

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)	
)	
CROW BUTTE RESOURCES, INC.)	Docket No. 40-8943
)	ASLBP No. 08-867-02-OLA-BD01
(License Renewal for the)	
In Situ Leach Facility, Crawford, Nebraska))	September 18, 2015

SUPPLEMENTAL TESTIMONY OF DR. HANNAN LAGARRY

The following is my supplemental testimony in this matter. Specifically, this testimony will address the recognition of the Chamberlain Pass Formation in Nebraska and South Dakota, and whether the Basal Chadron/Chamberlain Pass Formation exists beneath the Pine Ridge Reservation and its connection (if any) to the Basal Chadron/Chamberlain Pass formation beneath the license renewal area.

Background

In my previous written testimony in this proceeding I criticized Crow Butte Resources' 2008 License Renewal Application for using outdated stratigraphic terminology and concepts when referring to the mined strata as "basal Chadron." I repeated these criticisms when the use of outdated terms and concepts was repeated in the 2014 Environmental Assessment for the site (see LaGarry opinions from 2008 and 2015), and alleged that continued incorrect usage demonstrates a clear lack of due diligence and violation of standard scientific protocol by Crow Butte Resources and the NRC Staff. I further went on to state that such lack of diligence in this basic area of geological practice cast doubt upon the validity of the entirety of both the License Renewal Application and the Environmental Assessment.

During the August 2014 evidentiary hearings in Crawford, Nebraska, Crow Butte Resources and NRC Staff continued to assert that the terms and concepts related to the Chamberlain Pass Formation were not recognized by the USGS in Nebraska, and are therefore not valid. Furthermore, NRC staff went on to assert that these strata are not present, and therefore cannot be a contaminant source for the Pine Ridge Reservation. During this and later related discussions, a paper by Terry (1998) was repeatedly mentioned, and I will discuss it further here. Also, NRC staff offered papers by Souders (2004) and Davis & others (2014) to support their premise that

the Chamberlain Pass Formation is not formally recognized in Nebraska and on the Pine Ridge Reservation, respectively. In rebuttal, I offered a thumb drive with abstracts by LaGarry & others (2006), LaGarry & LaGarry (2010), Salvatore & others (2010), Bhattacharyya & others (2012), and LaGarry & Yellow Thunder (2012), along with papers by Stoffer & others (2001) and Stoffer (2003). Finally, I offered a recent poster by Garnette (2015). Later, NRC staff conceded that the USGS recognizes the Chamberlain Pass Formation in South Dakota, so the papers by Stoffer & others (2001) and Stoffer (2003) need not be discussed further here.

The Issue of Due Diligence

A review of relevant scientific research is a mandatory component of any document in which scientific data is used to establish policy or make an evidence-based decision. Such documents include theses, dissertations, scientific papers, policy reviews, license renewal applications, environmental assessments, and environmental impact statements, among others. In these instances, the purpose of the literature review is to objectively examine supporting and contradictory evidence within the context of the activities or ideas you intend to advance. To do otherwise is to introduce bias into the interpretations that follow and unduly limit the reader's understanding of the material being presented. This selective presentation of (usually) favorable evidence (called "cherry picking") is a form of scientific malpractice.

In his short paper *Ten Simple Rules for Writing a Literature Review*, Pautasso (2013, p. 3) writes:

"Reviewing the literature is not stamp collecting. A good review does not just summarize the literature, but discusses it critically, identifies methodological problems, and points out research gaps."

He goes on to state that a literature review should address the major achievements in the reviewed field (within the narrower topic area being discussed), the main areas of debate, and the outstanding research questions.

Further, Pautasso (2013) advises writers of literature reviews:

"Given the progressive acceleration in the publication of scientific papers, today's reviews of the literature need awareness not just of the overall direction and achievements of a field of inquiry, but also of the latest studies, so as not to become out-of-date before they have been published."

Whether the lack of a thorough review of the scientific literature represents an oversight, haste, neglect, or cherry picking, it leaves the informed reader with the impression of a lack of serious effort (at best) or a deliberate attempt to deceive (at worst). Crow Butte Resources' failure to include recent research and adopt the revised Chamberlain Pass Formation despite having it pointed out to them in my 2008 opinion falls somewhere on this spectrum.

Recognition of the Chamberlain Pass Formation in Nebraska

The Chamberlain Pass Formation is recognized as the basal stratum of the White River Group, which is composed primarily of volcanic ash that fell over a large area including southeastern Montana, southwestern North Dakota, western South Dakota, western Nebraska, most of Wyoming, and northeastern Colorado (Fig.1). The white river Group, as formally recognized, consists of the Chamberlain Pass, Chadron, and Brule Formations. Based on this diagram alone, one could reasonable expect all three of these formations to be ubiquitous on the Pine Ridge Reservation and in western Nebraska.

