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STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland 1, Oregon
Telephone: CApitol 6-2161, Ext. 488

Field Offices

2033 First Street, Baker

239 S.E."H"Street, Grants Pass

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NATURAL SOURCES OF CARBON DIOXIDE IN OREGON

By
Norman S. Wagner*

On looking over maps of Oregon, one frequently comes across names such as Soda, Dry Soda, or Fizz applied to springs, creeks, mountains, and even towns (Sodaville in Linn County). These names owe their origin to the presence of springs emitting soda water - that is, water having a high content of dissolved carbon dioxide. The large number of soda-water or carbon-dioxide springs in Oregon is not readily apparent from maps, however, because many of the springs either have no names or have names that are not descriptive.

Soda-water springs, or soda springs as they are commonly called, occur at many places in the State, from the Willamette Valley to the Snake River. Locations of thirty of these springs are shown on the map on page 104. At some of the springs the discharge of water is accompanied by the escape of free carbon dioxide gas. But whether free gas is present or not, all of the springs represent a leakage of natural carbon dioxide and some a potential source of this commodity.

Carbon dioxide industry

Carbon dioxide (CO_2) is an odorless, colorless, tasteless, inert and noninflammable gas. It can be converted to a liquid or a solid and held in that form with comparative ease. The liquid and solid forms retain the properties of the gas, but have additional properties of their own. For example, the solidified material, dry ice, has a temperature of -109.3° F. It also has a relatively high specific gravity and it evaporates back to gas without liquifying to a noticeable extent.

Because of its properties, dry ice is used extensively as a refrigerant in the storage and transportation of various foods, one pound substituting for 15 to 20 pounds of water ice. Dry ice is also used in the shrink fitting of machine parts and for hardening steel alloys. Liquified CO_2 is employed in some types of mechanical refrigeration and as an explosive in coal mines. The gas is popularly known for its use as the "sparkling agent" in carbonated beverages. It is also used in fire extinguishing and for food preservation in ways other than refrigeration. Both liquid and gaseous CO_2 are used as packaged power for inflation of collapsible life-saving gear and for spray application of canned insecticides, paints, and an ever-growing number of food products and housekeeping aids.

National production of CO_2 for 1953 was 743,368 short tons valued at 41.3 million dollars, according to the U. S. Bureau of Census, 1954. The bulk of this production represents by-product gas reclaimed from waste fumes from various industrial plants. However, approximately 40,000 short tons, or 5.3 percent of the national production having a gross value of 2.2 million dollars was derived from natural sources. Later figures in the U. S. Bureau of Mines Minerals Yearbook for 1957 indicate that CO_2 production from natural sources climbed from 670,600,000 cubic feet in 1953 to 704,276,000 cubic feet in 1957.

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*Geologist, State of Oregon Department of Geology and Mineral Industries.

The by-product production of CO_2 originates from industrial plants throughout the nation, but only six states are listed as having production from natural sources in 1957. These states are Oregon, California, Colorado, New Mexico, Utah, and Washington.

Origin of carbon dioxide

Both manufactured and natural CO_2 are derived by the burning or chemical treatment of: (1) organic matter, (2) materials of organic derivation such as coal, oil and the hydrocarbon gases, and (3) rocks composed of carbonate minerals. The manufactured CO_2 is liberated in plants where fuel is combusted, where cement and lime are burned, where ammonia and nitrogen are manufactured, where hydrocarbons are treated, and where alcohol fermentation is accomplished. A similar generation of CO_2 takes place in the earth's crust when natural materials containing carbon are subjected to: (1) magmatic assimilation, (2) heat generated by faulting, igneous intrusion, and metamorphism, (3) the action of acid ground waters on carbonate rocks, and (4) the kinds of decay and fermentation that occur during the transformation of buried organic matter into coal and hydrocarbons. Natural CO_2 is therefore found in varying degrees of concentration in gases of volcanic origin, in areas of recent volcanism where uncooled magmas remain in contact with limestones and sediments containing organic matter or materials of organic derivation, and in association with deposits of coal and hydrocarbons.

Once formed, natural CO_2 is subject to the same structural and physical controls that govern the entrapment, migration, and leakage of petroleum and the hydrocarbon gases. Thus while tremendous quantities of CO_2 are discharged annually from the vents of the world's volcanoes, and from lesser fumaroles and bedrock fractures in areas of recent volcanism, large accumulations also exist in subsurface traps from which there is little or no leakage. For this reason many CO_2 occurrences have been discovered accidentally during the course of drilling exploratory wells for oil. Several of the New Mexico occurrences are notable examples.

Uses of natural CO_2 in Oregon

Dry ice is being produced from natural CO_2 recovered from wells in a soda-water spring zone on Emigrant Creek, 3 miles east of Ashland. The operation is owned by the Gas-Ice Corporation of Seattle, Washington, one of the first companies on the West Coast to use natural CO_2 for ice-making purposes. Production at Ashland began in the summer of 1945, and through 1957 has totaled approximately 47 million pounds of dry ice.* At the rate of 10 cubic feet of gas for each pound of dry ice, this amounts to a recovery of 470 million cubic feet of gas from the field - an average somewhat in excess of 31 million cubic feet per year. For 1958, plant output was nearly 210 eighty-pound cakes of ice per 24-hour working day with a two-month shutdown of operations during the winter.

The only other way these natural "soda" springs are being utilized today is for drinking or bathing purposes at campgrounds, parks, and health resorts. During past decades, however, especially during the forepart of the century, several attempts were made to market natural soda water in bottled form. Most of these operations were short-lived and financially unrewarding. Artificial carbonation, brought about by the development of the carbon dioxide industry, now serves the same purpose in a much more effective and efficient manner.

Characteristics of Oregon's soda-water springs

All soda-water springs contain enough dissolved CO_2 to give the sour, fizzy taste of carbonic acid (H_2CO_3). Other characteristics generally present to some degree include a bluish, soapy cast to the water in semistagnant pools, patches of orange-brown coating in the bed of the discharge channels, abundant growths of deep-green, mosslike algae in both the springs and the discharge channels, and a graying of otherwise green grass in the area of the spring.

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*R. B. Newbern, President, Gas-Ice Corporation: personal communication.

Soda-water springs differ considerably among themselves with respect to size, shape, flow temperature, content of dissolved CO_2, and amount of associated free gas. For example, some springs consist of a single, clean-cut discharge orifice and nothing more, while others have several flowing discharge centers accompanied by zones of seepage. In some places a single-orifice spring, or a small compound spring, will occur in an area devoid of other known CO_2 leakages; in other places many clusters of springs and seepages occur in a compact area of considerable acreage, or extend for an appreciable distance in alignment with a fault or bedding trend. Deposits of calcareous tufa (travertine) occur at most springs, but are absent at others. The rate of flow varies likewise, although no definite flow figures can be given here because field conditions rarely permitted measurement. In fact, several of the larger springs discharge directly in the beds of rivers and creeks. On the whole, however, the flow at most sites is quite small, and in several instances it is negligible. Water temperatures range from 48° F. to 121° F. Thus some of the springs are hot, most are tepid, and a few are cold.

The CO_2 content of the water is strong in some springs and weak in others, due undoubtedly to mingling and dilution of the spring water with fresh ground water. A discharge of free CO_2 gas occurs at some sites along with the water, and is lacking at others. Its presence appears to bear no fixed relation to the CO_2 content of the spring water, however, as some springs with a high content of dissolved CO_2 show no observable discharge of gas while some springs with a low content show a conspicuous amount of gas.

When free gas is discharged from within the confines of a spring pool, or from points in the bed of a creek channel, its escape is manifest by bubbles rising through the water. Such bubbles are emitted in coarse bursts at some sites and in a steady succession of fine beads at others. In some places, emission is continuous but punctuated by surges of greater activity. At other places, periods of escape alternate with periods during which there is no observable discharge. There are also areas in which free gas escapes directly from the earth's surface to the atmosphere without passing through any pools of standing water. It is, of course, virtually impossible to determine the extent of areas of "dry" leakage. In fact, their existence can be recognized only when the ground is covered by puddles of standing water after prolonged rains or springtime thaws. Some sites of "dry" leakage are reportedly indicated by a tendency to be relatively snow-free during the winter.

Descriptions of individual CO_2 springs

Due to the prevalence of volcanic activity in Oregon and the rather commonplace by-product association of CO_2, it is reasonable to conclude that many of Oregon's numerous CO_2 springs are seepages of little significance. However, the Gas-Ice Corporations's operation at Ashland, and another owned by the same company and located in a spring area near Klickitat, Washington, about 30 miles north of The Dalles, Oregon, show that commercial quantities of natural CO_2 occur at some spring sites in the Northwest. This suggests that other leakage areas would warrant careful investigation should future market demands give rise to the need for developing additional supplies.

While a far more detailed study must be made before the full geologic picture can be determined in most instances, the following descriptions summarize the data presently available for the springs and seepages shown on the map. All water and gas analyses were made by Dr. R. E. Moser, Oregon State Board of Health.

1. Wilhoit Springs: A cluster of soda-water springs on northeast bank of Rock Creek in sec. 16, T. 6 S., R. 2 E., Clackamas County. Very light discharge of free CO_2 occurs sporadically from these springs and also at intervals in Rock Creek over a distance of about three-eighths of a mile, beginning at a point about one-eighth of a mile above the springs and continuing on downstream past the springs. Additional free gas leakage reportedly observed in meadow in vicinity of springs to distances of 300 to 400 feet east of creek when terrain is saturated,

according to Albert Schoenborn, property owner. Full extent of area over which such "dry" leakage occurs is unknown. Due to development and landscaping of campgrounds, springs are now boarded over and equipped with hand pumps. Original setting presumably consisted of boggy seepage with three or four separate flowing discharge centers in an area of about 50 by 100 feet. Temperature in one accessible spring measured 48° F. Water contained 3.1 volumes CO_2 per volume of H_2O at 25° C. Free gas sample from leakage in creek contained 80 percent CO_2; 3.5 percent O_2; and 15.5 percent N_2. No hydrogen or methane were detected. Springs emanate from Oligocene series of coal-bearing terrestrial and marine sediments with a presumably thick underlying sequence of older Tertiary sediments and volcanics. Leakage area traversed by axis of broad anticline with a strike roughly normal to the course of Rock Creek, according to mapping by Oregon Department of Geology and Mineral Industries (1944-1948) and Harper (1946). Because of this, jointing probably serves as the escape channelways, and "dry" leakage may occur along anticlinal axis over a far greater distance than has been currently observed.

2. Selah Spring: On west bank of Pudding River near center of the SW$\frac{1}{4}$ sec. 5, T. 7 S., R. 1 W., Marion County. Consists of a solitary spring enclosed in a concrete tower erected years ago as part of bottling works project. Water stands in tower an estimated 2 feet above ground surface and escapes in small flow from cracks near ground level. Gas given off almost continuously in numerous small bubbles, but total yield is small, and water is only mildly carbonated by taste. Temperature 52° F. Spring issues from "older (Pleistocene) alluvium and terrace deposits" in area underlain by Tertiary sediments and volcanics, according to Piper (1942).

3. Sodaville Springs State Park: This spring is in Sodaville in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 36, T. 12 S., R. 2 W., Linn County. It is housed in the basement of an establishment originally erected as a commercial venture but now operated as a public fountain by the Parks Division of the State Highway Department. As the spring was padlocked and the Park Service was unable to furnish any analysis, all that can be stated here is that the water from a fountain spigot was cold and had a very strong carbonated taste. Several local residents report that strong soda water has been encountered in several wells drilled for fresh water elsewhere in the Sodaville area, but no further details can be given as the wells have been plugged. The Sodaville area as a whole is underlain by a presumably thick series of sediments and volcanics of Tertiary age, according to available geologic mapping by Piper (1942).

4. Waterloo Soda Springs: Two very small springs on opposite sides of South Santiam River 400 to 500 feet upstream from bridge at Waterloo, about center of the W$\frac{1}{2}$ sec. 28, T. 12 S., R. 1 W., Linn County. Reported as having been persistently flowing 20 years ago, but flow from each is barely a trickle now. Both springs issue from crevices in a Tertiary basalt and both are subject to flooding during periods of high water.

5. Cascadia State Park: This is an attractive park built around three natural soda-water springs located on the north side of South Santiam River at mouth of Soda Creek, in the NW$\frac{1}{4}$ sec. 32, T. 13 S., R. 3 E., Linn County. Original springs are now buried under a rock terrace and piped to spigots and to an open piece of culvert about 10 inches in diameter set vertically in the terrace floor. Observable flow is small and probably only a portion of that available. Gas is emitted continuously and at a fairly constant rate from the culvert pool in the form of an abundance of small bubbles. Pool temperature is 49° F. Gas and water samples taken at the time of examination were lost because of defective capping, but water can be described as having had an exceptionally strong carbonated taste. However the park caretaker reports that the CO_2 content varies, making the water almost too strong to drink at times. Much difficulty in the form of bottle

breakage due to gas pressure is reportedly experienced by those who attempt to bottle the water. Many small springs, observable only during periods of low water, are said to occur in the river bed in the vicinity of the park, with other occurrences at less frequent intervals all the way to Waterloo. Tertiary lavas constitute the bedrock in the park area but no data on structural conditions are presently available due to lack of detailed geologic mapping in the region.

6. Upper Soda Spring: A seepage from a nearly vertical bluff on the north bank of the South Santiam River, 300 to 400 feet below the mouth of Soda Fork and within 6 to 8 feet of river in the SE¼ sec. 26, T. 13 S., R. 4 E., Linn County. Stagnant water fills a small, three-compartment trough built against bluff but the seepage-moistened face of cliff represents the only observable source of supply at this now deserted relic of a spring site. Tertiary volcanic area.

7. Toketee Soda Springs: Four small springs and much related seepage in a small cove on north side of Toketee Falls - Glide road on North Umpqua River a quarter of a mile downriver from Soda Springs dam, in the southwest corner of the NW¼ sec. 17, T. 26 S., R. 3 E., Douglas County. One spring, situated on steep hillside along trail to Indian Caves, issues from a picturesque, mug-shaped travertine cone 30 to 35 feet in diameter at base, while others issue from bench-type deposits in cove bottom at base of hill. Aggregate flow is small. Temperature 55° F. Tertiary volcanic bedrock.

