Bromine Geochemistry of Chloride Rocks of the Middle Pennsylvanian Paradox Formation of the Hermosa Group, Paradox Basin, Utah and Colorado

U.S. GEOLOGICAL SURVEY BULLETIN 2000-M

Cover. View south toward the La Sal Mountains along the Colorado River between Cisco and Moab, Utah. Fisher Towers in center is composed of Permian Cutler Formation and capped by Triassic Moenkopi Formation. The prominent mesa at left center is capped by Jurassic Kayenta Formation and Wingate Sandstone and underlain by slope-forming Triassic Chinle and Moenkopi Formations. The Chinle-Moenkopi contact is marked by a thin, white, ledge-forming gritstone. The valley between Fisher Towers and Fisher Mesa in the background is part of Richardson Mesa, part of Professor Valley. Photograph by Omer B. Raup.

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By Omer B. Raup *and* Robert J. Hite

EVOLUTION OF SEDIMENTARY BASINS—PARADOX BASIN

A.C. Huffman, Jr., Project Coordinator

U.S. GEOLOGICAL SURVEY BULLETIN 2000–M

A multidisciplinary approach to research studies of sedimentary rocks and their constituents and the evolution of sedimentary basins, both ancient and modern

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CONTENTS

FIGURES

[Figures follow References Cited and begin on page 21]

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ABSTRACT

Stratigraphic profiles of bromine distribution from analyses of 3,045 halite and sylvite samples from the Middle Pennsylvanian Paradox Formation of the Hermosa Group in the Paradox Basin of Utah and Colorado indicate that the 29 evaporite cycles are primarily of seawater origin. Interpretation of shapes of the profiles suggest that halite deposition was probably regulated by fluctuating sea level, a result of the waxing and waning of glaciers on the huge supercontinent of Gondwanaland in the Southern Hemisphere during Middle Pennsylvanian to Early Permian time. The basin was connected to the sea during periods of high sea level with a dynamic flow of seawater into the basin and probable reflux of denser brines out of the basin. Stages of lower sea level initially restricted reflux, then resulted in evaporative drawdown when the level of the sea dropped below the shelf-area inlet to the basin.

Averages of bromine values show salinity gradients within the basin during evaporite deposition. Salinity increases from the shallow edges of the basin to the deepest parts of the basin in a trough area adjacent to the Uncompahgre uplift. Facies distribution reflects the salinity gradients in that potash and halite is concentrated in the deeper parts of the basin and less soluble anhydrite and carbonate rocks are thicker toward the basin margins.

There is a positive correlation between halite beds that have high average levels of bromine and those that contain potash deposits. Bromine distribution, therefore, is a valuable tool in exploration for potash deposits in evaporites of marine origin.

INTRODUCTION

Determining the distribution of bromine in the chloride facies of marine evaporites aids in reconstruction of paleosalinities in evaporite basins and provides an important geochemical tool in the exploration for potash deposits. Detailed stratigraphic profiles of bromine distribution are also useful in resolving problems in correlation and in understanding some of the postdepositional processes that have occurred in the evaporite rocks (Raup and Hite, 1978).

Much work has been done on the geochemistry of bromine in the German Zechstein, such as by Baar (1954, 1955, 1963), Boeke (1908), Braitsch (1962, translation 1971), Braitsch and Herrmann (1963), D'Ans and Kühn (1940–1944), Herrmann (1958), Kühn (1955, 1968), Schulze (1960), and Schulze and Seyfert (1959). Examples of work done in Russia are by Ogienko (1959) and Valyashko (1956). More recently, bromine geochemical studies have been done by Baar (1966), Schwerdtner (1964), Schwerdtner and Wardlaw (1963), and Wardlaw (1964) in Canada; by Hite (1983), Holser (1966), Raup (1966), and Raup and others (1970) in the United States; and by Hite (1974) in Thailand.

Several studies have been made of bromine distribution in the evaporites of the Paradox Basin. Raup (1966) published the first profiles of bromine distribution in four halite beds near the top of the evaporite succession, using analyses of samples from a potash exploration drill core. Later, Raup and others (1970) published bromine profiles determined from analyses of well cuttings and interpreted the salinity gradient for several cycles for part of the basin. Hite (1983) published bromine profiles for most of the halite beds in the Middle Pennsylvanian Paradox Formation of the Hermosa Group from analyses of U.S. Department of Energy core samples.

Bromine distribution data in this study were obtained from five cores and cuttings from three wells within the Paradox Basin (fig. 1). The five coreholes lie on a roughly north-south line in the western part of the basin in San Juan and Grand Counties, Utah. Three wells, from which cuttings

were analyzed, lie along a northwest-southeast line that is essentially parallel with the axis of the basin in San Miguel and Dolores Counties, Colorado, and in San Juan County, Utah. All coreholes and wells were drilled in the area of halite deposition in the Middle Pennsylvanian Paradox Formation of the Hermosa Group.

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GEOLOGIC SETTING

The Paradox Basin in southeastern Utah and southwestern Colorado (fig. 1), in the eastern part of the Colorado Plateau, is a structural and depositional basin that trends northwest-southeast adjacent to the southwest flank of the Uncompahgre uplift. The depositional basin was asymmetrical in a northeast-southwest direction; it was deepest adjacent to the Uncompahgre uplift and shallowed toward the shelf areas, which were toward the west, southwest, and south. The present sedimentary basin covers an area of approximately 11,000 mi^2 (28,500 km^2), and its boundaries are defined by the maximum limit of the halite deposits in the Middle Pennsylvanian Paradox Formation of the Hermosa Group. The original maximum depositional thickness of the Paradox Formation was probably 5,000–6,000 ft (1,500–1,800 m) in the deepest part of the basin. The halite-bearing interval has been locally thickened to as much as 14,000 ft (4,600 m) in diapiric anticlines (Hite, 1968, p. 321).

The areal distribution of various elements of the evaporite facies reflects the asymmetry of the basin (fig. 1). The potash facies is best developed in the deepest parts of the basin, adjacent to the Uncompahgre uplift. The halite facies is more widely distributed, extending farther to the northwest, southwest, and southeast. The anhydrite facies extends beyond the halite facies, and the carbonate facies, both limestone and dolomite, extends onto the shelf areas beyond the edge of the basin (Hite and Buckner, 1981).

Paleozoic and Mesozoic rocks of the northeastern part of the Paradox Basin are folded into a series of parallel anticlines and synclines that trend northwest-southeast. Rocks of the evaporite facies, in the areas of thickest evaporites, have flowed into the cores of the anticlines from the adjacent synclines. Anticlines closest to the Uncompahgre uplift are diapiric, and large volumes of halite in the upper parts of their cores have been removed by dissolution. In anticlines farther from the uplift, the evaporite facies is conformable with overlying sedimentary rocks. The nondiapiric anticlines are the sources of the cores and cuttings used in this study.

The Paradox Basin formed in Pennsylvanian time in response to plate collisions that produced the Ouachita-Marathon orogeny (Kluth and Coney, 1981). The South American–African plate encountered the North American plate from the southeast starting in Late Mississippian to Early Pennsylvanian time. Major structural displacement occurred from Middle Pennsylvanian to Early Permian time. The major stresses of impact progressed from east to west, first in the present-day Ouachita area, then in the Marathon Basin area (Ross, 1979). Structural deformation in the ancestral Rocky Mountains responded to the same east to west sequence. Coarse arkose flanking the ancestral Front Range is Early Pennsylvanian to Early Permian in age (Mallory, 1975), whereas arkose flanking the Uncompahgre uplift is Late Pennsylvanian and Permian in age (Peterson and Hite, 1969).

Tectonism in and around the Paradox Basin reached its maximum with major downwarping of the basin in Desmoinesian time. The major positive elements were the ancestral Front Range, the Uncompahgre uplift, the Emery uplift, the Piute positive element (Mallory, 1975), and the ancestral Kaibab and Zuni-Defiance uplifts (Peterson and Hite, 1969). Except for the deep-water parts of the Paradox Basin, the surrounding areas were covered by shallow seas.

FACIES DISTRIBUTION

The evaporite facies in the Paradox Basin are generally concentrically arranged: the most soluble facies are in the basin depocenter and the less soluble facies are at the edges (fig. 1). The areal extent of these facies, because of the asymmetry of the depositional basin, is compressed against the northeast side of the basin adjacent to the Uncompahgre uplift. The less soluble facies extend toward the basin margins to the south, southwest, west, and northwest. The facies distribution described here is highly generalized because the facies distribution pattern varies greatly from cycle to cycle. Figure 2 illustrates that the halite and associated facies in cycle 1 are confined to small area in the north part of the basin, whereas in cycle 6 the halite facies are very widespread.

The greatest concentration of potash is in a fairly narrow trough that parallels the northeastern boundary of the basin adjacent to the Uncompahgre uplift. Rocks of the potash facies contain a maximum of about 30 percent potassium chloride (sylvite, KCl) and 70 percent halite. The halite facies overlaps and extends well beyond the potash facies. An anhydrite and carbonate facies overlaps and extends beyond the halite facies onto the shelf (Peterson and

Hite, 1969; Hite, 1970). The boundary between the anhydrite and carbonate facies is not known well enough to be plotted in figure 1. This distribution of facies, with the least soluble components at the shallow basin edges and progressively more soluble components in the deeper parts of the basin, suggests depositional control by a salinity gradient.

STRATIGRAPHY AND STRATIGRAPHIC CORRELATIONS

The Hermosa Group of Middle and Late Pennsylvanian (Atokan to Virgilian) age in the Paradox Basin contains three formations. The lowest of these is the Pinkerton Trail Formation (Middle Pennsylvanian), which overlies the Molas Formation of Early Pennsylvanian age (fig. 2). The Pinkerton Trail Formation, which in the Gibson Dome No. 1 core is 207 ft (63 m) thick, consists mostly of interbedded layers of silty dolomite, dolomitic siltstone, calcareous siltstone, silty limestone, fairly pure limestone, and several thick layers of anhydrite in the upper part of the formation (Woodward-Clyde Consultants, 1982). The thick beds of anhydrite signal the beginning of evaporitic conditions in the basin prior to the deposition of the Paradox Formation.

The Paradox Formation (Middle Pennsylvanian) consists of 31 known cycles of halite-bearing evaporite rocks. Each cycle contains penesaline and siliciclastic rocks (interbeds) at the base and a halite bed, with or without potash, at the top. Individual halite beds range in thickness from 20 to 800 ft (6–244 m) near the basin depocenter (Hite, 1968). Hite (1960) numbered the halite beds from 1 to 29, from top to bottom (fig. 2). Recent drilling has shown, however, that there are two younger, thin halite beds near the depocenter of the basin. These have not as yet been incorporated into the present numbering system. The cycles are separated by erosional or dissolution unconformities that are characterized by sharp contacts (Hite, 1970; Hite and Buckner, 1981; Raup and Hite, 1992).

The Paradox Formation and the upper part of the Pinkerton Trail Formation represent sediments deposited during an interruption of normal-marine carbonate deposition. A major tectonic event caused rapid downwarping of the basin, and elevation of the Uncompahgre uplift and minor uplifts, that restricted the flow of marine waters into the basin causing extended periods of hypersalinity and anoxia.

Hite (1960, 1970), Peterson and Hite (1969), and Hite and Buckner (1981) established stratigraphic correlation of the evaporite cycles in the Paradox Formation throughout the Paradox Basin. The correlations are based on distinctive geophysical log signatures of many of the penesaline and siliciclastic intervals (interbeds) within the evaporite sequence; these log signatures can be recognized and correlated from one end of the basin to the other and from the evaporite facies in the deep part of the basin to the carbonate rocks on the shelf of the basin.

Most of the interbeds are made up of anhydrite, dolomite, and organic-carbon-rich calcareous shale (black shale). Some interbeds are primarily anhydrite and dolomite and contain little or no black shale. Each of the interbeds has anhydrite at the top and bottom, and most contacts within the interbeds are gradational. The lithologies of the evaporite cycles and the cycle boundaries are discussed in Raup and Hite (1992).

Deposition of cycles 20 through 29 was restricted to a narrow, probably deep, trough adjacent to the southwest flank of the Uncompahgre uplift (figs. 1, 2). The halite intervals of cycles 22 through 29 are thin, but the halite in cycles 20 and 21 is quite thick. Cycles 6 through 19 have a much wider areal distribution than the underlying cycles, some extending onto the shelf area. The halite in cycles 6, 9, 18, and 19 is quite thick. From cycle 5 upward, deposition of the halite facies was progressively more restricted to the trough area of the basin.

Peterson and Ohlen (1963), Hite and Buckner (1981) and Raup and Hite (1992) attributed the cyclicity of the Paradox Basin evaporites to periodic changes in sea level in response to advance and retreat of glaciers in Gondwanaland in the Southern Hemisphere during Pennsylvanian time (Crowell, 1978). Interglacial melting caused a rise in sea level that increased water depths in the shelf areas of the Paradox Basin, resulting in an increase in marine circulation and a consequent lowering of basin-water salinity. The buildup of Gondwanaland glaciers caused a lowering of sea level that restricted marine circulation within the Paradox Basin, causing a rise in salinity of the basin brines and the deposition of soluble salts. The evaporite cycles of the Paradox Basin may possibly be correlative to cyclothems of the same age in the Midcontinent region of the United States because the deposition of both sequences was in response to the same sea-level events.

The Honaker Trail Formation (Middle and Upper Pennsylvanian) overlies the Paradox Formation. In the Gibson Dome core, it is 1,380 ft (420.6 m) thick. It consists mostly of interbedded layers of limestone, calcareous siltstone and shale, a few thin layers of sandstone, oolitic and fossiliferous limestone, and rarely dolomite and dolomitic siltstone (Woodward-Clyde Consultants, 1982). These lithologies show a return to normal marine depositional conditions following the evaporitic, hypersaline conditions of the Paradox Formation.

BROMINE DISTRIBUTION

OCCURRENCE OF BROMINE IN MARINE EVAPORITES

H.E. Boeke was one of the pioneer researchers on the mineralogy of the potash deposits of the Permian Zechstein

in Germany. He discovered that bromine, one of the minor constituents of seawater, does not form separate bromide minerals during the crystallization of salts from seawater but rather is present only in solid solution as a replacement of chlorine in chloride minerals (Boeke, 1908). The amount of bromine in the solid-phase chlorides is proportional to the concentration of bromine in the parent solution. Seawater contains about 65 ppm bromine. During formation of marine evaporites, this bromine is concentrated in the brines by evaporation until halite begins to precipitate. At that point, bromine is lost to the succession of chloride minerals. Each of the chloride minerals has its own coefficient of solid solution with regard to bromine. If the amount of bromine that can be taken into solid solution by halite is taken as 1, then the amount taken into solid solution by sylvite (KCl) is 10, by carnallite ($KMgCl_3 \cdot 6H_2O$) is 7, and by kainite ($KCl, MgSO_4 \cdot H_2O$) is 3.5 (Braitsch and Herrmann, 1963; Braitsch, 1971, p. 135). When two or more chlorides crystallize simultaneously from a brine, the bromine enters each solid phase according to each mineral's distribution coefficient. Consequently, the abundance of bromine in halite, to which the work described herein primarily addresses, is not affected by the presence or absence of other chloride minerals.

The coefficient of bromine between halite and brine is 0.14 throughout most of the range of halite precipitation, but it decreases to 0.07 near the brine concentration necessary for potash deposition as a result of increase of magnesium chloride in solution (Holser, 1966). This progressive change in the coefficient tends to moderate the steady rate of bromine increase in the halite as the brines become more concentrated through evaporation; however, the bromine in the halite does continually increase. Refer to Holser (1966), Kühn (1968), and Braitsch (1971) for more detailed discussion of distribution coefficients.

Studies of D'Ans and Kühn (1940–1944), Baar (1954), and Schulze (1960) show that stratigraphic profiles of the distribution of bromine in chloride rocks yield information on the salinity of brines from which evaporites precipitated and are useful in reconstructing the dynamics of influx, evaporation, and reflux in the Zechstein Basin. Since these studies several other researchers have used bromine profiles in the study of evaporite rocks (Braitsch and Herrmann, 1963; Schwerdtner and Wardlaw, 1963; Holser, 1966, 1979a, 1979b; Raup, 1966; Kühn, 1968; Raup and others, 1970; Braitsch, 1971; Raup and Hite, 1978)

THEORETICAL PROFILES

Experimental work by D'Ans and Kühn (1940–1944), Braitsch and Herrmann (1963), and Holser (1966) demonstrates that, as the dissolved constituents in seawater become concentrated through evaporation, bromine increases from 65 ppm in normal seawater to about 540 ppm at the beginning of halite precipitation. During the stage when only halite is precipitating, prior to the appearance of the first potash minerals, bromine in the brine increases from about 540 to about 3,900 ppm. The bromine content of halite increases from an initial 75 ppm to 280 ppm (Braitsch, 1971, p. 139). This upward increase of bromine in a halite bed precipitated from seawater is the expected distribution with progressive evaporation. Bromine profiles of halite rocks in various evaporite basins have been compared to the theoretical profiles established by experimentation.

Recrystallization during deformation of halite will affect bromine content only if the halite is recrystallized in the presence of brines that have bromine contents different from that of the original brine (Schwerdtner and Wardlaw, 1963, p. 241). The Paradox Basin halite beds, for the most part, have normal bromine distributions (Raup and Hite, 1978), but some deviate from the norm in minor ways. Thus, by studying the distribution of bromine content in the halite beds of the Paradox Basin, we have attempted to determine the relative salinities of the brines from which the halite precipitated and to reconstruct the history of salinity for each halite bed and for deposition in the basin as a whole.

METHODS OF SAMPLING AND ANALYSIS

Samples for bromine analysis were taken different ways through the duration of the studies. Each method was considered appropriate at the time, but subsequent methods were attempts to improve the technique. All of the samples from core were taken at 2-foot (0.6 m) intervals, and samples from cuttings were collected from the standard petroleum industry 10-foot (3 m) intervals.

Samples from the Cane Creek core were taken with a hammer and chisel at 2-foot (0.6 m) intervals. Each sample contained approximately 20–30 g of halite. Anhydrite laminations were avoided so that the samples had the highest possible sodium chloride content.

The Shafer core was sampled at 2-foot (0.6 m) intervals using a masonary drill. The holes were of sufficient size to yield about 20–25 g of cuttings and dust.

The Elk Ridge, Gibson Dome, and Utah cores were sampled by cutting a channel parallel with the long dimension of the core using a high-speed, hand-held power tool (Hite, 1983). The dust was collected from 2-foot (0.6 m) intervals, and each interval yielded about 20 g of sample. Thick intervals of anhydrite were avoided to minimize contamination by calcium sulfate. Channel samples, collected from the entire 2-foot (0.6 m) interval, yielded superior samples as compared to the spot samples taken earlier in the study.

Samples from the Lone Dome and Egnar wells were hand picked under a binocular microscope. About 6 g of clean halite from 10-foot (3 m) intervals was picked with care being taken to select halite that was free of included anhydrite.

Twenty samples from the Egnar well, which had been prepared for analysis by hand picking, were recrystallized and analyzed again. No significant differences were noted in the bromine content between the two methods of sample preparation.

Samples collected at 10-foot (3 m) intervals from the Chevron well were purified for X-ray analysis by recrystallization rather than by hand picking. This was done to speed the process of sample preparation. Approximately 7–8 g of sample was placed in 100 mL of distilled water and stirred to quickly dissolve the halite. A small amount of anhydrite went into solution; however, because less than 0.5 percent of the recrystallized halite was calcium sulfate, the contamination was insignificant for these analyses. The halite solution was filtered and placed in an evaporating dish lined with a commercially available plastic film. The plastic kept the recrystallizing salt from creeping up the sides of the dish and aided in removing salt after the liquid had evaporated. The recrystallized salt was scraped and brushed from the plastic film, thoroughly ground and mixed, dried for about 10 minutes under a heat lamp, and then thoroughly ground and mixed again. Great care was taken to prevent loss of any recrystallized salt. Because of the bromine distribution coefficient between liquid and solid phases, loss of even a small amount of late-crystallizing salt would adversely affect the bromine content of the sample.

All samples were ground to a fine powder. Samples from the Cane Creek and Shafer cores were placed in plastic cups and covered with thin plastic film that is transparent to X-rays. Samples from the Elk Ridge and Gibson Dome cores were placed in aluminum caps and pelletized at a pressure of 22,000 psi (15,500 kg/cm^2). Samples from the Utah core and cuttings from the Lone Dome, Chevron Federal, and Egnar wells were compressed into pellets, some with a backing of cellulose, at a pressure of 22,000 psi (15,500 kg/cm^2). The various types of sample preparations were stored in a desiccator until they were analyzed by X-ray fluorescence spectrometer.

Standards were prepared by mixing sodium bromide in a matrix of bromine-free sodium chloride. Each standard was fused, and the resulting ingot was ground in a mechanical mill. The resulting powder was pelletized at a pressure of 22,000 psi (15,500 kg/cm^2). The standards were stored in a desiccator until needed.

The analyses for bromine were made using X-ray fluorescence spectrometers of various types. Analyses were made in air or vacuum; radiation was from tungsten or molybdenum tubes, with a lithium fluoride analyzer crystal. Detectors were scintillation types; pulse-height analyzer circuits were used with window voltages selected to maximize sensitivity for the 11.91 Kev Kα energy of bromine, and a spinner in the spectrograph rotated the samples during analysis to insure uniform exposure to the X-rays.

Each sample was scanned from 28 to 32 degrees 2θ, at the rate of 1 degree per minute. The bromine peak scanned was Kα_1, first order at 29.96 degrees 2θ, and peak to background ratios were compared to standards, either manually or using computer analysis. The limit of detection for bromine in a matrix of bromine-free sodium chloride, using the various types of equipment and techniques, is approximately 30 ppm. The average precision in the range of 30–80 ppm bromine is plus or minus 15 percent and in the range of 80–400 ppm is plus or minus 6 percent. Above 400 ppm the precision is plus or minus 2 percent.

A total of 3,045 bromine analyses are included in this study. Of those, 2,169 analyses are from core samples, 846 are from borehole cuttings, and 15 each are of coexisting halite and sylvite from the potash ore zone of cycle 5 in the Texasgulf potash mine near Moab, Utah. The bromine analyses are listed in Appendix tables 1–104.

BROMINE PROFILES

Ninety-nine complete and three partial bromine profiles were plotted from analyses mentioned above. Forty-two profiles are from core samples, and 60 are from well cuttings. A chart illustrating the halite beds and their corresponding bromine profiles is shown in figure 3.

ANALYTICAL DATA AND SMOOTHED PROFILES

Bromine profiles for the Cane Creek and Shafer cores are presented in two forms: profile *A*, analytical data, and profile *B*, smoothed profile using a moving average of five points. Smoothed profiles were included for these two cores because the samples were taken at spot locations every 2 ft. The smoothing minimizes the variability of bromine concentration over short distances.

The top and bottom points of the smoothed profiles are an average of the top two and bottom two points, respectively. The second point from the top and bottom are averages of the top and bottom three points, respectively. All other points are the average of two points above and two points below (five points). In profiles that contain breaks, the segments of the profile are treated as separate profiles with regard to the top and bottom points.

The profiles of the Elk Ridge, Utah, and Gibson Dome cores represent analytical data without separate smoothed profiles. Because the samples were collected from channels collected continuously through 2-foot (0.6 m) intervals, a method that averages the bromine distribution within the intervals, the profiles were automatically smoothed.

The profiles from the Lone Dome, Chevron Federal, and Egnar cuttings also represent only analytical data because the mixing of such long, 10-foot (3 m) intervals tended to smooth the profiles.

SCALES OF PROFILES

The scale used to plot the profiles is important for comparison and interpretation of the bromine distribution data. Most profiles were plotted at the same horizontal scale (0–250 ppm bromine). For a few profiles, in which the bromine values exceed 250 ppm, the scale extends only far enough to include the data. The vertical scales are essentially the same from one profile to another except for profiles of very thick halite beds where the scale had to be reduced slightly in order for the profile to fit on one page.

REGULAR AND IRREGULAR PROFILES

Profiles of the stratigraphic distribution of bromine in halite beds of marine evaporites can be characterized as either regular or irregular. In regular profiles, bromine values vary within a narrow range from one sample to the next, usually within 20–30 ppm. Such profiles have the characteristic of appearing relatively smooth from bottom to top. In irregular profiles, bromine values vary more than 30 ppm from one sample to the next, and they are not smooth. These features are discussed in more detail later in the Characteristics and Interpretations of Bromine Profiles section.

BROMINE PROFILES FROM CORE SAMPLES

The bromine profiles constructed from samples from the five coreholes used in this study represent one of the most complete samplings ever done on the distribution of bromine in evaporites that are most probably of marine origin. The data points in all the profiles from these cores, based on samples collected at 2-foot (0.6 m) intervals, yielded profiles that have a high level of stratigraphic detail. Interpretations of this detail are presented later in the Characteristics and Interpretations of Bromine Profiles section.

DELHI-TAYLOR OIL CORPORATION, CANE CREEK NO. 1

The Cane Creek No. 1 corehole is in sec. 25, T. 26 S., R. 20 E., Grand County, Utah, near the crest of the Cane Creek anticline. It is about 5 mi (8 km) north-northeast of the Shafer No. 1 corehole and 9 mi (14 km) west-southwest of the Utah No. 1 corehole (fig. 1). It samples the Paradox Formation between depths of 1,846 and 2,825 ft (563–861 m), and it penetrates halite beds in cycles 2 through 5 (figs. 4–8). There are essentially no structural complications in this corehole.

The bromine profile of the halite bed of cycle 2 (fig. 5) illustrates several characteristics that will be discussed in more detail later in the Characteristics and Interpretations of Bromine Profiles section. After the initial high values at the base, which are considered anomalous and will be discussed later, the profile illustrates an increase of bromine from bottom to near the top. The profile is regular in that bromine values vary within narrow limits from one sample to the next. This profile also shows a rhythmic increase and decrease of bromine that is especially obvious in the smoothed profile. Exclusive of the high values at the base, minimum values are in the range of 50–100 ppm. The decrease in bromine values at the top of the profile indicates a decrease in salinity of the basin brines, probably as a result of returning open-sea conditions. Normal marine limestone is present in the Honaker Trail Formation a few feet above this halite bed.

The cycle 3 profile (fig. 6) illustrates a modest increase in bromine from bottom to top, and a rapid increase at the top. This profile is considered to have a regular bromine distribution. Minimum values at the base are in the range of 50–100 ppm. In the upper part of this halite bed, bromine content abruptly increases, indicative of conditions just short of potash deposition.

In the cycle 4 profile (fig. 7) bromine generally increases from bottom to top. The distribution of bromine is somewhat irregular in appearance; however, the variation in bromine content rarely exceeds 30 ppm. There is also some indication of rhythmic increase and decrease of the bromine values. Minimum bromine values are in the range of 50–100 ppm.

The profile of cycle 5 (fig. 8) is a regular profile that is essentially vertical in the bottom half and then increases rapidly in the upper part, indicating a rapid increase of salinity of the basin brines. The values at the top exceed 250 ppm, coincident with deposition of a 16-ft-thick (4.9 m) sylvite zone at the top of this halite bed. Bromine values in the halite and sylvite in this zone are discussed later. The minimum bromine values are about 100 ppm.

DELHI-TAYLOR OIL CORPORATION, SHAFER NO. 1

The Shafer No. 1 corehole is in sec. 15, T. 27 S., R. 20 E., San Juan County, Utah, on the crest of the Shafer anticline. It is approximately 21 mi (34 km) north-northwest of the Gibson Dome No. 1 corehole and 5 mi (8 km) south-southwest of the Cane Creek No. 1 corehole (fig. 1). The part of the Paradox Formation sampled by this core is between the depths of 2,209 and 4,156 ft (673–1,267 m). The corehole penetrates 11 halite beds, cycles 2 through 13. There are no structural complications in this corehole.

Ten complete and two partial profiles of bromine distribution were prepared for the halite beds in Shafer No. 1 corehole (figs. 10–20). The partial profiles are for halite beds in cycles 2 and 3. The complete profiles are for halite

beds in cycles 4 through 13, with the exception of cycle 12, which is not present at this location (fig. 9).

The short segment of profile at the top of halite bed in cycle 2 (fig. 10) is regular and shows a decrease in bromine content at the top, similar to the decrease at the top of the cycle 2 profile in the Cane Creek No. 1 core. The partial profile at the base of halite bed in cycle 3 (fig. 11) is regular and has minimum bromine values in the range of 50–100 ppm.

The halite bed of cycle 4 in the Shafer No. 1 core (fig. 12) is much thinner than that in the Cane Creek core. Most of the bromine values in the Cane Creek core are greater than 100 ppm, whereas most of those in the Shafer core are less than 100 ppm. It is obvious that the environment during the deposition of this halite bed was quite different at these two locations.

With the exception of anomalously high values at the base, the cycle 5 profile (fig. 13) is a good example of a regular profile; minimum values are in the 50–100 ppm range, and bromine rhythmically increases and decreases within the profile. Although the profile shows a general increase in salinity, the rate of increase is not as great at this location as that of cycle 5 at Cane Creek. The halite bed of cycle 5 at Cane Creek contains a commercial potash deposit at the top of the halite bed, whereas at the Shafer locality there is only a minor amount of sylvite disseminated in the halite.

The profile of the halite bed of cycle 6 (fig. 14) is regular in the bottom part but is quite irregular in the upper two-thirds. Minimum bromine values at the base are in the range of 50–100 ppm. The smoothed profile shows intervals of rhythmic increase and decrease in bromine content. An interval of 22 ft (6.7 m) near the top of the halite bed was unavailable for bromine analysis because it had been removed for potash testing. Bromine values for the halite immediately above and below this interval are greater than 200 ppm, indicating that salinity was very high during deposition.

The profile of the cycle 7 halite bed (fig. 15) is reasonably regular and shows an increase of bromine content from a minimum range of 50–100 ppm to a maximum of more than 250 ppm. This profile also displays a cyclic increase and decrease of bromine values.

The profile of the cycle 8 halite bed (fig. 16) is fairly regular and shows a modest increase in bromine upward and a slight decrease at the top. Minimum values are in the range of 50–100 ppm.

The profile of the cycle 9 halite bed (fig. 17) is similar to many other profiles in the basin in that the minimum bromine values are in the 50–100 ppm range (with the exception of the one sample at the base); the profile is essentially vertical in the lower half and then increases upward in the upper part. The nearly constant values in the lower part indicate constant salinity in the brine during deposition. This circumstance is discussed in more detail later. The halite bed of cycle 9 contains disseminated sylvite in the halite between 3,540 and 3,565 ft (1,079–1,087 m) (Raup and Hite, 1991), an interval that is clearly delineated by the high bromine values in the profile. The halite bed contains a potentially valuable potash deposit at Cane Creek and in other parts of the basin (Hite, 1961). The six bromine values at the top of the profile cluster at about 150 ppm and may represent a zone of recrystallization during which the bromine in the halite was homogenized.

The profile of the cycle 10 halite bed (fig. 18) is unusual in that it shows an increase of salinity in the bottom third of the halite bed, then a cyclic decrease in salinity in the upper two-thirds of the interval. The halite sample that contains 60 ppm bromine at 3,770 ft (1,149 m) also contains thin layers of anhydrite with coarse pseudomorphs after gypsum (Raup and Hite, 1991). The top of halite bed 10 is very coarsely crystalline in this and other cores in the basin, indicating perhaps that the top of the halite bed was massively recrystallized. The profile of the very thin cycle 11 halite bed (fig. 19) is indicative of only a slight increase in salinity from bottom to top.

The profile of the cycle 13 halite bed (fig. 20) shows a dramatic increase in salinity from the base upward. Bromine values are within the 50–100 ppm range near the base and increase cyclically upward to more than 800 ppm (off the scale of the profile) near the base of a potash zone at 4,035 ft (1,230 m). Forty-two ft (12.8 m) of core (the missing interval in the profile) was removed for potash testing and was unavailable for bromine analysis. A few samples were available at the top of the halite bed.

DELHI-TAYLOR OIL CORPORATION, UTAH NO. 2

The Utah No. 2 corehole is in sec. 18, T. 25 S., R. 21 E., Grand County, Utah, about 6 mi (10 km) northwest of Moab on the crest of the Moab Valley anticline in Seven-Mile Canyon. It is approximately 9 mi (15 km) north-northeast of the Cane Creek No. 1 corehole (fig. 1). The part of the Paradox Formation sampled by this core is between the depths of 2,352 and 3,360 ft (717 and 1,024 m) at the bottom of the hole. This hole penetrates all 29 halite beds; however, only halite beds in cycles 1 through 4 were cored (figs. 21–24). Because of sampling and analytical problems, the data from the halite bed of cycle 2 were unusable. There is no obvious structural complication in the core from this hole.

This is the only profile of the cycle 1 halite bed in the Paradox Basin (fig. 22). Cycle 1 has limited geographic extent in the basin and has been drilled by very few holes. The profile is similar to some of the other regular profiles of halite beds in that it increases in bromine content from near the bottom to the top. The strong inclination of this profile shows a rapid increase in brine salinity during halite

deposition. Minimum bromine values near the base are less than 50 ppm, and the significance of this is discussed later. The three high values at the base are considered to be anomalous and also are discussed later.

The narrow range in bromine values of the profile for the cycle 3 halite bed (fig. 23) is not particularly diagnostic of a trend in salinity change except for a general increase in the upper two-thirds of the profile. Minimum bromine values are generally greater than 100 ppm.

The profile of the cycle 4 halite bed (fig. 24) is irregular in character and shows an overall narrow range of bromine values. There are some general similarities between this profile and the profile of cycle 4 in the Cane Creek corehole (fig. 7). The average values in the Utah core are slightly higher than those at Cane Creek, perhaps because of the difference in positions of the two coreholes with respect to the depositional center of the basin. The Utah well is somewhat closer to the basin deep.

U.S. DEPARTMENT OF ENERGY, ELK RIDGE NO. 1

The Elk Ridge No. 1 corehole is in sec. 31, T. 37 S., R. 19 E., San Juan County, Utah, on the Elk Ridge anticline. It is approximately 18 mi (29 km) west-southwest of Blanding, Utah, and 45 mi (72 km) south-southwest of the Gibson Dome No. 1 corehole (fig. 1). The part of the Paradox Formation sampled by this core is between depths of 2,738 and 3,240 ft (834–988 m), a total thickness of 502 ft (153 m). The core penetrates five halite beds—cycles 6, 7, 9, 13, and 16—close to the edge of the depositional area for halite in the basin and was drilled outside of the potash depositional area (figs. 1, 25–30). There is no evidence of any structural complication in the halite intervals.

The profile for the cycle 6 halite bed (fig. 26) decreases in bromine content from bottom to top through a narrow range of 43–115 ppm and is atypical in that most other bromine profiles increase from bottom to top. Brine salinity apparently was decreasing during the deposition of this thin halite bed near the edge of the basin.

The profile for the thin halite bed of cycle 7 (fig. 27) is not diagnostic of salinity change in the basin brines. The minimum bromine content is, however, in the 50–100 ppm range. The profile of the cycle 9 halite bed (fig. 28) looks like a typical regular profile, but the range of values and the thickness of the halite bed are small. With the exception of the two high values at the base, minimum bromine values are in the range of 50–100 ppm. The profile of the cycle 13 halite bed (fig. 29), similar to other profiles for the Elk Ridge core, has a small range in bromine values.

The profile of the cycle 16 halite bed (fig. 30) shows a wider range of bromine values than the other four halite beds described in this core. Bromine content in the bottom three-quarters of the profile of this thin halite bed rapidly increases upward and then abruptly decreases at the top.

Each of the five profiles for the Elk Ridge core exhibits conditions of rapid changes in salinity through a fairly narrow range. Because the Elk Ridge corehole is located close to the depositional edge of the five halite beds, it is probable that the brine depths were quite shallow and subject to rapid changes in salinity.

U.S. DEPARTMENT OF ENERGY, GIBSON DOME NO. 1

The Gibson Dome No. 1 corehole is in sec. 21, T. 30 S., R. 21 E., San Juan County, Utah, on the southeast plunge of a small salt anticline known as Gibson dome. It is approximately 21 mi (34 km) south-southeast of the Shafer No. 1 corehole and 45 mi (72 km) north-northeast of the Elk Ridge No. 1 corehole (fig. 1). The part of the Paradox Formation sampled by this core is between the depths of 2,925 and 5,506 ft (891–1,678 m), a total of 2,581 ft (787 m). The core penetrates 19 halite beds—cycles 4 through 26 (figs. 31–50). Halite beds in cycles 11, 12, 22, and 23 are missing but are represented by anhydrite beds. Halite beds in cycles 13 and 18 contain important deposits of potash, and trace amounts of potash are present in evaporite cycles 6, 7, 9, 19, and 21 (Hite, 1982).

The halite bed of cycle 4 in the Gibson Dome No. 1 corehole is much thinner than the same bed in either the Shafer No. 1 or Cane Creek No. 1 corehole. The bromine content of the five samples in this profile (fig. 32) decreases from bottom to top, and the profile may represent the very top of a thicker halite bed elsewhere.

The partial profile of the halite bed in cycle 5 (fig. 33) is from the upper 48 ft (14.6 m) of the bed; 16 ft (4.8 m) at the base of the bed is missing because of core loss during drilling. Bromine values here are considerably lower than those in cycle 5 in the Shafer and Cane Creek cores.

Bromine values in the lower half of the halite bed of cycle 6 (fig. 34) increase rapidly to greater than 200 ppm. The strong inclination in this part of the profile indicates rapidly increasing salinity of the basin brines. The high values in the upper half of the profile reflect the thick deposit of disseminated potash in this interval.

Bromine values in the halite bed of cycle 7 (fig. 35) increase rapidly in the upper three-quarters of the profile. Similar to the profile for halite bed of cycle 6, this profile shows a rapid rise in salinity of the brines from which this halite bed was precipitated. With the exception of two higher bromine values at the base, the profile of the halite bed of cycle 8 (fig. 36) increases rapidly from bottom to top.

Bromine values in the halite bed of cycle 9 (fig. 37) increase rapidly upward. The high bromine value at the top

of the profile indicates salinity conditions close to those necessary for potash deposition. The cycle 9 halite bed at Cane Creek contains a major potash deposit.

The bromine distribution in the halite bed of cycle 10 (fig. 38) lacks the characteristic regularity and slope of most of the profiles of the Paradox Formation halite beds. Examination of the core reveals that much of the upper part of halite bed 10 has been thoroughly recrystallized, and this recrystallization has apparently caused a redistribution of the bromine. This profile is, in general, similar to the profile for halite bed of cycle 10 in the Shafer corehole (fig. 18). Both profiles indicate a widespread recrystallization of the upper part of the cycle 10 halite bed.

The profile of the cycle 13 halite bed (fig. 39) is regular and rapidly increases from bottom to top. The interval near the top has bromine values of greater than 250 ppm and contains sylvite.

The irregular profile of the cycle 14 halite bed (fig. 40) varies widely in the range between 65 and 140 ppm bromine and shows no obvious trend of salinity change. The irregular profile of the cycle 15 halite bed (fig. 41) is similar to that of cycle 14.

The profile of the cycle 16 halite bed (fig. 42) is somewhat irregular near its base. There is, however, an overall increase in bromine from bottom to top. This is a good example of a compound profile. The profile of the cycle 17 halite bed (fig. 43) is extremely irregular and shows no salinity trends.

The irregular characteristics of the bromine profiles of halite beds of cycles 14–17 (figs. 40–43) indicate that these beds may have been recrystallized to some extent.

The halite bed of cycle 18 is one of the thickest halite intervals in the Paradox Formation. Bromine values in this profile (fig. 44) increase upward from just less than 40 ppm near the base to more than 500 ppm near the top and then decrease slightly at the top. With the exception of a few scattered low values, this profile is remarkably regular throughout the great thickness of this halite bed. The three higher values at the base are probably the result of secondary alteration. The values of more than 250 ppm near the top indicate the presence of potash.

The profile of the cycle 19 halite bed (fig. 45) is remarkably regular. Bromine values of more than 250 ppm in the upper part of this bed indicate the presence of potash minerals. As with the halite bed of cycle 18, this profile has a few higher values at the base that may be the result of secondary alteration.

The profile of the thin cycle 20 halite bed (fig. 46) indicates a modest increase in brine salinity during deposition. The profile of the cycle 21 halite bed (fig. 47) has a classic normal and regular bromine distribution; values range from 50 ppm near the base to about 320 ppm near the top. With the exception of its base, this profile looks much like the cycle 19 profile (fig. 45). The high bromine values at the top indicate the presence of potash minerals.

The regular profile of the cycle 24 halite bed (fig. 48) increases greatly from bottom to top. The strongly inclined part of the profile, from 5,345 ft (1,629 m) upward, indicates rapidly increasing brine salinity. The high bromine at the top shows the presence of potash minerals.

The profile of the cycle 25 halite bed (fig. 49) shows a slight salinity increase from bottom to top through a narrow range of bromine values. There are too few data points in the profile of cycle 26 halite bed (fig. 50) to indicate any significant salinity trend.

BROMINE PROFILES FROM WELL CUTTINGS

After several bromine profiles had been obtained from core samples in the shallower parts of the basin, we attempted to determine if any useful profiles could be obtained from cuttings from wells drilled in the deeper parts of the basin (Chevron Federal, Egnar, and Lone Dome wells, fig. 1). We determined that the profiles from cuttings have limited use because (1) they contain less detail than profiles from core samples in that data points from the wells are at 10-foot (3 m) sample intervals, whereas samples from core samples are at 2-foot (0.6 m) intervals and (2) cuttings may have significant contamination because of downhole caving.

Evaporite beds in the deeper parts of the basin have been faulted and folded in some stratigraphic intervals. This faulting and folding has resulted in repetition of some beds and thus has disrupted the normal sequence of rock as determined by the bromine profiles.

Despite the complications resulting from sample contamination and structural complication, some general information about salinity gradients within the halite beds, especially the thicker beds, can be acquired from well cuttings, and a general indication of the average bromine content of the halite beds can be obtained.

Comments on profiles from individual cycles are limited only to those profiles that provide information comparable to that provided by profiles of core samples. For the most part, these profiles are from some of the thick halite beds.

CONTINENTAL OIL CORPORATION, LONE DOME NO. 1

The Lone Dome No. 1 well is in sec. 26, T. 40 N., R. 16 W., Dolores County, Colorado. It is approximately 18 mi (29 km) east-southeast of Dove Creek, Colorado, and 29 mi (47 km) southeast of the Egnar No. 1 borehole (fig. 1). The part of the Paradox Formation sampled by this borehole is between depths of 6,265 and 9,395 ft (1,910–2,864 m). A

total thickness of 3,130 ft (954 m), which includes 16 halite beds (cycles 6 through 27), was penetrated (figs. 51–67). At this location, halite beds in cycles 1–5, 11, 12, 15, 17, 22, 23, 28, and 29 are represented by an anhydrite-carbonate facies. Folding and faulting have rendered some of the data, and therefore the profiles, questionable or unusable. The worst problems involve halite beds in cycles 6, 9, 13, 16, 18, 19, and 21–27.

The profile of the cycle 7 halite bed (fig. 53) is quite regular and illustrates a steady, but modest, increase in bromine content from bottom to top.

With the exception of the two data points at 7,090 and 7,100 ft (2,161, 2,164 m) and the one high value at the base, the profile of the cycle 9 halite bed (fig. 55) shows a fairly regular increase in salinity from bottom to top. The abrupt decrease at 7,100 ft (2,164 m) may be due to structural complications, but, if it is not, the profile is an example of a compound profile resulting from a major influx of seawater during halite deposition.

The remainder of the profiles in this borehole are typical of profiles obtained from cuttings.

GULF OIL CORPORATION, CHEVRON FEDERAL NO. 1

The Chevron Federal No. 1 well is in sec. 24, T. 29 S., R. 23 E., San Juan County, Utah, on the extreme northwest flank of the Lisbon Valley anticline. Chevron Federal No. 1 is 29 mi (47 km) northwest of the Egnar No. 1 well and 17.5 mi (28 km) east-northeast of the Gibson Dome No. 1 corehole (fig. 1). Samples of the Paradox Formation were obtained between depths of 5,221 and 9,042 ft (1,591–2,756 m), a total thickness of 3,821 ft (1,165 m), and halite beds in cycles 4 through 28 were penetrated (figs. 68–90). At this location, the halite beds of cycles 1, 2, 3, 11, 12, and 22 are represented by an anhydrite-carbonate facies. Of the 25 halite beds penetrated by this borehole, eight contain beds of potash (mostly sylvinite, a mixture of halite and sylvite). These eight halite beds are in cycles 6, 7, 9, 13, 19–21, and 24. Although most of these eight beds contain only a trace of potash, halite beds in cycles 9, 19, and 24 contain significant potash deposits.

Between the halite bed in cycle 18 and the base of the halite bed in cycle 29, most of the halite beds and the intervening penesaline and clastic rocks are thinner than normal. Isopach maps (Hite, unpub. data) show that this well probably is located on a pre-Pennsylvanian positive structure. A gamma ray-neutron log of this well shows that some strata have been folded or faulted. Also, irregularities in the bromine profiles indicate probable folding or faulting in halite beds in cycles 18 (base), 19–21, and 24. The influence of this structure is not evident in the strata above the halite bed in cycle 18.

The profile of the cycle 6 halite bed (fig. 71) shows the overall high bromine content of the halite and clearly reflects the location of the potash-mineralized zone at the top. The profile of the cycle 9 halite bed (fig. 74) shows the general increase in bromine content from bottom to top and the high values at the top indicative of potash. The profile of the cycle 13 halite bed (fig. 76) is remarkably regular for a profile from cuttings and indicates a steady increase in bromine content from bottom to top and a potash interval at the top. The profiles of the halite beds of cycles 14 and 15 (figs. 77, 78) show regular and smooth increases in bromine content upward. The profiles of the halite beds in cycles 19–21 (figs. 82–84) are typical of some of the more irregular profiles from cuttings. The abrupt changes in bromine content are probably due to folding or faulting.

REYNOLDS MINING CORPORATION, EGNAR NO. 1

The Egnar No. 1 well is in sec. 14, T. 43 N., R. 19 W., San Miguel County, Colorado, near the crest of the Dolores anticline. It is about 29 mi (47 km) northwest of the Lone Dome No. 1 well and 29 mi (47 km) southeast of the Chevron Federal No. 1 well (fig. 1). Samples of the Paradox Formation were obtained between depths of 5,443 and 9,579 ft (1,659–2,920 m), a total thickness of 4,136 ft (1,261 m), and halite beds of cycles 4 through 29 were penetrated (figs. 91–113). At this location, halite beds of cycles 1, 2, 3, 12, 15, 24, and 26 are represented by an anhydrite and carbonate facies. Of the 26 halite beds penetrated by this well, three contain potash (mostly sylvinite). These three are the halite beds in cycles 19, 21, and 27.

Profiles for the cycles from 18 downward show irregularities that are probably the result of faulting and folding.

Profiles from the halite beds of cycles 5, 6, and 9 (figs. 93, 94, 97) are quite regular and indicate an increase in bromine content from bottom to top.

The profiles of cycles 19, 20, 21, 27, and 28 (figs. 105, 106, 107, 111, 112) are for thick halite beds. The irregularity of the profiles is probably due to structural complications, but it may also represent major influxes of seawater during deposition. All of the profiles, however, show an increase in bromine content from bottom to top, and the average bromine values indicated are useful for interpreting basin salinity during evaporite deposition.

STAGES OF SEA LEVEL AND BRINE FLOW IN THE PARADOX BASIN DURING EVAPORITE DEPOSITION

The characteristics and interpretations of the bromine profiles presented in the following section can best be explained by consideration of dynamics of sea level, seawater flow into the basin, and flow of brines out of the

basin and by the stages of evaporative drawdown after the basin was cut off from the sea when sea level dropped below the level of the shelf area. Variations in sea level, as dscussed earlier, probably resulted from advances and retreats of glaciers on the huge continent of Gondwanaland in the Southern Hemisphere during Middle to Late Pennsylvanian time. Accumulation of glaciers lowered sea level, and subsequent melting of the ice caused it to rise.

Four stages of brine-flow dynamics in the Paradox Basin, as related to sea level, are illustrated in figures 114*A–D*.

In the state of brine-flow dynamics illustrated by figure 114*A*, sea level was at a maximum and there was flow of seawater into the basin and outflow of brines (reflux) over the shelf area. This stage is, in general, the same as the classic barred-basin models described by Ochsenius (1888, 1893), Grabau (1920), King (1947), Scruton (1953), Richter-Bernburg (1955), and Schmalz (1969). During times of high sea level, water freely entered the basin over a broad shelf to replace the water lost by evaporation. Evaporation caused a slow increase in salinity and density as the water moved into and across the basin. By the time that the water reached the distal parts of the basin, both salinity and density had increased, producing a horizontal salinity gradient across the basin. As the surface layer of water became denser, parts of it sank until it reached water of the same specific gravity. This process formed a series of stratified brines, the densest on the bottom and the least dense at the top (Adams, 1944; King, 1947; Schmalz, 1969; Garrett, 1970; Hite, 1970; Raup, 1970, 1982; Raup and others, 1970). The brines having the longest residence time on the surface of the basin would have the highest density and be richest in bitterns. Once this dynamic system was established, the influx-evaporation-reflux process maintained the stratified brines. Brines refluxed out of the basin varied in composition and density depending on the amount of evaporative concentration in the basin and the ratio of influx to reflux over the shelf area. The highest sea level resulted in the lowest overall density of the brines in the basin, and, conversely, the lowest sea levels resulted in maximum salinities in the basin (Hite, 1970).

Figure 114*B* illustrates the stage at which sea level was lowered to a level such that the refluxing brine could not overcome the friction of the influxing surface currents. At this point, reflux stopped, the salinity of the brines in the basin increased greatly, and equilibrium was reached between evaporation losses and influx. Stratification of the brines was maintained by contribution of higher density brines from the surface. As the overall salinity of the brines in the basin increased, the density and salinity of the brines in the various layers increased. The basal brines were increasingly enriched in magnesium and potassium chlorides and sulfates.

Figure 114*C* illustrates a stage in which evaporative drawdown in the basin began after sea level dropped below the level of the shelf area and the basin was cut off from an influx of seawater. The brines in the basin were reduced in volume as evaporation continued. The brine level within the basin steadily lowered, and salinities rapidly increased. Drawdown resulted in a shrinking of the area of deposition of any given evaporite facies, and increasingly larger areas around the edge of the basin were exposed to subaerial erosion. Evaporative drawdown has been proposed as a mechanism for evaporite deposition in the Paradox Basin by Kendall (1988) and by Williams-Stroud, (1994a, 1994b); for the Middle Silurian evaporites of the Michigan Basin by Cercone (1988); for the Middle Devonian evaporites of the Elk Point Basin by Maiklem (1971); and for the upper Miocene evaporites of the Mediterranean Basins by Hsü, Cita, and Ryan (1973) and Hsü, Ryan, and Cita (1973).

Figure 114*D* illustrates an advanced stage of evaporative drawdown in which brines receded into the deeper parts of the basin and were greatly increased in salinity. Much more of the basin area was exposed to erosion and nondeposition than in the previous stage. Conditions during this stage could have progressed to the stage in which the brines were completely desiccated.

CHARACTERISTICS AND INTERPRETATIONS OF BROMINE PROFILES

SHAPES OF PROFILES

The shapes of bromine profiles include several characteristics: regular and irregular profiles; minimum bromine content in the lower parts of profiles; profiles that have anomalously high values at the base; profiles that exhibit rhythmic increases and decreases of bromine content; profiles that have a pronounced vertical (constant bromine value) component; profiles that are strongly inclined (rapidly increasing bromine content); and compound profiles. These variations in profile shape give indications of the conditions under which a halite bed was deposited.

A typical bromine profile in the halite beds of the Paradox Basin has bromine values in the range of 50–100 ppm near the base, followed by increasing bromine content upward, in a more or less regular manner. Most of the profiles show a maximum bromine content of somewhat less than 250 ppm. Several of the profiles, however, exceed 250 ppm bromine. Above 250 ppm, the evaporites include minerals containing potassium and possibly magnesium, as well as halite. The potash zones in the cores used in this study contain primarily sylvite (KCl) and some minor carnallite ($KMgCl_3 \cdot 6H_2O$) and kieserite ($MgSO_4 \cdot H_2O$).

REGULAR AND IRREGULAR PROFILES

Profiles showing the stratigraphic distribution of bromine in halite of marine evaporites can be divided into

two major groups: regular and irregular (Raup and Hite, 1978). A regular profile is one in which the bromine content from one sample to the next in the profile varies only within narrow limits (20–30 ppm), and the entire profile closely resembles one that might have been plotted from theoretical data. Some profiles characterized as regular may have 2 or 3 intervals of change greater than 20–30 ppm, but, if the rest of the values are within these limits, the profile is classified as regular. Most regular profiles show a steady increase in bromine content from the bottom to the top of the halite bed, paralleling a gradual salinity increase in the evaporite basin. About three-quarters of the profiles illustrated in this study have characteristics of regular profiles. Typical examples of regular profiles are shown in figures 5, 8, 17, 28, 34–37, 44, 45, 47, and 48. Regular profiles show that the bromine content in the brines from which the halite was being deposited was changing gradually (usually increasing) over the time necessary for the deposition of a halite bed. The stability of brine composition through time indicates that the basin contained a large volume of brine so that variables such as minor changes in influx or reflux of basin brines and inflow of continental waters from the adjacent highlands had minimal effect. Halite strata that have regular profiles are usually quite thick and are commonly part of a thicker sequence of evaporites. Such halite beds were protected from later recrystallization or other diagenetic alterations by the steady accumulation of overlying sediments.

Irregular bromine profiles are characterized by an erratic distribution of bromine values. For example, values vary from one sample to the next by more than 30 ppm. Irregular profiles indicate depositional conditions in which basin brines were fluctuating in composition including bromine content. Examples of irregular profiles are shown in figures 14, 15, 18, 24, and 43. Rapid compositional changes of brine would occur most easily in shallow depths, such as in isolated bays around the inner margins of the basin. They could also occur during the later stages of evaporative drawdown when overall brine volumes in the basin were diminished. Local meteoric runoff from the margins of the basin or runoff from the adjacent highlands would have greater effect on a smaller brine volume.

Halite deposited in shallow-water environments would be susceptible to redistribution of bromine prior to burial during early diagenesis or by dissolution and recrystallization during periods of meteoric water ingress.

Irregular profiles can also be the result of disruption of the strata by faulting and folding. This condition is especially common in the deeper parts of the basin that have been affected by salt tectonics.

MINIMUM BROMINE CONTENT IN LOWER PART OF PROFILES

The minimum bromine content in the lower part of a profile is indicative of the salinity of the brine at the beginning of halite deposition in a given cycle. Calculations of distribution coefficients and evaporation experiments by several researchers using seawater and artificial brines show that the bromine content of first-deposited halite from seawater brines should be about 75 ppm (D'Ans and Kühn, 1940–1944; Braitsch and Herrmann, 1963; Holser, 1966; Kühn, 1968). Evaporation experiments by Block and Scherb (1953) using Mediterranian seawater gave minimum bromine values as low as 38 ppm. Hite and Japakasetr (1979) reported minimum bromine values as low as 40 ppm in Cretaceous evaporites of Thailand. These various results have led to the conclusion that minimum bromine values may be anywhere within this range and may be determined by conditions of crystallization (Holser, 1966). Profiles from the Permian Zechstein of Germany, the Permian evaporites of Russia, and the Paradox Basin are typical and show minimum bromine values in the range of 50–100 ppm (Valyashko, 1956; Schulze, 1960; Holser, 1966; Raup, 1966; Kühn, 1968; Raup and Hite, 1978). This range brackets the theoretical and experimental value of 75 ppm (Braitsch, 1971, p. 138).

Fifty-eight percent of the profiles from halite beds in the Paradox Formation have minimum bromine values in the range of 50–100 ppm (fig. 123). Twenty percent have minimum values of less than 50 ppm and 22 percent exceed 100 ppm. Figures 115–122 show the minimum bromine profile ranges in samples from the five cores and cuttings from three wells. Figure 123 summarizes these data.

Because most of the profiles from the halite beds in the Paradox Formation show minimum bromine values close to the theoretical minimum, we conclude that these halite beds each were deposited during a single cycle of evaporation starting with an influx of "fresh" seawater that entered the basin prior to the beginning of each cycle. The thickness of the halite bed is indicative of the amount of brine available, whether from a single charge (one basin volume) of seawater or from a steady influx of seawater lasting the duration of halite deposition (figs. 114*A*, *B*).

Those coreholes that have most of the halite beds with minimum bromine in the 50–100 ppm range are west and southwest of the deepest parts of the depositional basin. These are the Cane Creek No. 1 (fig. 115), Shafer No. 1 (fig. 116), Elk Ridge No. 1 (fig. 118), and Gibson Dome No. 1 (fig. 119) coreholes. Most of the halite beds in the Egnar well (fig. 122) also have minimum bromine values in the 50–100 ppm range.

A few profiles have a minimum bromine content that is higher than the theoretical minimum. Higher than normal bromine values at the base of a profile are interpreted to mean that the initial halite deposition was from brines enriched by high-salinity brines that remained in the basin from the previous cycle. The resulting mixed brines would contain an abnormal enrichment of bromine from the carryover of highly concentrated bittern brines. It is significant to note that the holes that have a large number of

halite beds containing high minimum bromine values are closest to the deepest parts of the depositional basin.

Higher than normal basal bromine values may also be the result of depositional onlap. A halite bed in a given area may represent only the upper part of halite deposition in that cycle. Halite deposited in a deeper part of the basin would include a stratigraphically thicker, as well as lower, interval and therefore have lower bromine values. More detailed sampling is required to understand the complete depositional history of these halite beds.