The Chamberlain Pass Formation was formally proposed by Evans and Terry (1994) based on a stratotype exposed near Kadoka, SD in the Badlands National Park region. In doing so, they followed guidelines set forth in the North American Stratigraphic Code (1983). Subsequently, Terry (1998) correlated the Chamberlain Pass Formation and the Peanut Peak Member of the Chadron Formation from the stratotype across southwestern South Dakota into northwestern Nebraska (see his

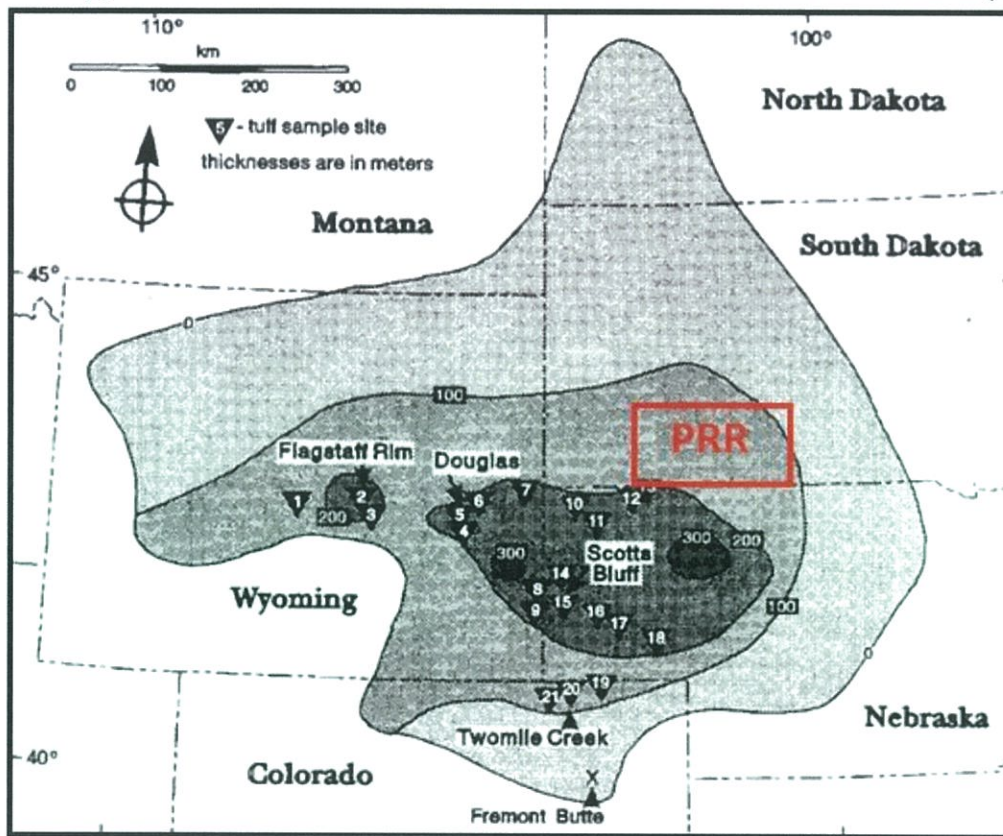


Figure 1. Areal distribution of the White River Group (after Larson & Evanoff 1998). Red box labeled “PRR” denotes the approximate boundaries of the Pine Ridge Reservation. Concentric shading represents thickness of the White River Group (ash) deposits, with darker shades representing greater thickness.

figs. 3A and 3B). The paper by Terry & LaGarry (1998) completes the formal revision of the Chadron Formation and has an expanded discussion of the relevant parts of the Code that apply to the revision of the Chadron A or "basal Chadron." One of the primary differences between the 1998 revision and earlier concepts applied to these rocks is that the revised units are *lithostratigraphic* units based on descriptions of *lithology*. Such descriptions are based on precise descriptions of material constituents including *heterogeneity*, *grain sizes* (from which porosity and permeability can be inferred), and *mineralogy*, among others. These were explicitly omitted from the older conceptual models that defined the Chadron A as such things were considered largely irrelevant (see Terry & LaGarry, p. 118).

NRC staff suggested that the USGS occupied the role of arbiter in stratigraphy, but that is a misperception. The sole arbiter of stratigraphic protocols in North America is the North American Commission on Stratigraphic Nomenclature as stated in the Code (NACSN, 1983). Whether or not the Code is followed by any particular writer is an issue of due diligence on the part of that writer.

