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Helium investigations in the Edgemont uranium district southern Black Hills, South Dakota and Wyoming

by

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ABSTRACT

Ground-water and soil-gas samples in the Edgemont uranium district of South Dakota and Wyoming yielded, respectively, 0.22 to >130 x 10^{-6} cm^3 He/cm^3 H_2O and <1 to 107 ppb He (with respect to air). Soil-gas helium is most abundant where artesian recharge occurs along fractured rocks of the Dewey structural zone, but it also is relatively abundant in the zone of artesian recharge near the outcrop of the Inyan Kara Group of Early Cretaceous age. The dissolved helium concentration in ground water from the uranium host rocks of the Inyan Kara increases in a basinward direction along the ground-water flow path. Dissolved helium concentrations are highest in the Long Mountain structural zone downdip from a number of uranium deposits at the Inyan Kara outcrop. Although no direct correlation was found between concentrations of dissolved helium and dissolved radon in the ground water or between concentrations of dissolved helium in the ground water and free-gas helium of the soil zone, geochemical targets for uranium exploration were provided by a dissolved-helium anomaly in uranium-depleted and hydrogen-sulfide-bearing ground water in the Long Mountain structural zone, and by soil gas anomalies in the Dewey structural zone.

INTRODUCTION

Ground water and soil gas were sampled in the Edgemont uranium district of the southern Black Hills of South Dakota and Wyoming (fig. 1) to study the distribution of dissolved- and soil-gas helium which may have been generated by uranium deposits located below the water table. Some determinations of dissolved radon were also made to assist data interpretation. The Edgemont district was chosen for study because some of the uranium deposits and occurrences lie below the water table, and because previous investigations summarized by Gott and others (1974) provide a geologic, hydrologic, and hydrochemical basis for interpretation of the helium data.

Helium is formed during radioactive disintegration of the uranium and thorium decay series. Anomalous concentrations of helium occurring either in ground water or in soil gas may indicate the presence of a uranium deposit (Reimer and Otton, 1976); therefore, helium data can be used, in the same manner as radon data has been used, in the geochemical exploration for uranium. Both gases occur dissolved in ground water or mixed with free gases within subsurface traps or in the soil zone. However, unlike radon which has a half-life of only 3.8 days, helium is stable. This difference enables helium to be detected farther away from its source, thereby providing a larger geochemical target.

The study area (fig. 1) is located on the plains at the southwest margin of the Black Hills and covers an area 30 km long by 3 to 8 km wide. The southeast end of the area lies 5 km northwest of Edgemont, S. Dak.. From there the area extends northwestward across the state line into Wyoming in the vicinity of Dewey, S. Dak.

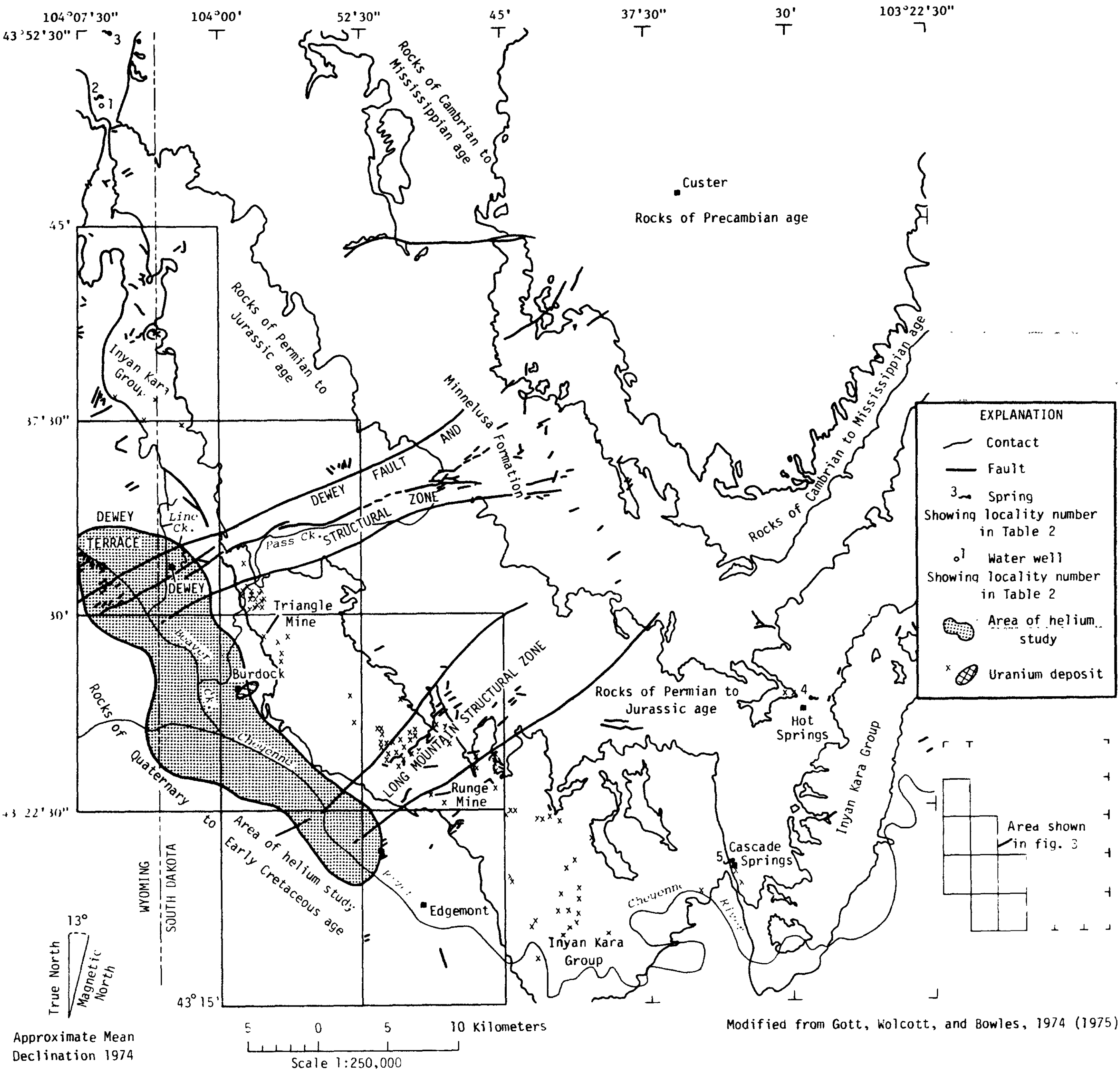


Figure 1.--Map showing location of helium study area and geologic setting of the Edgemont uranium district, southern Black Hills of South Dakota and Wyoming

GEOLOGIC SETTING

Maximum relief in the study area is 120 m; however, the topography is dominated by flood plains of the Cheyenne River and Beaver, Pass, and Line Creeks. The flood plains, which are underlain by alluvium and gravel of Pleistocene and Holocene age, are 1.6 to 3 km wide (Gott and others, 1974, pl. 1).

