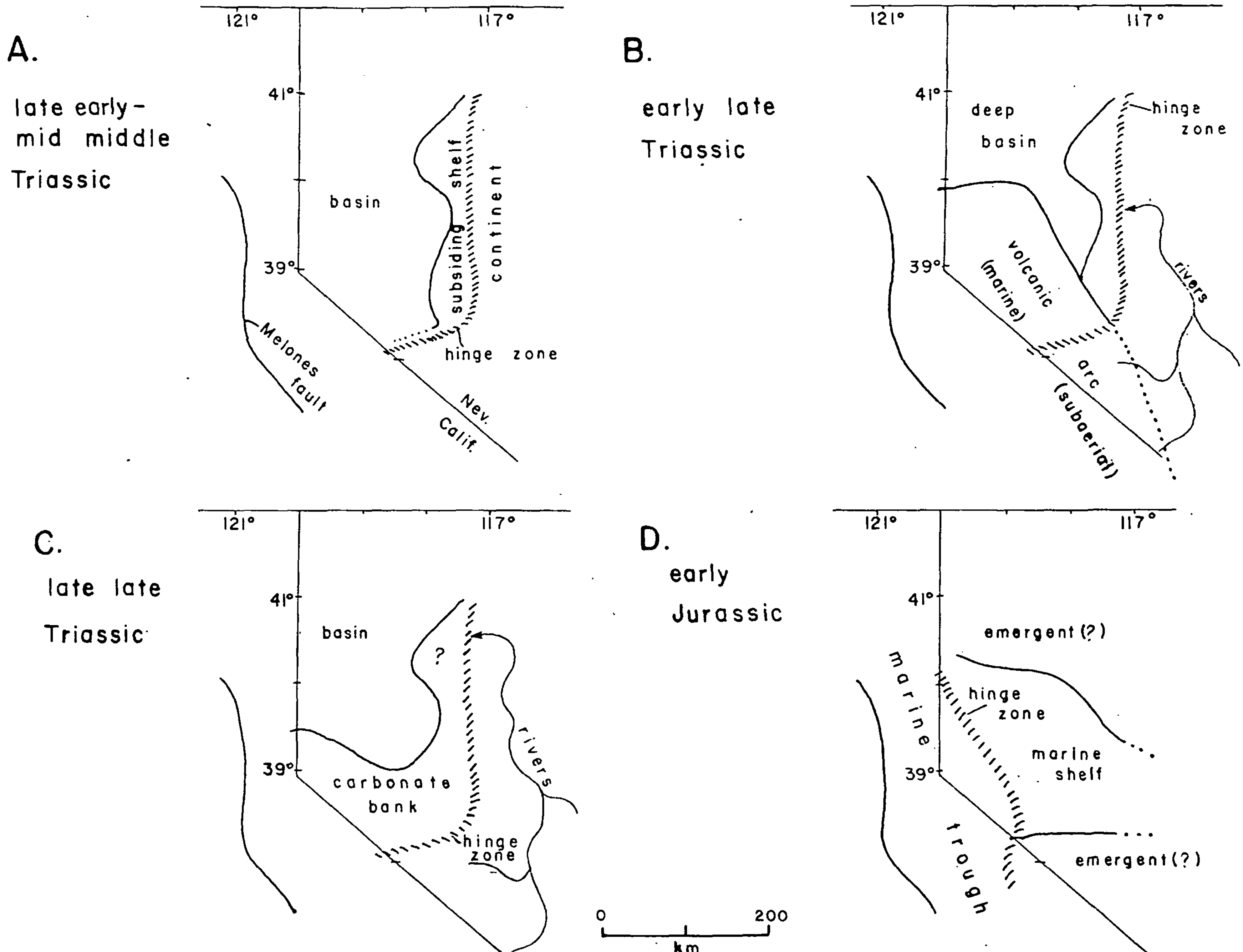
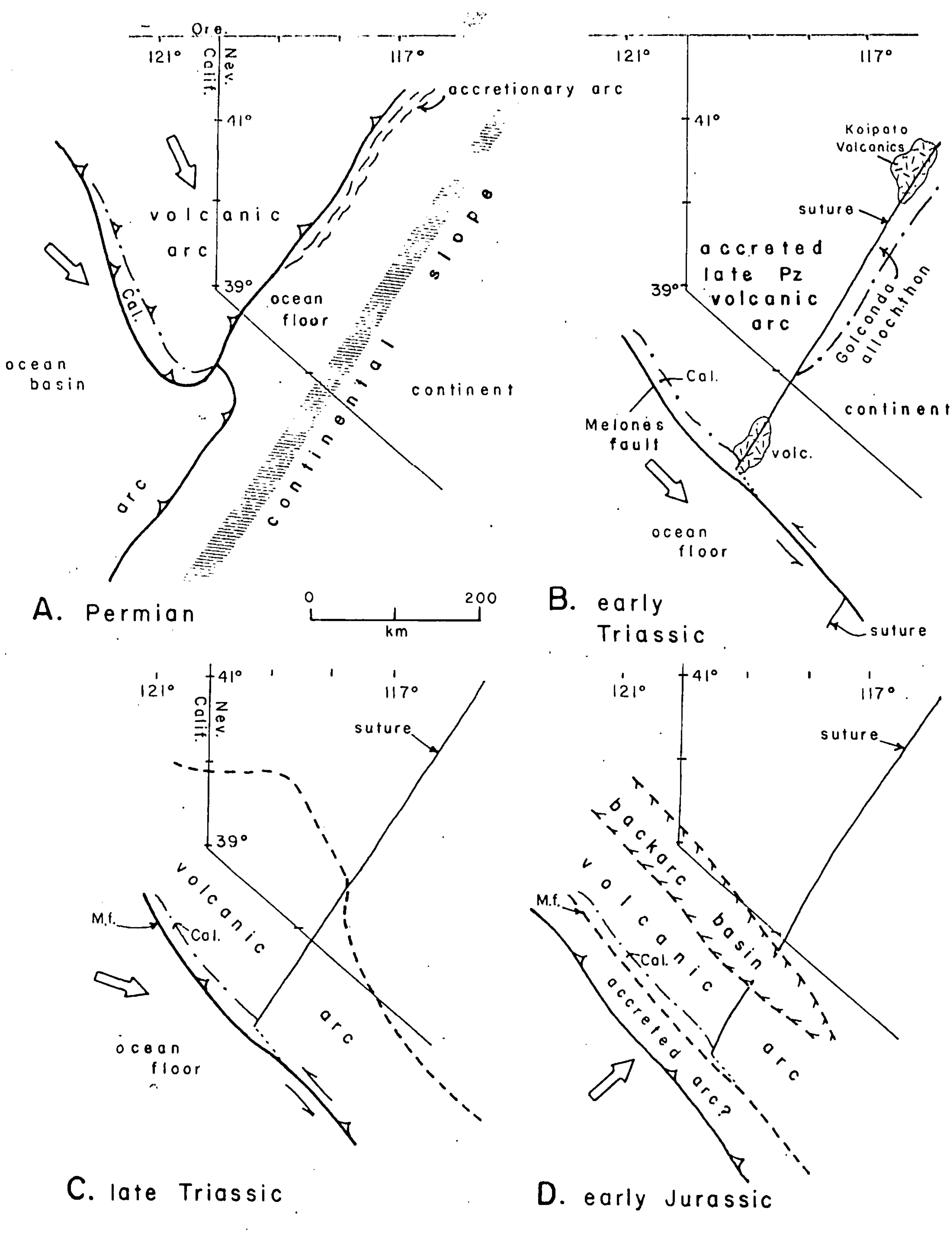


Figure 2: Paleogeographic evolution of the early Mesozoic western Marine province.


