Structure contours on Bone Spring Formation (Lower Permian), Delaware Basin

By

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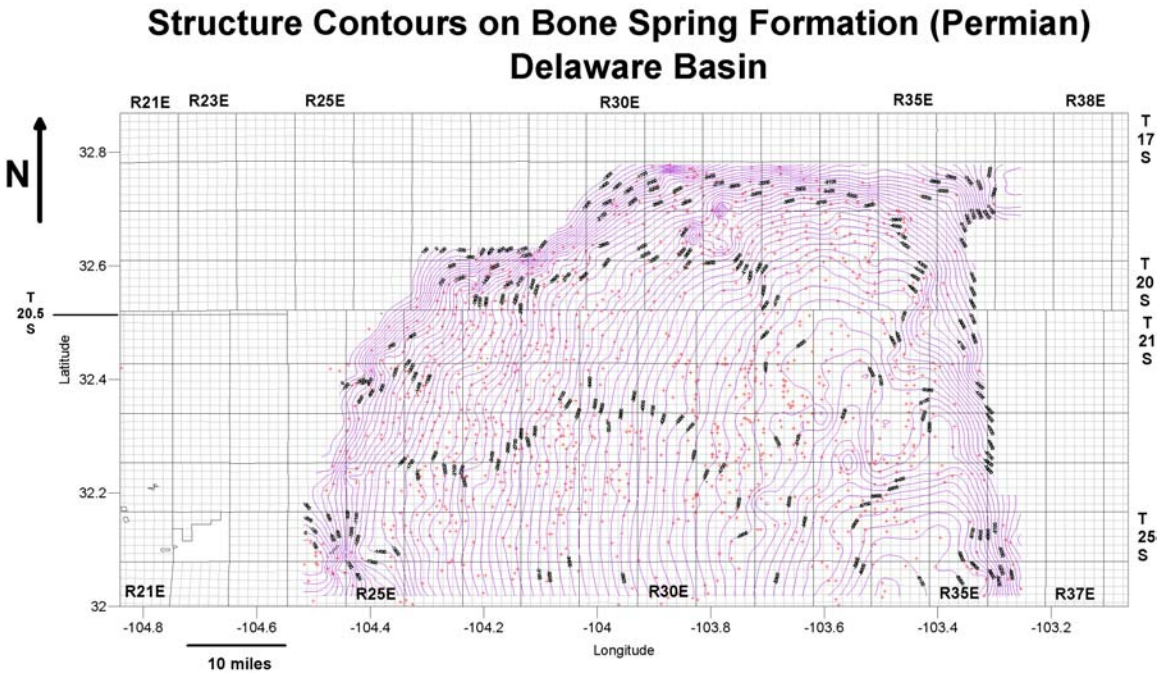

Open file report 488

New Mexico Bureau of Geology and Mineral Resources
A division of New Mexico Tech
Socorro, NM 87801

Dr. Peter A. Scholle, Director

October 2005

Project in cooperation with New Mexico State Land Office
The Honorable Patrick Lyons, Commissioner of Public Lands

INTRODUCTION

This open-file report contains a digital structure contour map of the upper surface of the Bone Spring Formation: (Lower Permian) in the Delaware Basin, southeastern New Mexico (Figures 1, 2, 3). This project was undertaken at the request of the New Mexico State Land Office and was funded by the New Mexico State Land Office.

This open-file report has three parts:

1. This pdf document that discusses the report, the digital database of well data, well location methodology, correlation of the top of the Bone Spring Formation, contouring methods, and the various methods available to view the structure contour map.
2. A digital database of 1048 wells, including well locations, depth to the Bone Spring in each well, surface elevation of each well, and the subsea elevation of the Bone Spring in each well.
3. The structure contour map on the upper surface of the Bone Spring, which is presented in four different formats: a large pdf image with a 25 ft contour interval, a small pdf image with a 100 ft contour interval, an ArcReader project, and an ArcMap project.