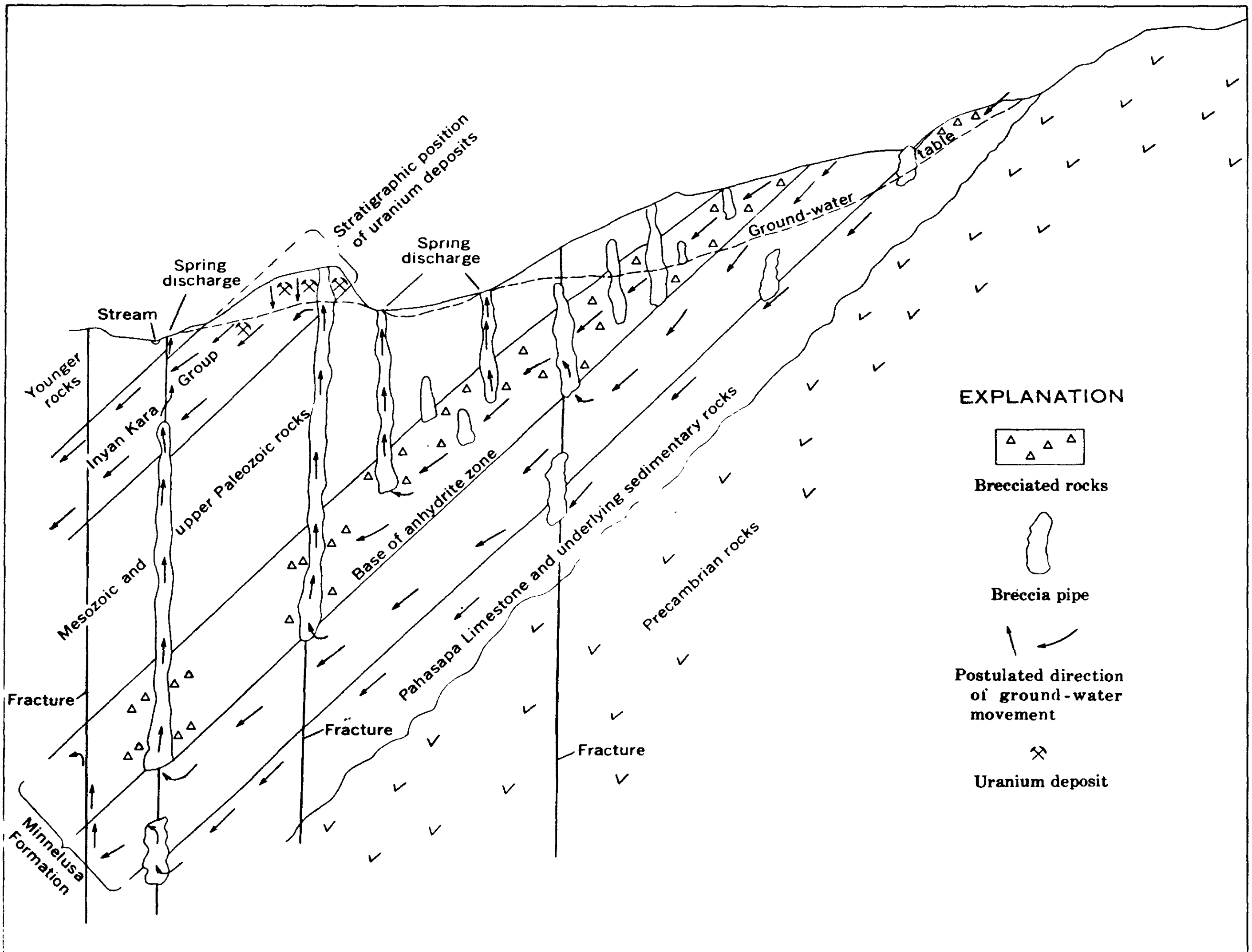
Stratigraphy

Formations cropping out over most of the study area are, in ascending order, the Skull Creek Shale and Mowry Shale of Early Cretaceous age and the Belle Fourche Shale of Late Cretaceous age (table 1). The formations range in thickness from 45 to 75 m, 40 to 53 m, and 56 to 130 m, respectively. The Inyan Kara Group, which contains the uranium deposits of the Edgemont district, lies immediately below the Skull Creek Shale.

Sedimentary rocks ranging in age from Cambrian to Early Cretaceous are buried beneath the plains. These rocks, measuring 850 m in thickness, are exposed to the east in the Black Hills (fig. 1). Within the buried sedimentary section, the Pahasapa Limestone of Mississippian age and the Minnelusa Formation of Permian and Pennsylvanian age (fig. 2) have a significant but indirect role in the formation of the uranium deposits. Strata from the Pahasapa Limestone to as high as the Inyan Kara Group are penetrated by breccia pipes of solution origin (Bowles and Braddock, 1963). Most of the pipes bottom within the upper anhydritic part of the Minnelusa Formation and were formed by solution of the evaporite. The pipes are major conduits for artesian recharge of the Inyan Kara Group at the margin of the Black Hills, and have indirectly affected the hydrodynamics, hydrochemistry, and mineralization of the Inyan Kara Group.

Table 1.--Stratigraphy of the helium study area, Edgemont District

System/ Series	Formation		Lithology	Thickness in meters
Quaternary			Alluvium and terrace gravel	0-15
Upper Cretaceous	Belle Fourche Shale		Gray to black shale; some bentonite beds	56-130
Lower Cretaceous	Mowry Shale		Dark-gray siliceous shale; thin beds of sandstone and bentonite	40-53
	Skull Creek Shale		Dark-gray to black shale with interbedded sandstone and siltstone	45-75
	Inyan Kara Group	Fall River Formation	Mudstone Sandstone Interbedded carbonaceous Sandstone and siltstone	40
		LaKota Formation	Sandstone, mudstone, and some limestone	60-150
Jurassic	Morrison Formation		Mudstone; some limestone	30
	Sundance Formation		Shale, silty; sandstone and some limestone	80-145
	Gypsum Spring Formation		Gypsum, claystone, and limestone	0-4
Triassic	Spearfish Formation		Siltstone, sandstone, gypsum and minor dolomite	150
Permian	Minnekahta Limestone		Limestone	8-12
	Opeche Formation		Shale, siltstone, sandstone, and gypsum	20-35
Pennsylvanian	Minnelusa Formation		Sandstone, limestone, shale and breccia in outcrop; anhydrite and gypsum present in subsurface	200-300
Mississippian	Pahasapa Limestone		Limestone	80-120
Devonian	Englewood Limestone		Limestone	12
Cambrian	Deadwood Formation		Sandstone, shale, conglomerate	3-15
Precambrian			Metamorphic and igneous rocks	



Modified from Gott and others, 1974

FIGURE 2.—Spatial relation of the uranium deposits to leaching of evaporites, brecciation, and postulated direction of ground-water movement. Diagram not to scale.

The Inyan Kara Group comprises the uranium-bearing Lakota and Fall River Formations of Early Cretaceous age. These formations consist dominantly of fluvial channel sandstones and their fine-grained flood-plain facies. A 105- to 180-m thick section of the Inyan Kara crops out 1.5 to 3 km east of the study area in a hogback that forms the outer margin of the Black Hills (fig. 1). Within the study area the top of the Inyan Kara generally lies 30 to 270 m below the ground surface.

Structure

Strata on the southwest flank of the Black Hills dip 2° to 4° to the southwest. In the vicinity of Dewey this dip is interrupted by a broad structural terrace which is bisected by the Dewey fault of Laramide age. The fault has dropped the southeast part of the terrace by as much as 150 m (fig. 1). The Dewey fault, within the Dewey structural zone, is one of two northeast-trending structural zones that were active first during Precambrian time and then were subjected to recurrent deformation during the Mesozoic and Cenozoic Eras. The Long Mountain structural zone (fig. 1) was continuously deformed during deposition of the Inyan Kara Group in Early Cretaceous time. Continuous downwarping at the southeast side of the structural zone controlled deposition and the superposition of fluvial channels and contributed to the fracturing of the Paleozoic and Mesozoic rocks, thus forming a favorable zone for the development of breccia pipes and the artesian movement of ground water (Gott and others, 1974, p. 31). Short segments of minor faults of Laramide age, which generally have a displacement of less than 15 m, cause a graben-type downward displacement of the central part of the Long Mountain structural zone.

