WELL DATABASE OF SALT CYCLES OF THE PARADOX BASIN, UTAH

by Terry W. Massoth and Bryce T. Tripp

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Cover photo: *View from Dead Horse Point of blue solar evaporation ponds for Intrepid Potash's Cane Creek underground solution mine near Moab, Utah. Photo by Jay Hill.*

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WELL DATABASE OF SALT CYCLES OF THE PARADOX BASIN, UTAH

ABSTRACT

Paradox Formation salt cycle top and base depths from more than 600 oil and gas wells within the Paradox Basin of Utah are incorporated into a well data spreadsheet and their distribution shown on an accompanying map. Some data from potash exploration holes were included. Wireline geophysical logs from 174 wells were reviewed and salt cycles correlated following current industry nomenclature. Ancillary location and header data were also included. Data were collected from previous workers, and some data include only the first or uppermost salt cycle encountered in a well. A basin-wide map showing wells included in the well data spreadsheet, and further identifying which wells encountered more than one salt cycle, was generated. Outlines of areas covered by selected past salt and potash studies are also shown on the map.

Purpose and Scope of Project

The purpose of this study was to develop a database of the salt cycles in the Pennsylvanian Paradox Formation of the Hermosa Group from selected wells in the Utah portion of the Paradox Basin.

The scope of the study includes:

1. A spreadsheet of wells penetrating the Paradox salt sequence with depths and tops of correlated individual salt cycles. This spreadsheet is appended as an Excel file.

2. A project map showing well locations, outlines of areas covered by selected past salt and potash studies, the master correlation section location, the land grid, and basic geographic information. This base map is appended as a .pdf file.

INTRODUCTION

Location of Study Area

The study area is the Utah portion of the Paradox Basin, a depositional basin that covers an area of about 12,000 square miles of southeast Utah and southwest Colorado, and which extends a short distance into northwestern New Mexico (figure 1). The study area is sparsely populated with only a few small towns. Access to the basin is fair with major highways crossing the area and an east-west railroad line crossing the northern end of the basin, with a spur extending southeastward along the axis of the basin to the Intrepid Potash mine near Moab, Utah.

Background

In response to a State solicitation for contract proposals from the Utah Geological Survey, the authors submitted a proposal on June 9, 2010, to create a Paradox Basin salt database. The proposal was selected competitively from the proposals received, and was funded under State of Utah Contract number 116047, which was signed in July 2010.