8. Umpqua Hot Spring: On north bank of North Umpqua River in unsurveyed area about 3 miles northeast of Toketee Reservoir, Douglas County. Hot water with a faint odor of sulphur and a questionable CO_2 content trickles from cracks and several very small circular craters in top of a travertine mound perched on steep valley side. Temperature 106° F. Tertiary volcanic bedrock.

9. McCallister Soda Springs: A picnic area in the Rogue River National Forest on the North Fork of Little Butte Creek, about at the center point of the NW¼ line, sec. 3, T. 37 S., R. 3 E., Jackson County. Principal spring issues from a concrete box with a pool area about 10 by 12 inches situated within a fenced enclosure adjacent to creek. A seepage zone in a brushy, cattle-trampled area extends upstream about 200 feet along creek bank. Both areas are subject to flooding during high water periods. Water has a strong carbonated taste and a temperature of 50° F. Bubbles of free gas given off constantly from spring pool but only sporadically in seepage zone. Volume small. Tertiary volcanic bedrock.

10. Dead Indian Soda Springs: Two soda-water springs in the channel of Dead Indian Creek a scant half mile above mouth, and a seepage near mouth, in the SE¼ sec. 22, T. 37 S., R. 3 E., Jackson County. The uppermost spring issues from crevices and a concrete-lined vent in an area of about 15 by 20 feet on the east bank of the creek. The second spring seeps from a small travertine mound about 500 feet downstream on the west bank. The seepage area at the creek mouth is 30 to 40 feet in length and occurs in the gutter of the logging road to Poole Mountain, just above bridge. Combined flow is small. Carbonic acid taste is only moderately strong, but strongest in uppermost spring. Temperature measurements range between 50° F. and 56° F. A constant but small discharge of gas at uppermost spring only. Tertiary volcanic bedrock.

11. White Sulphur Springs: On outskirts of Ashland in about the center of the W½ sec. 4, T. 39 S., R. 1 E., Jackson County. Hot water developed years ago for bath house and swimming usage. Principal source is one natural spring now confined within a rocked 10 by 10-foot enclosure and a drilled artesian well 150 feet deep. Gas given off continuously from 6-inch casing is reported to be CO_2, but odor indicates contamination by sulphur. Occurrence in area mapped by Wells (1956) as Umpqua (Eocene) sediments.

12. Lithia Springs: A chain of springs along Emigrant Creek principally in the SW$\frac{1}{4}$ sec. 7, T. 39 S., R. 2 E., Jackson County, about 3 miles east of Ashland. This is the site of the Gas-Ice Corporation's operation at which about ten producing wells drilled between 200 and 300 feet deep have yielded the production cited earlier. Drilled along an inferred fault in nonmarine sediments of the Umpqua formation (Eocene) with a 30° $\pm$ regional dip to the northeast. Normal flow no longer observable due to lowering of water level by pumping. Travertine present at some spring sites. The Umpqua formation contains no known limestone beds in the spring area but does contain coal and interbedded volcanics and is presumably underlain by an intrusive diorite which is exposed about 2$\frac{1}{2}$ miles from the spring area on both the southern and northwestern sides. If the CO_2 is migrating up the dip of the sediments to the fault zone, the originating source could be far to the northeast. Mapped by Wells (1956) and Schafer (1955).

13. Grizzly Soda Spring: Located in the northeast corner of sec. 7, T. 39 S., R. 4 E., Jackson County, but reportedly flooded by waters impounded behind diversion dam. Not visited.

14. Buckhorn Springs: A mineral-water health resort on Emigrant Creek near the center of sec. 12, T. 40 S., R. 2 E., Jackson County. Consists of a drilled well on one bank of the creek and a bath house constructed over a natural spring on the opposite side, with a strong gas leakage from the creek bed in between. Travertine exposed in cut behind bath house. Carbonic acid taste is strong. Free gas discharge is constant and many times more vigorous than that seen at any other spring in the State. Volcanic flows of the Roxy formation (Oligocene?) constitute the prevailing bedrock in the area. Two major faults intersect near the spring area according to mapping by Wells (1956).

15. Soda Spring: On Jenny Creek in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 8, T. 40 S., R. 4 E., Jackson County. Not visited.

16. Severance Soda Springs: Two areas of gas discharge in an isolated canyon of the South Fork of the Crooked River near the common western corner between secs. 24 and 25, T. 18 S., R. 22 E., Crook County. Both springs issue from discharge points in the river bed and are manifest only by chainlike strings of rising bubbles. The largest area, and also the one with the greatest density of discharge points, measures roughly 8 by 50 feet. This parallels the western bank of the river. The second area is approximately 300 feet upstream, and also on the west bank except for a narrow line of leakage that runs diagonally across the river to the opposite bank. Discharge takes place continuously in both areas but varies greatly with bubbles issuing at times from comparatively few discharge points in each area, while at other times they issue simultaneously from a great number of places. One very small seepage of weak, undoubtedly diluted, soda water issues from bank at upstream area. Temperature here measured 58° F. Abundance of plant life in main spring areas suggests discharge of warm water to river. "Dry" leakage probably present on banks. Volcanic tuffs of Tertiary age constitute bedrock in canyon.

17. Bernard Ranch Springs: Principal spring is a locally well-known landmark on Camp Creek in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 23, T. 17 S., R. 25 E., Crook County. Spring issues from bottomless 10-gallon crock located on the north bank of creek about one foot above water level. Spring water temperature 48° F. Contains 2.2 volumes CO_2 per volume H_2O at 25° C. Sporadic, light output of gas observable in spring and at random places in creek over a distance of 75 feet. Tested 72 percent CO_2; 3 percent O_2, and 25 percent N_2. Spring area underlain by Cretaceous sediments. Three small, essentially dormant seepages occur near the Bernard residence in the E$\frac{1}{2}$ sec. 11. One yields palatable water with a mild carbonated taste. Other two are undrinkable, strong in sulphur, and have thin, eroded travertine shelving.

18. Weberg Springs: An 80-acre tract of seepages and springs in bottom land adjacent to Warm Springs Creek, in the S½ sec. 18, T. 18 S., R. 26 E., Grant County. Two natural springs and a drilled well flow from a low travertine mound on the margin of meadow farthest removed from creek at point where valley-fill alluvium thins out to expose bedrock. Intervening meadow contains approximately 25 boggy seepage areas and small springs and is underlain, at least locally, by travertine. Yield at flowing springs small but steady. Water temperature 116° F. and 122° F. Temperature at well 60 feet from hottest spring is 108° F. Temperatures in springs in meadow range downward to 85° F. and undoubtedly reflect dilution by cold ground water. Gas given off continuously and fairly vigorously from both flowing springs and the drilled well and from a nearby cluster of springs in meadow below where sediment mantle is thinnest and back pressure of contained ground water is least. Additional discharge also noted at ten to twelve spring sites elsewhere in meadow but this is spasmodic and becomes progressively less to point of vanishing in portion of meadow nearest creek, where sediment mantle is thickest, ground water saturation greatest, and escape impeded the most. Analysis shows water from hottest spring to contain 1.8 volumes CO_2 per volume of H_2O at 25° C. The gas contains 64 percent CO_2; 5 percent O_2; and 31 percent N_2. Bedrock in spring area mapped by Lupher (1941) as Colpitts formation of Middle Jurassic age. The Colpitts is composed of limestones, sandstones, and shales. Jurassic section probably underlain by Paleo-Triassic section with similar lithology.

19. Silver Creek Springs: In the SW¼ SW¼ sec. 25, T. 19 S., R. 25 E., Harney County. Silver Creek flows directly over spring but minor soda water discharge is observable on both banks to maximum height of one foot above August water level. Only moderately carbonated by taste. Temperature 58° F. Gas discharged weakly at numerous places in both springs. Two dormant springs nearby on west bank and a small, near-dormant seepage 100 feet downstream suggest spring area is in dying-out phase. Exposed bedrock at east bank spring is highly vesicular Tertiary basalt.

20. Brisbois Ranch Springs: Several small springs, several nearly dormant seepages, and a few dormant springs occur at intervals for about 3 miles through the E½ secs. 13 and 24, and the N½ sec. 25, T. 17 S., R. 27 E., Grant County. Located along Dry Soda Creek, which flows south to South Fork of John Day River, and along Brisbois Gulch, which flows northeast, entering River a quarter of a mile downstream from Dry Soda Creek. Travertine present as shelf of very restricted size at most sites, but in larger quantity near mouth of Brisbois Gulch where it occurs: (1) as prominent cone on hillside a quarter of a mile southwest of River, (2) in deeply eroded creek channel directly below hillside cone, and (3) on north bank of River above creek mouth. Largest spring located by River. Water temperature is 72° F. Contains 79 percent CO_2; 3 percent O_2; and 12 percent N_2. Yields gas containing 3.0 volumes CO_2 per volume H_2O at 25° C. Similar analysis obtained for water and gas samples from spring on hillside cone. Water temperatures in other springs range downward to 56° F., and several show no associated discharge of free gas. However, free gas is given off persistently from River bed at several places over a distance of about 500 feet and is especially prominent in pool adjacent to the river-bank spring described above. Re-examination of area after prolonged rain when ground was saturated and puddles lay on surface showed "dry" leakage to be widespread in River area and even present in roadbed (old road) adjacent to the site of two very small, dormant springs located in the S½ SW¼ SE¼ sec. 24. Bedrock composed of upper Triassic sediments with calcareous members and limestones. Springs are located at northeastern end of the Mowich anticline according to mapping by Wallace and Calkins (1956).

21. Wickiup Camp Soda Spring: Near the northern quarter corner of sec. 10, T. 16 S., R. 29 E., Grant County. Shown on older Forest Service maps but not on recent ones. Spring issues

from bed of Wickiup Creek and reportedly had strong flow 20 years ago. Perceptible now only as a seepage on bank during periods of low water. A few float fragments of travertine in soil above bank. Location is near contact of Triassic-Jurassic sediments, as mapped by Wallace and Calkins (1956).

22. Seneca Soda Springs: On Silvies River, 2.4 miles by road south of Seneca and about on the line between the S½ secs. 11 and 12, T. 17 S., R. 31 E., Grant County. Two springs in meadow on east side of River and one on west bank adjacent to railroad tracks. Reportedly a much-used source of soda water during Prohibition days, but now unkept and with negligible flow. Temperature of the east bank springs 58° F., and 60° F. Travertine present but exposed only around the spring orifices. Otherwise springs issue from a veneer of recent stream sediments underlain by sediments of Jurassic age (Lupher, 1941).

23. Unnamed spring: On steep hillside above the East Fork of Canyon Creek in the NW¼ sec. 29, T. 15 S., R. 32 E., Grant County. Issues with weak flow from a large, bottomless pottery crock cemented in what was originally a natural discharge vent in a thin travertine shelf. Temperature 48° F. Bedrock of Triassic sediments (Thayer, 1956). Other small flows of soda water reportedly present at intervals in the bed of main Canyon Creek above East Fork junction, but observable only when the creek is nearly dry.

24. Limekiln Spring: On Indian Creek in the N½ sec. 10, T. 14 S., R. 33 E., Grant County. One well-defined spring and two boggy seepage areas in a 6- to 8-acre tract of travertine deposited in a sheet on older creek sediments. Water temperature 70° F. Only 0.16 volumes of CO_2 per volume of H_2O by analysis. A consistent but very light gas discharge which tested 94.5 percent N_2 and only 1.5 percent CO_2. These analyses show that a CO_2 content is not always found in travertine-rimmed springs. Spring area located on the contact of a large area of Triassic peridotite, but separated from it in part by a thin wedge of Eocene volcanics. Bounded on the opposite side by Miocene basalt. Mapping by Thayer (1956) shows a major fault along the base of Canyon Mountain passing through the spring area.

25. Unnamed spring: Small travertine deposit with minor seepage, on the north side of the Collins road in sec. 5, T. 7 S., R. 43 E., Baker County. Reportedly a "soda" spring but placarded "Poison". Bedrock of Triassic clastics and limestone.

26. Unnamed spring: On the south bank of Goose Creek, in the NW¼ NE¼ sec. 15, T. 7 S., R. 43 E., Baker County. Moderate soda-water taste. Discharges from creek alluvium underlain by Clover Creek greenstone of Permian age according to mapping by Ross (1938).

27. Fizz Spring: In small gulch on northeast side of Little Eagle Creek near southwest corner of NW¼ sec. 30, T. 7 S., R. 45 E., Baker County. Small seepage from cattle-trampled spring issuing from Tertiary basalt near exposure of Permian greenstone (Ross, 1938).

28. Soda Creek Spring: Now flooded by water of Brownlee Reservoir but formerly on a bluff above west bank of Snake River in NE¼ sec. 19, T. 11 S., R. 46 E., Baker County. A prominent slightly radioactive (thorium) travertine cone. Reportedly discharged soda water and free CO_2. Steeply dipping bedrock of Permo-Triassic slates close to limestone contact according to Livingston (1923).

29. Nelson Hot Springs: Above west bank of Burnt River in SE¼ NW¼ sec. 11, T. 12 S., R. 43 E., Baker County. Eroded remains of several travertine deposits surmounted by large, recent cone with near-dormant spring in crater on summit. Underlain by steeply dipping

Triassic(?) schists and limestone and Tertiary basalt dikes. Area now occupied by office and shop section of crushing operation for limestone quarry owned by Oregon Portland Cement Company.

30. Mud Spring: At foot of a travertine bench in sec. 29, T. 20 S., R. 45 E., Malheur County. Described by Washburne (1911) as a spring with a pool surface about 15 feet in diameter from which "an odorless, inflammable gas escapes copiously" in a "constant and extremely vigorous" manner. The water was described as "62° F. and drinkable, having only a slightly salty taste". Examination revealed that water yield was still substantial but that gas output is today negligible to the point of being almost nonexistent. Area mapped by Corcoran as occupied by Chalk Butte member of upper Idaho formation of Pliocene age. Chalk Butte formation composed of loosely consolidated sediments with occasional limestone lenses.