Uranium deposits

Uranium deposits in the Edgemont uranium district are present both above and below the water table (fig. 1). Deposits lie above the water table at the outcrop of the Inyan Kara Group on the hogback east of the study area. Most of these deposits contain carnotite as the dominant uranium mineral, although some, notably the Runge deposit (Gott and others, 1974), contain uraninite and coffinite as the major ore minerals. Uraninite ore, occurring near the water table, was produced from the Triangle Mine located at Pass Creek just east of the study area. In addition, drilling has reportedly encountered economic deposits of reduced uranium lying below the water table within the study area southeast of Dewey (fig. 1).

Throughout the Edgemont district, the proximity of structural features and paleostream courses to the uranium ore deposits suggest that both may have affected the ground-water hydrologic system during formation of the epigenetic deposits. The greatest number of deposits occur within the Long Mountain structural zone (fig. 1). Other deposits occur near the positions of paleostreams of late Tertiary to Quaternary age. The courses of these early streams are marked by terrace gravels and by wind and water gaps that incise the hogback (Gott and others, 1974, pl. 4).

Hydrology

Interpretation of the helium and radon data presented in this study is based largely upon an earlier interpretation of the hydrodynamics and hydrochemistry of the complex ground-water system (Bowles, 1968; Gott and others, 1974). According to this interpretation the Pahasapa Limestone and Minnelusa Formation receive a major portion of the Black Hills ground-water recharge from direct precipitation and stream runoff (fig. 2). Ground water in the Minnelusa Formation flows downdip and rises through breccia pipes and along fractures to recharge the Inyan Kara Group at the margin of the Black Hills. Artesian water provides the dominant recharge to the Inyan Kara, whereas surface water from direct precipitation and stream runoff provides perhaps as little as 10 percent of the total recharge (Gott and others, 1974, p. 39).

Areas of artesian recharge near the Inyan Kara Group outcrop and along the structural zones were postulated by Bowles (1968) from the distribution of major ions in solution (fig. 3). Different rates of basinward flow within this study area were also suggested by the hydrogeochemical data. These postulations were confirmed by the distribution of tritiated water (Gott and others, 1974). Data obtained in 1967 indicates especially heavy artesian recharge near Burdock and near the Long Mountain structural zone within 1 km of the Inyan Kara outcrop where water samples yielded less than 100 tritium units (T.U.) (fig. 4). Upon recharging the aquifers in the Inyan Kara the artesian waters migrated basinward. In the vicinity of Burdock, S. Dak., the tritium values indicate a mixing of the artesian water with the tritiated water introduced updip at the Inyan Kara outcrop.

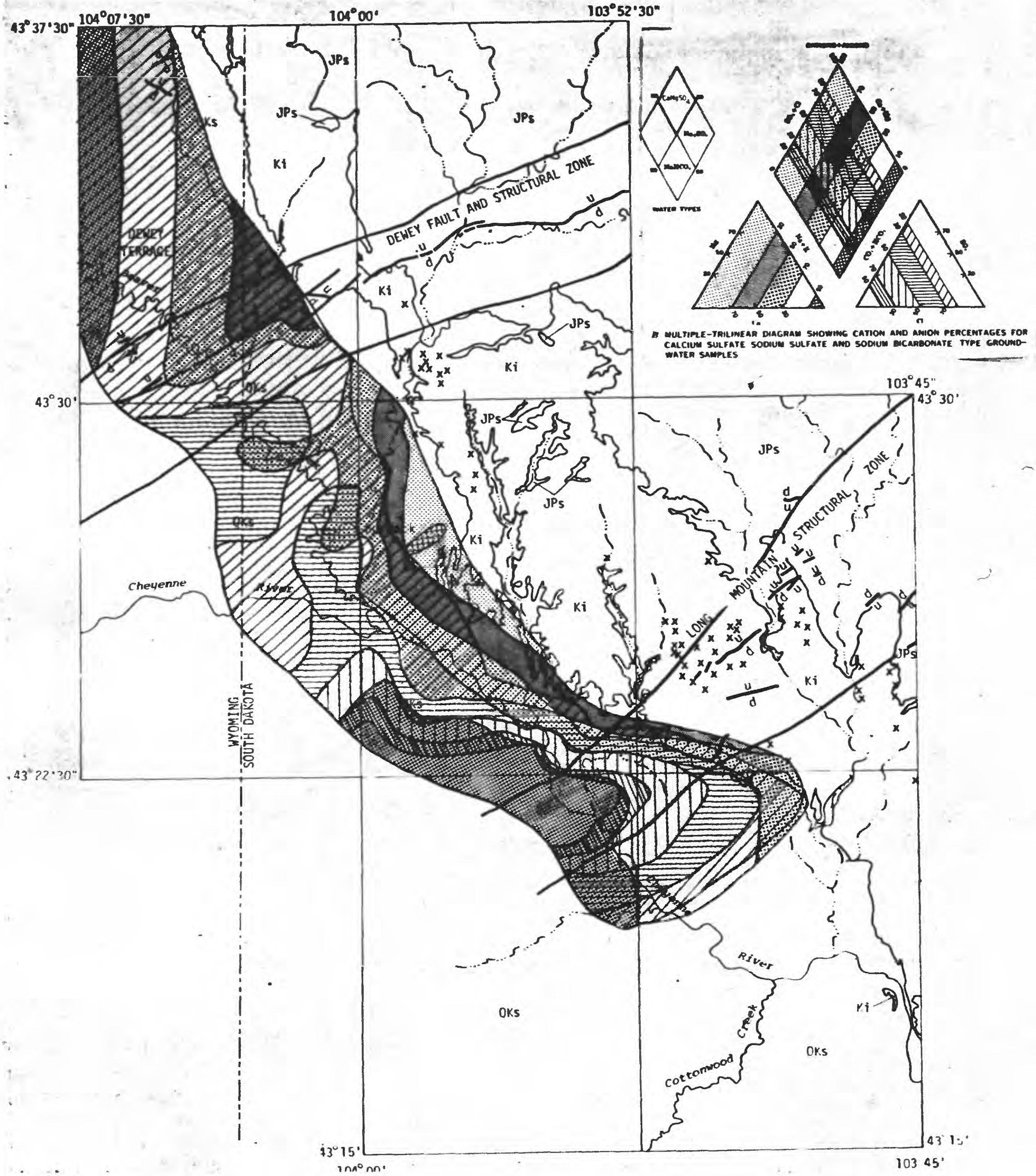
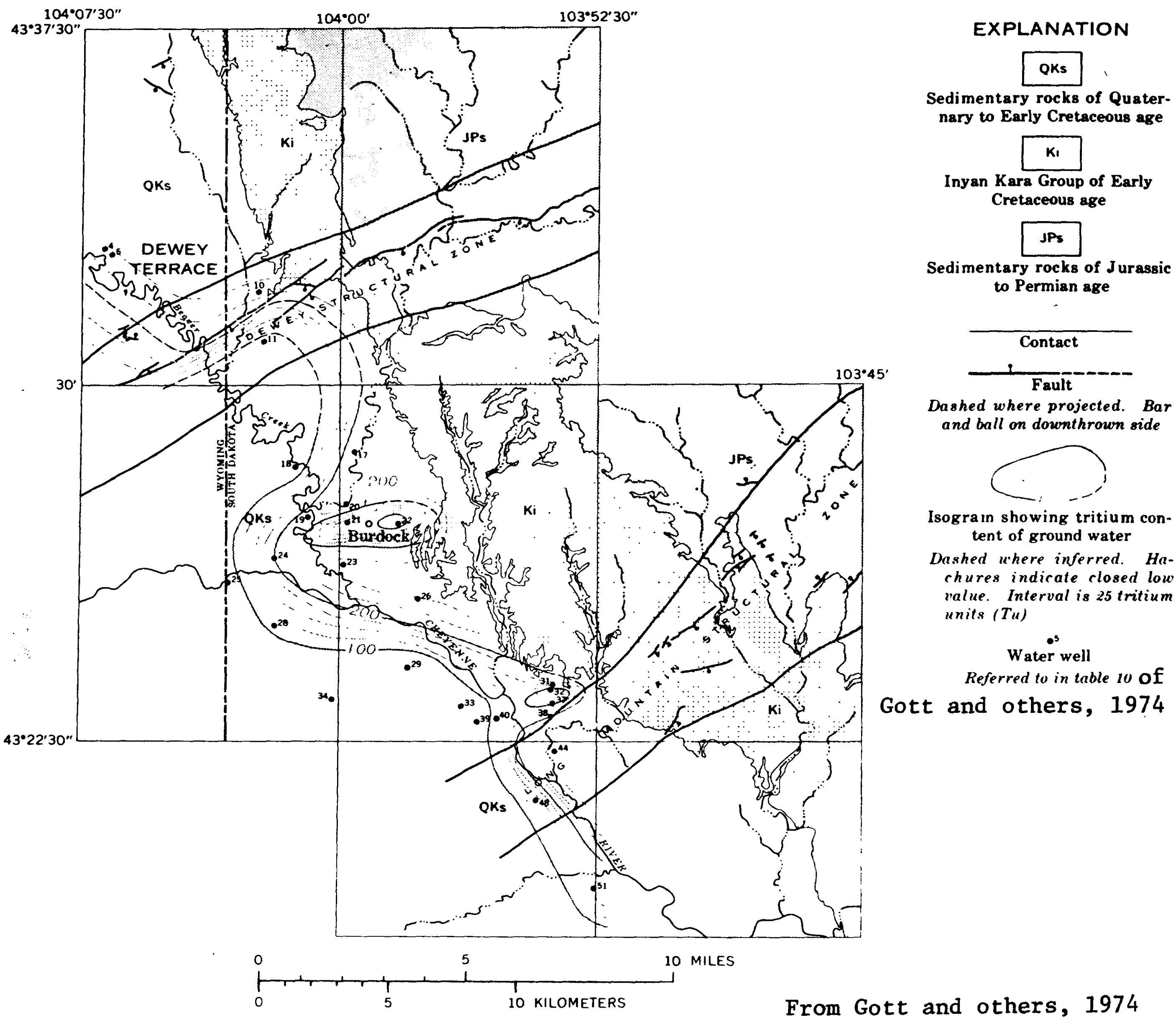