Some profiles have minimum bromine values of less than 50 ppm. Such values indicate that the bromine content of the initial brine at the beginning of the deposition of those halite beds was lower than the bromine content derived only from normal seawater. Low minimum bromine is difficult to explain if these evaporites were deposited primarily from seawater-derived brines. A possibility is that the brines from which those halite beds were deposited were altered by inflow of continental waters, perhaps from the Uncompahgre uplift or other adjoining highlands, that resulted in a change in the bromine-chlorine ratios of the basin brines. The amount of siliciclastic sediments in the interbeds is evidence of significant inflow from the highlands.

ANOMALOUSLY HIGH BROMINE VALUES AT PROFILE BASE

Several bromine profiles of halite beds in the Paradox Formation have anomalously high bromine values in the lowest 3–6 ft (1–2 m) of the halite beds before decreasing to a more normal value. Some notable examples of this characteristic are illustrated in figures 5, 8, 13, 16, 17, 22, 26, 28, 29, 36, 39, and 44–47. It is difficult to relate these basal high values to high-salinity brines in the basin because these halite beds immediately overlie interbeds that contain anhydrite and dolomite and some intervals of organic carbon-rich carbonate shale (black shale) that are assumed to be derived from brines of much lower salinity. One would expect a significant lowering of basin salinity during the deposition of the penesaline interbeds, and this, in turn, would result in a minimum bromine content in the first halite to precipitate in the overlying halite bed.

A plausible explanation of the anomaly is that the high initial bromine values are due to infusion of highly concentrated bromine-rich brines via fractures through the interbeds into the base of the overlying halite bed as interstitial brine was expelled from the underlying halite bed from the previous cycle. Such a relationship is illustrated in figure 124. These brines would have been injected through the intervening interbeds during compaction. Newly deposited halite may contain as much as 40 percent brine-filled voids. As this halite was compacted by the weight of overburden, the brine would have been squeezed into the overlying sediments. Interstitial brine from the upper part of a halite bed would, of course, have a relatively high bromine content, and this brine could have been the source of the high bromine values at the base of the overlying halite bed. Note in the illustration in figure 124 that bromine values at the top of halite bed 3 are similar to bromine values at the base of halite bed 2. In support of this concept, at least in the Paradox Formation, is the observation that most of the penesaline interbeds contain numerous halite veins that have very high bromine contents.

Similar relationships were observed by Hite in the Cretaceous halite deposits of Thailand (Hite and Japakasetr, 1979). In addition, Hite and Japakasetr noted that in the Thailand evaporites high-bromine first-deposited halite is present only where there are underlying halite deposits (Hite and Japakasetr, 1979).

RHYTHMIC INCREASES AND DECREASES OF BROMINE

Some profiles exhibit a rhythmic increase and decrease of bromine within the general trend of the profile. Some good examples of this are figures 5–8, 13–15, 34, 41, and 44. Other profiles show variations in bromine content to a more limited degree. Profiles that exhibit rhythmic increases and decreases of bromine have been interpreted to be the result of slight changes in sea level that would have changed the influx-reflux balance and therefore would have changed the composition of the basin brines to a limited degree (Raup, 1966; Raup and Hite, 1978, 1992). Such fluctuations in sea level would have occurred during the stages illustrated in figures 114*A* and *B*.

VERTICAL PROFILES OR VERTICAL COMPONENTS OF PROFILES

Vertical profiles, or those having major vertical components, suggest deposition from brines in which salinity and bromine content are constant (Braitsch, 1971; Holser, 1979b). Constant basin salinity is probably the result of a steady influx of seawater, with some amount of reflux to remove the higher salinity brines to maintain a balance (fig. 114*A*). It is only through reflux losses of brine from the basin that the salinity of the brines could maintain a fairly constant bromine content. The lower half of the profile of the halite bed in cycle 5 in the Cane Creek core (fig. 8) is essentially vertical. Also, the lower three-quarters of the profile of the halite bed in cycle 9 in the Shafer core (fig. 17) is essentially vertical. A few other profiles have some vertical components.

INCLINATION OF PROFILES

Inclined profiles—those in which the bromine content increases rapidly in a relatively thin stratigraphic

interval—indicate basin conditions of rapidly increasing salinity. Some profiles exhibit a modest increase in bromine in the bottom part of the profile and a rapid increase in the upper part. Such changes in slope of the profiles suggest rapid changes in the salinity conditions in the basin and, therefore, probable changes in the influx-reflux-evaporation balance. Many of the profiles of halite beds that contain potash deposits have a rapid increase of bromine just below the potash, indicating rapid salinity increase and probably rapid brine volume decrease. Maximum rate of bromine increase could have occurred during evaporative drawdown after seawater influx into the basin had stopped (fig. 114*C*). During the initial stages of drawdown, the volume of the basin brines would be large and the rate of bromine increase at a minimum. As drawdown continued, however, brine volume would decrease (fig. 114*D*), and the rate of salinity and bromine increase would accelerate, resulting in a strongly inclined profile. Some good examples of strongly inclined profiles, or parts of profiles, are in figures 8, 20, 34, 35, 37, 39, 44, 45, 47, and 48.

COMPOUND PROFILES

Some profiles exhibit fluctuations in bromine content that are greater in range than the rhythmic cycles described earlier. In some of these profiles, the bromine content decreases to such an extent as to suggest that halite deposition in a given evaporite cycle had come to an end. Some examples of compound profiles are in figures 14, 18, 38, and 41–43. Compound profiles are most easily explained by major influxes of seawater into the basin that result in a dilution of the basin brines. Such influxes may have occurred while the basin was still connected with the sea. Major influxes could also have occurred during evaporative drawdown, but this process should be recorded as major breaks in the lithologic sequence.

Some compound profiles may be the result of folding or faulting of the strata.

AVERAGE BROMINE CONTENT OF HALITE BEDS AND SALINITY GRADIENTS

The average of the bromine values of a single halite bed at any location in the basin is an index of the overall salinity of the brines from which the halite precipitated at that basin position. Examination of these values, in stratigraphically equivalent halite beds, shows that from one hole to another there is an increase in the average toward the basin depocenter. This increase would tend to suggest that a horizontal salinity gradient was controlling sedimentation; however, the increase can be more easily explained by a stratified brine column that actually represents a vertical gradient. Because of the slope of the basin floor, a vertical gradient would place brine of greatest density in contact with the sediment interface at the deepest point in the basin (fig. 114). In a more upslope position, the interface would be in contact with less dense brine. This relationship would result in a lateral bromine gradient in the halite sediment but not an actual lateral gradient in the brine.

The average bromine values reported herein are simple arithmetic averages of all the bromine analyses of a given halite bed, less any anomalously high values at the base of the bed that are judged to be of secondary origin. Some minor inaccuracies in averages may result from the fact that in any given halite bed the basal portion in a basin-deep position may not have a stratigraphic equivalent at a more upslope position. In addition, some averages were derived from bromine determinations made on well cuttings—not always an accurate means of sampling.

The average bromine value of each halite bed, in pairs of holes, is compared in figures 125–131. The data in figures 125–128 are from the five coreholes, which are in an approximate north-south orientation (fig. 1). The data in figures 129 and 130 are from cuttings from three wells, which are along a northwest-southeast orientation. In figure 131, the data from the Gibson Dome hole are from core samples, and the data from the Chevron well are from cuttings. In each of these figures, the difference in average bromine is expressed by arrows that point in the direction of bromine increase.

Figure 125 shows average bromine values of halite beds in the Elk Ridge and Gibson Dome cores. The five halite beds common to these two cores are from cycles 6, 7, 9, 13, and 16. The arrows show that the average bromine value in each of these five halite beds increases from the Elk Ridge to the Gibson Dome corehole, toward the basin depocenter.

Figure 126 shows average bromine values in the Gibson Dome and Shafer cores. The eight halite beds common to these cores are from cycles 4–10 and 13. In the halite beds 4, 5, 7, and 8, the average bromine content increases toward the Shafer corehole, and in halite beds 6, 9, 10, and 13, it increases toward the Gibson Dome corehole.

Figure 127 shows average bromine values in the Shafer and Cane Creek cores. In the two halite beds common to these cores, halite of cycles 4 and 5, the average bromine content increases toward the Cane Creek corehole, toward basin deep.

Figure 128 shows average bromine values in the Cane Creek and the Utah cores. In the two halite beds common to these cores, halite of cycles 3 and 4, the average bromine content increases toward the Utah corehole, which is in the deeper part of the basin.

Figure 129 shows average bromine values in the Lone Dome and Egnar wells. There are 14 halite beds common to these wells. In seven of the halite beds (6, 9, 10, 13, 14, 18, 21), the increase in bromine is toward the Egnar well, and in seven others others (7, 8, 16, 19, 20, 25, 27), it increases toward the Lone Dome well. There is a slight overall increase southeastward in average bromine content toward the Lone Dome well.

Figure 130 shows the average bromine values in the Egnar and Chevron wells. In most of the 19 halite beds common to these two wells, average bromine content increases toward the Chevron well, in a northwestward direction toward the deeper part of the basin.

Figure 131 shows average bromine values in the Gibson Dome core and in the cuttings from the Chevron well. In 12 of the 19 halite beds common to these holes, the average bromine content increases toward the Chevron well, and in seven, it increases toward the Gibson Dome corehole. The increase toward the Gibson Dome corehole is especially evident in halite bed 17.

The bromine-gradient illustrations (figs. 125–131) show an increase in average bromine content toward the northeast, north, and northwest (compare hole locations in fig. 1). Similarly, the thickness of the halite beds increases in these directions and the concentration of potash minerals increases. These characteristics agree with the interpretation that the Paradox Basin was an asymmetrical basin and was deepest bordering the Uncompahgre uplift.

The interpretation that the previously described relationships are the response to vertical rather than horizontal salinity gradients would not apply if all halite was precipitated at the brine surface. Surface sedimentation would result in a halite bed of uniform thickness and bromine content. It has been observed, however, that the Paradox halite deposits are characterized by fabrics indicating bottom-growth crystallization (Raup and Hite, 1992).

RELATIONSHIP BETWEEN AVERAGE BROMINE CONTENT IN HALITE BEDS AND POTASH DEPOSITS

Profiles of the average bromine values in halite beds for any given hole show the overall salinity history during deposition of the halite beds in that part of the basin. Figures 132–139 illustrate average bromine profiles for all of the coreholes and wells studied.

Figure 132 shows average bromine values of four halite beds in the Cane Creek No. 1 core. Of these four halite beds, salinity was at a maximum during halite bed 5. This halite bed contains a commercially valuable potash deposit that is currently being mined near Moab, Utah. Salinity conditions were lower during the deposition of the upper three halite beds.

Figure 133 illustrates average bromine values for the nine halite beds in the Shafer No. 1 core. Two salinity maxima are recorded by the average bromine values in halite beds for cycles 5 and 6, and 13. These three halite beds contain potash-mineralized rock, whereas the other halite beds contain none.

Figure 134 illustrates average bromine values for the three halite beds in the Utah No. 2 core. All of the halite beds in this core have relatively high average bromine contents (grand average for all of the halite beds, 137.7 ppm), but none of the three contains potash-mineralized rock. Potash might be present in these beds deeper in the basin.

Figure 135 illustrates average bromine values for the five halite beds in the Elk Ridge No. 1 core. The four upper halite beds have relatively low average bromine values. The halite bed 16 has an average bromine value of 117.9 ppm. Although there is no potash-mineralized rock at this location, the halite bed of cycle 16 contains a trace of potash in other parts of the basin.

Figure 136 illustrates average bromine values for the 19 halite beds in the Gibson Dome No. 1 core. Three of the halite beds, those in cycles 6, 13, and 18, that have high average bromine values contain potash-mineralized rock at this location.

Figure 137 illustrates average bromine values for the 16 halite beds in the Lone Dome well. Halite beds in cycles 19–21, 24, and 27 have average bromine values of more than 130 ppm, and they contain major potash deposits.

Figure 138 illustrates average bromine values for the 22 halite beds in the Chevron Federal No. 1 well. Eleven of the halite beds have average bromine values of more than 130 ppm. Most of these halite beds contain potash deposits.

Figure 139 illustrates average bromine values for the 22 halite beds in the Egnar No. 1 well. Six of the halite beds have average bromine values of more than 120 ppm. As in the Chevron Federal No. 1well, most of these halite beds contain potash deposits.

There is a direct relationship between halite beds that have a high average bromine content and those beds that contain potash deposits. This relationship is illustrated in figure 140, which shows the combined averages (average of averages) for the data in figures 136–139. The data for these four holes were combined to give an overall vertical salinity profile for the central part of the basin. These holes were selected because they penetrated the greatest number of halite beds and are located well within the evaporite facies of the basin (fig. 1).

Eighteen of the 29 halite beds in the Paradox Formation contain at least traces of potash minerals (Hite, 1961, 1982). The major potash deposits in the basin are shown by the boxes to the right of the profile in figure 140. Most of the halite beds that contain potash deposits have average bromine contents of more than 110 ppm. It is obvious, therefore, that high average bromine in a halite bed in the Paradox Basin is an indicator that the bed could host a potash deposit.

AREAL DISTRIBUTION AND THICKNESS OF HALITE AND POTASH DEPOSITS

Many of the Paradox Formation halite beds in the Paradox Basin have a very wide areal distribution (figs. 1, 2). Although the boundaries of the Paradox Basin are defined by the outer limits of the halite facies, the actual basin area was

much larger as shown by the extent of equivalent facies of sulfate and carbonate. If most of the halite beds in the Paradox Basin were the result of repeated single cycles of evaporative drawdown, the deposition of halite would be restricted to a very limited part of the basin. In a single cycle of basin filling followed by evaporative drawdown, 90 percent of that water would have to evaporate before any halite would be precipitated, and halite would be precipitated in an area occupied by only 10 percent of the original charge of seawater in the deepest parts of the basin. Many of the halite beds, however, presently occupy areas much greater than the reduced brine volume would imply. Several halite beds have very wide areal extent, such as those in cycles 6, 9, 13, 18, and 19 (fig. 2). Such halite beds were probably precipitated when the basin was full of halite-saturated brine and the basin was receiving a steady influx of seawater with possible minor reflux (figs. 114*A, B*)

The thickness of the halite beds is also an important factor in determining their mode of origin. If a halite bed was deposited from a single cycle of evaporative drawdown, the halite would be limited in thickness as well as areal extent, and its thickness would be directly related to its distribution. Thicker halite beds would occupy a smaller area and vice versa. As an example, the halite bed of cycle 6 in the Shafer core is 312 ft (95 m) thick (figs. 2, 9, 14), in the Gibson Dome core it is 240 ft (73.1 m) thick (figs. 31, 34), and in the Egnar well it is 310 ft (94.5 m) thick (figs. 91, 94). Halite bed 6 is also one of the two most widespread halite beds in the basin (fig. 2). Because of its thickness and widespread distribution, uniform lithology, and regularity of the bromine profiles, it is probable that this halite bed was deposited from brines that received continuous supplies of sodium chloride from the sea rather than deposited from a single cycle of basin recharge followed by evaporative drawdown. Several other halite beds in the Paradox Basin, such as those in cycles 9, 13, 14, 18, and 19–21, are hundreds of feet thick, and halite beds 9, 13, 18, and 19 also have wide distribution.

Potash deposited from a fresh charge of seawater during a single cycle of evaporative drawdown would occupy an area much smaller than that of halite. The deposition of potash minerals begins only after 98 percent of the seawater has been evaporated (Usiglio, 1849, *in* Stewart, 1963, p. Y12). Thus, potash deposited from a single cycle of basin fill, evaporative drawdown, and desiccation would occupy an area covered by less than 2 percent of the original brine and would occupy a very small part of the basin floor. Because some of the potash beds cover more than 50 percent of the area of halite deposition (Hite, 1961), these deposits, too, must have been deposited from a large volume of very concentrated brine.

The thickness of the potash beds is also an important factor in determining their origin. A potash bed deposited in a single episode of evaporative drawdown would be very thin, as well as of limited areal extent. If all of the potash deposits in the entire evaporite sequence of the Paradox Formation were deposited as a series of single drawdown episodes, the potash would be dispersed in thin layers throughout the whole evaporite sequence. Some of the potash beds in the Paradox Basin are, however, more than 100 ft (30 m) thick (Hite, 1961). They must have been deposited from a large volume of bittern brines that had accumulated in the basin through several evaporite cycles.

Almost all of the potash deposits in the Paradox Formation were deposited in the upper part of halite beds and represent a continuation of the chloride evaporite phase of deposition. Because the deposition of potash requires a large initial volume of brine, and also extreme conditions of brine concentration, it is probable that the potash was deposited through a combination of events including evaporative concentration, followed in later stages by evaporative drawdown, perhaps to the point of complete desiccation (figs. 114*A–D*).

BROMINE IN COEXISTING HALITE AND SYLVITE

In a separate but related study, samples of potash ore from the Paradox Formation were collected in the Texasgulf potash mine, near Moab, Utah. The samples were collected at 1-foot (30.5 cm) intervals from the deposit at the top of the halite bed of cycle 5 . This ore contains an intimately intergrown mixture of halite and sylvite. The samples were crushed to a very coarse sand-size and hand-separated into the two mineral components under a binocular microscope. To facilitate identification, the crushed material was irradiated by X-rays that temporarily colored the halite brown and the sylvite violet. The mineral separates were then analyzed for bromine by X-ray fluorescence. The analyses are listed in appendix table 104, and stratigraphic profiles of the analyses are illustrated in figure 141.

As stated earlier, each of the chloride minerals that is present in marine evaporites has a different partition coefficient for the inclusion of bromine when crystallizing simultaneously from a common brine derived from seawater. If the coefficient for halite is given as 1, then the coefficient for carnallite is 7 and that for sylvite is 10 (Braitsch, 1971, p. 135).

Bromine contents of the halite from the 20-foot (6 m) potash interval range from 177 to 272 ppm, whereas bromine contents of the sylvite range from 1,025 to 1,330 ppm. The right-hand column of appendix table 104 lists the ratios for bromine contents of the halite and sylvite. The ratios range from 1:3.9 to 1:6.4 and average 1:5.2.

The ratio between halite and contemporaneously precipitated primary sylvite should be 1:10 according to data given by Braitsch (1971, p. 135). Because the ratios in the potash zone of cycle 5 average 1:5.2, it is probable that this sylvite is the product of decomposition of a precursor carnallite deposit. The ratio between coexisting halite and

carnallite is 1:7 (Braitsch, 1971, p. 135). The average 1:5.2 ratio for the Paradox Formation potash ore is more in line with the alteration of carnallite to sylvite, which requires loss of magnesium chloride, and a probable simultaneous loss of bromine.

The progressive decrease of bromine content in the sylvite, from bottom to top of the ore deposit (fig. 141), may indicate alteration by brines working downward from the top of the sylvite-rich bed. This theory is further supported by the condition of the upper 1 m of the potash deposit in which all evidence of primary bedding has been destroyed and the sylvite crystals are colorless. Crystal textures of the ore suggest secondary growth of sylvite following the incongruent solution of a precursor carnallite deposit. Alteration of the potash deposit may have been (1) an early diagenetic event immediately after potash-mineral deposition, (2) a result of brines of lower salinity entering the basin during deposition of the overlying interbeds, or (3) the result of total desiccation of the covering brine layer, allowing alteration by rainfall.

CONCLUSIONS

The following is a summary of the conclusions drawn from interpretations of the bromine distribution in chloride rocks of the Middle Pennsylvanian Paradox Formation in the Paradox Basin of Utah and Colorado.

1. Minimum bromine content in the range of 50–100 ppm at the base of most of the profiles suggests deposition of halite from brines of a predominantly seawater source. Minimum bromine content of more than 100 ppm indicates possible deposition from mixed brines containing a significant component of carryover brines from a previous cycle. Minimum bromine content of less than 50 ppm indicates dilution of brines from lower salinity water originating from runoff within the basin during drawdown or from waters entering the basin from adjacent highlands. Recrystallization of the halite by lower salinity brines could also lower the bromine content.
2. Rhythmic increases and decreases of bromine content in the profiles indicate periodic influx surges of seawater into the basin. Such periodic influx surges would most likely have occurred while the brine surface in the basin was at sea level, before evaporative drawdown.
3. Bromine profiles that have a major vertical component indicate that those intervals of halite were deposited from brines that were maintained at a fairly constant salinity, probably by a balance of influx of seawater into the basin and a required amount of reflux out of the basin.
4. Strongly inclined profiles illustrate conditions of rapidly increasing salinity and bromine content in the basin brines. Such conditions most likely would have occurred during later stages of evaporative drawdown, when the brine volume in the basin was rapidly diminishing.
5. Compound profiles may indicate major seawater influx. They could also be the result of structural complexities in the strata.
6. Average bromine contents of halite beds in different locations in the basin show the presence of lateral bromine gradients. These gradients were the result of vertically stratified brines in contact with a sloping basin floor.
7. High average bromine content correlates directly with the occurrence of potash deposits. This correlation emphasizes the important role that bromine geochemistry plays in the exploration for potash deposits. Thick and areally extensive potash deposits probably were deposited from large volumes of high-salinity brines that were the result of the concentration of brines in a full-basin setting and further concentration during evaporative drawdown, perhaps to the stage of desiccation.
8. Thick and areally extensive halite beds indicate deposition during lengthy periods of seawater influx that allows for large quantities of sodium chloride to be brought into the basin.
9. Thick and areally extensive potash deposits indicate long periods of evaporative brine concentration, probably followed by evaporative drawdown to allow for maximum concentration of the brines.
10. The sylvite in the potash deposit in cycle 5 in the Texasgulf potash mine, near Moab, Utah, may be a secondary replacement after carnallite based on the ratio of bromine content between halite and sylvite.

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FIGURES 1–141

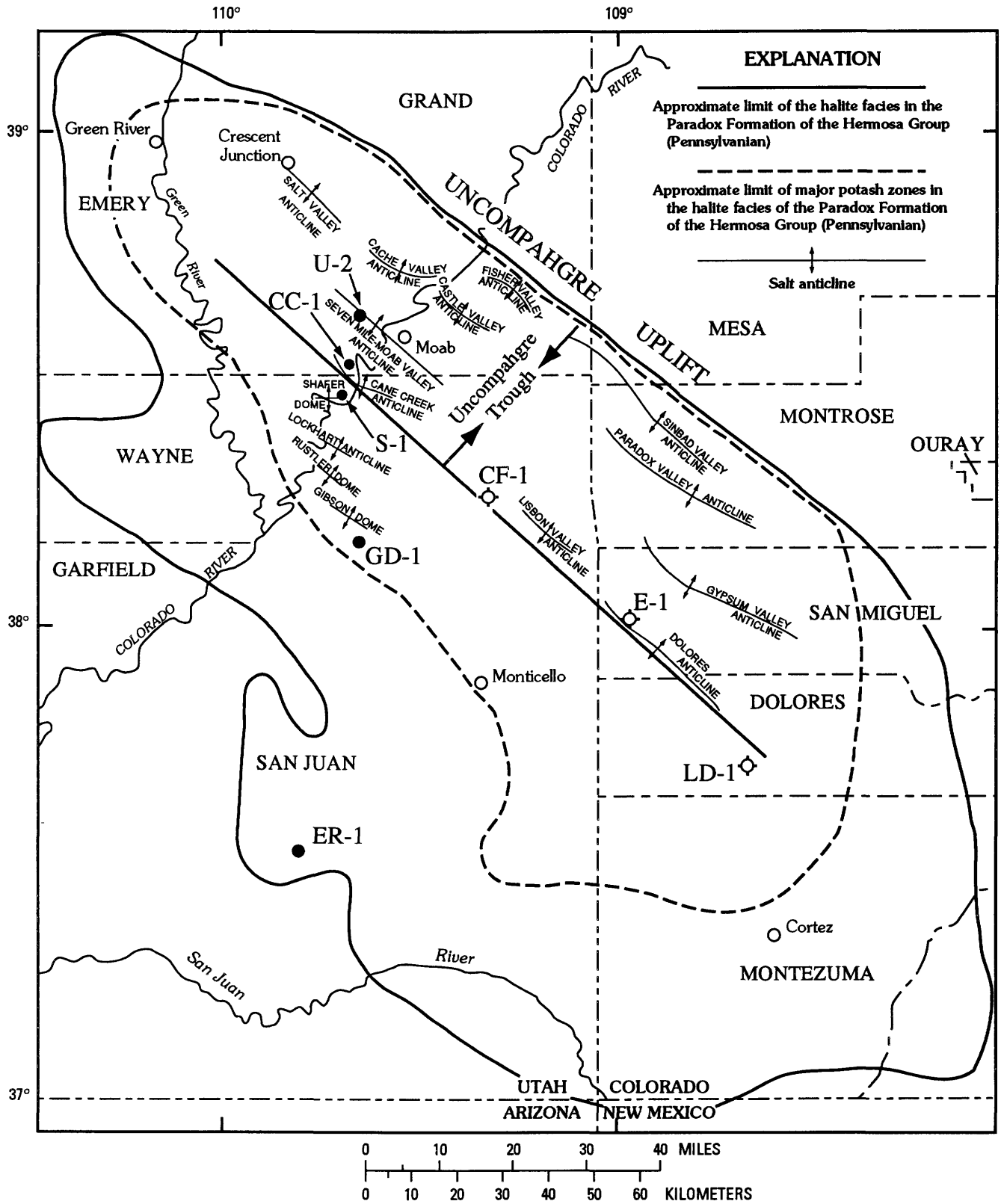


Figure 1. Index map of the Paradox Basin showing locations of the coreholes and wells used in this study. Coreholes: CC-1, Delhi-Taylor Oil Corporation, Cane Creek No. 1; ER-1, U.S. Department of Energy, Elk Ridge No. 1; GD-1, U.S Department of Energy, Gibson Dome No. 1; S-1, Delhi-Taylor Oil Corporation, Shafer No. 1; U-2, Delhi-Taylor Oil Corporation, Utah No. 2. Wells: CF-1, Gulf Oil Corporation, Chevron Federal No. 1; E-1, Reynolds Mining Corporation, Egnar No. 1; LD-1, Continental Oil Corporation, Lone Dome No. 1.

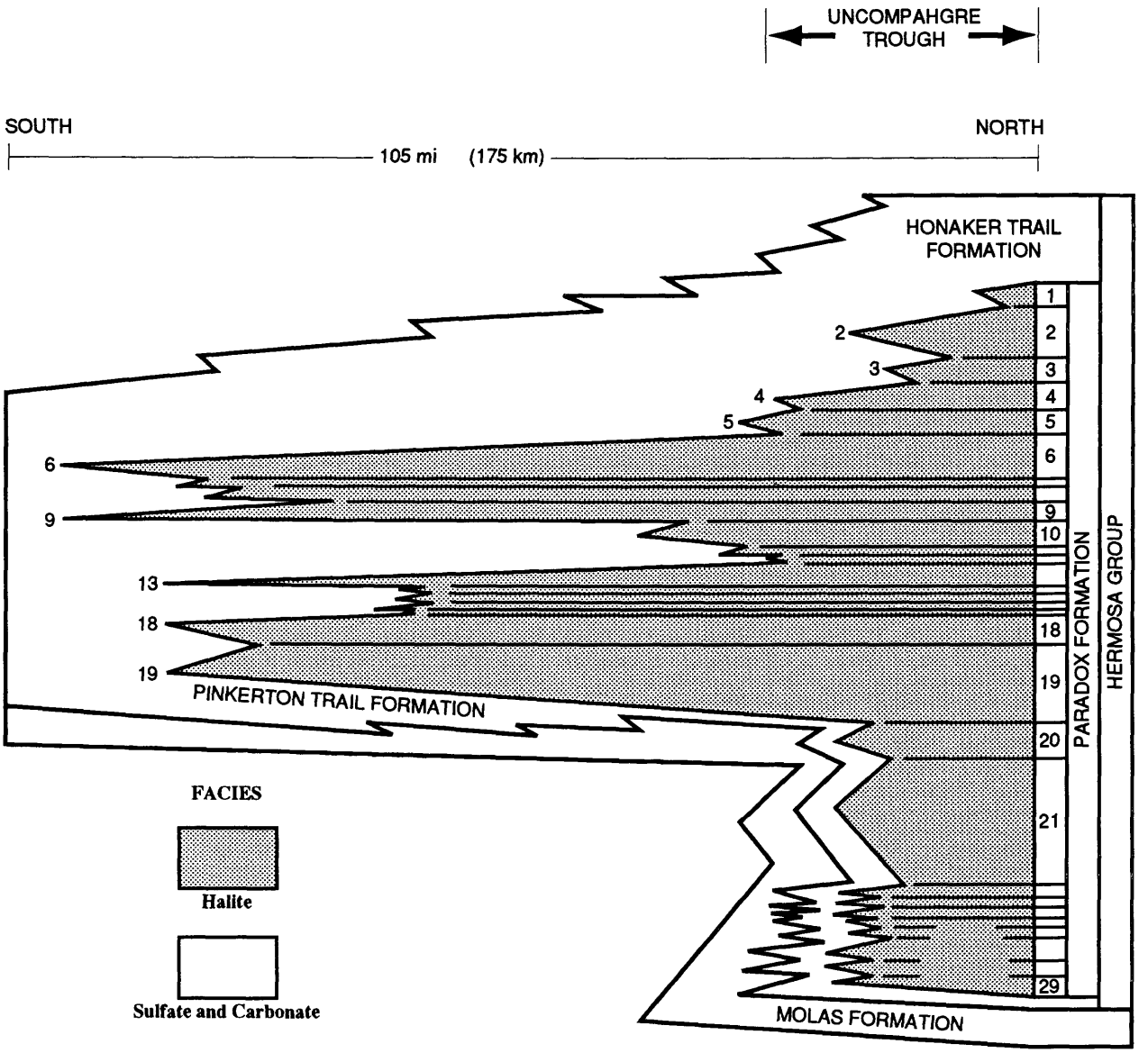


Figure 2. Diagrammatic north-south stratigraphic cross section across Paradox Basin, along the Utah-Colorado State line, showing stratigraphic nomenclature of the Middle and Late Pennsylvanian Hermosa Group as used in this report. Numbered units are evaporite cycles of the Paradox Formation, which consist primarily of halite. Note that the maximum extent of evaporite facies was during cycles 6, 9, 13, 18, and 19. Modified from Hite and Buckner (1981).

Halite beds	Cane Creek No. 1	Shafer No. 1	Utah No. 2	Elk Ridge No. 1	Gibson Dome No. 1	Lone Dome No. 1	Chevron Federal No. 1	Egnar No. 1
1			X					
2	X	x						
3	X	x	X					
4	X	X	X		X		X	X
5	X	X			x		X	X
6		X		X	X	X	X	X
7		X		X	X	X	X	X
8		X			X	X	X	X
9		X		X	X	X	X	X
10		X			X	X	X	X
11		X						X
12								
13		X		X	X	X	X	X
14					X	X	X	X
15					X		X	
16				X	X	X	X	X
17					X		X	X
18					X	X	X	X
19					X	X	X	X
20					X	X	X	X
21					X	X	X	X
22								X
23							X	X
24					X	X	X	
25					X	X	X	X
26					X	X	X	
27						X	X	X
28							X	X
29								X

Figure 3. Chart showing halite beds in the Paradox Formation for which bromine profiles were made. Numbers refer to evaporite cycles; small "x" indicates partial profile.

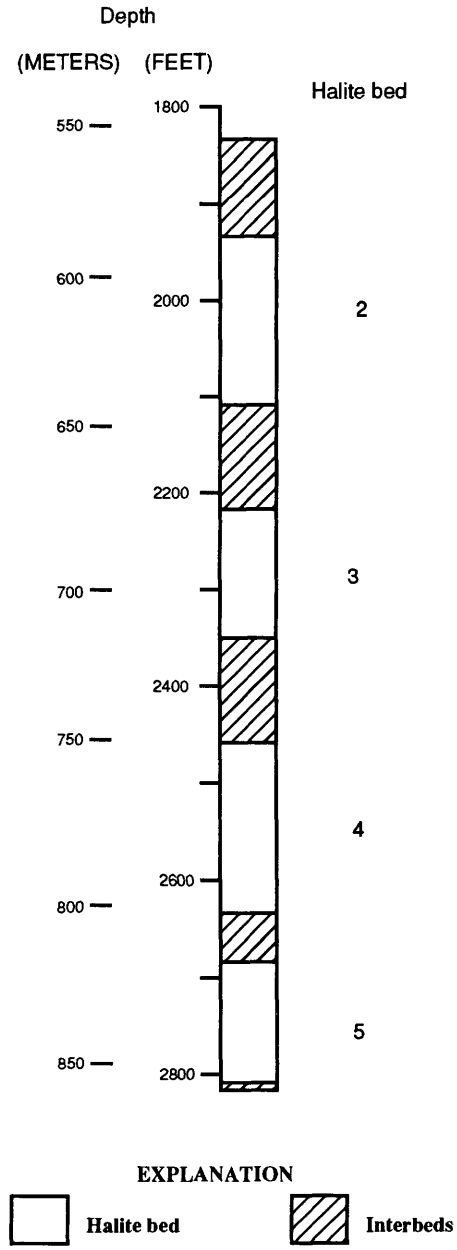
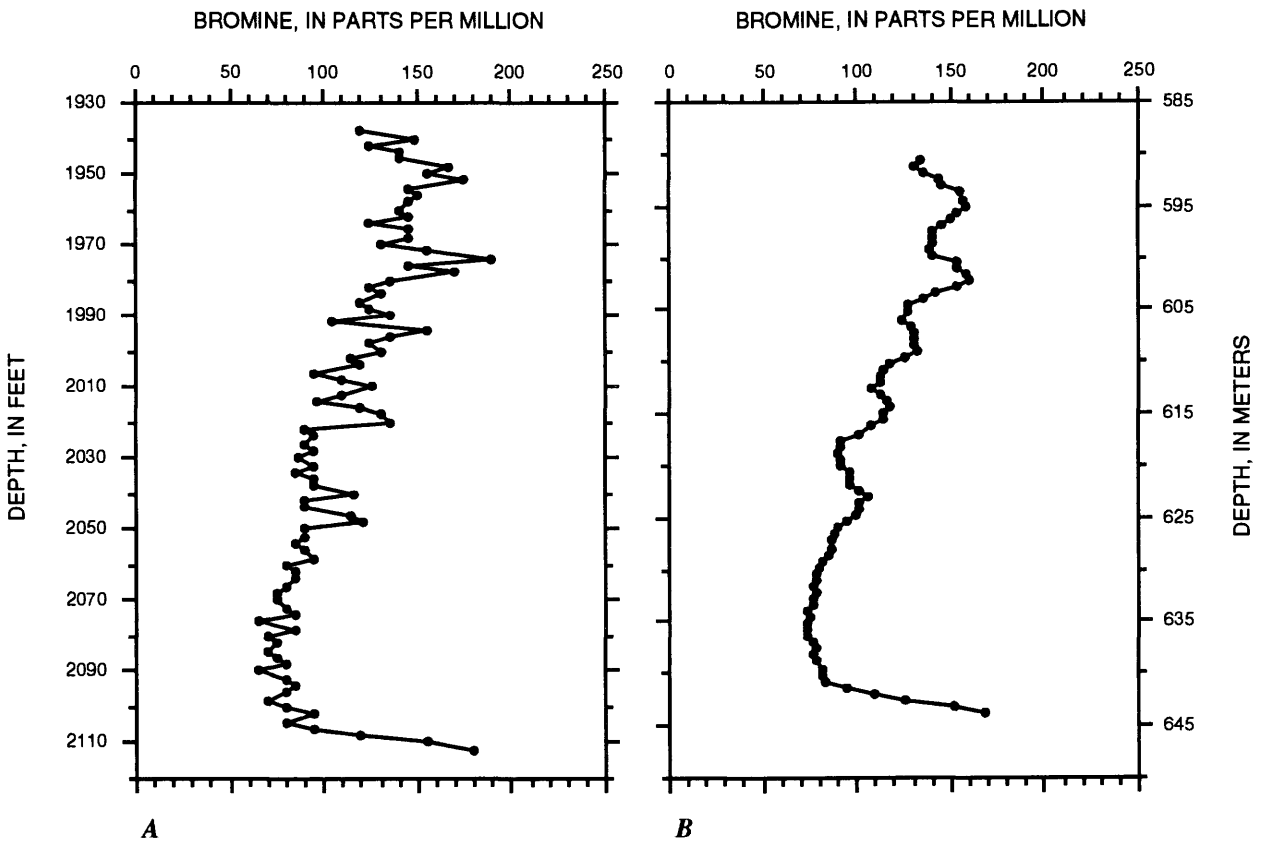
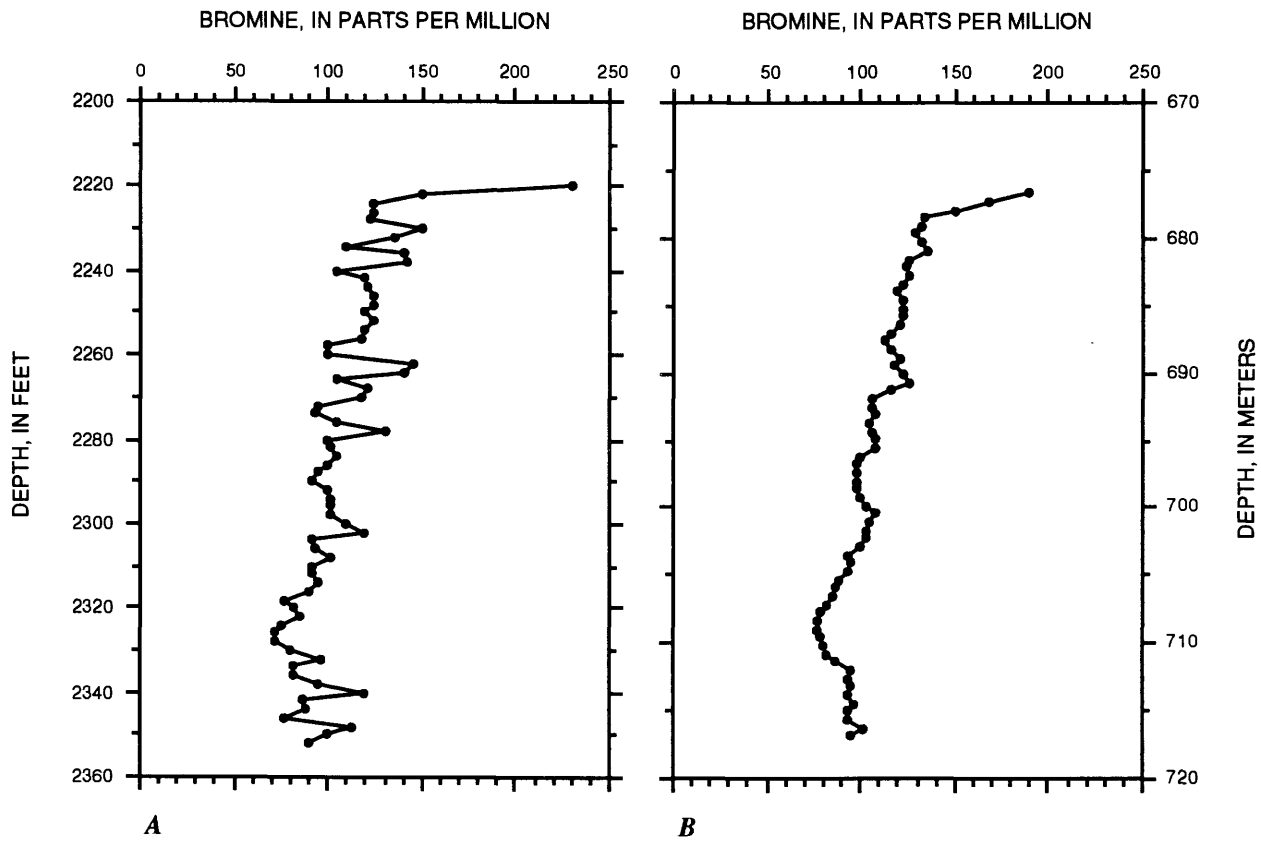


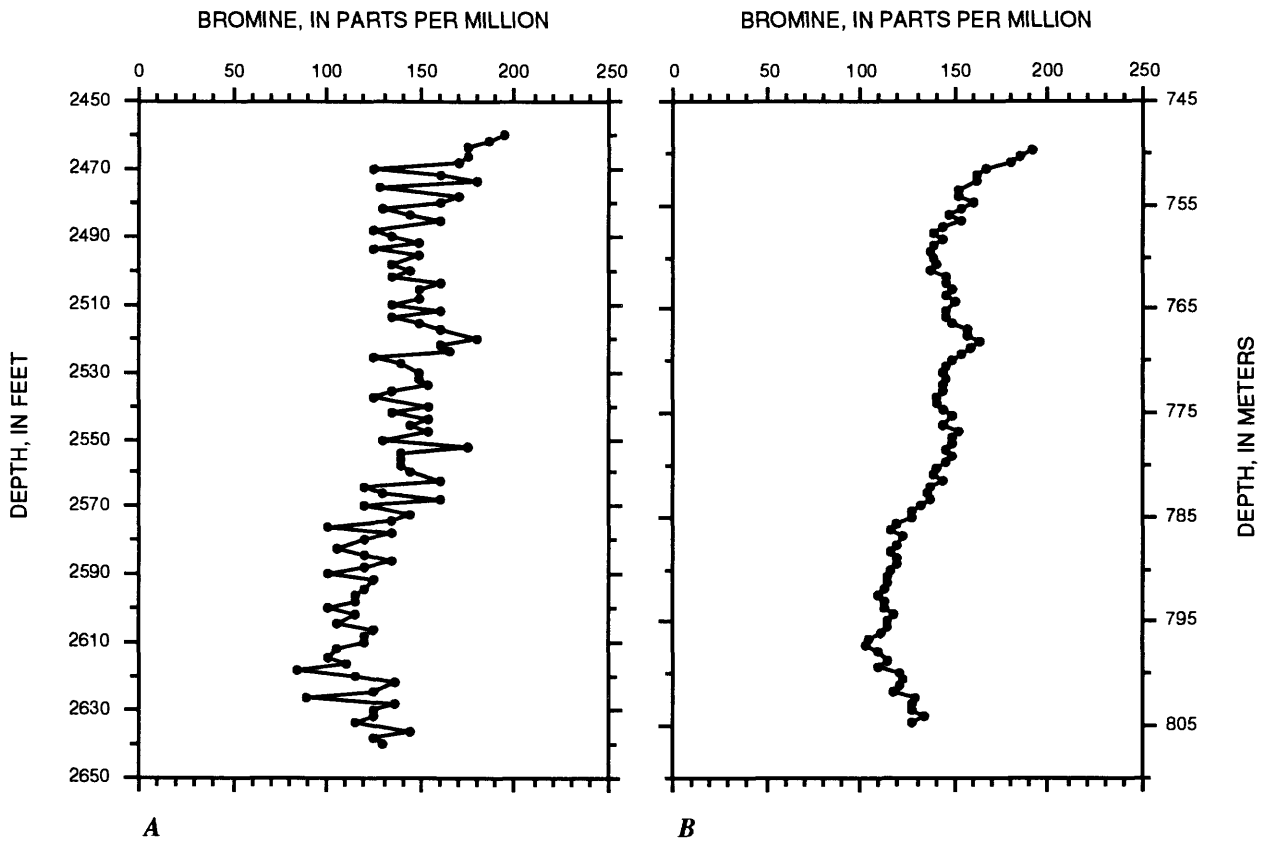
Figure 4. Generalized stratigraphic column of the Cane Creek No. 1 core. Scale 1 inch = 200 ft.

Figure 5 (facing page, top). Bromine distribution in halite bed of cycle 2, Cane Creek No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content for this profile, excluding the three high values at the base, is 110.4 ppm.

Figure 6 (facing page, bottom). Bromine distribution in halite bed of cycle 3, Cane Creek No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content of this halite bed is 107.6 ppm.


BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
1930
1950
1970
1990
2010
2030
2050
2070
2090
2110
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
585
595
605
615
625
635
645
DEPTH, IN METERS
B


BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
2200
2220
2240
2260
2280
2300
2320
2340
2360
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
670
680
690
700
710
720
DEPTH, IN METERS
B


BROMINE, IN PARTS PER MILLION
0 50 100 150 200 250
2450 2470 2490 2510 2530 2550 2570 2590 2610 2630 2650
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
0 50 100 150 200 250
745 755 765 775 785 795 805
DEPTH, IN METERS
B

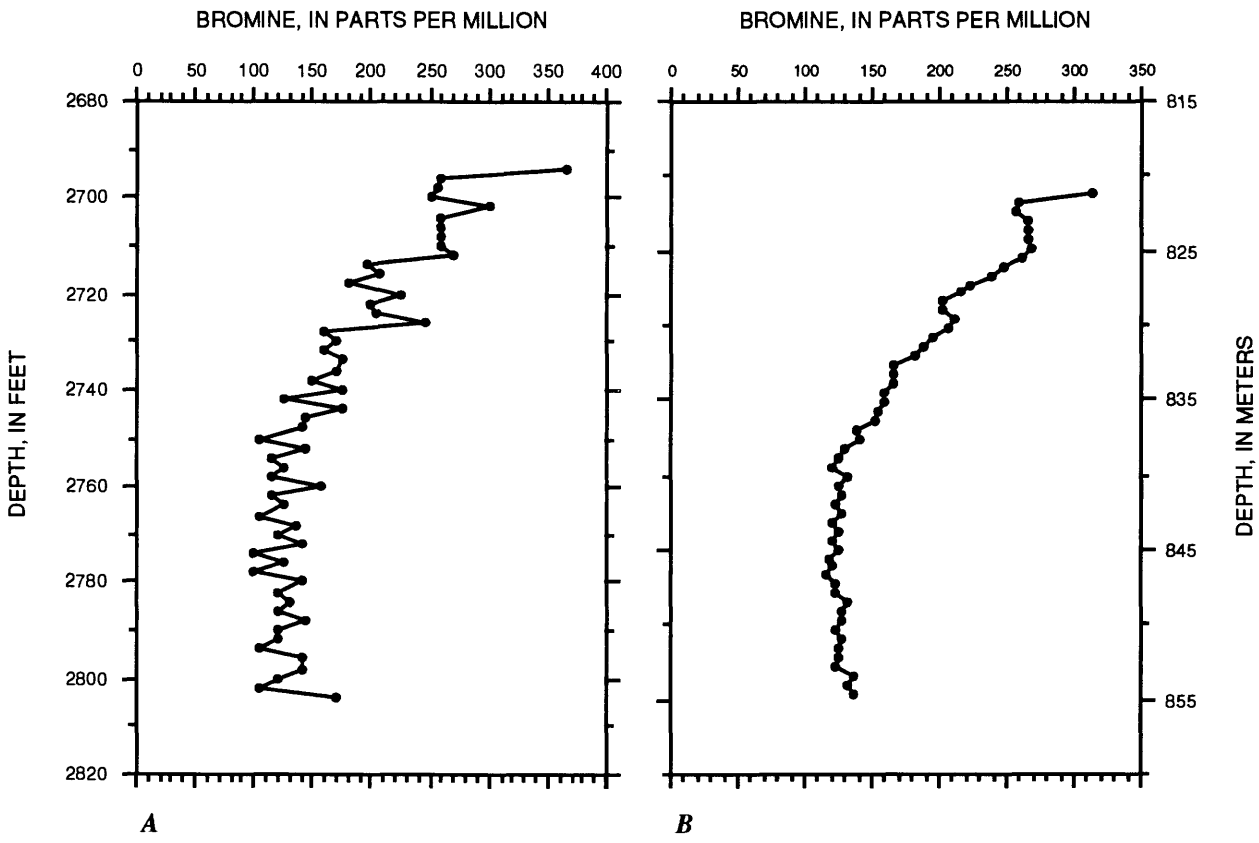

BROMINE, IN PARTS PER MILLION
0 50 100 150 200 250 300 350 400
2680 2700 2720 2740 2760 2780 2800 2820
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
0 50 100 150 200 250 300 350
815 825 835 845 855
DEPTH, IN METERS
B

Figure 7 (previous page, top). Bromine distribution in halite bed of cycle 4, Cane Creek No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content of this halite bed is 137.3 ppm.

Figure 8 (previous page, bottom). Bromine distribution in halite bed of cycle 5, Cane Creek No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content of this profile, excluding the one higher value at the base, is 168.7 ppm.

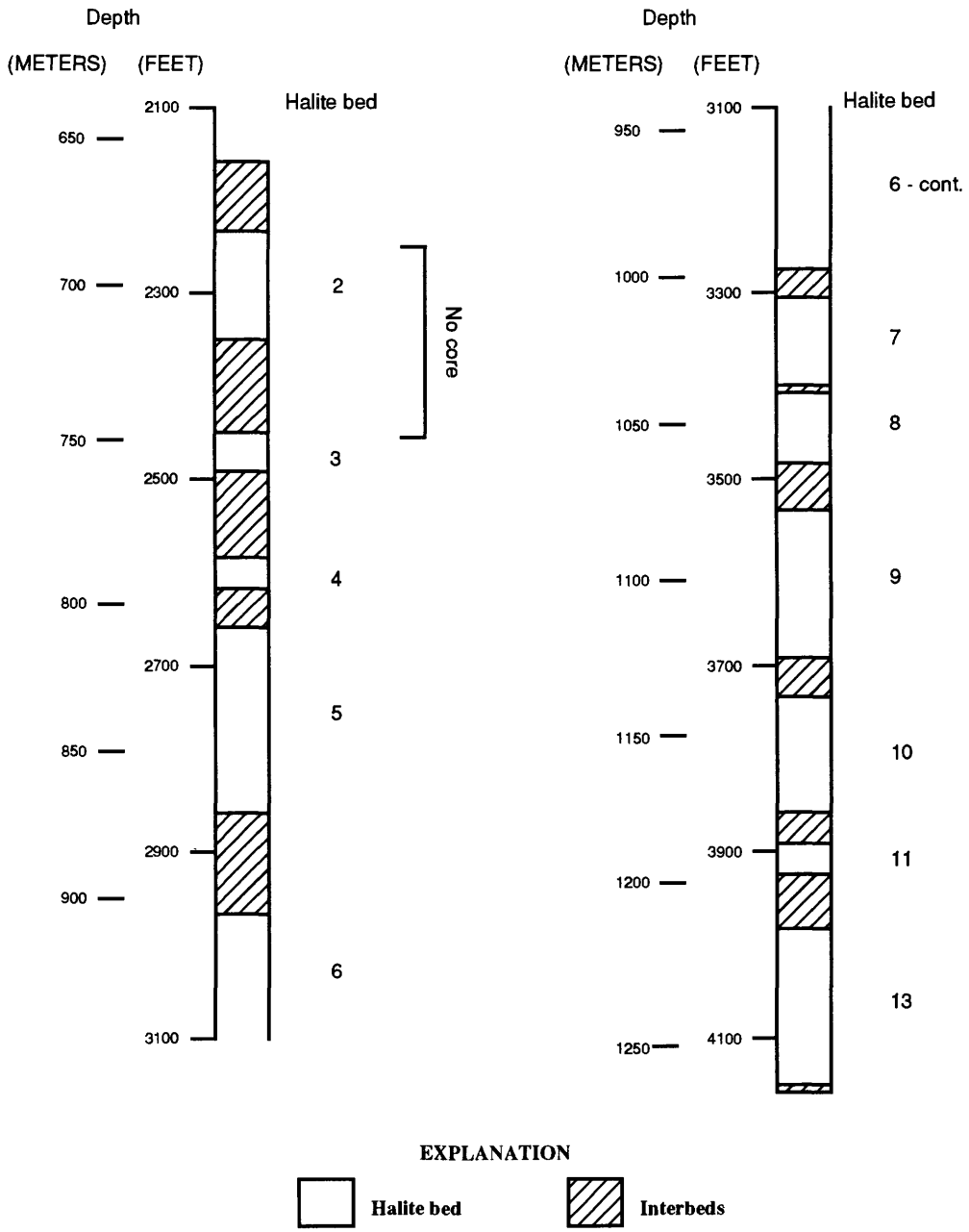


Figure 9. Generalized stratigraphic column of the Shafer No. 1 core. Scale 1 inch = 200 ft.

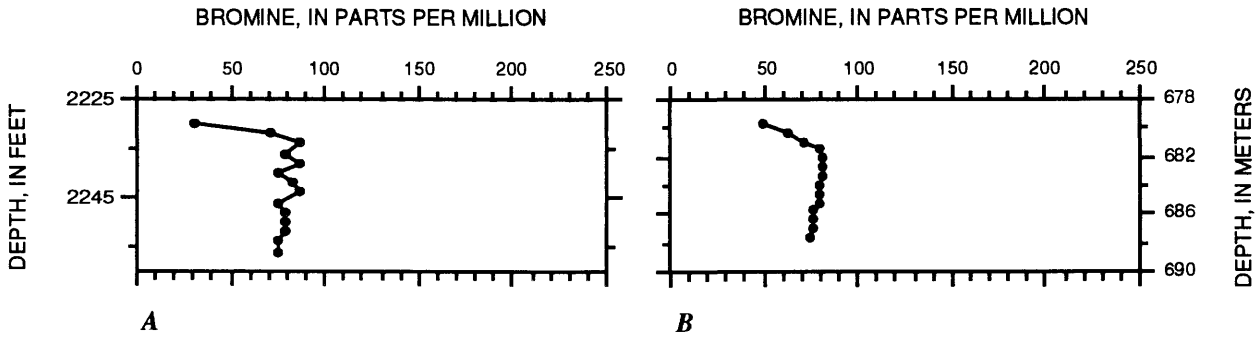


Figure 10. Bromine distribution in halite bed of cycle 2 (upper part), Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine value in this partial profile is 75.3 ppm.

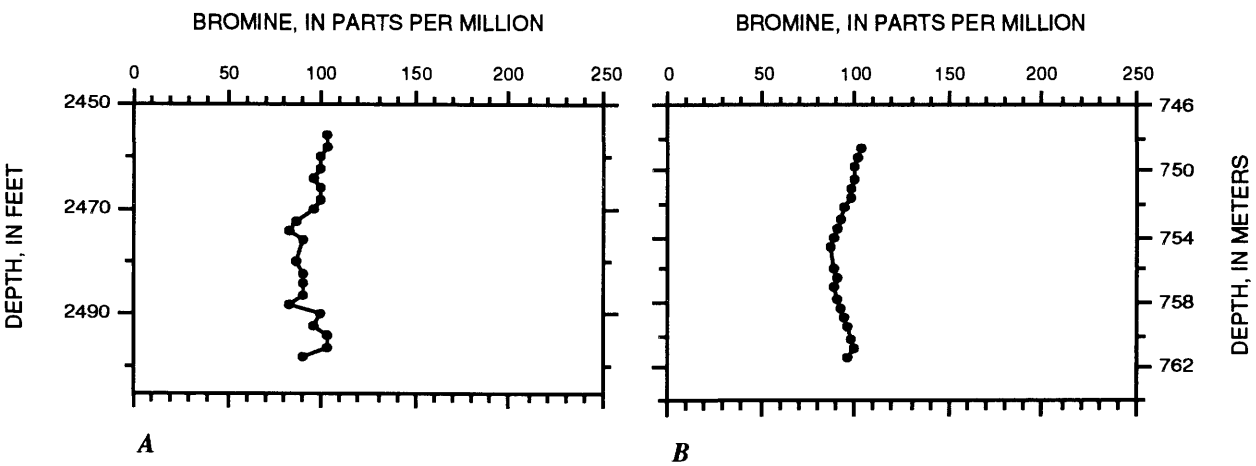


Figure 11. Bromine distribution in halite bed of cycle 3 (lower part), Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine value in this partial profile is 94.3 ppm

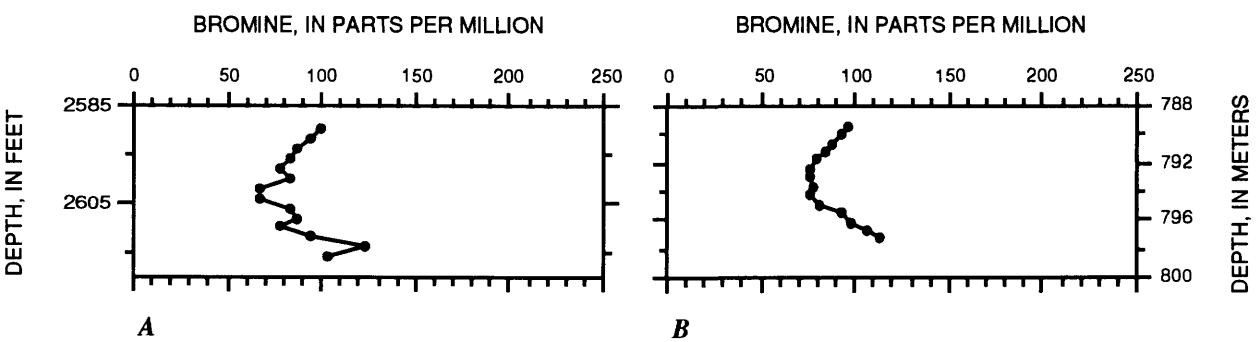
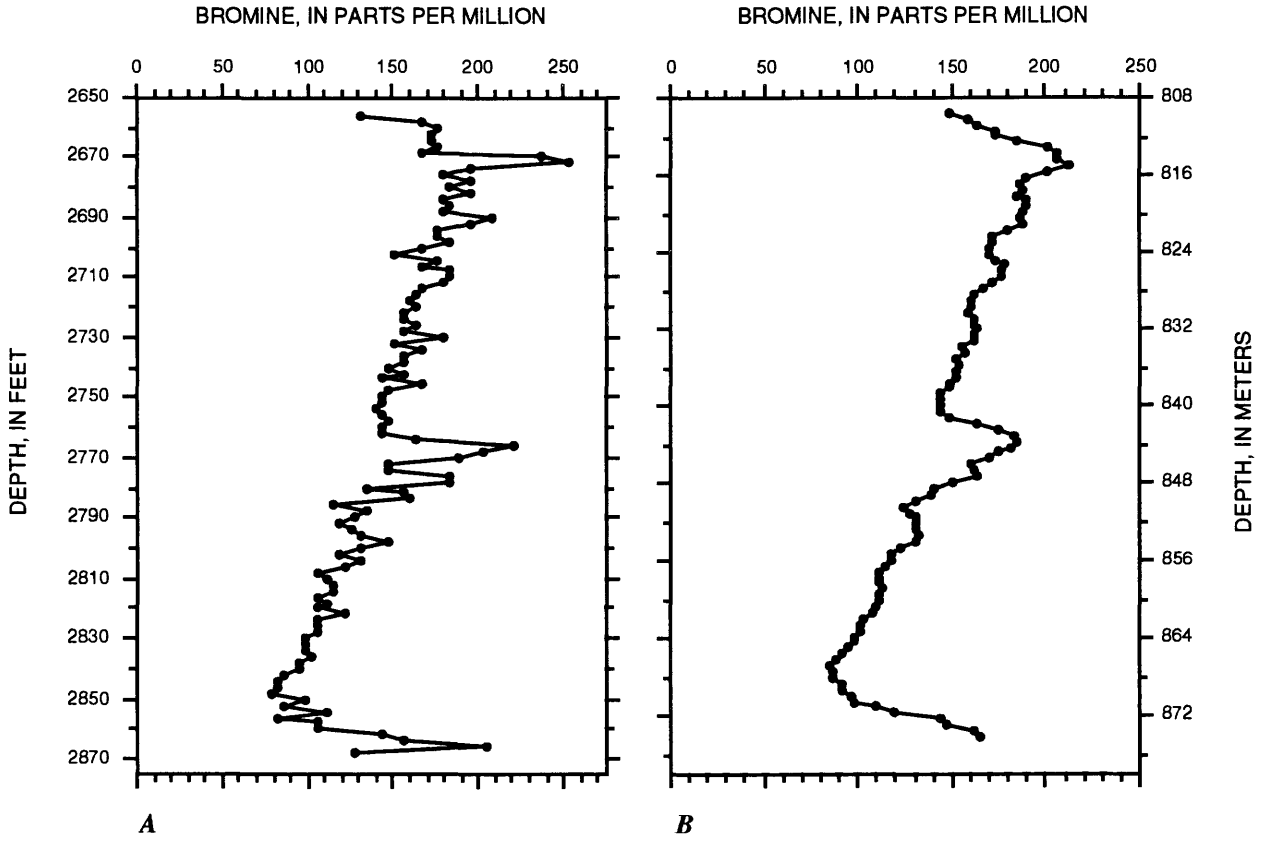


Figure 12. Bromine distribution in halite bed of cycle 4, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile is 87.5 ppm.


BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
2650
2670
2690
2710
2730
2750
2770
2790
2810
2830
2850
2870
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
808
816
824
832
840
848
856
864
872
DEPTH, IN METERS
B

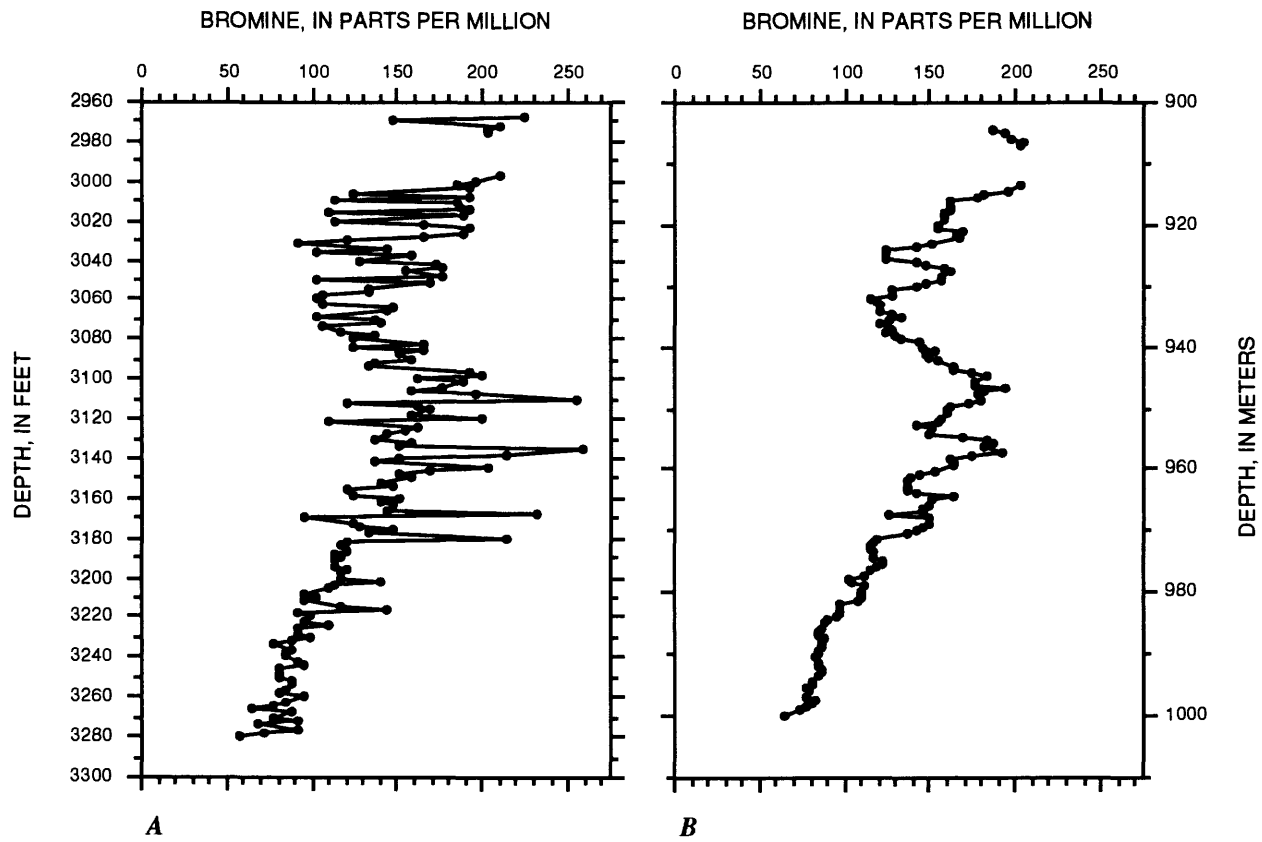

BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
2960
2980
3000
3020
3040
3060
3080
3100
3120
3140
3160
3180
3200
3220
3240
3260
3280
3300
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
900
920
940
960
980
1000
DEPTH, IN METERS
B

Figure 13 (previous page, top). Bromine distribution in halite bed of cycle 5, Shafer No. 1 core. A, Analytical results. B, Smoothed profile using a moving average of five points. The average bromine content in this profile, excluding the four high values at the base, is 147.3 ppm.

Figure 14 (previous page, bottom). Bromine distribution in halite bed of cycle 6, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile is 135.8 ppm.

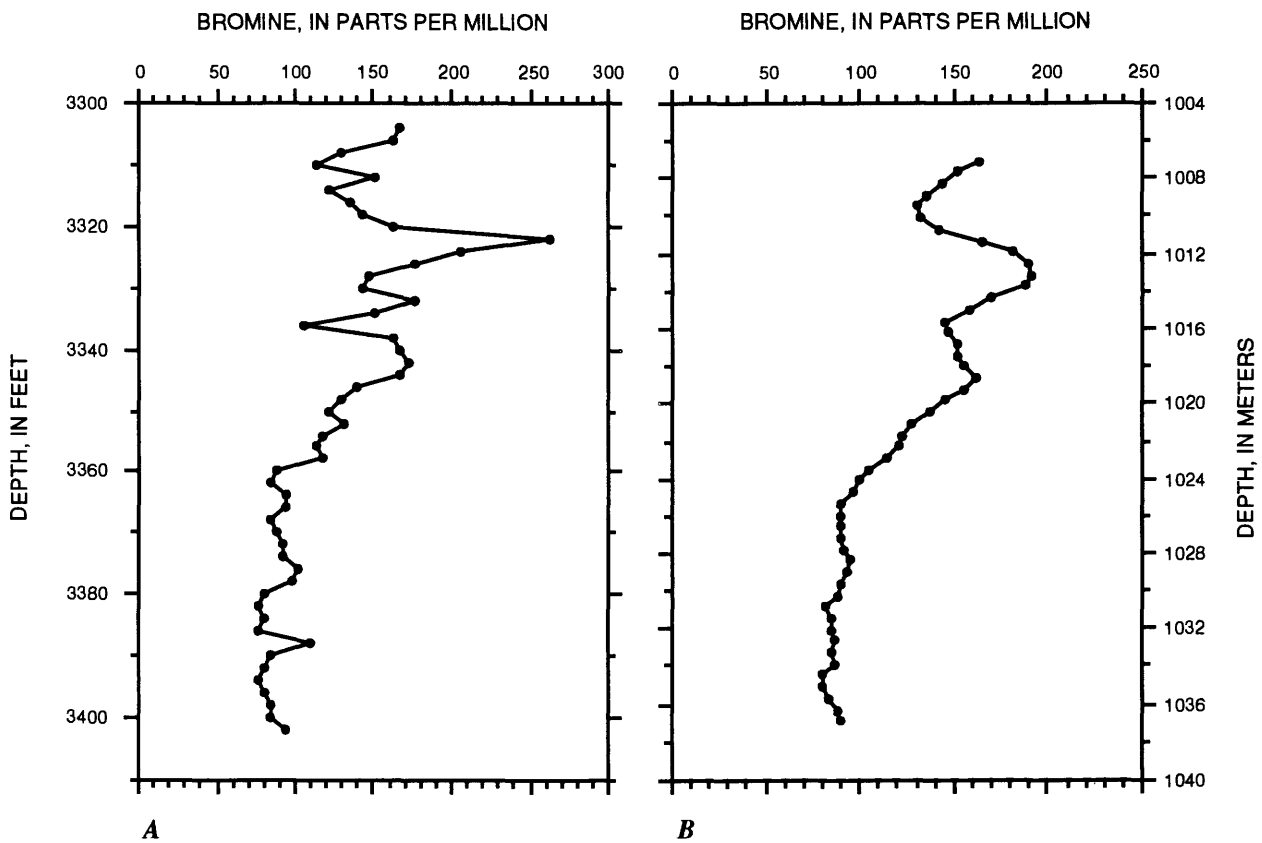
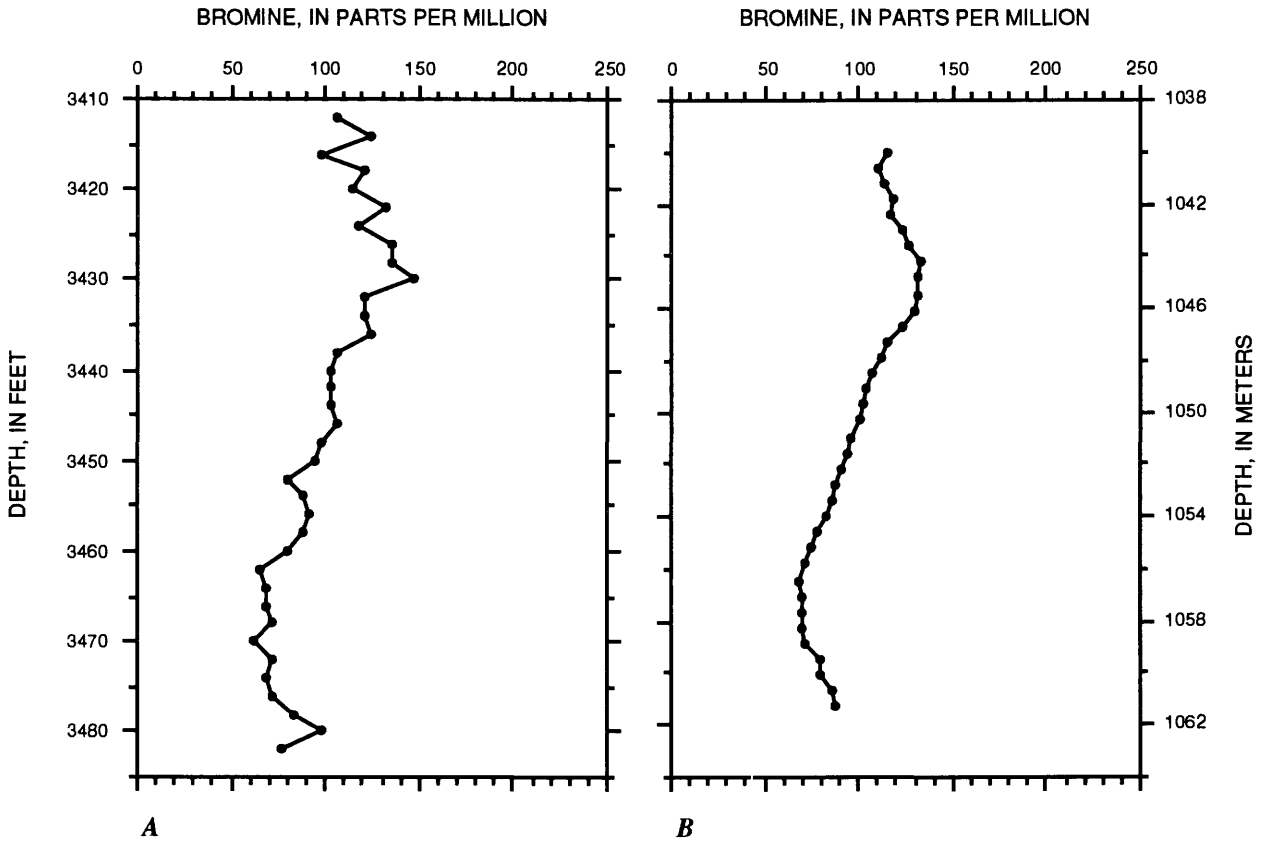
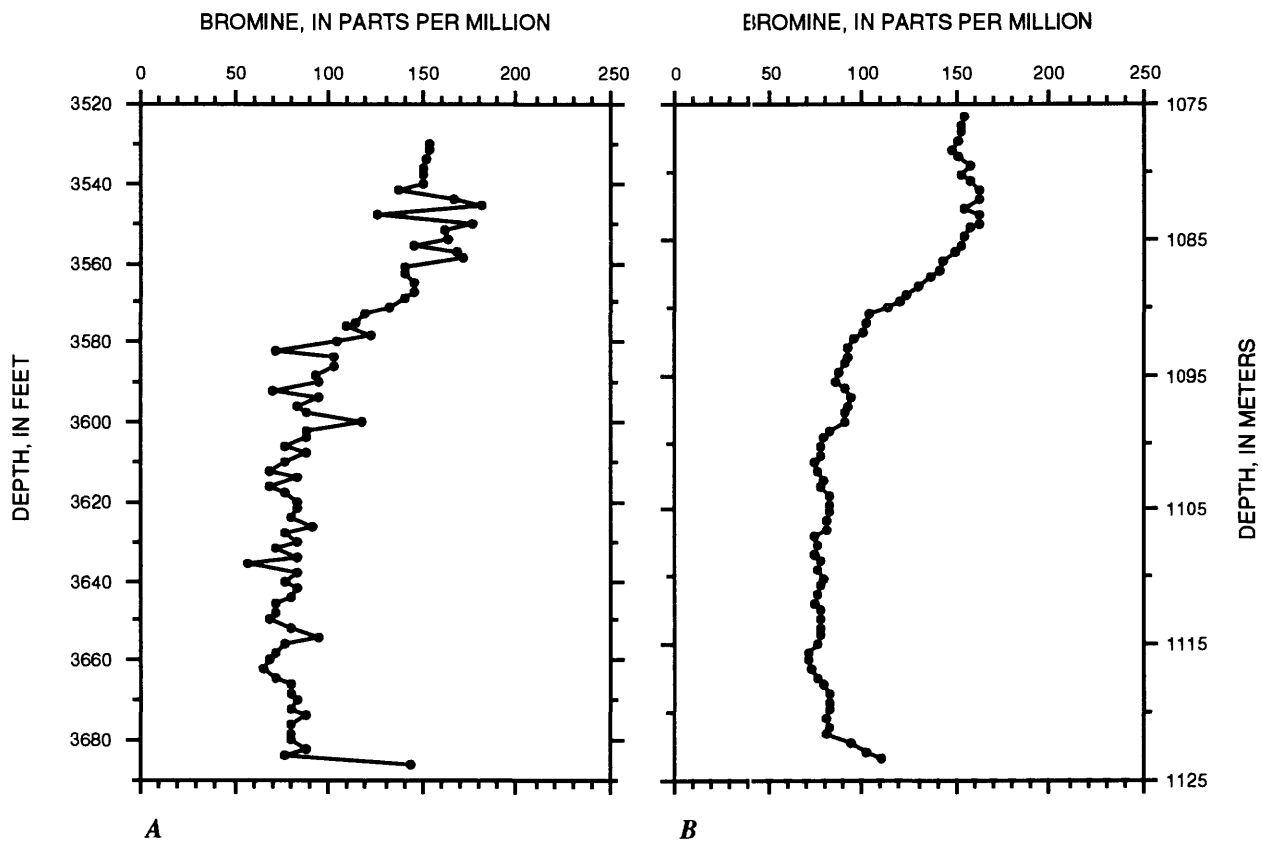


Figure 15. Bromine distribution in halite bed of cycle 7, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile is 122.2 ppm.

Figure 16 (facing page, top). Bromine distribution in halite bed of cycle 8, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile, excluding the three high values at the base, is 99.7 ppm.

Figure 17 (facing page, bottom). Bromine distribution in halite bed of cycle 9, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content of this profile, excluding the single high value at the base, is 103.3 ppm.


BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
3410
3420
3430
3440
3450
3460
3470
3480
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
1038
1042
1046
1050
1054
1058
1062
DEPTH, IN METERS
B


BROMINE, IN PARTS PER MILLION
0
50
100
150
200
250
3520
3540
3560
3580
3600
3620
3640
3660
3680
DEPTH, IN FEET
A
BROMINE, IN PARTS PER MILLION
1075
1085
1095
1105
1115
1125
DEPTH, IN METERS
B

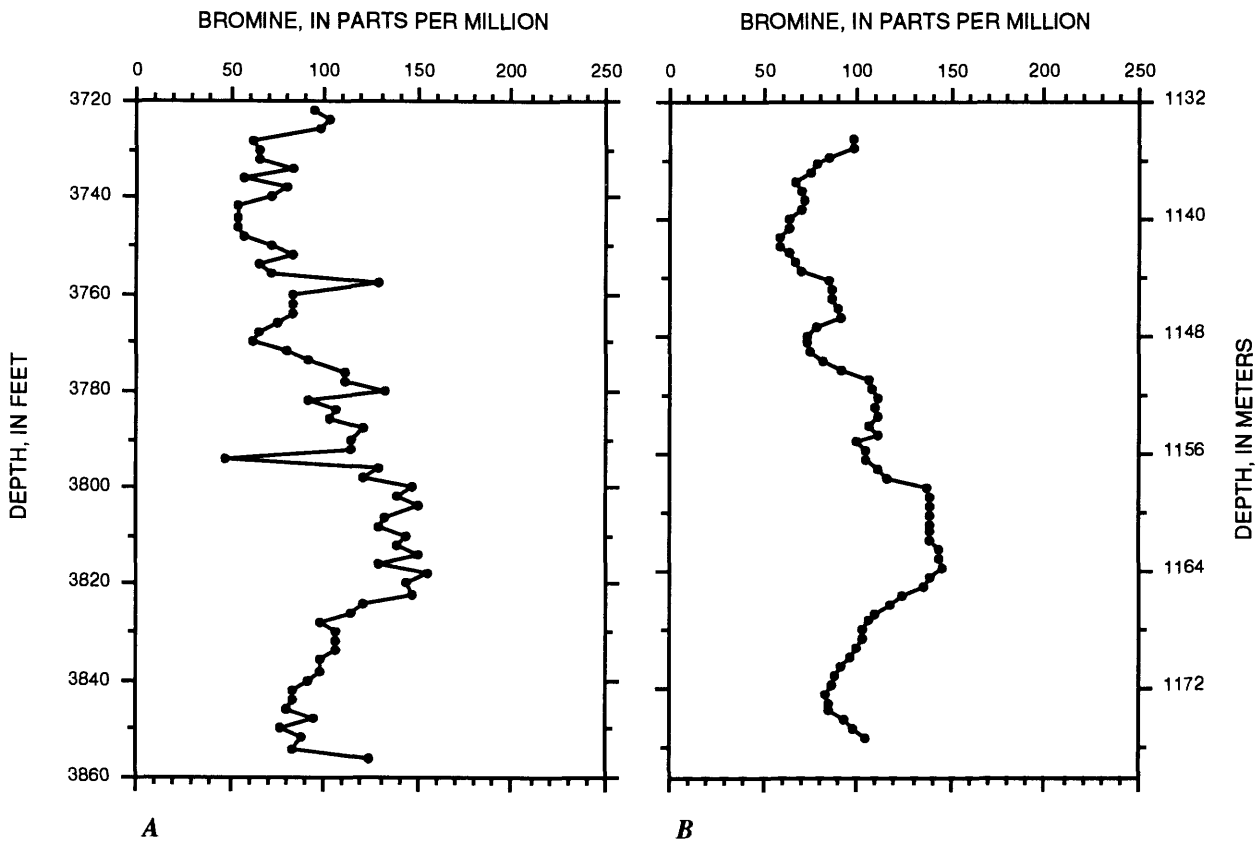


Figure 18. Bromine distribution in halite bed of cycle 10, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content of this profile, excluding the single high value at the base, is 98.3 ppm.

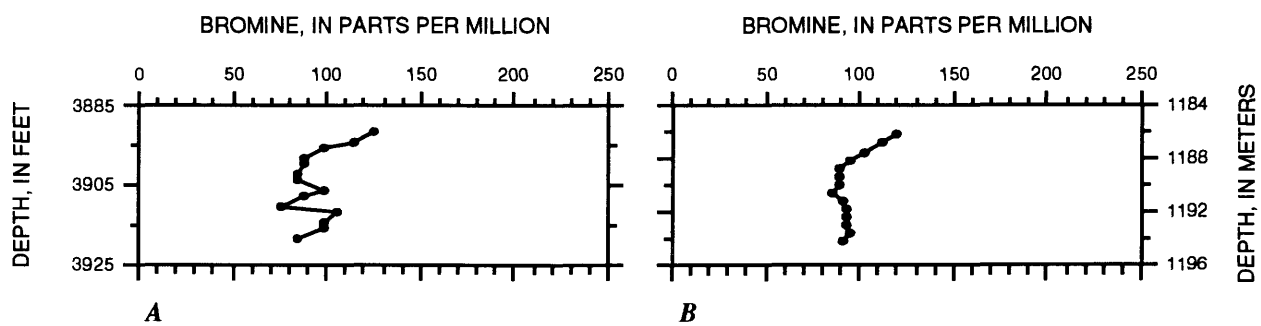


Figure 19. Bromine distribution in halite bed of cycle 11, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile is 95.0 ppm.

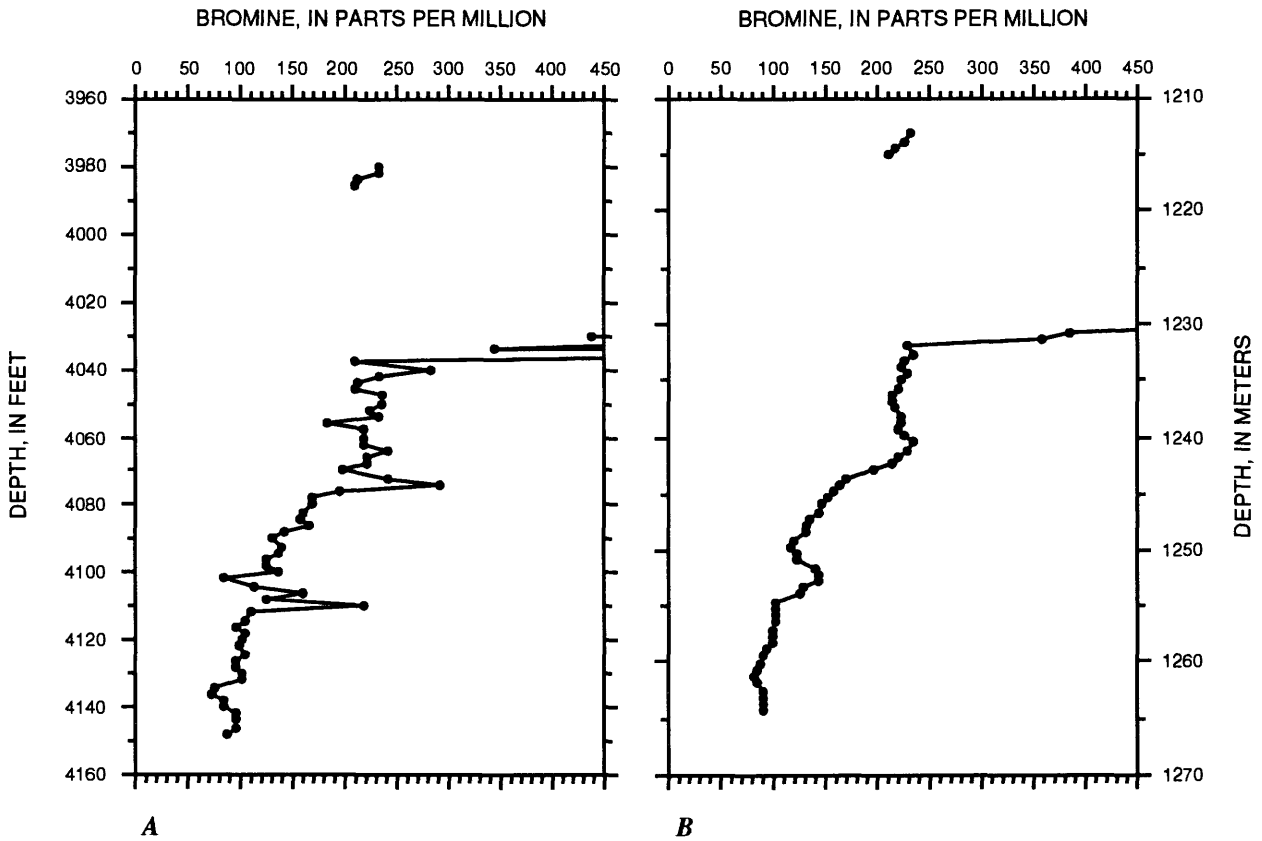


Figure 20. Bromine distribution in halite bed of cycle 13, Shafer No. 1 core. *A*, Analytical results. *B*, Smoothed profile using a moving average of five points. The average bromine content in this profile is 191.2 ppm.

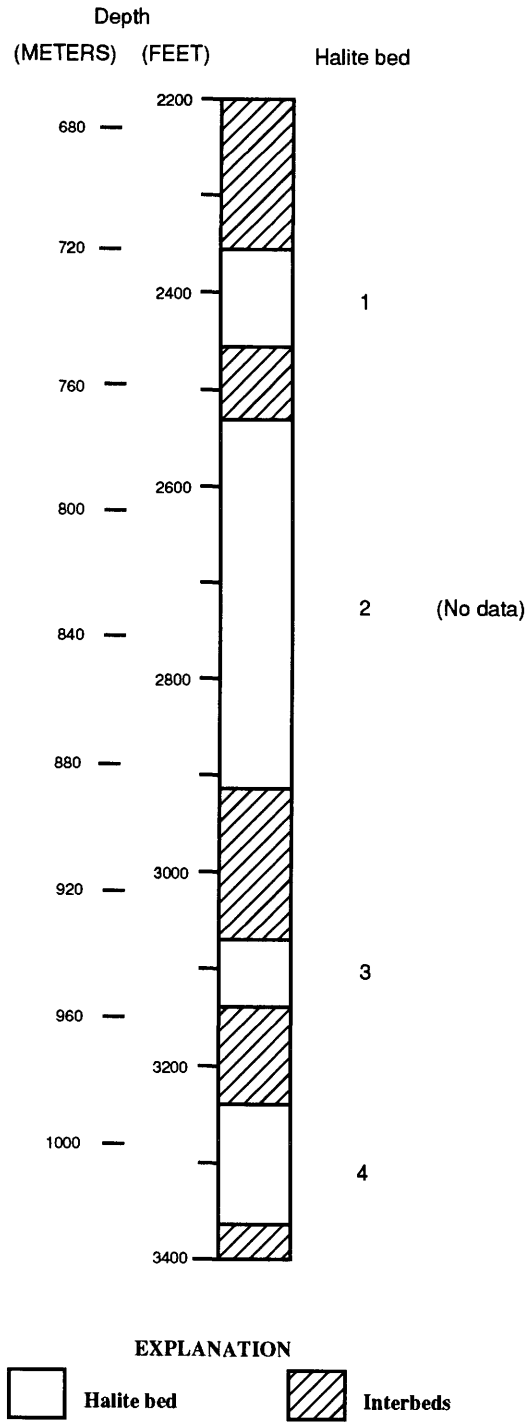


Figure 21. Generalized stratigraphic column of the Utah No. 2 core. Scale 1 inch = 200 ft.

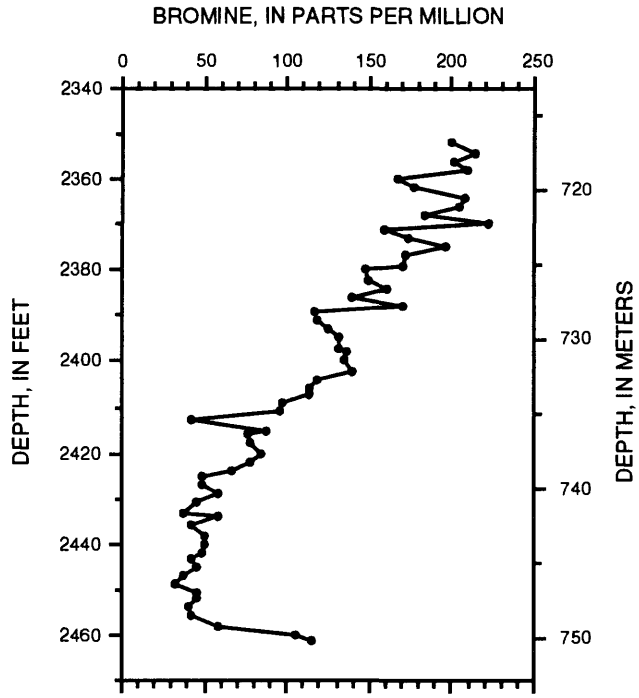


Figure 22. Bromine distribution in halite bed of cycle 1, Utah No. 2 core. The average bromine content of this profile, excluding the three high values at the base, is 112.6 ppm.

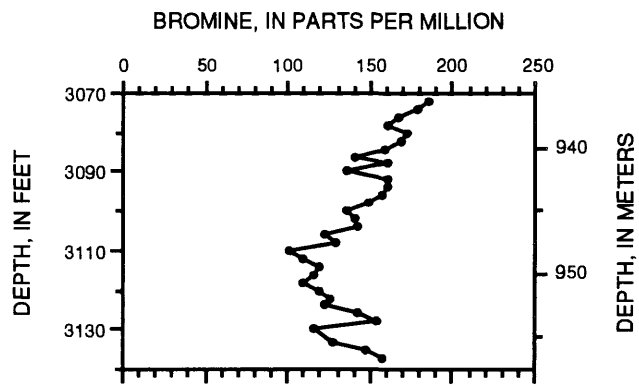


Figure 23. Bromine distribution in halite bed of cycle 3, Utah No. 2 core. The average bromine content of this profile, excluding the three high values at the base, is 141.7 ppm.

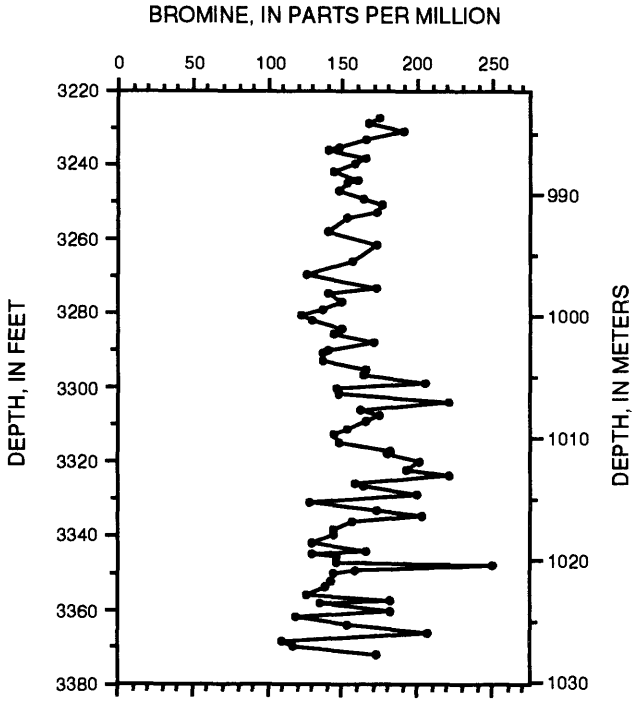


Figure 24. Bromine distribution in halite bed of cycle 4, Utah No. 2 core. The average bromine content in the profile is 158.7 ppm.

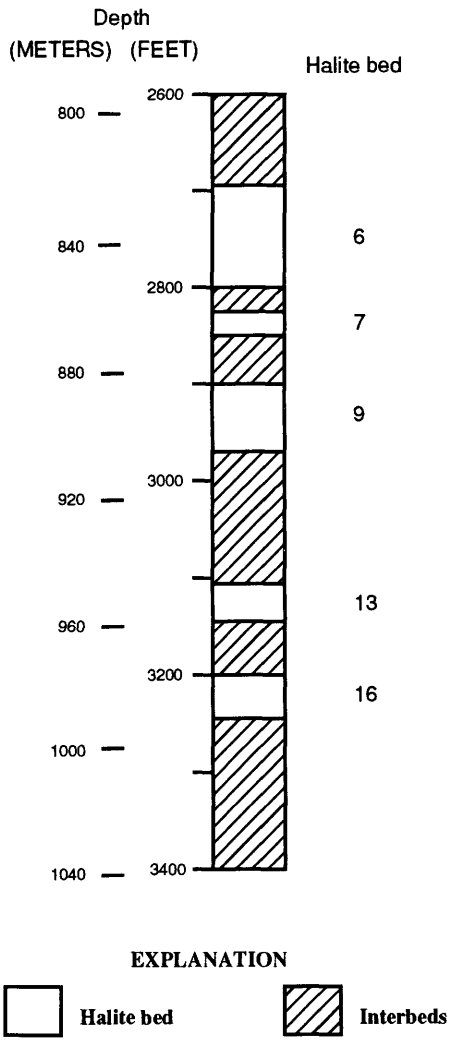


Figure 25. Generalized stratigraphic column of the Elk Ridge No. 1 core. Scale 1 inch = 200 ft.

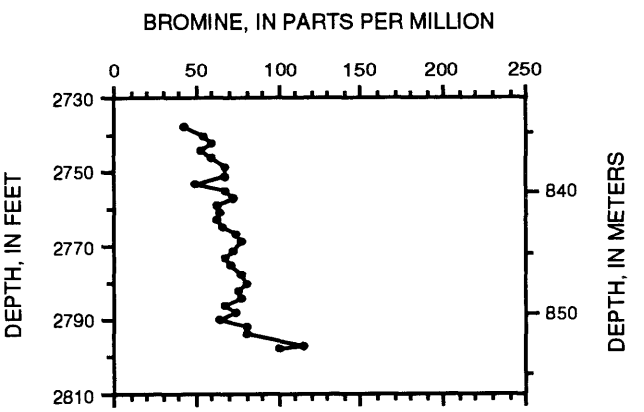


Figure 26. Bromine distribution in halite bed of cycle 6, Elk Ridge No. 1 core. The average bromine content of this profile, excluding the two high values at the base, is 67.4 ppm.

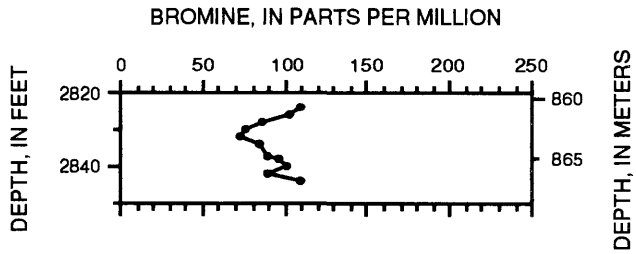


Figure 27. Bromine distribution in halite bed of cycle 7, Elk Ridge No. 1 core. The average bromine content in this profile is 92.4 ppm.

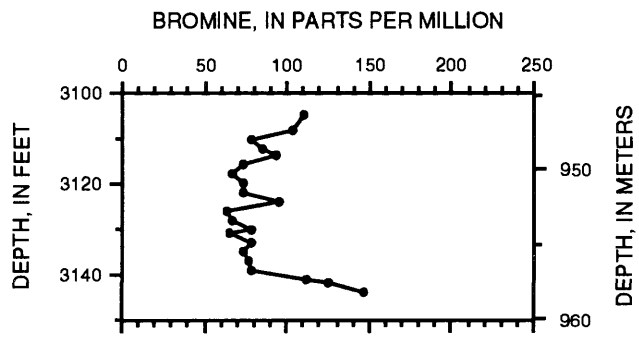


Figure 29. Bromine distribution in halite bed of cycle 13, Elk Ridge No. 1 core. The average bromine content in this profile, excluding the three high values at the base, is 79.6 ppm.

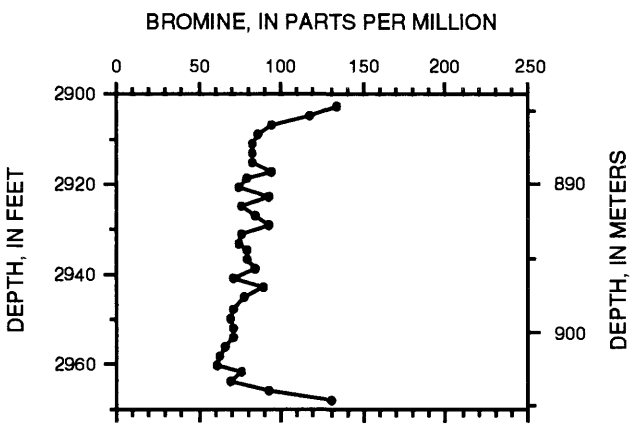


Figure 28. Bromine distribution in halite bed of cycle 9, Elk Ridge No. 1 core. The average bromine content in this profile, excluding the two high values at the base, is 81.5 ppm.

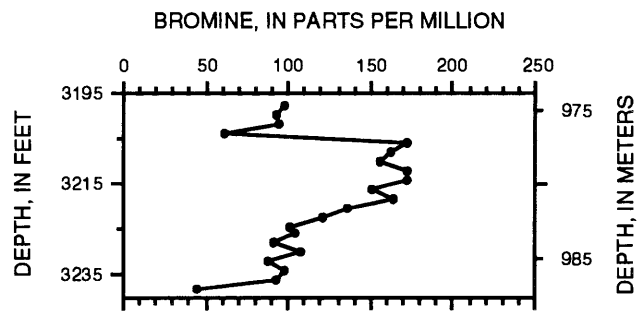


Figure 30. Bromine distribution in halite bed of cycle 16, Elk Ridge No. 1 core. The average bromine content in this profile is 117.9 ppm.

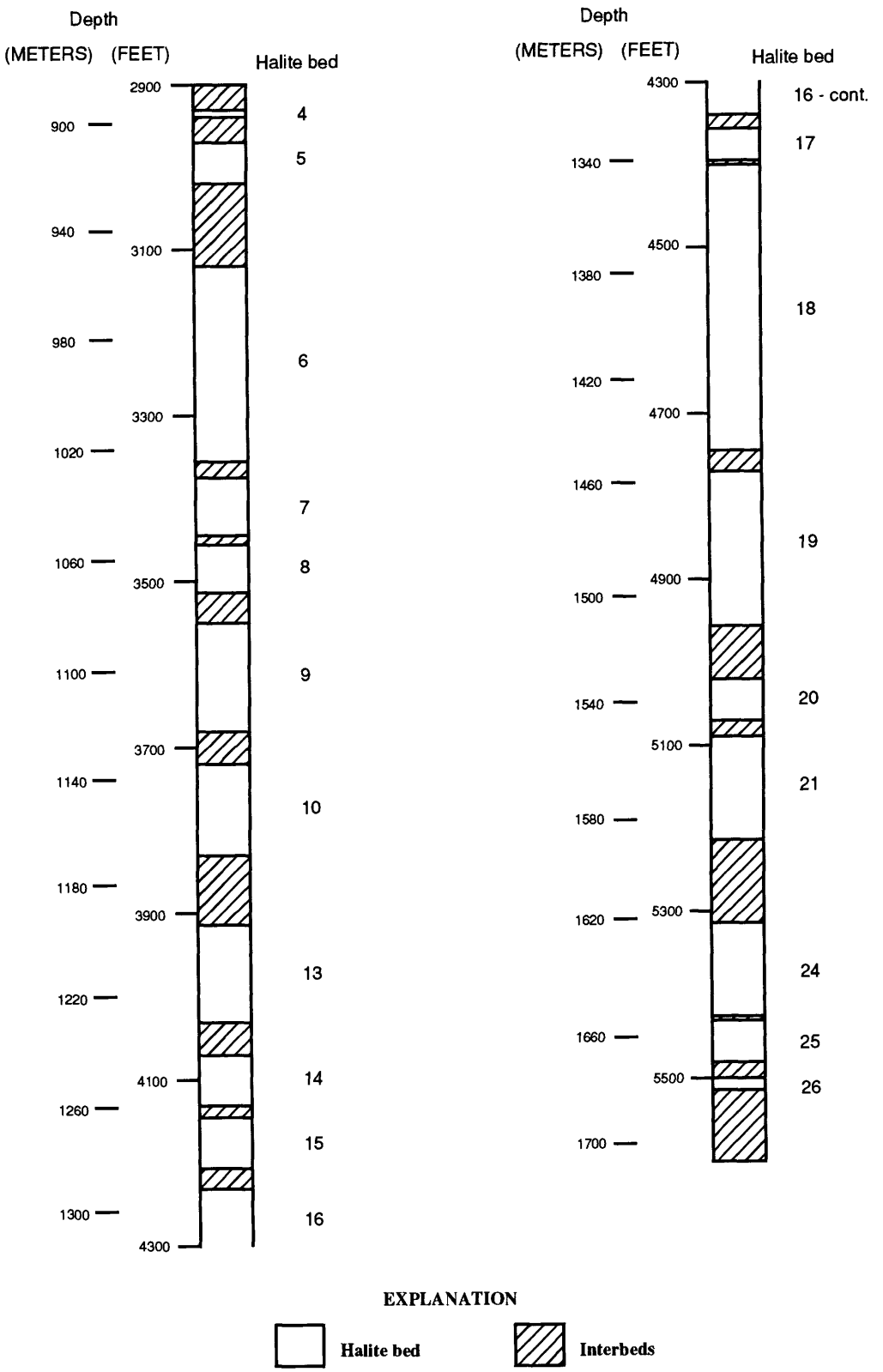


Figure 31. Generalized stratigraphic column of the Gibson Dome No. 1 core. Scale 1 inch = 200 ft.

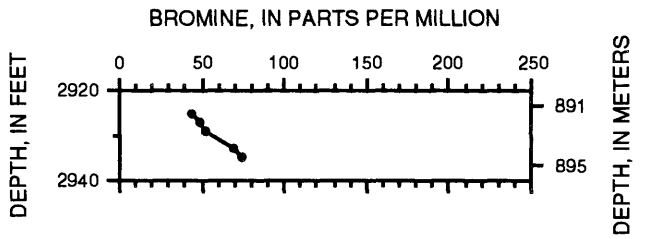


Figure 32. Bromine distribution in halite bed of cycle 4, Gibson Dome No. 1 core. The average bromine content in this profile is 57.8 ppm.

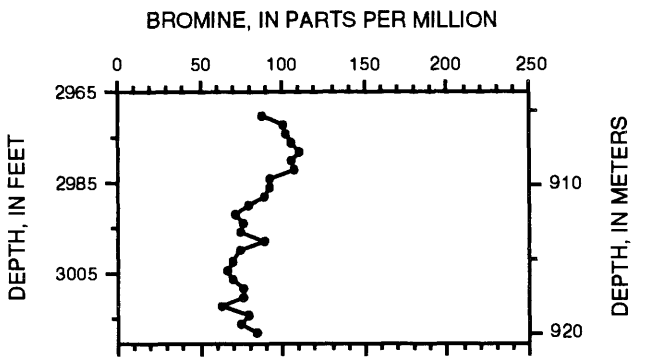


Figure 33. Bromine distribution in halite bed of cycle 5 (upper part), Gibson Dome No. 1 core. The average bromine content in this profile, that represents the upper 73 percent of the halite bed, is 84.8 ppm.

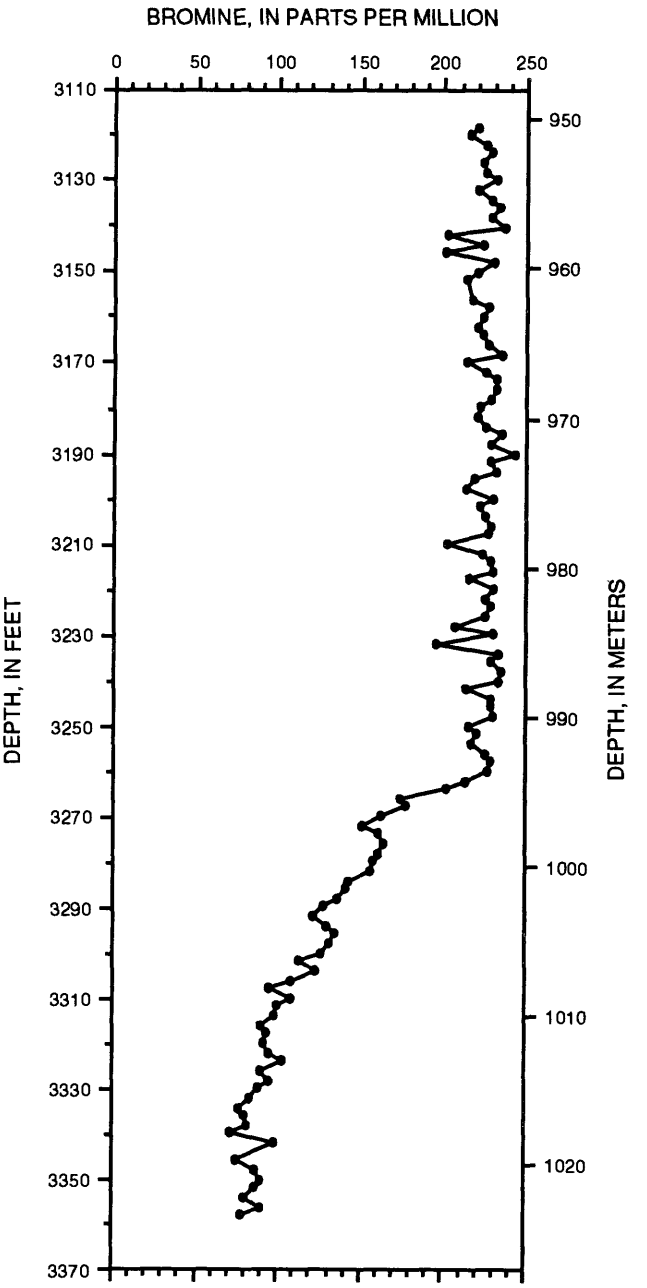


Figure 34. Bromine distribution in halite bed of cycle 6, Gibson Dome No. 1 core. The average bromine content in this profile is 181.4 ppm.

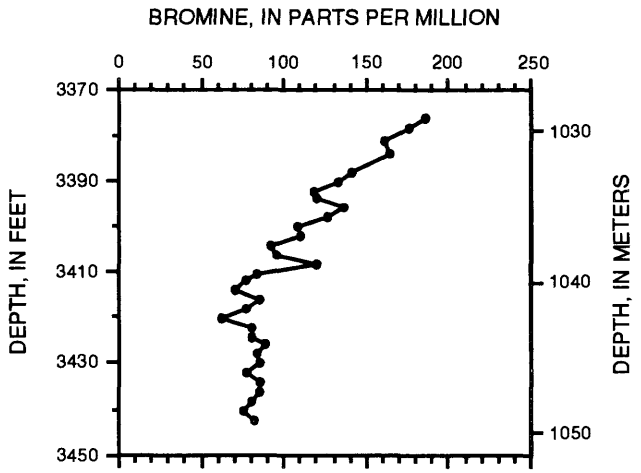


Figure 35. Bromine distribution in halite bed of cycle 7, Gibson Dome No. 1 core. The average bromine content in this profile is 105.0 ppm.

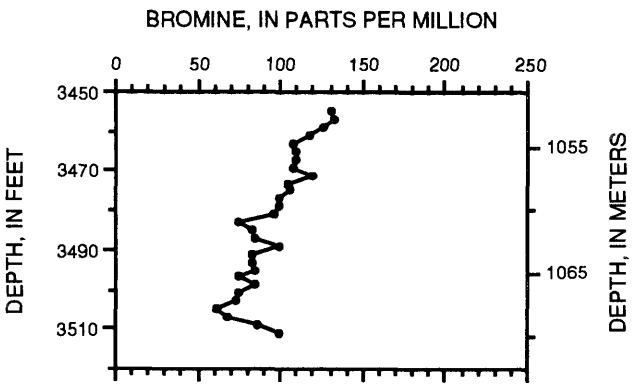
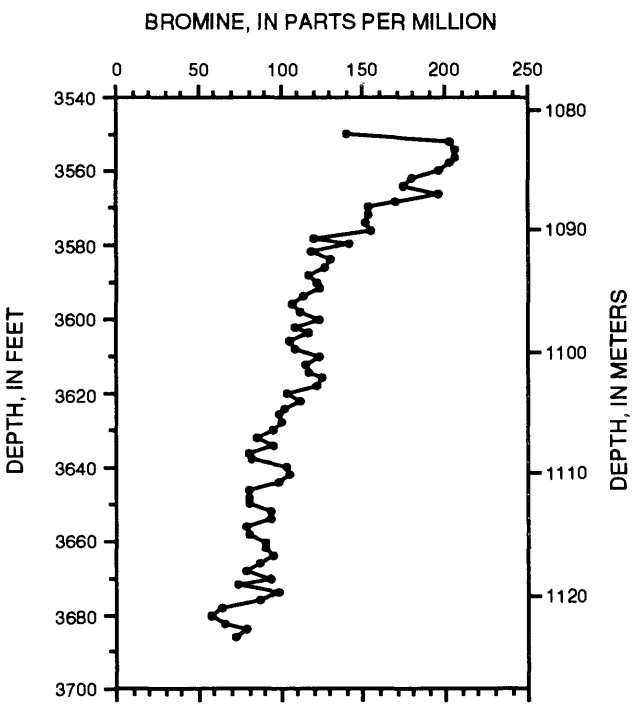


Figure 36. Bromine distribution in halite bed of cycle 8, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the two higher values at the base, is 95.9 ppm.



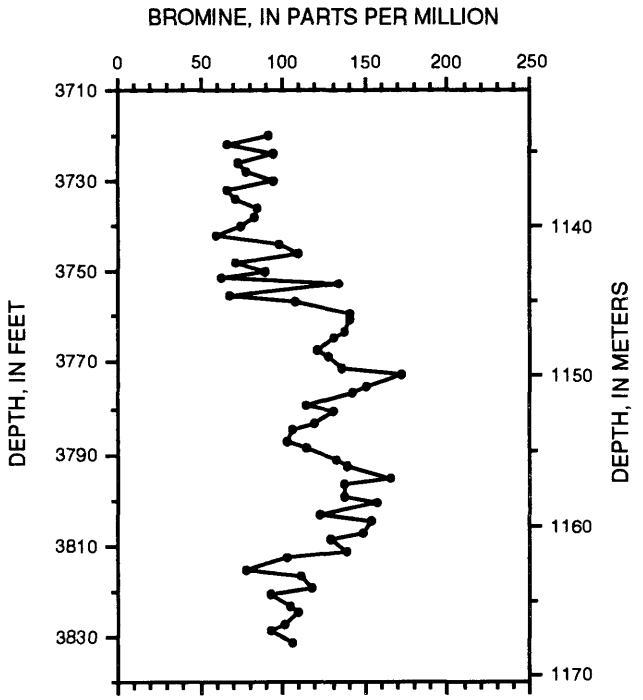


Figure 38. Bromine distribution in halite bed of cycle 10, Gibson Dome No. 1 core. The average bromine content in this profile is 111.2 ppm.

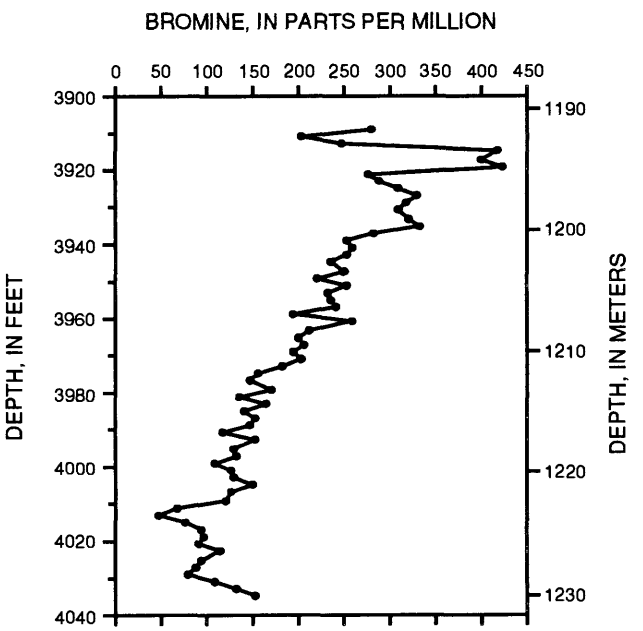


Figure 39. Bromine distribution in halite bed of cycle 13, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the three higher values at the base, is 199.6 ppm.

Figure 37 (left column). Bromine distribution in halite bed of cycle 9, Gibson Dome No. 1 core. The average bromine content in this profile is 115.3 ppm.

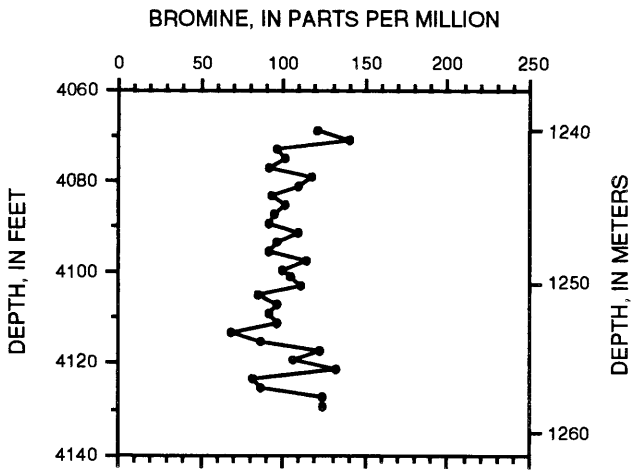


Figure 40. Bromine distribution in halite bed of cycle 14, Gibson Dome No. 1 core. The average bromine content in this profile is 102.9 ppm.

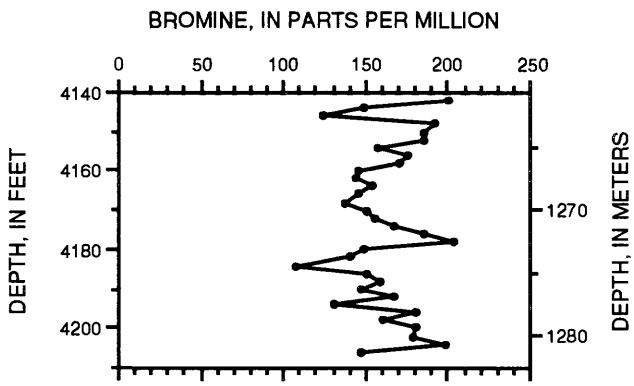


Figure 41. Bromine distribution in halite bed of cycle 15, Gibson Dome No. 1 core. The average bromine content in this profile is 161.4 ppm.

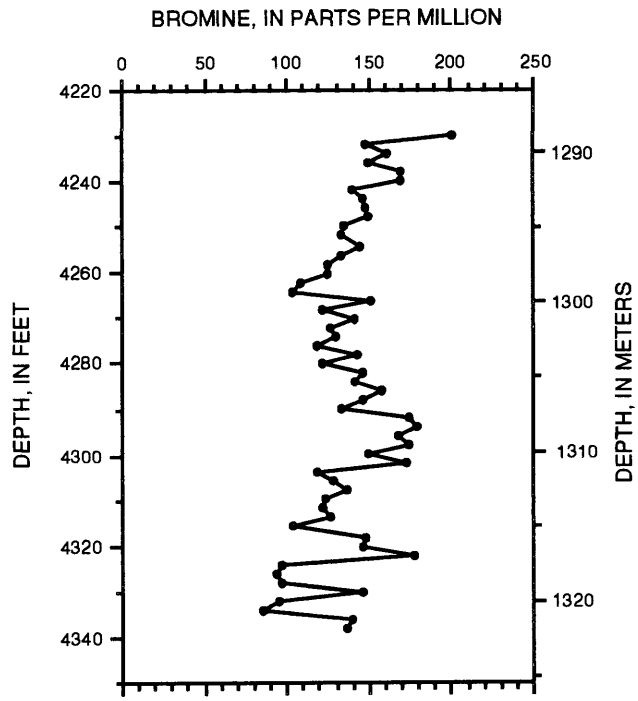


Figure 42. Bromine distribution in halite bed of cycle 16, Gibson Dome No. 1 core. The average bromine content in this profile is 138.4 ppm.