The structure contour map of the top of the Bone Spring Formation was constructed using the structural elevation of the upper surface of the Bone Spring in 1048 wells that cover a 3500 mi^2 area in southeastern New Mexico. Contours were made with a modern digital contouring program (*Surfer 8*, a product of Golden Software, Inc.). The database of wells and structural elevations is presented in this report in Microsoft Excel format so that the reader has the ability to plot the wells and structural data, and make contours on his/her own using different techniques and software than used for this project. The user also has the freedom to add additional well data to the database.

THE BONE SPRING STRUCTURE DATABASE

The Bone Spring structure database (*Bone Spring structure data.xls*) is presented on this CD in Microsoft Excel format. For each of the 1048 wells in the database, there are 18 data fields that pertain to the description of each well, its location, and the subsea

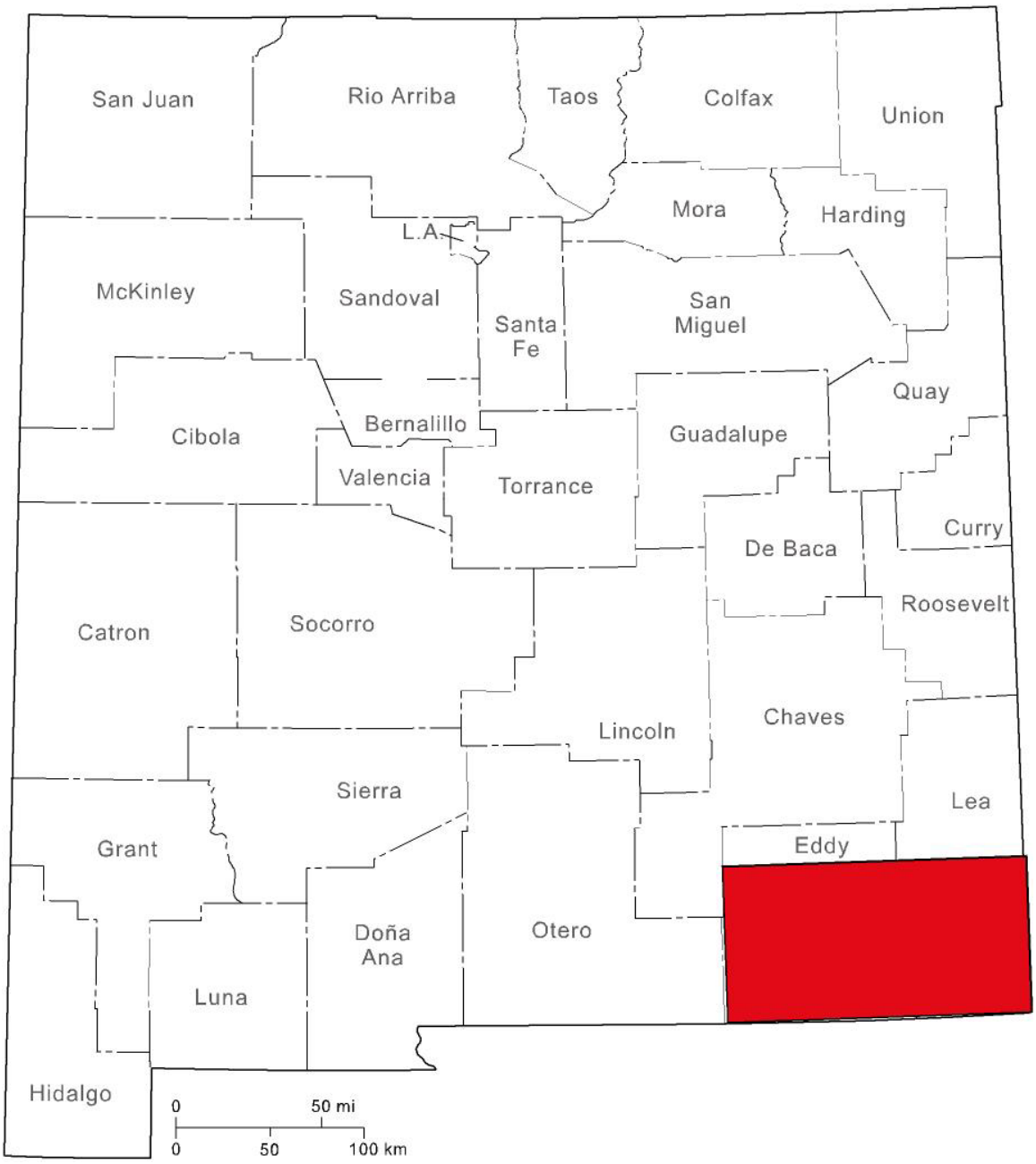

Figure 1. Location within New Mexico of structure contour map produced for this report.