Geologic significance of Oregon's springs and seepages

Although all seepages of any of the "mobile minerals"; namely petroleum, natural gas and ground water, reflect a subsurface source of the escaping material, seepages do not constitute a yardstick for appraising the development potentialities of the area in which they occur. There are several reasons for this. One is that a seepage can represent the tail-end dregs of discharge from a nearly depleted source just as much as it can represent overflow from a source that is loaded to capacity. Second, a seepage can originate from a source of very modest proportions as readily as it can from a large source. Third, in the instance of gases, it is possible under some circumstances for generation and seepage to occur almost simultaneously so that the observable output of gas at discharge sites would constitute approximately the maximum amount ever available. Finally, the size of a seepage does not constitute a reliable criterion for judging the size of the subsurface body of the escaping material because the rate and extent of seepage are regulated primarily by the size and nature of the escape channels rather than the size of the source.

Despite the importance of seepages as indicators, the fact should be kept in mind that wholly concealed accumulations of CO_2 can also occur in areas where no seepages are known. The chief value of seepages is that they alert an interested observer to the fact that subsurface occurrences of the seeping material can be anticipated in the general area. Beyond this, the task of evaluating the commercial potentialities of an area entails studies of the structural and stratigraphic factors normally recognized as essential to the subsurface storage of fluid materials. Such study may even entail exploratory drilling.

On the basis of available information, the CO_2 springs and seepages described in the previous section can be briefly appraised. Some of the springs have a geologic setting that is clearly negative insofar as commercial potentialities are concerned. For some spring areas the geology is not well enough known to warrant any conclusion as to the value of the occurrence. There are four areas in the State, however, where the geologic setting suggests that additional study may be worthwhile. These areas are: (1) the axis of the anticline in the vicinity of Wilhoit Springs, (2) the South Santiam River area in the vicinity of Sodaville and Cascadia State Park, (3) the Emigrant Creek area between Ashland and Buckhorn Springs, and (4) central Oregon in the vicinity of the Weberg and Brisbois ranches.

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NORTHWEST MINING ASSOCIATION OUTLINES SPOKANE SESSION

Big names in mining are on the varied program for the Northwest Mining Association's 65th annual convention December 4-5 in Spokane. They include:

E. I. Renouard, vice president in charge of western operations for the Anaconda Company, who will discuss his firm's operations at "the richest hill on earth" in Butte, Montana. Renouard was national program chairman for the recent American Mining Congress convention in Denver.

Bruce W. Gonser, technical director for Battelle Memorial Institute, Columbus, Ohio, who will report on "New uses for old metals." During his 25 years at Battelle, Gonser has initiated and guided much of the research which has contributed so greatly to the Institute's stature in the field of nonferrous metallurgy. He also is the author of more than 100 published articles and papers.

Howard I. Young, St. Louis, president of American Zinc, Lead & Smelting Company, who will tell of the big new zinc deposits opened by his firm in Tennessee. Young was president of the American Mining Congress for many years.

John D. Bradley, San Francisco, president of the Bunker Hill Company, who will discuss the Kellogg, Idaho, firm's position in the lead-zinc industry and its future plans. Bradley also is chairman of the board and president of the National Lead Industries Association.

The Honorable W. K. Kiernan, British Columbia Minister of Mines, who will discuss the province mining outlook.

Franc R. Joubin, discoverer of Canada's famed Blind River uranium field and now president of Bralorne-Pioneer Mines, Ltd., with headquarters at Vancouver, B. C., who will talk on "A Canadian producer looks at gold."

R. R. McNaughton, Trail, B. C., manager of metallurgy for Consolidated Mining & Smelting Company of Canada, who will report on Cominco's operations. McNaughton is slated to move up to presidency of the American Institute of Mining, Metallurgical and Petroleum Engineers in 1961.

The program, prepared under the direction of Frank C. Armstrong, Spokane geologist with the U. S. Geological Survey, will be mailed to NMA members in about 10 days. It lists 34 speakers in eight sessions, compared to 32 speakers in seven sessions last year.

In addition to a general opening session, sessions on metallurgy, economics of metals, new developments, mining and government, exploration, mine operating, and geology are scheduled. (From The Wallace Miner, November 12, 1959.)

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GROWNEY ELECTED PRESIDENT OF RAW MATERIALS SURVEY

Louis P. Growney, Industrial Development Engineer for Pacific Power & Light Company of Portland, has been elected president of the Raw Materials Survey Board. Growney has been a Survey director for the past six years. Raw Materials Survey, which was established in 1947, investigates sources of raw materials that appear feasible for profitable use by industry in the Lower Columbia River Basin.

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PACIFIC CARBIDE TO MAKE VINYL ACETATE

Pacific Carbide & Alloys Company of Portland has started construction of a half-million-dollar plant to produce vinyl acetate, a basic chemical product. The acetate will be made from acetylene manufactured by Pacific Carbide and acetic acid obtained from the Gulf states. The major market for the acetate will be California, but eventually it is hoped that local markets will develop.

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NEWCOMB TO STUDY HYDROLOGY OF COLUMBIA RIVER BASALT

Reuben C. Newcomb, formerly District Geologist, U. S. Geological Survey Ground-Water Branch in Portland, has accepted the position of Research Geologist for the Ground-Water Branch in a 5-year research project on the hydrology of the Columbia River basalt. Mr. Newcomb reports that the project is intended to further the public information on the ground-water resources and general hydrologic aspects of the Columbia River basalt. The project will include the entire 55,000 square-mile area in Oregon, Washington, and Idaho occupied by this extensive volcanic unit. Mr. Newcomb states:

> "The main objective of the study is to determine and describe the water-bearing characteristics of the basalt and the allied features of significance to the occurrence and development of these ground-water resources.
>
> "A preliminary paper on the ground water in the basalt has been published in Northwest Science. A plan for development and use of ground water reservoired behind fault barriers is now in preparation. Other sub-units of the project concern the effect of tectonic structures on the occurrence of ground water, the quantitative factors that govern the ground-water movement and the extraction of water through wells, erosion of the basalt in The Dalles type of river channel, and the construction of wells in the basalt."

Mr. Bruce L. Foxworthy, former acting District Geologist of the Tacoma office, is the new District Geologist in Portland.

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STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland 1, Oregon
Telephone: COlumbia 2161, Ext. 488

Field Offices

2033 First Street 239 S.E. "H" Street
Baker Grants Pass

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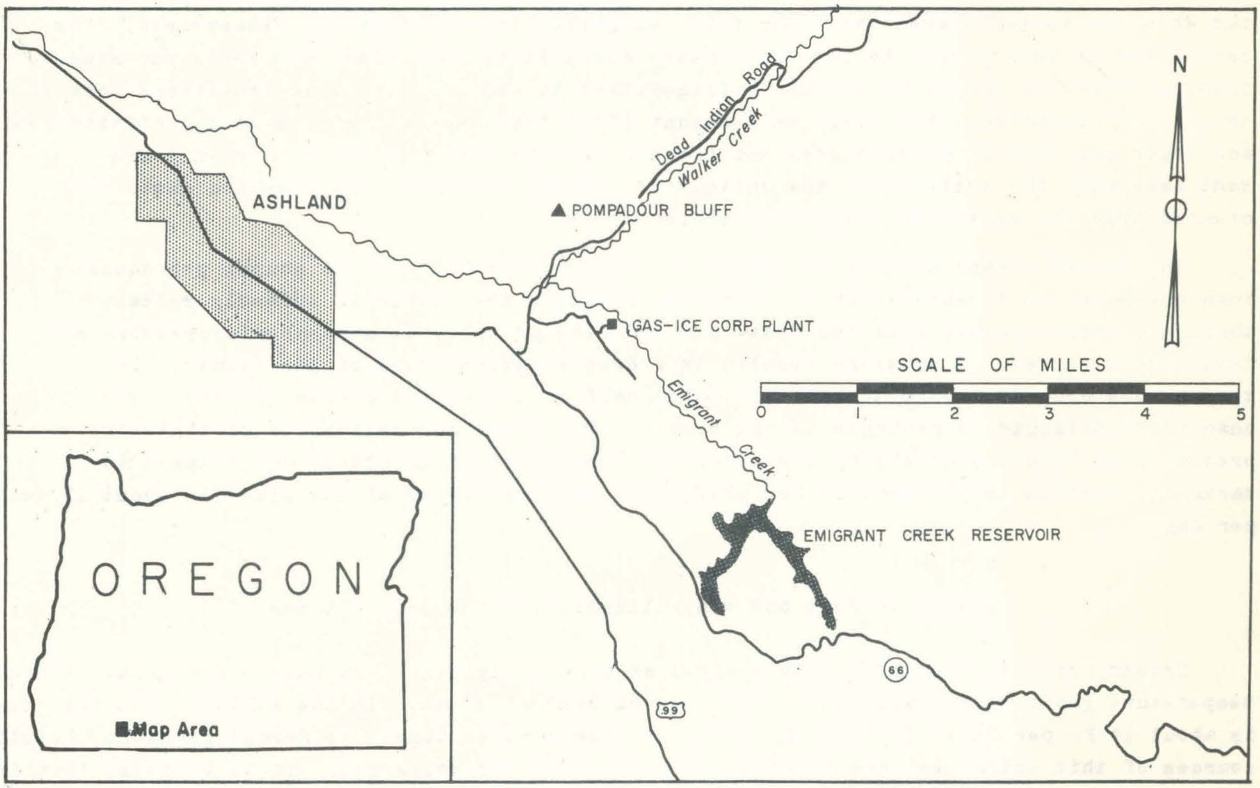
OCCURRENCE AND UTILIZATION OF CARBON-DIOXIDE-RICH WATER NEAR ASHLAND, OREGON

By
Max Schafer*

Introduction

Natural carbon-dioxide gas for the manufacture of solidified carbon dioxide (dry ice) is one of Oregon's lesser-known mineral products. Southeast of Ashland, Gas-Ice Corporation, whose headquarters are in Seattle, Washington, has an operation that obtains carbon dioxide from ground water in such quantities that in 1952 (latest U.S. Bureau of Mines figures) Oregon was the third-ranking state in the nation in the value of this product. The Ashland plant is the only one in the State that produces natural carbon dioxide. Portland Gas and Coke Company manufactures a liquid carbon dioxide scrubbed from flue gases.



Index Map

Reportedly the dry-ice industry came into being because of a British surgeon's liking for soda water with his Scotch whiskey. At his station in India, natural carbonated water, which came for the most part from Vichy, France, was often hard to come by. Through experimenting he was finally able to produce solidified carbon dioxide with which he could carbonate tap water, and he was happily assured of a steady supply of soda water. This use of dry ice for soda water is still important, although the refrigerating uses have since far surpassed it. Almost all "soda pop" and soda water is artificially carbonated with dry ice at the bottling plants.

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* Geologist, State Department of Geology and Mineral Industries.

The long-distance transportation of perishable foodstuffs and frozen foods accounts for the greater part of the dry-ice market today. Packing of ice cream containers with dry ice is a common practice. Fruits and vegetables can be transported for days with dry ice because of the slowness in loss of the ice and also because they seem to keep better in an atmosphere of carbon-dioxide gas. An advantage of dry ice is that it "sublimes" or goes directly from a solid to a gas, unlike regular ice which melts to water. Foodstuffs packed with dry ice can be sent through the mail because of this desirable characteristic. The future of refrigeration for the dry-ice industry is threatened because of the increasing use of ammonia- and freon-refrigerated railroad cars and trucks.

Operation of Gas-Ice Corporation's Ashland Plant

The Gas-Ice Corporation plant and wells are located about 3 miles southeast of Ashland on the west side of Emigrant Creek in the SW$\frac{1}{4}$ sec. 7, T. 39 S., R. 2 E. (see index map).

The plant has ten wells from which carbon-dioxide-rich water is pumped. Most of the wells are from 200 to 300 feet deep and bottom in a shale layer of the Umpqua (?) formation. Total production of water from the wells is about 1000 gallons per hour. Water from the wells is pumped into a separator, a tank with a pipe at the top and an outlet at the bottom. The gas bubbles rise to the top and are drawn off to the plant. The water flows out through the bottom of the tank and is diverted to the stream.

The gas pumped from the separating tanks enters a cooler and dehumidifier where the moisture is removed. Formerly some sulphur was present, necessitating a charcoal filter but when the wells lowered the water table slightly, this contaminant disappeared. The cooled gas is then pumped to the "condenser" where it is put under 500 pounds per square inch pressure and cooled by ammonia refrigeration to -10° F. At these conditions most of the gas is liquefied. The very small amount (less than one-half of 1 percent) of nitrogen and argon gas that is present does not liquefy at this temperature and pressure and is sent back into the system with the unliquefied carbon dioxide. The unwanted gases are cleaned from the system at regular intervals.

The liquid carbon dioxide is pumped to the "receiver" under 150 pounds per square inch pressure and at about -40° F. From the receiver the liquid is suddenly released through a small opening into the "snow press." The press is at atmospheric pressure and this sudden release of pressure results in a drop in temperature of the liquid. The temperature drop is enough to solidify about half of the liquid carbon dioxide. The unsolidified liquid is returned to the system. The "snow" or solidified particles are pressed into 80-pound blocks by the hydraulic "snow press," and these are wrapped in cardboard cartons in preparation for shipment. The production of the plant is about 10 tons per day.

Source of Heat and Mineralization of the Ground Water

Ground water in the Ashland area shows an abnormally high temperature gradient. Normal temperature gradient is about 1° F. rise per 80 feet of depth. In the Ashland area the rise is about 1° F. per 25 to 30 feet of depth, or nearly three times the normal gradient. Possible sources of this extra heat are friction from faulting and volcanism. It is believed that in the Ashland area faulting merely provides the conduits for the heated water while a cooling magma is the source of the heat.

Some of the wells and springs in the Ashland area contain unusually high concentrations of lithium, carbonate, chlorine, and sulphur, and show a predominance of carbonate over calcium and a low calcium-magnesium ratio. According to studies that have been made by Winchell (1914), White and Brannock (1950), and Behre and Garrels (1943) these are characteristics of waters from a volcanic environment. Minerals in ground water can be derived from solution of the rock penetrated by the water and from volcanism. Since no limestone or salt deposits are known to occur in the Ashland area from which the concentrations of minerals found in the waters could be derived, it seems likely that the minerals emanated along with fluids escaping from cooling magma. Only a small fraction of the water is likely to be of volcanic source. Most of it is probably deep meteoric water which has been returned to the surface.

Volcanism has taken place on a large scale and in relatively recent times in the Cascade Range, and this activity, although dormant at the present time in Oregon, is without doubt responsible for the heating and mineralization of the Ashland waters.

