MAP I—1301

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MAP SHOWING RELATION OF CARBON DIOXIDE-RICH SPRINGS AND GAS WELLS TO THE TECTONIC FRAMEWORK OF THE CONTERMINOUS UNITED STATES

By William P. Irwin and Ivan Barnes

MISCELLANEOUS INVESTIGATIONS SERIES
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IRWIN AND BARNES—CONTERMINOUS UNITED STATES 1:5,000,000 MAP I-1301

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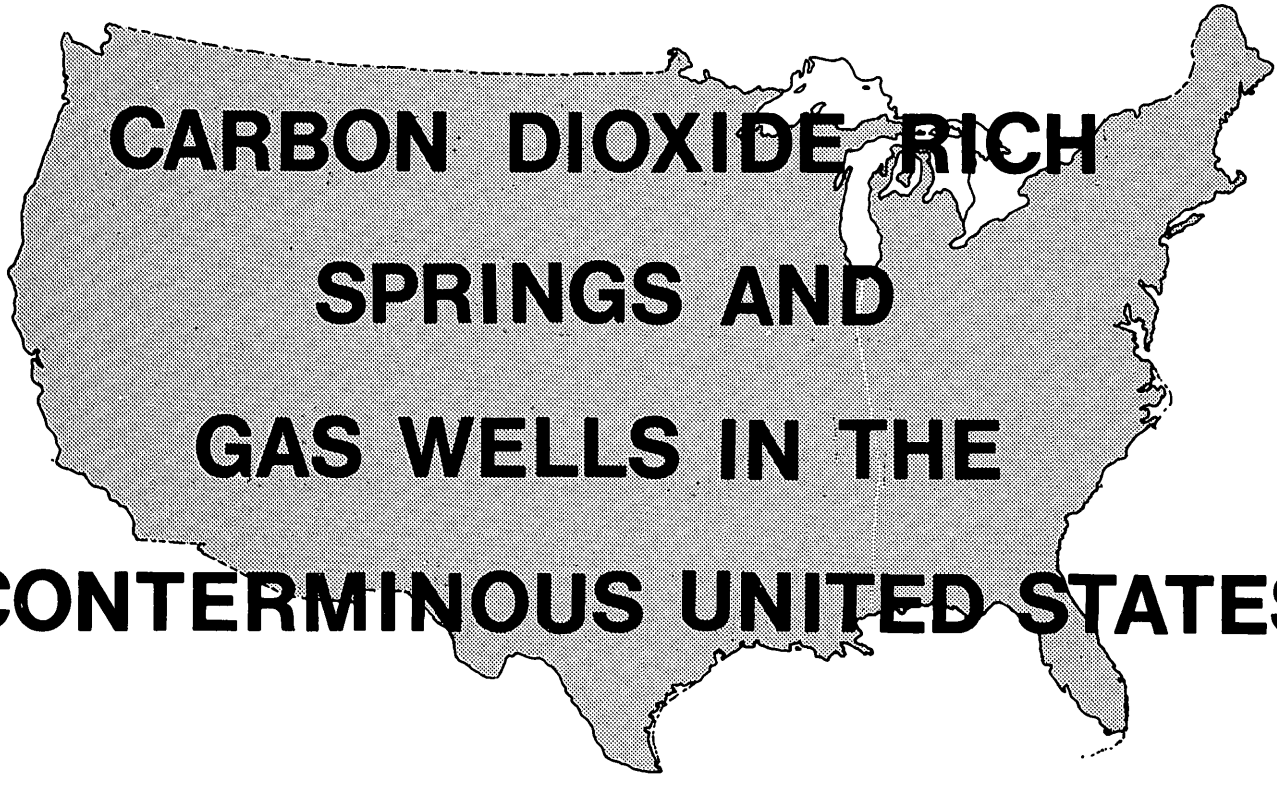
TO ACCOMPANY MAP I-1301



CARBON DIOXIDE-RICH SPRINGS AND GAS WELLS IN THE CONTERMINOUS UNITED STATES

by

William P. Irwin and Ivan Barnes

Miscellaneous Investigations Series
I-1301

OCCURRENCE OF CARBON DIOXIDE IN NATURAL SPRINGS AND GAS WELLS

Carbon dioxide is escaping from the lithosphere in impressive amounts from natural springs and gas wells, some wells discharging millions of cubic feet per day. To aid in evaluating the tectonic significance of these discharges in the conterminous United States, the locations of CO_2-rich springs and wells have been plotted on a simplified geologic map showing major tectonic features.