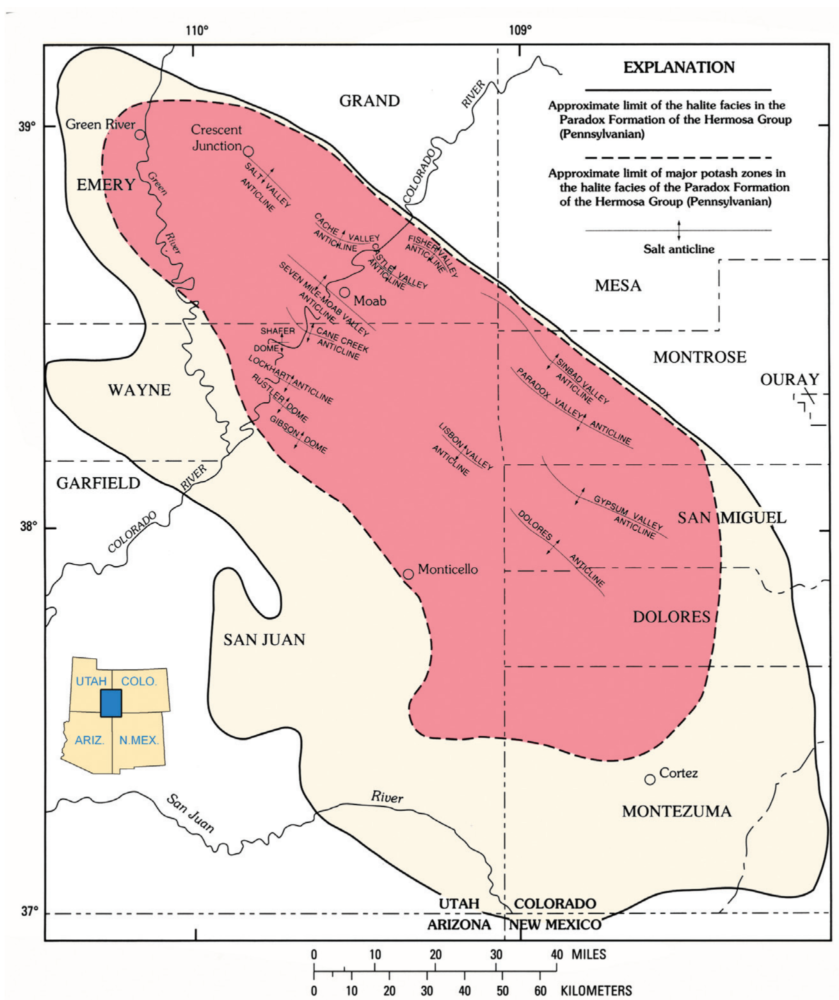

Figure 1. *Paradox Basin location map (after Raup and Hite, 1992).*

3. A final report describing the methodology, problems encountered, recommendations for future work, and references.

The authors primarily used oil and gas well data and down-hole geophysical wireline logs downloaded from the Utah Division of Oil, Gas, and Mining website. Not all oil and gas wells in the Paradox Basin were reviewed; only a geographically distributed subset that were felt to be representative and deep enough to penetrate the full salt section of the basin were examined. Some data were included from potash drill holes, but most of this type of data is confidential and not readily available. The study focused on identifying and correlating depths for up to 29 salt cycle tops and bases. Potash presence is noted as comments in spreadsheet cells, but a thorough investigation of potash present in various salt cycles in the wells was outside the scope of the project. Also, no salt cores were evaluated for the database. All measurements are in feet and miles; no metric conversions are included in the text.

Previous Studies

Geologists and engineers have extensively studied the Paradox Basin due to its interesting geology, oil and gas and potash resources, salt tectonics, and potential for use for high-level nuclear waste disposal. Although there are hundreds of geologic reports and maps for the Paradox Basin, there are only a few that are good basic overviews of the Paradox Basin geology of Utah. These include Elston and Shoemaker (1961), Woodward Clyde Consultants, Inc. (1979), Baars and Stevenson (1981), Doelling (2001), Doelling (2004), Hintze (2005), and Hintze and Kowallis (2009). Good general discussions of the basin's potash resource include Hite (1960), Ritzma and Doelling (1969), Hite and Cater (1972), Hite and Lohman (1973), Britt (1977), Hite and Buckner (1981), and Anderson (2008).

GENERAL GEOLOGY

Thick salt deposits of Middle Pennsylvanian age are present in an area of approximately 12,000 square miles in the Paradox Basin of southeast Utah and southwest Colorado. The salt deposits consist of cyclical sequences of thick halite units separated by thin units of black shale, dolomite, and anhydrite. Over much of the Paradox Basin the salt deposits occur at depths over 5000 feet. Many halite units are several hundred feet thick and locally several contain economically valuable potash deposits, usually in their uppermost levels. The greatest thicknesses of salt and evaporites are found in a trough-like depression bordering the ancestral Uncompahgre uplift (figure 1) along the northeast margin of the basin (Hite and Lohman, 1973).

In the Paradox Basin, a wedge-shaped sequence of sedimentary rocks overlies a basement complex of Precambrian crystalline rocks. Paleozoic and Mesozoic rocks dominate the sedimentary sequence; there are also local Tertiary intrusives as well as Quaternary cover. The units of interest in this study are in the Paradox Formation of the Hermosa Group (figure 2). The Paradox Formation can range in thickness from 500 ft to more than 9000 ft. There