Ore.
Nev.
Calif.
121°
117°
41°
39°
accretionary arc
volcanic arc
ocean floor
ocean basin
Cal.
arc
continental slope
continent
A. Permian
0
200
km
Koipato Volcanics
suture
accreted late Pz volcanic arc
Golconda allochthon
Cal.
Melones fault
volc.
ocean floor
B. early Triassic
volcanic
M.f.
Cal.
arc
ocean floor
C. late Triassic
backarc basin
volcanic arc
accreted arc?
D. early Jurassic

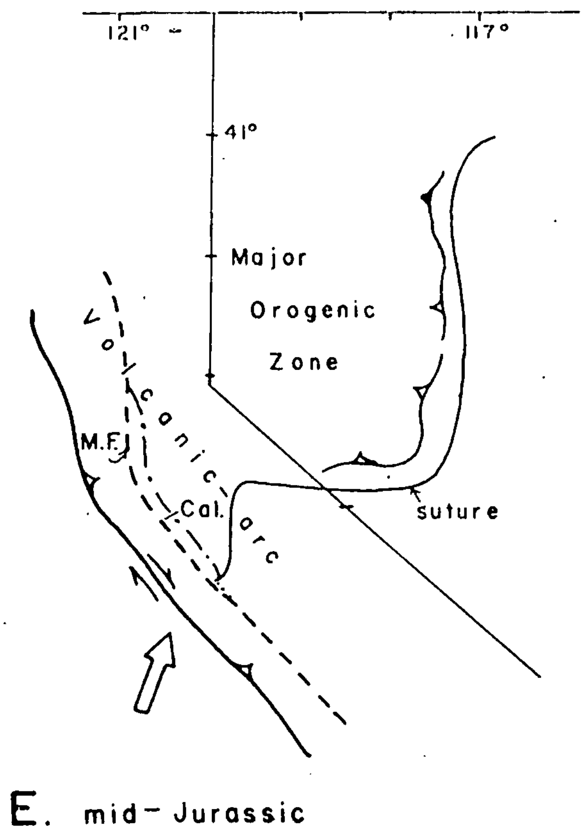


Figure 3: Diagrams showing model plate evolution in Permian to mid-Jurassic time; large arrows indicate direction of relative velocity of impinging plates, continent fixed; Cal. is Calaveras assemblage east of Melones fault and of the Merced River type.

of the middle member of the Luning Formation Oldow, 1977).

By late Norian time (200 mybp?), major changes had occurred in the marine province (Fig. 2c). Volcanism waned and may in fact have ceased. The southern region of the province was then covered partly if not continuously by carbonate banks. The basinal terrane received only meager influxes of silicaclastic debris relative to those of earlier time. Moreover, subsidence of the deeper basin waned, and the southeastern reaches of the basinal terrane shoaled as a carbonate bank near the end of Norian time. The entire marine province north of 40° may have emerged at about this time.

At about the beginning of the Jurassic, regions of the southern basinal terrane and the volcanic arc terrane were the remaining subsea realms of the marine province (Fig. 2d). The early Jurassic sea was probably of moderately uniform depth throughout, and it may have extended farther east than did Triassic seas of the province. The apparent prolongation of subsidence in the southern half of the province compared to that of the northern half may have been due to longer cooling time of its lithosphere because it was affected by a pulse of Late Triassic magmatism that was absent in the northern half.

The southwestern portion of the marine province in the Early Jurassic was transitional to a subsiding trough or basin that lay farther west and accumulated large volumes of volcanogenic material. Indeed, the evolution of the early Mesozoic marine province provides a record of the sudden creation of a basin marginal to the continent, its transformation through lithospheric cooling to a continental shelf-like regime, and the generation of a new marginal trough west of the accreted lithosphere.

Mid-Jurassic orogeny severely massaged the earlier marine province but probably had little to do with the inherent origin and evolution of the province. Rather, the orogeny seems more likely to have been related to reorganization of convergence at the new continental margin.

PLATE TECTONIC MODELS

Figure 3 illustrates a plate kinematic model which accounts for much of the evolution of the western marine province of the Great Basin and for certain other continental margin features. The kinematic constraints employed in the model are:
1) relative motion between late Paleozoic volcanic arc and continental margin at the time of collision was near-normal to the trend of the margin in central Nevada (Speed, 1977a); the suture has probably been rotated since collision, and the initial straightness and orientation are compliant parameters; northwesterly relative velocity is reasonable if the suture was initially straight, but more westerly if the suture has been little deformed.
2) the large width and lateral extent of the Jurassic phase of the Sierra batholith (Kistler, 1974) implies that Jurassic convergence was nearly normal to the trend of the plutonic mass (N25W) in California and parts south.
3) a component of right slip existed together with a large closing component during mid-Jurassic convergence at a boundary in or near the western Sierra Nevada; strong compression of Lower and Middle (?) Jurassic rocks in the Ritter pendant (Kistler, this vol.) was ascertained by Tobisch and Fiske (1977), and flattening of Jurassic strata in a N70°E direction exists in the southern region of the marine province; right slip is suggested by the configuration of the Early Triassic suture and continental margin as defined by the 0.706 strontium isotopic contour in the southern part of the marine province, assuming these trend lines were initially straighter as first argued by Albers (1967) and Stewart and others (1968); mid-Jurassic right slip may also be indicated by geometric analyses of deformed Mesozoic rocks in the western Sierra (Wetzel and Nokelberg, 1976) and by the possible north-westerly trend of the spreading center that created the mid-Jurassic Coast Range ophiolite (Hopson and others, 1974).

The models of Figure 3 assume a smooth transition in relative velocity from a north-westerly Permian direction to a north-northeast one in Middle Jurassic times.

Figure 3a shows a Late Paleozoic volcanic arc migrating southeast in the Permian and overriding ocean floor. The late Paleozoic volcanic rocks lie above earlier arc-related volcanic rocks and the lower Paleozoic Shoo-Fly Formation that are now exposed in the northern Sierra Nevada (D'Allura and others, 1977). Southwest of the volcanic arc was a plate boundary with slight convergence which had caused accretion of trench accumulations (the Calaveras Formation east of the Melones Fault;

Schweikert and others, 1977) against and under the arc pedestal. Migration of subduction zone below the Calaveras allowed Permian (259 my, Morgan and Stern, 1977) plutonism of the volcanic arc to affect the Calaveras as well as rocks of the arc pedestal. The plate southwest of the volcanic arc was presumably of chiefly oceanic character.

Figure 3b shows an assumedly straight Early Triassic collision boundary between volcanic arc and continent east of what is now the Melones fault. The accretionary arc of late Paleozoic ocean floor sediment propelled by the migrating volcanic arc lies on and was probably extruded over the continental shelf edge. A new convergent boundary developed about this time northwest of the area of Fig. 3 and the newly-defunct volcanic arc became welded to the continental margin, subsided, and created a successor Early Mesozoic marine province.

I speculate that the plate southwest of the late Paleozoic volcanic arc found means of detaching a fragment of the North American continent while maintaining essentially constant relative velocity. The new boundary is shown to be a transform fault with convergent motion taken up at an unknown location far to the southeast. This contrived boundary accounts for the oblique truncation of the continent first documented by Hamilton and Myers (1966); it accords with one of the truncation models of Burchfiel and Davis (1972), parallels the locus in the crestal Sierra Nevada of the 0.706 strontium isotopic line of Kistler (1974), and provides one means of explaining the major left lateral offset in Precambrian terranes of the Mojave region (Silver and Anderson, 1974). I agree with Schweikert (1976) (see also Kistler, this vol.) that the present Melones fault is the best candidate for the truncation surface.

By about 220-215 mybp (Ladinian-Karnian), relative velocity of the continent (and its accreted late Paleozoic arc in northwestern Nevada) rotated enough that the previous strike slip boundary had enough convergence to cause major magmatism (Fig. 3c). Zones of largely marine and largely subaerial volcanism were separated approximately at the Paleozoic continental margin because the substrata of those two zones had such disparate thermal, hence subsidence, histories in earlier Triassic time. The Late (and Middle?) Triassic volcanism shown in Figure 3c was the product of the first continental arc developed in the southern cordillera.