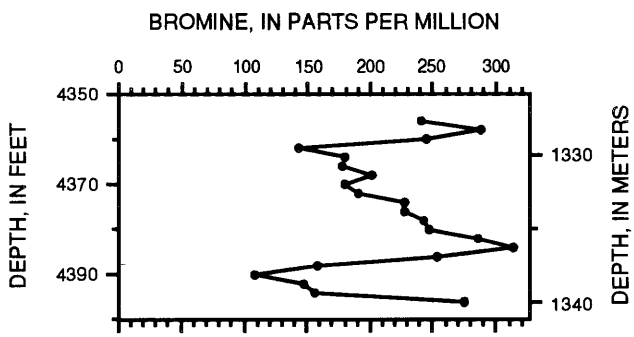


Figure 43. Bromine distribution in halite bed of cycle 17, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the one high value at the base, is 209.3 ppm.

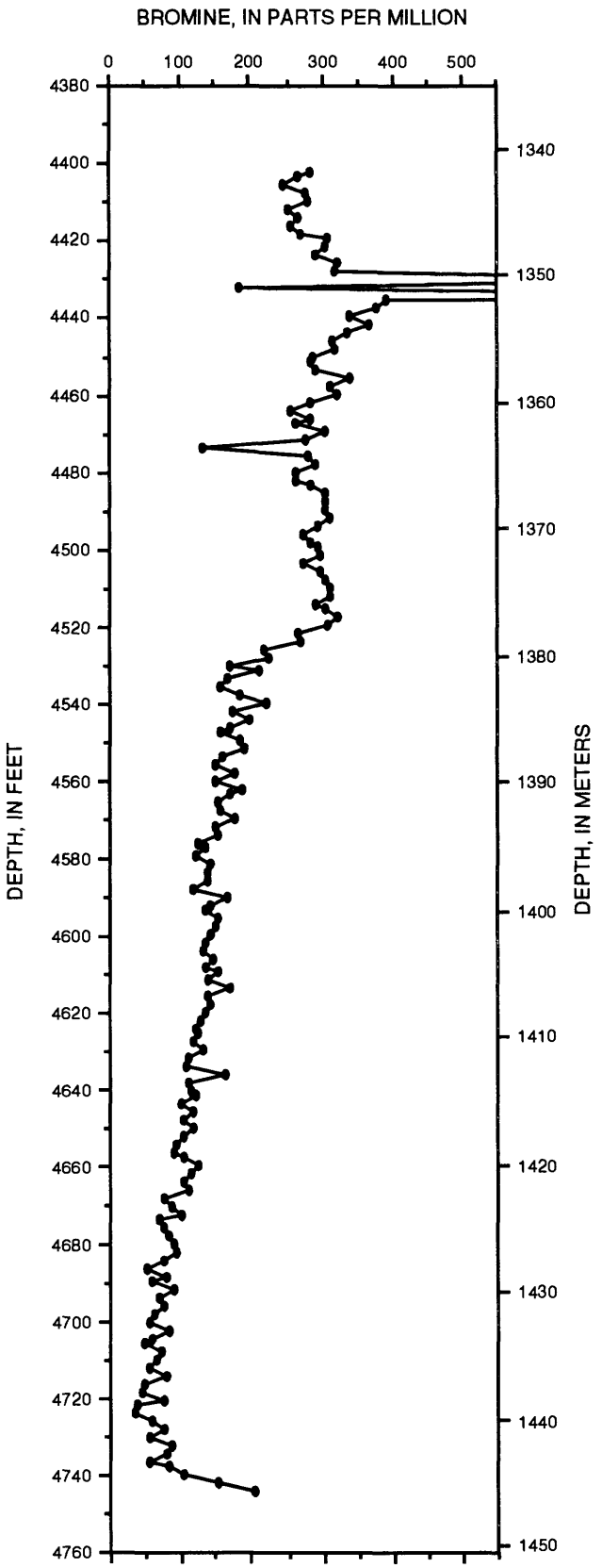


Figure 44. Bromine distribution in halite bed of cycle 18, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the three higher values at the base, is 189.9 ppm.

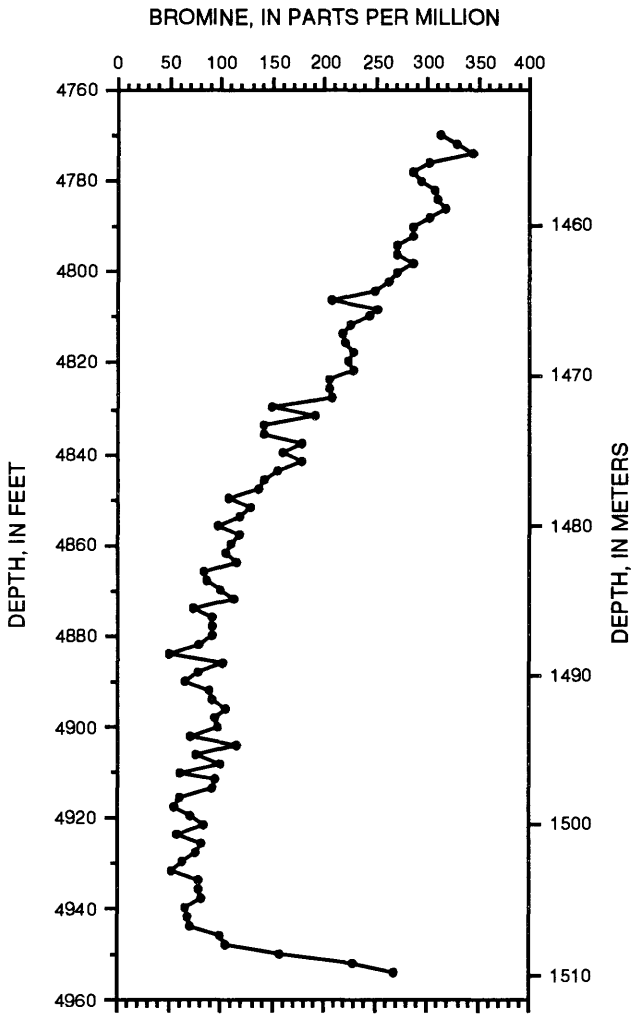


Figure 45. Bromine distribution in halite bed of cycle 19, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the five higher values at the base, is 155.6 ppm.

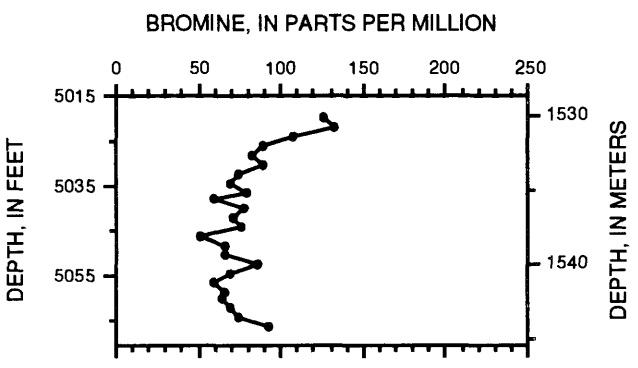


Figure 46. Bromine distribution in halite bed of cycle 20, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the one higher value at the base, is 78.5 ppm.

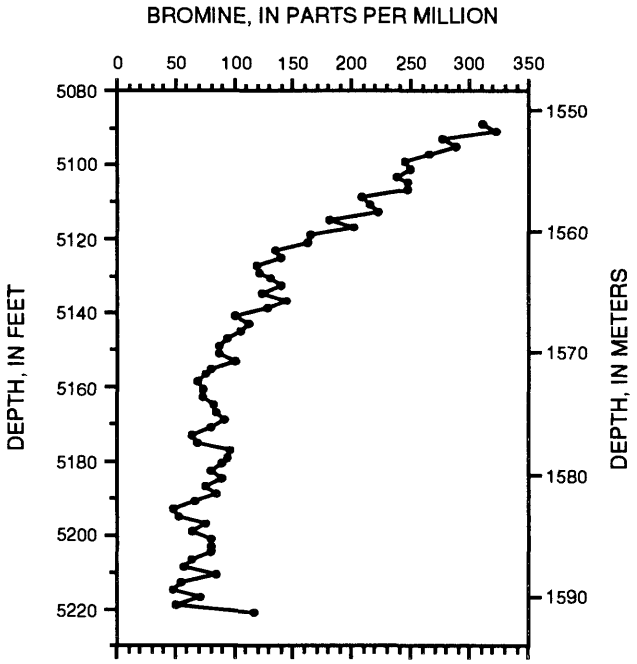


Figure 47. Bromine distribution in halite bed of cycle 21, Gibson Dome No. 1 core. The average bromine content in this profile, excluding the one higher value at the base, is 126 ppm.

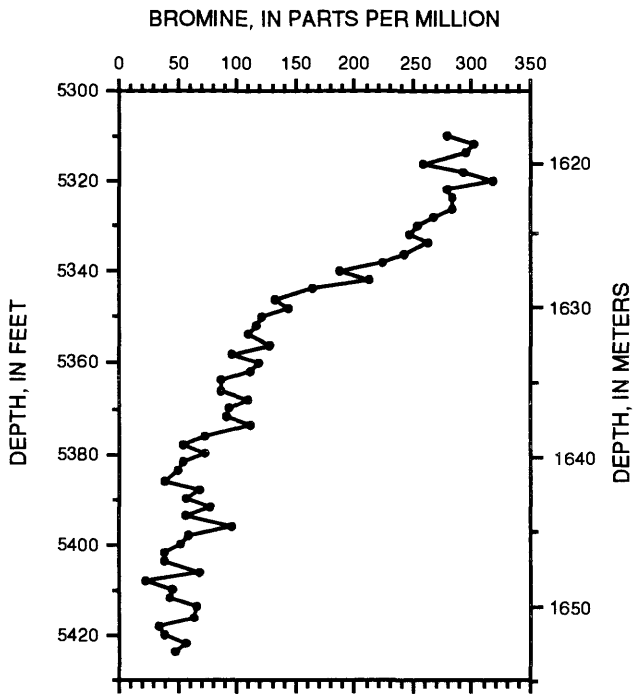


Figure 48. Bromine distribution in halite bed of cycle 24, Gibson Dome No. 1 core. The average bromine content in this profile is 132.6 ppm.

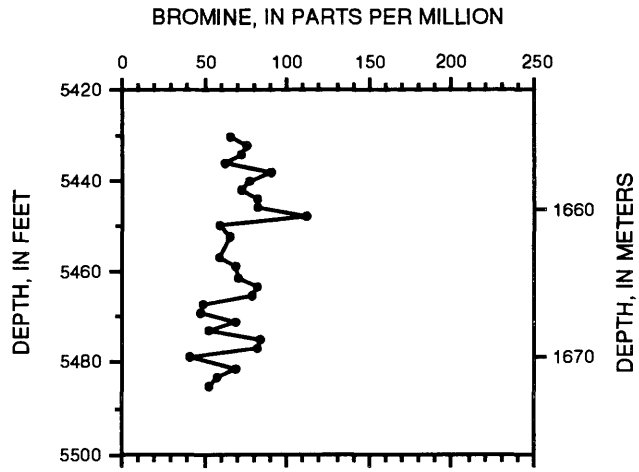


Figure 49. Bromine distribution in halite bed of cycle 25, Gibson Dome No. 1 core. The average bromine content in this profile is 69.6 ppm.

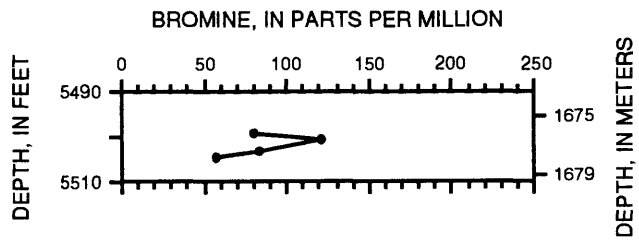


Figure 50. Bromine distribution in halite bed of cycle 26, Gibson Dome No. 1 core. The average bromine content in this profile is 85.2 ppm.

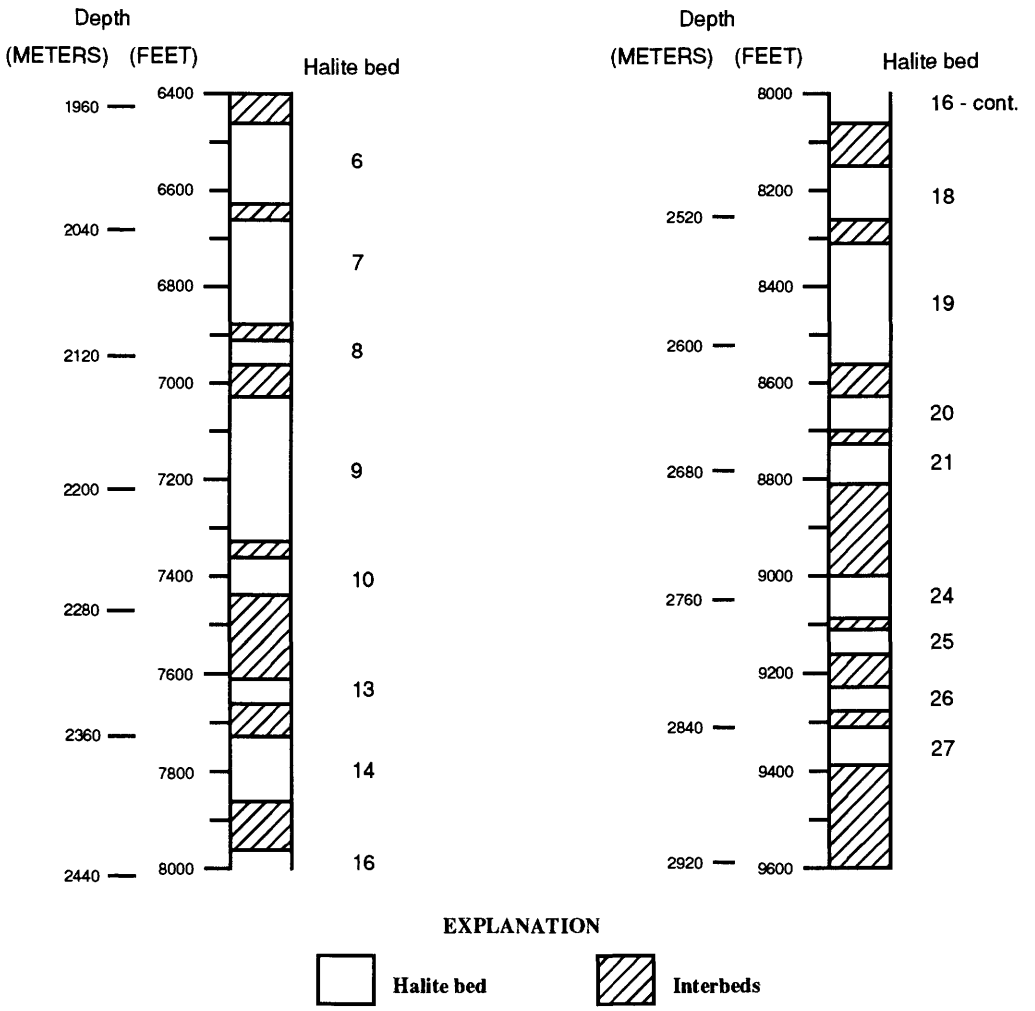


Figure 51. Generalized stratigraphic column of the Lone Dome No. 1 well. Scale 1 inch = 400 ft.

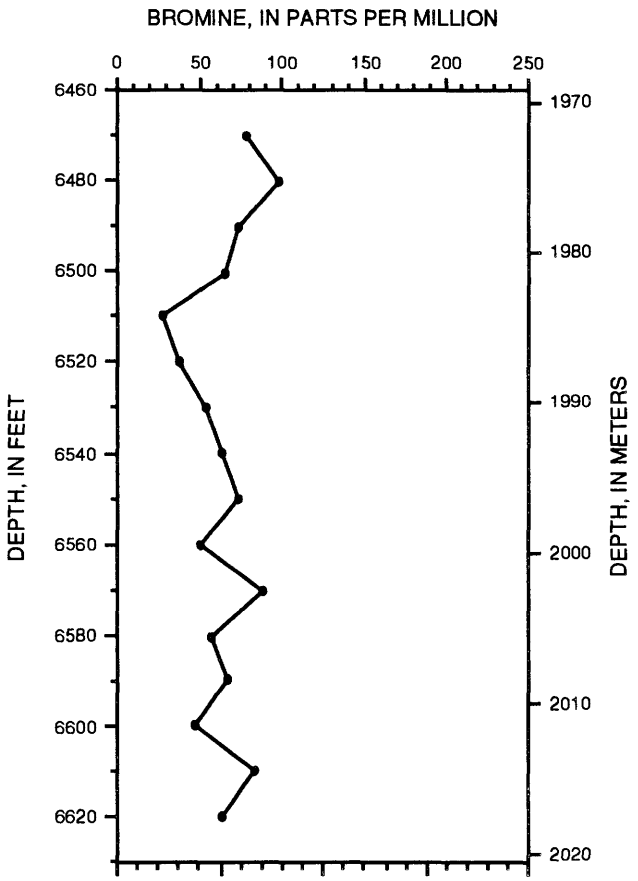


Figure 52. Bromine distribution in halite bed of cycle 6, Lone Dome No. 1 well. The average bromine content in this profile is 64.3 ppm.

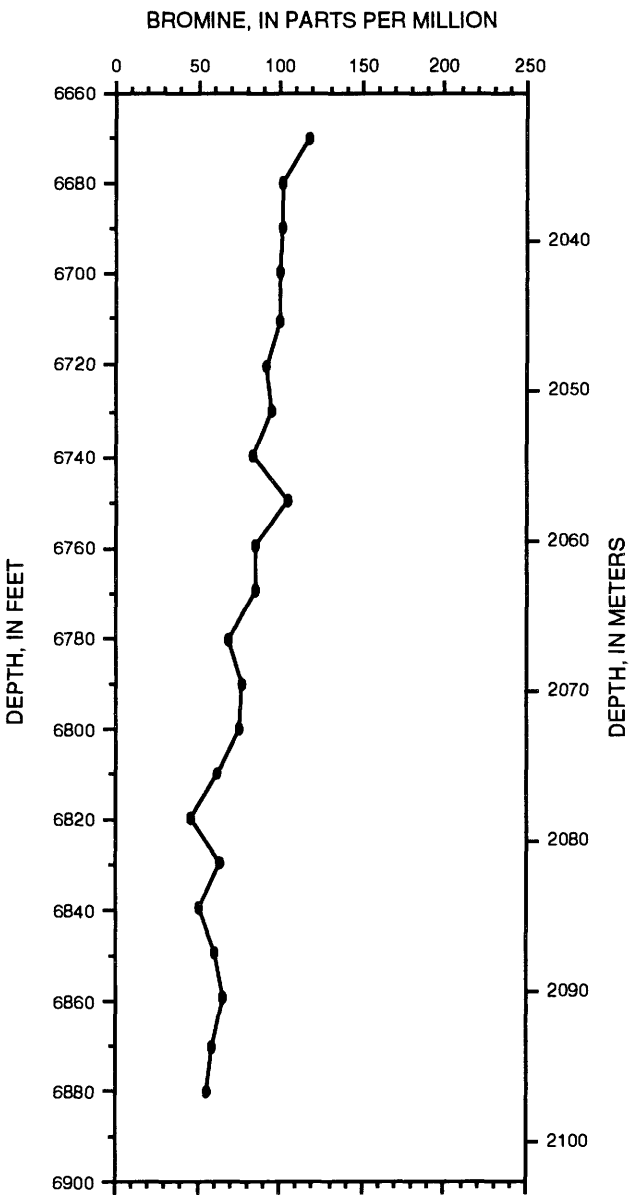


Figure 53. Bromine distribution in halite bed of cycle 7, Lone Dome No. 1 well. The average bromine content in this profile is 79.5 ppm.

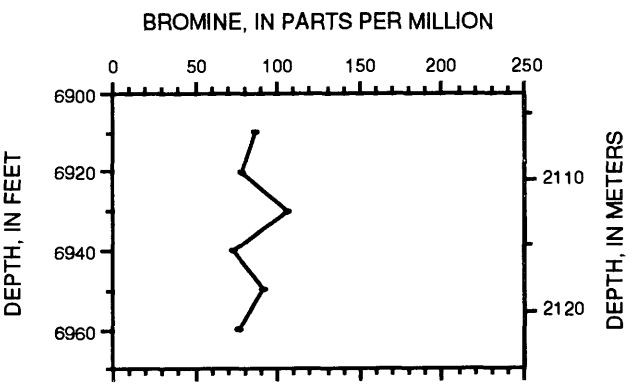


Figure 54 (right column). Bromine distribution in halite bed of cycle 8, Lone Dome No. 1 well. The average bromine content in this profile is 85.3 ppm.

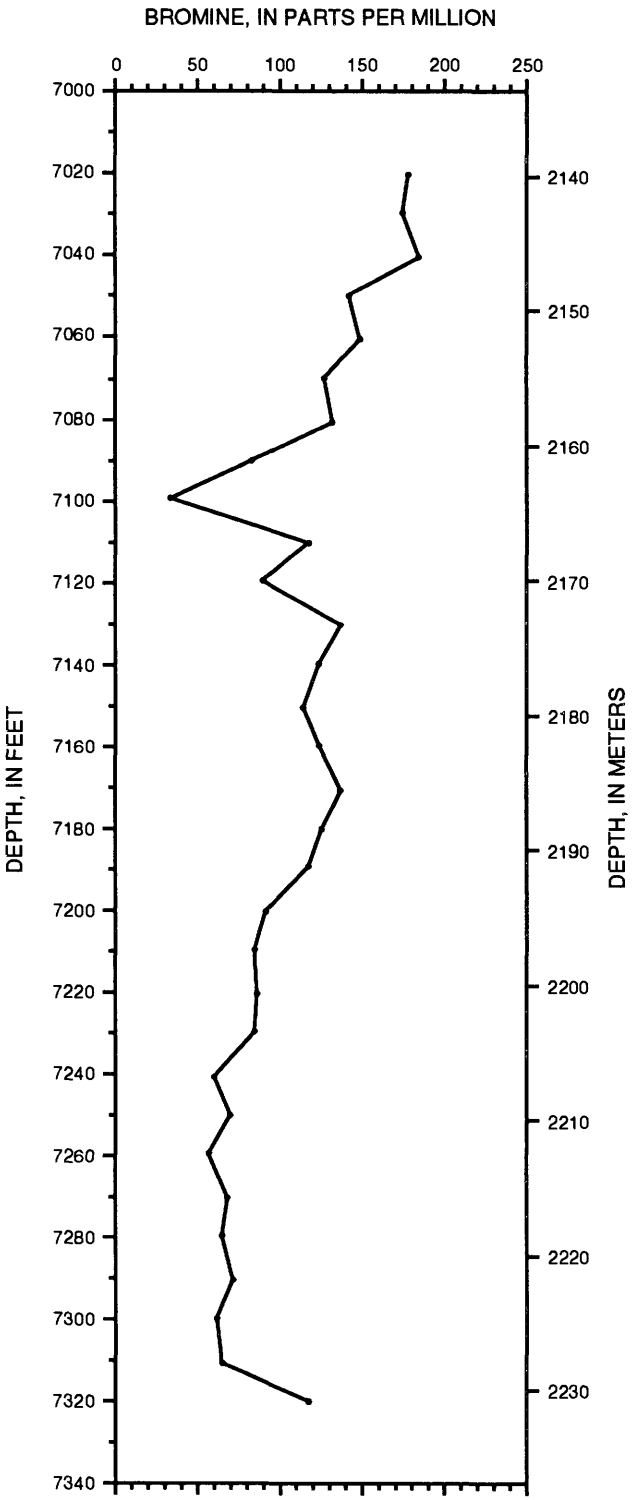


Figure 55. Bromine distribution in halite bed of cycle 9, Lone Dome No. 1 well. The average bromine content in this profile, excluding the one higher value at the base, is 105.4 ppm.

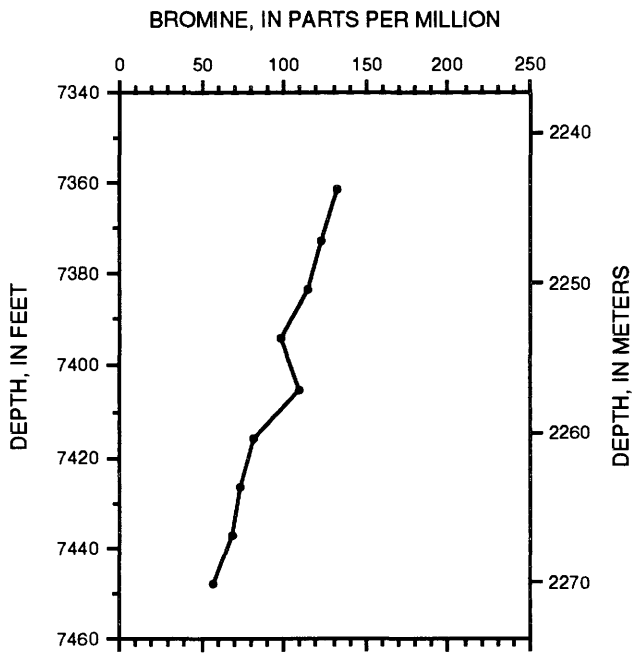


Figure 56. Bromine distribution in halite bed of cycle 10, Lone Dome No. 1 well. The average bromine content in this profile is 95.2 ppm.

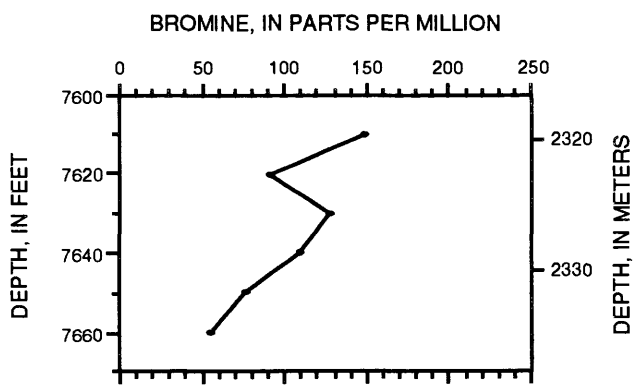


Figure 57. Bromine distribution in halite bed of cycle 13, Lone Dome No. 1 well. The average bromine content in this profile is 101.3 ppm.

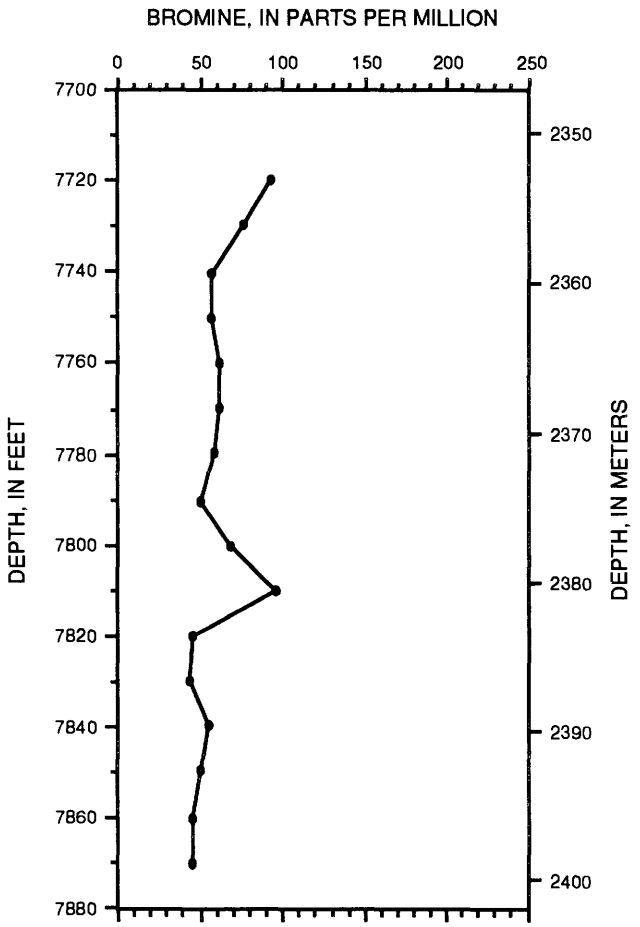


Figure 58. Bromine distribution in halite bed of cycle 14, Lone Dome No. 1 well. The average bromine content in this profile is 60.6 ppm.

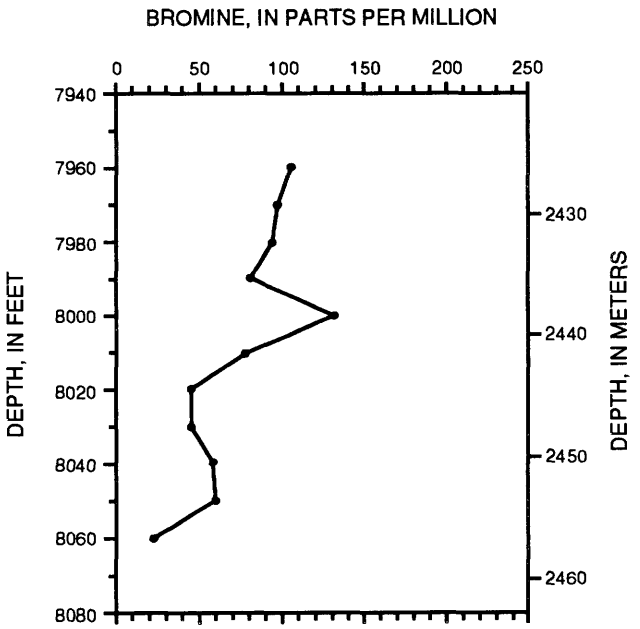


Figure 59. Bromine distribution in halite bed of cycle 16, Lone Dome No. 1 well. The average bromine content in this profile is 75.0 ppm.

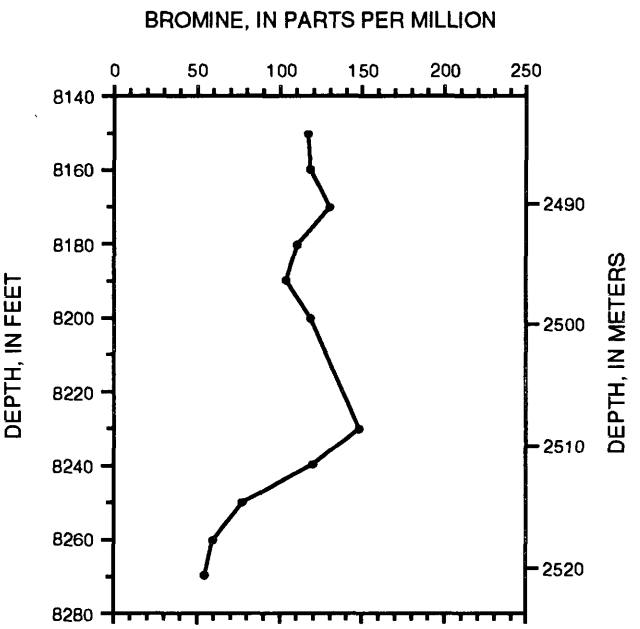


Figure 60. Bromine distribution in halite bed of cycle 18, Lone Dome No. 1 well. The average bromine content in this profile is 105.9 ppm.

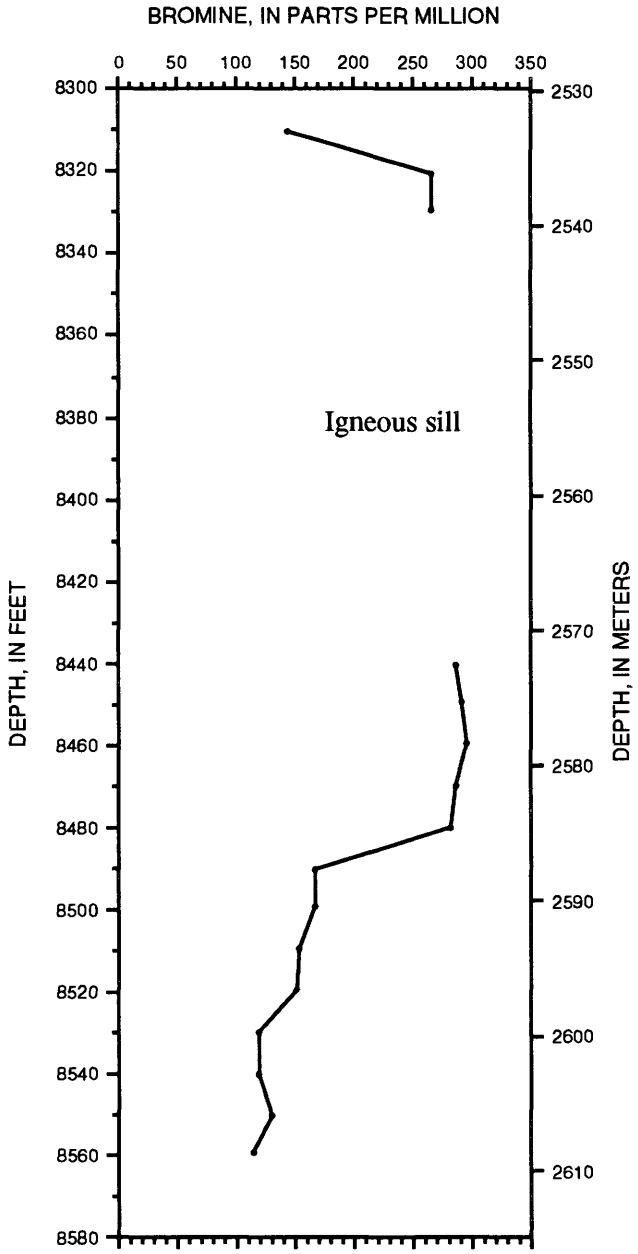


Figure 61. Bromine distribution in halite bed of cycle 19, Lone Dome No. 1 well. The average bromine content in this profile is 202.2 ppm.

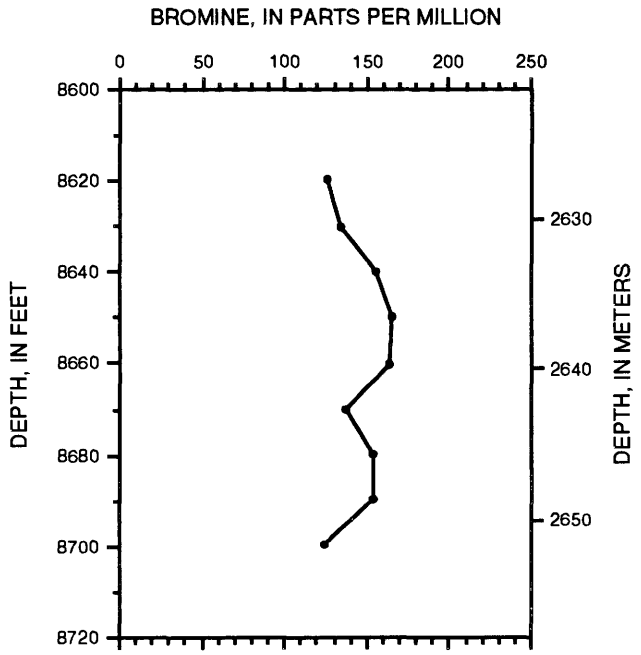


Figure 62. Bromine distribution in halite bed of cycle 20, Lone Dome No. 1 well. The average bromine content in this profile is 145.9 ppm.

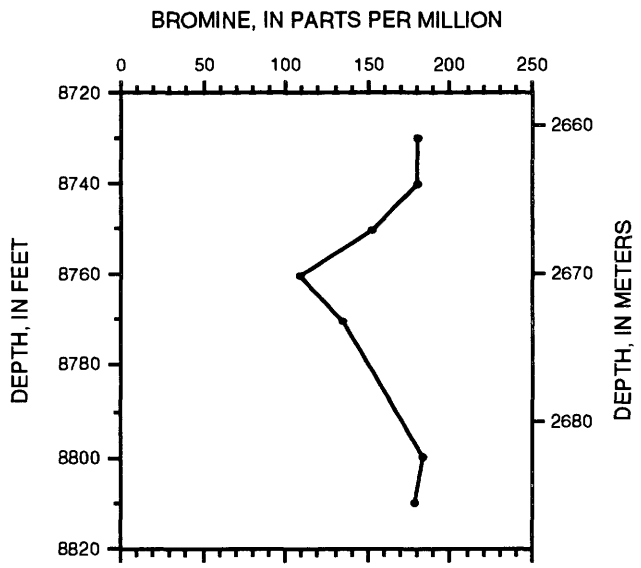


Figure 63. Bromine distribution in halite bed of cycle 21, Lone Dome No. 1 well. The average bromine content in this profile is 159.8 ppm.

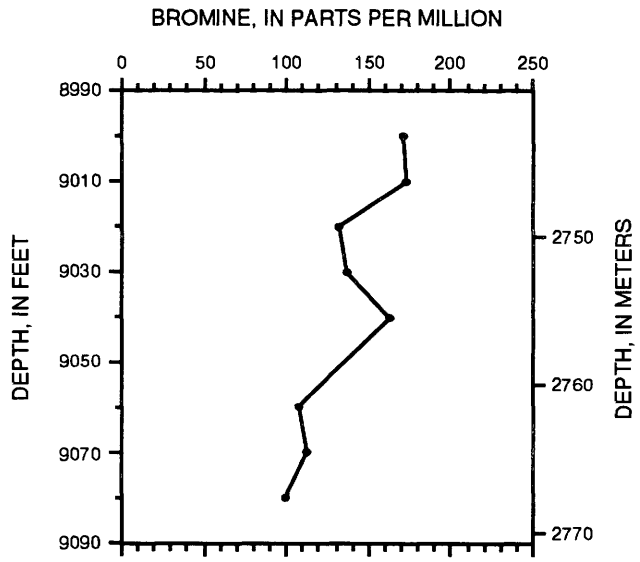


Figure 64. Bromine distribution in halite bed of cycle 24, Lone Dome No. 1 well. The average bromine content in this profile is 137.2 ppm.

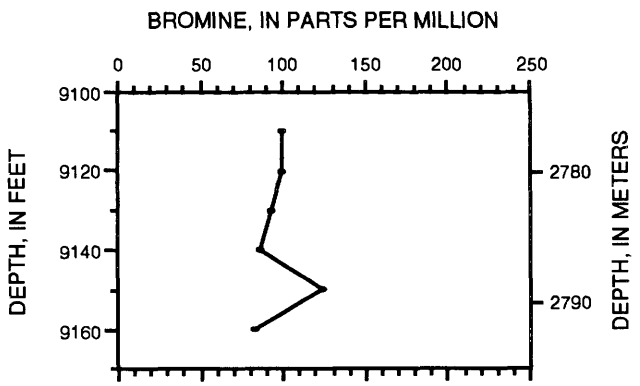


Figure 65. Bromine distribution in halite bed of cycle 25, Lone Dome No. 1 well. The average bromine content in this profile is 98.2 ppm.

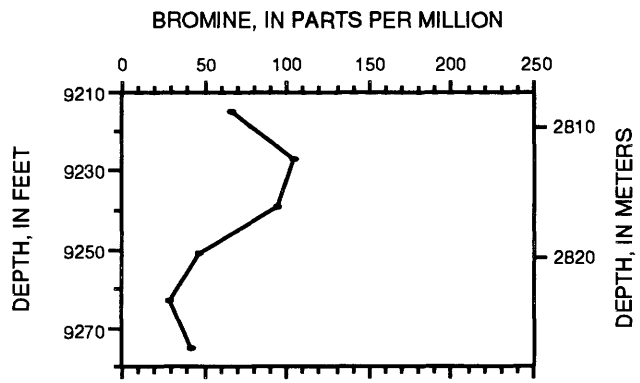


Figure 66. Bromine distribution in halite bed of cycle 26, Lone Dome No. 1 well. The average bromine content in this profile is 64.3 ppm.

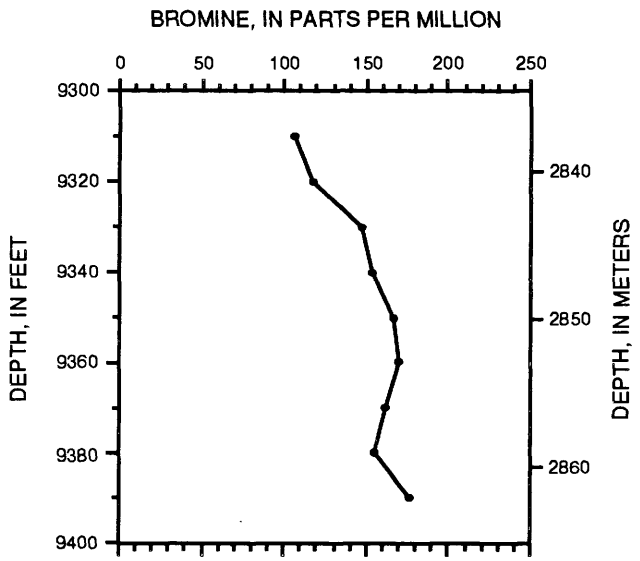


Figure 67. Bromine distribution in halite bed of cycle 27, Lone Dome No. 1 well. The average bromine content in this profile is 150.7 ppm.

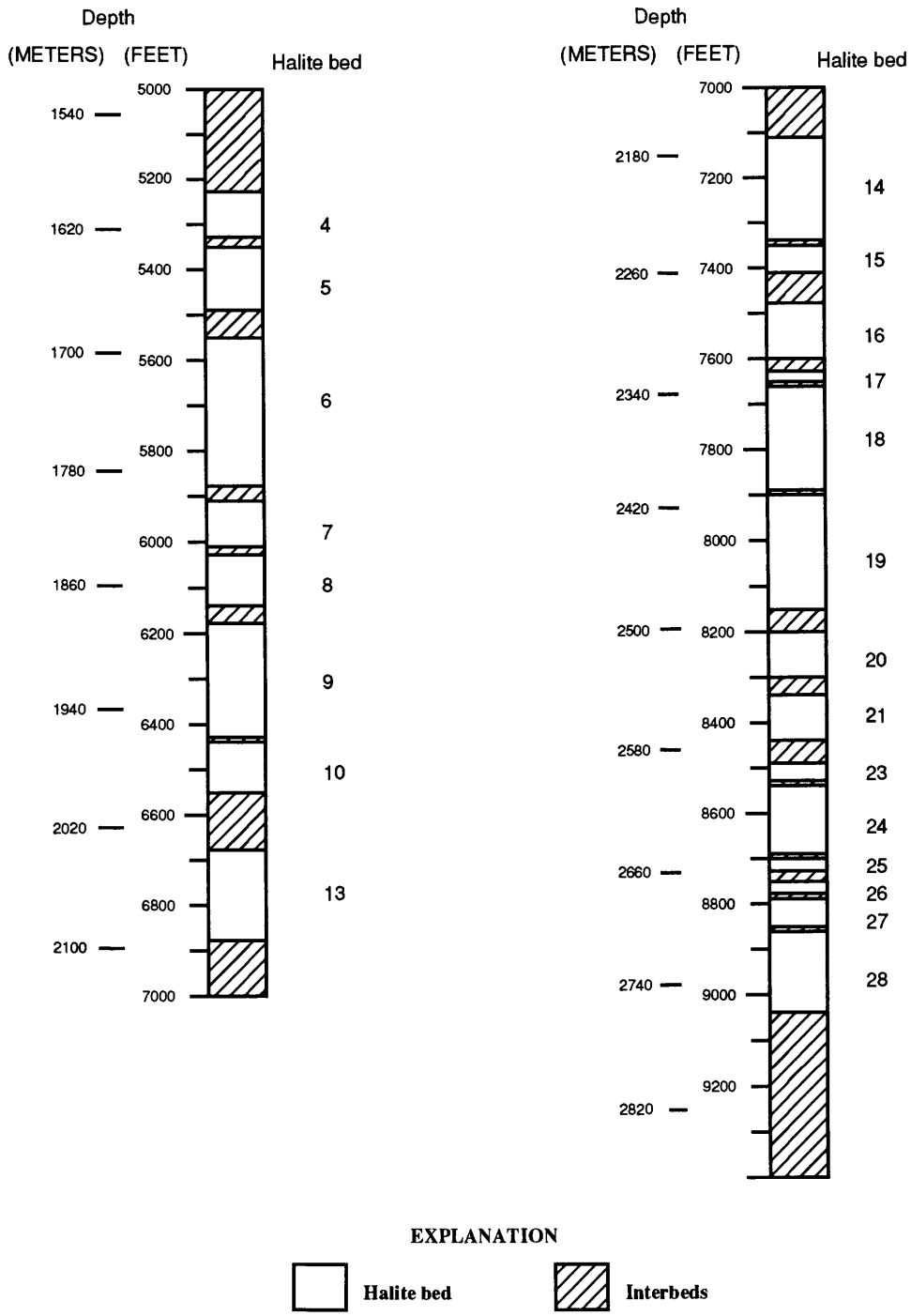


Figure 68. Generalized stratigraphic column of the Chevron Federal No. 1 well. Scale 1 inch = 400 ft.

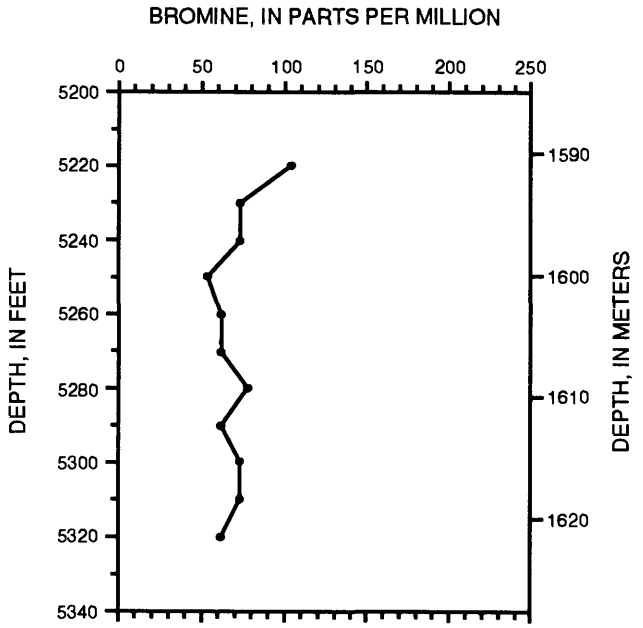


Figure 69. Bromine distribution in halite bed of cycle 4, Chevron Federal No. 1 well. The average bromine content in this profile is 70.9 ppm.

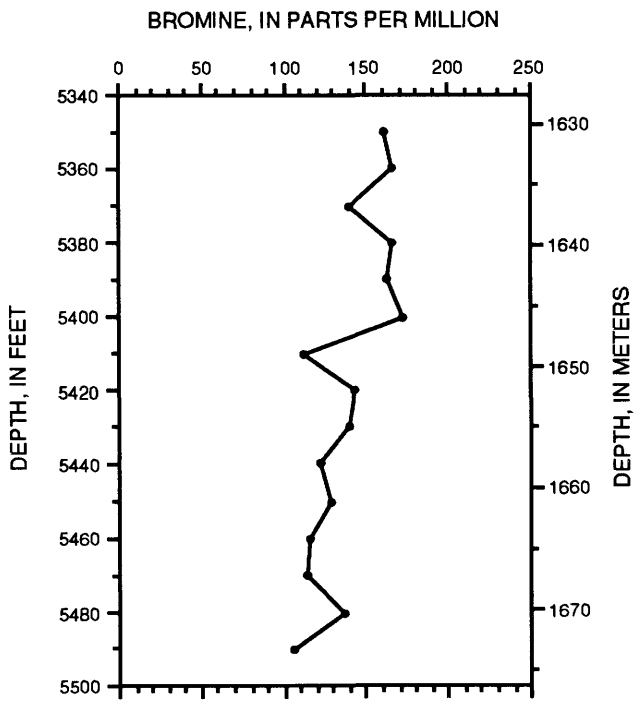


Figure 70. Bromine distribution in halite bed of cycle 5, Chevron Federal No. 1 well. The average bromine content in this profile is 138.7 ppm.

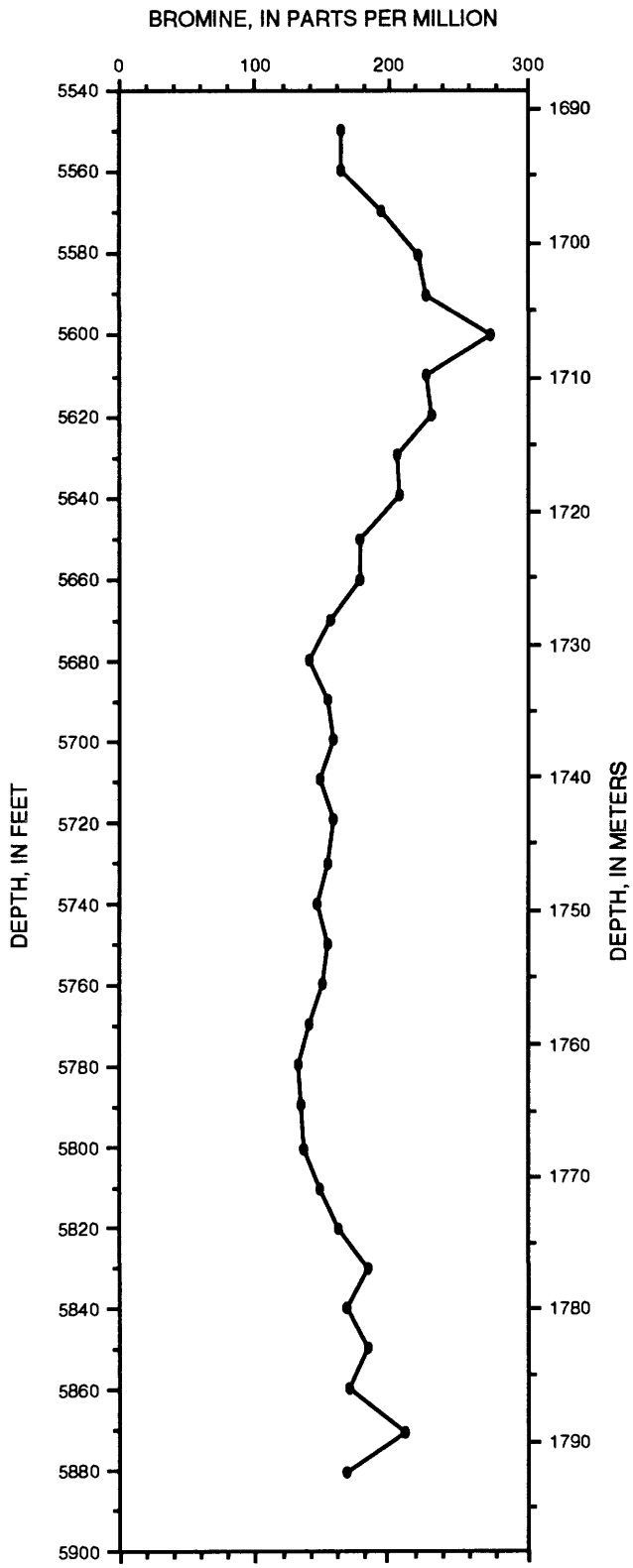


Figure 71. Bromine distribution in halite bed of cycle 6, Chevron Federal No. 1 well. The average bromine content in this profile is 172.9 ppm.

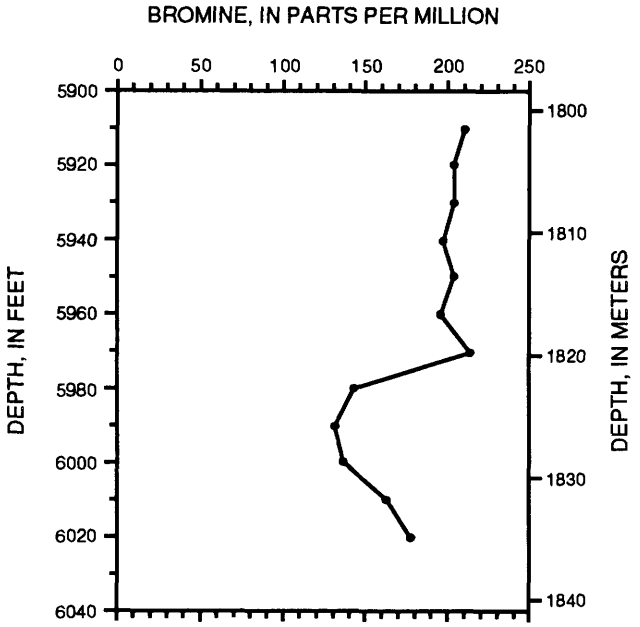


Figure 72. Bromine distribution in halite bed of cycle 7, Chevron Federal No. 1 well. The average bromine content in this profile is 182.2 ppm.

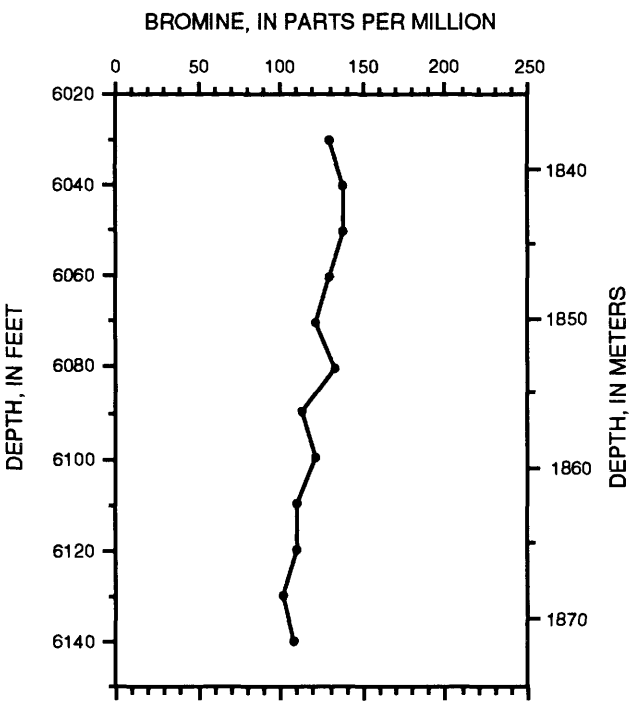


Figure 73. Bromine distribution in halite bed of cycle 8, Chevron Federal No. 1 well. The average bromine content in this profile is 121.5 ppm.

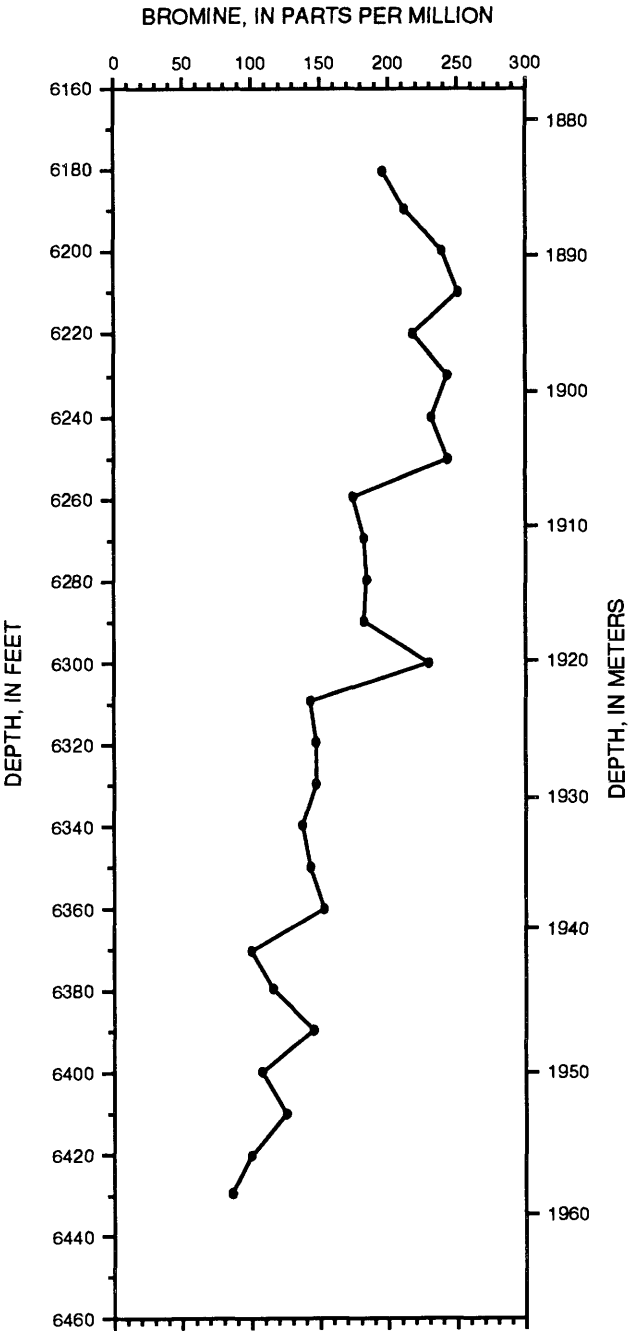


Figure 74. Bromine distribution in halite bed of cycle 9, Chevron Federal No. 1 well. The average bromine content in this profile is 170.8 ppm.

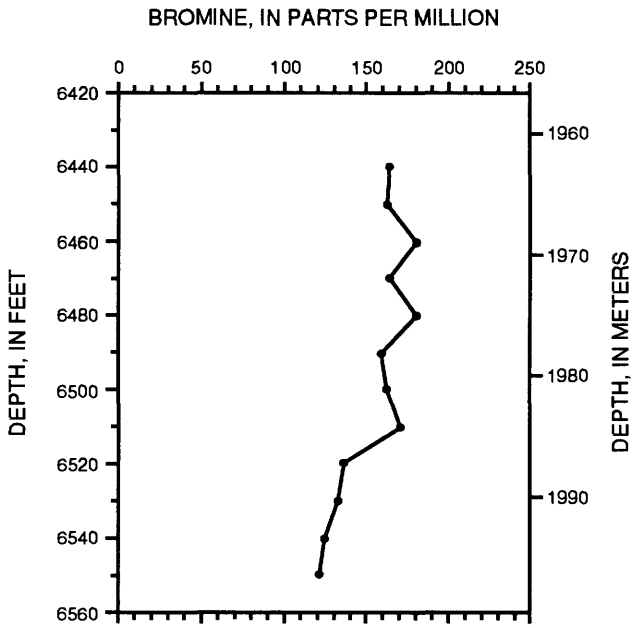


Figure 75. Bromine distribution in halite bed of cycle 10, Chevron Federal No. 1 well. The average bromine content in this profile is 156.1 ppm.