The paper by Souders (2004) provides a superficial view of the geology of northwestern Nebraska, but there are no citations within the paper detailing the source(s) of geological information. The cross sections mentioned in the text were provided but poorly legible, and my internet search did not locate better versions. The bibliography shows that despite its 2004 publication date, the papers used for the geology are dated 1946 (Scottsbluff County), 1946 (Box Butte County), 1956 (Niobrara County, WY and Sioux County NE), 1980 (Box Butte County), 1981 (southern Dawes and northern Sheridan counties), and 1985 (western Nebraska). The omission of Evans & Terry (1994), Terry (1998), and Terry and LaGarry (1998), despite being published in well-known, high profile venues, represents 1) a lack of due diligence on the part of Souders, 2) a publication process that lasted so long that their paper was outdated the moment it was published, or 3) a paper so narrowly focused on hydrogeology for a general audience that details were deliberately omitted. In any case, this paper represents in-house "gray" literature, and should not have been used in place of refereed publications such as *Sedimentary Geology* (e.g., Evans & Terry 1994) or a Geological Society of America Special Paper (Terry 1998, Terry & LaGarry 1998).

Recognition of the Chamberlain Pass Formation on the Pine Ridge Reservation

Terry (1998) shows photographs (fig. 2) and measured sections (figs. 3A and 3B) of the Chamberlain Pass and Chadron formations generally north (3A) and west (3B) of the Pine Ridge Reservation. However, location A in his figure 3A is located near Red Shirt village *on the Pine Ridge Reservation* (labeled by name in his figure). Also, his location 1 in his figure 3B is located at White Clay, Nebraska, on the southern border of the Pine Ridge Reservation (labeled as the state line in his figure). I have included color photographs of these outcrops, along with others for context, in Figure 2.