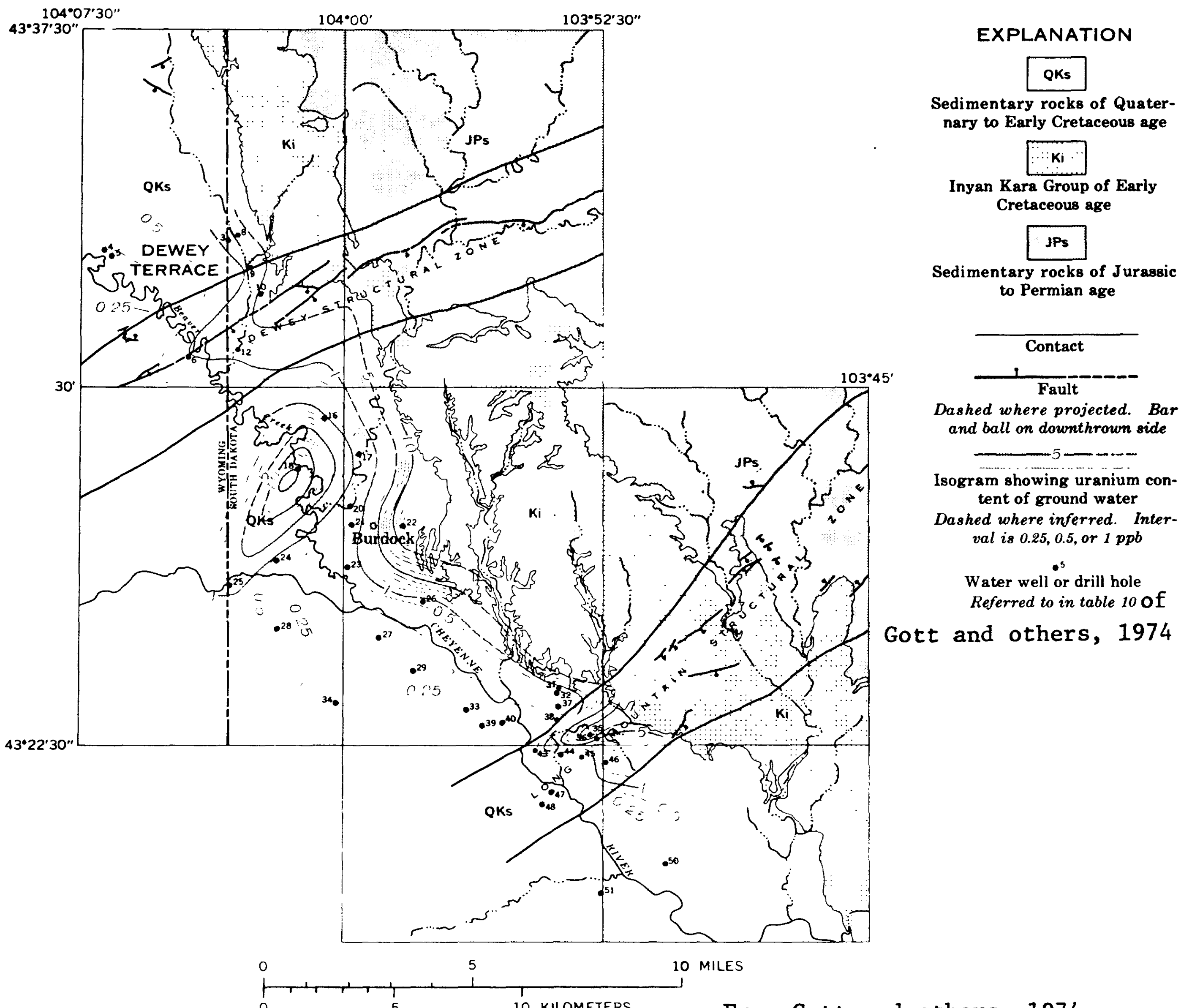
Figure 3.--Hydrochemical diagrams and map showing postulated evolution of artesian calcium-magnesium-sulfate-type ground water in the Inyan Kara Group.