It has become increasingly evident on a global scale that the CO_2-rich springs are virtually restricted to young orogenic belts and, more specifically, that they are related to major seismic zones (Barnes and others, 1978). The concentrations of CO_2-rich springs along the circum-Pacific belt and the alpine belt of the Mediterranean and Middle East regions are principal examples. CO_2-rich springs rarely occur in older orogenic belts such as the Caledonides and Urals. They also are uncommon in the tectonically stable cratonal regions of continents, except where the cratons are being actively rifted (Irwin and Barnes, 1980).

In the conterminous United States, the distribution of CO_2-rich springs follows the same pattern as on the global scale. The springs are abundant in the Cordilleran orogenic region of the western United States, particularly along the tectonically active and highly seismic coastal region where it is part of the circum-Pacific orogenic belt. The scarcity of CO_2-rich springs in much of the Great Basin is striking, but puzzling. In the old Appalachian orogenic belt of the eastern United States, CO_2-rich springs are rare, being known only at Saratoga Springs, New York. In the cratonal region of the United States, CO_2-rich springs are restricted to the western part where they are associated with a system of extensional faults that includes the Rio Grande rift.

Carbon dioxide is also a major component of the gas flowing from some wells that have been drilled for hydrocarbon gas or petroleum, but a global-scale study similar to the one made of the springs has not been attempted. Of nearly 10,000 analyses of gas from wells in the conterminous United States (Moore, 1976), only one percent are of gas consisting of 50 percent or more CO_2. Nearly all of these extraordinarily CO_2-rich gas wells are in platform deposits that lie on the cratonal Precambrian basement. Their distribution is similar to that of the few CO_2-rich springs found in the cratonal region, by virtue of their restriction to the actively fragmenting western part. The few CO_2-rich wells shown along coastal California were drilled in the vicinity of known CO_2-rich springs rather than having been found during drilling for hydrocarbon gas or petroleum.

The carbon dioxide of natural springs and gas wells is thought to come from three sources: (1) the mantle, (2) the metamorphism of marine carbonate-bearing sedimentary rocks, and (3) the decomposition of organic material. In some instances, the source can be identified by isotopic analysis of the carbon, but these data are available for only a few localities. CO_2-rich springs representative of all three sources have been identified in the Pacific Coast region. For example, carbon from the mantle issues from some springs

of the Sierra Nevada and along the San Andreas fault. Some carbon dioxide issuing from Franciscan terrane of the California Coast Ranges is a product of metamorphism of marine carbonate material, and some is from the breakdown of organic material. Carbon dioxide issuing from regions of young volcanic activity may be derived either from the mantle or from contact metamorphism of carbonate-bearing country rock, or from a combination of the two sources. The presence of abundant carbon dioxide in gas wells of the western cratonal region is commonly attributed to metamorphism of platform carbonate strata by young intrusive and volcanic rocks. However, isotopic analyses of the carbon dioxide from two wells in northeastern New Mexico and two in southeastern Utah (Zartman and others, 1961, table 3) show a depletion in ^{13}C of -3.9 to -5.9 per mil, which may indicate a mantle origin.