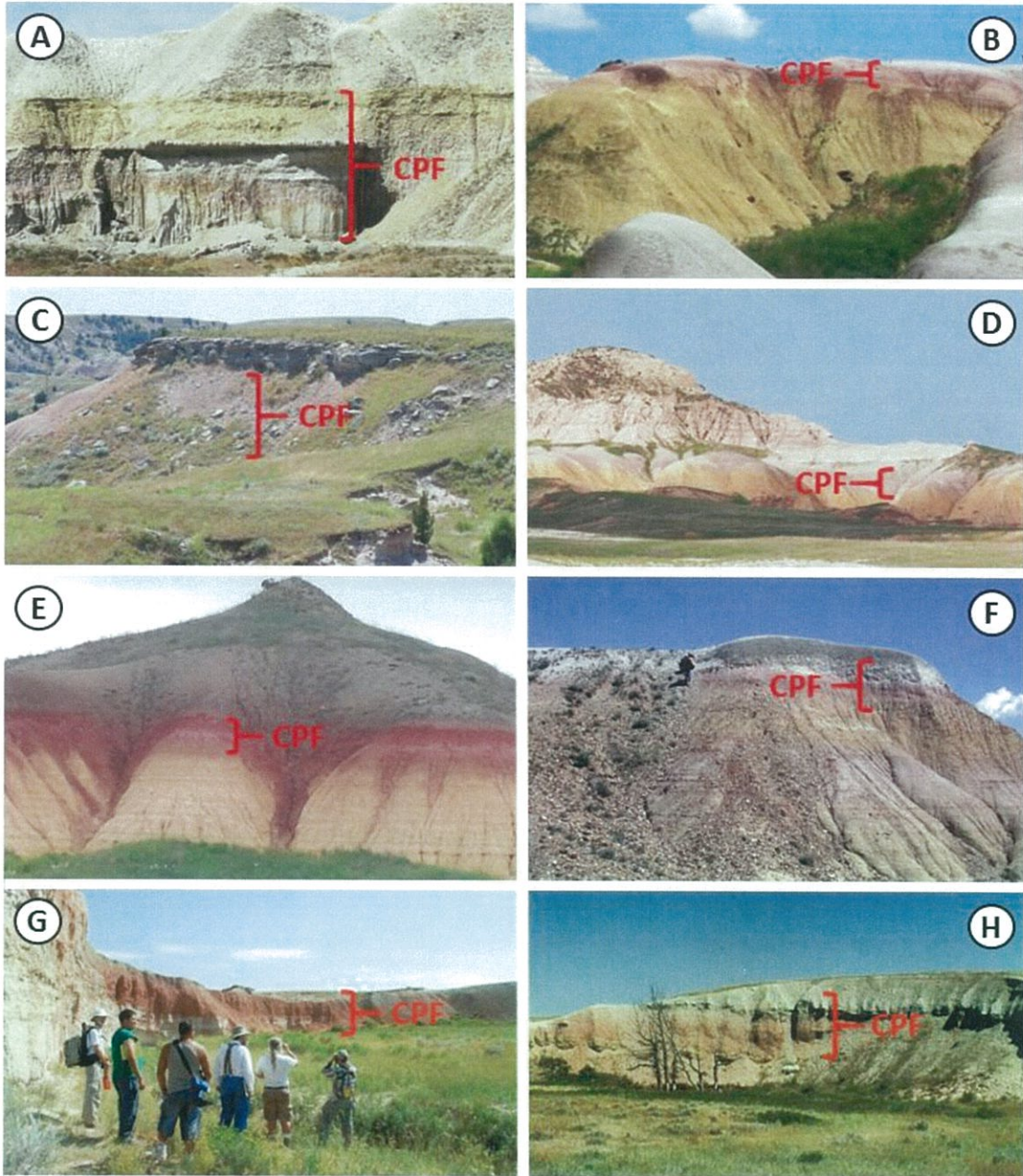


Figure 2. Photographs of the Chamberlain Pass Formation (CPF) at: A) Kadoka, SD (Terry 1998), B) Badlands National Park, SD (Terry 1998), C) Red Shirt, SD (Pine Ridge Reservation), D) near Oglala (Pine Ridge Reservation), E) near Pine Ridge, SD (Pine Ridge Reservation), F) Pete Smith Hill, NE (Terry 1998), G) Orella Bridge, NE (Terry 1998), H) Wyoming-Nebraska state line in NW Sioux County, NE. Locations C, D, and E are mentioned in LaGarry (2010), Bhattacharyya & others (2012), and LaGarry & Yellow Thunder (2012). All photographs by Hannan LaGarry except (E) by Shawn Garnette.

The NRC staff refuted the recognition of the Chamberlain Pass Formation on the Pine Ridge Reservation by deferring to a USGS study of groundwater modeling (Davis & others 2014). According to the authors, the scope and purpose of this study as to “describe conceptual and numerical models of groundwater flow in the Ogallala and Arikaree aquifers in the Pine Ridge Indian Reservation area.” The paper cites geological literature from 1959, 1960, 1965, 1967, 1969 and databases dated 2007, 2011, and 2012. Without more time to examine these databases, it’s difficult to estimate the quality of their contents or the appropriateness of the data in them. Davis & others (2014) do cite the 2004 geologic map of South Dakota (Martin & others 2004). The geological references used to compile that map date from 1899 to 1995, with the vast majority dating from the 1950’s, but they do not include Evans & Terry (1994) or Terry (1998).

The Chamberlain Pass Formation and its description are included in the map legend (see Martin & others 2004) but not in Davis & others (2014). Also, Davis & others (2014) describe the White River Group as Oligocene (considered Eocene-Oligocene since the early 1990’s), the Arikaree Group as Miocene (considered Oligocene-Miocene since the 1980’s), and the Ogallala Group as being Pliocene (considered Miocene-Pliocene since the late 1970’s). It’s worth noting that the geological map by Martin & others (2004) is correct in its age designations also. Therefore, I suggest that the disparities between accepted geological facts and those presented in Davis & others (2014) likely includes: 1) a lack of due diligence, and 2) a paper so narrowly focused on computer modeling of hydrogeology that details were omitted or overlooked.

Connection of the Chamberlain Pass Formation between the License Area and the Pine Ridge Reservation

In my early testimony (2008 and 2015) I indicated that the White River and its alluvium or a complex network of intersecting joints and faults were the most likely ways for contaminants to migrate from the Crow Butte Resources license area to the Pine Ridge Reservation. In my opinion, the newly proffered exhibit BRD 006 suggests that there might be another route through the Arikaree Group, but if so, it would likely be in combination with faults and joints for reasons discussed in the Crawford hearings. There is radionuclide contaminated water migrating along the Whiteclay Fault in southern Oglala Lakota County (Pine Ridge Reservation) but its specific source is as yet unknown (Salvatore & others 2010, Bhattacharyya & others 2012, Garnett & others 2015). It could be natural uranium concentrated by geothermal water, or it could be ISL contamination within a network of intersecting faults and joints.

Literature Cited

Bhattacharyya, P., K. Converse, J. W. Ejnack, H. E. LaGarry, & A. Riesen. 2012. Studying uranium contamination levels in groundwater from the Pine

Ridge Reservation, South Dakota: a community-university partnership. Geological Society of America Abstracts with Programs 44(6):77.