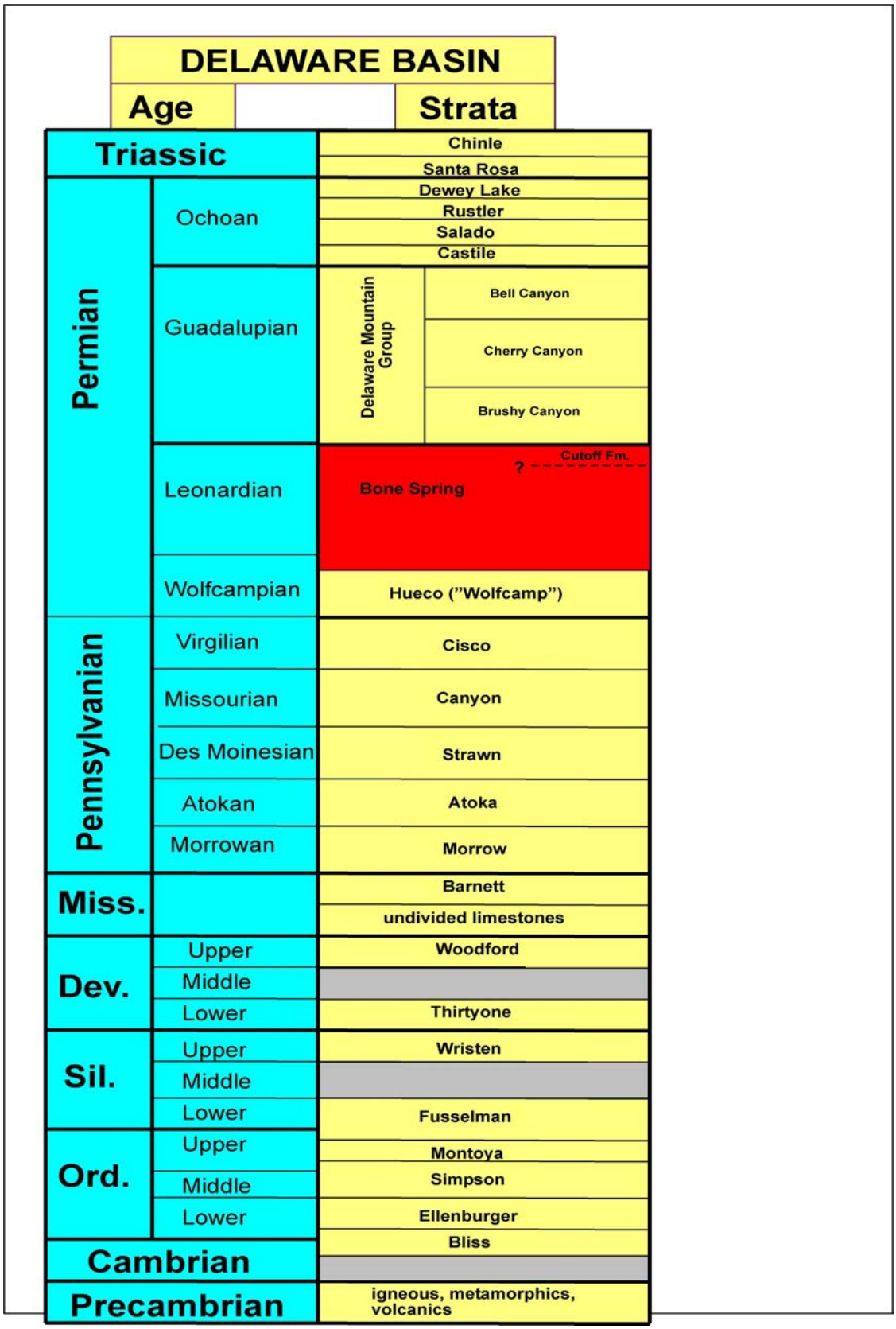

Figure 2. Stratigraphic column of Phanerozoic sedimentary rocks in the Delaware Basin. Bone Spring Formation shown in red.