BICARBONATE-RICH SPRINGS

Map No.	Spring name by state	Location	Reference
	ARIZONA		
1	Verde Hot Springs	31°57′ N., 113°01′ W.	12
	CALIFORNIA		
1	Cinnabar	Sec. 34, T. 48 N., R. 9 W.	6
2	Soda Creek	Sec. 1, T. 47 N., R. 9 W.	6
3	Bogus Creek	Sec. 13, T. 47 N., R. 5 W.	20
4	Soda	Sec. 13, T. 39 N., R. 3 W.	6
5	Shasta	Sec. 7, T. 39 N., R. 3 W.	20
6	Cave	Sec. 24, T. 39 N., R. 4 W.	6
7	Castle Rock	Sec. 15, T. 38 N., R. 4 W.	6
8	Altoona	Sec. 19, T. 38 N., R. 5 W.	6
9	Altoona Quicksilver	Sec. 22, T. 38 N., R. 6 W.	17
10	Mud	Sec. 19, T. 21 N., R. 15 W.	6
11	Mud	Sec. 2, T. 18 N., R. 17 W.	4
12	Soda	Sec. 15, T. 18 N., R. 10 W.	6
13	Sulphur	Sec. 9, T. 18 N., R. 6 W.	5
14	Parramore	Sec. 21, T. 17 N., R. 9 W.	6
15	Crabtree	Sec. 36, T. 17 N., R. 9 W.	6
16	Cooks	Sec. 9, T. 16 N., R. 6 W.	6
17	Hough	Sec. 10, T. 15 N., R. 7 W.	6
18	Allen	Sec. 8, T. 15 N., R. 7 W.	6
19	Bartlett	Sec. 2, T. 15 N., R. 8 W.	5
20	Saratoga	Sec. 4, T. 15 N., R. 10 W.	6
21	Vichy	Sec. 14, T. 15 N., R. 12 W.	6
22	Soda	Sec. 32, T. 14 N., R. 13 W.	20
23	Duncan	Sec. 25, T. 13 N., R. 12 W.	22
24	Highland	Sec. 31, T. 13 N., R. 9 W.	22
25	Big Soda	Sec. 6, T. 13 N., R. 8 W.	6
26	Adams	Sec. 26, T. 12 N., R. 8 W.	6

Map No.	Spring name by state	Location	Reference
	CALIFORNIA — Continued		
27	Seigler Hot	Sec. 24, T. 12 N., R. 8 W.	6
28	Howard	Sec. 30, T. 12 N., R. 7 W.	20
29	Big Injun	Sec. 35, T. 11 N., R. 8 W.	20
30	Skaggs	Sec. 25, T. 10 N., R. 11 W.	6
31	Aetna	Sec. 1, T. 9 N., R. 6 W.	6
32	Walter	Sec. 12, T. 9 N., R. 5 W.	6
33	Napa Rock Soda	Sec. 25, T. 8 N., R. 4 W.	4
34	White Sulphur	Sec. 19, T. 6 S., R. 2 E.	5
35	Azule	Sec. 3, T. 8 S., R. 2 W.	20
36	Congress	Sec. 11, T. 8 S., R. 2 W.	20
37	Madrone Soda	Sec. 10, T. 9 S., R. 4 E.	5
38	Gilroy Hot	Sec. 36, T. 9 S., R. 4 E.	5
39	Sulphur	Sec. 24, T. 16 S., R. 11 E.	20
40	Unnamed	Sec. 36, T. 18 S., R. 11 E.	5
41	Table Mountain	Sec. 21, T. 23 S., R. 15 E.	20
42	Newsome	Sec. 23, T. 32 S., R. 13 E.	5
43	Hollywood Spa	Sec. 14, T. 1 S., R. 14 W.	5
44	La Vida Mineral	Sec. 2 T. 3 S., R. 9 W.	5
45	Quail	Sec. 33, T. 1 S., R. 7 E.	5
46	Humbug Valley	Sec. 6, T. 26 N., R. 7 E.	20
47	Soda	Sec. 17, T. 26 N., R. 7 E.	20
48	V and M Quarry	Sec. 3, T. 25 N., R. 9 E.	20
49	Twain	Sec. 24, T. 25 N., R. 8 E.	20
50	Belden	Sec. 23, T. 25 N., R. 6 E.	20
51	Summit Soda	Sec. 9, T. 16 N., R. 15 E.	20
52	Wentworth	Sec. 31, T. 14 N., R. 15 E.	20
53	Rubicon	Sec. 31, T. 14 N., R. 16 E.	22
54	Glen Alpine	Sec. 9, T. 12 N., R. 17 E.	20
55	Fales Hot	Sec. 24, T. 6 N., R. 23 E.	20
56	Bridgeport Hot	Sec. 34, T. 5 N., R. 25 E.	20
57	Mono Lake	Sec. 18, T. 1 N., R. 27 E.	20
58	Toulumne Meadows	Sec. 5, T. 1 S., R. 24 E.	5
59	Devils Post Pile	Sec. 34, T. 3 S., R. 26 E.	20
60	Soda	Sec. 30, T. 6 S., R. 24 E.	20
61	Lime Canyon	Sec. 31, T. 13 S., R. 34 E.	20
62	Jordan Hot	Sec. 33, T. 19 S., R. 34 E.	20
63	Pyles Camp	Sec. 35, T. 20 S., R. 32 E.	20
64	Camp Nelson	Sec. 34, T. 20 S., R. 31 E.	20
65	Soda	Sec. 31, T. 20 S., R. 31 E.	20
66	Soda	Sec. 2, T. 21 S., R. 29 E.	20
	COLORADO		
1	Steamboat	Sec. 8, T. 6 N., R. 84 W.	20
2	Juniper	Sec. 16, T. 6 N., R. 94 W.	20
3	Idaho	Sec. 36, T. 3 S., R. 73 W.	20
4	Glenwood	Sec. 9, T. 6 S., R. 88 W.	20
5	Iron	Sec. 6, T. 14 S., R. 67 W.	20
6	Manitou	Sec. 5, T. 14 S., R. 67 W.	20
7	Mineral Austin	Sec. 31, T. 14 S., R. 94 W.	20
8	Guffey Yellow Soda	Sec. 23, T. 15 S., R. 73 W.	20
9	Cimarron	Sec. 5, T. 48 N., R. 6 W.	20
10	Powderhorn	Sec. 32, T. 47 N., R. 2 W.	20
11	Rico	37°41′ N., 108°00′ W.	20
12	Trimble	Sec. 15, T. 36 N., R. 9 W.	20