- Davis, K. W., L. D. Putnam, & A. R. LaBelle. 2014. Conceptual and Numerical Models of Groundwater Flow in the Ogallala and Arikaree Aquifers, Pine Ridge Indian Reservation Area, South Dakota, Water Years 1980–2009. Scientific U.S. Department of the Interior/U.S. Geological Survey Investigations Report 2014–5241, 68 p.
- Evans, J. E. & D. O. Terry, Jr. 1994. The significance of incision and fluvial sedimentation in the basal White River Group (Eocene-Oligocene), Badlands of South Dakota. *Sedimentary Geology* 90:137-152.
- Garnette, J. S, J. Tinant, J. Sanovia, & H. LaGarry. 2015. Measuring ionizing Radiation levels in Oglala Lakota County soils on the Pine Ridge Reservation. Poster presented at the 2015 National Science Foundation Tribal College Research Symposium, Arlington VA, 17-19 August 2015.
- LaGarry, H. E. & L. A. LaGarry. 2010. Proposed lithostratigraphic revision, redescription, and redefinition of the White River Group (Eocene-Oligocene), South Dakota. Geological Society of America Abstracts with Programs 42(3):14.
- LaGarry, H. E. & E. Yellow Thunder. 2012. Surface and subsurface distributions of uranium-bearing strata in northwestern Nebraska and southwestern South Dakota. Proceedings of the 122nd Annual Meeting of the Nebraska Academy of Sciences, pp. 91-92.
- Larson, E.E., & E. Evanoff, 1998. Tephrostratigraphy and source of the tuffs of the White River sequence, pp. 1-14 in (D.O. Terry, Jr., H.E. LaGarry, and R.M. Hunt, Jr., eds.), *Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America)*: Geological Society of America Special Paper 325, 216 p.
- Martin, J.E., Sawyer, J.F., Fahrenbach, M.D., Tomhave, D.W., & Schulz, L.D., 2004, Geologic map of South Dakota: South Dakota Geological Survey General Map Series G-10, scale 1:500,000.
<http://www.sdgs.usd.edu/publications/downloads.html>.
- Pautasso, M. 2013. Ten Simple Rules for Writing a Literature Review. *PLoS Computational Biology* 9(7):1-4. 1003149. doi:10.1371/journal.pcbi.1003149 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3715443/>

- Salvatore, M., H. E. LaGarry, P. Lee, & L. One Feather. 2010. Preliminary report: isolation and detection of filterable contaminants in drinking water, Pine Ridge Reservation, South Dakota. Geological Society of America Abstracts with Programs 42(3):44.
- Souders, V. L. 2004. Report on Hydrologically Connected Ground Water and Surface Water in the Upper Niobrara-White Natural Resources District. Nebraska Department of Water Natural Resources, 24 p.
- Stoffer, P. W. 2003. Geology of Badlands National Park: a preliminary report. U.S. Department of the Interior/U.S. Geological Survey Open-File Report 03-35, 63 p.
- Stoffer, P. W., P. Messina, J. A. Chamberlain, & D. O. Terry, Jr. 2001. The Cretaceous-Tertiary boundary interval in Badlands National Park, South Dakota. U.S. Department of the Interior/U.S. Geological Survey Open-File Report 01-56, 49 p.
- Terry, D. O. 1998. Lithostratigraphic revision and correlation of the lower part of the White River Group, South Dakota and Nebraska, pp. 15-37 *in* (D. O. Terry, Jr., H. E. LaGarry, and R. M. Hunt, Jr., eds.) Depositional environments, lithostratigraphy, and biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America). Geological Society of America Special Paper 325, 216 p.
- Terry, D. O., Jr. & H. E. LaGarry. 1998. The Big Cottonwood Creek Member: a new member of the Chadron Formation of northwestern Nebraska, pp. 117-142 *in* (D. O. Terry, Jr., H. E. LaGarry, & R. M. Hunt, Jr., eds.) Depositional environments, lithostratigraphy, and biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America). Geological Society of America Special Paper 325, 216 p.

Pursuant to 10 C.F.R. § 22.304(d) and 28 U.S.C. § 1746, I declare, under penalty of perjury, that the foregoing is true and correct to the best of my knowledge and belief.

Dated this 18th day of September, 2015.

Respectfully submitted,



A handwritten signature in cursive script, appearing to read "Hannon LaGarry". The signature is written in black ink and is positioned above a horizontal line.

Hannan LaGarry, Ph.D.