Geology of the Area

General

The region near the wells is hilly with a relief of about 600 feet. Emigrant and Walker creeks flow across the mapped area (see geologic map opposite page 51) and are tributary to Bear Creek. All are part of the Rogue River drainage system. Pompadour Bluff is the most prominent topographic feature near the wells. Briefly the regional geology is as follows: To the west, metasediments and metavolcanics of the Triassic Applegate formation are intruded by granodiorite of the Ashland stock. Marine sandstones of the Cretaceous Chico formation unconformably overlie the Triassic rocks and the granodiorite. Lying unconformably on the Chico formation is the Eocene Umpqua formation which in this area is a series of nonmarine sediments and volcanic rocks. To the northeast, Tertiary lavas and pyroclastics of the Western Cascades overlie the Umpqua rocks. The Umpqua formation and the Tertiary volcanics are intruded by basalt and diorite sills and dikes. Remnants of recent volcanic flows are present northwest of Medford.

Geologic units

Umpqua formation

The oldest rocks that crop out in the mapped area are the nonmarine sediments and volcanics of the Eocene Umpqua formation. The Umpqua formation has been subdivided in this report as follows:

Undifferentiated sediments: Sandstone is the predominant material in the undifferentiated sediments. It ranges in color from greenish-gray to buff and contains varying amounts of quartz, feldspar, mica, and volcanic glass fragments. The sandstone usually does not form prominent outcrops except where conglomerate lenses are present, as in Pompadour Bluff. Beds range in thickness from 1 inch to 10 feet. Coal has been found in shale of the undifferentiated sediments. On the east side of Emigrant Creek across from the dry-ice plant is the abandoned shaft of the Ashland coal mine. Parks and Swartley (1916) reported a good grade of sub-bituminous coal that attained a width of 6 inches and contained coaly shale separations.

Shales and siltstones: The shales and siltstones are fine-grained equivalents of the coarser sediments except that mica is usually absent. These rocks are usually finely interbedded with sandstone and the layers are generally less than 6 inches thick.

Conglomerates: Boulders and cobbles as much as 6 inches in diameter are contained in a sandstone matrix that ranges from medium to coarse. The boulders are of quartzitic and metamorphic material and are usually present in soil developed on the Umpqua formation. The conglomerates thicken and thin noticeably within a very few feet.

Tuffs: Two layers of tuff, made up of quartz and volcanic glass, were found in the area mapped. One of the layers is a flaggy, white tuff that contains carbonized plant fragments, apparently the remains of stems or limbs.

Andesite flow: An andesite flow, conformable within the Umpqua formation, is present on the east side of Emigrant Creek near the dry ice plant. The flow is porphyritic, containing phenocrysts of feldspar, and ranges in color from gray to buff. A crude columnar jointing is developed.

Tertiary volcanics

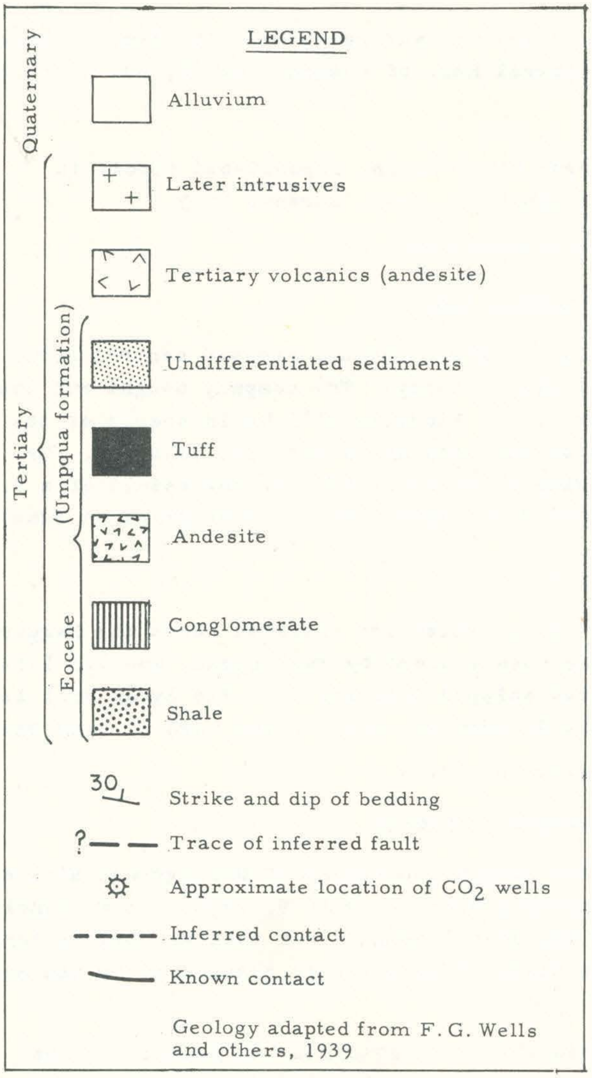
The northeast corner of the mapped area is underlain by flows of dark gray andesite. These flows often show a well-developed columnar jointing. The columns are 1 to 2 feet wide and are broken up approximately every 2 inches by fracturing parallel to the surfaces of the flow.

Later intrusives

Two exposures of diorite which may represent a single body are shown on the map. In the field the outcrops form knobs and the soil is a dark reddish-brown that is easily distinguished from the dull, dark gray of the soil developed on the Umpqua formation.

Alluvium

Stream deposits have been laid down in recent times by Walker and Emigrant creeks. These unconsolidated sediments are composed of sand, gravel, silt, and boulders. The larger material is well-rounded and includes many boulders from the Umpqua conglomerates.



Structure

The sediments and volcanics of the Umpqua formation and the Tertiary volcanics have a regional dip to the northeast. Folding and faulting occurred after the Tertiary flows were extruded. Later intrusives are probably younger than the faulting.

A fault has been plotted on the map along Emigrant Creek. Lack of continuity of beds across the creek, the occurrence of the hot water wells along the creek, and the drainage pattern are evidence for the fault. Young (1953) plotted a fault along Emigrant Creek southeast of the mapped area.

Acknowledgement

The author wishes to express his gratitude to Mr. C. E. Smith, manager of the Gas-Ice Corporation plant, for information and assistance given.

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EASTERN OREGON MINING NEWS

The Comstock Uranium-Tungsten Company, Inc., of Elko, Nevada, assumed control April 1, 1955, of the lease on the Haggard and New mine, Grant County. The company bought out the Burt Hayes interest in the lease last fall. Mr. J. J. Kinsella will be in charge of the Comstock Company's work and the Oregon address of the company is Box 416, John Day. Mr. Kinsella reports that the company has started driving a low-level adit as the result of a drilling program which indicated extension of the ore body with depth. The company plans to examine other chromite properties in the area.

* * * * *

Work on the Mott, Spider, and Last Chance claims which are situated above the Haggard and New property on Dog Creek, Grant County, has been resumed by Earl Lyman, and two lots of development ore have been milled and concentrates shipped this season. The Lyman mill is located on Dog Creek about a mile south of State Highway 26, east of the town of John Day.

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DOLE APPOINTED DEPARTMENT DIRECTOR

Hollis M. Dole was appointed Director of the Oregon Department of Geology and Mineral Industries at a meeting of the Department's Governing Board on July 9, 1955. In announcing the appointment, Mason L. Bingham, Chairman of the Board, pointed out that Mr. Dole's long residence and wide geological experience in the State of Oregon were considered by the Board as important factors in its choice.

Mr. Dole has been a resident of Oregon since 1917. He obtained his bachelor's and master's degrees from Oregon State College, and completed scholastic requirements for a doctorate degree at the University of Utah. Dole has been with the Department since 1946. In August 1954 he was made Assistant Director and in November of the same year, at the retirement of F. W. Libbey, was appointed Acting Director.

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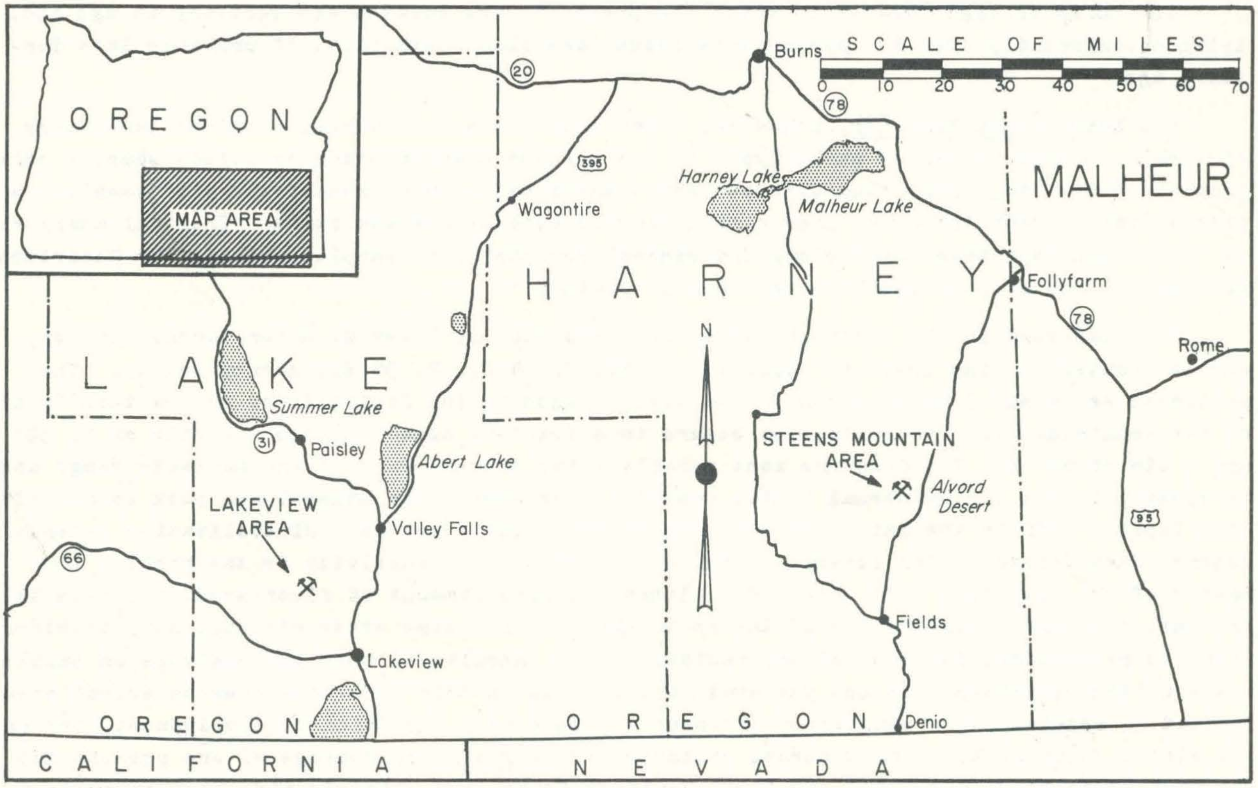
COMMERCIAL URANIUM DEPOSITS FOUND IN OREGON

Discovery of commercial-grade uranium deposits in two separate localities (see index map) in Oregon during June has recently been announced. Examinations of the prospects by geologists of the State of Oregon Department of Geology and Mineral Industries confirmed the presence of secondary uranium minerals and high radioactive anomalies in the areas of the prospects. Preliminary development indicates that both localities are capable of furnishing some tonnage of ore.



Index Map

Deposits near Lakeview are located on Augur Creek in sec. 30, T. 37 S., R. 19 E. and in sec. 25, T. 37 S., R. 18 E. The area is approximately 14 miles northwest of Lakeview in Lake County. The original discovery was made on claims of the White King group by John Roush and Don Tracy, Lakeview. The early development work on these claims shows that a fluorescent, yellowish-green mineral thought to be autunite and a bright green, nonfluorescent mineral which may be torbernite are the principal uranium minerals. Associated minerals are mercury sulphide (cinnabar) and arsenic sulphides (realgar and orpiment). The host rock is volcanic tuff that has been silicified and altered. In places it is banded and is similar to opalite, a rock consisting of a mixture of chalcedony, quartz, and opal. Flaky crystals and masses of autunite fill fractures in the brittle opalite, and irregular disseminations of torbernite and autunite are found in the clayey, altered tuff. Occasionally a bright-green mineral, torbernite (?), is found as bladed aggregates in the form of rosettes, which may be as much as half an inch in diameter, and as small rectangular crystals. The mercury and arsenic sulphides occur as small irregular streaks and crystals in the host rock. Northwest-trending fractures cut the rocks of the exploration pits and may possibly control the mineralization. The exploration to date indicates an outcrop width of about 100 feet, and high radioactive anomalies are found along what is thought to be the strike for at least 300 feet. No definite uranium mineral is found in the pits until a depth below the soil zone of a foot or more is reached.

Less than 1 mile northwest of the White King claims another occurrence of autunite-torbernite is being opened up by a group from Lakeview headed by Bob Adams, Jr. The prospect, known as the Lucky Lass, is in a weakly sheared zone in an altered lithic-lapilli tuff or agglomerate. The sheared zone as exposed in the only cut opened at the time of visit is approximately 8 feet wide and trends northwest. Length and depth of mineralization is unknown. The predominant mineral visible is powdery or flaky and when freshly exposed is grass-green in color. Under the ultraviolet lamp the claylike rock shows bright yellowish-green fluorescent spots scattered through it. A soil zone three to four feet thick blankets the deposit. The discovery was made in a small cut in a logging road.

The tuffs or agglomerates in which the prospects are located are Tertiary in age and, lying unconformably over the pyroclastic rocks, are black lava flows of probable late Tertiary age.

The Lake County Examiner, Lakeview, reports that the U.S. Bureau of Mines laboratory at Albany, Oregon, obtained an analysis of 1.3 percent uranium oxide on select samples taken from the White King claims and 0.66 percent uranium oxide on a "run-of-the-pit" sample. A pit-run sample from the Lucky Lass claims ran 0.7 percent uranium oxide. Chemical analyses by the Oregon Department of Geology and Mineral Industries on samples obtained by Department geologists from both groups have not been completed.