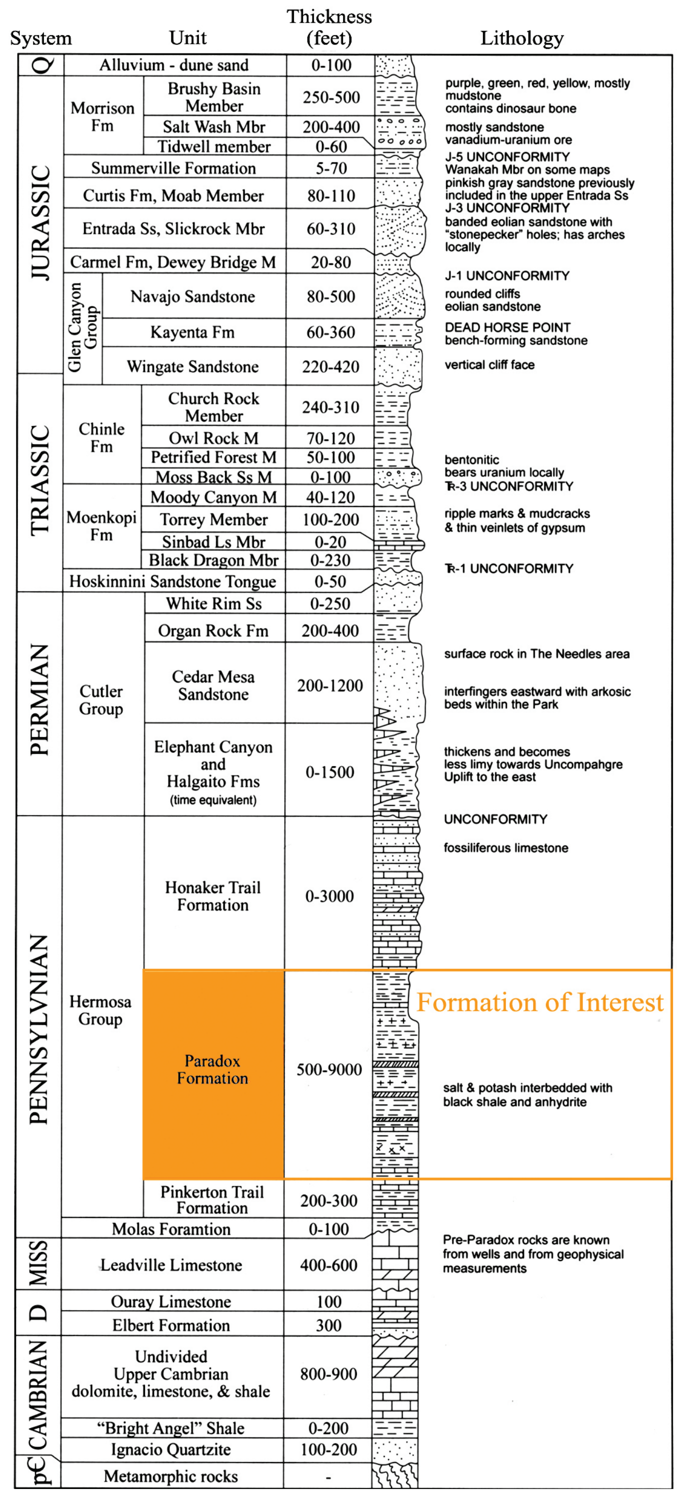

***Figure 2**. Regional stratigraphic column (from Hintze and Kowallis, 2009; used with permission).*

are up to 29 salt cycles in the Paradox Formation, but not all cycles are present at every location. By convention, the cycles are numbered in descending vertical order from surface to depth. Figure 3 shows a detailed version of the Paradox Formation salt cycle stratigraphy.

"Along the northeast margin of the basin, bordering the Uncompahgre uplift, the salt-bearing rocks of the Paradox Formation are faulted down against the Precambrian core of the uplift and covered by a thick wedge of coarse Permian age clastics. The top of the salt in this area is from 14,000 to 15,000 feet below surface. In the rest of the basin depths to the salt average about 5,000 to 6,000 feet, except in salt anticlines where locally it is brought up to within 500 feet of the surface" (Hite and Lohman, 1973).

METHODS

Listed below are the steps followed in this study to compile and organize well and wireline data into the salt cycle well data spreadsheet appended to this report.

1. Select oil and gas wells to be evaluated based on their proximity to "master" wells or cored wells found on cross sections correlated by Hite (Hite, 1960; Hite and others, 1972; etc.), distance from faults and anticlines, and geographical distribution. Determine well API numbers.

2. Go to Utah Division of Oil, Gas, and Mining (DOGM, at http://www.ogm.utah.gov), Oil & Gas Program, LiveData Search, "Well Information," "Formation Tops," insert the well's API number in appropriate box, and click "Submit." (http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/scan_data_lookup.cfm)

Note the depths to the tops of relevant Pennsylvanian and Mississippian age formations. This information is often collected from Well Completion Reports submitted by well operators during the course of filings, and may not necessarily be accurate. Sometimes these tops are actually pre-drilling estimations of formation top depths. All information is in feet. In this study, relevant formation, member, or zone tops are "Hermosa" ("Honaker Trail"), "Paradox," "Molas," "Pinkerton," and "Mississippian" ("Redwall", "Leadville"); others may include "Ismay," "Desert Creek," "Akah," "Barker Creek," and "Alkali Gulch" oil zones. These data reveal if a well was drilled deep enough for evaluation purposes. Note that column headers can be clicked to sort data by depth. Note also that DOGM's UTM coordinate information is in NAD27, not NAD83.