Map No.	Spring name by state	Location	Reference
	IDAHO		
1	Hooper	Sec. 36, T. 8 S., R. 41 E.	20
	NEVADA		
1	Wells	Sec. 20, T. 38 N., R. 62 E.	8
2	Hot Sulphur	Sec. 17, T. 38 N., R. 62 E.	8
3	Crescent Valley Hot	Sec. 1, T. 29 N., R. 48 E.	8
4	Spring	Sec. 2, T. 36 N., R. 41 E.	8
5	Spring	Sec. 3, T. 37 N., R. 39 E.	8
6	Spring	Sec. 28, T. 35 N., R. 36 E.	8
7	Spring	Sec. 28, T. 35 N., R. 28 E.	8
8	Coyote	Sec. 3?, T. 33 N., R. 25 E.	8
	NEW MEXICO		
1	Ojo Caliente	Sec. 24, T. 24 N., R. 8 E.	20
2	San Ysidro	Sec. 16, T. 15 N., R. 1 E.	12
3	Granite Test Wells	Sec. 13, T. 19 N., R. 2 E.	18
4	Indian Springs	Sec. 29, T. 16 N., R. 2 E.	18
5	Warm Springs	Sec. 1, T. 16 N., R. 1 W.	20
6	Soda Dam Springs	Sec. 14, T. 18 N., R. 2 E.	20
7	Railroad Springs	34°51′40″ N., 107°04′55″ W.	20
	NEW YORK		
1	Saratoga Springs	43°02.4′ N., 73°28.2′ W.	2
	OREGON		
1	Wilhoit Soda	Sec. 16, T. 6 S., R. 2 E.	20
2	Joaquin Miller	Sec. 11, T. 15 S., R. 31 E.	20
3	Lithia	Sec. 7, T. 39 S., R. 2 E.	20
4	Weberg	Sec. 18, T. 18 S., R. 26 E.	20
5	Alvord	Sec. 33, T. 34 S., R. 34 E.	20
6	Umpqua	Sec. 20, T. 26 S., R. 4 E.	20
7	Toketee Soda	Sec. 17, T. 26 S., R. 3 E.	20
8	Dead Indian	42°20′ N., 122°27′ W.	20
9	McAllister Soda	42°23′ N., 122°27′ W.	20
10	Cascadia Soda	44°23′ N., 122°29′ W.	20
11	Island Ranch	Sec. 7, T. 25 S., R. 32 E.	20
12	Soda Springs Sodaville	Sec. —, T. 12 S., R. 2 W.	20
13	Abe Boehm well	Sec. 28, T. 4 S., R. 9 E.	20
14	Jack Liskey well	Sec. 2, T. 41 S., R. 9 E.	20
	UTAH		
1	Strawberry	40°10′ N., 110°24′ W.	14