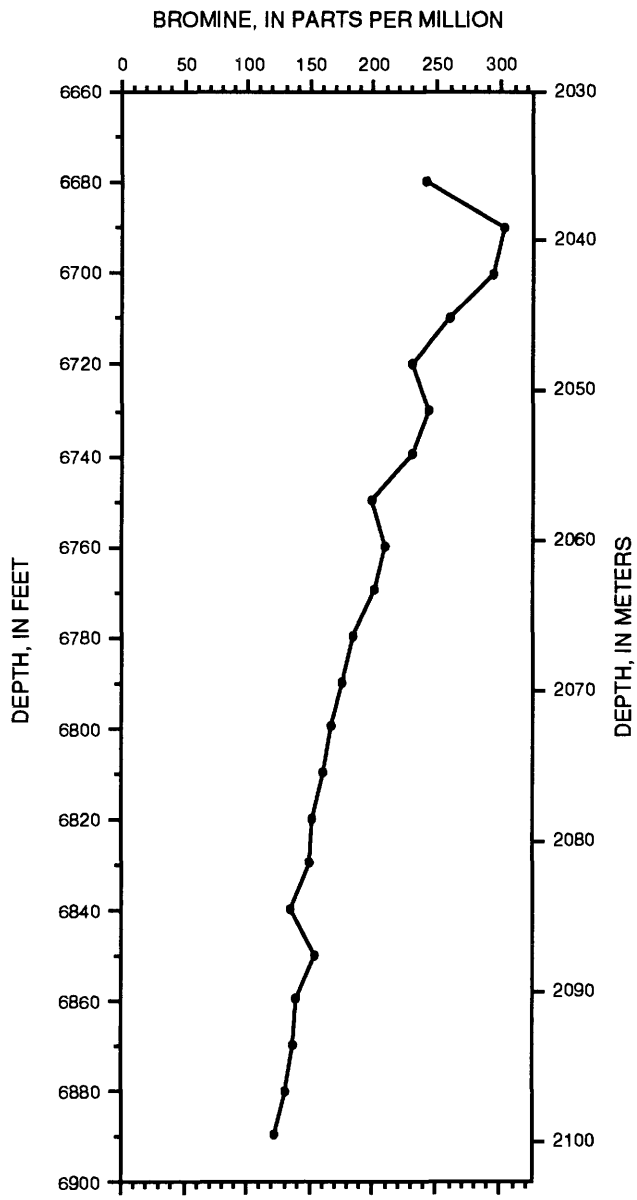


Figure 76. Bromine distribution in halite bed of cycle 13, Chevron Federal No. 1 well. The average bromine content in this profile is 190.6 ppm.

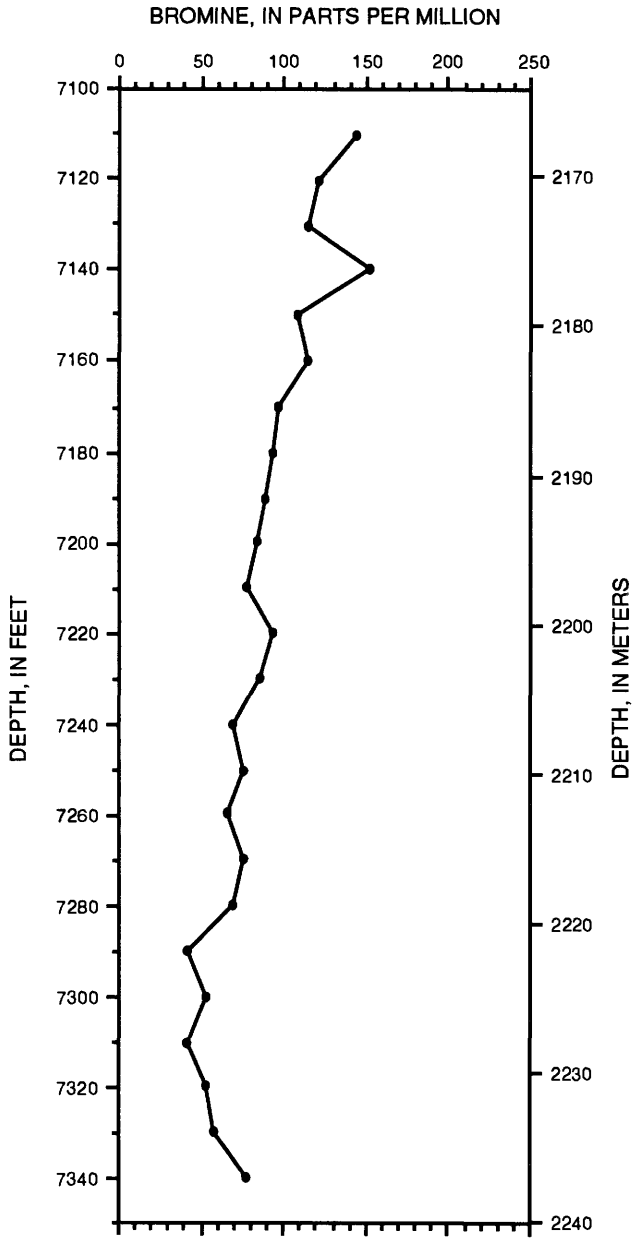


Figure 77. Bromine distribution in halite bed of cycle 14, Chevron Federal No. 1 well. The average bromine content in this profile, excluding the two higher values at the base, is 87.7 ppm.

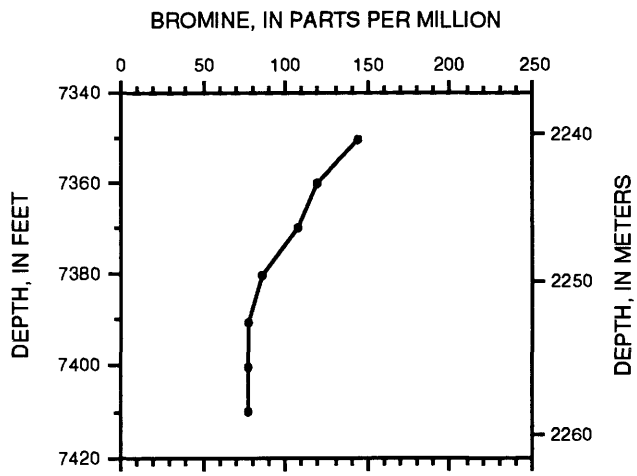


Figure 78. Bromine distribution in halite bed of cycle 15, Chevron Federal No. 1 well. The average bromine content in this profile is 98.8 ppm.

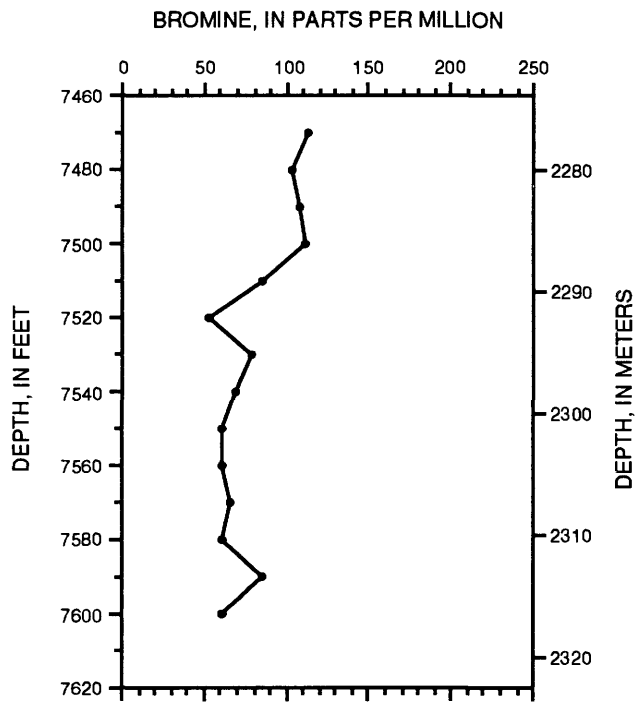


Figure 79. Bromine distribution in halite bed of cycle 16, Chevron Federal No. 1 well. The average bromine content in this profile is 80.5 ppm.

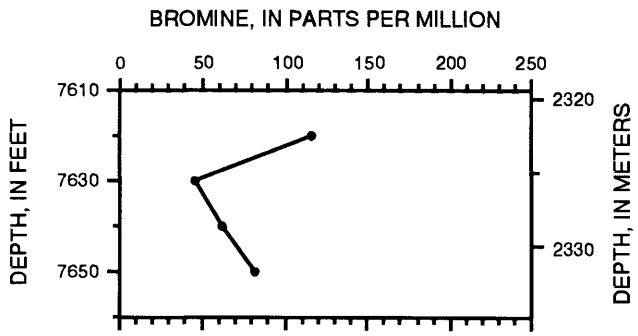


Figure 80. Bromine distribution in halite bed of cycle 17, Chevron Federal No. 1 well. The average bromine content in this profile is 76.5 ppm.

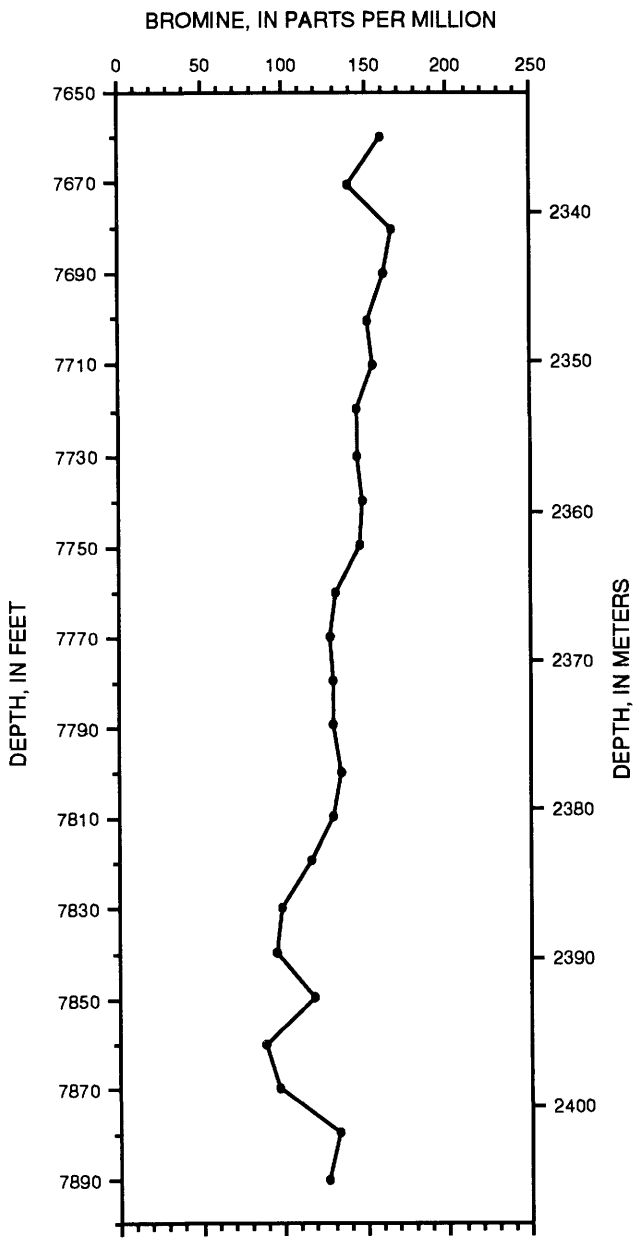


Figure 81. Bromine distribution in halite bed of cycle 18, Chevron Federal No. 1 well. The average bromine content in this profile, excluding the two higher values at the base, is 132.6 ppm.

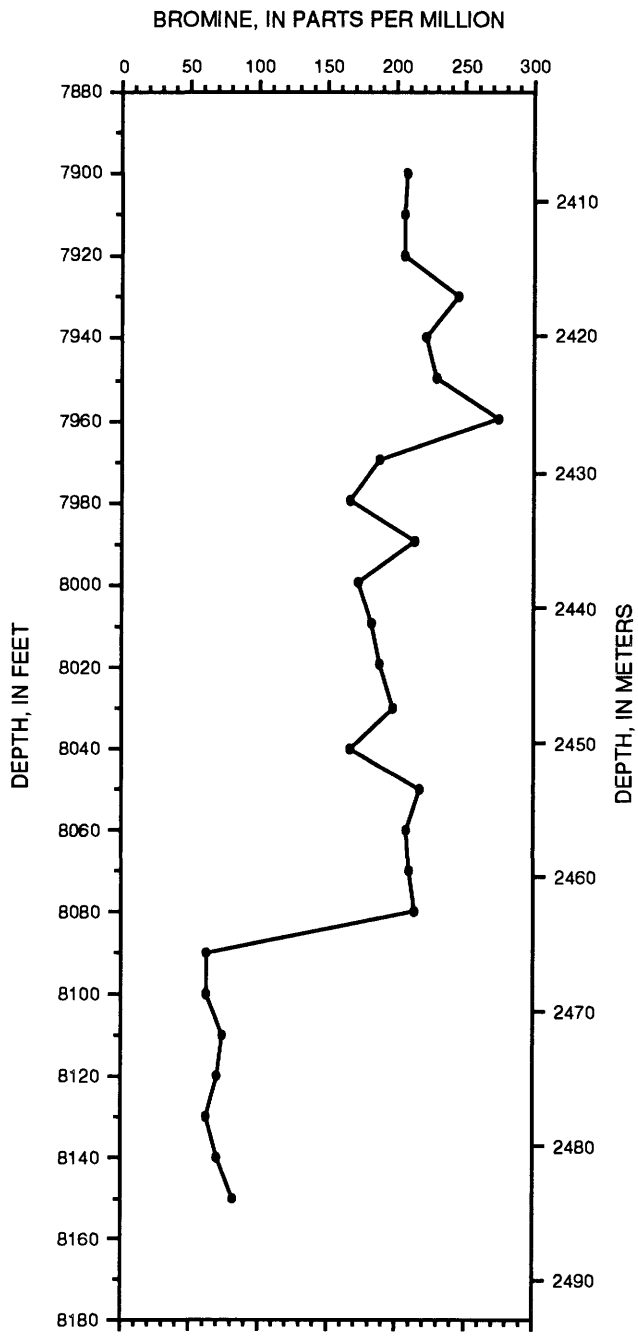


Figure 82. Bromine distribution in halite bed of cycle 19, Chevron Federal No. 1 well. The average bromine content in this profile is 169.0 ppm.

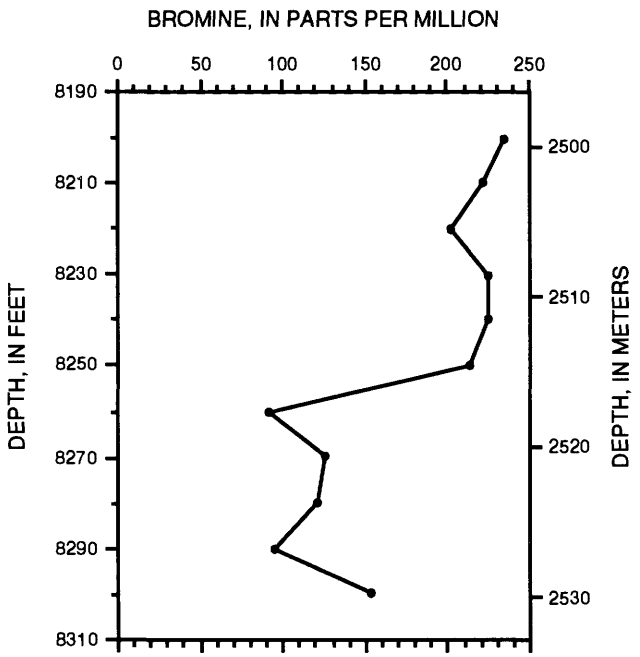


Figure 83. Bromine distribution in halite bed of cycle 20, Chevron Federal No. 1 well. The average bromine content in this profile, excluding the one higher value at the base, is 176.3 ppm.

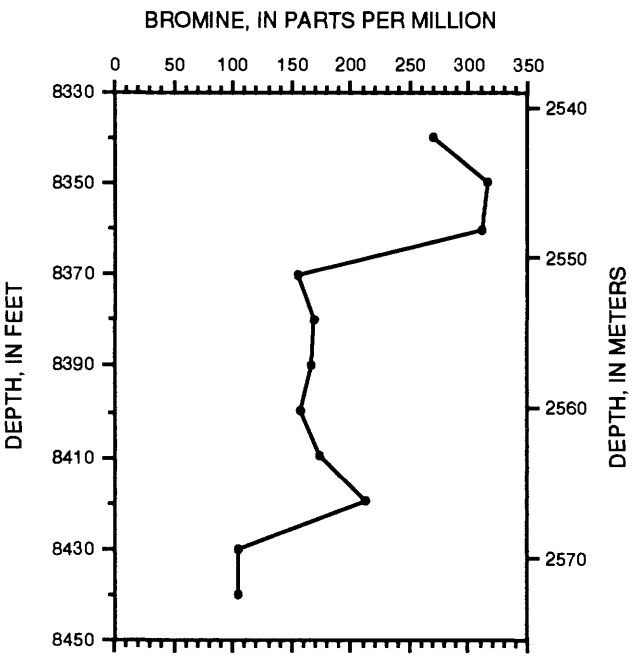


Figure 84. Bromine distribution in halite bed of cycle 21, Chevron Federal No. 1 well. The average bromine content in this profile is 195.0 ppm.

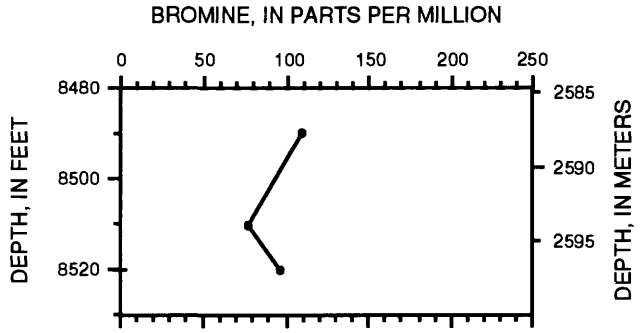


Figure 85. Bromine distribution in halite bed of cycle 23, Chevron Federal No. 1 well. The average bromine content in this profile is 95.7 ppm.

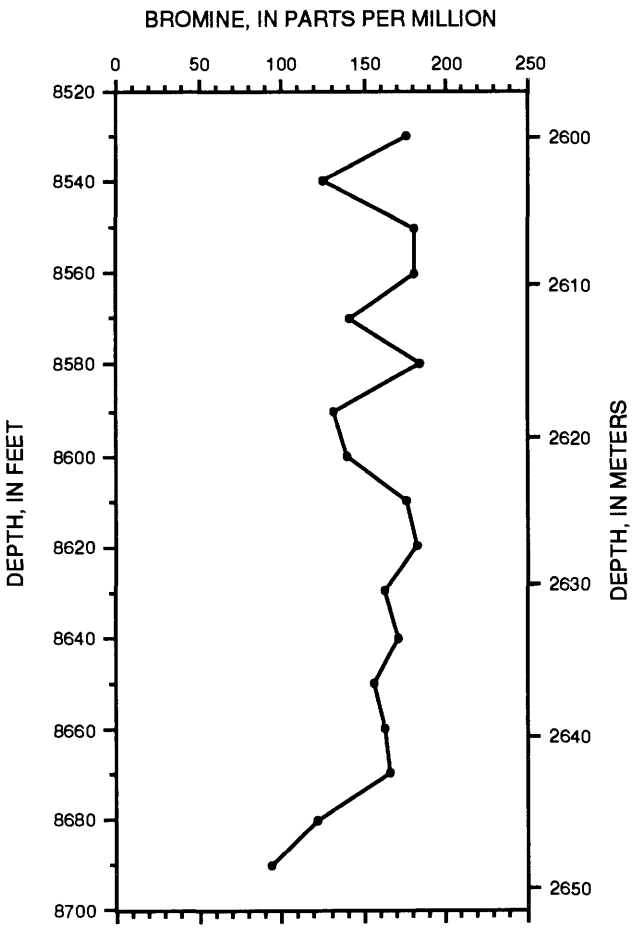


Figure 86. Bromine distribution in halite bed of cycle 24, Chevron Federal No. 1 well. The average bromine content in this profile is 156.6 ppm.

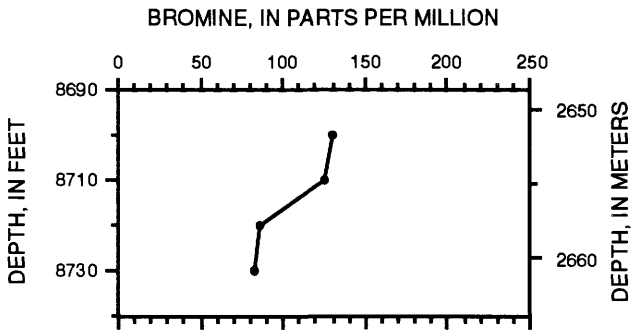


Figure 87. Bromine distribution in halite bed of cycle 25, Chevron Federal No. 1 well. The average bromine content in this profile is 106.5 ppm.

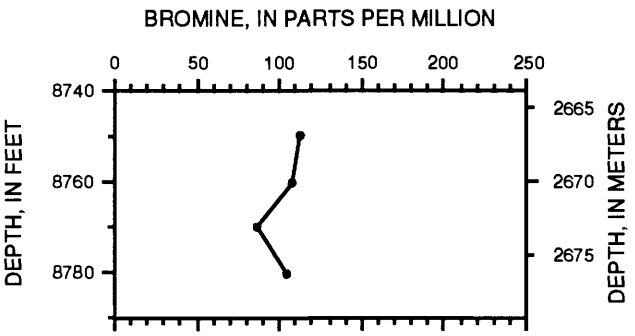


Figure 88. Bromine distribution in halite bed of cycle 26, Chevron Federal No. 1 well. The average bromine content in this profile is 102.5 ppm.

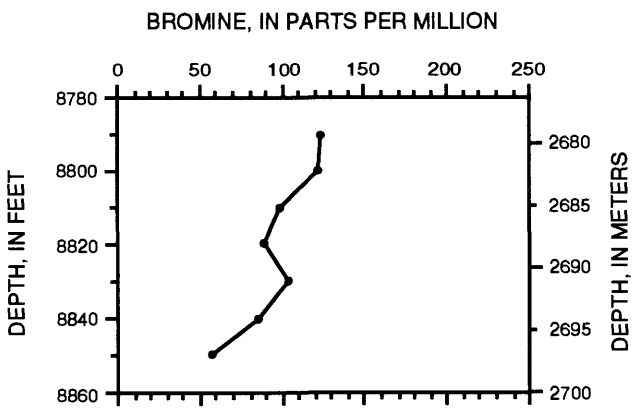


Figure 89. Bromine distribution in halite bed of cycle 27, Chevron Federal No. 1 well. The average bromine content in this profile is 97.1 ppm.

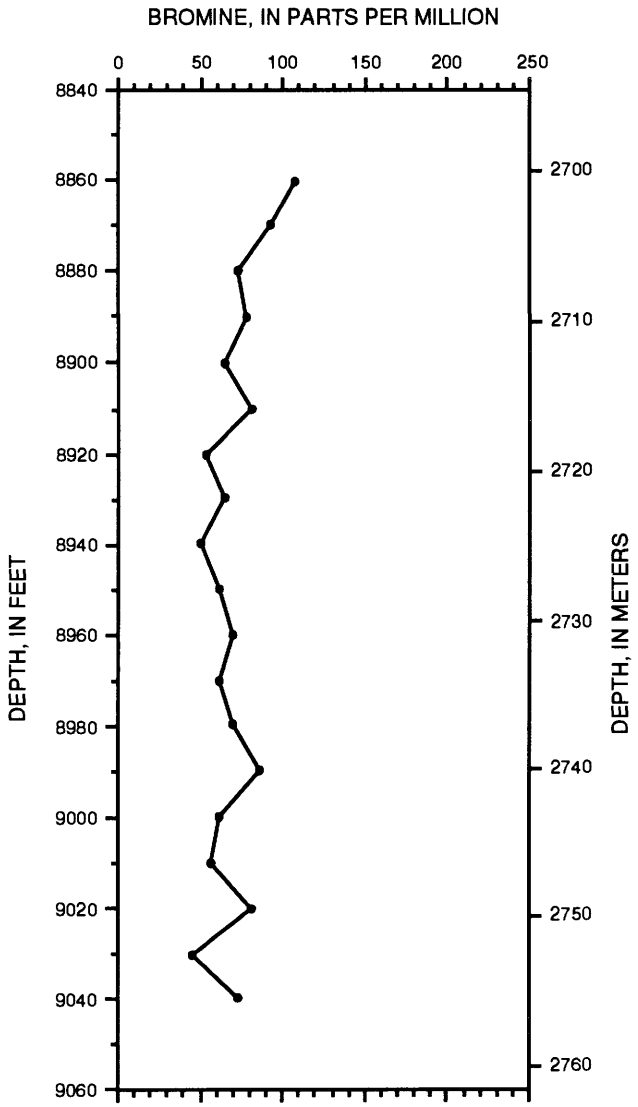


Figure 90. Bromine distribution in halite bed of cycle 28, Chevron Federal No. 1 well. The average bromine content in this profile is 70.7 ppm.

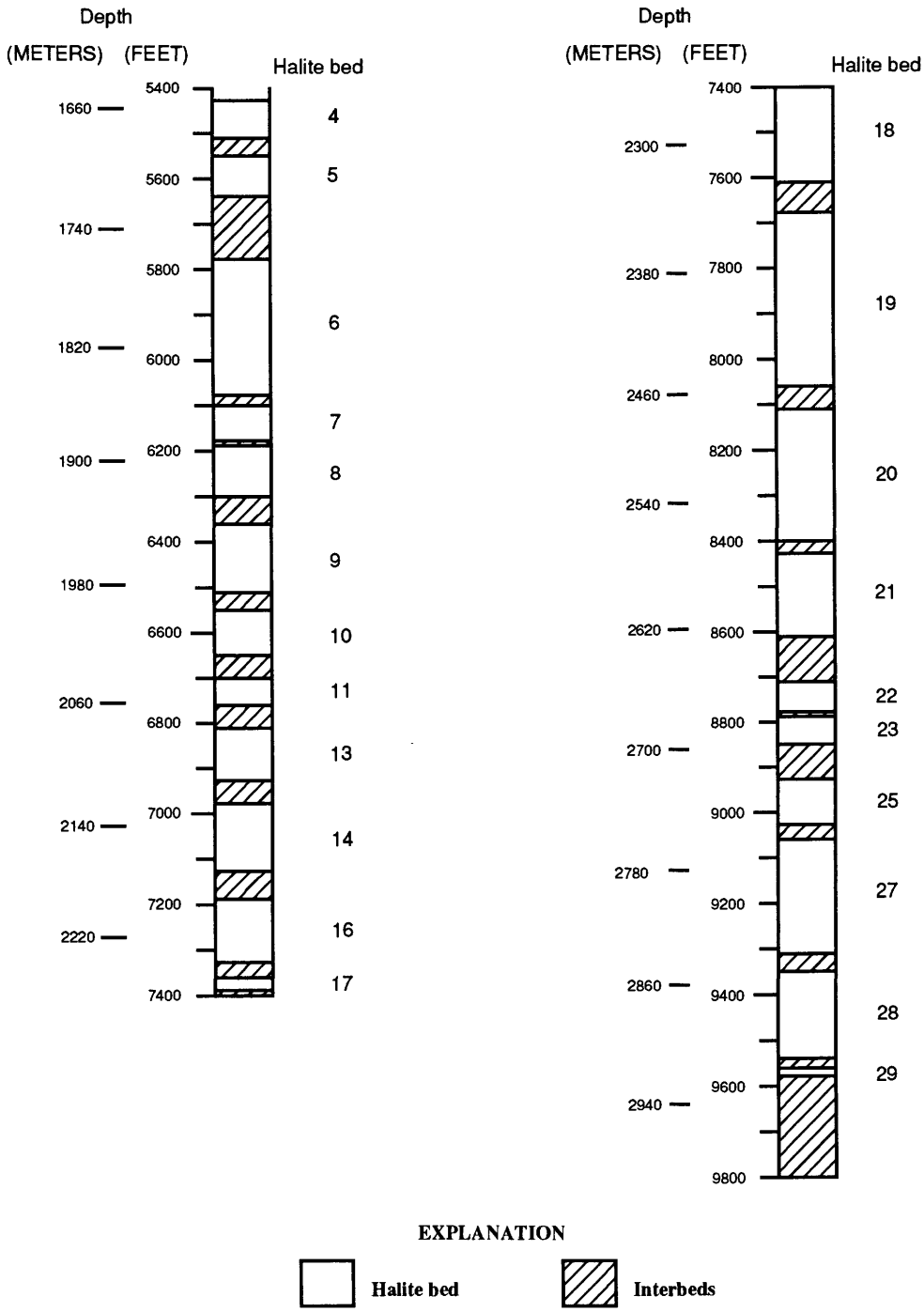


Figure 91. Generalized stratigraphic column of the Egnar No. 1 well. Scale 1 inch = 400 ft.

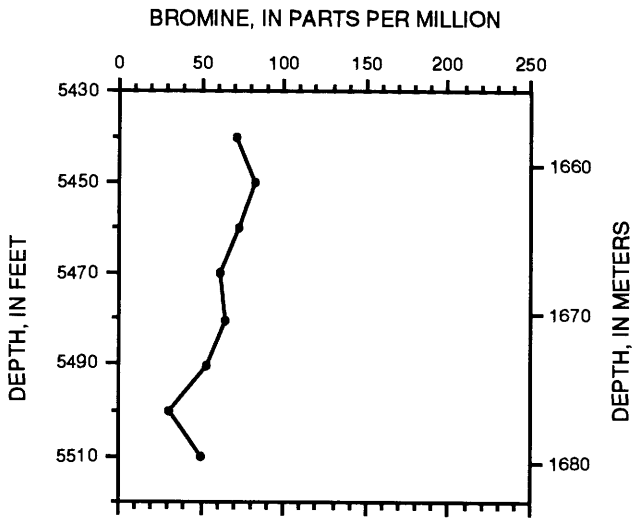


Figure 92. Bromine distribution in halite bed of cycle 4, Egnar No. 1 well. The average bromine content in this profile, excluding the single higher value at the base, is 62.6 ppm.

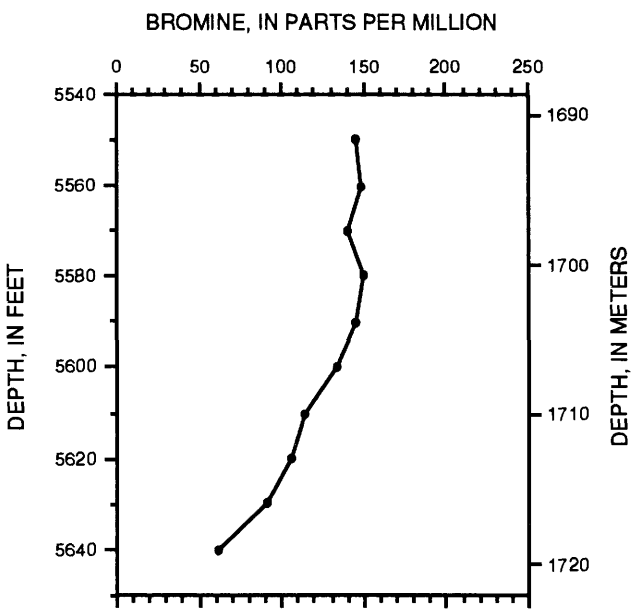


Figure 93. Bromine distribution in halite bed of cycle 5, Egnar No. 1 well. The average bromine content in this profile is 124.1 ppm.

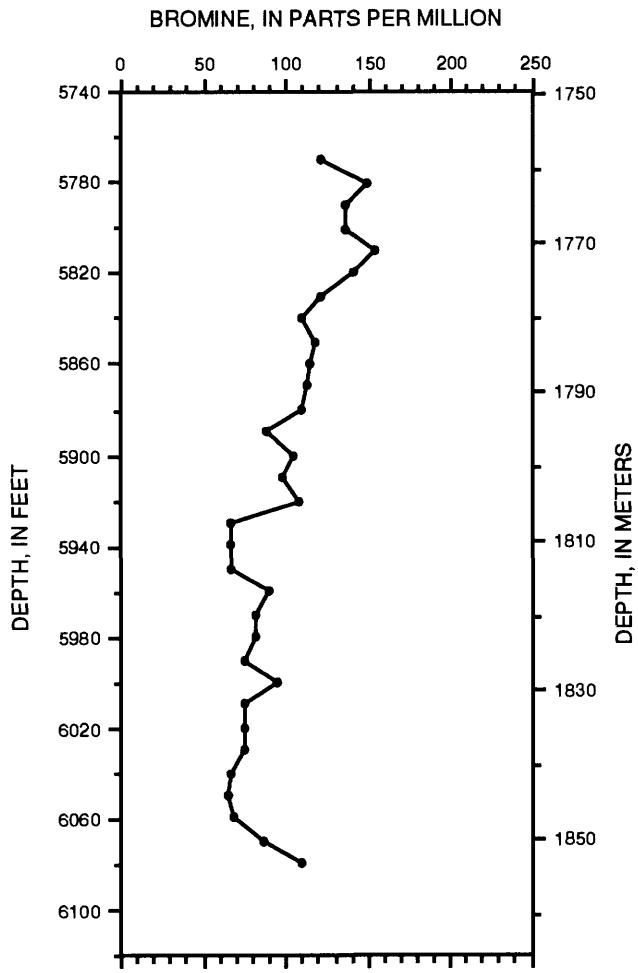


Figure 94. Bromine distribution in halite bed of cycle 6, Egnar No. 1 well. The average bromine content in this profile, excluding the two higher values at the base, is 99.6 ppm.

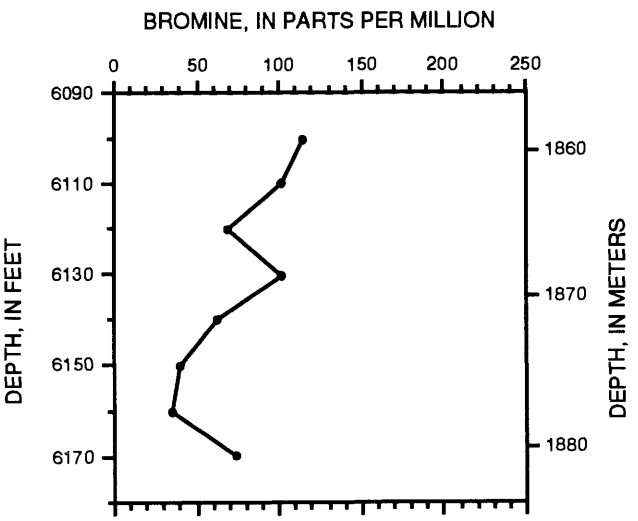


Figure 95. Bromine distribution in halite bed of cycle 7, Egnar No. 1 well. The average bromine content in this profile, excluding the single higher value at the base, is 75.7 ppm.

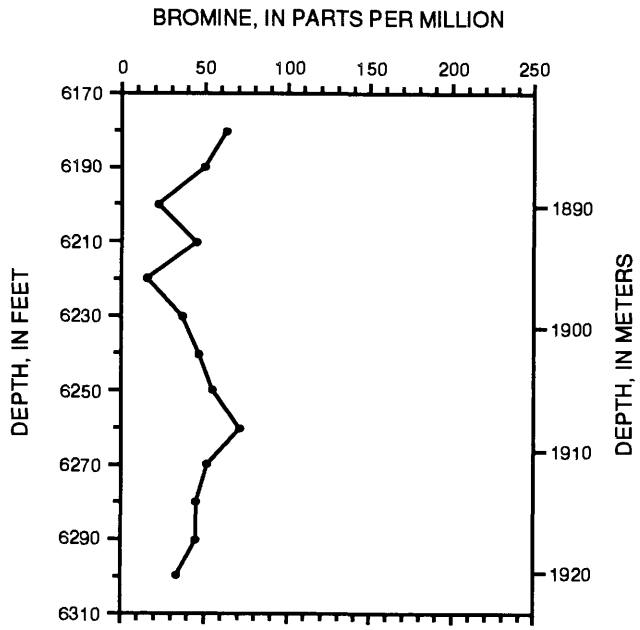


Figure 96. Bromine distribution in halite bed of cycle 8, Egnar No. 1 well. The average bromine content in this profile is 45.3 ppm.

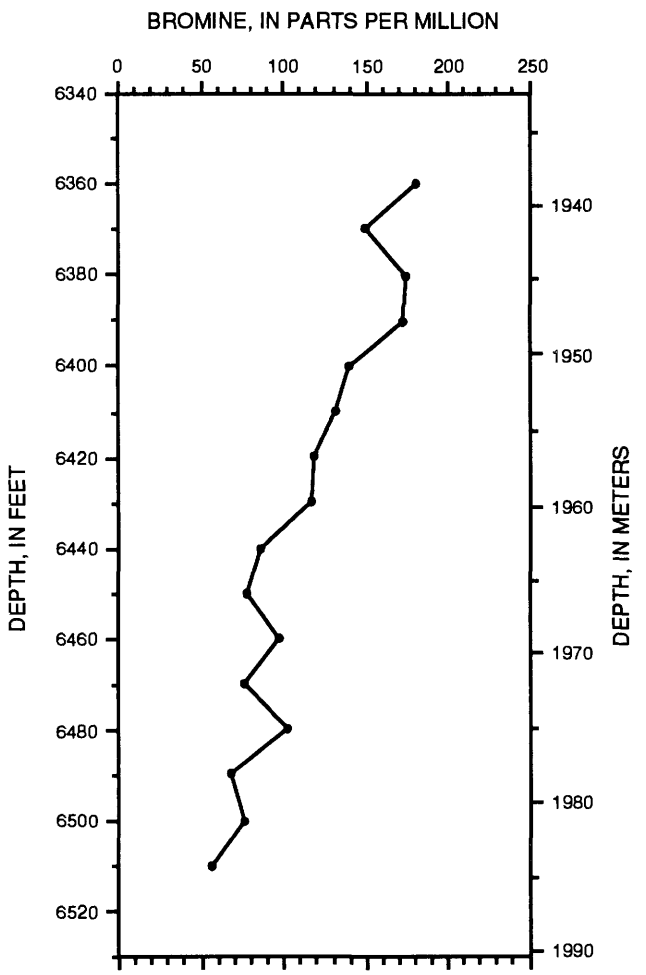


Figure 97. Bromine distribution in halite bed of cycle 9, Egnar No. 1 well. The average bromine content in this profile is 114.5ppm.

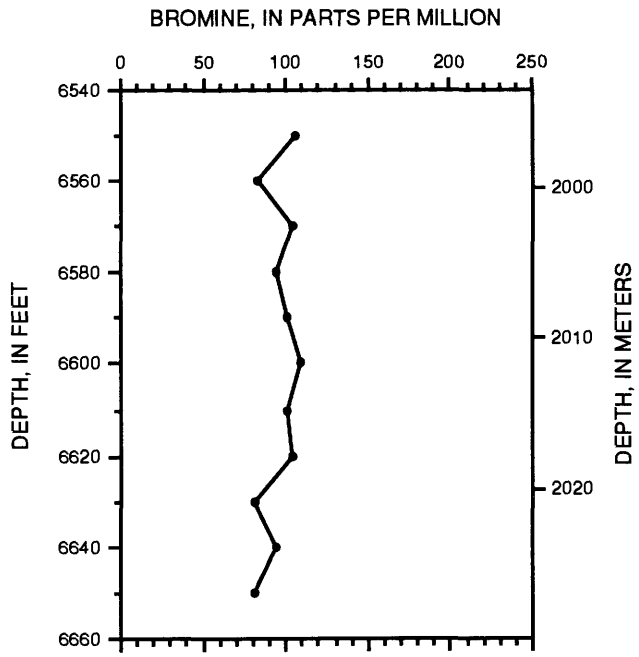


Figure 98. Bromine distribution in halite bed of cycle 10, Egnar No. 1 well. The average bromine content in this profile is 96.5 ppm.

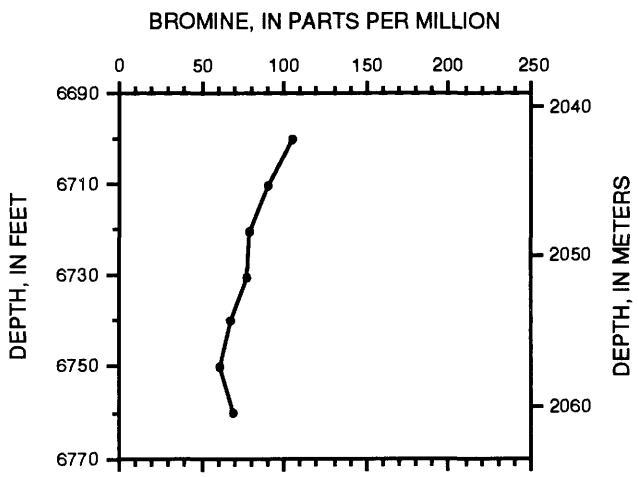


Figure 99. Bromine distribution in halite bed of cycle 11, Egnar No. 1 well. The average bromine content in this profile is 79.0 ppm.

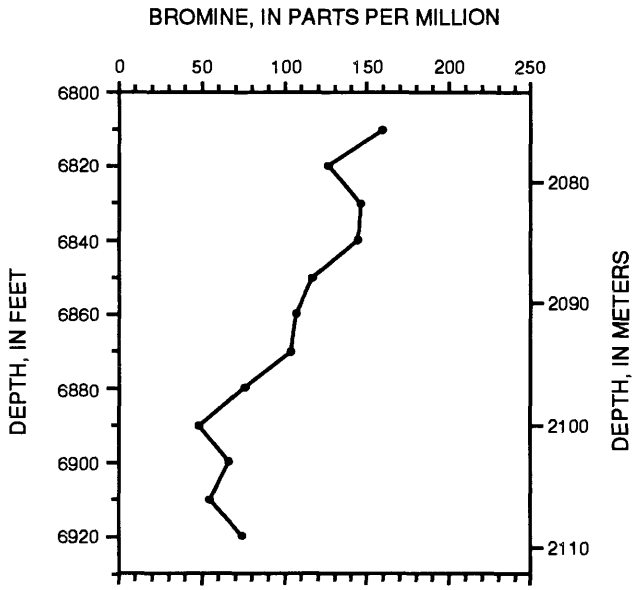


Figure 100. Bromine distribution in halite bed of cycle 13, Egnar No. 1 well. The average bromine content in this profile is 102.8 ppm.

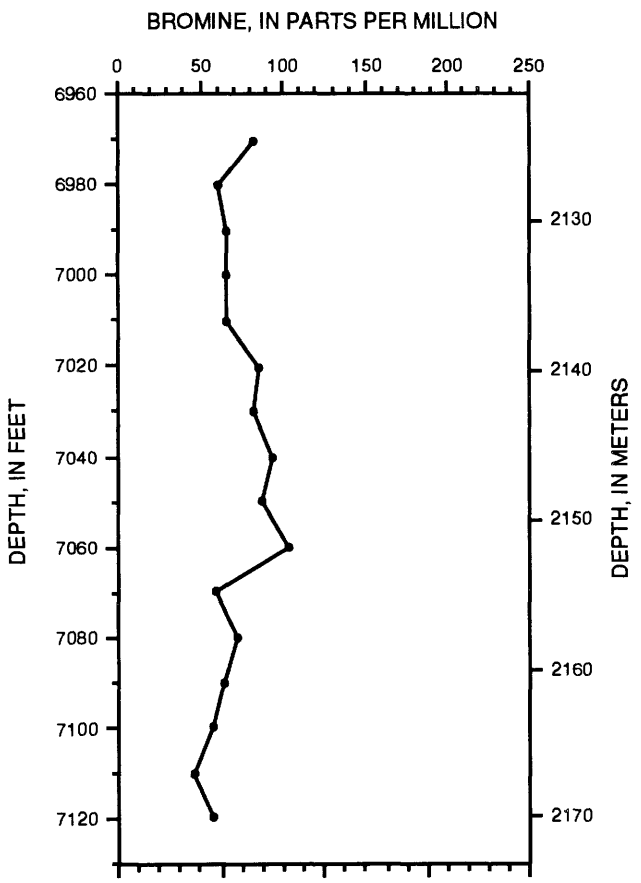


Figure 101. Bromine distribution in halite bed of cycle 14, Egnar No. 1 well. The average bromine content in this profile is 72.4 ppm.

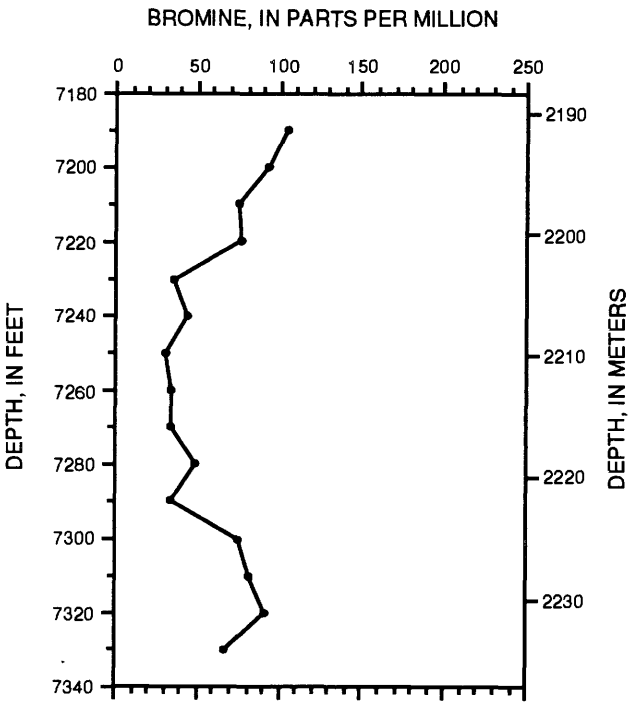


Figure 102. Bromine distribution in halite bed of cycle 16, Egnar No. 1 well. The average bromine content in this profile is 62.3 ppm.

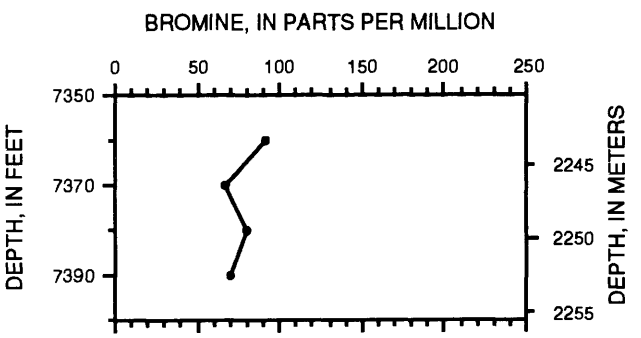


Figure 103. Bromine distribution in halite bed of cycle 17, Egnar No. 1 well. The average bromine content in this profile is 77.7 ppm.

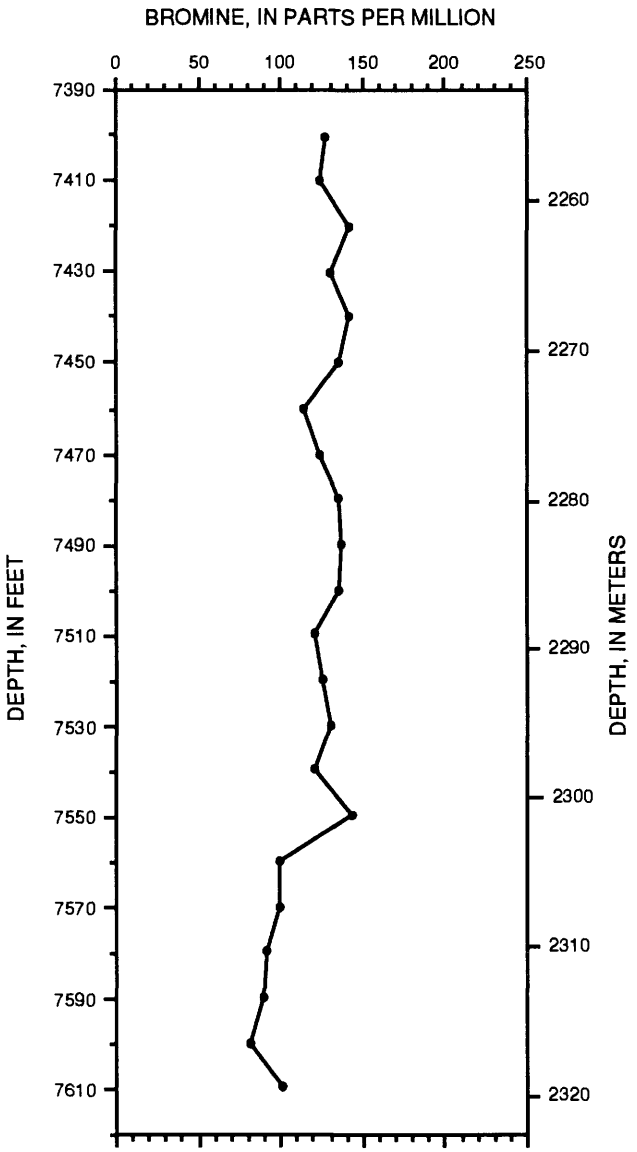


Figure 104. Bromine distribution in halite bed of cycle 18, Egnar No. 1 well. The average bromine content in this profile, excluding the single higher value at the base, is 121.6 ppm.

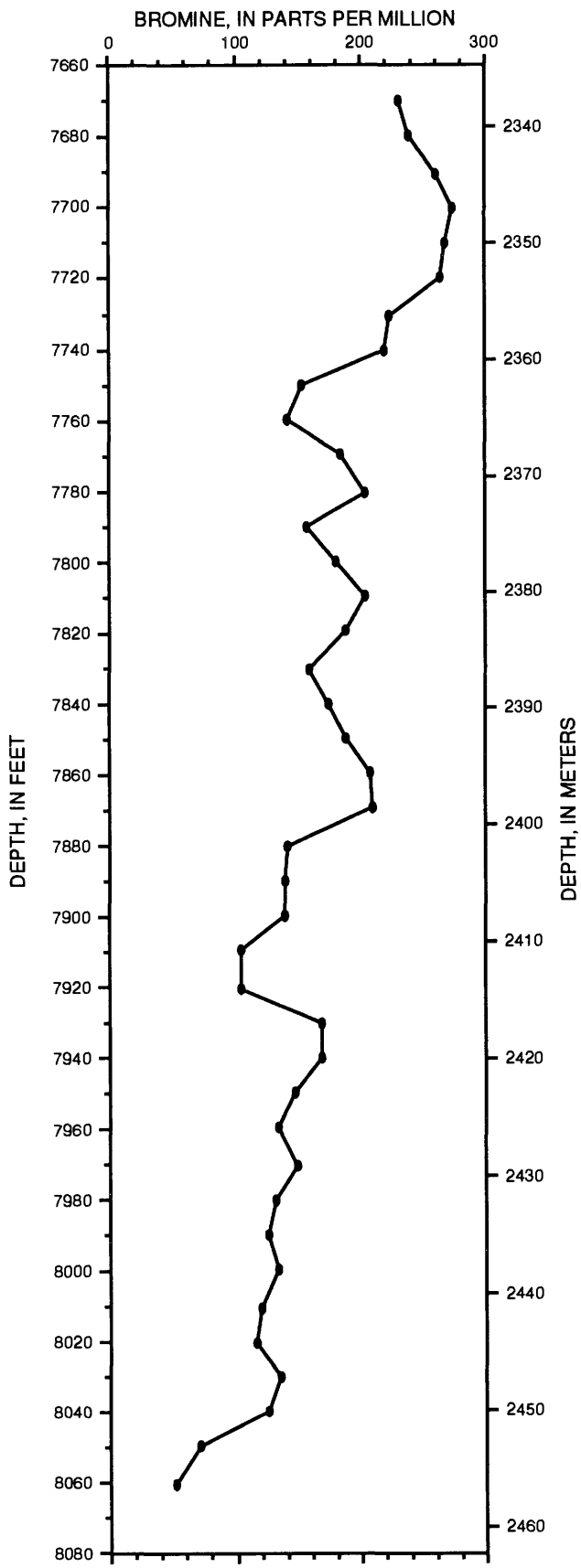


Figure 105 (right column). Bromine distribution in halite bed of cycle 19, Egnar No. 1 well. The average bromine content in this profile is 169.2 ppm.

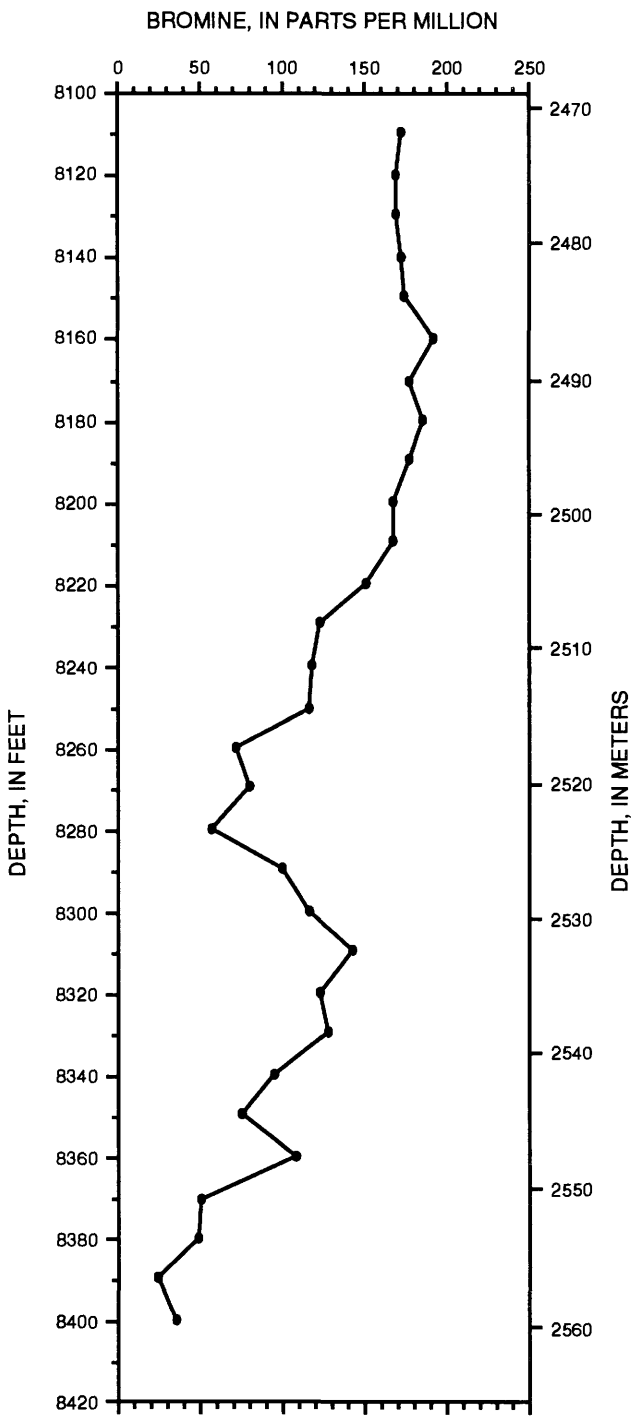


Figure 106. Bromine distribution in halite bed of cycle 20, Egnar No. 1 well. The average bromine content in this profile is 123.4 ppm.

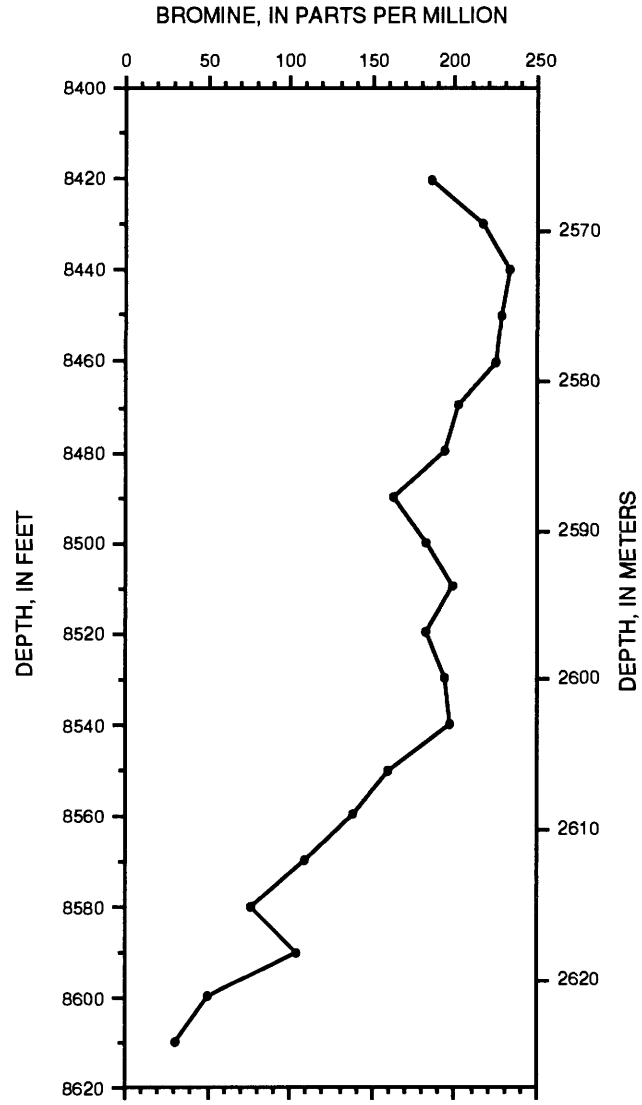


Figure 107. Bromine distribution in halite bed of cycle 21, Egnar No. 1 well. The average bromine content in this profile is 164.0 ppm.