3. Return to DOGM LiveData Search "Main Menu." Click

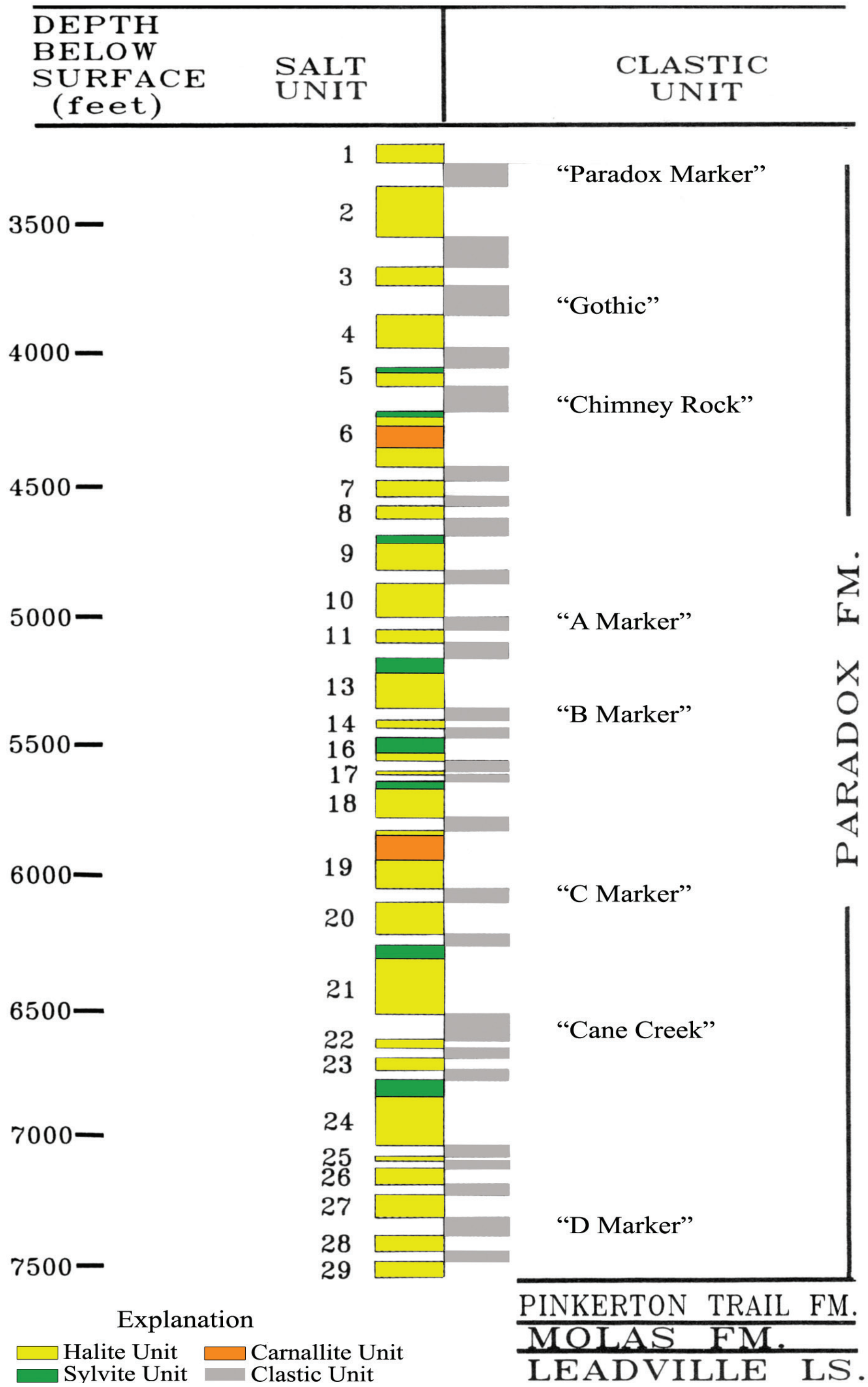

Figure 3. *Detailed salt stratigraphy (after Morgan and others, 1991).*

"Well Logs" tab, "Search Well Logs," insert well API number in appropriate box, click "Submit." Well wireline logs that are in the DOGM scanned system are listed. These are in .tiff format. There are no .las format files available. Not all wells drilled have logs in the system.

Note that the various logs' minimum and maximum logged depths are given. Compare depths to those noted in the Formation Tops step above. Download well log types desired by right-clicking "Download" under the "Available Logs" header. Have a pre-made file directory and file folder ready for this. Navigate to directory and folder, and label file with API number and log type for ease in follow-on work (e.g., 4303716238-Sonic). For salt evaluation work, the natural gamma, density, sonic, neutron, and sample wireline well logs are valuable and should be acquired.