From Gott and others, 1974

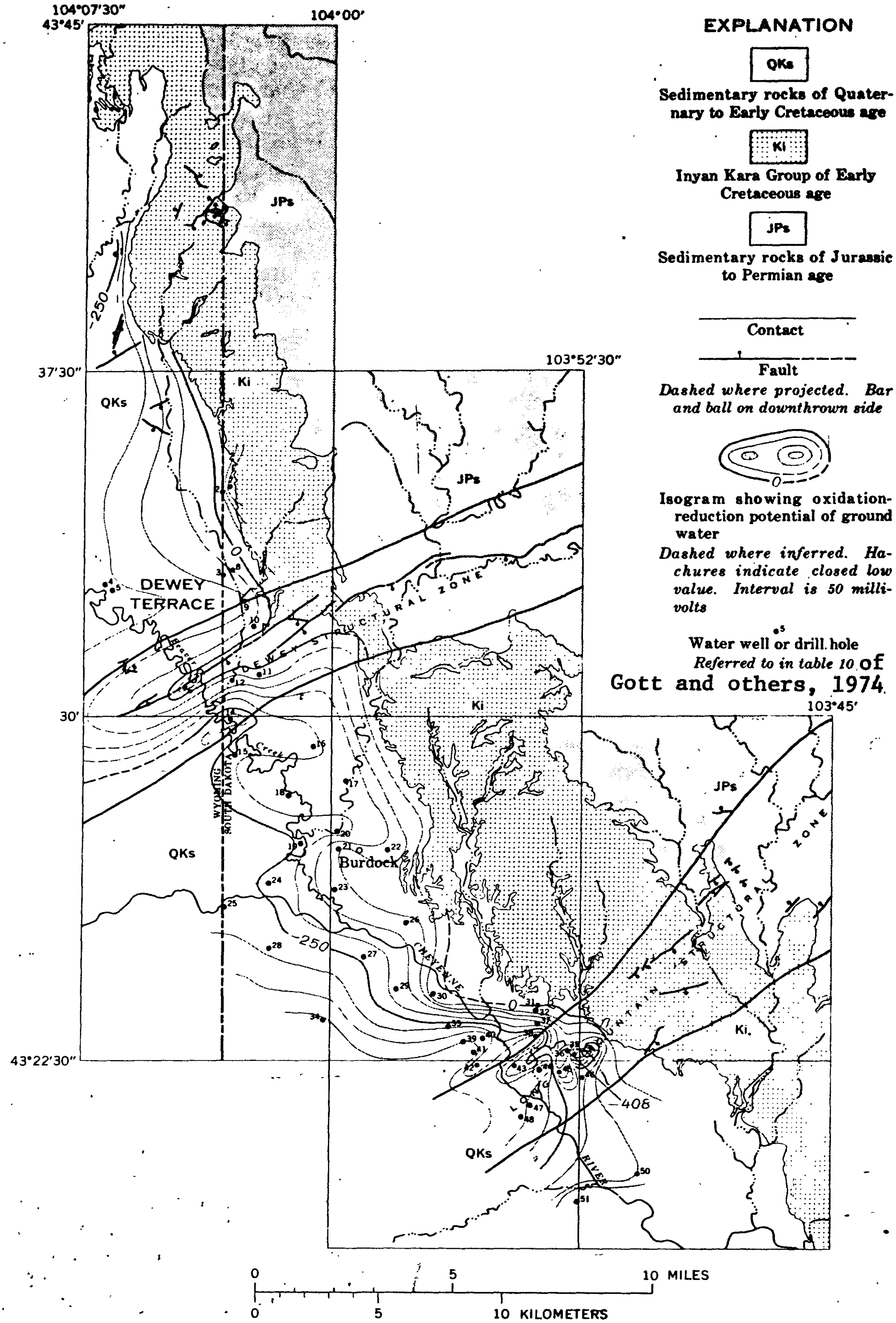
FIGURE 4.—Tritium distribution in ground water of the Inyan Kara Group of the southern Black Hills, August 1967.

Uranium is introduced into the Inyan Kara with the artesian recharge of calcium-magnesium sulfate water (fig. 5), but during the middle to late Tertiary significant amounts of uranium probably were also introduced by downward percolating meteoric waters that leached overlying tuffaceous sandstones and mudstones of Oligocene age. As ground water migrates downdip within the Inyan Kara, it is modified by ion exchange and sulfate reduction to either a sodium sulfate or a sodium-bicarbonate-type water, and redox potentials (fig. 6) decrease correspondingly. Reduction of sulfate in the ground water has been a major factor in creating a favorable environment for the precipitation of uranium. The depletion of dissolved uranium from the reducing ground water has prevented the detection of uranium deposits by an analysis of uranium in solution. However, helium and radon generated by uranium deposits can be readily detected in reducing ground waters. Therefore, the analysis of these gaseous emanations provides a hydrochemical technique for the detection of uranium deposits that may be present in reducing environments within the study area.



From Gott and others, 1974

FIGURE 5.—Uranium distribution in ground water of the Inyan Kara Group of the southern Black Hills.



From Gott and others, 1974

FIGURE 6.—Oxidation-reduction potential (mv) of ground water in the Inyan Kara Group of the southern Black Hills. Redox potential referred to KCl-saturated calomel electrode.

ANALYSIS AND SAMPLING PROCEDURE

The analytical equipment used for helium analysis was the mobile helium analyzer developed by the U.S. Geological Survey. This unit consists of a small mass-spectrometer mounted in a 4-wheel drive, 4-door pickup truck (Reimer, 1976). The equipment is capable of performing a helium analysis in the field with a sensitivity of 10 ppb and with equal precision.

Water samples were collected in one-liter plastic bottles that have a rubber septum fitted into a needle guide which, in turn, was attached to the bottle cap. The bottle was filled three-fourths full with the sampled water and the remaining space was occupied by air. It was then capped and vigorously shaken for 30 seconds to degas the water. After allowing the bottle to stand for 2 minutes, 10 cm^3 of air was injected using a hypodermic syringe into the bottle to insure a positive pressure and thus enabling withdrawal of a gas sample into the syringe. If the sample could not be analyzed within 8 hours, the sample in the syringe was transferred to a metal container for later analysis. The metal containers will maintain the sample without significant (5 percent) helium loss for several months.

Soil gas samples were collected from a 1-meter depth using a hollow probe equipped with the same septum holder as the plastic bottles. The samples were also collected in 10 cm^3 hypodermic syringes and those not analyzed within 8 hours were stored in metal cylinders.

Helium analyses of the water samples are reported in cm^3 He cm^3 H_2O. Water in equilibrium with air at STP contains 0.045×10^{-6} cm^3 He/cm^3 H_2O. Helium analyses of the soil gas samples are reported for convenience as ppb of helium with respect to air which contains 5,240 ppb helium (Glueckauf, 1946).

Water samples for radon analysis are collected in the same manner as samples for helium analysis. The only difference is that 50 cm^3 of gas is collected instead of 10 cm^3. Analyses are performed with an activated-phosphor alpha-sensitive scintillometer. The inlet system has been modified to accept a constant volume of gas that is injected from a hypodermic syringe.

Radon analysis of water is reported as pCi (picocuries) per liter of gas extracted from the water.

Sampling and analysis of helium and radon dissolved in ground water of the Inyan Kara Group of Early Cretaceous age commenced July 29, 1978 and continued for two days. Additional sampling resumed October 4, 1978, and the survey, including the sampling and analysis of helium in soil gas, was completed two days later. During the combined periods of field work, 29 samples of ground water from the Inyan Kara were analyzed for dissolved helium and 22 of the samples were analyzed for dissolved radon. In addition to the ground water samples, 93 soil-gas samples were analyzed for helium. Although Minnelusa water could not be sampled within the study area, five samples of artesian water from the Minnelusa Formation (table 2) were collected to determine the concentration of dissolved helium and radon that could be expected in the artesian recharge to the Inyan Kara. These samples were collected from three localities east of Newcastle, Wyo. and from two localities in South Dakota, a spring at Cascade Springs and Evans Plunge at Hot Springs.