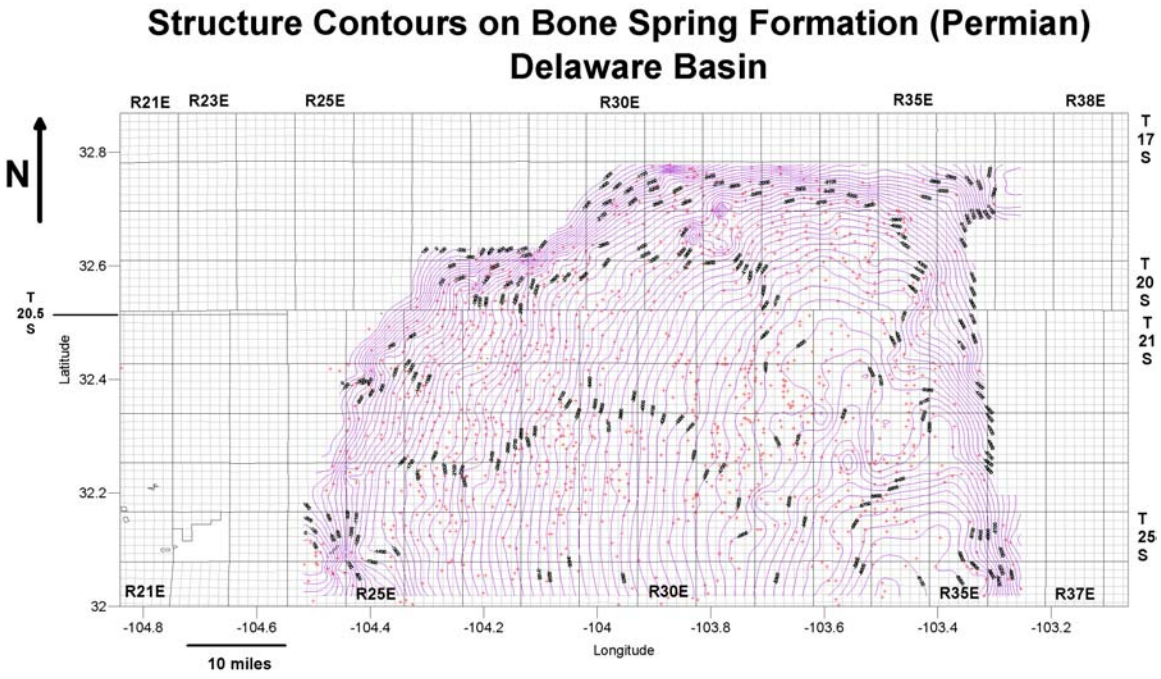

Figure 3. Structure contours on upper surface of Bone Spring Formation, Delaware Basin.

(or structural) elevation of the upper surface of the Bone Spring Formation in each well.

The data fields are described below.

Operator: The name of the company that drilled the well.

Lease name: The name of the lease the well was drilled on.

Well number: The number of the well in the lease.

API number: The unique API well number, if present in the well files of the New Mexico Bureau of Geology and Mineral Resources.

Township (south): The township, south of the regional base line, in which the well is located.

Range (east): The range, east of the New Mexico Principal Meridian, in which the well is located.

Section: The section within the township and range, specified above, in which the well is located.

Footage FNL: The location of the well in feet from the north boundary of the section.

Footage FSL: The location of the well in feet from the south boundary of the section.

Footage FEL: The location of the well in feet from the east boundary of the section.

Footage FWL: The location of the well in feet from the west boundary of the section.

Longitude: The longitude of the well, in decimal degrees. See section on *Well locations* in this report to find out how longitude was calculated.