4. Open the well wireline log in an appropriate viewing software package. Weatherford's "PreView" free, downloadable software was used for this project (version 11.01.1863 dated June 29, 2010, Weatherford International Ltd., www.weatherford.com). In PreView, logs can be depth registered, text can be added, and marker or correlation lines can be annotated. Multiple versions of the software can be run side-by-side on a monitor to aide in on-screen correlations. If one is an expert in log interpretations and fully knowledgeable of the salt cycles of the Paradox Basin, this method of cycle recognition and correlation work may be useful.

However, the authors' preferred method was to print paper copies of the logs, and correlate them by placing logs physically side-by-side for visual comparisons. Printing was easy with the Weatherford "PreView" software; clicking "File" and "Print Preview" allows one to select individual pages or ranges of pages to print, and also allows for scaling of the printed logs. A printed scale of 1 inch = 100 feet was used in this study. For some logs the "Settings" button needs to be clicked and "Log Height" adjusted in order for the logs to print to the scale desired. After printing, the pages can be taped together with suitable overlap.

5. Inspect the selected well wireline log and compare it to logs from adjacent wells, especially if those adjacent logs have been previously correlated and completed satisfactorily. Especially helpful are well logs that have been vetted in published literature, or analyzed by knowledgeable specialists in the field, or are from wells for which core was also available.

This study used well log and cross sections interpreted and correlated by Robert Hite (Hite, 1960; Hite and others, 1972) as a reference to make subsequent correlations for other wells. We often first focused on locating and correlating major shale marker beds ("Gothic," "Chimney Rock," "Marker A," "Marker B," "Marker C," "Cane Creek," "Marker D") within well logs, and afterward identifying the salt cycles between the marker beds. The marker beds usually display a gamma-ray log kick that wraps around off-scale not to be confused with potash beds which can exhibit similar kicks. A few other minor, yet seemingly widespread, thin marker beds were noted in the Paradox Formation sequence, especially in salts 10 and 18, and between salts 18 and 19.

In an effort to help minimize correlation errors, an initial "master section" trending northwest-southeast through the central portion of the basin was created consisting of only Hite-correlated well logs (see Appendix A project map). Especially helpful were wells studied by Hite and others (1972). Next, wells located approximately along this trend and between those Hite wells were correlated to the Hite wells. Finally, other wells located farther off this master section were correlated back to the original Hite wells.

6. Compare logs to the idealized Paradox salt sequence. Figure 6 of Morgan and others (1991) is a good, simplified stratigraphic guide to follow when working on well logs. If no structural complications are present, then the regular sequence of salt cycles should be present in the order shown, along with intervening shale-dolomite-anhydrite marker beds, which were laid down under shallow marine to marginal marine, low-energy depositional conditions. Some salt cycles (especially the lower salts) may thicken, thin, or be absent due to paleotopography or diagenetic conditions. Some upper salt cycles may not be present due to diagenetic conditions (dissolution of salts and conversion to anhydrite).

7. Look for features characteristic of individual salt cycles. Some general and some more specific observations concerning log responses or characteristics of different salt cycles follow.

Most salt cycle tops and bottoms appear "blocky" in gamma-ray and sonic wireline log responses, with no apparent "fining upward" or "coarsening upward" log patterns.

Potash beds are found at or near the top of salt cycles 5, 6, 9, 13, 16, 18, 19, 20, 21, 22, and 24. A major carnallite "marker" zone is in the middle of salt 6. Potash bed identification was not the focus of this study, but potash comments are included in the spreadsheet.

The top of a salt cycle in this study is defined as the top (uppermost) halite in the cycle's lithology, not the top anhydrite in the sequence, if an anhydrite is present. Similarly, the base of a salt cycle is the lowest halite in the cycle, not including any adjacent lower anhydrite.

• Salt cycle 1 (S1) is usually not present.

• The so-called "Paradox Marker" bed or zone is a persistent shale zone (high natural gamma kick) between salt cycle 1 (S1) and salt cycle 2 (S2).

• S2 is usually the uppermost salt present. It is often an anhydrite, or partially so.

• S3 often has a few distinctive, approximately 5-ft-thick, moderate gamma-ray kicks in its upper portion that become recognizable with study of multiple wireline logs. S3 may consist entirely of anhydrite, or only its upper and/or lower portions. This is the first salt above the “Gothic Shale” marker.

• S4 thickens and thins throughout the basin and is not too distinctive. Often the upper 20 ft may be an anhydrite.

• S5 may contain a major sylvite bed (potash bed which displays a “strong” gamma-ray log kick) near its top, from a few feet to up to 20 ft or more thick. This is the first salt above the “Chimney Rock” marker.

• S6 usually contains the diagnostic “Carnallite Marker Bed” (which displays a “weak” gamma-ray log kick), which is from 20 to 80 ft thick (often up to 100 ft thick) and is present in the middle of S6. Thin potash beds may be present near the top of S6.