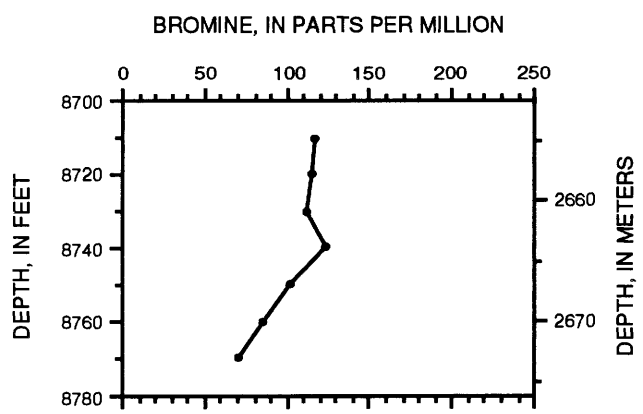


Figure 108. Bromine distribution in halite bed of cycle 22, Egnar No. 1 well. The average bromine content in this profile is 103.7 ppm.

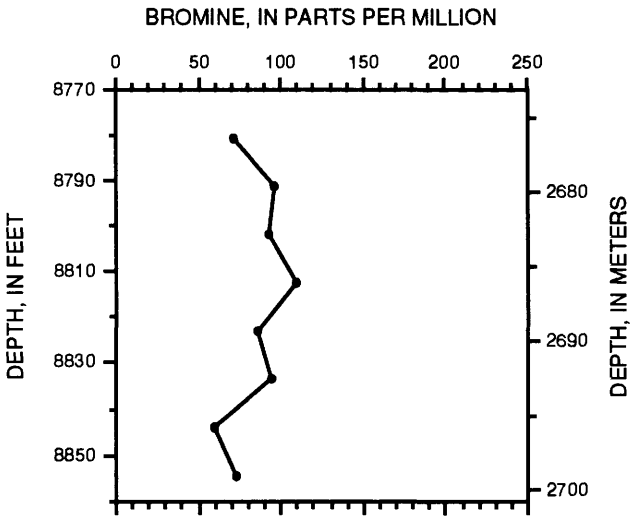


Figure 109. Bromine distribution in halite bed of cycle 23, Egnar No. 1 well. The average bromine content in this profile is 85.1 ppm.

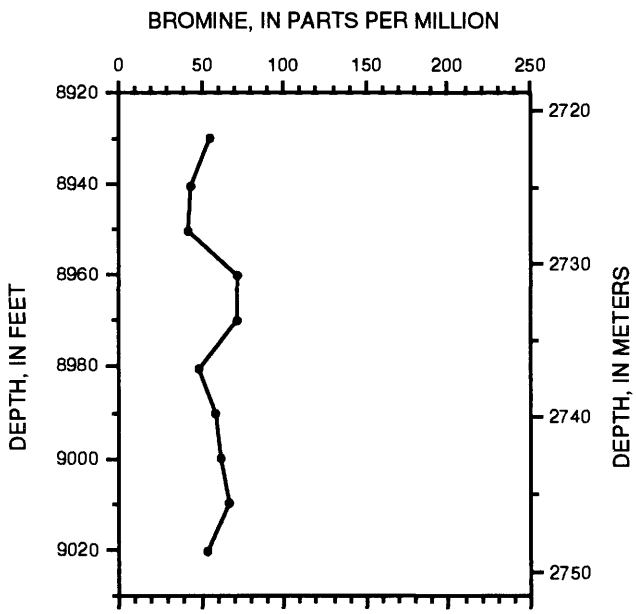


Figure 110. Bromine distribution in halite bed of cycle 25, Egnar No. 1 well. The average bromine content in this profile is 57.9 ppm.

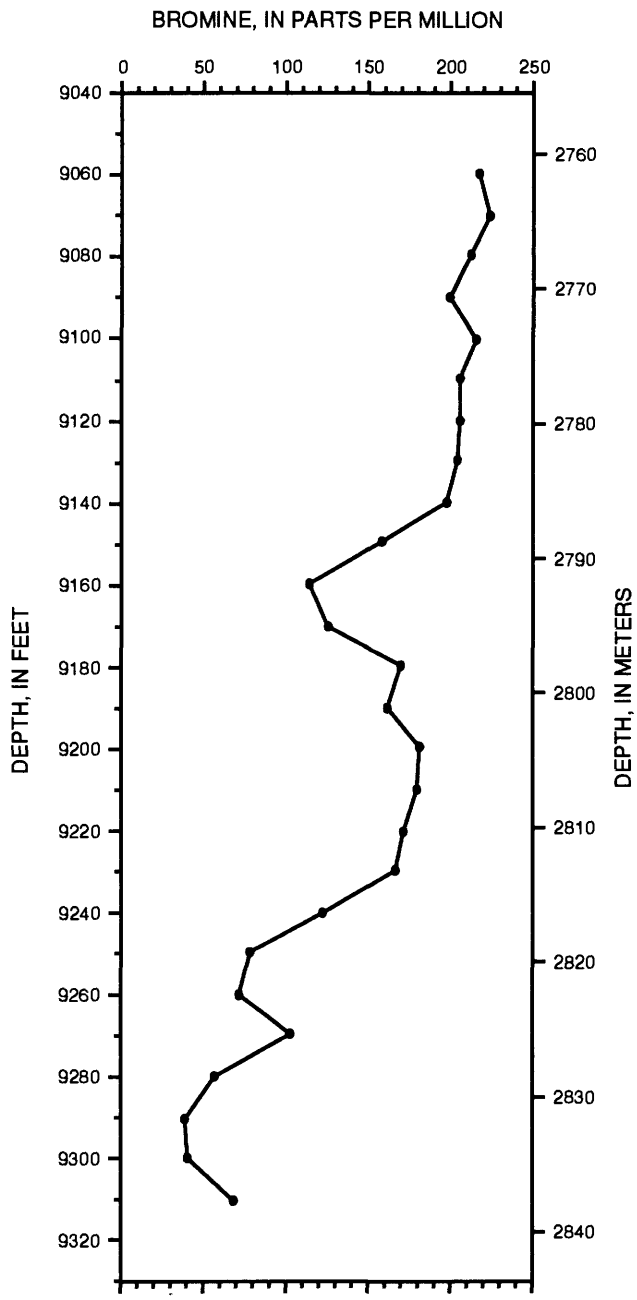


Figure 111. Bromine distribution in halite bed of cycle 27, Egnar No. 1 well. The average bromine content in this profile is 149.8 ppm.

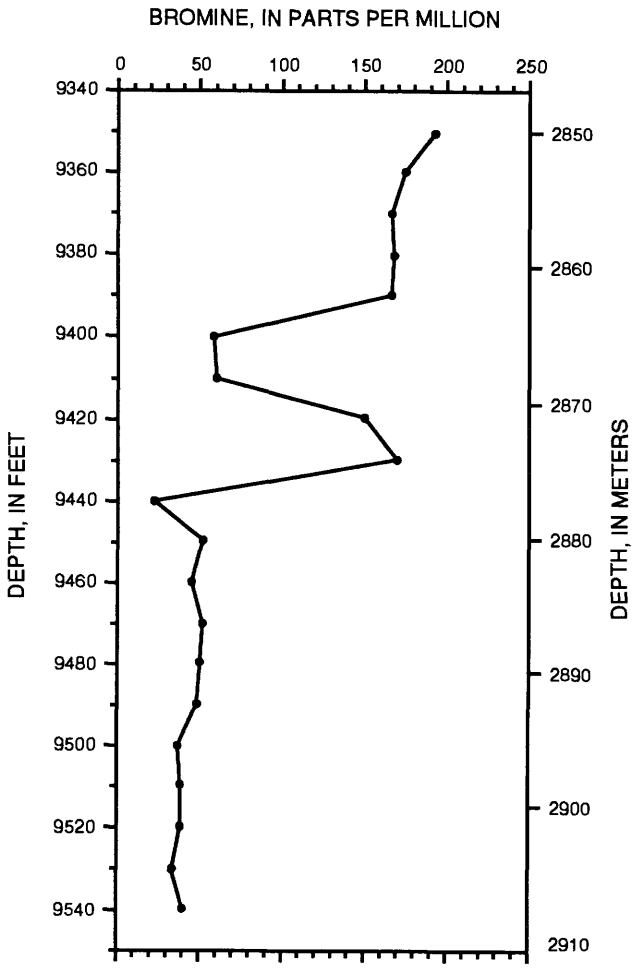


Figure 112. Bromine distribution in halite bed of cycle 28, Egnar No. 1 well. The average bromine content in this profile is 88.8 ppm.

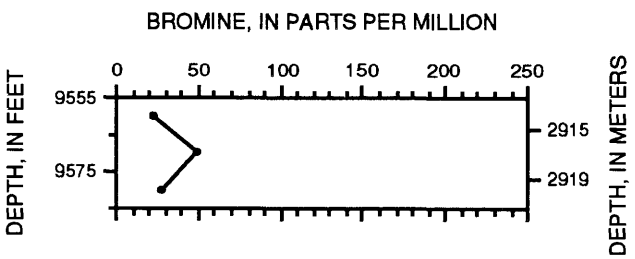


Figure 113. Bromine distribution in halite bed of cycle 29, Egnar No. 1 well. The average bromine content in this profile is 33.7ppm.

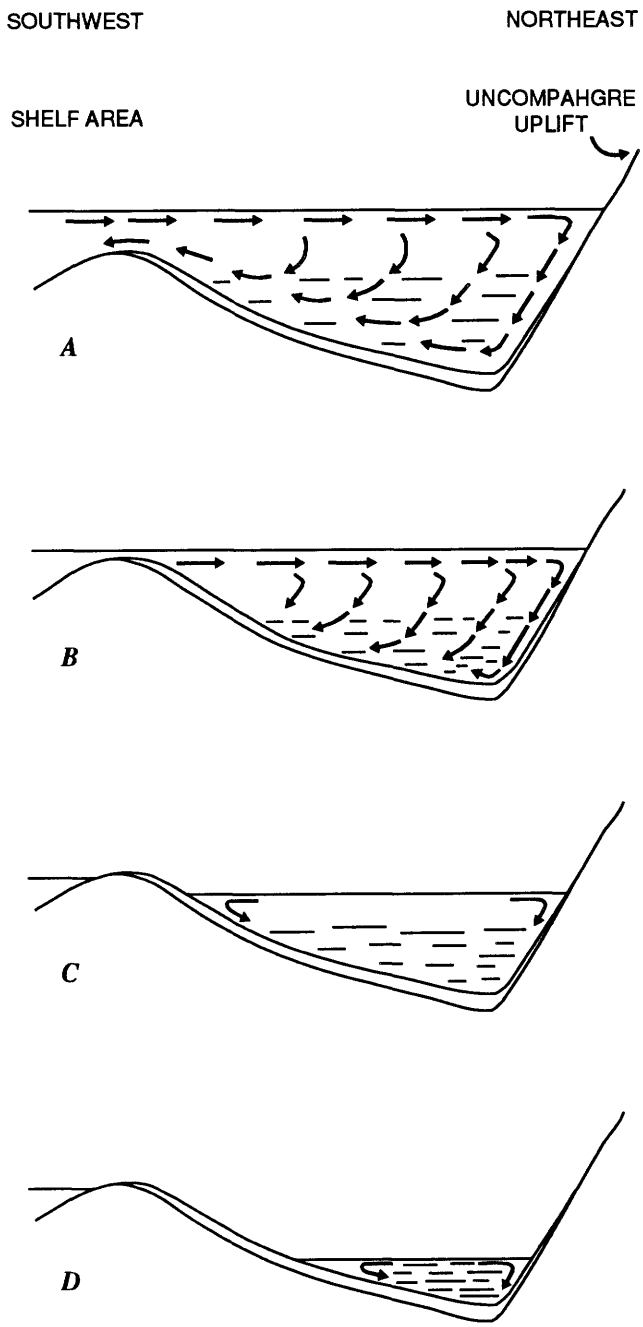


Figure 114. Schematic southwest to northeast cross section of the Paradox Basin illustrating various stages of sea level and evaporative drawdown. See text for discussion, p. M10.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
5	2		X	
6	3		X	
7	4		X	
8	5			X

Figure 115. Range of minimum bromine values, lower part of profile, Cane Creek No. 1 core samples.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
11	3		X	
12	4		X	
13	5		X	
14	6		X	
15	7		X	
16	8		X	
17	9		X	
18	10		X	
19	11		X	
20	13		X	

Figure 116. Range of minimum bromine values, lower part of profile, Shafer No. 1 core samples.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
22	1	X		
23	3			X
24	4			X

Figure 117. Range of minimum bromine values, lower part of profile, Utah No. 2 core samples.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
26	6		X	
27	7		X	
28	9		X	
29	13		X	
30	16		X	

Figure 118. Range of minimum bromine values, lower part of profile, Elk Ridge No. 1 core samples.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
32	4		X	
34	6		X	
35	7		X	
36	8		X	
37	9		X	
38	10		X	
39	13		X	
40	14		X	
41	15			X
42	16		X	
43	17			X
44	18	X		
45	19		X	
46	20		X	
47	21	X		
48	24	X		
49	25	X		
50	26		X	

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
52	6	X		
53	7		X	
54	8		X	
55	9		X	
56	10		X	
57	13		X	
58	14	X		
59	16	X		
60	18		X	
61	19			X
62	20			X
63	21			X
64	24			X
65	25			X
66	26	X		
67	27			X

Figure 120. Range of minimum bromine values, lower part of profile, Lone Dome No. 1 cuttings.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
69	4		X	
70	5			X
71	6			X
72	7			X
73	8			X
74	9			X
75	10			X
76	13			X
77	14	X		
78	15		X	
79	16		X	
80	17		X	
81	18		X	
82	19		X	
83	20			X
84	21			X
85	23		X	
86	24			X
87	25		X	
88	26			X
89	27		X	
90	28		X	

Figure 121. Range of minimum bromine values, lower part of profile, Chevron Federal No. 1 cuttings.

Figure 119 (left column). Range of minimum bromine values, lower part of profile, Gibson Dome No. 1 core samples.

Figure no.	Halite bed	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm
92	4	X		
93	5		X	
94	6		X	
95	7	X		
96	8	X		
97	9		X	
98	10		X	
99	11		X	
100	13		X	
101	14		X	
102	16	X		
103	17		X	
104	18		X	
105	19		X	
106	20	X		
107	21	X		
108	22		X	
109	23		X	
110	25	X		
111	27	X		
112	28	X		
113	29	X		

Figure 122. Range of minimum bromine values, lower part of profile Egnar No. 1 cuttings.

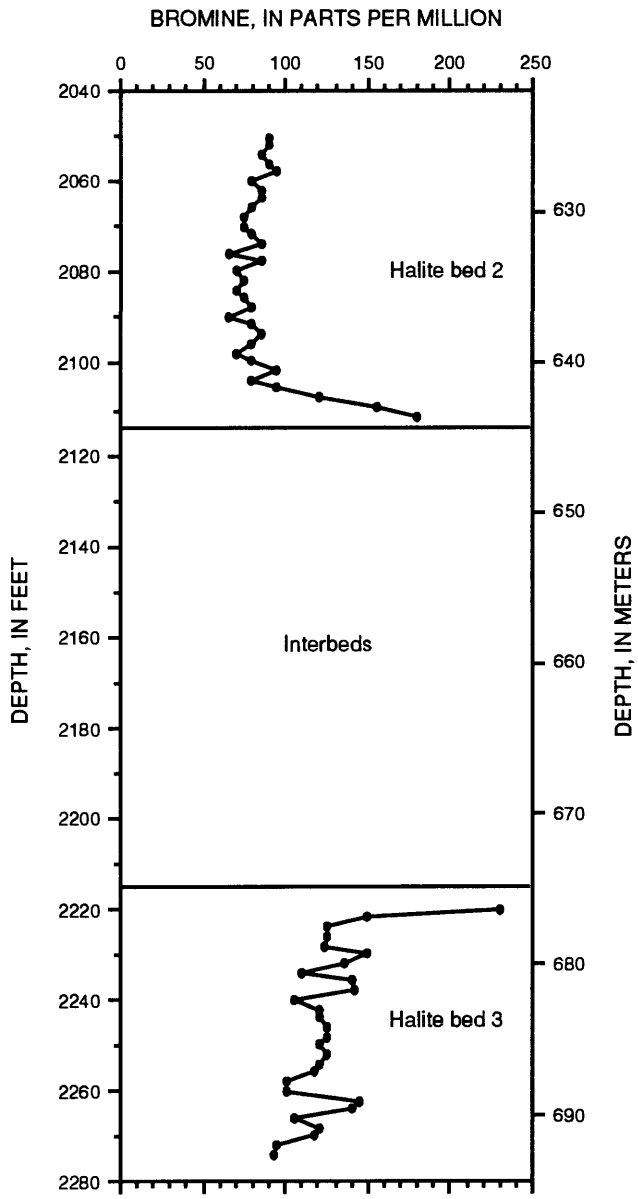


Figure 124. Base of bromine profile of halite bed 2 (fig. 5) and top of profile of halite bed 3 (fig. 6) and relationship to the interbeds between them, Cane Creek No. 1 core.

Figure no.	Well	Less than 50 ppm	50 - 100 ppm	Greater than 100 ppm	Total
115	Cane Creek	-	3	1	4
116	Shafer	-	10	-	10
117	Utah	1	-	2	3
118	Elk Ridge	-	5	-	5
119	Gibson dome	4	12	2	18
120	Lone Dome	4	6	6	16
121	Chevron Fed.	1	10	11	22
122	Egnar	10	12	-	22
Total		20	58	22	100

Figure 123. Number of bromine profiles and ranges of minimum bromine values, lower parts of profiles in each of the wells studied in the Paradox Basin.

Halite bed	Average bromine values (parts per million)	
	Elk Ridge No. 1	Gibson Dome No. 1
4	-	57.8
5	-	84.8
6	67.4	181.4
7	92.4	105.0
8	-	95.9
9	81.5	115.3
10	-	111.2
11	-	-
12	-	-
13	79.6	199.6
14	-	102.9
15	-	161.4
16	117.9	138.4
17	-	209.3
18	-	189.9
19	-	155.6
20	-	78.5
21	-	126.3
22	-	-
23	-	-
24	-	132.6
25	-	69.6
26	-	85.2
27	-	-
28	-	-
29	-	-

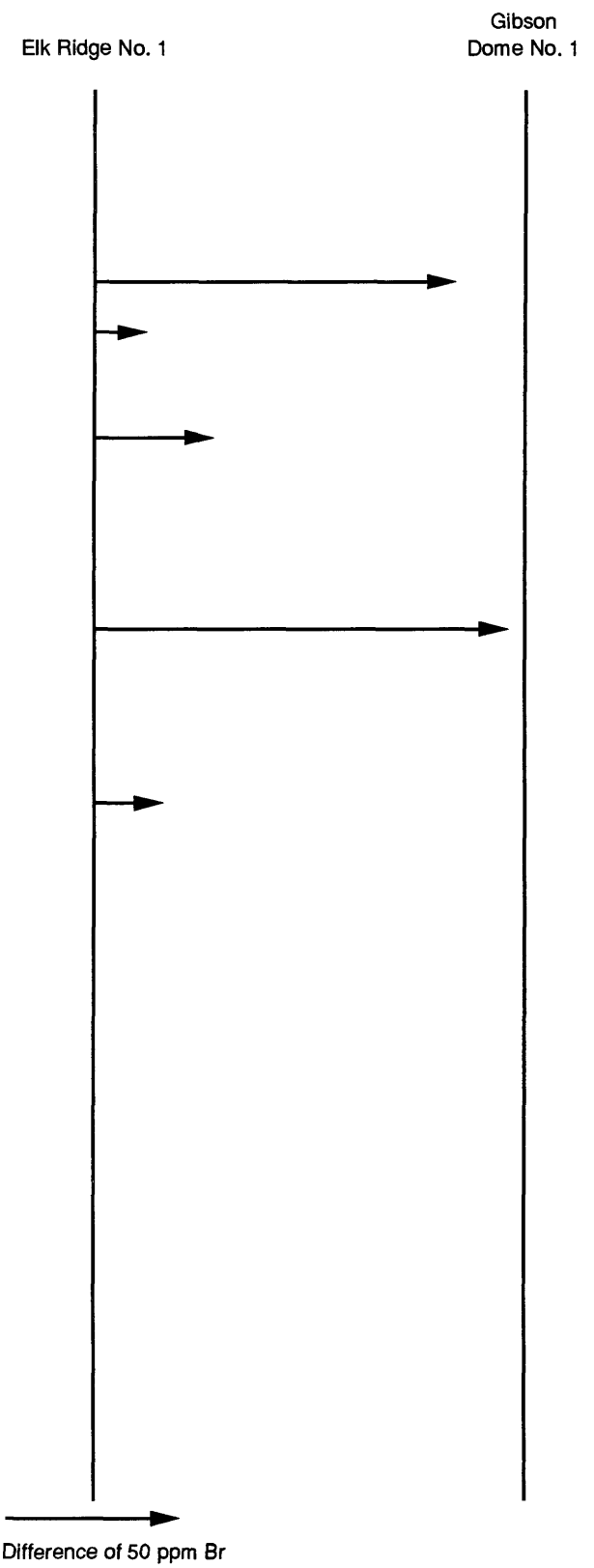


Figure 125. Tabulation of halite beds and average bromine values in the Elk Ridge and Gibson Dome cores and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two coreholes. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

Halite bed	Average bromine values (parts per million) Gibson Dome No. 1	Shafer No. 1
4	57.8	87.5
5	84.8	147.3
6	181.4	135.8
7	105.0	122.2
8	95.9	99.7
9	115.3	103.3
10	111.2	98.3
11	-	95.0
12	-	-
13	199.6	191.2
14	102.9	-
15	161.4	-
16	138.4	-
17	209.3	-
18	189.9	
19	155.6	
20	78.5	
21	126.3	
22	-	
23	-	
24	132.6	
25	69.6	
26	85.2	
27	-	
28	-	
29	-	

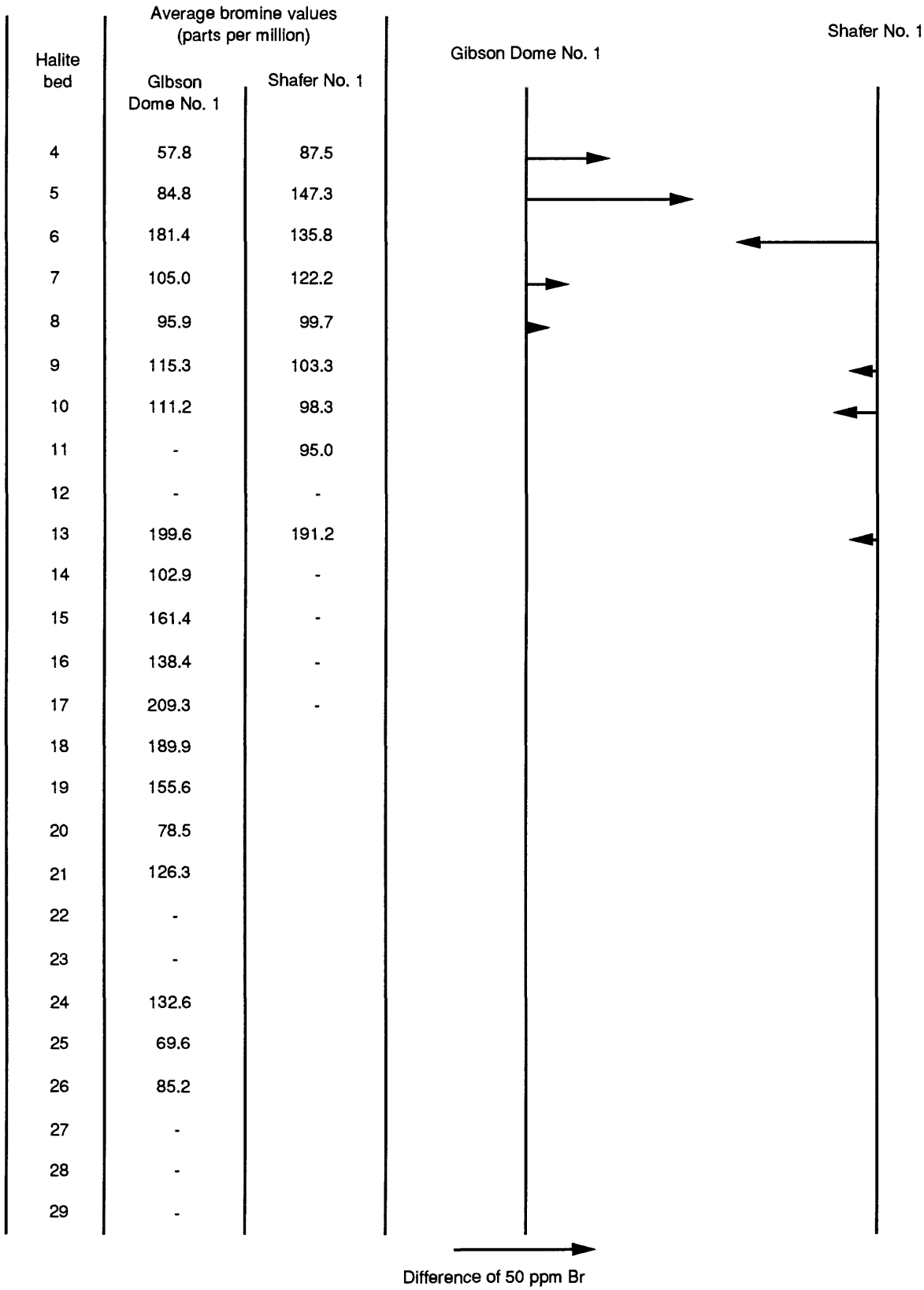


Figure 126. Tabulation of halite beds and average bromine values in the Gibson Dome and Shafer cores and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two coreholes. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

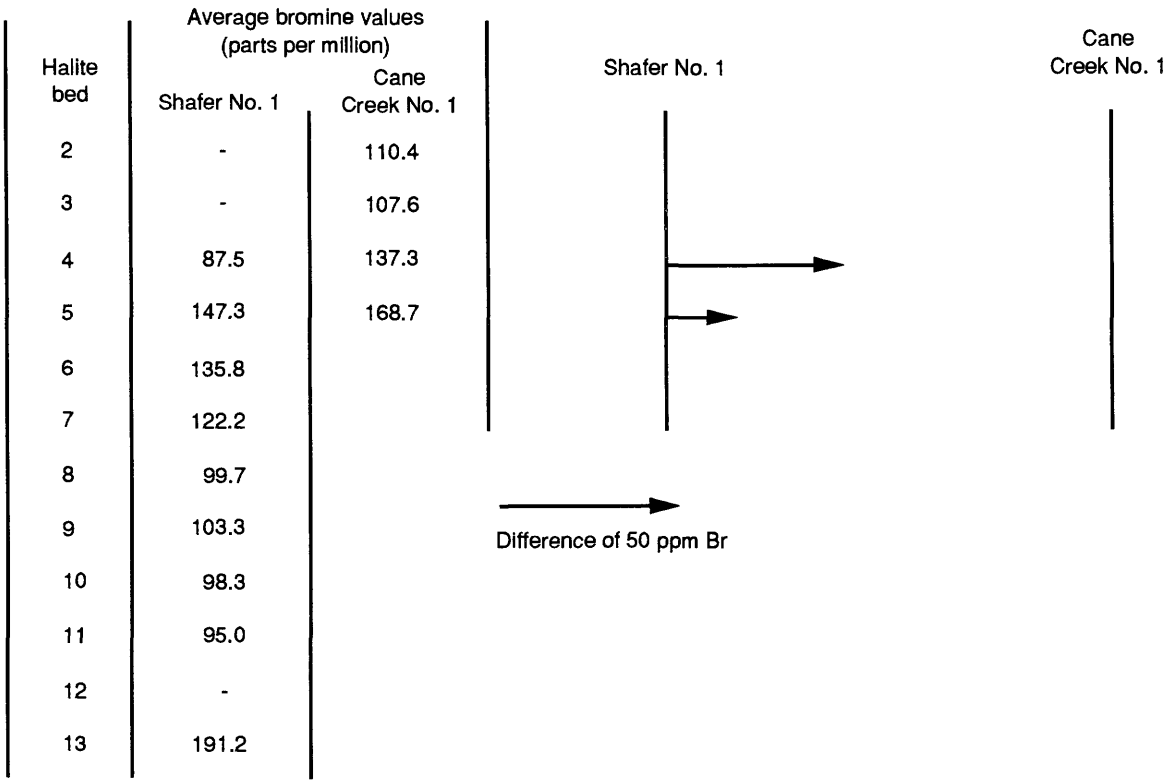


Figure 127. Tabulation of halite beds and average bromine values in the Shafer and Cane Creek cores and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two coreholes. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

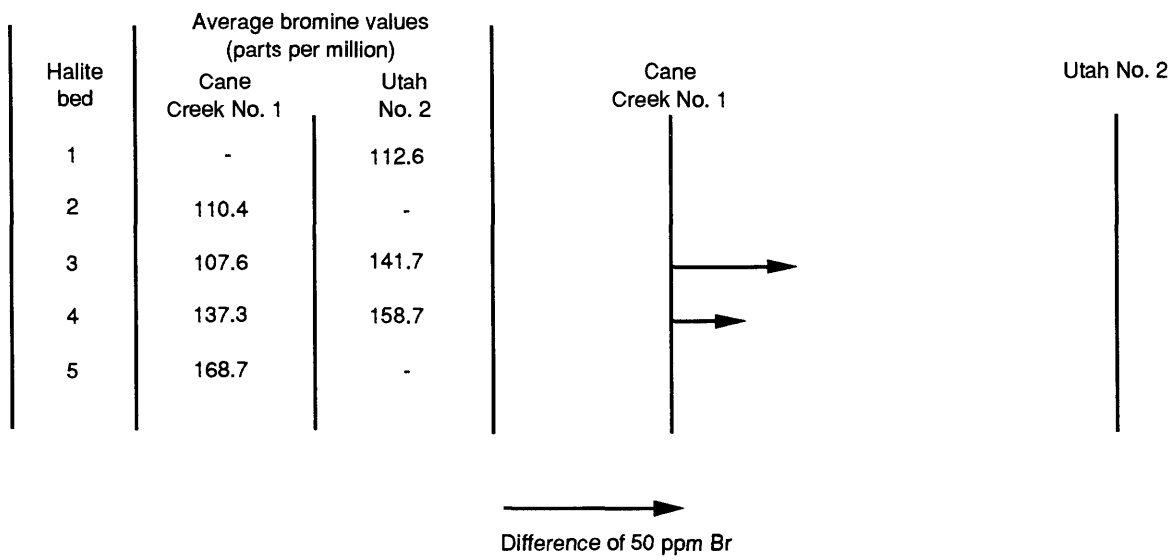


Figure 128. Tabulation of halite beds and average bromine values in the Cane Creek and Utah cores and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two coreholes. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

Halite bed	Average bromine values (parts per million) Lone Dome No. 1	Egnar No. 1
4	-	62.6
5	-	124.1
6	64.3	99.6
7	79.5	75.7
8	85.3	45.3
9	105.4	114.5
10	95.2	96.5
11	-	79.0
12	-	-
13	101.3	102.8
14	60.6	72.4
15	-	-
16	75.0	62.3
17	-	77.7
18	105.9	121.6
19	202.2	169.2
20	145.9	123.4
21	159.8	164.0
22	-	103.7
23	-	85.1
24	137.2	-
25	98.2	57.9
26	64.3	-
27	150.7	149.8
28	-	88.8
29	-	33.7

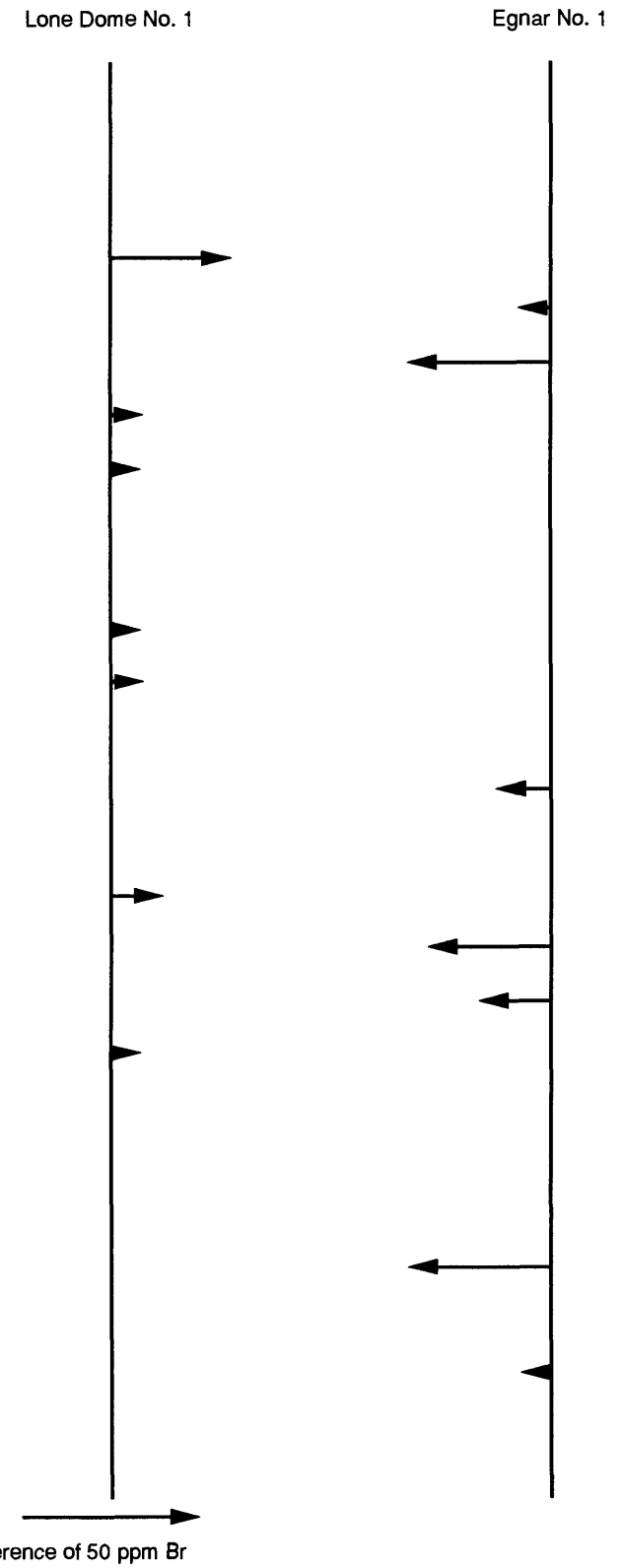


Figure 129. Tabulation of halite beds and average bromine values from cuttings in the Lone Dome and Egnar wells and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two wells. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

Halite bed	Average bromine values (parts per million)	
	Egnar No. 1	Chevron Federal No. 1
4	62.6	70.9
5	124.1	138.7
6	99.6	172.9
7	75.7	182.2
8	45.3	121.5
9	114.5	170.8
10	96.5	156.1
11	79.0	-
12	-	-
13	102.8	190.6
14	72.4	87.7
15	-	98.8
16	62.3	80.5
17	77.7	76.5
18	121.6	132.6
19	169.2	169.0
20	123.4	176.3
21	164.0	195.0
22	103.7	-
23	85.1	95.7
24	-	156.6
25	57.9	106.5
26	-	102.5
27	149.8	97.1
28	88.8	70.7
29	33.7	-

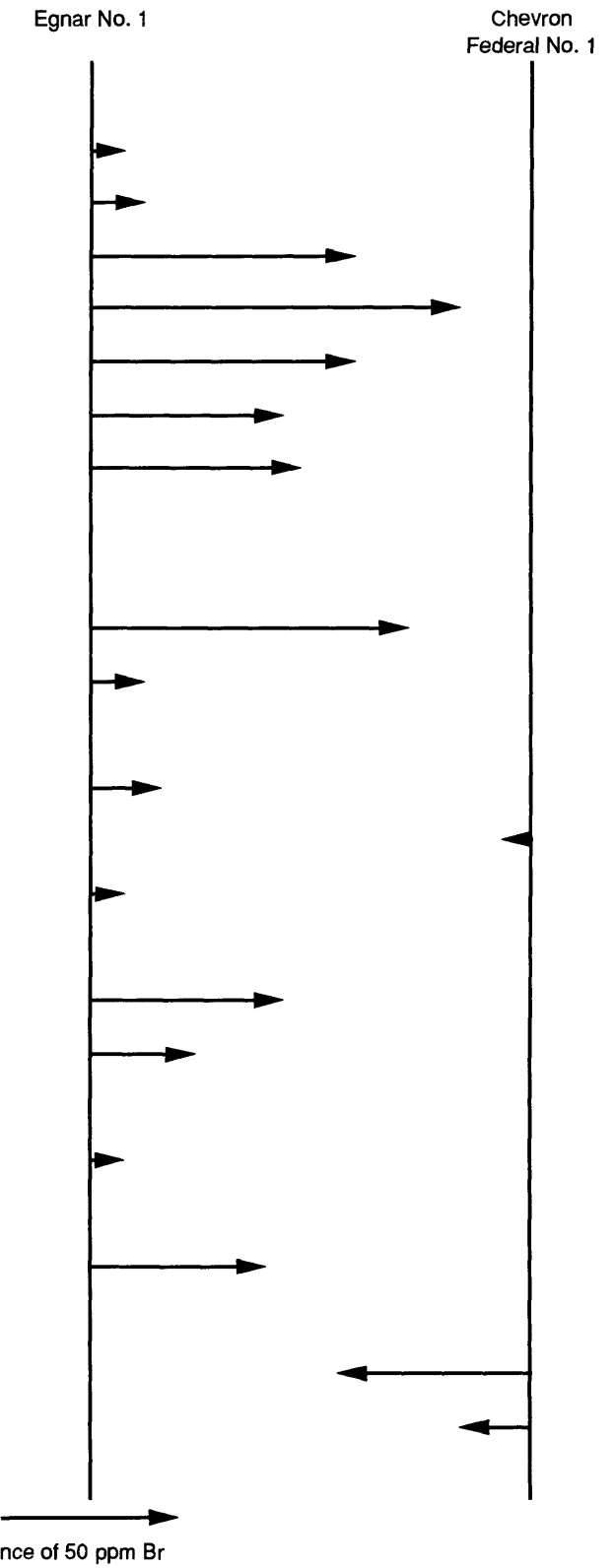


Figure 130. Tabulation of halite beds and average bromine values from cuttings in the Egnar and Chevron Federal wells and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two wells. Arrows indicate direction of bromine increase; length of arrow is proportional to amount of increase.

Halite bed	Average bromine values (parts per million) Gibson Dome No. 1	Chevron Federal No. 1
4	57.8	70.9
5	84.8	138.7
6	181.4	172.9
7	105.0	182.2
8	95.9	121.5
9	115.3	170.8
10	111.2	156.1
11	-	-
12	-	-
13	199.6	190.6
14	102.9	87.7
15	161.1	98.8
16	138.4	80.5
17	209.3	76.5
18	189.9	132.6
19	155.6	169.0
20	78.5	176.3
21	126.3	195.0
22	-	-
23	-	95.7
24	132.6	156.6
25	69.6	106.5
26	85.2	102.5
27	-	97.1
28	-	70.7
29	-	-

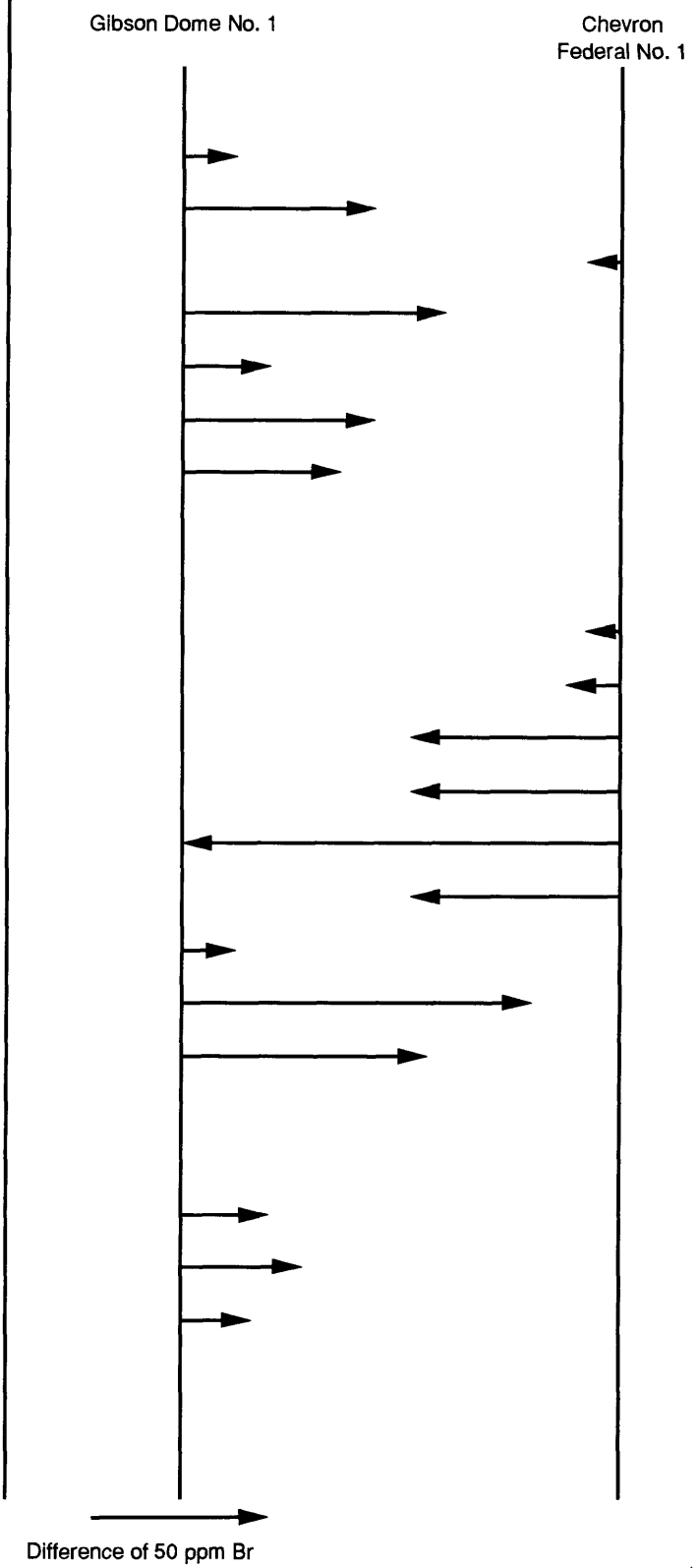


Figure 131. Tabulation of halite beds and average bromine values in the Gibson Dome core and from cuttings in the Chevron Federal well; and a graphic representation of the lateral bromine gradients in equivalent halite beds between the two wells. Arrows indicate direction of bromine increase; length of arrow is proportional to the amount of increase.

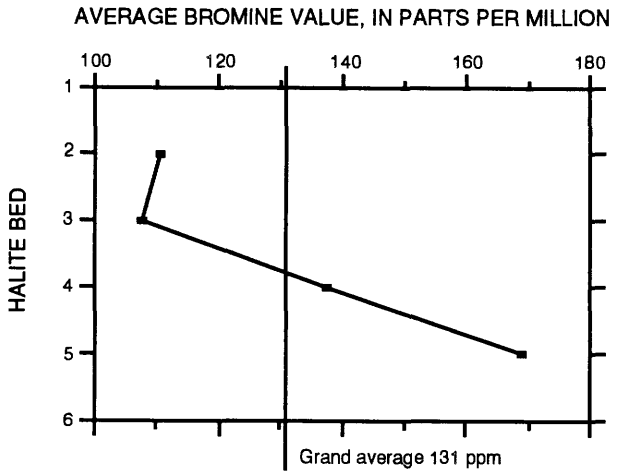


Figure 132. Profile of average bromine content in halite beds in the Cane Creek No. 1 corehole.

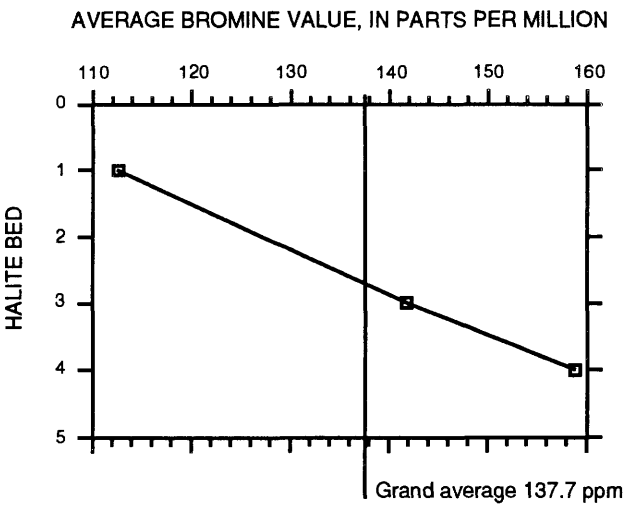


Figure 134. Profile of average bromine content in halite beds in the Utah No. 2 corehole.

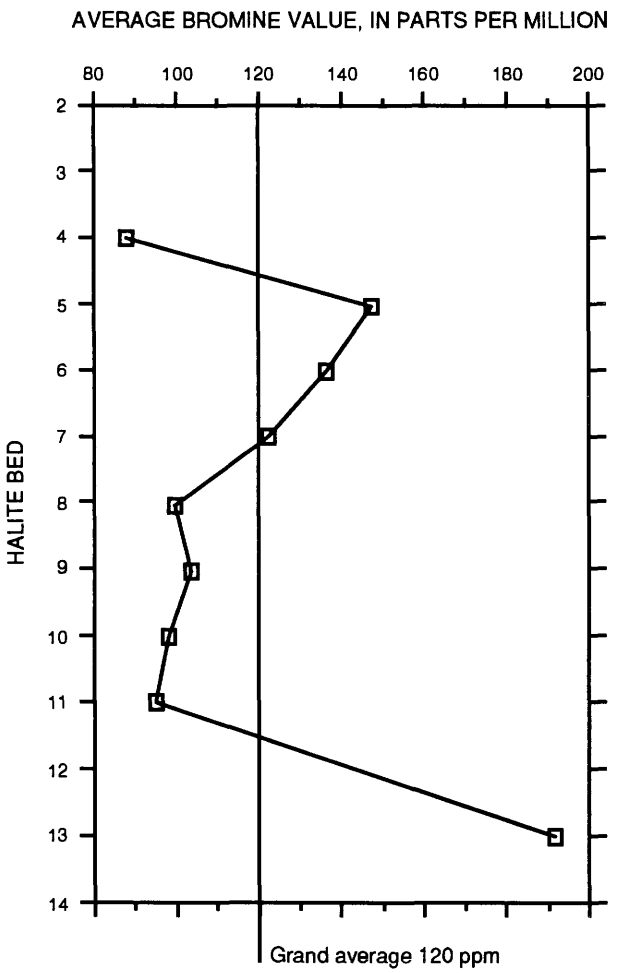


Figure 133. Profile of average bromine content in halite beds in the Shafer No. 1 corehole.

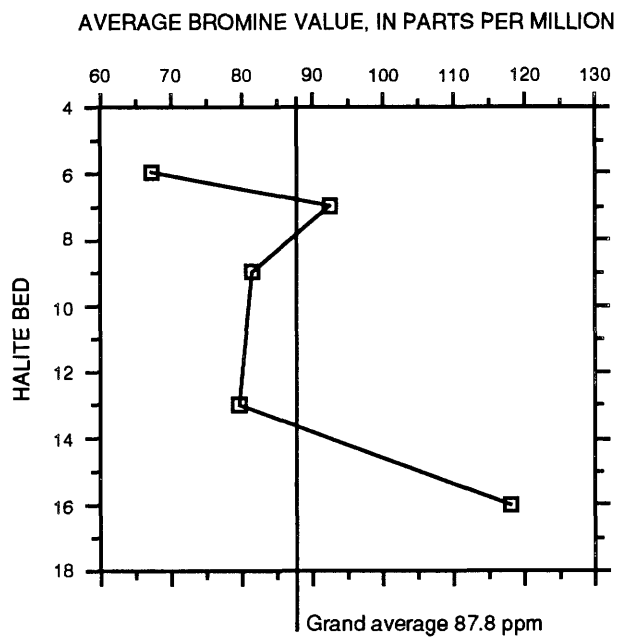


Figure 135. Profile of average bromine content in halite beds in the Elk Ridge No. 1 corehole.

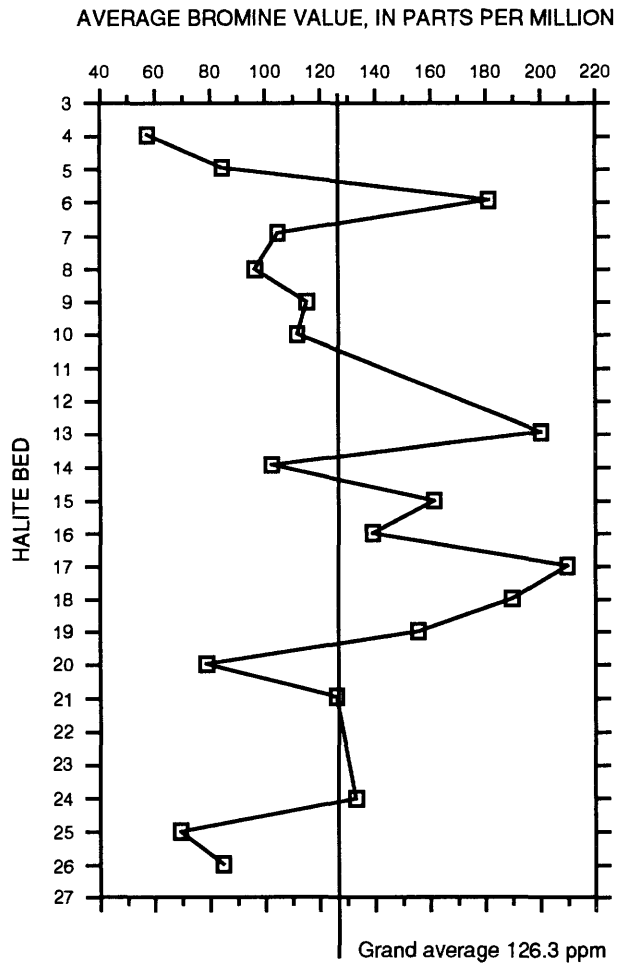


Figure 136. Profile of average bromine content in halite beds in the Gibson Dome No. 1 corehole.

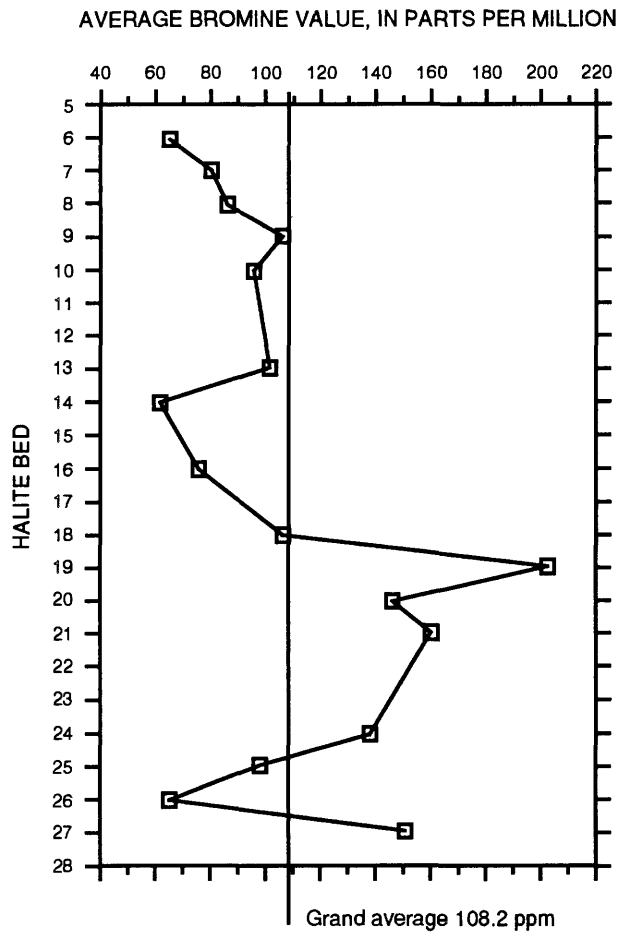


Figure 137. Profile of average bromine content in halite beds obtained from cuttings in the Lone Dome No. 1 well.

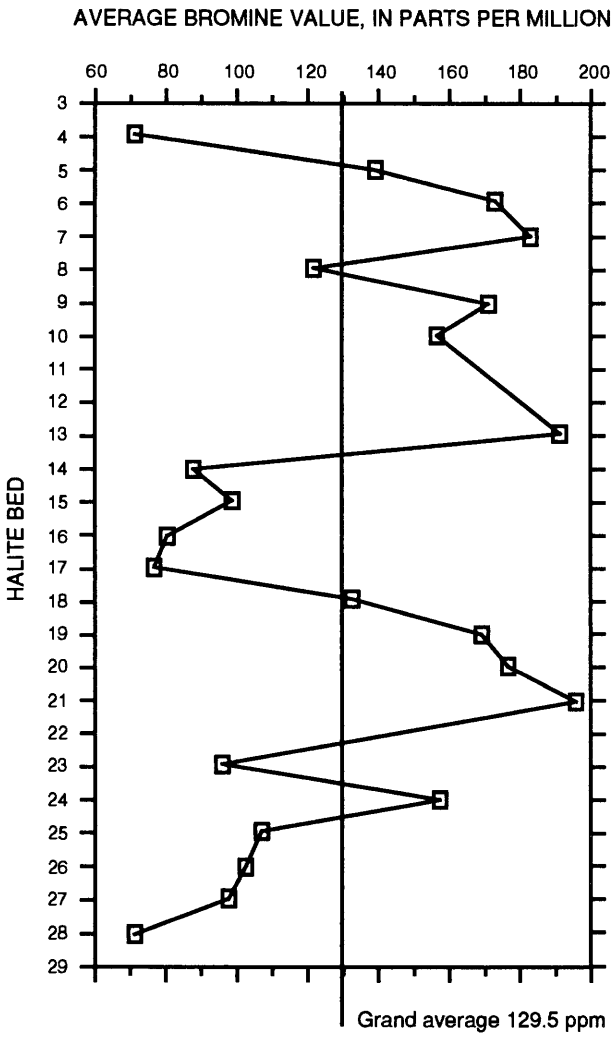


Figure 138. Profile of average bromine content in halite beds obtained from cuttings in the Chevron Federal No. 1 well.

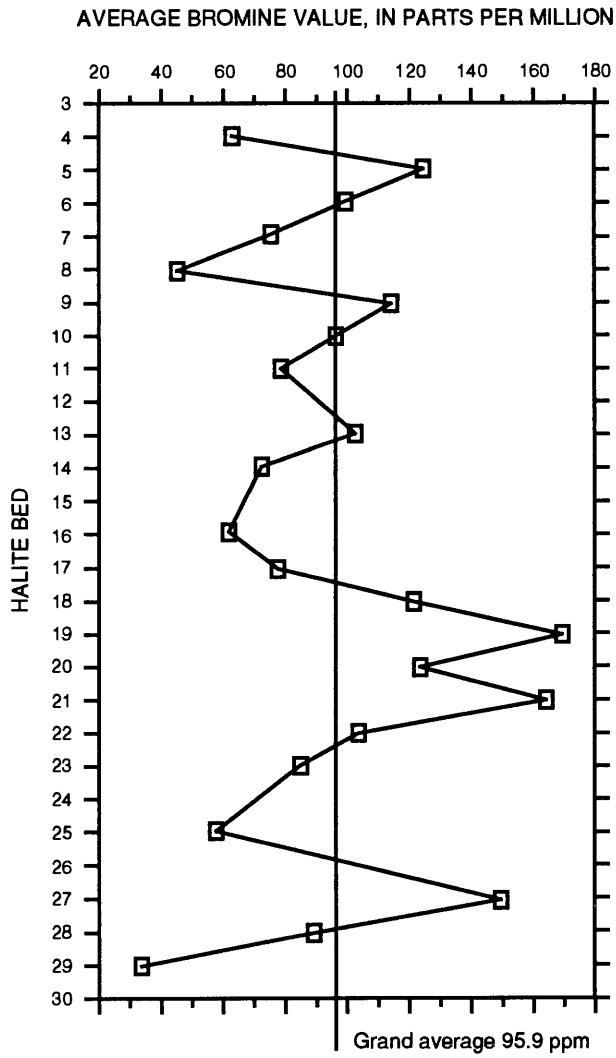


Figure 139. Profile of average bromine content in halite beds obtained from cuttings in the Egnar No. 1 well.