The discovery in the Steens Mountain area was made by Dewey M. Quier, Burns, Oregon, and is located on Pike Creek in secs. 17 and 20, T. 34 S., R. 34 E., Harney County. The prospects are about 3 miles south of the Alvord Ranch in the foothills of the eastern front of the mountain. The mineralization occurs in a fracture zone that has a strike of S. 30° W. and a dip of 60° E. The fracture zone parallels the eastern face of the mountain range and is apparently one of the normal faults common to the area. The mineralized rock is a silicified lapilli tuff in the late Tertiary Pike Creek volcanic series. Mineralization extends outward from fractures for several inches and where the radioactivity is the highest the matrix of the rock is a dull dark red. Although a minor amount of fluorescent autunite is present, the high radioactivity of the rock suggests that some other mineral, as yet unidentified, is responsible for most of the radioactivity. Results of chemical analyses on samples taken by the Department are not yet available but radiometric determinations on select pieces indicate a uranium oxide equivalent of about 0.5 percent. Insufficient development work on the claims does not allow an accurate estimate of the grade and tonnage of ore present but the high radioactive anomalies and float boulders found over a fairly wide area indicate a substantial quantity of ore may be present.

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SALEM HILLS BAUXITE BEING EXPLORED

Aluminium Laboratories Limited, a Canadian organization, is exploring the bauxite of the Salem Hills in Marion County, Oregon. Exploration is being done by four drill rigs under the supervision of company geologists. Mr. H. R. Hose, Chief Geologist of Aluminium Laboratories Limited, is in charge of the exploration work and Salem Sand and Gravel Company is doing the drilling. Samples are being tested at the company's laboratories in Arvida, Canada. Description of the area under investigation was published in the September 1954 and April 1955 issues of The Ore.-Bin.

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TWO NEW PERMITS TO DRILL ISSUED

Drilling Permit No. 12 was issued July 22, 1955, to Oroco Oil and Gas Company, 2 North 8th, Payette, Idaho, to drill in the SW¼ sec. 16, T. 18 S., R. 47 E., Malheur County. The lessor is J. D. Lane, Ontario, Oregon.

Drilling Permit No. 13 was issued July 26, 1955, to Sinclair Oil and Gas Company, 1010 Broadway Building, Portland, Oregon, for a test east of Jamieson, Malheur County. Drilling Permit No.13 takes the place of Permit No. 10 which was issued to R. N. Ranger, 1007 Broadway Building, Portland, Oregon. The test is in the SW¼ sec. 15, T. 16 S., R. 44 E. The lessor is Eastern Oregon Land Company, San Francisco, California.

****

Gas trapped from well-water
Refridgerated with ammonia &
600lb pressure to liquid then
put into "snow" machine + pressed.

1722 cu. ft. CO_2 to make
80' ice.

500-550 psi to 150 psi
in press to make snow

Sulphur above 100' down
None now
CO_2 gas clean but cooled
& dehumidified.
Nitrogen goes off after
liquif because it won't
liq.
liquif -50°F, 500 psi
to reciever 150 psi,
-40°F. To press at
no pressure. About
50% to gas, 50% to
solid snow.
Pressed to 80 lb. cakes

Flowing in 1945 springs

When S present, charcoal
filters cleaned gas.
No used now.

10 T production normal.
14 T tops.

\$45 / T in Portland.

1000 gal / hr approx.

Well water 70°F

C. H. Smith mngr.

Wells about 300' in shale.
need pumps.

Have argon

Analysis 1915

milligrams / liter

Na Cl	4515
Na Metaborate	521.3
Na Sulphate	3.9
Na Bicarb	2456
K Bicarb	279.5
Li "	153.8
Ca "	1404.
Mn "	1153.
Fe & Al Oxides	12.5
Silica	94.9

3" vacuum on gas separator

Gas - Ice

1 ~~Pebble~~ Boulder (2") congl. Bedding N55W, 25NE
12' thick. Some frag. 8". Qtzte
boulders in cg ss.

2. 50' along stream bed. V c-g ss.
Massive. Tan to buff.

3. Flaggy & massive m-f-g ss
buff to tan with some cg
1' thick in lower parts of
section. Bedding N40W, 35NE.
Cg layers in massive ss?

4. Tuffaceous ss & sh. ss. Bedding
N60W, 35NE. From top of
ditch @④ 100' SW cg with
some tuff. No good bedding
N40W, 15NE? Sample

5. Lt brown tuff & rhy flow? Runs
NW.

6 Whole area with Typical M-Cg ss
of Tea. Some qtzite pebble
float.

7. Black m-g igneous rock - basalt, or d
Looks like sill, Sample

8 Top of hill. still on sill (dia?)
Trending toward Pomp Bluff.
N30W? 18° NE? Not good.

9 Dip on sill N30w, 20 NE. Pretty
good thin ss between 8+9

lg. rock gives a brown soil
typical of basalt soils.

10 ctc - ss below - dio. above
SS soil duller brown or
gray-brown. Dio. soil darker
brown slightly reddish.

SS below ctc is m-g clayey
lt. tan in color.

Sills show a good columnar
structure - col. abou 1-2'
Cleavage(?) ll to bedding every
2-6"

11 Sample of some kind of rock looks intru. contact highly indefinite.

12 SS etc. MCg ss with qtz & mica, feld.

13 Bedding N50W, 35NE

14. Tuffaceous ss & cg (about 25 (?) thick) along ditch. Diff. from ss soil. Can't get sample. Colored green, & reds. Cg layer with boulders < 3". Goes into ss & boulders back along ditch SE.

15. Bottom of cg layer. Back into clayey ss. Massive cg. Must be at least 40' thick.

16 Massive flow or tuff coming in. Sample. Well jointed - no flow or bedding. 200' along ditch then into sh. f-g ss N40W, 30NE

17 Sample of flow? or intr?
or faulted-up ss.

Shale Marker - Mann

5 - 5' in shale

7 - 15' in shale

Mann says wells all stay at the same shale layer - except #5

Gas Ice — Hot ! Thurs ~~[illegible]~~ 6/9

18 Fairly continuous congl. layer below white tuff(?) ss. Pt in ss. Bedding in ss N40W, 35N. Prob. not tuff. Just sh ss. Finely bedded

19. Congl. below & white ss go out and and. flow comes in. Late alluvium in all flats in valley. Just above pt 19 – coal mine. Coal mine sunk in ss. and sandy shale. Coal is mostly ~~[illegible]~~ carboniferous shale. Shaft N75E from plant, about 500! Shaft – looks like about 500' worth of dump material.?
Spring coming from above coal mine –

20. Just across ck from plant. And. flow. Gray porh. rock. Shows rude columnar jointing – not as good as basalt. N45W, 30NE

Just above and. is thin-bedded flaggy, sh. ss. white-same as before. Bedding S85 W, 25 SE No good. Under power line. Congl. is thinning, above and.. And. flow goes out at well #18. White sh. ss is thickening and is getting more sandst.
Sample of rock - hard, aphan. near well #18.
In ss on ck.

ss & cg on ck to flat. Opposite well #14 (with rig)

Talk with Mann
Latest drilling - 250' of blue shale essentially. Looks just like the stuff that is in the Riddle Oil well.

21 Massive gray-gr. ss - m-g. with
clayey layers. N50W, 20NE

22 Massive buff ss. N60W, 30NE
Not good.

23. On Pomp. Bluff. Massive buff ss.
bedding N50W, 25NE Pretty good
Layers of cg & some white ss.
Stuff is prob. more than 200' thick

24. Below massive ss of bluff - finely
bedded brown & red shales. along
ditch.

25. Massive ss & cg. Same as on
top?

Intrusive cuts through road.
Looks same as on knoll.

Friday - ~~6/9~~ 6/10 HOT

26 Alternating beds of f-g ss + shale
Finely bedded. Some 18" ss
layers. Usually smaller.
~~N20W, 15~~ NE N53W, 15NE

27. Massive cg holding dip-slope of
hill

Has to be fault in valley between
27 + intru.?

28. Finely bedded sh + ss [ofc] from 28 to
26 along road. Same trend.

Cg of 27 is ~~underneath~~ over
ss + sh beds.

29. Cg layers, mostly massive, some
bedding. N45W, 30NE

West side of road - Ti leading
to Airway Beacon to S.
Across to ? Cg - Bedding N30W, 15N
Over sh + ss.

Traverse along ditch N20E from plant - in shlgSS layers.

Near first draw - up into cg. - then back down into shlg-ss. N45W, 25NE
Into big draw - up into cg.
Out of draw - nearing Power Line Massive ss - down section.
At power line - narrow white sh-ss flaggy. Below and - Tuff?
Around curve from power line - massive and. flow.
Down through flow to ss & sh-ss +sh layers - some finely bedded. Could be same as over near road at pt 26 but these aren't over 25' thick. At least 150' at 26. And about 15' thick. Down into white flaggy rock at end of traverse. Cg. ~~at~~ under white flagstone.

Massive ss & cg down bank ~~[illegible]~~ and all the way back to plant. Forms small bluff.

Sunday

Otc of Chico just NW of Ashland
looks like shale at bottom of
Gas-ke wells – also stuff
at bottom of Riddle oil well.

Get samples of
both intrusives.
Ctc of Intrusive
Sample of coal.

June 22
Sample of ss matrix of cg
(*) " " sh above and. flow.
Coal mine maybe 50' above flow
strat. Low grade - thin. layers
of coal & carb shale.
S. of plant - across ck. Sh.
below flow - same as above
flow. Plant fossils. Little
below coal mine. Probably
related.
* Sample of white below and. flow

39/2-7N5 Gas-Ice Corp.
1930' all. 1940 drilled

Material	Thickness	Depth
Younger Alluvium		
Soil & gravel	7	7
Boulders	7	14
Umpqua fm.		
"Slate", blue, & mud, talc	11	25
ss	30	55
Cg	25	80
ss	5	85
ss & cg streaks	20	105
ss, hard	22	127
ss, soft	10	137
cg w/ qtzite pebbles	33	170
ss	10	180
Talc mud (Tuff?)	10	190
ss (soft)	68	258
Clay, blue (sh.?)	6	264
cg	93	357
sh, blue	7	364
ss	1	365

sh, brown	22	396

59/2-7N6 Gas-Ice all 1930'

Drilled 1946

Younger alluvium

Soil	2	2
Sh, brown & gravel	11	13
Gravel	2	15

Umpqua

ss	55	70
cg	13	83
ss with qtz x'ls (cg)	37	120
sh, brown	50	170
Sh, blue	10	180
Sh, brown	40	220
Sh, blue	15	235
Sh, brown	40	275
ss	134	409
Sh, blue	2	411
cg & sh	24	435
Sh, br & bl	52	487
Sh, green	3	490
ss	15	505

ss	5	550
basalt, gray, (sill?)	5	555
ss	5	560
basalt - sill?	28	588
ss	33	621

39/2 - 7N11 Gas-Ice 1930' alt
1947 Drilled

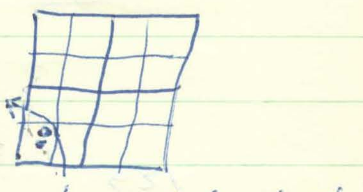
Younger alluvium		
soil	2	2
boulders	13	15
Umpqua		
Rock (ss?)	13	28
sh, blue	27	55
Sh, br	5	60
Sh, bl	32	92
Broken rock (contact or fault breccia?)	1	93
SS. water + CO_2 bearing	77	170
Cg. CO_2 at 190-195'	30	200
ss	20	220
cg	70	290

ss	40	330
cg	45	375
ss	32	407
sh, blue	5	412
sh, br	6	418

Ground-Water Resources of the Rogue River Basin
by
Richard A. Young

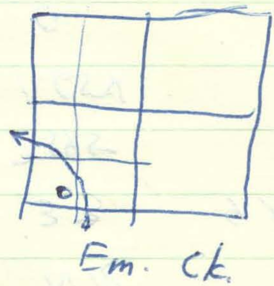
Unpublished Report in preparation of Ground Water Division - USGS, 1953

Field Notes
39/2 - 7NS
SE¼

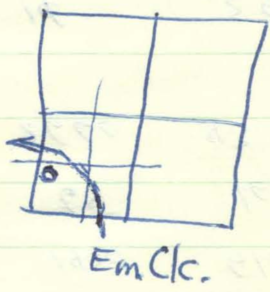


Gas-Ice Corp
Depth 396 8" diam
Chief aquifer ss & congl.

Depth 621 8" diam
55 x cngl.



39/2 - 7N11
418' Depth
Congl.
8" diam
280' to water



D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Scheme for locati[ng]
wells in a
section

Wells in Sec 7, T39S, R2E
SW $\frac{1}{4}$ of SW $\frac{1}{4}$

Analysis 3/12 - 71x11

parts / million
equivalents / million

Temp 66° F

SiO_2 68 ppm

Fe

Iron in soln .12

Total Fe 2.1

	PPM	EPM
Mn	.00	
Ca	132	6.59
Mg	74	6.08
Na	1410	61.31
K	65	1.66
Bicarb HCO_3	2660	43.60
Carb CO_3		
Sulf SO_4	14	.29
Chloride Cl	1140	32.16
Fluoride F	NR	
Nitrate NO_3	NR	
Boron B	33	9.15
Total Dissolved solid	7,895	
" Hardness as $CaCO_3$	1,654	
Non-carb "	0	

% Na 77

4 ppm Li

① Temperature relations, including surface temperatures of springs, geothermal gradients of spring system & possible sources of excess heat.

66°F surface temperature

Wells - deepest 621' (39/2-7N6)

Possible source of heat - volcanism

Wells aren't deep enough to account for the ~~heat~~ high temperature by mere natural gradient. Gradient could be ~~assisted~~ raised by volcanism with no addition to meteoric water. This is unlikely because of high mineral content. Contrast surface, meteoric and CO_2 well water.

[illegible]

1°F / 50.8' to 1°F / 93.3'

Gradient in Calif well

1°F / ~~85.6~~ 79.5' (to 21,482' 20,003 depth)

Calif. Div. of Mines
Min. Info. Serv.
April 1, 1955

mean annual T around Bakersfield Jan. 47 to July 47 83.5°F US Weather Bureau

Gradient in Ashland Dom. & CO_2 well

125' & 418', 54° & 66°

1°F / 24.4'

especially <u>Cl</u>, <u>B</u>, S & CO_2

Source – possible acid-lime reaction source of ~~radioactivity~~ CO_2. Not too much lime in Teu recorded.

	PPM	EPM
Cl	1140	32.16
B	33	9.15
SO_4	14	0.29
HCO_3 (bicarb)	2260	43.60

Carb highly predom. over Ca & Mg – high temp. thermal springs.
Why is carbonate in bicarb instead of carb — HCO_3 instead of CO_3

Sulphur near top of well.