• Salt cycles 7 and 8 often appear almost merged, with only a very thin non-salt bed separating them. They could be considered a couplet or “twins”.

• Salt 9 may contain a major sylvite bed near its top, from 5 to 50 ft thick, and may also contain an additional carnallite zone.

• Salts 10 and 18 often have a distinctive, higher natural gamma-ray log spike near their mid points. These spikes are usually thin (5 to 10 ft maximum) yet seemingly regional shale partings. They are often very diagnostic of these two salt cycles.

• Salt cycles 11, 12, 14, and 15 may be thin, or discontinuous throughout portions of the basin. Portions of their beds may consist of anhydrites.

• S11 is the first salt below the “A Marker” and is usually nondescript.

• S12 is often absent, or is thin and may consist of anhydrite.

• S13 often displays multiple beds of thin to moderately thick “mixed” potash, described in literature as a mixture of sylvite, halite, and carnallite. This potash zone is encountered from the middle to the top of S13, and can reach from 25 ft to 75 ft thick.

• S14 is the first salt below the “B marker”, and is usually nondescript.

• S15 is often nondescript.

• S16 often has a carnallite zone (weak to modest, higher natural gamma-ray log signature) in its middle, from 25 ft to 100 ft thick.

• S17 is usually rather thin.

• S18 often has potash near its top, sometimes in two distinctive beds separated by halite. The potash is usually described as sylvite, and is from 7 ft to 80 ft thick. It also has a weak but distinctive natural gamma-ray log spike near its center, probably a thin but regionally significant shale parting.

• S19 often has potash near its top, usually described as sylvite, from 25 ft to 200 ft thick.

• S20 is the first salt below the “C Marker”, and is usually nondescript.

• S21 often contains a substantial potash zone (up to 100 ft thick in its middle or near its top). This is the first salt above the “Cane Creek Marker Bed.”

• Salts below (deeper than) the Cane Creek Marker Bed are usually much harder to correlate, probably due to sporadic in-filling of basin paleotopographic lows, and the on-lap and off-lap nature of these salt cycles. Salt cycle correlations below the Cane Creek Marker Bed are difficult and unreliable; therefore, less time was expended on correlating those beds, especially because salt or potash resources are much less economic at greater depth.

• Salt cycles 22 through 25 may be thin or discontinuous throughout portions of the basin, and often show as couplets or “twins”.

• Salt cycles 26 through 29 were rarely present, and are the most difficult cycles to correlate.

Table 1 lists minimum, average, and maximum salt and interbed thickness derived from the well data spreadsheet.

8. Daniels and others (1980), Figure 7 of BPB Instruments (1981), and Nelson (2007) give good discussions on wireline logging responses for interpreting evaporite deposits. Table 2 is a synthesis of parameters from these references.

As this study was a first-pass through several hundred logs from oil and gas wells and potash exploration holes, lengthy examinations of log responses were not possible or practical. Instead, salt cycles were quickly established, usually from visual inspection of a single log, although there may be multiple logs available, either from DOGM or from log vendors, for each well. Also, in some locations, numerous wells can be closely spaced.

From this study, Paradox halite displays near-baseline (essentially zero) natural gamma-ray log signatures (low content of naturally occurring radioactive components); seem to lie in the 65-70 microsecond/ft range (67 on average) on sonic logs; have very high resistance values (so resistivity or laterolog curve deflections should be well to the right); have high neutron log responses (low water contents); and, if a true density log is available, halite density is close to 2.16g/cc.

9. Annotate the paper wireline logs in pencil, marking the various salt cycles and marker beds. Lightly color known or suspected potash beds with red pencil on the gamma-ray log curve.

10. Compile the oil and gas well data, or potash exploration hole data, into a single, flat Excel spreadsheet. Table 3 lists the categories of data used in this study.