To account for the waning of Late Triassic volcanism and the apparent accumulation of thick volcanogenic strata in a subsiding trough in Early and Middle Jurassic time, I postulate (Fig. 3d) that the convergent boundary migrated west relative of its early Late Triassic position. The migration may have been caused by the further rotation of the relative velocity between continent and subducting plate to an orientation nearly normal to the earlier boundary and by accretion of various Jurassic arcs (Schweikert and Cowan, 1975). Thus, the Melones fault may have been abandoned at this time. A subsiding trough developed in back of the Early Jurassic arc, and caused deposition of rocks of the Ritter pendant, Sailor Canyon Formation, part of the Mt. Jura sequence, and the westernmost beds of western marine province of the Great Basin. The rest of the province was either emergent or a marine platform.

Figure 3e shows continuing rotation of the relative velocity to a north-northeasterly orientation and a sense of right-oblique convergence relative to the plate boundary. Figure 3e indicates major closure of the back-arc trough and right lateral drag together with major shortening of features in the Great Basin in a direction normal to the convergent component. Discrete right slip offset may have occurred on many faults in a zone which lies within the present Sierra Nevada. Thrusts in the Great Basin allowed rocks of the basinal and volcanic terranes to squeeze out over the shelf of the marine province to accommodate the shortening. Albers' (1967) sigmoidal bends were created by such tectonics. The Sierra foothills belt east of the Melones fault contains rocks that were originally contiguous with the substratum of the marine province of the Great Basin. Such rocks moved north relative to their Triassic position during Jurassic plutonism by virtue of the postulated right slip component of relative motion in Middle Jurassic and probably later times. The foothills belt may also have moved relatively west due to insertion of the plutonic belt.

ACKNOWLEDGMENTS

I am grateful to J. H. Stewart for review of this paper and to E. C. Bingler for his supply of unpublished data. This paper is an outgrowth of work supported by NSF grants GA-1574 and 28505 and a grant from Ralph W. Penn.

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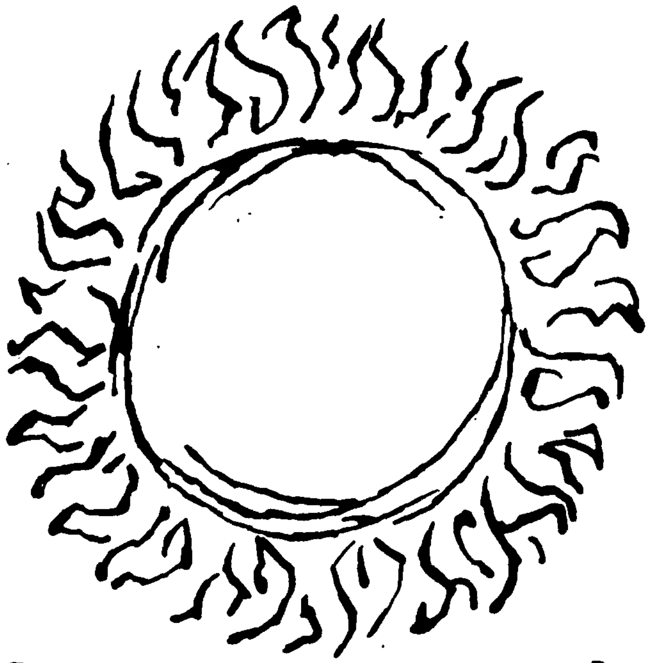
Ward



energy research
in the
Rocky Mountain States

abstracts

February 14 & 15, 1974
Albuquerque, New Mexico

Rocky Mountain Science Council

Author Index

This book contains those abstracts which were received by February 11, 1974.

ABSTRACT 1

Energy Research in the College of Engineering, University of Utah

Dr. M. Taylor Abegg, Director, University of Utah Research Institute

A description of the grants and projects on energy research currently funded in the College of Engineering will be presented. Proposals submitted but not yet funded, along with anticipated proposals, will also be described.

The mechanism for handling contacts which cannot be accommodated within academic departments will be discussed.

Other energy related research is underway in the College of Mines and Mineral Industries and is a subject of a separate presentation by Dr. Larry Anderson.

Prof. Edward Allen

Utah State University

Abstract

Utah State University, Logan, Utah, is pursuing a vigorous program of energy research in four areas:

1) We are helping Utah's local governments develop a more adequate response to the special management problems arising from the energy crisis (funding by the U.S. Department of Agriculture).
2) In association with the Federation of Rocky Mountain States and others in the region, we are studying the feasibility of developing a more unified region-wide policy response to the demands upon the region's energy resources (funding by the Rockefeller Foundation).
3) In addition, we are pursuing a number of technical projects including: optimizing the design of solar flate plate collectors and of solar energy storage devices, generation of methane from animal waste and its use in automobiles, design of solar crop driers, and measurements on combustion gases.
4) The Institute for Socioscience Research on Natural Resources at Utah State University is investigating the socioeconomic impact of various energy problems on the region.

February 8, 1974

Energy Research in the College of Mines and Mineral Industries, University of Utah

Dr. Larry Anderson, Associate Professor, Department of Fuels Engineering.

Energy research in the College of Mines and Mineral Industries is now funded and active in the general areas of coal conversion, mining, geothermal resources, and basic research. The major areas of present effort will be discussed as well as proposals that have been submitted but not yet funded. Anticipated research on energy will also be outlined.

Abstract

A review of the Los Alamos Scientific Laboratory's programs to find new ways to alleviate the energy shortage will be presented. Long-term solutions such as LASL's extensive program in Controlled Thermonuclear Research will be discussed as well as shorter-term solutions such as dry-rock geothermal energy, rock melting drills, superconducting power transmission lines, superconducting magnetic energy storage, and the use of solar energy for heating and cooling of buildings.

ABSTRACT 5

A WIND ENERGY CONVERSION SYSTEM
BASED ON THE TRACKED VEHICLE-AIRFOIL CONCEPT

R. E. Powe, H. W. Townes, D. O. Blackketter

This paper describes a program for determining the feasibility of using a car-airfoil system for extracting energy from the wind and converting this energy to electrical energy. This system is expected to consist basically of a continuous string of cars travelling around a track consisting of two long parallel sections with turns at the ends. Mounted on each car would be several airfoils. The orientation of these airfoils relative to the wind direction would be automatically controlled so that a maximum amount of power could be extracted from the wind on both parallel track sections, regardless of wind direction. The power from the airfoils would be converted to electrical power by generators attached to the car axles, and then removed from the system by a slide rail arrangement. It is reasonable to expect that such a system is more feasible now than at any time in the past because of relatively recent developments in aerodynamics, solid state electronics, and process control, developments which have not previously been applied to wind power devices.

An assessment of the technical feasibility of utilizing this particular momentum interchange device for conversion of wind energy to mechanical energy is currently being made through support of the Research Applied to National Needs (RANN) Program of the National Science Foundation. Using

a systems approach to design, the system has been subdivided into four major components: airfoil aerodynamics, airfoil structure, carriage, and track. At least two alternative designs are being considered for each of these major components. A computer program has been developed for simulating the entire system while incorporating any of the alternative designs for the major system components. Using this program, the system operation can be simulated at any desired location for which wind speed and direction data are available.

Progress to date has indicated that this particular system has significant potential for extracting large quantities of energy from the wind. It is anticipated that a typical capacity of such a system would be 10 to 20 megawatts. Thus, this system is more likely to be useful in a central station role, whereas the conventional windmill will probably be more useful in a somewhat individualized application.

This paper presents some of the specific alternative designs for the major system components, as well as power output estimates for operation of the system at a specific geographic location. Comparisons are made between this system and windmill type conversion systems.