Behre & Garrels (1943) – ascending solutions tend to have a lower Ca:Mg ratio than descending ones
Rankama & Sahama p279

CO_2 well — 198 ppm Carb for calcite 2660

B — 185 " " " magn 383

383 " " 2277 ppm carb left.

2277 ppm carb left in CO_2 well

only 325 ppm in ~~CO_2~~ dom well orig.

Excess of CO_2 converts $CaCO_3$ into the more soluble bicarb and hence considerable quantities of "lime" are frequently held in natural waters which contain CO_2 in solution

$H_2CO_3 + CaCO_3 \rightleftharpoons [Ca^{2+} + 2HCO_3^-]$. A considerable excess of CO_2 is required to convert the whole of the carbonate into the soluble bicarb, since the action is remarkedly reversible. (Smith, p 383)

⑤ Regional and local geology - age & extent of volcanic rocks

Local late Tert. intrusives & flows.

Check on confusion of Wells' Ti & Teu. Maybe late carb. or sil. related to springs.

Check amount of Cl & SO_4 relations - possibly used in converting lime to CO_3

No lime recorded in Teu

Coal present but will not form CO_2 from acid

Umpqua in Coos Bay has calcite p14 Coos Bay Coal Fields

matrix of calcite (55%) in f-g ss. p13 minor calcite frag. in SS.

STATE DEPARTMENT OF GEOLOGY & MINERAL INDUSTRIES
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Field Offices:
2033 First Street, Baker, Oregon
714 East "H" Street, Grants Pass, Oregon

WELL LOG

Date Aug. 17 19 51 Number 18

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19 ___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	2	
Gravel & sand	2	3	
Gravel	5	2	
? Blue (hard)	7	3	
Sand rock (hard)	10	15	
Sand rock (hard)	25	3	
Black Shale	28	7	
Sand rock	35	3	
Sand rock	38	1	
B. shale	39	6	
Sand	45	1	
B. shale	46	5	
Blue sticky shale	51	5	
Lt. colored shale & small pieces of sand rock	56	5	
B. shale	61	9	
Sand rock	70	5	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Sand rock & shale	75	5	
Sand rock	80	15	
Sand rock filled with crystals	95	20	
Sand rock filled with crystals	115	20	
Sand rock - last 10' hard	135	20	
Sand rock	155	13	
Sand rock filled with crystals	168	22	
Sand rock	190	15	
Sand rock	205	12	
Sand rock	217	28	
Sand rock	245	35	
Sand rock (soft)	280	35	
Sand rock filled with crystals	315	5	
Sand rock and crystals	320	5	
Sand rock (soft)	325	5	
Sand rock	330	40	
Sand rock	370	15	
Sand rock	385	10	
Blue shale	395	1	
Brown shale	396	4	

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WELL LOG

Date May 5 19 47 Number 7

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

(Drilling Company and Address)

Method of Drilling ______ Date ______ 19__

(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Gravel & boulders	5	5	
Sand, rocks	10	3	
Sand, rock	13	11	
Sand, rock (hard)	24	11	
Sand, rock filled with Xl quartz (Hard)	35	10	
Sand, rock filled with Xl quartz	45	15	
Blue shale	60	25	
Sand, rock filled with Xl quartz	85	20	
Sand, rock	105	15	
Sand, rock crystal quartz and talc	120	25	
Sand, rock filled with quartz Xl.	145	25	
Sand, rock (hard)	170	10	
Sand, rock (softer)	180	10	
Crevice -- no return	190	5	
Sand, rock	195	10	
Sand, rock	205	45	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Blue Shale	250	5	
Blue & brown shale	255	5	
Brown lava	260	5	

WL-28 (2)

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WELL LOG

Date Oct. 19 19 49 Number 15

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___ 1/4 ___ 1/4 sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	2	
Sand, gravel & boulders	2	2	
Boulders, sand & gravel	4	3	
Sand, gravel & boulders	7	1	
Boulders & gravel	8	2	
Sand rock & shale	10	15	
Sand rock (hard)	25	10	
Sand rock (hard)	35	7	
Sand rock filled with crystals & shale	42	28	
Sand rock (soft) filled w/crystals	70	35	
Sand rock	105	5	
Br Brn shale	110	20	
Sand rock	130	10	
Sand rock filled with crystals	140	25	
Sand rock filled with crystals	165	40	
Sand rock filled with crystals	205	30	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Sand rock (soft)	235	45	
Sand rock (hard)	280	15	
Sand rock (hard)	295	8	
Blue shale	303	2	

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WELL LOG

Date Nov. 10 1948 Number 14

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19__

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	8	
Rock	8	7	
Sand, rock (hard)	15	2	
Sand, rock	17	8	
Sand, rock (hard)	25	13	
Sand, rock	38	12	
Sand, rock, ~~blue~~ B. shale	50	5	
Sand, rock & shale	55	5	
Sand, rock	60	18	
Sand, rock & shale	78	22	
Sand, rock	100	40	
Sand, rock	140	5	
Brown shale	145	5	
Blue shale	150	10	
Sand, rock	160	10	
Sand, rock	170	37	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Sand, rock	207	18	
Sand, rock	225	5	
Sand & sand rock	230	15	
Sand rock	245	15	
Running sand or quick sand	260	1	

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WELL LOG

Date ____________ 19___ Number 5

Recorded by ____________ Source ____________

County ____________ Area ____________

Quadrangle ____________ ___ 1/4 ___ 1/4 sec. 7 T 39 N/S., R 2 E/W.

____
(Drilling Company and Address)

Method of Drilling ____________ Date Aug. 18 1945

____
(Property Owner and Address)

Land surface, datum ____________ ft. above / below ____________

Material	Thickness (feet)	Depth (feet)	Remarks
Sand, rock (hard)	355	3	
Sand, rock	358	9	
Blue shale	367	2	
Blue shale	369	5	
Sand break	374	1	
Blue shale	375	5	
Blue shale	380	4	
Brown shale	384	5	
Brown shale	389	7	

WL-28

Material	Thickness (feet)	Depth (feet)	Remarks

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WELL LOG

Date July 24 19 47 Number 10

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___ ¼ ___ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Boulders & gravel	0	3	
Sand, rock	3	10	
Sand, rock. Last 5' HARD	13	17	
Sand, rock (hard)	30	15	
Shale	45	8	
Sand, rock	53	2	
Sand, rock (hard)	55	15	
	70	12	
	87	2	
Sand, rock (hard)	89	11	
Sand, rock (hard)	100	10	
Sand, rock	110	15	
Sand, rock	125	20	
Sand, rock	145	20	
Sand, rock & crystals	165	35	
Sand, rock	200	60	

WL-28

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WELL LOG

Date July 17 1946 Number 6

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___¼ ___¼ sec. 7 T 39 ~~N~~/S., R 2 E/~~W~~.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	2	
Brown shale & gravel	2	3	
Brown clay & rock	5	8	
Gravel, caving	13	1	
Gravel (caving)	14	1	
Sand, rock	15	2	
Sand, rocks	17	20	
Sand, rock (hard) filled with crystals	37	6	
Sand, rock	43	5	
Sand, rock	48	22	
Conglomerate	70	13	
Sand, rock	83	7	
Sand, rock	90	5	
Sand, rock	95	4	
Sand, rock filled with crystal quartz (hard)	99	15	
Sand, rock	114	6	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)
Brown shale (very sticky)	120	15
Brown shale (sticky)	135	12
Brown shale (sticky)	147	8
Brown shale; sticky; some gravel think change in formation	155	3
Brown shale (sticky)	158	12
Blue shale	170	10
Brown shale	180	2
Brown shale (very sticky)	182	25
Brown shale (sticky)	207	13
Blue shale	220	5
Blue shale	225	10
Brown shale (very sticky)	235	20
Lava & brown shale	255	2
Reamed	257	3
Lava brown (sticky)	260	3
Blue shale	263	12
Sand, rock	275	8
Sand, rock	283	37
Sand, rock	320	28
Green sand, rock (hard)	348	2
Sand, rock (hard)	350	5
Sand, rock (HARD)	355	7
Sand, rock (hard)	362	3
Sand, rock	365	5
Sand, rock	370	14
Sand, rock	384	25
Blue shale	409	2
Conglomerate	411	9

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WELL LOG
Date ______ 19 46 Number 6

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19 ___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Brown shale & rock	420	5	
Shale & rock	425	10	
Blue & brown shale	435	35	
Alternate blue & brown shale	465	20	
Brown shale	485	2	
Green shale	487	3	
Conglomerate, sand, rock & shale	490	10	
Sand, rock	500	5	
Green & blue shale	505	5	
Brown coarse shale	510	7	
Brown shale	517	12	
Brown shale	529	16	
Sand, rock	545	3	
Sand, rock	548	2	
G. (Gray) Basalt	550	5	
Sand, rock	555	5	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Basalt (Hard)	560	5	
Sand, rock & quartz crystals (hard)	565	5	
Gray basalt (hard)	570	13	
Basalt	583	2	
Sand, rock and quartz crystals (HARD)	585	5	
Sand, rock (hard)	590	8	
Sand, rock	598	2	
Sand, rock	600	2	
Sand, rock (hard)	602	8	
Sand, rock (hard)	610	8	

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WELL LOG

Date June 4 19 47 Number 8

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___ ¼ ___ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	3	
Clay & boulders	3	4	
Rock HARD	7	1	
Sand, rock - filled with talc or clay	8	12	
Sand, rock	20	5	
Sand, rock - filled with crystal quartz (soft)	25	25	
Sand, rock	50	20	
Sand, rock - filled with crystals & talc	70	25	
Sand, rock - filled with clay	95	15	
Sand, rock & clay	110	10	
Blue Shale	120	5	
Brown shale	125	5	
Blue shale	130	15	
Broken formation	145	5	
B. Shale	150	5	

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WELL LOG

Date June 26 19 47 Number 9

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___ 1/4 ___ 1/4 sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Boulders & gravel	0	3	
Big boulders & gravel	3	4	
Boulders & gravel	7	5	
Boulders & gravel	12	3	
Boulders & gravel	15	3	
Sand, rock	18	12	
Yellow Clay	30	10	
Blue Clay (sticky)	40	2	
Blue shale (sticky)	42	25	
Blue & Brown shale alternating (sticky)	67	23	
Brown shale (sticky)	90	20	
Brown shale	110	15	Hole caving badly 115'-120'

WL-28

STATE DEPARTMENT OF GEOLOGY & MINERAL INDUSTRIES
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Field Offices:
2033 First Street, Baker, Oregon
714 East "H" Street, Grants Pass, Oregon

WELL LOG

Date Nov. 17 19 47 Number 11

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19__

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	2	
Boulders	2	2	
Boulders	4	4	
Boulders & rock	8	7	
Rock	15	7	
Rock	22	1	
Rock (Hard)	23	5	
Blue shale (sticky)	28	17	
Blue shale "	45	10	
Brown shale	55	5	
Blue Shale	60	20	
B. shale	80	12	
Broken rock	92	1	
Sand, rock	93	1	
Sand, rock	94	16	
Sand, rock	110	30	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Sand, rock	140	30	
Sand, rock - filled with crystals	170	30	
Sand, rock	200	20	
Sand, rock - filled with crystals	220	40	
Sand, rock " " "	260	30	
Sand rock	290	40	
Sand, rock & crystals	330	35	
Sand, rock & crystals	365	10	
Sand, rock	375	30	
Sand, rock	405	2	
Blue shale	407	5	
Brown shale	412	6	

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WELL LOG

Date May 11 1948 Number 13

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19__

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil	0	3	
Boulders	3	3	
Boulders	6	2	
Sand, rock	8	14	
Sand, rock	22	13	
Sand, rock	35	5	
B. Shale	40	30	
Blue & Brown shale	70	35	
Shale	105	5	
Shale	110	10	
Shale (sticky)	120	10	
B. Shale	130	25	
B. shale	155	30	
Soft sand, rock	185	5	
Sand, rock (hard)	190	5	
Sand, rock	195	15	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
B. shale	210	15	

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[redacted]

WELL LOG

Date Dec. 30 1947 Number 12

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___ ¼ ___ ¼ sec. 7 T 39 ~~N~~/S., R 2 E/~~W~~.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above / below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Soil & gravel	0	1	
Boulders & gravel	1	2	
Gravel	3	2	
Gravel & boulders	5	3	
Gravel	8	4	
Gravel & boulders	12	5	
Blue & brown shale	17	3	
Brown shale	20	4	
Sand & gravel	24	1	
Brown shale	25	4	
Rock	29	1	
Blue shale	30	4	
Shale	34	1	
Rock, water & gas	35	5	
Brown shale	40	5	
Blue shale	45	8	

WL-28

(over)

Material	Thickness (feet)	Depth (feet)	Remarks
Blue shale	53	2	
Shale (hard)	55	10	
Blue shale	65	4	
Sand, rock	69	1	
Sand, rock	70	4	
Blue shale (soft)	74	2	
Blue shale (hard)	76	4	
Sand, rock (HARD)	80	19	
Sand, rock	99	25	
Sand, rock	124	30	
Sand, rock (hard)	154	18	
Sand, rock & crystals (hard)	172	18	
Sand, rock & crystals	190	25	
Sand, rock	215	20	
Sand, rock (hard)	235	17	
Sand, rock (hard)	252	8	
Sand, rock (softer)	260	15	
Sand, rocks	275	20	
Sand, rock	295	20	
Sand, rock	315	8	
Sand, rock (hard)	323	5	
Sand, rock (softer)	328	7	
Sand, rock	335	20	
Sand, rock (hard)	355	10	
Sand, rock & crystals	365	20	
Sand, rock & crystals	385	15	
Sand, rock	400	18	
Blue Shale	418	1	

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WELL LOG

Date Nov. 15 1949 Number 16

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ___¼ ___¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19___

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Gravel	0	3	
Sand	3	1	
Gravel & boulders	4	4	
Gravel & boulders	8	7	
B. Mud	15	5	
Blue shale	20	15	
Sand rock Hard	35	5	
Blue shale	40	5	

WL-28

STATE DEPARTMENT OF GEOLOGY & MINERAL INDUSTRIES
Head Office: 702 Woodlark Bldg., Portland 5, Oregon

Field Offices:
2033 First Street, Baker, Oregon
714 East "H" Street, Grants Pass, Oregon

WELL LOG

Date Nov. 21, 1949 Number 17

Recorded by ______ Source ______

County ______ Area ______

Quadrangle ______ ¼ ¼ sec. 7 T 39 N/S., R 2 E/W.