Table 1. *Paradox Formation salt cycle and interbed thickness statistics.*

Salt	Minimum	Average	Maximum	Interbed	Minimum	Average	Maximum
S1	20	87	267	S1 to S2	40	85	190
S2	10	168	760	S2 to S3	15	80	300
S3	5	73	288	S3 to S4	20	74	270
S4	5	70	210	S4 to S5	9	43	225
S5	5	113	855	S5 to S6	18	75	242
S6	25	228	483	S6 to S7	5	25	75
S7	20	81	170	S7 to S8	4	10	40
S8	5	54	175	S8 to S9	10	45	135
S9	15	126	365	S9 to S10	10	43	160
S10	15	139	940	S10 to S11	5	35	132
S11	5	56	2940	S11 to S12	2	18	65
S12	5	15	65	S12 to S13	6	24	90
S13	40	141	580	S13 to S14	5	27	70
S14	5	68	330	S14 to S15	3	18	110
S15	5	49	775	S15 to S16	3	21	85
S16	15	133	297	S16 to S17	5	17	55
S17	5	39	315	S17 to S18	2	10	110
S18	90	243	835	S18 to S19	3	19	610
S19	11	244	1055	S19 to S20	5	48	245
S20	10	102	318	S20 to S21	4	21	180
S21	5	225	1820	S21 to S22	25	90	265
S22	5	46	300	S22 to S23	5	17	60
S23	5	60	265	S23 to S24	4	22	125
S24	10	86	485	S24 to S25	5	17	150
S25	10	50	115	S25 to S26	5	30	170
S26	20	78	240	S26 to S27	5	30	225
S27	10	130	834	S27 to S28	15	42	155
S28	15	120	240	S28 to S29	13	84	256
S29	21	108	204				

Table 2. *General log responses and characteristics of evaporite rock sequences.*

Rock/ Mineral	Density	Natural Radio-activity	Gamma Ray Response	Water Content	Neutron Response	Sonic Response	Sonic Actual	Resistivity Response
	g/cc	relative	relative	relative	relative	relative	ms/ft	relative
Anhydrite	2.96	None	Low	Very low	High	High	52	High
Halite	2.16	None	Very low	Very low	High	Low	67	High
Sylvite	1.99	Very high	Very high	Low	High	High		Low
Carnallite	1.61	Low	Intermed	High	Intermed	High		Low
Shale	2.2–2.6	High	High	Intermed	Low	Low		Low
Dolomite	2.87	None	Low	Low	High	Intermed		Variable
Limestone	2.2–2.6	None	Low	Low	High	Intermed		Variable
Gypsum	2.32	None	Low	Intermed	Low	Low		High

In the spreadsheet, each row or line (record) contains data for an individual well; each column (field) is a particular attribute or characteristic related to a well, or salt contained in it. Columns also show relevant header and location information, references, and depth data related to salt tops and bottoms for all salt cycles and intervening non-salt units.

Table 3. *Drill data categories used in this study.*

	Oil & Gas wells		Potash Exploration holes	
County	Spread-sheet	Printed logs	Spread-sheet	Printed logs
Emery	17	15	0	0
Grand	184	88	56	0
San Juan	403	71	51	0
Wayne	2	0	0	0
Totals	606	174	107	0

Often, the top and base of salts were nominally estimated to the nearest five foot depth interval for this study. Suspected potash zones within the salt cycles were noted on the paper logs as comments in the appropriate cells of the spreadsheet. Many of the potash observations were taken from a study by Britt (1977).

RESULTS

A simple though extensive well data spreadsheet (in Excel format) was created with depths and elevations for the top and base of salt cycles of the Paradox Formation in the Utah portion of the Paradox Basin. More than 600 oil and gas wells and more than 100 potash exploration holes are incorporated into the spreadsheet, and their distribution is shown on the accompanying map.

Wireline geophysical logs from 174 oil and gas wells were reviewed and salt cycles correlated following Hite's salt cycle nomenclature. Salt cycle data were collected from previous studies, some of which include only the depth of the first or uppermost salt cycle encountered.

A basin-wide map displaying which wells were included in the spreadsheet, and further identifying which wells encountered one or more salt cycles, is provided. Outlines of areas covered by selected past salt and potash studies are also shown on the map.

Some problems were encountered during this project, and they are listed below:

• The DOGM well database is incomplete; there are several instances of known oil and gas wells not currently listed in the DOGM online database. Additionally, not all publicly available geophysical well logs are in the DOGM online database. The authors tracked down some logs available via private vendors, but did not acquire them due to budget constraints.

• In the accompanying well data spreadsheet, several fields for multiple records could not be populated completely, as information from either DOGM or the log header was missing. Examples of some missing data are: UTM coordinates (rare); quarter-quarter section designations; total depths; or ground, Kelly bushing, or derrick floor elevations. Additional time to search for and fill in such missing data was deemed unfeasible.

• Some salt cycles are thickened or repeated by flowage, folding, or faulting, and the spreadsheet does not adequately capture where salt thicknesses are anomalous, as this was outside the scope of the project.

• Many salt cycles were found to have anhydrite layers either directly above, directly below, or both above and below the main halite bed of a particular salt cycle. This is especially apparent for cycles 2 through 4, 11 and 12, and for several salt cycles below the Cane Creek Marker Bed. Some previous workers include these anhydrite layers with the halite and reference the anhydrite's top (or base) as the top (or base) of a salt cycle. This study's spreadsheet only uses the salt as the beginning and end of a cycle.