ABSTRACT 7

TITLE: The "Hydrogen Energy" Concept

BY: Dr. Kenneth E. Cox
Associate Professor
Chemical and Nuclear Engineering
University of New Mexico
Albuquerque, New Mexico

ABSTRACT

Hydrogen, produced from water by relatively inexhaustible nonfossil energy sources (e.g., solar, nuclear), can be a promising, pollution-free energy medium to supply the world's future energy requirements. Although hydrogen production itself consumes energy, the advantages of distributing a gaseous or liquid energy carrier as well as the storage possibilities makes the hydrogen system attractive.

Production of hydrogen from water using a thermal energy source may be accomplished at high efficiencies by a multi-step closed-cycle thermochemical decomposition process. Electrolysis of water to obtain hydrogen, however, suffers from energy conversion inefficiencies.

With transmission, storage and distribution techniques already developed for natural gas --- as well as innovative techniques to be developed --- hydrogen makes an excellent fuel that is compatible with most of today's end uses. Thus it can be used as a replacement for today's fossil fuels that are becoming in short supply. Finally, as the product of combustion is mainly water, hydrogen offers significant environmental benefits.

AN OVERVIEW OF U. S. BUREAU OF MINES AND OFFICE OF COAL RESEARCH ENERGY RELATED PROGRAMS

A B S T R A C T

By

James I. Craig
Liaison Officer - New Mexico
U. S. Bureau of Mines

The U. S. Bureau of Mines and Office of Coal Research have a wide range of programs designed to contribute to the effective utilization of our country's natural mineral and fuel resources in the best interest of the nation's social, economic, and security requirements. To meet these problems, the Bureau and the Office of Coal Research are pursuing a course to better insure that our fuel needs are adequately provided for and to minimize and alleviate the deleterious effects to the environment caused by current processing and disposal practices.

Research has been financed for the most part by direct appropriation from the Congress. However, a good portion of the projects represent work requested and paid for through cooperative agreements between the Government agencies and the requesting organization.

The two agencies combined represent approximately 435 on-going research projects which are currently funded by approximately $250 million. These projects cover a variety of energy production and conservation. Many projects relate to research in already known areas, while others are delving into fields which until the present had been considered noneconomic.

RESEARCH PROGRAM OF LARAMIE ENERGY RESEARCH CENTER
U.S. BUREAU OF MINES

by

Gerald U. Dinneen

ABSTRACT

The Laramie Energy Research Center conducts research programs to help assure an adequate supply of petroleum, to improve the efficiency of recovery and use of this material, to encourage the exploitation of oil shale as a supplementary source of energy for economic development and national security, and to develop techniques for the underground gasification of coal. Petroleum research projects are concerned with in situ methods of recovering oil from tar sands, evaluation of the tar and oil, characterization of high-boiling petroleum distillates, and examination of asphalt. Oil-shale projects are concerned with the occurrence and characterization of oil shale; recovery of oil from it, particularly by in situ techniques; and the evaluation and utilization of shale oil. The underground coal gasification project is concerned with the production of low Btu gas by direct combustion with air. These projects are conducted at the main research center facility in Laramie, a pilot scale retorting site a short distance north of Laramie, and two field sites--one for in situ oil-shale experiments near Rock Springs, Wyoming and one for coal gasification experiments near Hanna, Wyoming.

NCAR's AEROSOL AND CLIMATE PROJECTS AND THE ENERGY CRISIS

by

Ronald L. Drake

Abstract

As increased coal burning, oil shale mining and open mining operations are employed to help provide needed energy, it is important to assess the impact of such operations on the quality of the air locally and regionally, and to determine the long-term effects on global climate. If clean air standards are to be compromised, it will be important to understand the effect on air quality for a given level of compromise. Much of the work of NCAR's Aerosol and Climate Projects are specifically related to the evaluation.

Energy Research at the University of Arizona

Emphasis will be on the following:

- Summary of the Energy Inquiry panel and workshop discussion of the meeting sponsored by the American Association for the Advancement of Science, held here on January 18, 1974.
- Activities of the Energy Economics Research Committee.
- Survey of other energy research on campus.
- Project Power.

Fusion-Plasma Confinement in Topologically Stable Hydromagnetic Equilibria

John H. Gardner and Robert W. Bass
Brigham Young University

Abstract

An extensive study of the topological features of hydromagnetic equilibria has led to the discovery of a class of magnetic confinement arrangements which possesses the property of topological or structural stability. A device for confining high temperature plasmas using one of these confinement arrangements is immune to magnetic interchange instabilities and to magnetic braiding. When analyzed on the basis of the energy principle it proves to be an optimal toroidal magnetic well.

Brigham Young University is undertaking to develop a computer simulation of this unique magnetic bottle with a view towards building an experimental model which is capable of demonstrating the feasibility of the device as a nuclear energy source.

Abstract of Remarks Concerning Energy Research

Electrical Engineering Department
University of Colorado

Energy-oriented research in electrical engineering at the University of Colorado can be divided into three primary categories:

1. Transportation. Work has been in progress at the undergraduate level for the last two years in the evaluation of battery-operated propulsion equipment for private automobiles and in the development of a hybrid propane-electric vehicle. An operational battery-powered vehicle has been undergoing efficiency and operational tests during this period and the hybrid vehicle has operated under its own power.

   Our machinery group has been looking seriously at the combination of the linear induction motor and magnetic levitation. Although no prototype vehicle has been constructed, the theoretical feasibility has been evaluated.

2. Solar energy. Research is getting under way in the form of a joint effort between our materials and power groups to evaluate and develop a solar house in which both heating and electrical requirements will be partially met from solar energy. Unique features include the development of a low-cost solid-state roofing material in sheet form which can be used directly as a solar to electrical converter, and the use of existing utility sources for energy storage. This latter effort requires close cooperative effort with the Public Service Company of Colorado.

3. Air Pollution Control. Our power group has been working with the Public Service Company of Colorado on stack emission measurement studies and the development of monitoring equipment for instack use. Graduate students have been working on a mathematical model of the power plant to account for trace elements in the firing and discharge streams. Attempts are being made to correlate the low sulphur, high resistivity fly ash characteristics and behaviour towards these trace elements and their removal in scrubbers and precipitators. A separate study is being done on cooling pond plume formation equations.

ENERGY RELATED RESEARCH IN PROGRESS AT THE ARIZONA ECONOMIC INFORMATION CENTER

The Arizona Economic Information Center is currently engaged in four projects related to the production and consumption of energy in the Southwest. One, concerned primarily with energy production, involves a continuation of work completed in 1971 for the Four Corners Regional Commission. Now being done independently by the Center, it consists principally of a more detailed examination of the role of energy mineral resources in the economic development of the non-metropolitan areas of the Four Corners states.

The other three projects are concerned primarily with energy consumption in Arizona. The first is an examination of the copper industry as a user of energy and is being done in cooperation with the Arizona Mining Association. The second is a study of the impact of the current energy curtailment on travel and tourism in Arizona and is being conducted in cooperation with a number of private visitor industry organizations in Southern Arizona. The third is being performed independently by the Center and consists of a study of gasoline consumption patterns and trends in Arizona.

- George F. Leaming
Director

January 25, 1974

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Energy in Utah

Rodney D. Millar and Richard E. Turley

An energy study is presently being conducted by the Utah Advisory Council on Science and Technology. The scope of this study is an 18 year assessment (1955 to 1973) of energy production, consumption, and reserves in the state of Utah.

The data being assembled will be used to develop a total energy "picture" of past and present energy flow patterns in Utah. This "picture" is expected to be the basis for developing alternative energy futures for the state.

Some of the problems encountered in developing the data base will be discussed along with possible solutions. Other interesting aspects which surface from the study will also be mentioned.

OPERATION AND ECONOMIC EVALUATION OF DRY COOLING SYSTEMS FOR POWER GENERATING PLANTS

ABSTRACT

A means of disposing of waste heat from steam-electric generating plants directly to the atmosphere is available to the utility industry as an alternative to either once-through cooling systems or evaporative cooling towers. Dry cooling systems, which operate like an automobile radiator, have been used successfully in a number of generating plants in Europe and in one small plant in the United States. Also, plans are underway to construct a 330-MW dry-cooled plant in the United States.