Map No.	Spring name by state	Location	Reference
	WASHINGTON		
1	Lithia	48°52′ N., 122°37′ W.	21
2	Garland	Sec. 25, T. 28 N., R. 11 E.	21
3	Money	Sec. 30, T. 26 N., R. 11 E.	21
4	Bubbling Mike	45°53′ N., 122°00′ W.	21
5	Goose Egg Soda	Sec. 33, T. 14 N., R. 14 E.	21
6	Bumping River Soda	Sec. 34, T. 17 N., R. 13 E.	21
7	Longmire Mineral	46°45′ N., 121°48′ W.	21
8	Kennedy Hot	Sec. 1, T. 30 N., R. 12 E.	21
9	Ohanapecosh	Sec. 4, T. 14 N., R. 10 E.	21
10	Upper Soda Klikitat	Sec. 24, T. 11 N., R. 12 E.	21
11	Soda Spring Campground	45°53′ N., 121°06′ W.	20
12	Summit Creek Soda	Sec. —, T. 14 N., R. 11 E.	21
	WYOMING		
1	De Maris Soda	Sec. 3, T. 52 N., R. 102 W.	20
2	Auburn Hot	42°49′ N., 111°00′ W.	20

GAS WELLS RICH IN CARBON DIOXIDE

Map No.	Name of well by state	Location	Percent CO_2	Reference
	ALABAMA			
1	E.L. Godwin No. 1	Sec. 18, T. 1 N., R. 9 E.	44.9	15
	ARIZONA			
1	Taylor-Fuller No. 1	Sec. 21, T. 17 N., R. 20 E.	79.4	15
2	State No. 1	Sec. 20, T. 9 N., R. 31 E.	87.3	15
	CALIFORNIA			
1	Gas seepage	Sec. 24, T. 47 N., R. 5 W.	95.6	15
2	Gibson	39°08.7′ N., 123°13.1′ W.	—	16
3	Hopland	2 mi. N. of Hopland	97.0	16
4	Niland	Sec. 2, 12 T. 11 S., R. 13 E.	99.1	20
	COLORADO			
1	Hoye No. 1	Sec. 34, T. 9 N., R. 76 W.	97.5	15
2	Hoye No. 3	Sec. 34, T. 9 N., R. 78 W.	91.3	15
3	Ballinger Federal No. 1	Sec. 8, T. 9 N., R. 78 W.	90.4	15
4	Sherman No. 1	Sec. 12, T. 9 N., R. 79 W.	92.1	15
5	Glenwood Springs No. 1	Sec. 12, T. 9 N., R. 79 W.	91.8	15