• Correlations of salt cycles below the Cane Creek Marker Bed are difficult and may be unreliable.

• Some comments for data cells in the spreadsheet do not display fully when "mousing" or "cursoring" over them. The authors are not sure of the cause, and do not know of a "universal" fix for viewing all such comments.

RECOMMENDATIONS

• Approximately 25 oil and gas wells identified within UGS in-house databases for San Juan County could not be completed during this study. Data from wireline logs for these 25 wells could be compiled and incorporated into the project spreadsheet in the future.

• The DOGM well database for this study was downloaded on July 8, 2010. There are no doubt additional oil and gas wells drilled in the Paradox Basin since then. Data from these newer wells could be compiled and incorporated into the well data spreadsheet.

• There are dozens of additional oil and gas wells in Grand and San Juan Counties that could be incorporated into the well data spreadsheet. Consultation with UGS staff could develop a list of additional wells to study and add.

• Searches could be made via private data vendors for select wells not in the DOGM database. For important wells without adequate DOGM coverage, purchase of a small number of significant logs could be warranted.

• Consideration should be given to evaluating well logs in Colorado adjacent to the Utah border to aid in correlation and future contouring efforts. Strategically located wells within a buffer of 3 to 6 miles could be considered for incorporation into the well data spreadsheet.

• A multitude of interpreted maps can be generated from the data within the database spreadsheet. A few maps to consider might be:

> isopach map of the entire Paradox Formation salt package

> isopach maps of individual salt cycles

> isopach maps of interburden intervals between individual salt cycles

> structure contour map on the top of the uppermost Paradox Formation salt cycle

> structure contour maps on the tops (or bases) of individual salt cycles

> overburden map to the top of the uppermost Paradox Formation salt

> overburden maps on the tops (or bases) of individual salt cycles

• With an appropriate cross-section generating program, a few stratigraphic and/or structural cross sections could be prepared depicting key parts of the Paradox Basin.

• Additional study of the wells in the current database to identify the location and thickness of potash beds on the well wireline logs is warranted. Estimates of potash bed grade could be made with reference to a log's natural gamma ray deflections and the log's scaling. If enough wells with both potash core chemical analyses and gamma ray wireline logs can be located and studied in the Paradox Basin, a basin-specific correlation or cross plot might be possible of gamma ray log response versus K_2O content.

ACKNOWLEDGMENTS

Initial lists of candidate oil and gas wells and the general spreadsheet format were obtained from Utah Geological Survey (UGS) files of David Tabet and Craig Morgan. Digital wireline logs for this study were obtained predominantly from the Utah Division of Oil, Gas, and Mining (DOGM). Our present study benefited greatly from previous work or permission to use interpretations of salt cycles from logs from Robert Hite, Terry Britt, Paul Anderson, and Tom Faddies.

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Well Database of Salt Cycles of the Paradox Basin, Utah
Base Map
EXPLANATION
Oil and gas wells (DOGM), unclassified
Well with no salt data
Well with data on only salt top and/or base
Well with data on one or more salt cycles
Approximate limit of salt facies of Paradox Fm.
Approximate limit of major potash zones in salt facies of Paradox Fm.
Master correlation section following R. Hite well selections
Published detailed mapping related to salt, potash, or oil and gas (see explanation to right)
Base: UTM Zone 12, NAD83. Boundary tics in meters. Utah Automated Geographic Reference Center (AGRC) GIS data Wells: Div. of Oil, Gas and Mining (DOGM) data, 08July2010
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May 2011
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Published detailed mapping related to salt, potash, or oil and gas
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11 Lisbon Valley potash project | Behre Dolbear & Co., 1962 | Plate 3
12 San Juan-Dolores-Montezuma area | Hite, 1978a | Figure 1
Master correlation section following R. Hite well selections
Intrepid Potash workings
CARBON
EMERY
UINTAH
GRAND
WAYNE
GARFIELD
SAN JUAN
KANE
WELLINGTON
SUNNYSIDE
CEDAR
WOODSIDE
GREEN RIVER
CRESCENT JUNCTION
SEGO
CISCO
WESTWATER
CASTLE VALLEY
MOAB
HANKSVILLE
LA SAL JUNCTION
LA SAL
MONTICELLO
BLANDING
TICABOO
HALLS CROSSING
BLUFF
MONTEZUMA CREEK
ANETH
LITTLE WATER
SCALE
1 : 200,000
0 1 2 3 4 5 6 7 8 9 10 miles
0 1 2 3 4 5 6 7 8 9 10 kilometers