______
(Drilling Company and Address)

Method of Drilling ______ Date ______ 19__

______
(Property Owner and Address)

Land surface, datum ______ ft. above/below ______

Material	Thickness (feet)	Depth (feet)	Remarks
Boulders & gravel	0	7	
Rock & gravel	7	12	
Sand rock	19	5	
Sand rock	24	16	
Sand rock (extra hard)	40	25	
Sand rock filled with crystals	65	30	
Sand rock and crystals	95	30	
Sand rock	125	15	
B. shale	140	5	
Sand rock & crystals	145	30	
Sand rock	175	25	
Sand rock (hard)	200	20	
Sand rock filled with crystals	220	40	
Sand rock	260	40	

WL-28

SUBMISSION OF TITLE
FOR MEETING OF

O R E G O N   A C A D E M Y   O F   S C I E N C E

11/28/56
Date

Please Print:

Section Geology + Geography

Name of Author(s)
(as it will appear on the program) Max Schafer

Academic, Professional
or Industrial
connection (if any) Field Geologist, Oregon Dept. of Geol. + Min. Ind.

Exact Title of Paper: Geology of CO_2-Rich Waters Near Ashland, Oregon

If you will need the following for your presentation, please check:

Blackboard ___ Projection Lantern X Other ___
(SIZE: 35 mm)

How much time will you require: 10 min. (An outside limit of 15 minutes has been set)

Any additional information or comments:

A T T A C H   A B S T R A C T (about 200 words) to this blank before submission
(Opportunity will be given to revise these abstracts before publication)

The following sections have been arranged: (1) Biology, (2) Chemistry,
(3) Geology and Geography, and (4) Mathematics and Physics

RETURN THIS BLANK BEFORE JANUARY 4, 1957 to:

F. A. Gilfillan, Secretary
Oregon Academy of Science
Oregon State College
Corvallis, Oregon

NOTE: The author (or, in case of joint authorship, at least one of them) should be a member of the Academy in good standing.

O R E G O N   A C A D E M Y   O F   S C I E N C E

Office of the Secretary
Oregon State College
Corvallis, Oregon

November 14, 1956

TO ALL MEMBERS OF THE ACADEMY:

TIME AND PLACE OF MEETING	The fifteenth annual meeting of the Academy is to be held on the Oregon College of Education campus, Monmouth, on Saturday, February 23, 1957.
SUBMISSION OF TITLES FOR PAPERS	A form is enclosed on which you may submit titles for papers offered for presentation at the meeting. Those engaged in research are urged to present papers in all fields of science. Four sections will be organized: (1) Biology, (2) Chemistry, (3) Geology and Geography, and (4) Mathematics and Physics.
DEADLINE DATE ON TITLES	In order to have time for distribution of the program previous to the meeting, it is necessary that the title of your paper, as indicated on the enclosed form, be in the Secretary's office before Friday, January 4. If you have more than one title to submit, additional copies of the enclosed form will be sent on request, or you may type them out yourself, following the mimeographed form enclosed.
PAYMENT OF DUES	Your annual dues for 1957 are now payable, unless you have sent them in since October 1st. It is requested that you remit by mail, rather than wait for the annual meeting, since collection at that time is rather inconvenient, due to the rush of business at the meeting.
NEW MEMBERS	While it is not expected that the Oregon Academy of Science will ever be a large and powerful group, like its sister organization in California, the fact remains that we do not now have in our membership as many of Oregon's amateur and professional scientists as we should have. Your aid in increasing our membership will be of great assistance to the Academy. Application forms will be sent you on request.

Very truly yours,

Gilfillan

F. A. Gilfillan
Secretary

GEOLOGY OF AN OCCURRENCE OF CO_2-RICH WATER
NEAR ASHLAND, OREGON

By

Max Schafer
Field Geologist

State Department of
Geology & Mineral Industries

1955

CONTENTS

35

GEOLOGY OF THE OCCURRENCE OF CO_2-RICH WATER NEAR ASHLAND, OREGON

Introduction

The presence of the Gas-Ice Corp Plant #2 near Ashland, Oregon is not widely known. This plant, which utilizes CO_2-rich ground water in the manufacture of dry ice, has been responsible for making Oregon the 3rd ranking state in value of natural carbon-dioxide. (Min. Yearbook, 1951).

This plant is the only carbon-dioxide manufacturer using natural gas in Oregon. Portland Gas & Coke Co. uses flume gases to manufacture liquid CO_2.

The author wishes to express his thanks to Mr. C. E. Smith, manager of the Gas-Ice Corp. plant for the great amount of information and assistance given.

GEOLOGY OF AREA NEAR GAS-ICE CORP.

Introduction

The area mapped is about 3 square miles in sections 12 & 13, T. 39 S., R. 1 E. and sections 6, 7 & 18, T. 39 S. R. 2 E. The bulk of the mapping was done in section 12, T. 39 S., R. 1 E. and section 7, T. 39 S., R. 2 E. where the plant is.

The area is hilly with a relief of about 600 feet. Two creeks cut the mapped area, one flowing from SE to NW and the other from NE to SW. Hills and bluffs, the most prominent of which is Pompadour Bluff, overlook the stream valleys.

Geologically, this area is a part of the transition from the older Mesozoic and Tertiary rocks to the younger volcanics of the Western Cascades. The area has been described by Wells, et al (1939) in Preliminary Geology of the Medford Quadrangle.

Briefly, the regional geology is as follows: the Cretaceous Chico formation, a marine sandstone is unconformably overlain by the Umpqua formation, a series of Eocene terrestial sedimentary and volcanic rocks. Tertiary andesite flows, tuffs and agglomerates were laid down on the Umpqua formation. These rocks were later intruded by basalt and diorite intrusives.

Umpqua Formation (Eocene)

In the area mapped the Umpqua formation is present as sandstones, shales, conglomerates, tuffs and intercalated flows.

The predominant type present in the area is the sandstone. It varies from a greenish-gray to buff and tan. The rock contains varying amounts of feldspar, quartz, mica and volcanic glass fragments. Most of the sediments could properly be called tuffaceous as volcanic material is invariably present in varying degrees. The sandstone usually does not leave prominent outcrops but when there are conglomerate layers present the finer-grained purer sands do form bluffs such as Pompadour Bluff. The sands range from coarse to very fine grained. The sands range in thickness down to an inch.

The shales and siltstones are finer-grained equivalents of the coarser material with the possible exception of absence of mica. The shales are usually finely interbedded with sandstone layers, being usually less than 6 inches thick. An excellent example of this may be seen on the highway on the north side of the knob which rises just south of the center of section 12.

The conglomerates have boulders up to about 6 inches in diameter and are principally quartzitic with some granitic and metamorphic rocks. The boulders are sub-rounded to very well rounded, the majority being slightly ellipsoidal in shape. The matrix may be the impure micaceous sand or the purer quartz-rich sand. The particles of the matrix range from medium to coarse. These conglomerate layers may attain 30 feet in thickness and a series of them may be much thicker. The conglomerate forms a noticeable part of the sedimentary series because of the prominence of their outcrops. Boulders and cobbles from the conglomerate are nearly always present in Umpqua soil. The boulders may make up a maximum of 40% ~~60%~~ of a conglomerate layer although the amount is usually much less.

The conglomerate layers thicken and thin noticeably within a very few feet. They are not continuous over the area mapped.

The tuffs are white beds made up of glass or quartz. One of them is flaggy, breaking up into slabs up to 2 inches in thickness.

Two layers of the tuff were found in the mapped area, just above and below the andesite flow. The flaggy tuff contained many carbonized vegetable remains. None of the remains found was well enough preserved to discern their exact nature. They were only fragments of stems or limbs.

Coal Bed In Umpqua Formation

The abandoned shaft of the Ashland Coal mine is just across Emigrant Creek from the dry ice plant. The mine adit lies above the flaggy tuff in a carbonaceous and coaly shale layer. Parks and Swartley, 1916, say that the coal mined was a good grade of sub-bituminous coal that attained a width of 6 inches and was separated by coaly shale. A 425 foot incline trending 27° N. 50° E. followed the coal seams. The company was dissolved in 1912.

An intercalated flow is present in the Umpqua sediments and volcanic sediments on the NE side of Emigrant Creek in section 7. It is a porphyritic andesite and is buff to light gray in color. Euhedral crystals of andesine-labradorite plagioclase are set in a very fine mesh of quartz and feldspar. The feldspar phenocrysts average about 2 mm. in size. Near the creek, the flow is altered from the buff to the gray color. The flow is conformable to the Umpqua sediments. A crude columnar jointing is developed.

Tertiary Volcanics of Western Cascades

The northeast corner of the mapped area is underlain by a dark gray to black andesite which is part the lava series of the Western Cascades. The rock is largely a fine to medium grained rock composed of augite and andesine feldspar. Laths of the feldspar are contained in a fine felted mass of feldspar and augite.

These flows often show a well-developed columnar jointing. The columns are about 1-2 feet in width and are broken up every 2 inches by fracturing parallel to bedding.

Although Wells (1939) has mapped several varieties of volcanic rocks in this group including andesite flows, breccias, glasses, tuffs, and tuffaceous sediments, the dark andesite flows are the only variety present in the mapped area.

Later Intrusives

Two bodies of diorite were found in the mapped area. The two bodies seem to be part of a single dike but may be two related elongate stocks. The bodies form knobs in some places and color the soil a dark reddish brown, similar to the color of the basalt soil and different from the dull dark gray of the Umpqua soil.

The diorite is composed of about 20% augite and its alteration products hornblende and magnetite, and 80% sodic labradorite feldspar. The rock is medium-grained, with equidimensional grains which are of wholly crystalline minerals.

Wells (1939) says that these dikes and sills of basalt and diorite cut the Tertiary volcanics and therefore are younger. No evidence for this was present in the mapped area but the bodies do intrude, and are younger than the Eocene Umpqua near the dry-ice plant.

Alluvium

Stream deposits have been laid down in recent times by the two streams shown in the mapped area. These deposits are shallow and often very narrow. Probably the deepest alluvial deposits exist in the western part of the mapped area where the two streams join.

These deposits are composed of sand, gravel, silt and boulders. The larger debris is usually well-rounded and includes many of the boulders from the Umpqua conglomerate.

Structure

The sediments and volcanics of the Eocene Umpqua formation and the later volcanics, which lie conformably upon the Umpqua, all have a regional dip to the NE. It is probable that the country has been faulted and tilted after the Western Cascade lavas were poured out upon the surface. The later intrusives may have been later than the faulting although there is no evidence for this in the map area.

In an unpublished report of the Ground Water Branch of the Geological Survey, R. A. Young has mapped a fault following the creek valley from NW to SE. There is little direct evidence for this fault in the mapped area, but there is much reason to believe that the structure does exist.

One of the reasons for the belief is the presence of the stream itself. It may be that a zone of weakness enabled the stream to cut more easily into its present channel along the fault.

Throughout the Medford Quadrangle, mineralized waters occur along fault systems. Wells, (1939) shows several wells along faults and says, "The springs are related to faults . . . . ."

The andesite flow in the Umpqua formation is not found across the creek. There are no extensions of rocks from one side of the creek to the other with the possible exception of a conglomerate layer that underlies the area immediately surrounding the dry ice plant. A conglomerate layer is also present across the creek. However since conglomerates seem to be fairly common in the Umpqua and there is no sign of the flow continuing across on the SW side of the creek, a fault has been put in the creek bed. There is not enough data to make any conclusion concerning the movement of this fault.

THE GAS-ICE CORP. PLANT #2

Location

The dry ice plant #2 of the Gas-Ice Corp. is located in Sec. 7, T. 39 S., R. 2 E. about 3 miles from Ashland.

Manufacturing Process

The plant has ten wells from which gas is pumped. Most of the wells are from 200-300 feet deep and bottom in a shale layer of the Umpqua (?) formation. In all but one of the wells, water is pumped to the surface and the gas bubbles are separated. The wells total production is about 1000 gal/hr. Water is pumped into a separator, a tank with a pipe at the top and an outlet at the bottom. The water is pumped into the tanks and the gas bubbles rising to the top are drawn off to the plant. The water flows out through the bottom of the tank.

The CO_2 pumped from the separating tanks enters a cooler and dehumidifier where the moisture is removed. Formerly, some sulphur was present, necessitating a charcoal filtering process, but as the wells lowered the water table slightly, the sulphur disappeared. The cooled gas is then pumped to the "condenser" where it is put under about 500 lb./sq. in. pressure and cooled by ammonia refrigeration to -10° F. At these conditions most of the gas is liquified. At this point the very small amount of nitrogen and argon gas, which will not liquify under these conditions, is sent back into the system with the unliquified CO_2. These foreign gases are cleaned from the system at regular intervals.

The liquid CO_2 is then pumped to the "receiver" still under 150 lb./sq. in. and at about -40° F. From the receiver the liquid is suddenly released into the "snow press" through a small opening. The press is at atmospheric pressure and this sudden release of pressure causes a corresponding drop in temperature of the liquid. The temperature drop is enough to solidify about half of the liquid CO_2. The unsolidified liquid is returned to the system. The "snow" or solidified particles are pressed into 80 lb. blocks by the hydraulic "snow press", and these are wrapped in cardboard cartons in preparation for shipment. The production of the plant is about 10 T/day.