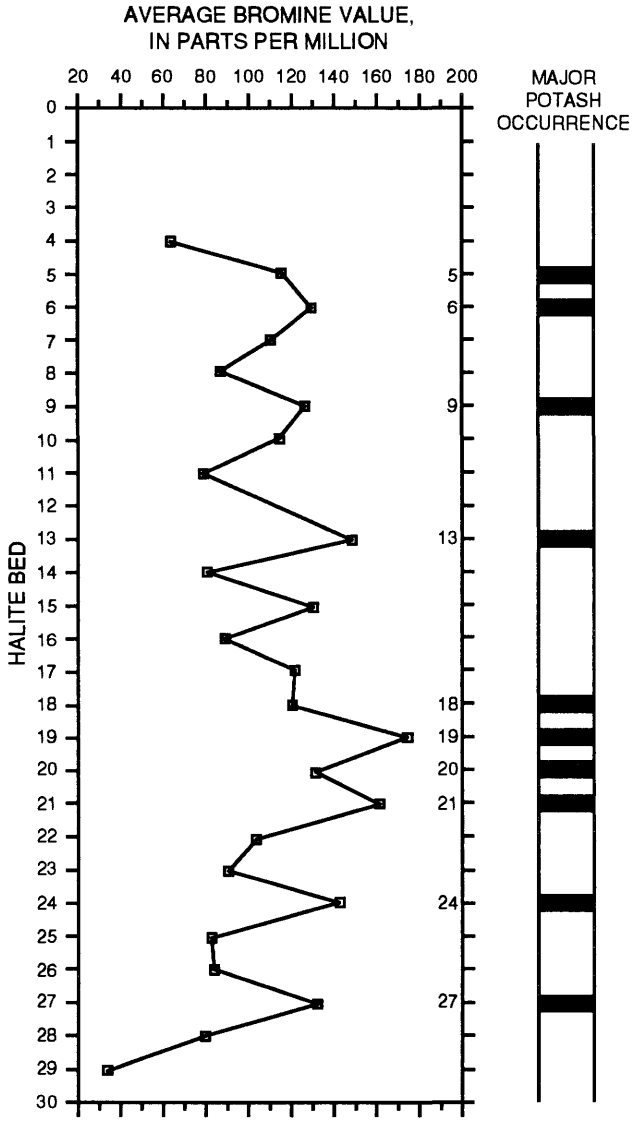


Figure 140. Profile of average bromine contents of halite beds in the Gibson Dome corehole and from cuttings in the Lone Dome, Chevron Federal, and Egnar wells. Halite beds containing potash are from Hite (1961).

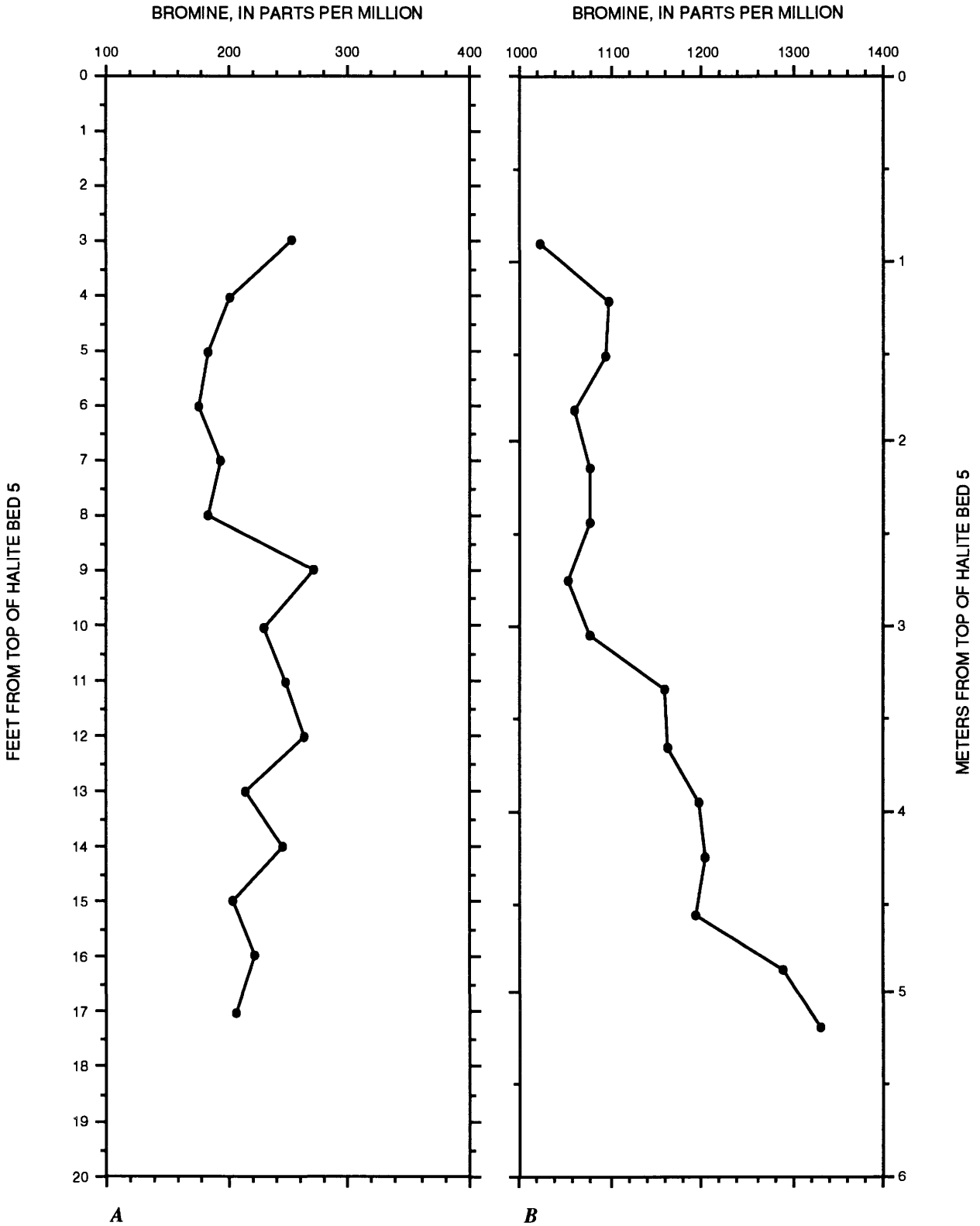


Figure 141. Profiles of bromine content in halite (*A*) and sylvite (*B*) in the potash ore zone of the halite bed of cycle 5 at the Texas gulf potash mine, near Moab, Utah.

APPENDIX—DATA TABLES

Appendix table 1. Bromine data for the halite bed of cycle 2, Cane Creek No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
1,938	590.70	120	134.0
1,940	591.31	148	131.0
1,942	591.92	125	135.0
1,944	592.53	141	144.2
1,946	593.14	141	145.6
1,948	593.75	166	155.6
1,950	594.36	155	156.4
1,952	594.97	175	158.2
1,954	595.58	145	154.0
1,956	596.19	150	151.0
1,958	596.80	145	145.2
1,960	597.41	140	141.2
1,962	598.02	146	140.2
1,964	598.63	125	140.2
1,966	599.24	145	138.4
1,968	599.85	145	140.2
1,970	600.46	131	153.2
1,972	601.07	155	153.4
1,974	601.68	190	158.4
1,976	602.28	146	159.4
1,978	602.89	170	153.4
1,980	603.50	136	141.6
1,982	604.11	125	136.4
1,984	604.72	131	127.4
1,986	605.33	120	127.4
1,988	605.94	125	123.4
1,990	606.55	136	128.4
1,992	607.16	105	131.4
1,994	607.77	156	131.4
1,996	608.38	135	130.4
1,998	608.99	125	132.4
2,000	609.60	131	125.2
2,002	610.21	115	117.2
2,004	610.82	120	114.2
2,006	611.43	95	113.2
2,008	612.04	110	112.2
2,010	612.65	126	107.4
2,012	613.26	110	112.4
2,014	613.87	96	116.4
2,016	614.48	120	118.4
2,018	615.09	130	114.4
2,020	615.70	136	114.2
2,022	616.31	90	108.2
2,024	616.92	95	101.2
2,026	617.52	90	91.2
2,028	618.13	95	92.2
2,030	618.74	86	90.2
2,032	619.35	95	91.2
2,034	619.96	85	91.2
2,036	620.57	95	97.2
2,038	621.18	95	96.2
2,040	621.79	116	97.2
2,042	622.40	90	101.0
2,044	623.01	90	106.2

Appendix table 1. Bromine data for the halite bed of cycle 2, Cane Creek No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,046	623.62	114	101.0
2,048	624.23	121	101.0
2,050	624.84	90	100.0
2,052	625.45	90	95.2
2,054	626.06	85	90.0
2,056	626.67	90	88.0
2,058	627.28	95	87.0
2,060	627.89	80	87.0
2,062	628.50	85	85.0
2,064	629.11	85	81.0
2,066	629.72	80	80.0
2,068	630.33	75	79.0
2,070	630.94	75	79.0
2,072	631.55	80	76.0
2,074	632.16	85	78.0
2,076	632.76	65	77.0
2,078	633.37	85	76.0
2,080	633.98	70	73.0
2,082	634.59	75	75.0
2,084	635.20	70	74.0
2,086	635.81	75	73.0
2,088	636.42	80	74.0
2,090	637.03	65	77.0
2,092	637.64	80	78.0
2,094	638.25	85	76.0
2,096	638.86	80	79.0
2,098	639.47	70	82.0
2,100	640.08	80	81.0
2,102	640.69	95	84.0
2,104	641.30	80	94.0
2,106	641.91	95	109.0
2,108	642.52	120	126.0
2,110	643.13	155	151.7
2,112	643.74	180	167.5

Appendix table 2. Bromine data for the halite bed of cycle 3, Cane Creek No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,220	676.66	230	190.0
2,222	677.27	150	168.3
2,224	677.88	125	150.6
2,226	678.48	125	134.6
2,228	679.09	123	131.6
2,230	679.70	150	128.6
2,232	680.31	135	131.8
2,234	680.92	110	135.6
2,236	681.53	141	126.6
2,238	682.14	142	123.6
2,240	682.75	105	125.8

Appendix table 2. Bromine data for the halite bed of cycle 3, Cane Creek No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,242	683.36	120	122.6
2,244	683.97	121	119.2
2,246	684.58	125	122.2
2,248	685.19	125	123.2
2,250	685.80	120	123.0
2,252	686.41	125	121.4
2,254	687.02	120	116.4
2,256	687.63	117	112.4
2,258	688.24	100	116.4
2,260	688.85	100	120.4
2,262	689.46	145	118.0
2,264	690.07	140	122.2
2,266	690.68	105	125.8
2,268	691.29	121	115.8
2,270	691.90	118	106.4
2,272	692.51	95	106.4
2,274	693.12	93	108.4
2,276	693.72	105	104.8
2,278	694.33	131	106.2
2,280	694.94	100	108.6
2,282	695.55	102	107.6
2,284	696.16	105	100.4
2,286	696.77	100	98.8
2,288	697.38	95	98.4
2,290	697.99	92	97.8
2,292	698.60	100	98.2
2,294	699.21	102	99.6
2,296	699.82	102	103.2
2,298	700.43	102	107.2
2,300	701.04	110	105.0
2,302	701.65	120	103.2
2,304	702.26	91	103.0
2,306	702.87	93	99.2
2,308	703.48	101	93.4
2,310	704.09	91	94.2
2,312	704.70	91	93.6
2,314	705.31	95	88.6
2,316	705.92	90	86.6
2,318	706.53	76	85.4
2,320	707.14	81	81.4
2,322	707.75	85	77.8
2,324	708.36	75	77.0
2,326	708.96	72	76.8
2,328	709.57	72	79.0
2,330	710.18	80	80.2
2,332	710.79	96	82.0
2,334	711.40	81	86.6
2,336	712.01	81	94.6
2,338	712.62	95	92.6
2,340	713.23	120	94.2
2,342	713.84	86	93.2
2,344	714.45	89	96.6
2,346	715.06	76	92.6
2,348	715.67	112	93.4

Appendix table 2. Bromine data for the halite bed of cycle 3, Cane Creek No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,350	716.28	100	100.7
2,352	716.89	90	95.0

Appendix table 3. Bromine data for the halite bed of cycle 4, Cane Creek No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,460	749.81	194	190.5
2,462	750.42	187	185.3
2,464	751.03	175	180.2
2,466	751.64	175	166.4
2,468	752.25	170	161.0
2,470	752.86	125	162.0
2,472	753.47	160	152.6
2,474	754.08	180	152.6
2,476	754.68	128	159.6
2,478	755.29	170	153.6
2,480	755.90	160	146.6
2,482	756.51	130	153.0
2,484	757.12	145	144.0
2,486	757.73	160	139.0
2,488	758.34	125	143.0
2,490	758.95	135	139.0
2,492	759.56	150	137.0
2,494	760.17	125	139.0
2,496	760.78	150	141.0
2,498	761.39	135	138.0
2,500	762.00	145	145.0
2,502	762.61	135	145.0
2,504	763.22	160	148.0
2,506	763.83	150	146.0
2,508	764.44	150	151.0
2,510	765.05	135	146.0
2,512	765.66	160	146.0
2,514	766.27	135	148.0
2,516	766.88	150	157.0
2,518	767.49	160	157.0
2,520	768.10	180	163.0
2,522	768.71	160	158.0
2,524	769.32	165	154.0
2,526	769.92	125	148.0
2,528	770.53	140	146.0
2,530	771.14	150	144.0
2,532	771.75	150	146.0
2,534	772.36	155	143.0
2,536	772.97	135	144.0
2,538	773.58	125	141.0
2,540	774.19	155	141.0
2,542	774.80	135	143.0
2,544	775.41	155	149.0

Appendix table 3. Bromine data for the halite bed of cycle 4, Cane Creek No. 1 core—*Continued.*

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,546	776.02	145	144.0
2,548	776.63	155	152.0
2,550	777.24	130	149.0
2,552	777.85	175	148.0
2,554	778.46	140	145.0
2,556	779.07	140	148.0
2,558	779.68	140	145.0
2,560	780.29	145	141.0
2,562	780.90	160	139.0
2,564	781.51	120	143.0
2,566	782.12	130	138.0
2,568	782.73	160	135.0
2,570	783.34	120	138.0
2,572	783.95	145	132.0
2,574	784.56	135	127.0
2,576	785.16	100	127.0
2,578	785.77	135	119.0
2,580	786.38	120	116.0
2,582	786.99	105	123.0
2,584	787.60	120	120.0
2,586	788.21	135	116.0
2,588	788.82	120	120.0
2,590	789.43	100	120.0
2,592	790.04	125	116.0
2,594	790.65	120	115.0
2,596	791.26	115	115.0
2,598	791.87	115	113.0
2,600	792.48	100	110.0
2,602	793.09	115	112.0
2,604	793.70	105	113.0
2,606	794.31	125	117.0
2,608	794.92	120	115.0
2,610	795.53	120	114.0
2,612	796.14	105	111.0
2,614	796.75	100	104.0
2,616	797.36	110	103.0
2,618	797.97	85	109.2
2,620	798.58	115	114.2
2,622	799.19	136	110.2
2,624	799.80	125	120.4
2,626	800.40	90	122.4
2,628	801.01	136	120.2
2,630	801.62	125	118.2
2,632	802.23	125	129.2
2,634	802.84	115	127.0
2,636	803.45	145	128.0
2,638	804.06	125	133.3
2,640	804.67	130	127.5

Appendix table 4. Bromine data for the halite bed of cycle 5, Cane Creek No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,694	821.13	365	312.5
2,696	821.74	260	260.0
2,698	822.35	257	255.7
2,700	822.96	250	265.4
2,702	823.57	300	265.4
2,704	824.18	260	265.6
2,706	824.79	260	267.6
2,708	825.40	258	261.6
2,710	826.01	260	248.6
2,712	826.62	270	237.8
2,714	827.23	195	222.2
2,716	827.84	206	215.4
2,718	828.45	180	201.4
2,720	829.06	226	203.0
2,722	829.67	200	211.0
2,724	830.28	203	207.0
2,726	830.88	246	195.8
2,728	831.49	160	187.8
2,730	832.10	170	182.2
2,732	832.71	160	167.0
2,734	833.32	175	165.0
2,736	833.93	170	166.0
2,738	834.54	150	159.0
2,740	835.15	175	159.0
2,742	835.76	125	154.0
2,744	836.37	175	152.0
2,746	836.98	145	138.0
2,748	837.59	140	142.0
2,750	838.20	105	130.0
2,752	838.81	145	126.0
2,754	839.42	115	120.8
2,756	840.03	125	131.0
2,758	840.64	114	125.0
2,760	841.25	156	127.2
2,762	841.86	115	123.2
2,764	842.47	126	127.8
2,766	843.08	105	120.6
2,768	843.69	137	125.8
2,770	844.30	120	120.6
2,772	844.91	141	124.6
2,774	845.52	100	117.2
2,776	846.12	125	121.2
2,778	846.73	100	117.0
2,780	847.34	140	123.4
2,782	847.95	120	122.4
2,784	848.56	132	131.4
2,786	849.17	120	127.4
2,788	849.78	145	127.4
2,790	850.39	120	122.0
2,792	851.00	120	126.2
2,794	851.61	105	125.4
2,796	852.22	141	125.4
2,798	852.83	141	122.4
2,800	853.44	120	135.4

Appendix table 4. Bromine data for the halite bed of cycle 5, Cane Creek No. 1 core—*Continued.*

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,802	854.05	105	131.7
2,804	854.66	170	137.5

Appendix table 5. Bromine data for the halite of cycle 2 (upper part), Shafer No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,230	679.70	29.9	50.15
2,232	680.31	70.4	62.30
2,234	680.92	86.6	70.40
2,236	681.53	78.5	79.32
2,238	682.14	86.6	81.76
2,240	682.75	74.5	81.76
2,242	683.36	82.6	80.96
2,244	683.97	86.6	79.34
2,246	684.58	74.5	80.14
2,248	685.19	78.5	79.32
2,250	685.80	78.5	76.90
2,252	686.41	78.5	76.90
2,254	687.02	74.5	75.83
2,256	687.63	74.5	74.50

Appendix table 6. Bromine data for the halite bed of cycle 3 (lower part), Shafer No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,456	748.59	102.8	102.80
2,458	749.20	102.8	101.47
2,460	749.81	98.8	99.58
2,462	750.42	98.8	98.78
2,464	751.03	94.7	97.98
2,466	751.64	98.8	97.16
2,468	752.25	98.8	94.72
2,470	752.86	94.7	92.30
2,472	753.47	86.6	90.68
2,474	754.08	82.6	88.24
2,476	754.68	90.7	87.44
2,480	755.90	86.6	88.26
2,482	756.51	90.7	89.88
2,484	757.12	90.7	88.26
2,486	757.73	90.7	90.70
2,488	758.34	82.6	91.50
2,490	758.95	98.8	93.92
2,492	759.56	94.7	96.34
2,494	760.17	102.8	97.96
2,496	760.78	102.8	98.77
2,498	761.39	90.7	96.75

Appendix table 7. Bromine data for the halite bed of cycle 4, Shafer No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,590	789.43	98.8	96.75
2,592	790.04	94.7	93.37
2,594	790.65	86.6	88.24
2,596	791.26	82.6	85.00
2,598	791.87	78.5	79.34
2,600	792.48	82.6	75.30
2,602	793.09	66.4	75.30
2,604	793.70	66.4	76.92
2,606	794.31	82.6	76.10
2,608	794.92	86.6	81.76
2,610	795.53	78.5	93.10
2,612	796.14	94.7	97.14
2,614	796.75	123.1	106.87
2,616	797.36	102.8	112.95

Appendix table 8. Bromine data for the halite bed of cycle 5, Shafer No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
2,656	809.55	131.2	149.40
2,658	810.16	167.6	158.17
2,660	810.77	175.7	163.58
2,662	811.38	171.7	172.48
2,664	811.99	171.7	172.48
2,666	812.60	175.7	184.64
2,668	813.21	167.6	200.84
2,670	813.82	236.5	205.70
2,672	814.43	252.7	206.52
2,674	815.04	196	212.20
2,676	815.64	179.8	201.66
2,678	816.25	196	190.32
2,680	816.86	183.8	187.08
2,682	817.47	196	187.88
2,684	818.08	179.8	184.64
2,686	818.69	183.8	189.50
2,688	819.30	179.8	189.50
2,690	819.91	208.1	188.68
2,692	820.52	196	187.06
2,694	821.13	175.7	187.86

Appendix table 8. Bromine data for the halite bed of cycle 5, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,696	821.74	175.7	179.76
2,698	822.35	183.8	170.84
2,700	822.96	167.6	170.84
2,702	823.57	151.4	169.22
2,704	824.18	175.7	169.22
2,706	824.79	167.6	172.46
2,708	825.40	183.8	178.14
2,710	826.01	183.8	176.52
2,712	826.62	179.8	175.72
2,714	827.23	167.6	170.86
2,716	827.84	163.6	166.82
2,718	828.45	159.5	161.96
2,720	829.06	163.6	159.54
2,722	829.67	155.5	159.54
2,724	830.28	155.5	158.74
2,726	830.88	163.6	161.98
2,728	831.49	155.5	161.16
2,730	832.10	179.8	163.58
2,732	832.71	151.4	161.96
2,734	833.32	167.6	161.96
2,736	833.93	155.5	155.48
2,738	834.54	155.5	156.30
2,740	835.15	147.4	151.44
2,742	835.76	155.5	153.80
2,744	836.37	143.3	152.18
2,746	836.98	167.3	151.36
2,748	837.59	147.4	148.92
2,750	838.20	143.3	148.12
2,752	838.81	143.3	143.32
2,754	839.42	139.3	143.32
2,756	840.03	143.3	143.32
2,758	840.64	147.4	143.32
2,760	841.25	143.3	148.18
2,762	841.86	143.3	163.58
2,764	842.47	163.6	174.90
2,766	843.08	220.3	183.82
2,768	843.69	204	184.64
2,770	844.30	187.9	181.40
2,772	844.91	147.4	174.10
2,774	845.52	147.4	170.06
2,776	846.12	183.8	159.52
2,778	846.73	183.8	161.14
2,780	847.34	135.2	163.56
2,782	847.95	155.5	149.80
2,784	848.56	159.5	140.08
2,786	849.17	115	138.46
2,788	849.78	135.2	131.16
2,790	850.39	127.1	124.26
2,792	851.00	119	127.50
2,794	851.61	125	129.94
2,796	852.22	131.2	130.76
2,798	852.83	147.4	130.76
2,800	853.44	131.2	132.00
2,802	854.05	119	130.38

Appendix table 8. Bromine data for the halite bed of cycle 5, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,804	854.66	131.2	122.28
2,806	855.27	123.1	118.22
2,808	855.88	106.9	117.42
2,810	856.49	110.9	114.18
2,812	857.10	115	110.94
2,814	857.71	115	111.74
2,816	858.32	106.9	110.94
2,818	858.93	110.9	112.56
2,820	859.54	106.9	110.94
2,822	860.15	123.1	110.94
2,824	860.76	106.9	110.14
2,826	861.36	106.9	108.52
2,828	861.97	106.9	103.66
2,830	862.58	98.8	102.04
2,832	863.19	98.8	101.22
2,834	863.80	98.8	98.78
2,836	864.41	102.8	97.96
2,838	865.02	94.7	95.52
2,840	865.63	94.7	92.28
2,842	866.24	86.6	88.24
2,844	866.85	82.6	85.00
2,846	867.46	82.6	85.82
2,848	868.07	78.5	85.82
2,850	868.68	98.8	91.48
2,852	869.29	86.6	91.48
2,854	869.90	110.9	97.16
2,856	870.51	82.6	98.78
2,858	871.12	106.9	110.12
2,860	871.73	106.9	119.04
2,862	872.34	143.3	143.34
2,864	872.95	155.5	147.38
2,866	873.56	204.1	162.23
2,868	874.17	127.1	165.60

Appendix table 9. Bromine data for the halite bed of cycle 6, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,968	904.65	225.3	186.20
2,970	905.26	147.1	194.23
2,972	905.87	210.3	197.66
2,974	906.48	202.8	205.30
2,976	907.08	202.8	202.80
2,978	907.69		
2,980	908.30		
2,982	908.91		
2,984	909.52		
2,986	910.13		
2,988	910.74		
2,990	911.35		

Appendix table 9. Bromine data for the halite bed of cycle 6, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
2,992	911.96		
2,994	912.57		
2,996	913.18		
2,998	913.79	210.3	202.85
3,000	914.40	195.4	196.67
3,002	915.01	184.3	181.30
3,004	915.62	191.7	177.58
3,006	916.23	124.8	161.22
3,008	916.84	191.7	161.22
3,010	917.45	113.6	161.22
3,012	918.06	184.3	158.24
3,014	918.67	191.7	157.50
3,016	919.28	109.9	157.50
3,018	919.89	188	153.78
3,020	920.50	113.6	153.78
3,022	921.11	165.7	169.40
3,024	921.72	191.7	164.94
3,026	922.32	188	166.42
3,028	922.93	165.7	151.54
3,030	923.54	121	141.88
3,032	924.15	91.3	124.78
3,034	924.76	143.4	123.28
3,036	925.37	102.5	124.78
3,038	925.98	158.2	141.14
3,040	926.59	128.5	147.82
3,042	927.20	173.1	158.22
3,044	927.81	176.8	161.94
3,046	928.42	154.5	156.74
3,048	929.03	176.8	156.00
3,050	929.64	102.5	147.08
3,052	930.25	169.4	142.62
3,054	930.86	132.2	128.50
3,056	931.47	132.2	128.50
3,058	932.08	106.2	115.86
3,060	932.69	102.5	118.84
3,062	933.30	106.2	121.08
3,064	933.91	147.1	120.34
3,066	934.52	143.4	127.02
3,068	935.13	102.5	133.70
3,070	935.74	135.9	125.52
3,072	936.35	139.6	120.30
3,074	936.96	106.2	126.98
3,076	937.56	117.3	124.76
3,078	938.17	135.9	129.98
3,080	938.78	124.8	133.70
3,082	939.39	165.7	143.38
3,084	940.00	124.8	146.36
3,086	940.61	165.7	153.04
3,088	941.22	150.8	147.08
3,090	941.83	158.2	148.56
3,092	942.44	135.9	153.76
3,094	943.05	132.2	163.42
3,096	943.66	191.7	164.16
3,098	944.27	199.1	174.58

Appendix table 9. Bromine data for the halite bed of cycle 6, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,100	944.88	161.9	183.50
3,102	945.49	188	176.80
3,104	946.10	176.8	176.06
3,106	946.71	158.2	194.66
3,108	947.32	195.4	181.26
3,110	947.93	254.9	178.28
3,112	948.54	121	180.52
3,114	949.15	161.9	173.08
3,116	949.76	169.4	161.92
3,118	950.37	158.2	159.70
3,120	950.98	199.1	159.70
3,122	951.59	109.9	156.72
3,124	952.20	161.9	153.76
3,126	952.80	154.5	141.12
3,128	953.41	143.4	150.78
3,130	954.02	135.9	148.56
3,132	954.63	158.2	169.38
3,134	955.24	150.8	183.50
3,136	955.85	258.6	186.48
3,138	956.46	214	182.02
3,140	957.07	150.8	192.42
3,142	957.68	135.9	174.58
3,144	958.29	202.8	161.94
3,146	958.90	169.4	163.42
3,148	959.51	150.8	164.16
3,150	960.12	158.2	153.02
3,152	960.73	139.6	143.34
3,154	961.34	147.1	138.14
3,156	961.95	121	136.66
3,158	962.56	124.8	136.66
3,160	963.17	150.8	136.66
3,162	963.78	139.6	141.14
3,164	964.39	147.1	162.70
3,166	965.00	143.4	151.54
3,168	965.61	232.6	148.58
3,170	966.22	95	144.86
3,172	966.83	124.8	145.60
3,174	967.44	128.5	125.52
3,176	968.04	147.1	149.32
3,178	968.65	132.2	148.56
3,180	969.26	214	146.32
3,182	969.87	121	141.10
3,184	970.48	117.3	137.38
3,186	971.09	121	118.04
3,188	971.70	113.6	116.56
3,190	972.31	117.3	115.82
3,192	972.92	113.6	115.82
3,194	973.53	113.6	116.56
3,196	974.14	121	116.56
3,198	974.75	117.3	121.76
3,200	975.36	117.3	121.76
3,202	975.97	139.6	119.48
3,204	976.58	113.6	115.02
3,206	977.19	109.6	112.06

Appendix table 9. Bromine data for the halite bed of cycle 6, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,208	977.80	95	103.14
3,210	978.41	102.5	103.88
3,212	979.02	95	110.64
3,214	979.63	117.3	109.90
3,216	980.24	143.4	109.14
3,218	980.85	91.3	109.14
3,220	981.46	98.7	107.66
3,222	982.07	95	97.24
3,224	982.68	109.9	97.24
3,226	983.28	91.3	97.24
3,228	983.89	91.3	95.76
3,230	984.50	98.7	89.06
3,232	985.11	87.6	88.32
3,234	985.72	76.4	86.84
3,236	986.33	87.6	83.88
3,238	986.94	83.9	84.62
3,240	987.55	83.9	88.34
3,242	988.16	91.3	86.84
3,244	988.77	95	86.08
3,246	989.38	80.1	85.32
3,248	989.99	80.1	84.58
3,250	990.60	80.1	83.10
3,252	991.21	87.6	83.86
3,254	991.82	87.6	83.86
3,256	992.43	83.9	86.84
3,258	993.04	80.1	86.10
3,260	993.65	95	83.86
3,262	994.26	83.9	80.14
3,264	994.87	76.4	81.64
3,266	995.48	65.3	77.92
3,268	996.09	87.6	79.40
3,270	996.70	76.4	77.92
3,272	997.31	91.3	83.12
3,274	997.92	69	80.14
3,276	998.52	91.3	76.42
3,278	999.13	72.7	73.93
3,280	999.74	57.8	65.25

Appendix table 10. Bromine data for the halite bed of cycle 7, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,304	1,007.06	165.7	163.80
3,306	1,007.67	161.9	152.03
3,308	1,008.28	128.5	144.10
3,310	1,008.89	113.6	135.16
3,312	1,009.50	150.8	129.96
3,314	1,010.11	121	132.94
3,316	1,010.72	135.9	142.60
3,318	1,011.33	143.4	164.90

Appendix table 10. Bromine data for the halite bed of cycle 7, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,320	1,011.94	161.9	182.02
3,322	1,012.55	262.3	190.20
3,324	1,013.16	206.6	190.94
3,326	1,013.76	176.8	187.24
3,328	1,014.37	147.1	170.14
3,330	1,014.98	143.4	158.98
3,332	1,015.59	176.8	144.86
3,334	1,016.20	150.8	147.82
3,336	1,016.81	106.2	152.28
3,338	1,017.42	161.9	151.54
3,340	1,018.03	165.7	154.52
3,342	1,018.64	173.1	161.20
3,344	1,019.25	165.7	154.52
3,346	1,019.86	139.6	145.58
3,348	1,020.47	128.5	137.40
3,350	1,021.08	121	127.72
3,352	1,021.69	132.2	122.52
3,354	1,022.30	117.3	120.28
3,356	1,022.91	113.6	113.60
3,358	1,023.52	117.3	103.94
3,360	1,024.13	87.6	99.48
3,362	1,024.74	83.9	95.76
3,364	1,025.35	95	89.08
3,366	1,025.96	95	89.08
3,368	1,026.57	83.9	90.56
3,370	1,027.18	87.6	89.82
3,372	1,027.79	91.3	91.32
3,374	1,028.40	91.3	94.28
3,376	1,029.00	102.5	92.78
3,378	1,029.61	98.7	89.80
3,380	1,030.22	80.1	87.56
3,382	1,030.83	76.4	82.34
3,384	1,031.44	80.1	84.58
3,386	1,032.05	76.4	85.34
3,388	1,032.66	109.9	86.08
3,390	1,033.27	83.9	85.34
3,392	1,033.88	80.1	86.08
3,394	1,034.49	76.4	80.88
3,396	1,035.10	80.1	80.88
3,398	1,035.71	83.9	83.86
3,400	1,036.32	83.9	87.60
3,402	1,036.93	95	89.45

Appendix table 11. Bromine data for the halite bed of cycle 8, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,412	1,039.98	106.2	115.50
3,414	1,040.59	124.8	109.90
3,416	1,041.20	98.7	112.86

Appendix table 11. Bromine data for the halite bed of cycle 8, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,418	1,041.81	121	118.06
3,420	1,042.42	113.6	116.56
3,422	1,043.03	132.2	124.00
3,424	1,043.64	117.3	126.98
3,426	1,044.24	135.9	133.68
3,428	1,044.85	135.9	131.44
3,430	1,045.46	147.1	132.18
3,432	1,046.07	121	129.96
3,434	1,046.68	121	124.02
3,436	1,047.29	124.8	115.10
3,438	1,047.90	106.2	111.40
3,440	1,048.51	102.5	107.70
3,442	1,049.12	102.5	103.98
3,444	1,049.73	102.5	102.48
3,446	1,050.34	106.2	100.98
3,448	1,050.95	98.7	96.50
3,450	1,051.56	95	93.52
3,452	1,052.17	80.1	90.54
3,454	1,052.78	87.6	88.32
3,456	1,053.39	91.3	85.34
3,458	1,054.00	87.6	82.38
3,460	1,054.61	80.1	78.66
3,462	1,055.22	65.3	74.20
3,464	1,055.83	69	71.22
3,466	1,056.44	69	67.52
3,468	1,057.05	72.7	69.00
3,470	1,057.66	61.6	69.00
3,472	1,058.27	72.7	69.74
3,474	1,058.88	69	71.98
3,476	1,059.48	72.7	79.40
3,478	1,060.09	83.9	80.14
3,480	1,060.70	98.7	86.33
3,482	1,061.31	76.4	87.55

Appendix table 12. Bromine data for the halite bed of cycle 9, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,530	1,075.94	154	153.50
3,532	1,076.55	153	153.00
3,534	1,077.16	152	151.80
3,536	1,077.77	150	151.00
3,538	1,078.38	150	148.00
3,540	1,078.99	150	150.80
3,542	1,079.60	138	157.20
3,544	1,080.21	166	152.40
3,546	1,080.82	182	157.60
3,548	1,081.43	126	162.20
3,550	1,082.04	176	161.80
3,552	1,082.65	161	154.60

Appendix table 12. Bromine data for the halite bed of cycle 9, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,554	1,083.26	164	163.00
3,556	1,083.87	146	162.20
3,557	1,084.17	168	158.20
3,559	1,084.78	172	153.60
3,561	1,085.39	141	153.40
3,563	1,086.00	141	149.00
3,565	1,086.61	145	142.80
3,567	1,087.22	146	141.00
3,569	1,087.83	141	136.60
3,571	1,088.44	132	130.40
3,573	1,089.05	119	123.00
3,575	1,089.66	114	119.40
3,576	1,089.96	109	114.00
3,578	1,090.57	123	104.60
3,580	1,091.18	105	102.40
3,582	1,091.79	72	101.20
3,584	1,092.40	103	95.20
3,586	1,093.01	103	93.00
3,588	1,093.62	93	92.80
3,590	1,094.23	94	91.20
3,592	1,094.84	71	87.38
3,594	1,095.45	95	86.30
3,596	1,096.06	83.9	90.96
3,598	1,096.67	87.6	94.28
3,600	1,097.28	117.3	92.80
3,602	1,097.89	87.6	91.30
3,604	1,098.50	87.6	91.30
3,606	1,099.11	76.4	83.12
3,608	1,099.72	87.6	79.40
3,610	1,100.33	76.4	78.66
3,612	1,100.94	69	77.18
3,614	1,101.55	83.9	74.94
3,616	1,102.16	69	76.44
3,618	1,102.77	76.4	79.42
3,620	1,103.38	83.9	78.66
3,622	1,103.99	83.9	83.12
3,624	1,104.60	80.1	83.12
3,626	1,105.20	91.3	83.12
3,628	1,105.81	76.4	80.88
3,630	1,106.42	83.9	81.64
3,632	1,107.03	72.7	74.94
3,634	1,107.64	83.9	76.44
3,636	1,108.25	57.8	74.94
3,638	1,108.86	83.9	77.18
3,640	1,109.47	76.4	76.42
3,642	1,110.08	83.9	79.40
3,644	1,110.69	80.1	77.16
3,646	1,111.30	72.7	75.68
3,648	1,111.91	72.7	74.92
3,650	1,112.52	69	77.90
3,652	1,113.13	80.1	78.64
3,654	1,113.74	95	78.64
3,656	1,114.35	76.4	78.64
3,658	1,114.96	72.7	75.68

Appendix table 12. Bromine data for the halite bed of cycle 9, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,660	1,115.57	69	71.22
3,662	1,116.18	65.3	71.96
3,664	1,116.79	72.7	73.44
3,666	1,117.40	80.1	76.42
3,668	1,118.01	80.1	79.38
3,670	1,118.62	83.9	82.36
3,672	1,119.23	80.1	82.36
3,674	1,119.84	87.6	82.36
3,676	1,120.44	80.1	81.60
3,678	1,121.05	80.1	83.10
3,680	1,121.66	80.1	80.86
3,682	1,122.27	87.6	93.52
3,684	1,122.88	76.4	102.47
3,686	1,123.49	143.4	109.90

Appendix table 13. Bromine data for the halite bed of cycle 10, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,722	1,134.47	95	98.75
3,724	1,135.08	102.5	98.73
3,726	1,135.68	98.7	84.62
3,728	1,136.29	61.6	78.68
3,730	1,136.90	65.3	74.96
3,732	1,137.51	65.3	66.78
3,734	1,138.12	83.9	70.48
3,736	1,138.73	57.8	71.96
3,738	1,139.34	80.1	69.72
3,740	1,139.95	72.7	63.76
3,742	1,140.56	54.1	63.02
3,744	1,141.17	54.1	58.56
3,746	1,141.78	54.1	58.56
3,748	1,142.39	57.8	64.52
3,750	1,143.00	72.7	66.76
3,752	1,143.61	83.9	70.48
3,754	1,144.22	65.3	84.62
3,756	1,144.83	72.7	86.86
3,758	1,145.44	128.5	86.86
3,760	1,146.05	83.9	90.58
3,762	1,146.66	83.9	90.96
3,764	1,147.27	83.9	78.32
3,766	1,147.88	74.6	73.86
3,768	1,148.49	65.3	73.10
3,770	1,149.10	61.6	74.58
3,772	1,149.71	80.1	82.00
3,774	1,150.32	91.3	91.28
3,776	1,150.92	111.7	105.40
3,778	1,151.53	111.7	107.64
3,780	1,152.14	132.2	110.62
3,782	1,152.75	91.3	108.78

Appendix table 13. Bromine data for the halite bed of cycle 10, Shafer No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,784	1,153.36	106.2	110.64
3,786	1,153.97	102.5	106.92
3,788	1,154.58	121	111.38
3,790	1,155.19	113.6	99.48
3,792	1,155.80	113.6	104.68
3,794	1,156.41	46.7	104.68
3,796	1,157.02	128.5	111.38
3,798	1,157.63	121	116.58
3,800	1,158.24	147.1	137.40
3,802	1,158.85	139.6	138.14
3,804	1,159.46	150.8	139.64
3,806	1,160.07	132.2	138.90
3,808	1,160.68	128.5	138.90
3,810	1,161.29	143.4	138.90
3,812	1,161.90	139.6	138.16
3,814	1,162.51	150.8	143.36
3,816	1,163.12	128.5	143.36
3,818	1,163.73	154.5	144.86
3,820	1,164.34	143.4	138.90
3,822	1,164.95	147.1	135.92
3,824	1,165.56	121	124.76
3,826	1,166.16	113.6	117.32
3,828	1,166.77	98.7	109.14
3,830	1,167.38	106.2	106.18
3,832	1,167.99	106.2	103.20
3,834	1,168.60	106.2	103.20
3,836	1,169.21	98.7	100.22
3,838	1,169.82	98.7	95.76
3,840	1,170.43	91.3	91.30
3,842	1,171.04	83.9	87.58
3,844	1,171.65	83.9	86.84
3,846	1,172.26	80.1	83.86
3,848	1,172.87	95	84.60
3,850	1,173.48	76.4	84.60
3,852	1,174.09	87.6	93.54
3,854	1,174.70	83.9	98.77
3,856	1,175.31	124.8	104.35

Appendix table 14. Bromine data for the halite bed of cycle 11, Shafer No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)	Smoothed value (parts per million)
3,892	1,186.28	124.8	119.20
3,894	1,186.89	113.6	112.37
3,896	1,187.50	98.7	102.46
3,898	1,188.11	87.6	94.28
3,900	1,188.72	87.6	88.34
3,902	1,189.33	83.9	88.34
3,904	1,189.94	83.9	88.34
3,906	1,190.55	98.7	86.10

Appendix table 14. Bromine data for the halite bed of cycle 11, Shafer No. 1 core—*Continued.*

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
3,908	1,191.16	87.6	90.56
3,910	1,191.77	76.4	93.52
3,912	1,192.38	106.2	93.52
3,914	1,192.99	98.7	92.78
3,916	1,193.60	98.7	93.77
3,918	1,194.21	83.9	91.30

Appendix table 15. Bromine data for the halite bed of cycle 13, Shafer No. 1 core.

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
3,980	1,213.10	232.6	232.60
3,982	1,213.71	232.6	226.40
3,984	1,214.32	214	218.97
3,986	1,214.93	210.3	212.15
3,988	1,215.54		
3,990	1,216.15		
3,992	1,216.76		
3,994	1,217.37		
3,996	1,217.98		
3,998	1,218.59		
4,000	1,219.20		
4,002	1,219.81		
4,004	1,220.42		
4,006	1,221.03		
4,008	1,221.64		
4,010	1,222.25		
4,012	1,222.86		
4,014	1,223.47		
4,016	1,224.08		
4,018	1,224.69		
4,020	1,225.30		
4,022	1,225.91		
4,024	1,226.52		
4,026	1,227.12		
4,028	1,227.73		
4,030	1,228.34	437.1	572.80
4,032	1,228.95	708.5	496.57
4,034	1,229.56	344.1	511.44
4,036	1,230.17	857.2	480.94
4,038	1,230.78	210.3	385.76
4,040	1,231.39	284.6	359.74
4,042	1,232.00	232.6	230.36
4,044	1,232.61	214	235.56
4,046	1,233.22	210.3	225.90
4,048	1,233.83	236.3	224.42
4,050	1,234.44	236.3	228.14
4,052	1,235.05	225.2	222.94
4,054	1,235.66	232.6	219.22
4,056	1,236.27	184.3	215.50

Appendix table 15. Bromine data for the halite bed of cycle 13, Shafer No. 1 core—*Continued.*

Depth		Bromine content	Smoothed value
(feet)	(meters)	(parts per million)	
4,058	1,236.88	217.7	214.00
4,060	1,237.49	217.7	216.22
4,062	1,238.10	217.7	223.64
4,064	1,238.71	243.7	224.38
4,066	1,239.32	221.4	220.66
4,068	1,239.93	221.4	225.86
4,070	1,240.54	199.1	235.54
4,072	1,241.15	243.7	230.34
4,074	1,241.76	292.1	219.94
4,076	1,242.36	195.4	214.00
4,078	1,242.97	169.4	197.64
4,080	1,243.58	169.4	170.88
4,082	1,244.19	161.9	164.94
4,084	1,244.80	158.3	159.74
4,086	1,245.41	165.7	152.30
4,088	1,246.02	143.4	147.84
4,090	1,246.63	132.2	143.36
4,092	1,247.24	139.6	135.18
4,094	1,247.85	135.9	131.46
4,096	1,248.46	124.8	132.20
4,098	1,249.07	124.8	121.06
4,100	1,249.68	135.9	116.60
4,102	1,250.29	83.9	124.02
4,104	1,250.90	113.6	124.02
4,106	1,251.51	161.9	140.38
4,108	1,252.12	124.8	145.58
4,110	1,252.73	217.7	144.12
4,112	1,253.34	109.9	130.74
4,114	1,253.95	106.3	127.02
4,116	1,254.56	95	103.98
4,118	1,255.17	106.2	101.74
4,120	1,255.78	102.5	101.72
4,122	1,256.39	98.7	101.72
4,124	1,257.00	106.2	99.48
4,126	1,257.60	95	99.48
4,128	1,258.21	95	100.24
4,130	1,258.82	102.5	94.28
4,132	1,259.43	102.5	89.82
4,134	1,260.04	76.4	87.60
4,136	1,260.65	72.7	83.88
4,138	1,261.26	83.9	82.38
4,140	1,261.87	83.9	86.10
4,142	1,262.48	95	90.56
4,144	1,263.09	95	91.30
4,146	1,263.70	95	92.53
4,148	1,264.31	87.6	91.30

Appendix table 16. Bromine data for the halite bed of cycle 1, Utah No. 2 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,352	716.89	200
2,354	717.50	214
2,356	718.11	202
2,358	718.72	210
2,360	719.33	167
2,362	719.94	177
2,364	720.55	207
2,366	721.16	204
2,368	721.77	183
2,370	722.38	222
2,371	722.68	159
2,373	723.29	174
2,375	723.90	196
2,377	724.51	172
2,379	725.12	171
2,380	725.42	148
2,382	726.03	150
2,384	726.64	160
2,386	727.25	140
2,388	727.86	170
2,389	728.17	117
2,391	728.78	119
2,393	729.39	125
2,395	730.00	132
2,397	730.61	131
2,398	730.91	137
2,400	731.52	134
2,402	732.13	139
2,404	732.74	118
2,406	733.35	113
2,407	733.65	114
2,409	734.26	98
2,411	734.87	96
2,413	735.48	42
2,415	736.09	87
2,416	736.40	76
2,418	737.01	78
2,420	737.62	84
2,422	738.23	78
2,424	738.84	67
2,425	739.14	48
2,427	739.75	49
2,429	740.36	58
2,431	740.97	45
2,433	741.58	37
2,434	741.88	58
2,436	742.49	42
2,438	743.10	51
2,440	743.71	51
2,442	744.32	48
2,443	744.63	42
2,445	745.24	46
2,447	745.85	37
2,449	746.46	32

Appendix table 16. Bromine data for the halite bed of cycle 1, Utah No. 2 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,451	747.06	46
2,452	747.37	45
2,454	747.98	41
2,456	748.59	42
2,458	749.20	59
2,460	749.81	105
2,461	750.11	116

Appendix table 17. Bromine data for the halite bed of cycle 3, Utah No. 2 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,072	936.35	185
3,074	936.96	178
3,076	937.56	168
3,078	938.17	161
3,080	938.78	172
3,082	939.39	169
3,084	940.00	159
3,086	940.61	141
3,088	941.22	161
3,090	941.83	136
3,092	942.44	161
3,094	943.05	161
3,096	943.66	158
3,098	944.27	149
3,100	944.88	136
3,102	945.49	141
3,104	946.10	143
3,106	946.71	123
3,108	947.32	129
3,110	947.93	101
3,112	948.54	110
3,114	949.15	119
3,116	949.76	116
3,118	950.37	109
3,120	950.98	119
3,122	951.59	126
3,124	952.20	123
3,126	952.80	142
3,128	953.41	154
3,130	954.02	116
3,133	954.94	128
3,135	955.55	148
3,137	956.16	157

Appendix table 18. Bromine data for the halite bed of cycle 4, Utah No. 2 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,227	983.59	174
3,229	984.20	167
3,231	984.81	190
3,233	985.42	166
3,235	986.03	147
3,236	986.33	141
3,238	986.94	165
3,240	987.55	159
3,242	988.16	144
3,244	988.77	160
3,245	989.08	152
3,247	989.69	148
3,249	990.30	164
3,251	990.90	177
3,253	991.51	172
3,254	991.82	152
3,258	993.04	141
3,262	994.26	172
3,266	995.48	156
3,270	996.70	125
3,273	997.61	172
3,275	998.22	140
3,277	998.83	149
3,279	999.44	137
3,281	1,000.05	123
3,282	1,000.35	130
3,284	1,000.96	150
3,286	1,001.57	144
3,288	1,002.18	171
3,290	1,002.79	140
3,291	1,003.10	136
3,293	1,003.71	137
3,295	1,004.32	165
3,297	1,004.93	163
3,299	1,005.54	205
3,300	1,005.84	145
3,302	1,006.45	147
3,304	1,007.06	221
3,306	1,007.67	162
3,308	1,008.28	174
3,309	1,008.58	165
3,311	1,009.19	153
3,313	1,009.80	143
3,315	1,010.41	148
3,317	1,011.02	182
3,318	1,011.33	179
3,320	1,011.94	202
3,322	1,012.55	192
3,324	1,013.16	221
3,326	1,013.76	158
3,327	1,014.07	163
3,329	1,014.68	200
3,331	1,015.29	127
3,333	1,015.90	172

Appendix table 18. Bromine data for the halite bed of cycle 4, Utah No. 2 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,335	1,016.51	204
3,336	1,016.81	156
3,338	1,017.42	143
3,340	1,018.03	143
3,342	1,018.64	130
3,344	1,019.25	166
3,345	1,019.56	129
3,346	1,019.86	146
3,347	1,020.17	146
3,348	1,020.47	249
3,349	1,020.78	159
3,350	1,021.08	144
3,352	1,021.69	142
3,354	1,022.30	138
3,356	1,022.91	126
3,357	1,023.21	182
3,358	1,023.52	134
3,360	1,024.13	181
3,362	1,024.74	119
3,364	1,025.35	153
3,366	1,025.96	206
3,368	1,026.57	109
3,370	1,027.18	116
3,372	1,027.79	172

Appendix table 19. Bromine data for the halite bed of cycle 6, Elk Ridge No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,738	834.54	43
2,740	835.15	55
2,742	835.76	60
2,744	836.37	53
2,746	836.98	60
2,749	837.90	68
2,751	838.50	67
2,753	839.11	50
2,755	839.72	67
2,757	840.33	73
2,759	840.94	62
2,761	841.55	64
2,763	842.16	63
2,765	842.77	66
2,767	843.38	74
2,769	843.99	78
2,771	844.60	72
2,773	845.21	67
2,775	845.82	70
2,778	846.73	78
2,780	847.34	80

Appendix table 19. Bromine data for the halite bed of cycle 6, Elk Ridge No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,782	847.95	75
2,784	848.56	77
2,786	849.17	67
2,788	849.78	74
2,790	850.39	64
2,792	851.00	80
2,794	851.61	81
2,797	852.53	115
2,798	852.83	101

Appendix table 20. Bromine data for the halite bed of cycle 7, Elk Ridge No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,824	860.76	109
2,826	861.36	103
2,828	861.97	86
2,830	862.58	76
2,832	863.19	73
2,834	863.80	84
2,837	864.72	90
2,838	865.02	96
2,840	865.63	101
2,842	866.24	90
2,844	866.85	109

Appendix table 21. Bromine data for the halite bed of cycle 9, Elk Ridge No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,903	884.83	134
2,905	885.44	117
2,907	886.05	94
2,909	886.66	86
2,911	887.27	83
2,913	887.88	83
2,915	888.49	82
2,917	889.10	94
2,919	889.71	80
2,921	890.32	74
2,923	890.93	93
2,925	891.54	76
2,927	892.15	84
2,929	892.76	93
2,931	893.37	76
2,933	893.98	75

Appendix table 21. Bromine data for the halite bed of cycle 9, Elk Ridge No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,935	894.59	79
2,937	895.20	79
2,939	895.81	85
2,941	896.42	71
2,943	897.03	90
2,945	897.64	78
2,948	898.55	72
2,950	899.16	70
2,952	899.77	71
2,954	900.38	72
2,956	900.99	66
2,958	901.60	63
2,960	902.21	62
2,962	902.82	76
2,964	903.43	70
2,966	904.04	93
2,968	904.65	130

Appendix table 22. Bromine data for the halite bed of cycle 13, Elk Ridge No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,105	946.40	110
3,108	947.32	103
3,110	947.93	78
3,112	948.54	85
3,114	949.15	93
3,116	949.76	73
3,118	950.37	66
3,120	950.98	74
3,122	951.59	74
3,124	952.20	95
3,126	952.80	64
3,128	953.41	66
3,130	954.02	79
3,131	954.33	65
3,133	954.94	79
3,135	955.55	73
3,137	956.16	77
3,139	956.77	79
3,141	957.38	111
3,142	957.68	125
3,144	958.29	147

Appendix table 23. Bromine data for the halite bed of cycle 16, Elk Ridge No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,198	974.75	97
3,200	975.36	93
3,202	975.97	94
3,204	976.58	61
3,206	977.19	173
3,208	977.80	162
3,210	978.41	155
3,212	979.02	172
3,214	979.63	173
3,216	980.24	150
3,218	980.85	164
3,220	981.46	135
3,222	982.07	121
3,224	982.68	101
3,226	983.28	104
3,228	983.89	91
3,230	984.50	108
3,232	985.11	87
3,234	985.72	98
3,236	986.33	93
3,238	986.94	45

Appendix table 24. Bromine data for the halite bed of cycle 4, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,925	891.54	44
2,927	892.15	49
2,929	892.76	53
2,933	893.98	69
2,935	894.59	74

Appendix table 25. Bromine data for the halite bed of cycle 5, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,970	905.26	87
2,972	905.87	100
2,974	906.48	103
2,976	907.08	105
2,978	907.69	110
2,980	908.30	105
2,982	908.91	107
2,984	909.52	93
2,986	910.13	93
2,988	910.74	90

Appendix table 25. Bromine data for the halite bed of cycle 5, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
2,990	911.35	79
2,992	911.96	71
2,994	912.57	77
2,996	913.18	75
2,998	913.79	90
3,000	914.40	75
3,002	915.01	69
3,004	915.62	66
3,006	916.23	69
3,008	916.84	77
3,010	917.45	76
3,012	918.06	64
3,014	918.67	80
3,016	919.28	75
3,018	919.89	84

Appendix table 26. Bromine data for the halite bed of cycle 6, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,118	950.37	221
3,120	950.98	216
3,122	951.59	225
3,124	952.20	228
3,126	952.80	224
3,128	953.41	226
3,130	954.02	232
3,132	954.63	220
3,134	955.24	229
3,136	955.85	234
3,138	956.46	228
3,140	957.07	237
3,142	957.68	202
3,144	958.29	224
3,146	958.90	201
3,148	959.51	230
3,150	960.12	220
3,152	960.73	213
3,156	961.95	217
3,158	962.56	227
3,160	963.17	224
3,162	963.78	220
3,164	964.39	223
3,166	965.00	227
3,168	965.61	236
3,170	966.22	214
3,172	966.83	226
3,174	967.44	232
3,176	968.04	232
3,178	968.65	228

Appendix table 26. Bromine data for the halite bed of cycle 6, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,180	969.26	222
3,182	969.87	220
3,184	970.48	226
3,186	971.09	236
3,188	971.70	228
3,190	972.31	243
3,192	972.92	228
3,194	973.53	232
3,196	974.14	219
3,198	974.75	214
3,200	975.36	231
3,202	975.97	222
3,204	976.58	226
3,206	977.19	228
3,208	977.80	227
3,210	978.41	202
3,212	979.02	224
3,214	979.63	228
3,216	980.24	231
3,218	980.85	215
3,220	981.46	230
3,222	982.07	226
3,224	982.68	229
3,226	983.28	226
3,228	983.89	207
3,230	984.50	230
3,232	985.11	195
3,234	985.72	234
3,236	986.33	229
3,238	986.94	235
3,240	987.55	234
3,242	988.16	213
3,244	988.77	228
3,246	989.38	228
3,248	989.99	231
3,250	990.60	216
3,252	991.21	221
3,254	991.82	217
3,256	992.43	226
3,258	993.04	229
3,260	993.65	227
3,262	994.26	214
3,264	994.87	202
3,266	995.48	174
3,268	996.09	178
3,270	996.70	163
3,272	997.31	152
3,274	997.92	162
3,276	998.52	165
3,278	999.13	161
3,280	999.74	158
3,282	1,000.35	156
3,284	1,000.96	143
3,286	1,001.57	142

Appendix table 26. Bromine data for the halite bed of cycle 6, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,288	1,002.18	137
3,290	1,002.79	129
3,292	1,003.40	121
3,294	1,004.01	130
3,296	1,004.62	135
3,298	1,005.23	131
3,300	1,005.84	127
3,302	1,006.45	114
3,304	1,007.06	123
3,306	1,007.67	109
3,308	1,008.28	95
3,310	1,008.89	109
3,312	1,009.50	100
3,314	1,010.11	98
3,316	1,010.72	90
3,318	1,011.33	94
3,320	1,011.94	92
3,322	1,012.55	96
3,324	1,013.16	104
3,326	1,013.76	91
3,328	1,014.37	95
3,330	1,014.98	89
3,332	1,015.59	84
3,334	1,016.20	78
3,336	1,016.81	80
3,338	1,017.42	82
3,340	1,018.03	73
3,342	1,018.64	99
3,346	1,019.86	75
3,348	1,020.47	87
3,350	1,021.08	90
3,352	1,021.69	87
3,354	1,022.30	81
3,356	1,022.91	90
3,358	1,023.52	79

Appendix table 27. Bromine data for the halite bed of cycle 7, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,376	1,029.00	186
3,378	1,029.61	176
3,381	1,030.53	162
3,384	1,031.44	165
3,388	1,032.66	142
3,390	1,033.27	133
3,392	1,033.88	119
3,394	1,034.49	120
3,396	1,035.10	137
3,398	1,035.71	127

Appendix table 27. Bromine data for the halite bed of cycle 7, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,400	1,036.32	109
3,402	1,036.93	110
3,404	1,037.54	92
3,406	1,038.15	96
3,408	1,038.76	120
3,410	1,039.37	84
3,412	1,039.98	77
3,414	1,040.59	71
3,416	1,041.20	85
3,418	1,041.81	78
3,420	1,042.42	63
3,422	1,043.03	80
3,424	1,043.64	81
3,426	1,044.24	89
3,428	1,044.85	84
3,430	1,045.46	86
3,432	1,046.07	78
3,434	1,046.68	86
3,436	1,047.29	86
3,438	1,047.90	81
3,440	1,048.51	76
3,442	1,049.12	83