Table 2.--Dissolved helium and radon in waters ascending from the Minnelusa Formation

Locality (fig. 1) No.	Locality description	Dissolved Helium ($cm^3 He/cm^3 H_2O$)	Dissolved radon pCi/L
1	Localities sampled Flowing well, LAK Ranch center W1/2NW1/4 sec. 5, T. 44 N., R. 60 W., Weston County, Wyo.	0.09×10^{-6}	17
2	Spring, SE1/4 sec 31, T. 45 N., R. 60 W., Weston County, Wyo.	0.09×10^{-6}	16
3	Spring, SW1/4 sec 17, T. 45 N., R. 60 W., Weston County, Wyo.	0.44×10^{-6}	21
4	Evans Plunge, Hot Springs, NW1/4 sec. 13, T. 7 S., R. 5 E., Fall River County, S. Dak.	200×10^{-6}	17
5	Spring, Cascade Springs, SW1/4 sec. 20, T. 8. S., R. 5 E., Fall River County, S. Dak.	40.8×10^{-6}	23

HELIUM AND RADON DISTRIBUTION

Dissolved helium in the ground water samples from the Inyan Kara ranges from 0.22 to >130 x 10^{-6} cm^3 He/cm^3 H_2O. Low concentrations of dissolved helium (<1 x 10^{-6} cm^3 He/cm^3 H_2O) commonly are present near the Inyan Kara outcrop and less frequently occur within the structural zones (fig. 7). Helium concentrations generally increase downdip to as much as 2 x $10^{-6}$$cm^3$ He/cm^3 H_2O. However, within the Long Mountain structural zone the dissolved helium concentration is mostly one order of magnitude higher than the concentrations present at comparable distances from the Inyan Kara outcrop elsewhere in the study area. The largest concentration of dissolved helium detected in the area (>130 x 10^{-6} cm^3 He/cm^3 H_2O) occurred in the Long Mountain structural zone.

Dissolved radon in the ground water from the Inyan Kara Group ranges from 1 to 167 pCi/L (fig. 8). The general distribution pattern for dissolved radon (fig. 8) is the opposite of that for dissolved helium. For the most part dissolved radon decreases downdip, ranging from as much as 53 pCi/L near the Inyan Kara outcrop to as little as 1 p/Ci/L west of the Cheyenne River. The largest concentrations of dissolved radon (167 and 151 pCi/L) occur in the Dewey structural zone.

The distribution of soil-gas helium (fig. 9) does not reflect the distribution of dissolved helium measured in the Inyan Kara Group. High values of soil-gas helium (75 to 107 ppb He above ambient air) are present up dip toward the Inyan Kara outcrop and along the Dewey structural zone. Soil-gas helium decreases toward the west to less than 25 ppb in a basinward direction.

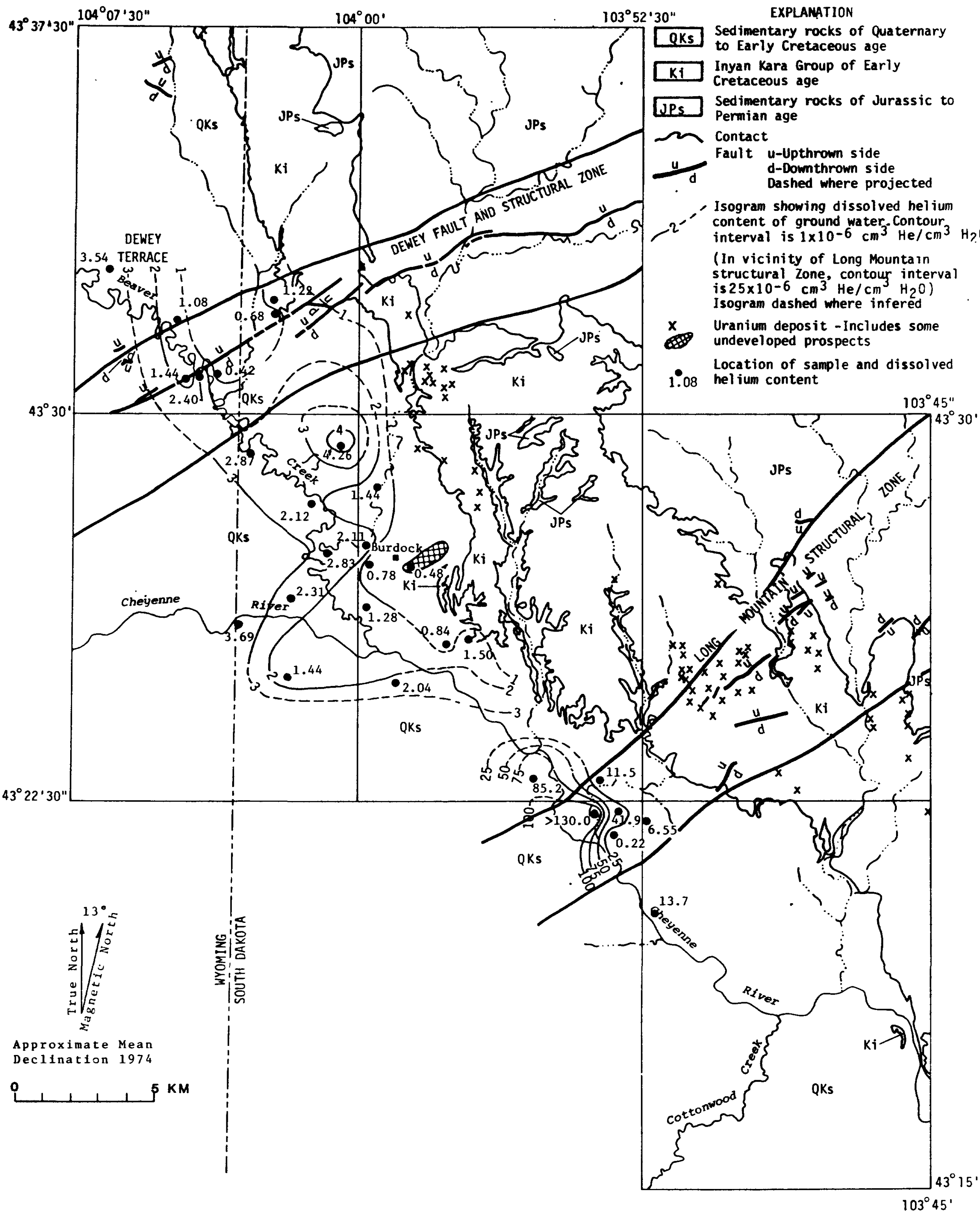


Figure 7.-- Dissolved helium distribution in ground water of the Inyan Kara Group of the southern Black Hills.