Two types of dry cooling systems have been developed: the indirect system and the direct system. The indirect system historically utilizes a direct-contact condenser at the turbine to condense the exhaust steam, and water from the condenser is pumped to the dry tower for cooling and recirculation to the spray jets in the condenser. In the direct system, steam is condensed in the air-cooled heat exchangers without the use of a direct-contact condenser or circulating water.

The heat exchange characteristics of a dry cooling system are different from those of an evaporative cooling system, and an economically-optimum-sized dry cooling system generally would be equipped with high-back-pressure turbine-generators which would lose a certain amount of generating capability during hot weather.

Recent studies of the economics of using dry cooling systems with large pressurized-water nuclear generating plants indicate that the capital cost of the dry system would be more than double the capital cost of an evaporative cooling system and that the capital cost of replacing generating capacity to compensate for the loss in turbine-generator capacity during hot weather would add an additional capital cost to the dry system.

A computer program has been developed to determine the economically optimum dry cooling system, taking into account annual capital costs, total plant fuel costs, cost of cooling system auxiliary power, operation and maintenance costs, cost of replacing generating capacity lost during hot weather and other costs influenced by the cooling system.

In a recent study, the increase in bus-bar electrical energy cost for a large nuclear generating plant using dry cooling as compared to conventional evaporative cooling was found to be in the order of 0.9 mill per kWh, including fixed costs on capital and replacement cost of capacity and energy lost with the dry system during hot weather. The increase, which is equivalent to approximately 12 percent of the bus-bar energy cost, could possibly be offset by certain advantages of dry cooling such as flexibility of siting, water savings, and ability to install additional generating units at sites otherwise limited by lack of cooling water.

ENERGY RESEARCH AT NEW MEXICO STATE UNIVERSITY

BY

ROBERT L. SAN MARTIN

This University, in its commitment to serve the people of New Mexico, has a long history of conducting energy research. Every College, the Physical Science Laboratory, and the Water Resources Research Institute are actively involved in energy research.

Some of the current projects include the assessment of the environmental impact caused by the removal of mineral and fossil fuel, the assessment of stratigraphic problems in sections that produce natural gas, studies of the production of hydrogen gas by a continuous catalytic process, studies of the production of hydrogen gas by solar powered high temperature chemical dissociation methods, the assessment of water supplies in New Mexico as they relate to the development of alternate energy sources, and the assessment of the electric utility resources of the state. In the agricultural areas, studies are being conducted on minimum tillage programs, double cropping methods, drip and trickle irrigation methods, and the development of greater crop yields. All of these methods result in energy savings and develop the basic criteria needed for the assessment of the most energy conserving methods which can be used in growing crops.

The University's Blue Mesa Observatory currently has part of its electrical needs supplied by wind power and studies are currently being undertaken to increase the electrical production to make the site self-sufficient and to provide for solar heating of the facilities. In other areas of solar energy application research is being conducted on concentrating and non-concentrating solar collectors, the development of solar residences, the development of solar air conditioning schemes, the development of a "solar turf" collector, and the integration of greenhouses with solar collection methods.

The University hopes that it will be able to begin construction this summer of two major solar heated and cooled buildings. One will be a 19,000 square foot structure to house the offices and laboratories of the State Department of Agriculture. The other is a solar demonstration home which would be used to test and assess the advantages of solar utilization methods in a typical New Mexico climate.

The faculty of the University, in support of the Governor's Energy Task Force, are preparing several position papers on energy related matters which include the assessment of solar energy, wind energy, direct energy conversion methods, the production of synthetic liquid fuels from coal and the societal needs and demands which will result from energy development as well as from energy shortages. These topics will be studied and evaluated with respect to their impact on the State of New Mexico.

ENERGY-RELATED PROGRAMS AT SANDIA LABORATORIES

A. Narath
Vice President
Sandia Laboratories

ABSTRACT

A major fraction of Sandia Laboratories' energy-related efforts are concentrated in five areas. These include (1) Nuclear Fuel Cycle Safety and Security, (2) Solar Energy, (3) Non-Nuclear In Situ Recovery of Oil from Shale, (4) Pulsed Fusion, and (5) Advanced Drilling Technology. Lesser efforts are also being devoted to other areas -- Conservation Technology, Hydrogen Economy, Improving Combustion Efficiency in Automotive Engines, and Energy System Studies. The proposed approaches and objectives in each of these areas will be briefly described.

PROPOSED COLORADO ENERGY AND MINERAL INSTITUTE

Abstract

The best interests of the people of Colorado and the Nation for wise development of the State's energy and mineral resources can be served effectively by establishing a Colorado Energy and Mineral Institute with the goals (1) to contribute significantly to alleviating and eliminating State, regional, and national energy and mineral shortages in a way which will safeguard the development of the State's natural resources, and (2) to further the education and training of present and future Colorado citizens for lifetime service in the production and utilization of her natural resources.

The best interests of the State may not coincide precisely with the national interests in some cases. Therefore, policy-making and legislative considerations as well as technical programs must be integral to the work of the Institute to provide input for complementary State and Federal decisions.

This Institute should place Colorado in a position of national energy and mineral development leadership. Other states, Federal agencies, and industry will certainly turn to an institute of this type for help as it gains experience and stature. This will strengthen Colorado's ability to maintain a strong voice in the development of its resources.

To achieve the stated goals, it is proposed that the Institute have three major areas of responsibility: (1) enhancement of the coordination and interaction between State government, university, and industry energy and mineral development efforts, (2) development of technical and policy research programs, particularly directed toward problems of energy and mineral exploration, development, and production in the State of Colorado and the Rocky Mountain region, and (3) support of education programs to develop engineers, scientists, and skilled workers who will be needed in the expanding energy and mineral industry sector of Colorado's economy so that Colorado citizens may benefit to the fullest degree from development of its resources.

The Institute is seen as being an organization with initial emphasis on energy and energy-related minerals and longer term emphasis on both energy and minerals. The first year funding objective is $2,000,000 from a combination of State, Federal, and industry fund sources. First year State funding for operating is requested to be $980,000.

"ENERGY RESEARCH IN THE ROCKY MOUNTAIN STATES"

FEBRUARY 14, & 15, 1974

ALBUQUERQUE, NM

ROCKY MOUNTAIN SCIENCE COUNCIL

STATES"
COUNCIL

MEMORANDUM

from Larry L. Anderson

Attached are my notes from the meeting in Albuquerque on "Energy Research in the Rocky Mountain States". The notes are my own and are only as accurate as my memory and note taking were at the time of the meeting. No publication will result from the meeting but several speakers gave information on where related or additional information could be obtained. Since the meeting I have received a rough draft of "Activities of Q Division, The Energy Division at the Los Alamos Scientific Laboratory" from Ed Hamel. A copy of the final report will be sent to me upon publication. Copies of reports on hydrogen as a fuel can be obtained by writing for Vol. I and/or Vol. II of "A Hydrogenergy Carrier", Summary (1973) NASA-ASEE, Johnson Space Center - Rice University. The copies may be ordered from Dr. John Howell, University of Houston, Mechanical Engineering Dept., Houston, Texas 77004.

Notes are not given on the reports delivered by Dr. Abegg or myself from the University of Utah. In order to make these notes complete outlines of these reports follow.

Dr. M. T. Abegg

Energy Research in the College of Engineering - University of Utah

Areas of research in energy, either in progress or proposed, fall into the three general categories.

1. Technology related to existing resources
2. Basic science of these resources
3. Total systems studies including technology and societal problems.

The current research on energy at the University of Utah was indicated to be $1.1 million. New proposals submitted but not yet funded amount to $7.7 million or approximately $2.63 million/year.

Some proposals which have been submitted are from the Engineering Experiment Station. Two of these were discussed:

Communication of Environmental Information

Background Concentration of Particulates

L. L. Anderson

Energy Research in the College of Mines and Mineral Industries - University of Utah.