Appendix table 28. Bromine data for the halite bed of cycle 8, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,455	1,053.08	131
3,457	1,053.69	133
3,459	1,054.30	126
3,461	1,054.91	117
3,463	1,055.52	107
3,465	1,056.13	110
3,467	1,056.74	109
3,469	1,057.35	107
3,471	1,057.96	120
3,473	1,058.57	104
3,475	1,059.18	106
3,477	1,059.79	100
3,479	1,060.40	100
3,481	1,061.01	96
3,483	1,061.62	75
3,485	1,062.23	83
3,487	1,062.84	85
3,489	1,063.45	99
3,491	1,064.06	82
3,493	1,064.67	82
3,495	1,065.28	84
3,497	1,065.89	74
3,499	1,066.50	84

Appendix table 28. Bromine data for the halite bed of cycle 8, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,501	1,067.10	74
3,503	1,067.71	73
3,505	1,068.32	61
3,507	1,068.93	68
3,509	1,069.54	86
3,511	1,070.15	100

Appendix table 29. Bromine data for the halite bed of cycle 9, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,550	1,082.04	140
3,552	1,082.65	202
3,554	1,083.26	205
3,556	1,083.87	205
3,558	1,084.48	203
3,560	1,085.09	196
3,562	1,085.70	179
3,564	1,086.31	174
3,566	1,086.92	195
3,568	1,087.53	169
3,570	1,088.14	153
3,572	1,088.75	153
3,574	1,089.36	152
3,576	1,089.96	154
3,578	1,090.57	120
3,580	1,091.18	141
3,582	1,091.79	119
3,584	1,092.40	130
3,586	1,093.01	126
3,588	1,093.62	116
3,590	1,094.23	121
3,592	1,094.84	124
3,594	1,095.45	114
3,596	1,096.06	107
3,598	1,096.67	112
3,600	1,097.28	124
3,602	1,097.89	108
3,604	1,098.50	116
3,606	1,099.11	106
3,608	1,099.72	108
3,610	1,100.33	124
3,612	1,100.94	115
3,614	1,101.55	117
3,616	1,102.16	125
3,618	1,102.77	121
3,620	1,103.38	103
3,622	1,103.99	112
3,624	1,104.60	102
3,626	1,105.20	98

Appendix table 29. Bromine data for the halite bed of cycle 9, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,628	1,105.81	101
3,630	1,106.42	95
3,632	1,107.03	85
3,634	1,107.64	95
3,636	1,108.25	81
3,638	1,108.86	83
3,640	1,109.47	103
3,642	1,110.08	105
3,644	1,110.69	98
3,646	1,111.30	81
3,648	1,111.91	81
3,650	1,112.52	81
3,652	1,113.13	93
3,654	1,113.74	94
3,656	1,114.35	79
3,658	1,114.96	80
3,660	1,115.57	90
3,662	1,116.18	91
3,664	1,116.79	95
3,666	1,117.40	87
3,668	1,118.01	79
3,670	1,118.62	93
3,672	1,119.23	74
3,674	1,119.84	98
3,676	1,120.44	87
3,678	1,121.05	64
3,680	1,121.66	58
3,682	1,122.27	65
3,684	1,122.88	79
3,686	1,123.49	72

Appendix table 30. Bromine data for the halite bed of cycle 10, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,720	1,133.86	91
3,722	1,134.47	67
3,724	1,135.08	94
3,726	1,135.68	73
3,728	1,136.29	78
3,730	1,136.90	94
3,732	1,137.51	67
3,734	1,138.12	71
3,736	1,138.73	84
3,738	1,139.34	82
3,740	1,139.95	75
3,742	1,140.56	60
3,744	1,141.17	97
3,746	1,141.78	109
3,748	1,142.39	72

Appendix table 30. Bromine data for the halite bed of cycle 10, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,750	1,143.00	90
3,751	1,143.30	63
3,753	1,143.91	134
3,755	1,144.52	68
3,757	1,145.13	108
3,759	1,145.74	141
3,761	1,146.35	140
3,763	1,146.96	137
3,765	1,147.57	131
3,767	1,148.18	121
3,769	1,148.79	128
3,771	1,149.40	135
3,773	1,150.01	172
3,775	1,150.62	150
3,777	1,151.23	142
3,779	1,151.84	115
3,781	1,152.45	131
3,783	1,153.06	120
3,785	1,153.67	106
3,787	1,154.28	103
3,789	1,154.89	114
3,791	1,155.50	133
3,793	1,156.11	139
3,795	1,156.72	165
3,797	1,157.33	137
3,799	1,157.94	138
3,801	1,158.54	157
3,803	1,159.15	122
3,805	1,159.76	154
3,807	1,160.37	149
3,809	1,160.98	129
3,811	1,161.59	139
3,813	1,162.20	103
3,815	1,162.81	77
3,817	1,163.42	111
3,819	1,164.03	117
3,821	1,164.64	93
3,823	1,165.25	105
3,825	1,165.86	109
3,827	1,166.47	101
3,829	1,167.08	92
3,831	1,167.69	106

Appendix table 31. Bromine data for the halite bed of cycle 13, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,909	1,191.46	280
3,911	1,192.07	204
3,913	1,192.68	246

Appendix table 31. Bromine data for the halite bed of cycle 13, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
3,915	1,193.29	418
3,917	1,193.90	401
3,919	1,194.51	425
3,921	1,195.12	276
3,923	1,195.73	289
3,925	1,196.34	309
3,927	1,196.95	330
3,929	1,197.56	318
3,931	1,198.17	308
3,933	1,198.78	320
3,935	1,199.39	332
3,937	1,200.00	281
3,939	1,200.61	254
3,941	1,201.22	260
3,943	1,201.83	252
3,945	1,202.44	236
3,947	1,203.05	250
3,949	1,203.66	222
3,951	1,204.26	252
3,953	1,204.87	231
3,955	1,205.48	235
3,957	1,206.09	240
3,959	1,206.70	193
3,961	1,207.31	258
3,963	1,207.92	212
3,965	1,208.53	200
3,967	1,209.14	207
3,969	1,209.75	195
3,971	1,210.36	203
3,973	1,210.97	182
3,975	1,211.58	157
3,977	1,212.19	147
3,979	1,212.80	171
3,981	1,213.41	134
3,983	1,214.02	165
3,985	1,214.63	140
3,987	1,215.24	153
3,989	1,215.85	146
3,991	1,216.46	118
3,993	1,217.07	153
3,995	1,217.68	129
3,997	1,218.29	133
3,999	1,218.90	108
4,001	1,219.50	126
4,003	1,220.11	130
4,005	1,220.72	150
4,007	1,221.33	127
4,009	1,221.94	121
4,011	1,222.55	68
4,013	1,223.16	47
4,015	1,223.77	76
4,017	1,224.38	93
4,019	1,224.99	97
4,021	1,225.60	92

Appendix table 31. Bromine data for the halite bed of cycle 13, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,023	1,226.21	115
4,025	1,226.82	93
4,027	1,227.43	88
4,029	1,228.04	80
4,031	1,228.65	109
4,033	1,229.26	133
4,035	1,229.87	153

Appendix table 32. Bromine data for the halite bed of cycle 14, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,069	1,240.23	121
4,071	1,240.84	140
4,073	1,241.45	96
4,075	1,242.06	102
4,077	1,242.67	91
4,079	1,243.28	117
4,081	1,243.89	109
4,083	1,244.50	93
4,085	1,245.11	102
4,087	1,245.72	94
4,089	1,246.33	91
4,091	1,246.94	110
4,093	1,247.55	97
4,095	1,248.16	92
4,097	1,248.77	115
4,099	1,249.38	100
4,101	1,249.98	104
4,103	1,250.59	111
4,105	1,251.20	85
4,107	1,251.81	97
4,109	1,252.42	91
4,111	1,253.03	96
4,113	1,253.64	68
4,115	1,254.25	87
4,117	1,254.86	122
4,119	1,255.47	107
4,121	1,256.08	133
4,123	1,256.69	81
4,125	1,257.30	87
4,127	1,257.91	125
4,129	1,258.52	125

Appendix table 33. Bromine data for the halite bed of cycle 15, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,142	1,262.48	200
4,144	1,263.09	149
4,146	1,263.70	124
4,148	1,264.31	192
4,150	1,264.92	185
4,152	1,265.53	186
4,154	1,266.14	158
4,156	1,266.75	175
4,158	1,267.36	170
4,160	1,267.97	145
4,162	1,268.58	144
4,164	1,269.19	154
4,166	1,269.80	146
4,168	1,270.41	138
4,170	1,271.02	150
4,172	1,271.63	156
4,174	1,272.24	168
4,176	1,272.84	186
4,178	1,273.45	203
4,180	1,274.06	149
4,182	1,274.67	141
4,184	1,275.28	107
4,186	1,275.89	150
4,188	1,276.50	159
4,190	1,277.11	148
4,192	1,277.72	168
4,194	1,278.33	130
4,196	1,278.94	180
4,198	1,279.55	161
4,200	1,280.16	181
4,202	1,280.77	178
4,204	1,281.38	198
4,206	1,281.99	148

Appendix table 34. Bromine data for the halite bed of cycle 16, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,230	1,289.30	200
4,232	1,289.91	148
4,234	1,290.52	161
4,236	1,291.13	150
4,238	1,291.74	169
4,240	1,292.35	169
4,242	1,292.96	140
4,244	1,293.57	147
4,246	1,294.18	148
4,248	1,294.79	149
4,250	1,295.40	135
4,252	1,296.01	134

Appendix table 34. Bromine data for the halite bed of cycle 16, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,254	1,296.62	144
4,256	1,297.23	134
4,258	1,297.84	125
4,260	1,298.45	125
4,262	1,299.06	108
4,264	1,299.67	104
4,266	1,300.28	151
4,268	1,300.89	122
4,270	1,301.50	141
4,272	1,302.11	126
4,274	1,302.72	130
4,276	1,303.32	118
4,278	1,303.93	143
4,280	1,304.54	121
4,282	1,305.15	146
4,284	1,305.76	141
4,286	1,306.37	158
4,288	1,306.98	147
4,290	1,307.59	134
4,292	1,308.20	174
4,294	1,308.81	180
4,296	1,309.42	168
4,298	1,310.03	174
4,300	1,310.64	150
4,302	1,311.25	173
4,304	1,311.86	118
4,306	1,312.47	128
4,308	1,313.08	137
4,310	1,313.69	124
4,312	1,314.30	122
4,314	1,314.91	127
4,316	1,315.52	103
4,318	1,316.13	148
4,320	1,316.74	147
4,322	1,317.35	178
4,324	1,317.96	97
4,326	1,318.56	94
4,328	1,319.17	97
4,330	1,319.78	147
4,332	1,320.39	95
4,334	1,321.00	85
4,336	1,321.61	140
4,338	1,322.22	136

Appendix table 35. Bromine data for the halite bed of cycle 17, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,356	1,327.71	238
4,358	1,328.32	287

Appendix table 35. Bromine data for the halite bed of cycle 17, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,360	1,328.93	243
4,362	1,329.54	141
4,364	1,330.15	178
4,366	1,330.76	176
4,368	1,331.37	200
4,370	1,331.98	178
4,372	1,332.59	190
4,374	1,333.20	226
4,376	1,333.80	227
4,378	1,334.41	241
4,380	1,335.02	245
4,382	1,335.63	285
4,384	1,336.24	312
4,386	1,336.85	251
4,388	1,337.46	158
4,390	1,338.07	108
4,392	1,338.68	146
4,394	1,339.29	156
4,396	1,339.90	273

Appendix table 36. Bromine data for the halite bed of cycle 18, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,402	1,341.73	285
4,404	1,342.34	267
4,406	1,342.95	247
4,408	1,343.56	280
4,410	1,344.17	282
4,412	1,344.78	255
4,414	1,345.39	269
4,416	1,346.00	257
4,418	1,346.61	273
4,420	1,347.22	310
4,422	1,347.83	307
4,424	1,348.44	293
4,426	1,349.04	323
4,428	1,349.65	319
4,430	1,350.26	839
4,432	1,350.87	183
4,434	1,351.48	809
4,436	1,352.09	392
4,438	1,352.70	378
4,440	1,353.31	341
4,442	1,353.92	368
4,444	1,354.53	336
4,446	1,355.14	316
4,448	1,355.75	319
4,450	1,356.36	290
4,452	1,356.97	284

Appendix table 36. Bromine data for the halite bed of cycle 18, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,454	1,357.58	293
4,456	1,358.19	341
4,458	1,358.80	313
4,460	1,359.41	324
4,462	1,360.02	285
4,464	1,360.63	257
4,466	1,361.24	285
4,468	1,361.85	265
4,470	1,362.46	308
4,472	1,363.07	278
4,474	1,363.68	134
4,476	1,364.28	281
4,478	1,364.89	294
4,480	1,365.50	263
4,482	1,366.11	266
4,484	1,366.72	284
4,486	1,367.33	306
4,488	1,367.94	307
4,490	1,368.55	305
4,492	1,369.16	315
4,494	1,369.77	295
4,496	1,370.38	274
4,498	1,370.99	287
4,500	1,371.60	295
4,502	1,372.21	299
4,504	1,372.82	274
4,506	1,373.43	299
4,508	1,374.04	308
4,510	1,374.65	313
4,512	1,375.26	313
4,514	1,375.87	291
4,516	1,376.48	308
4,518	1,377.09	324
4,520	1,377.70	311
4,522	1,378.31	268
4,524	1,378.92	271
4,526	1,379.52	221
4,528	1,380.13	228
4,530	1,380.74	172
4,532	1,381.35	213
4,534	1,381.96	167
4,536	1,382.57	156
4,538	1,383.18	185
4,540	1,383.79	222
4,542	1,384.40	174
4,544	1,385.01	199
4,546	1,385.62	170
4,548	1,386.23	156
4,550	1,386.84	186
4,552	1,387.45	190
4,554	1,388.06	160
4,556	1,388.67	151
4,558	1,389.28	176
4,560	1,389.89	149

Appendix table 36. Bromine data for the halite bed of cycle 18, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,562	1,390.50	187
4,564	1,391.11	170
4,566	1,391.72	154
4,568	1,392.33	158
4,570	1,392.94	178
4,572	1,393.55	151
4,574	1,394.16	154
4,576	1,394.76	127
4,578	1,395.37	136
4,580	1,395.98	122
4,582	1,396.59	144
4,584	1,397.20	140
4,586	1,397.81	140
4,588	1,398.42	118
4,590	1,399.03	168
4,592	1,399.64	144
4,594	1,400.25	135
4,596	1,400.86	154
4,598	1,401.47	151
4,600	1,402.08	144
4,602	1,402.69	137
4,604	1,403.30	133
4,606	1,403.91	146
4,608	1,404.52	137
4,610	1,405.13	154
4,612	1,405.74	140
4,614	1,406.35	169
4,616	1,406.96	138
4,618	1,407.57	143
4,620	1,408.18	136
4,622	1,408.79	129
4,624	1,409.40	121
4,626	1,410.00	126
4,628	1,410.61	120
4,630	1,411.22	133
4,632	1,411.83	110
4,634	1,412.44	108
4,636	1,413.05	163
4,638	1,413.66	112
4,640	1,414.27	114
4,642	1,414.88	123
4,644	1,415.49	101
4,646	1,416.10	118
4,648	1,416.71	103
4,650	1,417.32	120
4,652	1,417.93	104
4,654	1,418.54	94
4,656	1,419.15	89
4,658	1,419.76	105
4,660	1,420.37	124
4,662	1,420.98	115
4,664	1,421.59	105
4,666	1,422.20	112
4,668	1,422.81	78

Appendix table 36. Bromine data for the halite bed of cycle 18, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,670	1,423.42	88
4,672	1,424.03	101
4,674	1,424.64	71
4,676	1,425.24	77
4,678	1,425.85	83
4,680	1,426.46	89
4,682	1,427.07	94
4,684	1,427.68	75
4,686	1,428.29	53
4,688	1,428.90	79
4,690	1,429.51	60
4,692	1,430.12	91
4,694	1,430.73	71
4,696	1,431.34	78
4,698	1,431.95	62
4,700	1,432.56	54
4,702	1,433.17	83
4,704	1,433.78	58
4,706	1,434.39	48
4,708	1,435.00	72
4,710	1,435.61	65
4,712	1,436.22	54
4,714	1,436.83	80
4,716	1,437.44	50
4,718	1,438.05	46
4,720	1,438.66	76
4,722	1,439.27	38
4,724	1,439.88	34
4,726	1,440.48	59
4,728	1,441.09	78
4,730	1,441.70	55
4,732	1,442.31	88
4,734	1,442.92	79
4,736	1,443.53	57
4,738	1,444.14	83
4,740	1,444.75	105
4,742	1,445.36	152
4,744	1,445.97	205

Appendix table 37. Bromine data for the halite bed of cycle 19, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,770	1,453.90	314
4,772	1,454.51	330
4,774	1,455.12	346
4,776	1,455.72	302
4,778	1,456.33	286
4,780	1,456.94	294
4,782	1,457.55	307

Appendix table 37. Bromine data for the halite bed of cycle 19, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,784	1,458.16	310
4,786	1,458.77	319
4,788	1,459.38	302
4,790	1,459.99	287
4,792	1,460.60	287
4,794	1,461.21	270
4,796	1,461.82	272
4,798	1,462.43	286
4,800	1,463.04	270
4,802	1,463.65	264
4,804	1,464.26	250
4,806	1,464.87	207
4,808	1,465.48	253
4,810	1,466.09	245
4,812	1,466.70	226
4,814	1,467.31	218
4,816	1,467.92	220
4,818	1,468.53	230
4,820	1,469.14	223
4,822	1,469.75	230
4,824	1,470.36	206
4,826	1,470.96	205
4,828	1,471.57	209
4,830	1,472.18	151
4,832	1,472.79	193
4,834	1,473.40	143
4,836	1,474.01	141
4,838	1,474.62	180
4,840	1,475.23	160
4,842	1,475.84	178
4,844	1,476.45	154
4,846	1,477.06	142
4,848	1,477.67	138
4,850	1,478.28	108
4,852	1,478.89	128
4,854	1,479.50	119
4,856	1,480.11	97
4,858	1,480.72	118
4,860	1,481.33	110
4,862	1,481.94	105
4,864	1,482.55	115
4,866	1,483.16	85
4,868	1,483.77	87
4,870	1,484.38	99
4,872	1,484.99	114
4,874	1,485.60	73
4,876	1,486.20	91
4,878	1,486.81	92
4,880	1,487.42	92
4,882	1,488.03	79
4,884	1,488.64	50
4,886	1,489.25	103
4,888	1,489.86	80
4,890	1,490.47	66

Appendix table 37. Bromine data for the halite bed of cycle 19, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
4,892	1,491.08	90
4,894	1,491.69	91
4,896	1,492.30	106
4,898	1,492.91	94
4,900	1,493.52	97
4,902	1,494.13	70
4,904	1,494.74	116
4,906	1,495.35	76
4,908	1,495.96	99
4,910	1,496.57	61
4,912	1,497.18	95
4,914	1,497.79	93
4,916	1,498.40	61
4,918	1,499.01	55
4,920	1,499.62	70
4,922	I,500.23	84
4,924	1,500.84	59
4,926	1,501.44	81
4,928	1,502.05	77
4,930	1,502.66	63
4,932	1,503.27	53
4,934	1,503.88	79
4,936	1,504.49	78
4,938	1,505.10	81
4,940	1,505.71	67
4,942	1,506.32	68
4,944	1,506.93	71
4,946	1,507.54	99
4,948	1,508.15	104
4,950	1,508.76	158
4,952	1,509.37	228
4,954	1,509.98	269

Appendix table 38. Bromine data for the halite bed of cycle 20, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,020	1,530.10	125
5,022	1,530.71	132
5,024	1,531.32	107
5,026	1,531.92	90
5,028	1,532.53	83
5,030	1,533.14	89
5,032	1,533.75	75
5,034	1,534.36	69
5,036	1,534.97	79
5,038	1,535.58	59
5,040	1,536.19	77
5,042	1,536.80	71
5,044	1,537.41	76

Appendix table 38. Bromine data for the halite bed of cycle 20, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,046	1,538.02	51
5,048	1,538.63	66
5,050	1,539.24	66
5,052	1,539.85	86
5,054	1,540.46	69
5,056	1,541.07	60
5,058	1,541.68	67
5,060	1,542.29	65
5,062	1,542.90	70
5,064	1,543.51	74
5,066	1,544.12	93

Appendix table 39. Bromine data for the halite bed of cycle 21, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,089	1,551.13	312
5,091	1,551.74	322
5,093	1,552.35	276
5,095	1,552.96	288
5,097	1,553.57	265
5,099	1,554.18	245
5,101	1,554.78	250
5,103	1,555.39	237
5,105	1,556.00	247
5,107	1,556.61	246
5,109	1,557.22	209
5,111	1,557.83	216
5,113	1,558.44	221
5,115	1,559.05	180
5,117	1,559.66	201
5,119	1,560.27	164
5,121	1,560.88	163
5,123	1,561.49	134
5,125	1,562.10	140
5,127	1,562.71	120
5,129	1,563.32	121
5,131	1,563.93	130
5,133	1,564.54	139
5,135	1,565.15	123
5,137	1,565.76	144
5,139	1,566.37	128
5,141	1,566.98	101
5,143	1,567.59	113
5,145	1,568.20	106
5,147	1,568.81	94
5,149	1,569.42	86
5,151	1,570.02	87
5,153	1,570.63	100
5,155	1,571.24	79

Appendix table 39. Bromine data for the halite bed of cycle 21, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,157	1,571.85	75
5,159	1,572.46	69
5,161	1,573.07	73
5,163	1,573.68	73
5,165	1,574.29	83
5,167	1,574.90	84
5,169	1,575.51	92
5,171	1,576.12	81
5,173	1,576.73	64
5,175	1,577.34	68
5,177	1,577.95	95
5,179	1,578.56	94
5,181	1,579.17	90
5,183	1,579.78	81
5,185	1,580.39	89
5,187	1,581.00	75
5,189	1,581.61	84
5,191	1,582.22	66
5,193	1,582.83	47
5,195	1,583.44	52
5,197	1,584.05	75
5,199	1,584.66	65
5,201	1,585.26	81
5,203	1,585.87	79
5,205	1,586.48	80
5,207	1,587.09	64
5,209	1,587.70	58
5,211	1,588.31	85
5,213	1,588.92	55
5,215	1,589.53	48
5,217	1,590.14	72
5,219	1,590.75	50
5,221	1,591.36	117

Appendix table 40. Bromine data for the halite bed of cycle 24, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,310	1,618.49	279
5,312	1,619.10	302
5,314	1,619.71	294
5,316	1,620.32	258
5,318	1,620.93	292
5,320	1,621.54	317
5,322	1,622.15	280
5,324	1,622.76	284
5,326	1,623.36	283
5,328	1,623.97	268
5,330	1,624.58	255
5,332	1,625.19	246

Appendix table 40. Bromine data for the halite bed of cycle 24, Gibson Dome No. 1 core—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,334	1,625.80	262
5,336	1,626.41	243
5,338	1,627.02	224
5,340	1,627.63	188
5,342	1,628.24	213
5,344	1,628.85	164
5,346	1,629.46	132
5,348	1,630.07	145
5,350	1,630.68	121
5,352	1,631.29	116
5,354	1,631.90	110
5,356	1,632.51	128
5,358	1,633.12	96
5,360	1,633.73	118
5,362	1,634.34	112
5,364	1,634.95	88
5,366	1,635.56	86
5,368	1,636.17	109
5,370	1,636.78	94
5,372	1,637.39	91
5,374	1,638.00	112
5,376	1,638.60	73
5,378	1,639.21	56
5,380	1,639.82	73
5,382	1,640.43	54
5,384	1,641.04	50
5,386	1,641.65	40
5,388	1,642.26	69
5,390	1,642.87	57
5,392	1,643.48	77
5,394	1,644.09	58
5,396	1,644.70	96
5,398	1,645.31	60
5,400	1,645.92	52
5,402	1,646.53	39
5,404	1,647.14	39
5,406	1,647.75	69
5,408	1,648.36	23
5,410	1,648.97	45
5,412	1,649.58	43
5,414	1,650.19	67
5,416	1,650.80	64
5,418	1,651.41	35
5,420	1,652.02	40
5,422	1,652.63	57
5,424	1,653.24	48

Appendix table 41. Bromine data for the halite bed of cycle 25, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,430	1,655.06	65
5,432	1,655.67	75
5,434	1,656.28	72
5,436	1,656.89	62
5,438	1,657.50	90
5,440	1,658.11	77
5,442	1,658.72	72
5,444	1,659.33	82
5,446	1,659.94	83
5,448	1,660.55	112
5,450	1,661.16	60
5,452	1,661.77	65
5,457	1,663.29	59
5,459	1,663.90	69
5,461	1,664.51	71
5,463	1,665.12	83
5,465	1,665.73	79
5,467	1,666.34	49
5,469	1,666.95	47
5,471	1,667.56	69
5,473	1,668.17	53
5,475	1,668.78	84
5,477	1,669.39	83
5,479	1,670.00	41
5,481	1,670.61	69
5,483	1,671.22	57
5,485	1,671.83	52

Appendix table 42. Bromine data for the halite bed of cycle 26, Gibson Dome No. 1 core.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,499	1,676.10	80
5,501	1,676.70	121
5,503	1,677.31	83
5,505	1,677.92	57

Appendix table 43. Bromine data for the halite bed of cycle 6, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,470	1,972.06	78
6,480	1,975.10	98
6,490	1,978.15	73
6,500	1,981.20	65
6,510	1,984.25	27

Appendix table 43. Bromine data for the halite bed of cycle 6, Lone Dome No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,520	1,987.30	38
6,530	1,990.34	54
6,540	1,993.39	64
6,550	1,996.44	73
6,560	1,999.49	51
6,570	2,002.54	89
6,580	2,005.58	57
6,590	2,008.63	67
6,600	2,011.68	48
6,610	2,014.73	83
6,620	2,017.78	64

Appendix table 44. Bromine data for the halite bed of cycle 7, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,670	2,033.02	118
6,680	2,036.06	102
6,690	2,039.11	101
6,700	2,042.16	100
6,710	2,045.21	100
6,720	2,048.26	91
6,730	2,051.30	94
6,740	2,054.35	84
6,750	2,057.40	105
6,760	2,060.45	85
6,770	2,063.50	85
6,780	2,066.54	68
6,790	2,069.59	76
6,800	2,072.64	75
6,810	2,075.69	62
6,820	2,078.74	46
6,830	2,081.78	64
6,840	2,084.83	51
6,850	2,087.88	61
6,860	2,090.93	66
6,870	2,093.98	59
6,880	2,097.02	56

Appendix table 45. Bromine data for the halite bed of cycle 8, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,910	2,106.17	86
6,920	2,109.22	79
6,930	2,112.26	107

Appendix table 45. Bromine data for the halite bed of cycle 8, Lone Dome No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,940	2,115.31	73
6,950	2,118.36	91
6,960	2,121.41	76

Appendix table 46. Bromine data for the halite bed of cycle 9, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,020	2,139.70	178
7,030	2,142.74	175
7,040	2,145.79	184
7,050	2,148.84	142
7,060	2,151.89	148
7,070	2,154.94	128
7,080	2,157.98	132
7,090	2,161.03	83
7,100	2,164.08	34
7,110	2,167.13	118
7,120	2,170.18	90
7,130	2,173.22	137
7,140	2,176.27	125
7,150	2,179.32	114
7,160	2,182.37	125
7,170	2,185.42	137
7,180	2,188.46	126
7,190	2,191.51	118
7,200	2,194.56	92
7,210	2,197.61	85
7,220	2,200.66	87
7,230	2,203.70	85
7,240	2,206.75	60
7,250	2,209.80	70
7,260	2,212.85	58
7,270	2,215.90	68
7,280	2,218.94	65
7,290	2,221.99	72
7,300	2,225.04	62
7,310	2,228.09	65
7,320	2,231.14	117

Appendix table 47. Bromine data for the halite bed of cycle 10, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,360	2,243.33	132
7,370	2,246.38	123

Appendix table 47. Bromine data for the halite bed of cycle 10, Lone Dome No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,380	2,249.42	114
7,390	2,252.47	98
7,400	2,255.52	109
7,410	2,258.57	81
7,420	2,261.62	74
7,430	2,264.66	68
7,440	2,267.71	58

Appendix table 48. Bromine data for the halite bed of cycle 13, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,610	2,319.53	148
7,620	2,322.58	91
7,630	2,325.62	128
7,640	2,328.67	109
7,650	2,331.72	77
7,660	2,334.77	55

Appendix table 49. Bromine data for the halite bed of cycle 14, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,720	2,353.06	93
7,730	2,356.10	77
7,740	2,359.15	58
7,750	2,362.20	57
7,760	2,365.25	62
7,770	2,368.30	62
7,780	2,371.34	59
7,790	2,374.39	50
7,800	2,377.44	68
7,810	2,380.49	97
7,820	2,383.54	45
7,830	2,386.58	44
7,840	2,389.63	55
7,850	2,392.68	50
7,860	2,395.73	46
7,870	2,398.78	46

Appendix table 50. Bromine data for the halite bed of cycle 16, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,960	2,426.21	107
7,970	2,429.26	98
7,980	2,432.30	95
7,990	2,435.35	82
8,000	2,438.40	132
8,010	2,441.45	78
8,020	2,444.50	46
8,030	2,447.54	45
8,040	2,450.59	59
8,050	2,453.64	60
8,060	2,456.69	23

Appendix table 51. Bromine data for the halite bed of cycle 18, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,150	2,484.12	118
8,160	2,487.17	120
8,170	2,490.22	131
8,180	2,493.26	111
8,190	2,496.31	104
8,200	2,499.36	119
8,230	2,508.50	148
8,240	2,511.55	121
8,250	2,514.60	78
8,260	2,517.65	60
8,270	2,520.70	55

Appendix table 52. Bromine data for the halite bed of cycle 19, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,310	2,532.89	144
8,320	2,535.94	266
8,330	2,538.98	266
8,440	2,572.51	287
8,450	2,575.56	291
8,460	2,578.61	294
8,470	2,581.66	285
8,480	2,584.70	282
8,490	2,587.75	166
8,500	2,590.80	168
8,510	2,593.85	153
8,520	2,596.90	152
8,530	2,599.94	119
8,540	2,602.99	118

Appendix table 52. Bromine data for the halite bed of cycle 19, Lone Dome No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,550	2,606.04	130
8,560	2,609.09	115

Appendix table 53. Bromine data for the halite bed of cycle 20, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,620	2,627.38	126
8,630	2,630.42	134
8,640	2,633.47	155
8,650	2,636.52	165
8,660	2,639.57	164
8,670	2,642.62	137
8,680	2,645.66	153
8,690	2,648.71	154
8,700	2,651.76	125

Appendix table 54. Bromine data for the halite bed of cycle 21, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,730	2,660.90	180
8,740	2,663.95	180
8,750	2,667.00	153
8,760	2,670.05	109
8,770	2,673.10	134
8,800	2,682.24	184
8,810	2,685.29	179

Appendix table 55. Bromine data for the halite bed of cycle 24, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,000	2,743.20	171
9,010	2,746.25	173
9,020	2,749.30	133
9,030	2,752.34	137
9,040	2,755.39	164
9,060	2,761.49	108
9,070	2,764.54	113
9,080	2,767.58	99

Appendix table 56. Bromine data for the halite bed of cycle 25, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,110	2,776.73	100
9,120	2,779.78	100
9,130	2,782.82	93
9,140	2,785.87	87
9,150	2,788.92	125
9,160	2,791.97	84

Appendix table 57. Bromine data for the halite bed of cycle 26, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,220	2,810.26	67
9,230	2,813.30	105
9,240	2,816.35	95
9,250	2,819.40	48
9,260	2,822.45	29
9,270	2,825.50	42

Appendix table 58. Bromine data for the halite bed of cycle 27, Lone Dome No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,310	2,837.69	106
9,320	2,840.74	118
9,330	2,843.78	147
9,340	2,846.83	154
9,350	2,849.88	167
9,360	2,852.93	170
9,370	2,855.98	162
9,380	2,859.02	155
9,390	2,862.07	177

Appendix table 59. Bromine data for the halite bed of cycle 4, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,220	1,591.06	104
5,230	1,594.10	74
5,240	1,597.15	74
5,250	1,600.20	54
5,260	1,603.25	62
5,270	1,606.30	62

Appendix table 59. Bromine data for the halite bed of cycle 4, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,280	1,609.34	78
5,290	1,612.39	62
5,300	1,615.44	74
5,310	1,618.49	74
5,320	1,621.54	62

Appendix table 60. Bromine data for the halite bed of cycle 5, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,350	1,630.68	160
5,360	1,633.73	166
5,370	1,636.78	140
5,380	1,639.82	166
5,390	1,642.87	162
5,400	1,645.92	172
5,410	1,648.97	112
5,420	1,652.02	143
5,430	1,655.06	140
5,440	1,658.11	121
5,450	1,661.16	128
5,460	1,664.21	115
5,470	1,667.26	113
5,480	1,670.30	136
5,490	1,673.35	106

Appendix table 61. Bromine data for the halite bed of cycle 6, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,550	1,691.64	163
5,560	1,694.69	163
5,570	1,697.74	192
5,580	1,700.78	220
5,590	1,703.83	226
5,600	1,706.88	272
5,610	1,709.93	226
5,620	1,712.98	229
5,630	1,716.02	203
5,640	1,719.07	206
5,650	1,722.12	176
5,660	1,725.17	176
5,670	1,728.22	154
5,680	1,731.26	139
5,690	1,734.31	152
5,700	1,737.36	156

Appendix table 61. Bromine data for the halite bed of cycle 6, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,710	1,740.41	148
5,720	1,743.46	156
5,730	1,746.50	152
5,740	1,749.55	146
5,750	1,752.60	152
5,760	1,755.65	150
5,770	1,758.70	140
5,780	1,761.74	132
5,790	1,764.79	133
5,800	1,767.84	136
5,810	1,770.89	148
5,820	1,773.94	160
5,830	1,776.98	182
5,840	1,780.03	166
5,850	1,783.08	182
5,860	1,786.13	168
5,870	1,789.18	210
5,880	1,792.22	166

Appendix table 62. Bromine data for the halite bed of cycle 7, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,910	1,801.37	211
5,920	1,804.42	204
5,930	1,807.46	204
5,940	1,810.51	198
5,950	1,813.56	204
5,960	1,816.61	196
5,970	1,819.66	214
5,980	1,822.70	144
5,990	1,825.75	133
6,000	1,828.80	138
6,010	1,831.85	163
6,020	1,834.90	178

Appendix table 63. Bromine data for the halite bed of cycle 8, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,030	1,837.94	130
6,040	1,840.99	138
6,050	1,844.04	138
6,060	1,847.09	130
6,070	1,850.14	122
6,080	1,853.18	134

Appendix table 63. Bromine data for the halite bed of cycle 8, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,090	1,856.23	114
6,100	1,859.28	121
6,110	1,862.33	111
6,120	1,865.38	110
6,130	1,868.42	102
6,140	1,871.47	108

Appendix table 64. Bromine data for the halite bed of cycle 9, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,180	1,883.66	196
6,190	1,886.71	211
6,200	1,889.76	240
6,210	1,892.81	250
6,220	1,895.86	218
6,230	1,898.90	244
6,240	1,901.95	231
6,250	1,905.00	244
6,260	1,908.05	174
6,270	1,911.10	182
6,280	1,914.14	185
6,290	1,917.19	182
6,300	1,920.24	229
6,310	1,923.29	144
6,320	1,926.34	148
6,330	1,929.38	148
6,340	1,932.43	137
6,350	1,935.48	144
6,360	1,938.53	152
6,370	1,941.58	100
6,380	1,944.62	115
6,390	1,947.67	146
6,400	1,950.72	108
6,410	1,953.77	126
6,420	1,956.82	100
6,430	1,959.86	86

Appendix table 65. Bromine data for the halite bed of cycle 10, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,440	1,962.91	165
6,450	1,965.96	163
6,460	1,969.01	182
6,470	1,972.06	165

Appendix table 65. Bromine data for the halite bed of cycle 10, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,480	1,975.10	182
6,490	1,978.15	160
6,500	1,981.20	163
6,510	1,984.25	172
6,520	1,987.30	138
6,530	1,990.34	134
6,540	1,993.39	126
6,550	1,996.44	123

Appendix table 66. Bromine data for the halite bed of cycle 13, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,680	2,036.06	241
6,690	2,039.11	301
6,700	2,042.16	294
6,710	2,045.21	260
6,720	2,048.26	229
6,730	2,051.30	242
6,740	2,054.35	230
6,750	2,057.40	198
6,760	2,060.45	208
6,770	2,063.50	200
6,780	2,066.54	182
6,790	2,069.59	174
6,800	2,072.64	166
6,810	2,075.69	159
6,820	2,078.74	150
6,830	2,081.78	148
6,840	2,084.83	134
6,850	2,087.88	152
6,860	2,090.93	138
6,870	2,093.98	136
6,880	2,097.02	130
6,890	2,100.07	122

Appendix table 67. Bromine data for the halite bed of cycle 14, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,110	2,167.13	144
7,120	2,170.18	122
7,130	2,173.22	116
7,140	2,176.27	152
7,150	2,179.32	108
7,160	2,182.37	116

Appendix table 67. Bromine data for the halite bed of cycle 14, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,170	2,185.42	97
7,180	2,188.46	94
7,190	2,191.51	89
7,200	2,194.56	84
7,210	2,197.61	78
7,220	2,200.66	94
7,230	2,203.70	86
7,240	2,206.75	70
7,250	2,209.80	76
7,260	2,212.85	66
7,270	2,215.90	76
7,280	2,218.94	70
7,290	2,221.99	42
7,300	2,225.04	54
7,310	2,228.09	42
7,320	2,231.14	54
7,330	2,234.18	58
7,340	2,237.23	78

Appendix table 68. Bromine data for the halite bed of cycle 15, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,350	2,240.28	144
7,360	2,243.33	120
7,370	2,246.38	108
7,380	2,249.42	86
7,390	2,252.47	78
7,400	2,255.52	78
7,410	2,258.57	78

Appendix table 69. Bromine data for the halite bed of cycle 16, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,470	2,276.86	113
7,480	2,279.90	104
7,490	2,282.95	108
7,500	2,286.00	112
7,510	2,289.05	86
7,520	2,292.10	54
7,530	2,295.14	80
7,540	2,298.19	70
7,550	2,301.24	62
7,560	2,304.29	62
7,570	2,307.34	66

Appendix table 69. Bromine data for the halite bed of cycle 16, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,580	2,310.38	62
7,590	2,313.43	86
7,600	2,316.48	62

Appendix table 70. Bromine data for the halite bed of cycle 17, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,620	2,322.58	116
7,630	2,325.62	46
7,640	2,328.67	62
7,650	2,331.72	82

Appendix table 71. Bromine data for the halite bed of cycle 18, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,660	2,334.77	160
7,670	2,337.82	140
7,680	2,340.86	166
7,690	2,343.91	162
7,700	2,346.96	152
7,710	2,350.01	155
7,720	2,353.06	144
7,730	2,356.10	144
7,740	2,359.15	148
7,750	2,362.20	146
7,760	2,365.25	132
7,770	2,368.30	128
7,780	2,371.34	130
7,790	2,374.39	130
7,800	2,377.44	135
7,810	2,380.49	130
7,820	2,383.54	116
7,830	2,386.58	99
7,840	2,389.63	95
7,850	2,392.68	119
7,860	2,395.73	89
7,870	2,398.78	97
7,880	2,401.82	134
7,890	2,404.87	126

Appendix table 72. Bromine data for the halite bed of cycle 19, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,900	2,407.92	208
7,910	2,410.97	205
7,920	2,414.02	205
7,930	2,417.06	246
7,940	2,420.11	222
7,950	2,423.16	229
7,960	2,426.21	274
7,970	2,429.26	188
7,980	2,432.30	166
7,990	2,435.35	214
8,000	2,438.40	172
8,010	2,441.45	182
8,020	2,444.50	188
8,030	2,447.54	198
8,040	2,450.59	166
8,050	2,453.64	218
8,060	2,456.69	208
8,070	2,459.74	210
8,080	2,462.78	214
8,090	2,465.83	62
8,100	2,468.88	62
8,110	2,471.93	74
8,120	2,474.98	70
8,130	2,478.02	62
8,140	2,481.07	71
8,150	2,484.12	82

Appendix table 73. Bromine data for the halite bed of cycle 20, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,200	2,499.36	235
8,210	2,502.41	222
8,220	2,505.46	203
8,230	2,508.50	226
8,240	2,511.55	226
8,250	2,514.60	214
8,260	2,517.65	93
8,270	2,520.70	126
8,280	2,523.74	122
8,290	2,526.79	96
8,300	2,529.84	154

Appendix table 74. Bromine data for the halite bed of cycle 21, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,340	2,542.03	270
8,350	2,545.08	316
8,360	2,548.13	312
8,370	2,551.18	156
8,380	2,554.22	170
8,390	2,557.27	166
8,400	2,560.32	157
8,410	2,563.37	174
8,420	2,566.42	212
8,430	2,569.46	106
8,440	2,572.51	106

Appendix table 75. Bromine data for the halite bed of cycle 23, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,490	2,587.75	111
8,510	2,593.85	78
8,520	2,596.90	98

Appendix table 76. Bromine data for the halite bed of cycle 24, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,530	2,599.94	176
8,540	2,602.99	126
8,550	2,606.04	182
8,560	2,609.09	182
8,570	2,612.14	142
8,580	2,615.18	184
8,590	2,618.23	132
8,600	2,621.28	140
8,610	2,624.33	176
8,620	2,627.38	183
8,630	2,630.42	163
8,640	2,633.47	172
8,650	2,636.52	157
8,660	2,639.57	164
8,670	2,642.62	166
8,680	2,645.66	122
8,690	2,648.71	95

Appendix table 77. Bromine data for the halite bed of cycle 25, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,700	2,651.76	130
8,710	2,654.81	126
8,720	2,657.86	86
8,730	2,660.90	84

Appendix table 78. Bromine data for the halite bed of cycle 26, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,750	2,667.00	112
8,760	2,670.05	108
8,770	2,673.10	86
8,780	2,676.14	104

Appendix table 79. Bromine data for the halite bed of cycle 27, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,790	2,679.19	124
8,800	2,682.24	122
8,810	2,685.29	98
8,820	2,688.34	88
8,830	2,691.38	104
8,840	2,694.43	86
8,850	2,697.48	58

Appendix table 80. Bromine data for the halite bed of cycle 28, Chevron Federal No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,860	2,700.53	108
8,870	2,703.58	93
8,880	2,706.62	74
8,890	2,709.67	78
8,900	2,712.72	66
8,910	2,715.77	82
8,920	2,718.82	54
8,930	2,721.86	66
8,940	2,724.91	50
8,950	2,727.96	62
8,960	2,731.01	70
8,970	2,734.06	62

Appendix table 80. Bromine data for the halite bed of cycle 28, Chevron Federal No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,980	2,737.10	70
8,990	2,740.15	86
9,000	2,743.20	62
9,010	2,746.25	58
9,020	2,749.30	82
9,030	2,752.34	46
9,040	2,755.39	74

Appendix table 81. Bromine data for the halite bed of cycle 4, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,440	1,658.11	72
5,450	1,661.16	83
5,460	1,664.21	73
5,470	1,667.26	61
5,480	1,670.30	65
5,490	1,673.35	53
5,500	1,676.40	31
5,510	1,679.45	50

Appendix table 82. Bromine data for the halite bed of cycle 5, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,550	1,691.64	145
5,560	1,694.69	149
5,570	1,697.74	141
5,580	1,700.78	151
5,590	1,703.83	146
5,600	1,706.88	134
5,610	1,709.93	115
5,620	1,712.98	107
5,630	1,716.02	91
5,640	1,719.07	62

Appendix table 83. Bromine data for the halite bed of cycle 6, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,770	1,758.70	122
5,780	1,761.74	150

Appendix table 83. Bromine data for the halite bed of cycle 6, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
5,790	1,764.79	137
5,800	1,767.84	137
5,810	1,770.89	154
5,820	1,773.94	141
5,830	1,776.98	121
5,840	1,780.03	110
5,850	1,783.08	118
5,860	1,786.13	115
5,870	1,789.18	113
5,880	1,792.22	111
5,890	1,795.27	88
5,900	1,798.32	105
5,910	1,801.37	99
5,920	1,804.42	108
5,930	1,807.46	68
5,940	1,810.51	67
5,950	1,813.56	68
5,960	1,816.61	90
5,970	1,819.66	83
5,980	1,822.70	83
5,990	1,825.75	75
6,000	1,828.80	96
6,010	1,831.85	75
6,020	1,834.90	76
6,030	1,837.94	75
6,040	1,840.99	68
6,050	1,844.04	65
6,060	1,847.09	69
6,070	1,850.14	87
6,080	1,853.18	110

Appendix table 84. Bromine data for the halite bed of cycle 7, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,100	1,859.28	116
6,110	1,862.33	102
6,120	1,865.38	70
6,130	1,868.42	103
6,140	1,871.47	63
6,150	1,874.52	41
6,160	1,877.57	35
6,170	1,880.62	74

Appendix table 85. Bromine data for the halite bed of cycle 8, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,180	1,883.66	64
6,190	1,886.71	50
6,200	1,889.76	23
6,210	1,892.81	45
6,220	1,895.86	17
6,230	1,898.90	38
6,240	1,901.95	48
6,250	1,905.00	55
6,260	1,908.05	72
6,270	1,911.10	52
6,280	1,914.14	45
6,290	1,917.19	45
6,300	1,920.24	35

Appendix table 86. Bromine data for the halite bed of cycle 9, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,360	1,938.53	182
6,370	1,941.58	151
6,380	1,944.62	175
6,390	1,947.67	174
6,400	1,950.72	140
6,410	1,953.77	132
6,420	1,956.82	119
6,430	1,959.86	117
6,440	1,962.91	86
6,450	1,965.96	78
6,460	1,969.01	98
6,470	1,972.06	76
6,480	1,975.10	103
6,490	1,978.15	68
6,500	1,981.20	76
6,510	1,984.25	57

Appendix table 87. Bromine data for the halite bed of cycle 10, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,550	1,996.44	106
6,560	1,999.49	84
6,570	2,002.54	104
6,580	2,005.58	94
6,590	2,008.63	101
6,600	2,011.68	109
6,610	2,014.73	102

Appendix table 87. Bromine data for the halite bed of cycle 10, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,620	2,017.78	105
6,630	2,020.82	81
6,640	2,023.87	94
6,650	2,026.92	82

Appendix table 88. Bromine data for the halite bed of cycle 11, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,700	2,042.16	105
6,710	2,045.21	91
6,720	2,048.26	80
6,730	2,051.30	78
6,740	2,054.35	68
6,750	2,057.40	61
6,760	2,060.45	70

Appendix table 89. Bromine data for the halite bed of cycle 13, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,810	2,075.69	160
6,820	2,078.74	128
6,830	2,081.78	147
6,840	2,084.83	145
6,850	2,087.88	118
6,860	2,090.93	108
6,870	2,093.98	104
6,880	2,097.02	77
6,890	2,100.07	49
6,900	2,103.12	67
6,910	2,106.17	56
6,920	2,109.22	75

Appendix table 90. Bromine data for the halite bed of cycle 14, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
6,970	2,124.46	83
6,980	2,127.50	62
6,990	2,130.55	66
7,000	2,133.60	67

Appendix table 90. Bromine data for the halite bed of cycle 14, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,010	2,136.65	66
7,020	2,139.70	86
7,030	2,142.74	82
7,040	2,145.79	95
7,050	2,148.84	88
7,060	2,151.89	104
7,070	2,154.94	60
7,080	2,157.98	73
7,090	2,161.03	65
7,100	2,164.08	58
7,110	2,167.13	46
7,120	2,170.18	58

Appendix table 91. Bromine data for the halite bed of cycle 16, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,190	2,191.51	106
7,200	2,194.56	93
7,210	2,197.61	75
7,220	2,200.66	78
7,230	2,203.70	36
7,240	2,206.75	45
7,250	2,209.80	31
7,260	2,212.85	35
7,270	2,215.90	34
7,280	2,218.94	49
7,290	2,221.99	35
7,300	2,225.04	75
7,310	2,228.09	83
7,320	2,231.14	92
7,330	2,234.18	68

Appendix table 92. Bromine data for the halite bed of cycle 17, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,360	2,243.33	92
7,370	2,246.38	68
7,380	2,249.42	80
7,390	2,252.47	71

Appendix table 93. Bromine data for the halite bed of cycle 18, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,400	2,255.52	127
7,410	2,258.57	125
7,420	2,261.62	142
7,430	2,264.66	130
7,440	2,267.71	142
7,450	2,270.76	136
7,460	2,273.81	115
7,470	2,276.86	125
7,480	2,279.90	136
7,490	2,282.95	137
7,500	2,286.00	135
7,510	2,289.05	121
7,520	2,292.10	126
7,530	2,295.14	131
7,540	2,298.19	121
7,550	2,301.24	143
7,560	2,304.29	99
7,570	2,307.34	99
7,580	2,310.38	91
7,590	2,313.43	90
7,600	2,316.48	82
7,610	2,319.53	102

Appendix table 94. Bromine data for the halite bed of cycle 19, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,670	2,337.82	231
7,680	2,340.86	239
7,690	2,343.91	262
7,700	2,346.96	275
7,710	2,350.01	269
7,720	2,353.06	264
7,730	2,356.10	224
7,740	2,359.15	220
7,750	2,362.20	153
7,760	2,365.25	142
7,770	2,368.30	185
7,780	2,371.34	205
7,790	2,374.39	158
7,800	2,377.44	182
7,810	2,380.49	204
7,820	2,383.54	188
7,830	2,386.58	159
7,840	2,389.63	175
7,850	2,392.68	188
7,860	2,395.73	209
7,870	2,398.78	210
7,880	2,401.82	142
7,890	2,404.87	141

Appendix table 94. Bromine data for the halite bed of cycle 19, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
7,900	2,407.92	141
7,910	2,410.97	106
7,920	2,414.02	105
7,930	2,417.06	170
7,940	2,420.11	170
7,950	2,423.16	148
7,960	2,426.21	135
7,970	2,429.26	150
7,980	2,432.30	132
7,990	2,435.35	127
8,000	2,438.40	135
8,010	2,441.45	121
8,020	2,444.50	116
8,030	2,447.54	136
8,040	2,450.59	127
8,050	2,453.64	72
8,060	2,456.69	53

Appendix table 95. Bromine data for the halite bed of cycle 20, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,110	2,471.93	173
8,120	2,474.98	169
8,130	2,478.02	169
8,140	2,481.07	172
8,150	2,484.12	175
8,160	2,487.17	193
8,170	2,490.22	177
8,180	2,493.26	186
8,190	2,496.31	178
8,200	2,499.36	168
8,210	2,502.41	167
8,220	2,505.46	151
8,230	2,508.50	123
8,240	2,511.55	118
8,250	2,514.60	117
8,260	2,517.65	72
8,270	2,520.70	81
8,280	2,523.74	57
8,290	2,526.79	100
8,300	2,529.84	117
8,310	2,532.89	143
8,320	2,535.94	124
8,330	2,538.98	128
8,340	2,542.03	96
8,350	2,545.08	76
8,360	2,548.13	109
8,370	2,551.18	51
8,380	2,554.22	49

Appendix table 95. Bromine data for the halite bed of cycle 20, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,390	2,557.27	25
8,400	2,560.32	37

Appendix table 96. Bromine data for the halite bed of cycle 21, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,420	2,566.42	186
8,430	2,569.46	218
8,440	2,572.51	234
8,450	2,575.56	228
8,460	2,578.61	226
8,470	2,581.66	202
8,480	2,584.70	194
8,490	2,587.75	164
8,500	2,590.80	183
8,510	2,593.85	199
8,520	2,596.90	183
8,530	2,599.94	195
8,540	2,602.99	197
8,550	2,606.04	160
8,560	2,609.09	139
8,570	2,612.14	110
8,580	2,615.18	77
8,590	2,618.23	104
8,600	2,621.28	50
8,610	2,624.33	31

Appendix table 97. Bromine data for the halite bed of cycle 22, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,710	2,654.81	117
8,720	2,657.86	115
8,730	2,660.90	112
8,740	2,663.95	124
8,750	2,667.00	102
8,760	2,670.05	85
8,770	2,673.10	71

Appendix table 98. Bromine data for the halite bed of cycle 23, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,780	2,676.14	71
8,790	2,679.19	96
8,800	2,682.24	93
8,810	2,685.29	109
8,820	2,688.34	86
8,830	2,691.38	94
8,840	2,694.43	59
8,850	2,697.48	73

Appendix table 99. Bromine data for the halite bed of cycle 25, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
8,930	2,721.86	56
8,940	2,724.91	44
8,950	2,727.96	42
8,960	2,731.01	73
8,970	2,734.06	72
8,980	2,737.10	49
8,990	2,740.15	59
9,000	2,743.20	63
9,010	2,746.25	67
9,020	2,749.30	54

Appendix table 100. Bromine data for the halite bed of cycle 27, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,060	2,761.49	217
9,070	2,764.54	224
9,080	2,767.58	213
9,090	2,770.63	199
9,100	2,773.68	216
9,110	2,776.73	206
9,120	2,779.78	206
9,130	2,782.82	205
9,140	2,785.87	198
9,150	2,788.92	159
9,160	2,791.97	115
9,170	2,795.02	126
9,180	2,798.06	170
9,190	2,801.11	162
9,200	2,804.16	181
9,210	2,807.21	179
9,220	2,810.26	171
9,230	2,813.30	167

Appendix table 100. Bromine data for the halite bed of cycle 27, Egnar No. 1 cuttings—*Continued.*

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,240	2,816.35	123
9,250	2,819.40	78
9,260	2,822.45	72
9,270	2,825.50	103
9,280	2,828.54	57
9,290	2,831.59	39
9,300	2,834.64	41
9,310	2,837.69	68

Appendix table 101. Bromine data for the halite bed of cycle 28, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,350	2,849.88	193
9,360	2,852.93	175
9,370	2,855.98	167
9,380	2,859.02	168
9,390	2,862.07	167
9,400	2,865.12	59
9,410	2,868.17	61
9,420	2,871.22	150
9,430	2,874.26	170
9,440	2,877.31	23
9,450	2,880.36	53
9,460	2,883.41	45
9,470	2,886.46	53
9,480	2,889.50	50
9,490	2,892.55	49
9,500	2,895.60	38
9,510	2,898.65	39
9,520	2,901.70	40
9,530	2,904.74	35
9,540	2,907.79	41

Appendix table 102. Bromine data for the halite bed of cycle 29, Egnar No. 1 cuttings.

Depth (feet)	Depth (meters)	Bromine content (parts per million)
9,560	2,913.89	24
9,570	2,916.94	49
9,580	2,919.98	28

Appendix table 103. Tabulation of halite beds and average bromine values for samples from five coreholes and for cuttings from three wells in the Paradox Basin.

[Values in parts per million. Leaders (--) indicate no data]

Halite bed	Cane Creek No. 1	Shafer No. 1	Utah No. 2	Elk Ridge No. 1	Gibson Dome No. 1	Lone Dome No. 1	Chevron Federal No. 1	Egnar No. 1
1	--	--	112.6	--	--	--	--	--
2	110.4	--	--	--	--	--	--	--
3	107.6	--	141.7	--	--	--	--	--
4	137.3	87.5	158.7	--	57.8	--	70.9	62.6
5	168.7	147.3	--	--	84.8	--	138.7	124.1
6	--	135.8	--	67.4	181.4	64.3	172.9	99.6
7	--	122.2	--	92.4	105	79.5	182.2	75.7
8	--	99.7	--	--	95.9	85.3	121.5	45.3
9	--	103.3	--	81.5	115.3	105.4	170.8	114.5
10	--	98.3	--	--	111.2	95.2	156.1	96.5
11	--	95	--	--	--	--	--	79
12	--	--	--	--	--	--	--	--
13	--	191.2	--	79.6	199.6	101.3	190.6	102.8
14	--	--	--	--	102.9	60.6	87.7	72.4
15	--	--	--	--	161.4	--	98.8	--
16	--	--	--	117.9	138.4	75	80.5	62.3
17	--	--	--	--	209.3	--	76.5	77.7
18	--	--	--	--	189.9	105.9	132.6	121.6
19	--	--	--	--	155.6	202.2	169	169.2
20	--	--	--	--	78.5	145.9	176.3	123.4
21	--	--	--	--	126	159.8	195	164
22	--	--	--	--	--	--	--	103.7
23	--	--	--	--	--	--	95.7	85.1
24	--	--	--	--	132.6	137.2	156.6	--
25	--	--	--	--	69.6	98.2	106.5	57.9
26	--	--	--	--	85.2	64.3	102.5	--
27	--	--	--	--	--	150.7	97.1	149.8
28	--	--	--	--	--	--	70.7	88.8
29	--	--	--	--	--	--	--	33.7
Grand average	124.3	120.0	137.7	87.8	114.6	104.3	126.7	95.4

Appendix table 104. Bromine data for mineral separates of halite and sylvite from samples of the potash ore zone, halite bed of cycle 5, Texasgulf potash mine, Moab, Utah.

[Bromine values in parts per million]

Feet from top	Meters from top	Halite	Sylvite	Halite:Sylvite
3	0.91	255	1,025	1:4.0
4	1.22	203	1,100	1:5.4
5	1.52	185	1,095	1:5.9
6	1.83	177	1,060	1:6.0
7	2.13	195	1,080	1:5.5

Appendix table 104—*Continued.*

Feet from top	Meters from top	Halite	Sylvite	Halite:Sylvite
8	2.44	185	1,080	1:5.8
9	2.74	272	1,055	1:3.9
10	3.05	230	1,080	1:4.7
11	3.35	250	1,160	1:4.6
12	3.66	265	1,165	1:4.4
13	3.96	215	1,200	1:5.6
14	4.27	245	1,205	1:4.9
15	4.57	205	1,195	1:5.8
16	4.88	222	1,292	1:5.8
17	5.18	207	1,330	1:6.4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