Latitude: The latitude of the well, in decimal degrees. See section on *Well locations* in this report to find out how latitude was calculated.

Elevation: The surface elevation of the well in feet above sea level.

Total depth: Total depth of the well, in feet.

Top Bone Spring (ft): Depth to the top of the Bone Spring Formation, in feet.

Bone Spring subsea elevation (ft): The subsea (or structural) elevation of the upper surface of the Bone Spring Formation was calculated by subtracting the depth to the top of the Bone Spring Formation from the surface elevation of the well.

Source Bone Spring top:

Scout ticket = the depth to the top of the Bone Spring Formation was obtained from well records on file at the New Mexico Bureau of Geology and Mineral Resources.

Log correlation = the depth to the top of the Bone Spring Formation was determined by correlating geophysical borehole logs and/or sample logs on file at the New Mexico Bureau of Geology and Mineral Resources.

WELL LOCATIONS

Well locations in the Bone Spring structure database are provided in both section-township-range format and in latitude-longitude format. Section-township-range format is the legal surveyed well location and is provided with every well record; this is the location used in every well permit. A location in latitude-longitude format is necessary to plot wells on a map using a computer and to perform contouring with a computer.

Latitude and longitude were calculated from the section-township-range coordinates at the New Mexico Bureau of Geology and Mineral Resources using the Geographix Exploration Program (a product of Landmark Graphics) and the Whitestar Corporation digital land grid of New Mexico (1997 version). This method allows translation of section-township-range coordinates into latitude-longitude coordinates based on the 1927 North American datum. In general, wells located with our version of the Whitestar land grid appear to plot within 250 feet of the surveyed locations on a 1:24,000 topographic map. In general, these locations will be accurate to at least the

nearest quarter-quarter-quarter section. This is sufficient accuracy to produce a valid structure contour map on a basinal scale with a maximum well density of one well per section.

DETERMINATION OF DEPTH TO TOP OF BONE SPRING FORMATION

The database contains values for depth to the upper surface ("top") of the Bone Spring Formation for 1048 wells. Of these, tops for 7 wells were obtained from well records on file at the New Mexico Bureau of Geology and Mineral Resources. Tops for 1041 well were obtained by correlating geophysical borehole logs and, where available, sample logs. Therefore, 99.3% of the Bone Spring tops were the result of correlations made with well logs. Approximately one-half of the log correlations were made explicitly for this project. The other one-half of log correlations were made for work on an earlier project funded by the U.S. Department of Energy (Risk Reduction with a Fuzzy Expert Exploration Tool – U.S. Department of Energy (DOE) Contract with New Mexico Tech DE-AC-26-99BC15218); Heidi Justman, formerly a geology graduate student at New Mexico Tech and now matriculated, correlated a number of the wells in the earlier DOE-funded project and her efforts are gratefully acknowledged.

Bone Spring tops listed in well records are not always coincident with Bone Spring tops correlated for this project. There are several reasons for the differences between reported and correlated tops. Some differences are systematic and result from the placement of the top of the Bone Spring at different stratigraphic positions by different workers. In most places within the Delaware Basin, the top of the Bone Spring is marked by the boundary between the dark micritic limestones of the upper Bone Spring and the sandstones, siltstones, and shales of the overlying Brushy Canyon Formation of the Delaware Mountain Group. In many places in the central, northern, and western parts of the study area, this boundary is sharp and easily correlatable. Towards the southeast, however, the boundary is less distinct and is perhaps in places conformable and gradational. The upper Bone Spring section appears to thicken to the southeast as a wedge of sediments that is not present to the north and west. Tyrell (2002) indicates the top of the Bone Spring on electric logs in portions of the basin and would place a portion of what is correlated as the uppermost Bone Spring in this report within the Cutoff Formation. For this report, strata that Tyrell (2002) indicated as correlatable with the

Cutoff Formation in the deep Delaware Basin are placed within the Bone Spring and not recognized as a separate stratigraphic entity because lithology and well log characteristics are similar to the characteristics of underlying Bone Spring strata. In addition, most industry geologists do not recognize the Cutoff as a separate stratigraphic entity and the term Cutoff is rarely present on scout tickets and completion reports.