Major research areas in the College are:

I. Conversion of Coal to Liquids and Gases (This includes catalysis, characterization of products, gas synthesis, solvent extraction and process development)

II. In situ Recovery of Coal by Solution Mining

III. Desulfurization of Coal and Coal-Derived Products

IV. Refining and Processing of Coal-Derived Liquids

V. Application of Geological and Geophysical Methods to Discovery of Oil and Gas Deposits (Both at great depths and offshore)

VI. Detection, Delineation and Economic Evaluation of Geothermal Energy Resources.

This includes development of exploration architecture and actual exploration of geothermal resources.

VII. Availability of Water Supplies for Coal Gasification and Liquefaction

The effort in the College of Mines is currently funded at slightly more than $700,000/year. Over $2 million/year has been proposed in proposals submitted but not yet funded.

THE ROCKY MOUNTAIN SCIENCE COUNCIL

"Energy Research in the Rocky Mountain States"

Albuquerque, New Mexico

Notes by L. L. ANDERSON

The purpose of the symposium was to provide an overview of energy research in the Rocky Mountain Area.

Thursday, Feb. 14 Session — Chairman - R. S. Claassen, Director, Sandia Laboratories

Senator Joseph M. Montoya - (Sr. Senator, N. Mexico)

We use more energy for air conditioning in the U. S. than China uses for all purposes.

Chase Manhattan Bank predicts we must put up $\$400 \times 10^9$ in the next 10 years for energy development.

Three E's Energy, Environment, Economy - are interrelated and must be considered simultaneously.

Where is the blame? Government has failed to provide proper leadership. Industry has failed to be totally honest. Scientists and Engineers haven't explained sufficiently the problems, solutions and implications to others besides the congressional committees in the national congress and other scientists.

One of the problems today is the fragmentation of Government involvement in Energy. At present, the USBM, Transportation, EPA, FEO, Commerce, Treasury, FPC, AEC, and many others. (25 Depts. in 17 different agencies in the Government are studying the energy picture).

Responsibility of scientists is to explain to the public in terms they can understand what the problems and choice of solutions are.

Senator Pete V. Domenici - (Jr. Senator, N. Mexico)

"National Energy R & D Thrusts and Related Legislation"

National energy R & D program will be established in the U. S. presently. Proposals will have to be made for a logical step by step development for research efforts.

Frank C. DiLuzio - (Sc. Adv. to Governor of N. Mexico)

"Petroleum Crisis" more accurate than "Energy Crisis" 32 states which produce energy. (N. M. 10th in Σ coal reserves) (anhydrous NH_3 tripled in price in last 40 or 50 days, critically needed in Western states).

J. I. Craig - USBM

Voluntary reduction of gasoline consumption in the U.S. has been significant. Dec. 16%, January 12%.

Exploration peak for crude oil was in 1966. Production peak for crude oil was in 1970.

Nuclear power is presently less than 1% of E energy. Nuclear projection: possibly 10% by 1985.

Importing of petroleum

In four years - imports grew from 14% to 39% (1969-1973).

Project - Independence

Research in B of Mines

Expenditures

1979 $23.972 x 10^6

1975 $32.9 x 10^6
requested

President's budget shows 137 x 10^6

Mining Research
Metallurgy
Energy - Bartlesville, MERC, PERC, Laramie, San Francisco
394 projects funded in the energy area - $140,023
Example - Citrate process for SO_2
(Kellog, Idaho)
Underground gasification - Laramie
MHD - can use coals with up to 4.0% S.
Insitu retorting of oil shale
CH_4 Drainage of Coal Mines
36" hole in coal in West Virginia - present output 900,000 ft^3 CH_4/day without pumping.

Removal of CH_4 from exhausts of coal mines - up to ~ 0.75% CH_4
This CH_4 could be significant since in many mines up to 500,000 ft^3/minute air is exhausted.

Projects for synthetic oil and gas from coal include: Synthoil - PERC
Synthane - also at PERC

OCR

1972 - $260 x 10^6 (research in progress)
1974 (Budget) $143 x 10^6

Work with AGA in development of gasification of coal. In this program the Government will fund 2/3 of the cost with 1/3 coming from industry.

$283.4 x 10^6 President's budget request

Projects

Pipeline quality gas

HYGAS Process - a form of Lurgi gasification $34 x 10^6 spent so far on this pilot plant(capacity 15 tons/hr.)

Low Btu gas
MHD
Fluidized Bed
Supporting projects for power generation
Low-Sulfur Liquids from Coal

Other supporting projects
There are 41 projects now being supported by OCR

W. J. Hanna - (U of Colorado) [Engineering]

Power (Electrical) Engineering
Mission - Student Excitement
Research
Electric Power
Transportation Eardley
(Battery Operated Car - Renault)
Air Quality Control
SO_2, particulates
Gas precipitators
Lightning Research
Solar Energy (Frank Shreath)
Mostly spherical reflecting mirrors, etc.
Household application
Wind power

Dr. A. T. Whatley - (Western Interstate Nuclear Board) (12 states)

Present budget corresponds to about $10,000 per state.

Mission - Provide information to state governments on nuclear energy development

Ed F. Hammel (Los Alamos Scientific Labs)

Energy R & D

Time scale
Short term (present - 1985)
Intermediate (1985-2000)
Long term 2000+

Areas

Sources
Utilization
Efficiency (conservation)

Considerable planning on fusion R & D

Non-technical

Balance of payments
Patent policies
Regulations
Lisences

Major Effort @ LASL is in Fusion

Pulsed high β, θ pinch machine

100×10^6°C, confining pressure; purity, time of confinement also necessary.

Geometric shape found most suitable is a torus.

LASL now working with a Toroidal sector (5 meters long) with a 10 M joule magnetic field strength

Laser fusion

Another way to carry on fusion reactions is by laser initiation.

A solid Deuteruim-Tritium pellet undergoes oblation and implosion to initiate the fusion reaction.

Geothermal Resources

4 pronged attack and support from studies

Geoscience

1. geothermal - hot dried rock
2. Chemical fracturing
3. Hydraulic fracturing
4. Subterrene program

Types of resources

Dry steam
Wet steam
Hot Bine
Dry Rock

For example the cooling by 200°C of 40 cubic miles of rock would have provided enough E for the country's needs in 1970.

3. Hydraulic fracturing

Theory At ~ 15,000 ft. depth T temperature is about 300°C. The problem is to drill down and then initally crack the rock perpendicular to the drillhole axis by hydraulic fracturing. Cold water is then piped down and hot water and steam brought back to the surface for power. One of the problems is that about 2500 tons/day of SiO_2 would be dissolved in the water that would be circulated. This silica would have to be disposed of.

Field experiments

First hole successful in fracturing. Next step will spend about $\$3 \times 10^6$ this year.

4. Subterrene:

Drilling by melting the rock without rotation (penetration)

This drilling technique works in rock where $\rho_{liq\ rock} > \rho_{solid\ rock}$ (actually the liquid cools to a glass lining on the wall of the hole)

A 114 mm (diameter)

Correr has been used

One consequence is that a glass wall on the sides of the hole forms helping to seal and support it.

Fission Reactor Program

Liquid water reactors

AEC has recently conc. on LMFBR. Other types will now look at other types such as HTGR (High temperature gas reactor).

Solar Energy

Solar panels

For example an expanded metal solar collector expands to a pillow, costs about 80¢/ft^2

This project probably will result in a joint program with U S Steel Corporation

Solar heating for mobile homes

Use of superconductors for electrical transmission

765 KV highest voltages now transmitted. If we are to handle much greater electrical use there are two possible solutions to greatly increased capacity.

(1) increased voltage up to $\sim 1\text{-}1.5 \times 10^6$ volts. This entails serious safety problems and results in high losses.

(2) Reduce losses by using Superconductors.

Superconductors have capacities of 10^4 to 10^5 times the capacity of conventional conductors of the same diameter. Refrigeration stations would be necessary every 20 miles. T of operation would be $\sim 10°K$.