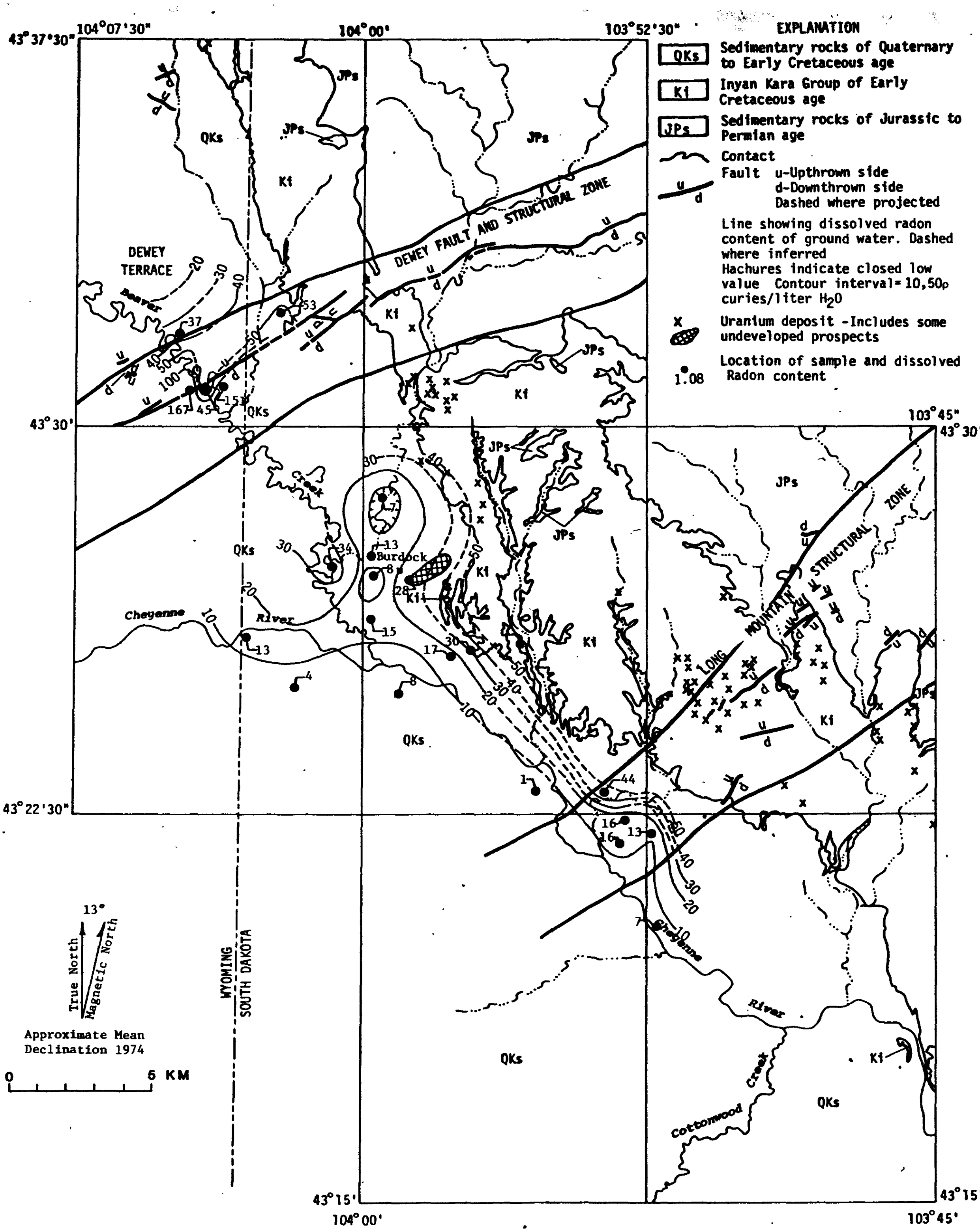


Figure 8.--Dissolved radon distribution in ground water of the Inyan Kara Group of the southern Black Hills.

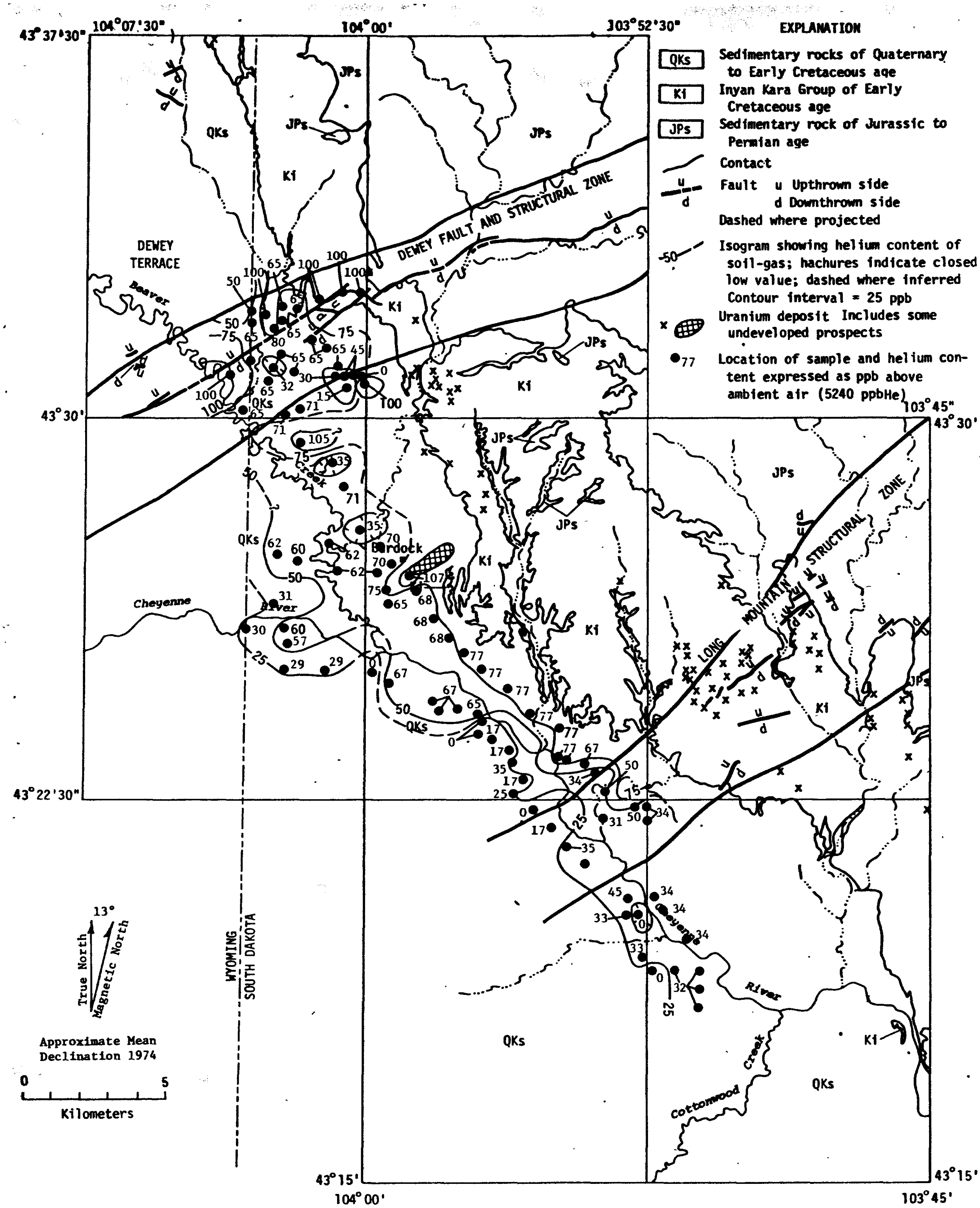


Figure 9.--Distribution of soil-gas helium in a part of the Edgemont uranium district, southern Black Hills.

DISCUSSION

Helium sources

Helium in the Inyan Kara Group originates from three different sources: (1) helium in air absorbed by meteoric waters that directly recharge the Inyan Kara Group, (2) helium generated by the radioactive decay of the uranium series within rocks underlying the Inyan Kara, and (3) helium generated by the radioactive decay of the uranium series within the Inyan Kara Group. Helium in air absorbed by meteoric waters contributes to background and accounts for about one-tenth of the minimum dissolved helium concentration in the Inyan Kara and can be ignored during the interpretation of data; however, helium generated in the underlying rocks can affect the data to a greater extent.

The maximum possible concentration of dissolved helium in meteoric waters that directly recharge the Inyan Kara through precipitation and surface runoff is approximately 0.045×10^{-6} cm^3 He/cm^3 H_2O. About this same concentration can be expected in vadose water percolating downward toward the water table through unsaturated rock whenever air occupies the pore space. Radioactive decay of uranium and its daughters in this rock could increase the free-gas helium concentration to slightly more than the 5.24 ppm level of air, and cause a proportionate increase of dissolved helium in the vadose water.