Map No.	Name of well by state	Location	Percent CO_2	Reference
	COLORADO —Continued			
6	Government Lanmon No. 1-A	Sec. 7, T. 9 N., R. 80 W.	96.3	15
7	Wick No. 13	Sec. 10, T. 4 N., R. 91 W.	98.4	15
8	National No. 1	Sec. 6, T. 8 S., R. 102 W.	57.6	15
9	No. 1	Sec. 6, T. 15 S., R. 94 W.	82.3	15
10	Doe Canyon No. 1	Sec. 13, T. 40 N., R. 18 W.	92.6	15
11	Glade Canyon Unit No. 1	Sec. 13, T. 40 N., R. 17 W.	95.8	15
12	J. A. Fulks No. 1	Sec. 27, T. 37 N., R. 17 W.	97.7	15
13	Dean Dudley No. 2	Sec. 13, T. 36 N., R. 18 W.	96.2	15
14	Schmidt No. 1	Sec. 24, T. 36 N., R. 18 W.	81.9	15
15	King No. 1	Sec. 1, T. 28 S., R. 53 W.	95.9	15
16	Well No. 2	Sec. 7, T. 28 S., R. 52 W.	96.6	15
17	Well No. 3	Sec. 7, T. 28 S., R. 52 W.	96.7	15
18	Well No. 4	Sec. 7, T., 28 S., R. 52 W.	97.6	15
19	Brumley No. 1	Sec. 6, T. 29 S., R. 51 W.	98.8	15
20	Bore hole No. F614	Sec. 20, T. 29 S., R. 50 W.	99.4	15
21	Ingle No. 1	Sec. 27, T. 29 S., R. 50 W.	91.0	15
22	Well	Sec. 7, T. 19 S., R. 68 W.	81.7	15
	IDAHO			
1	T. J. Weber No. 1-A	Sec. 24, T. 2 S., R. 44 E.	97.1	15
2	Hooper Spring	Sec. 36, T. 8 S., R. 41 E.	96.2	15
3	Iron Spring	Sec. 7, T. 9 S., R. 42 E.	95.7	15
4	Mound Spring	Sec. 12, T. 9 S., R. 41 E.	98.7	15
5	Idanha Spring	Sec. 2, T. 9 S., R. 41 E.	92.5	15
6	Soda Mound Spring	Sec. 12, T. 9 S., R. 41 E.	94.0	15
7	Sulpher Spring	Sec. 13, T. 9 S., R. 42 E.	84.2	15
8	Mammoth Spring	Sec. 23, T. 8 S., R. 41 E.	91.0	15
	LOUISIANA			
1	Salt Mine	Sec. 20, T. 11 N., R. 3 W.	94.2	15
	MISSISSIPPI			
1	J. R. Cameron No. 1	Sec. 36, T. 10 N., R. 1 E.	95.6	15
2	Willie J. Wade No. 1	Sec. 32, T. 8 N., R. 7 E.	65.3	15
	MONTANA			
1	Thisted No. 1	Sec. 17, T. 36 N., R. 1 E.	79.9	15
2	Goeddertz-Agen No. 1	Sec. 16, T. 35 N., R. 3 W.	91.9	15
3	State No. 50	Sec. 36, T. 35 N., R. 2 W.	95.6	15
4	Kitchen No. 1	Sec. 2, T. 34 N., R. 1 W.	52.7	15
5	Larson No. 2	Sec. 17, T. 34 N., R. 1 W.	82.3	15
6	Shannon-Roberts No. 1	Sec. 12, T. 20 N., R. 1 E.	49.4	15