One big advantage is that the efficiency is about 99.6% for superconductors.

M Reiter - (N. Mexico Inst. of Mining and Technology)

Regional Geothermal Analysis in SW U.S.

Gradient found in NE N. Mexico is about 30.2°C/km

Conclusion of their studies are that there is a geothermally active area along the Rio Grand Rift.

When questioned about remote sensing techniques Dr. Reiter's opinion was that ERTS & EREP were likely much less reliable than direct measurements done by NMIM in wells.

H. W. Campen (Aerojet Nuclear Co.)

Major area Light Water Rxtr Safety

Loft (Loss of fluid test) 1974-75 test on 50 MW

Power Burst Facility - Pressurized water rxtr 20 MW

Also have activities on research and engineering to support other projects.

Power rxtrs

Construction and site services

Idaho Geothermal R & D Project w/ several universities including U of U, ID State University, Boise State College.

J. P. Rossie - R. W. Beck & Associates

Report (GPO) "Res. on Dry Cooling Towers for Power Generation"

also report (GPO) Research on Conventional and Dry Cooling Towers in Representative Nuclear plants

Conventional cooling towers - 15 x 10^6 gal H_2O used per day for a 1000 MW power plant (most of this water is lost to the atmosphere)

Dry coolers

5 x 120 MW built in England

160 MW unit in operation in Spain (installed ~ 2-3 years ago)

Typical European peak periods in Winter vs. U.S. where a peak exists in the summer due to air conditioning optimum T found 57F.
Back pressure very important since present turbines are not designed for high back pressures.

F. J. Stermole - Proposed (Energy Research Institute at Colorado School of Mines)

Goals - contribute to mineral and energy supply problems (research)
Education and training of people in energy related fields (both the public and students)

First year budget proposed - $985,000

Budget includes $250,000 for scholarship programs

Research - Technical

Economical

Environmental

Policy research
Legal, regulatory, etc.

These people visualize the Res. Institute to become regional in nature.

Ralph Powe - (Montana State University) Wind Energy Conversion

Historical - Windmills
Largest - Burma 85 ft. in diameter
The tower was about 100 ft. high
The capacity was 1250 kw - failed due to stresses in the structure.

In Montana a few years ago an idea was proposed by a rancher - a horizontal track mill powered by wind. Some work has been done to investigate the removal of the kinetic energy from the system. Computer simulation has shown good possibility.

RANN is supporting a feasibility study on this concept.

Questions to be answered regarding location of such a facility

Avg Wind velocity

Avg wind velocity above a certain value on a specified number of days/year.

Elevated track system - take advantage of greater wind velocities.

J. H. Gardner - (B.Y.U.)

Fusion - Plasma confinement in topologically stable hydromagnetic equilibria.

Structure stability of torroidal configuration

Accomplished by feed back stabilization.

Feasibility study now proposed . . . .

FRIDAY SESSION - Chairman, Charles Tapp (Sandia)

Remarks - Dean Thompson (A.S.U.)
for RMSC (Chairman)

Al Narath - (Sandia)

Major Areas of Research on Energy

Decreasing level of funding.

I. Nuclear Fuel Cycle
  Safety and Security

II. Fusion Technology
  E-Beam
  Advanced Laser
  Materials

III. Solar Energy
  Commercial and Subdivision applications

IV. Shale Oil - In situ retorting

V. Drilling Program

I. Nuclear Fuel Cycle

Security and safety to acts of sabotage

Code developments

Containment systems analysis

Transportation accident criteria

Waste management

Waste disposal
- deep ocean disposal feasibility
- deep rock disposal feasibility
- Liquid waste conversion to high level solid waste (by concentration).

II. Fusion Technology

Laser experiments - 4 beam

~ 200 Joule laser system has been used to bombard Dueterated polyethylene particles

Electron beam
  Accelerators - REBA
  Hermes II

Need is to increase capacity of the laser beams (pulsed electron beams)

Work has been done on H_2, F_2

Need is for a laser having at least 1000 Joule capacity

Direct use of electron beam
  Relativistic electron beam (REB)

  Problems - Focusing

High energy El. beam accelerator (Ripper)

III. Solar Energy

Rocky mountain area in an area of high flux (of solar energy)

Coal → Electric power	efficiency	35%
Solar → Electric power (T = 1000°F)	"	∿ <35%

Problems can be minimized by a total solar energy community.

By utilizing the waste heat to heat offices, homes, water, etc. only about 25% of the heat is lost.

Cost ∿ $\$4/ft^2$ panels (results calculated) T = 400-500°F using focus collectors.

This would be a competitive system. Use stored hot pressurized fluid (H_2O or other) for overnight loads.

Intend to work with utility company to develop a solar community.

For impetus the design group is presently housed in the building which will be solarized.

One of the big problems - public acceptance of solar heating.

IV. In situ Fossil Fuel Conversion and Recovery

This effort is concentrated on oil shale

Recovery

(Garret process depicted. In situ oil shale retort)

Mining - demonstrated experience

Crushing - demonstrated experience

Objective of Sandia is to eliminate the mining in the operation as depicted in the Garret process.

V. Drilling program

Objective: reduce drilling times and wear

By - spark drilling (physics of rock disintegration unknown)

continuous belt drill bits - particle bombardment

R. P. Millar - (Utah State Advisory Council on Science and Technology)

Data base being established for consumption, production, exploration

Study on energy will begin from 1955. At present Utah has approximately 1.2×10^6 people and the growth curve is very steep.

Natural gas usage reserves were depicted.

Utah production gradually decreasing while the population is increasing. Therefore, the consumption is gradually increasing (all of the difference coming from Colorado and Wyoming).

Robert L. San Martin (New Mexico State University) (delivered by another NMSU Staff member not registered at the meeting)

Projects

Agricultural efficiency enhancement methods:

Minimum tillage

Double cropping

Irrigation methods for greater crop yields and reduced water usage

Wind Power Studies

Blue Mesa Observatory ~ 30% of the needs are supplied by wind power.

Solar heating - heating, air conditioning, solar turf.

Early work (~ 35 years ago)

Solar heat was utilized for melting of ice for drinking water for cattle.

Current work - Utilization of solar energy for heating and cooling. Thru efficient use of insulation ~ 40% reduction in heating demand can be realized (1700 ft^2/house).

Telescopic solar trap tested

T = 291°F achieved (max) eff. ~ 55%

Flat plate solar collectors

Heat is transferred to H_2O which is circulated. Plastic material is used to prevent reradiation.

Solar demonstration house to be built and tested (3 bedroom). Trickle collector - using water - for the 1700 ft^2/house. The house uses a 5000 gal. tank (25% efficiency).

Another building (probably) to be built. The proposal for this building is now before the state legislature and prospects are good.

This will be the largest solar heated building in the country if it is built.

Specifications :

19,000 ft^2 of living space with 7000 ft^2 of collectors

35 x 10^3 gal tank (operating at 30 psi)

The cooling medium is a H_2O - antifreeze solution.

The building will have 3 to 4 days storage in case of inclement weather.

Lithium salt absorption aux. boiler for aux. system

Robert M. Lawrence - (C.S.U.)

Major areas of energy research (Direct)

A. I. (SEAL) (Solar Energy Applications Laboratory)

P.I. George Löf

House to be tested: 1500 ft^2 (main level floor area) + basement + 2 car garage. Solar energy will be used both for cooling and heating - 16' x 48' panel to be used as a collector.

II. Computer simulation to check 5 other U.S. areas to predict the application of solar energy in other climates.

III. Cost benefit analysis.

B. Flora and Fauna -

Wayne Cook - Revegetation of spent shale
Effects of oil shale mining and spent shale on hoofed animal life.

C. Saline quality of Upper Colorado Basin water.

The researchers are now obtaining baseline data on water quality for later comparison when an oil shale industry has developed.

D. Wind Tunnel Research

Jack Cernak

Effects of mountains and tall buildings on wind velocities and transport of pollutants.