CONTOURING METHODS

The structure on top of the Bone Spring Formation was contoured digitally using *Surfer 8*, a modern digital contouring program (*Surfer 8* is a registered trademark of Golden Software, Inc.). Gridding of the well data, provided in the Excel spreadsheet on this CD, was done in Surfer using the point kriging method with default parameters. The gridded data were then contoured at 25 ft and at 100 ft contour intervals. For both the 25 ft and 100 ft contour-interval maps, the contours were smoothed with the high smoothing option in order to remove the straight-line aspects of contours that are made without the smoothing option. Although smoothing results in contours are more rounded and look more natural, this option can locally cause contour lines to cross over each other in areas where contour spacing is very close. Once the contours were made in Surfer, they were exported to ArcMap for use in the GIS projects.

One of the drawbacks to the kriging method in the gridding of data is that the method can extrapolate structural elevation values beyond the known range of values, thereby producing a map that in places may have unrealistically high or unrealistically low contours. However, kriging generally minimizes this effect compared to other gridding techniques and generally results in contours that more closely approximate a good hand-contoured map than other gridding techniques. Kriging also attempts to minimize bulls eye patterns in the data and will attempt to connect isolated high points along ridgelines, thereby expressing trends between data points (Golden Software, Inc., 2002).

ACCESSING THE MAPS

The structure contour map of the upper surface of the Bone Spring Formation is presented in three formats for your use.

1. **Pdf format.** This format may be viewed on any computer that has Adobe Acrobat Reader installed and is a fixed map that cannot be modified or overlain on other maps. Two versions of the pdf map are give, one with 100 ft structure contour intervals (Bone Spring structure 100 ft contours.pdf) and one with 25 ft contour intervals (Bone Spring structure 25 ft contours.pdf). The 25 ft contour interval map has greater resolution than the 100 ft contour interval map and therefore will produce a larger map when plotted on paper, but will also require more computer memory and processing power to produce the map in a timely manner. Users that have older computers with limited memory and processing power may wish to use the map with the 100 ft contour intervals. Both maps were exported directly from Surfer 8. The pdf format is easy to use and a paper map may be easily plotted using a large format plotter. The pdf maps show contours and their values, a section-township-range grid, and well locations. If you do not have Adobe Acrobat Reader installed on your computer, a free copy is included on this CD in the file "Acrobat Reader" and may be downloaded and used in accordance with the license agreement provided with the software.
2. **ArcMap format.** ArcMap is a Geographic Information System (GIS) product of ESRI Corp. With this map, you can plot well locations, well data, contours, and other geologic and geographic data in a system of digital maps that may be spatially related to other geologic and geographic data that the user chooses to import from other sources. The user must have ArcMap v 8.2 from ESRI in order to view and use the contour map in ArcMap format. The files for the ArcMap version of the Abo structure contour map are located in the folder "*ArcMap*". The structure contours in the ArcMap format were first created in Surfer 8 and then exported to ArcMap.
3. **ArcReader format.** ArcReader, a product of ESRI Corp., is a free viewer that allows the user to view the GIS version of the contour map, but not modify or change it. This format is located on this CD in the folder "*ArcReader map*". If Arc Reader is not installed on your computer, you may download it from this CD by opening the folder "*ArcReader program*" and then by double clicking on the "license agreement" icon and accepting the terms of the license agreement. You may then double click on the "*setup*" icon in order to install ArcReader. After installation is complete, you may view the Bone Spring structure map by clicking on the Bone Spring-structure ArcReader project.

REFERENCES

Golden Software, Inc., 2002, Surfer 8 users guide: Golden Software, Inc., Golden, CO., 640 p.

Tyrrell, W., W., 2002, Atlas of well log cross sections helps relate Permian sequences, Guadalupe Mountains area, New Mexico and west Texas, *in* Hunt, T.J., and Lufholm, P.H., eds., The Permian Basin: preserving our past – securing our future: West Texas Geological Society, Publication 02-111, p. 217-233.