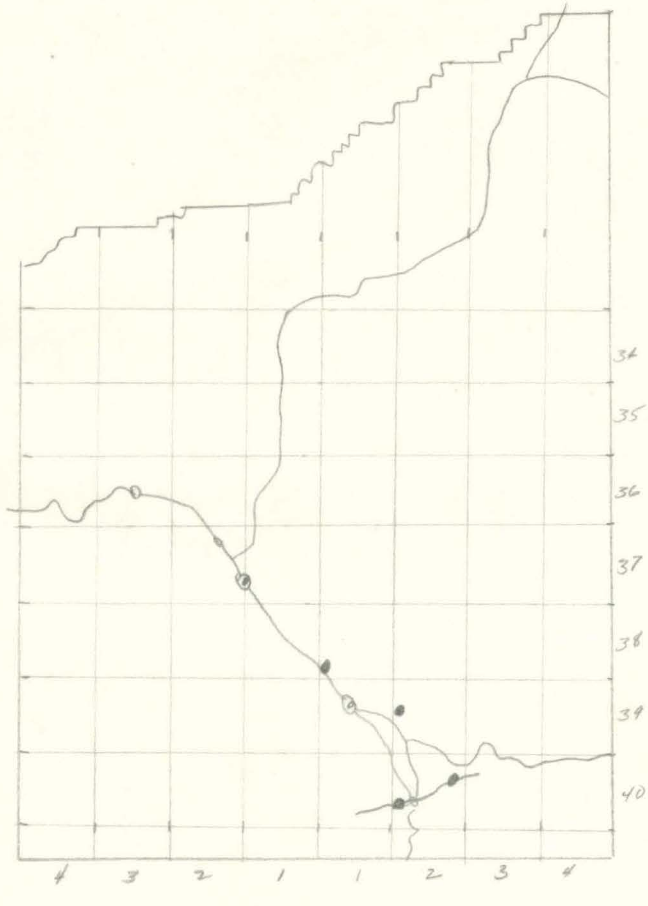
Uses and Markets

The dry ice industry came into being because of a British surgeon's liking for soda with his Scotch whiskey. At his station in India, natural carbonated water, which came, for the most part, from Vichy, France, was often hard to come by. By experimenting he was finally able to produce carbonated water from tap water, and he was happily assured of a steady supply of soda-water.

This use of dry ice is still important, although the refrigerating uses have far surpassed it. Almost all "soda-pop" and soda water is artificially carbonated at the bottling plants.

The long-distance transportation of perishable foodstuffs and frozen foods has accounted for the greater part of the dry ice market. Packing of ice cream containers with dry ice is a common practice. Fruits and vegetables can be transported for days with dry ice because of the slowness in loss of the ice and also because they seem to keep better in an atmosphere of CO_2 gas. A great advantage of dry ice is that it "sublimes" or goes directly from a solid to a gas, unlike regular ice which melts to water. Foodstuffs can be sent through the mail because of this desirable characteristic. The future of refrigeration for the dry ice industry is in doubt however, because of the recent great use of ammonia refrigerated railroad cars and trucks.

Most of the Ashland Plant's production is shipped to Portland with some sold in Southern Oregon and in the Willamette Valley cities.



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Geology of CO_2-Rich Water Near
Ashland, Oregon

The occurrence of mineralized hot-springs near Ashland, Oregon has been known for many years. A rather complete section of analyses was included in Petrology and Mineral Resources of Jackson and Josephine Counties Oregon, published by the Oregon Bureau of Mines and Geology in August, 1914 by A. N. Winchell. Winchell included analyses of 15 hot springs in the Ashland area, which he named, but unfortunately, did not locate. The chemical data was taken from this source and from unpublished reports of the U.S.G.S.

The purpose of this paper will be to present evidence concerning the source of the heat and the mineral content of these waters, and particularly the CO_2-rich water used by the Gas-Ice Corporation of Ashland can be directly or indirectly related to recent volcanic activity of the Cascade range.

Classification of Thermal Waters

Thermal waters, those which are heated to temperatures above normal, are classified as to source of heat and water supply. Non-volcanic waters are those which the heat and water supply are not immediately related to volcanism; intermediate waters are those which are heated indirectly by volcanism but their water supply is entirely meteoric; and volcanic, when the heat and at least part of the water is related to a volcanic source.

The heating of ground waters by a volcanic source may be indirect or direct. In the intermediate type the heat is supplied by indirect methods. A volcanic rock is the source of heat which warms a considerable volume of surrounding rock. When meteoric water penetrates this warmed area, the water is heated and is then returned to the surface with an abnormally high temperature that cannot be related to a normal geothermal gradient alone.

Waters may be heated directly by steam or hot juvenile water escaping from a volcanic rock. Evidence has been presented to show that there is enough "late magmatic" water contained in a cooling magma to supply a small spring system for thousands of years. This fact does not mean that many thermal waters are entirely juvenile in origin. It is probable that in most thermal waters the ratio of juvenile water to meteoric water is small.

Evidence Indicating Origin of Water and Heat

Evidence indicating the origin of water and heat of thermal waters is: (1) temperature relations of ground water system and possible sources of heat; (2) mineral content, especially Cl, B, also S & CO_2; (3) composition of associated gases; and (4) regional and local geology.

Temperature Relations of the Ground Water System and Possible Sources of Heat

There is evidence of a high geothermal gradient in the Ashland area. Accepted figures of a normal geothermal gradient range between 1° F/50.8' and 1° F/93.3' (Van Orstand 1939). A recent oil exploration well drilled to a depth of 21,482 feet near Bakersfield, California (Min. Inf. Service, April 1, 1955) had a bottom temperature of 335° F at 20,003 feet. Using the difference between the bottom temperature and the mean annual temperature of Bakersfield, about 70° F, the geothermal gradient for this area is 1° F/75' which falls well within the two accepted limits.

The gradient, at Ashland is much higher. Using a 418' mineralized Gas-Ice Corp. well and a 125' domestic well drilled 6000' away, the following calculations may be made. Taking 52° F as the mean annual temperature of Ashland the gradient of the domestic well, which has a water temperature at the top of 54°, is 1° F/62.5'. The 66° F Gas-Ice Corp. well has a gradient of 1° F/29.9'. These temperatures are of the water at the top of the hole. Perhaps a safer calculation would be to take the difference in temperatures and depths of the two Ashland wells. There is a 12° rise in temperature between 418' and 125', a distance of 293 feet. This gradient is 1° F/24.4 feet. These figures indicate that the geothermal gradient near Ashland is high. ~~The similarity of the gradient of~~

The mere fact that the water in some wells and springs is hotter than the mean annual temperature illustrates at least a high "hydrothermal" gradient. Whether this is indicative of an abnormally high geothermal gradient is another question. The great difference between the gradients for the two Ashland wells mentioned might indicate that the mineralized water is much hotter. Any such reasoning on the basis of these two wells, especially the one comparatively shallow well, is dangerous.

The inaccuracies of these calculations are obvious. Cooling of ascending waters by mixing with descending meteoric waters probably takes place. Cooling of abnormally hot ascending waters by country rock is probable.

Logical sources of heat for the water in the Ashland area are two: a cooling magma and faulting. A cooling magma would warm up considerable areas of surrounding rock which, in turn, would heat any meteoric waters entering this area. A cooling magma could also contribute hot juvenile fluids to the ground water system.

Friction of two rock masses moving against each other along a fault could contribute heat to a ground water system. It is believed, although many springs occur along faults near Ashland, these faults are a structural control rather than a source for any appreciable amounts of heat.

It is thought that a cooling magma is at least an indirect, if not a direct, source of the heat of the Ashland waters.

Mineral Content of Ashland Hot Springs

There are two principal types of mineral waters in the Ashland area: a carbonate type and a chloro-carbonate type which contains high sulphur and lithium. Various waters are high also in potassium, boron and iodine. The salinity of the lithium-rich waters are higher than others.

One of the outstanding features is the dominance of total CO_2 over calcium and magnesium present in the waters. In the 15 analyses published in Winchell, theoretical combinations were postulated. Carbonate radical was combined with K, Fe, Ca, Mg and Na. In only two analyses was there sufficient Ca and Mg to take up the total carbonate present. The chemists used up surplus carbonate by combination usually with Na. $NaHCO_3$ ranged from 16.28 to 71.9 percent of the total salts present. Excess carbonate, over and above conbination with Ca and Mg, was also taken up as $KHCO_3$ in two cases. These were 16.47 and 21.88 percent of the total salts present. A factor not considered in these measurements is the presence of free CO_2 gas.

A criteria for ascending solutions is a low Ca:Mg ratio in comparison with descending solutions. If we again compare the two Ashland wells, one at the Gas-Ice Plant and a nearby domestic well, the first has a Ca:Mg ratio of 1.78:1, the second 4:1.

The same calculations performed from the analyses quoted in Winchell show that these ratios range from 0.372:1 to 6.3:1. Only three of 15 of these calculations are as much as 3:1.

Sources for the mineral content of these waters are; first, juvenile waters from a cooling magma, and; second, dissolved material from rocks the heated waters pass through on their way to the surface.

It is thought that these figures would indicate a magmatic source for at least some of the minerals present in the water. The great dominance of carbonate over Ca and Mg would indicate the inability of a limey sediment to contribute these minerals.

In the files of the DOGAMI in Grants Pass are about 20 analyses of limestone from Douglas, Josephine and Jackson Counties. In only two does the MgO content rise over 0.5%. One was 4.19%, the other 8.47%. These analyses came from the Applegate district in Jackson County. It seems logical that if a limestone or a dolomitic limestone were contributing minerals to this water, the ratio of Ca:Mg would not be nearly so small as the analyses of the mineralized water show.

Additional proof would lie in analysis for metallic elements in the waters. Unfortunately these are not available.

Composition of Associated Gases

The dominant gas associated with the water of the Gas-Ice well is, of course, CO_2. A very small percentage, less than $\frac{1}{2}$ of one percent, of nitrogen and argon are present. Sulphur was present until the water table was lowered slightly, then it disappeared.

It is probable that most of the nitrogen and argon originated in the atmosphere and was carried into the ground by meteoric water; although some may be of a magmatic origin.

Regional and Local Geology

Francis Wells has mapped rocks ranging in age from pre-Triassic to recent in the Medford Quadrangle. The oldest rocks which could conceivably have any bearing on the problem of the mineralized waters is the Triassic (?) Applegate group. These rocks are altered basic volcanics and intrusives, tuffaceous sediments, argillite, chert, quartzite, limestone and marble and gneiss. Intruding these rocks are Jurassic or Cretaceous granitic intrusives, mostly granodiorite and quartz diorite with some more basic and acid differentiates. Deposited over these rocks is Upper Cret. Hornbrook ss. and cg. (formerly called Chico), Eocene Umpqua ss, sh, and cg. and Tertiary volcanics and intrusive rocks, ranging from basalt to rhyolite. The intrusives, principally dioritic and gabbroic, are later than the volcanics.

Several large faults are shown by Wells on his geologic map, and he states that there are undoubtedly more he did not recognize.

In the mine area, the geology can be given in a little more detail.

Geologic units

Umpqua formation

The oldest rocks that crop out in the mapped area are the non-marine sediments and volcanics of the Eocene Umpqua formation. The Umpqua formation has been subdivided in this report as follows:

Undifferentiated sediments: Sandstone is the predominant material in the undifferentiated sediments. It ranges in color from greenish-gray to buff and contains varying amounts of quartz, feldspar, mica, and volcanic glass fragments. The sandstone usually does not form prominent outcrops except where conglomerate lenses are present, as in Pompadour Bluff. Beds range in thickness from 1 inch to 10 feet. Coal has been found in shale of the undifferentiated sediments. On the east side of Emigrant Creek across from the dry-ice plant is the abandoned shaft of the Ashland coal mine. Parks and Swartley (1916) reported a good grade of sub-bituminous coal that attained a width of 6 inches and contained coaly shale separations.

Shales and siltstones: The shales and siltstones are fine-grained equivalents of the coarser sediments except that mica is usually absent. These rocks are usually finely interbedded with sandstone and the layers are generally less than 6 inches thick.

Conglomerates: Boulders and cobbles as much as 6 inches in diameter are contained in a sandstone matrix that ranges from medium to coarse. The boulders are of quartzitic and metamorphic material and are usually present in soil developed on the Umpqua formation. The conglomerates thicken and thin noticeably within a very few feet.

Tuffs: Two layers of tuff, made up of quartz and volcanic glass, were found in the area mapped. One of the layers is a flaggy, white tuff that contains carbonized plant fragments, apparently the remains of stems or limbs.

Andesite flow: An andesite flow, conformable within the Umpqua formation is present on the east side of Emigrant Creek near the dry ice plant. The flow is porphyritic, containing phenocrysts of feldspar, and ranges in color from gray to buff. A crude columnar jointing is developed.

Tertiary volcanics

The northeast corner of the mapped area is underlain by flows of dark gray andesite. These flows often show a well-developed columnar jointing. The columns are 1 to 2 feet wide and are broken up approximately every 2 inches by fracturing parallel to the surfaces of the flow.

Later intrusives

Two exposures of diorite which may represent a single body are shown on the map. In the field the outcrops form knobs and the soil is a dark reddish-brown that is easily distinguished from the dull, dark gray of the soil developed on the Umpqua formation.

Alluvium

Stream deposits have been laid down in recent times by Walker and Emigrant creeks. These unconsolidated sediments are composed of sand, gravel, silt, and boulders. The larger material is well-rounded and includes many boulders from the Umpqua conglomerates.

Structure

The sediments and volcanics of the Umpqua formation and the Tertiary volcanics have a regional dip to the northeast. Folding and faulting occurred after the Tertiary flows were extruded. Later intrusives are probably younger than the faulting.

A fault has been plotted on the map along Emigrant Creek. Lack of continuity of beds across the creek, the occurrence of the hot water wells along the creek, and the drainage pattern are evidence for the fault. Young (1953) plotted a fault along Emigrant Creek southeast of the mapped area.

To summarize

Evidence points to a magmatic source for part of the heat and mineral content of the Ashland mineralized waters.

The presence of a warm area of rock or of hot magmatic emanations is thought to be the source of the heat. Heat of friction from faulting was not considered to have contributed any appreciable amount of heat. The faults have merely served as zones of easy access to the surface for the mineralized waters.

Chemical evidence is based principally on the fact that throughout the Ashland area some waters have a high chlorite, boron, sulphur and carbonate content. Practically universal with the available analyses of mineral waters is the predominance of carbonate over Ca plus Mg, and the low Ca:Mg ratio. These two facts would seem to preclude a limestone as the source of all the minerals present in these waters. It is probable that some mineral content was leached from the country-rock. It is suspected that much of the sodium, which ranges from 37.3 to 18.9 percent, came from this source.

There is no need to look far for recent volcanic activity. Mt. Lassen in California has been recently active, Mt. Hood has at least one steam vent, and Crater Lake is only about 6500 years old.

In conclusion, heat from the rock surrounding a cooling magma and magmatic emanations have heated the waters near Ashland, and these magmatic emanations have provided much of the mineral content of these waters. It is believed, however, that the waters are highly diluted and the juvenile waters make up probably less than 10 percent of the total water content.