E. Organic wastes

Conversion and utilization of animal and other organic wastes to more usable energy forms.

F. Atmospheric Research Center

Electrical Engineering Department - Nuclear (NSF supported) separation of U_{235} from U_{ore} by lasers.

G. Social Science Political Science

Affect decision making processes of the exploitation of the Rocky Mountain energy sources.

Alternative tax modes VAT, severence, etc. This would include impacts of such things as alcoholism, fluctuations of community populations, auto accidents, water supplies, etc. due to new population centers which would develop as a result of the development of energy resources in the Rocky Mountain area.

One answer might be to work to get authority for a Regional agency(ies) to influence development such as the Port of N.Y. Authority which has definite powers in New York even though it is not a state or city government.

Future possibilities

National development of Products from or associated with Rocky Mountain Energy resources.

G. U. Dinneen - (USBM - Laramie)

150 people ~ 1/2 professional at the Laramie Center located in the center of the state, near the University of Wyoming and Laramie.

Pilot plant (PDU)
Field sites
Rock Springs
Hanna

Anvil points site is now operated by consortium of 18 companies testing oil shale processing.

AREAS OF RESEARCH

I. Petroleum Research (oldest program) (~ 20% of budget)

Areas

Production
Utilization and Chemistry
(Also some connection with Utah Geological Survey on recovery of oil from tar sands).
Effort - some research on in situ processes for bituminous sands by reverse combustion. Laboratory work so far using a reactor

4" in diameter x 4' long to look at problems in reverse combustion.

This work has a good possibility of going into the field at Asphalt Ridge or in the PR Springs area.

Petroleum Chemistry

1. Mainly looking at properties of oil from tar sands.
2. Properties of high boiling petroleum fractions (BP. > 700°F) This research will be discontinued. Separation of hi bp. fractions into classes (TA, TB, oils, etc).

Asphalt properties on road application, in fresh state, alteration of properties.

II. Oil Shale Research Areas have been very general (~ 30 years working in this area) (~ 60% of budget)

Location of oil shale
Exploration, Production of oil shale
Properties of oil shale
Utilization of oil shale

<u>Oil Shale</u>

<u>Present work</u> - coordination of the prototype leasing program
6 leases (2 each in Utah, Wyoming, Colorado)

Evaluation of areas of lease properties
Coring
Analysis, lithology

<u>Continuing work</u> - Properties of kerogen (to be phased out during the next year)

<u>Retorting of O.S.</u>

No work on aboveground retorting
No work on mining of O.S.

Insitu Processing Work

A. Underground rubbleized volume
Combustion
10 ton capacity
150 ton capacity 11'ϕ 145' high

Studying - properties of oil obtained
feed gas composition
grade, particle size
variation of shale properties in the combustion bed
gas pressure, mechanical pressure
transport problems

This work to be continued.

B. Fracturing in O.S. without extensive rubbleizing. Hydraulic or chemical explosive.

This work will use simulated petroleum fire flooding techniques. Near Rock Springs, Wyoming a field test is now in progress. Several tests have been completed.

The 9th experiment is now in progress using hydraulic fracturing.

Oil from oil shale properties

<u>Reactions studied</u>

Hydrogenation and oxidation to get rid of the nitrogen in the oil.

Comparison of in situ oil product with that oil produced in above ground retorting.

Waste problem - spent shale. Above ground retorting - effects on ground water quality. Also possible effects on ground water quality of insitu processing.

III. Coal - Field Experiment on Underground gasification of sub-bituminous coal (Hanna, Wyoming) for production of low Btu gas for Electric Power. ($\sim$ 20% of budget)

Heating value of the gas produced is 120-140 Btu/ft^3. Production is from a 30 ft seam which is about 400 feet deep.

The location of the test is 3/4 of mile off the highway near Hanna.

Technique - 16 holes with fracturing in center hole. Air is being pumped in and gases pumped out. The Bureau has spent about 9 months work on this experiment. It will end soon since they are reaching the limits of the experiment.

Laramie Center expects to continue this work with oxygen enriched gases for feed gas and also using horizontal holes in coal beds.

Helmut Frank - (University of Arizona) Economist

I. Economics of Energy

II. Examples of interdisciplinary resources on energy

III. Research in Science and Engineering Departments at the University of Arizona.

IV. Energy Conservation Project proposed in Tucson.

I. Coordination of Research on Energy in different departments and with outside agencies.

Modeling for petroleum supply and demand in the U.S. with FEO and Interior

(Frank Alesio leaving FEO to go to EPRI in Economic Research)

Assessment of impacts on economics, pollution etc. in intermountain area by increased energy production.

Statistical modeling of various possibilities (Dr. Wes Taylor) of usage patterns for energy in U.S.
For example - gasoline consumption

Measuring of balance of payments impact by Natural Resource Journal (publication is available)

Oil importing policies

Implementation of this money in Saudi Arabia

Econometric Model for the 48 states - tries to predict energy consumption patterns for each state.

Capital Investment and Earnings for oil refining and other energy activies.

Cause for the energy crisis.

Earth Sciences Departments at the University of Arizona

Studying - 1. Water supply effects by gasification and other conversion processes.
2. Desulfurization of coal by roasting.

Harold Southward - (University of New Mexico)

Energy Conservation in buildings
Energy conversion and distribution systems - conventional
Solid waste research
Energy conversion - unconventional
Solar energy
- Heating
- Cooling
- Solar cells - use of collectors coupled to conventional solar cells.

Energy Conversion - conventional
- Solid Waste - combustion for heating and power generation

Energy Conversion - unconventional
- Wind Power
- Direct Energy conversion
  - Thermoelectric
  - Fuel cells, photovoltaic, MHD
- Geothermal
- Coal gasification - modified Lurgi Process
- Insitu oil shale processing
- Plow Share - Technology assessment

Materials - This work being done in cooperation with LASL and Sandia Laboratories

1. Thermal and mechanical properties of Uranium and Uranium-alloys
2. Fast neutron damage of materials for LMFBR and Fusion rxtr development.

Power Rxtr Systems

Assessment of future rxtrs.

System development in SW U.S. Assessment of radioactive waste disposal methods.

Hydrogen as a Fuel

$$H_2O \rightarrow H_2 + \frac{1}{2} O_2$$

This can be done by:
a) electrolysis
b) thermal dissociation (T = 2500°K)
c) thermo-chemical HTGCRxtr (700°C)

Thermal $\rightarrow H_2$ efficiencies found 50-60%

Solar energy shortcomings (low concentration)

Methods of H_2 generation from solar energy:

Silicon solar cell process - Eff ∿ 15%
Vapor power cycle - Eff ∿ 20%
Cost is ∿ $1,000/KW

Thermal-chemical process Eff ~ 30%

Cost ~ $575/KW

Storage - large dewar at Cape Canaveral which holds ~ 1 x 10^6 gal LH_2.

Minimum time estimated for hydrogen to take over 10% of the energy market would be about 30 years if it were developed as oil and gas have been.

R. L. Drake - National (Non-profit) Corporation for Atm. Research (NCAR)

With about 40 members and about 500 employees (of which about one half are scientific personnel)

Research Computer facility - CDC 6600-CDC 7600
Use of Computer - 50% split between NCAR and University Programs
Aircraft facility - with aircraft and glider (also about 50-50 split NCAR - Universities)

Global Atm. Res. Program

Research on particulates analysis
They are conducting field tests measuring :

Wind blown - soil particles. Emission of soil particles into the atmosphere in Death Valley, Nebraska and West Texas, plains.

Aerosol Physics

Long term effects of exposure to radioactive materials

Future research to be conducted at NCAR will include:

MESO scale flow modelling with application to transportation of pollutants (use as national facilities).

General circulation models - CO_2 from combustion-facilities, etc.

MOUNTAIN

"ENERGY RESEARCH IN THE ROCKY MOUNTAIN STATES"

NOTES FROM: LARRY L. ANDERSON

ABSTRACTS