Helium generated in rocks of pre-Cretaceous age is apparently introduced into the Inyan Kara Group both as a free gas and as a dissolved gas within the artesian water from the Minnelusa Formation. Control samples of ascending Minnelusa waters collected outside the study area yielded dissolved helium and dissolved radon in concentrations ranging from 0.09 to 200 x 10^{-6} cm^3 He/cm^3 H_2O and from 16 to 23 pCi/L, respectively (table 2). The highest dissolved helium was found in the water from Evans Plunge where 4.0 percent helium has been detected in the free gases reported by G. L. Cook (written commun., 1959) (table 3). Both free-gas helium and dissolved helium in the waters discharged by the spring at Evans Plunge are about four orders of magnitude greater than normal helium concentrations in air and in surface water at equilibrium with the air. The control samples of Minnelusa waters suggest that widely varying amounts of helium may be introduced into the Inyan Kara Group by artesian waters from the Minnelusa Formation.

Interpretation

Interpretation of the helium data from the study area is made more complex by the artesian recharge of the Inyan Kara Group. No consistent relationship exists among the concentrations of dissolved helium, dissolved radon, and soil-gas helium in samples collected from areas near Burdock and within the Dewey and Long Mountain structural zones. Each of these areas has somewhat different geologic and hydrologic characteristics that apparently affect the distribution of gases.

Table 3.--Composition of gases collected from Evans Plunge, Hot Springs, Fall River County, South Dakota

[Analyses, in percent (calculated on an air-free basis), reported by G. L. Cook, Supervisory Chemist, Laramie Petroleum Research Center, U. S. Bureau of Mines, Laramie, Wyoming, written commun., 1959]

Component	Evans Plunge, Hot Springs, S. Dak.
Methane	0.1
Carbon dioxide	2.9
Nitrogen	91.9
Argon	1.2
Helium	4.0
Total	100.1
Air (as received)	24.3

Within the area of artesian recharge east of Burdock the distribution of gases appears to be characteristic of much of the area close to the Inyan Kara outcrop. The dissolved helium concentration is low, and the dissolved radon concentration is relatively high compared to that of samples collected farther downdip. Soil gas is also relatively high in helium (107 ppb He). These values are believed to reflect a release of dissolved helium from the artesian waters of the Minnelusa as they ascend to the Inyan Kara. The free-gas helium can then escape to the surface where it is detected in the soil. In contrast, dissolved radon tends to remain in solution, because radon is much more soluble than helium, and because the radon molecule is not as easily purged by the release of other free gases.

Westward from the Burdock recharge area the distribution of dissolved helium, dissolved radon, and soil-gas helium follows the general patterns common to the study area. The gradual downdip increase of dissolved helium represents the accumulation in the ground water of helium generated within the Inyan Kara. The westward decrease in dissolved radon reflects the rapid decay of radon and a lower uranium content in the rocks downdip from the redox front. West of Beaver Creek an increase in dissolved radon was detected. This increase is consistent with other geochemical data that indicates an area of artesian recharge lying downdip from the general redox front. The westward decrease of soil-gas helium probably reflects both the decrease of free-gas helium within the Inyan Kara downdip from the area of artesian recharge and the thickening of a wedge of marine shale that overlies the Inyan Kara and progressively inhibits upward diffusion of free-gas helium into the soil zone.

A high rate of ground-water flow in the Burdock area apparently is responsible for the absence of anomalous concentrations of dissolved helium, which would be expected down flow from a uranium deposit reported to be of commercial size and grade (fig. 7). A strong artesian recharge occurs near the Inyan Kara outcrop, and then the ground water flows extremely rapidly downdip towards the confluence of the Cheyenne River and Beaver Creek where much of the water apparently leaks upwards and discharges into the surface drainage. The westward flow rate was calculated from the tritium data to be as much as 1 mile per year (14.4 m/day) (Gott and others, 1974). Low dissolved-helium concentrations in the ground water extend far downdip within the area outlined by the tongue of tritiated water (fig. 3). It is concluded that the high flow rate allows the ground water only a very short residence time within the mineralized rock; that is, this time span is not long enough for the generation and accumulation of anomalous concentrations of dissolved helium before the ground water flows out of the mineralized ground.

Water samples from the Long Mountain structural zone collected near the Inyan Kara outcrop yield high concentrations of dissolved helium in contrast to the amounts detected in the Burdock area, but both dissolved radon and soil-gas helium are present in normal concentrations. Calcium-magnesium-sulfate-type water within this structural zone averages about 10 times as much dissolved helium as similar water from the Burdock area. Although this helium could be generated within either the Inyan Kara or the underlying rocks, helium generation within the Inyan Kara appears more likely because of numerous oxidized uranium deposits updip at the outcrop, and because adjacent to the outcrop uranium occurrences are reported within the zone of oxidation below the water table. The absence of anomalous concentrations of soil-gas helium supports the interpretation that helium in this area is largely being generated from uranium occurrences within the Inyan Kara.

Farther downdip within and near the Long Mountain structural zone anomalous concentrations of dissolved helium (130 and 85 x 10^{-6} cm^3 He/cm^3 H_2O) provide a favorable geochemical target for uranium exploration. The water is not of the calcium-magnesium-sulfate type that characterizes artesian water from the Minnelusa Formation. This water was modified to a sodium-bicarbonate type by ion exchange and sulfate reduction while it flowed downdip within the Inyan Kara (Gott and others, 1974). Low redox potentials (fig. 6) in the sodium-bicarbonate waters result from sulfate reduction that causes uranium to disappear from the ground water at a redox front where uranium deposits may be present. The absence of high dissolved radon in the anomalous helium samples indicates that the postulated uranium deposits are not penetrated by the wells that yield the anomalous concentrations of helium, but the site of helium generation must lie updip toward the area of artesian recharge.

The Dewey structural zone has yet a third combination of helium and radon values. The Dewey area is characterized by a normal range of dissolved helium values, but high to anomalous concentrations of dissolved radon occur along faults at a distance of 2-3 miles (3-5 km) from the nearest Inyan Kara outcrop. Soil-gas helium concentrations are generally high, even as far downdip as Beaver Creek, suggesting that artesian waters ascending along faults and fractures are releasing dissolved helium which reaches the surface and is detected in the soil. Two of the water samples contained dissolved radon that was significantly higher than other radon values from the study area. High dissolved radon unaccompanied by high dissolved helium suggests that helium is being released or is being purged by other free gases released from the artesian water as it ascends along faults and fractures. It is possible that radon and helium were generated from nearby uranium occurrences in the Inyan Kara south of the Dewey fault and within the downdropped fault block. Artesian pressures may cause these waters to ascend along faults and fractures and enter aquifers of the Inyan Kara within the uplifted block. The decrease in pressure would more readily trigger the release of the less soluble dissolved helium to the free-gas state, causing only the anomalous amounts of radon to be retained in solution. The helium and radon data within the Dewey structural zone do not exhibit the characteristic basinward change in values, but instead their distribution reflect a structural control by the northeast trending faults.

CONCLUSIONS

(1) The analysis of dissolved helium in ground water complements other hydrochemical exploration techniques used in the search for uranium. Anomalous concentrations of helium in reducing ground waters in the study area provided an exploration target, whereas analyses of dissolved uranium during earlier investigations yielded no indication of a uranium deposit.

(2) The release of dissolved helium from artesian ground water, as it ascends to higher aquifers, may support an upward migration of free-gas helium and cause anomalous concentrations of helium in the soil zone.

(3) The dissolved helium detection technique may be more difficult to apply to uranium exploration in areas of very rapid ground water flow, because insufficient time exists for the accumulation of anomalous concentrations of dissolved helium as the ground water passes through a uranium deposit.

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