Map No.	Name of well by state	Location	Percent CO_2	Reference
	NEW MEXICO			
1	Ute	Sec. 10, T. 31 N., R. 14 W.	88.0	15
2	No. 1 Mountain Tribal D. No. 1	Sec. 32, T. 26 N., R. 15 W.	96.2	15
3	Navajo C No. 1	Sec. 8, T. 23 N., R. 5 W.	88.1	15
4	Morten No. 1	Sec. 24, T. 24 N., R. 5 E.	96.5	15
5	Rogers No. 1	Sec. 4, T. 29 N., R. 29 E.	98.4	15
6	York Denton No. 1 State	Sec. 2, T. 26 N., R. 24 E.	99.8	19
7	Floersheim No. 1 State	Sec. 15, T. 23 N., R. 24 E.	67.0	19
8	Gallagher No. 1	Sec. 9, T. 21 N., R. 30 E.	99.9	19
9	Gonzales No. 1	Sec. 28, T. 21 N., R. 30 E.	99.6	19
10	Adams No. 1 State	Sec. 27, T. 21 N., R. 30 E.	99.6	19
11	Kerlin No. 1	Sec. 34, T. 21 N., R. 30 E.	99.9	19
12	Powers-Marshell No. 1	Sec. 34, T. 21 N., R. 30 E.	99.7	19
13	Baca No. 1	Sec. 19, T. 20 N., R. 31 E.	99.4	15
14	Mitchell No. 3	Sec. 18, T. 19 N., R. 30 E.	99.8	19
15	Mitchell No. 2	Sec. 20, T. 19 N., R. 30 E.	99.8	19
16	C. F. Cruse No. 1	Sec. 11, T. 19 N., R. 21 E.	92.2	15
17	Oil test	Sec. 1, T. 16 N., R. 1 W.	86.4	15
18	Water well	Sec. 36, T. 11 N., R. 6 E.	78.8	15
19	J. B. Witt test	Sec. 12, T. 7 N., R. 7 E.	97.4	15
20	Pace No. 1	Sec. 12, T. 6 N., R. 7 E.	99.0	15
21	Indian water well of Mesita	Sec. 12, T. 9 N., R. 5 W.	52.1	15
22	Spring	Sec. 15, T. 8 N., R. 3 W.	92.1	15
23	Spring	Sec. 35, T. 6 N., R. 3 W.	98.4	15
24	Navajo K-2	Sec. 31, T. 30 S., R. 16 W.	88.5	15
	TEXAS			
1	Camp Unit No. 1	Sec. 3, blk 4, H & GN SUR	52.0	15
2	Blackstone-Slaughter No. 1	Sec. 1, blk 130, T & STL SUR	47.7	15
3	Brown-Bassett No. 1-LT	Sec. 227, blk Y, TCRR SUR	53.2	15
	UTAH			
1	No. 1	Sec. 12, T. 15 S., R. 11 E.	98.9	15
2	No. 4	Sec. 12, T. 15 S., R. 11 E.	98.3	15
3	R. Bryner No. 2	Sec. 25, T. 14 S., R. 7 E.	89.3	15
4	R. Bryner No. 1	Sec. 24, T. 14 S., R. 7 E.	99.5	15
5	Gas seep	Sec. —, T. 14 S., R. 15 E.	97.2	15
6	Ferron Unit No. 3	Sec. 21, T. 20 S., R. 7 E.	52.4	15
7	Packsaddle No. 1	Sec. 12, T. 18 S., R. 12 E.	94.7	15
8	Government-Wheatley No. 1	Sec. 27, T. 16 S., R. 12 E.	91.2	15
9	Escalante No. 2	Sec. 29, T. 32 S., R. 3 E.	96.1	15
10	Bluff Unit No. 3	Sec. 4, T. 40 S., R. 23 E.	85.7	15
11	Desert Creek No. 1	Sec. 2, T. 42 S., R. 23 E.	77.5	15
12	Boundary Butte N. No. 1	Sec. 33, T. 42 S., R. 22 E.	56.8	15
13	Coalbed Canyon Unit No. 2	Sec. 20, T. 35 S., R. 26 E.	62.3	15
14	Navajo-Gothic No. 2	Sec. 36, T. 40 S., R. 21 E.	93.4	15
15	No. 30-1	Sec. 7, T. 41 S., R. 21 E.	73.2	15
16	Deadman Canyon No. 1	Sec. 20, T. 37 S., R. 24 E.	93.6	15

Map No.	Name of well by state	Location	Percent CO_2	Reference
	UTAH — Continued			
17	Navajo No. 30	Sec. 20, T. 40 S., R. 24 E.	69.9	15
18	Government Fehr-Lyon No. 1	Sec. 33, T. 40 S., R. 21 E.	69.2	15
19	USA B No. 1	Sec. 9, T. 35 S., R. 25 E.	88.6	15
20	Emery Unit No. 1	Sec. 34, T. 22 S., R. 5 E.	92.2	15
21	No. 1	Sec. 31, T. 41 S., R. 11 W.	86.8	15
	WYOMING			
1	Hamilton Dome	Sec. 13&14, T. 44 N., R. 98 W.	96.4	15
2	Hoback II Unit No. 2	Sec. 15, T. 28 N., R. 115 W.	60.4	15
3	Tip Top Unit No. 22-19-G	Sec. 19, T. 28 N., R. 113 W.	64.2	15
4	Bruff Unit No. 1	Sec. 22, T. 19 N., R. 112 W.	92.1	15
5	Union Pacific No. 4	Sec. 11, T. 19 N., R. 104 W.	82.0	15
6	Church Buttes Unit No. 19	Sec. 8, T. 16 N., R. 112 W.	86.6	15

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