Cayuse Basin: A Study in Multiple Working Hypotheses

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Abstract

Impact craters in the landscape and subsurface have received increasing attention in recent decades, particularly after popularization of the impact theory for the demise of the dinosaurs. Diluvialists also debate the possible role of impacts in the Genesis Flood. Thus, both uniformitarians and diluvialists have been on the lookout for more impact craters. In 2012, we investigated a candidate crater, Cayuse Basin in Judith Basin County, Montana. While we did not discover evidence for a crater, the process itself provided good lessons for both impact enthusiasts and detractors.

Key Words: Cayuse Basin, impact crater, multiple working hypotheses, models, dome, Central Montana Alkalic Province, sequence stratigraphy

Introduction

Cayuse Basin is a topographic basin in Judith Basin County in Central Montana (Figure 1). Michael J. O'Brien, a coworker who formerly piloted small planes, once flew over Cayuse Basin and told me about what seemed to be a meteorite crater. I looked on Google Earth (Figure 2), and there definitely appeared to be an impact crater. A friend joined us for a site visit on May 19, 2012.

Cayuse Basin is owned by the Hayes Livestock Company. When I contacted the landowner for permission to hike the basin, he told me I was not the first person to come hunting for an impact crater. There are other structures in Central Montana that have attracted similar attention.

Perhaps much of this attention arose from the dinosaur extinction impact theory (Alvarez, 1997; Alvarez et al., 1980; DePalma et al., 2019). Impacts have been increasingly popular among creationists too, as a possible trigger for the Deluge (Steveson, 1975; Unfred, 1984; Northrup, 1987; Fischer, 1991; Auldaney, 1992; Spencer, 1992; 1994; Froede and DeYoung, 1996; Froede and Brelsford, 1998; Oard, 2009). While catastrophic plate tectonics appears to be the most popular geologic model among creationists at present, many entertain bolide impacts as an addition or alternative.

Oard and Reed (2020, p. 5) list five possible diluvial models:

1. Catastrophic plate tectonics
2. The hydroplate model
3. Meteorite impacts followed by differential vertical tectonics
4. Combinations of parts of these models
5. A totally new model

Oard and Reed (2020) convinced me that writing up our Cayuse Basin experience could be beneficial for those interested in Flood models, not to vindicate any existing model, but to show the research process, potential pitfalls, and how to avoid them. Non-geologists may benefit from the glossary at the end of this paper.

The Problem

The origin of Cayuse Basin, like most geologic features, is a matter of history, not science. Its origin cannot be recreated or measured or tested or observed, but a forensic hypothesis can generate predictions to test. This is what we set

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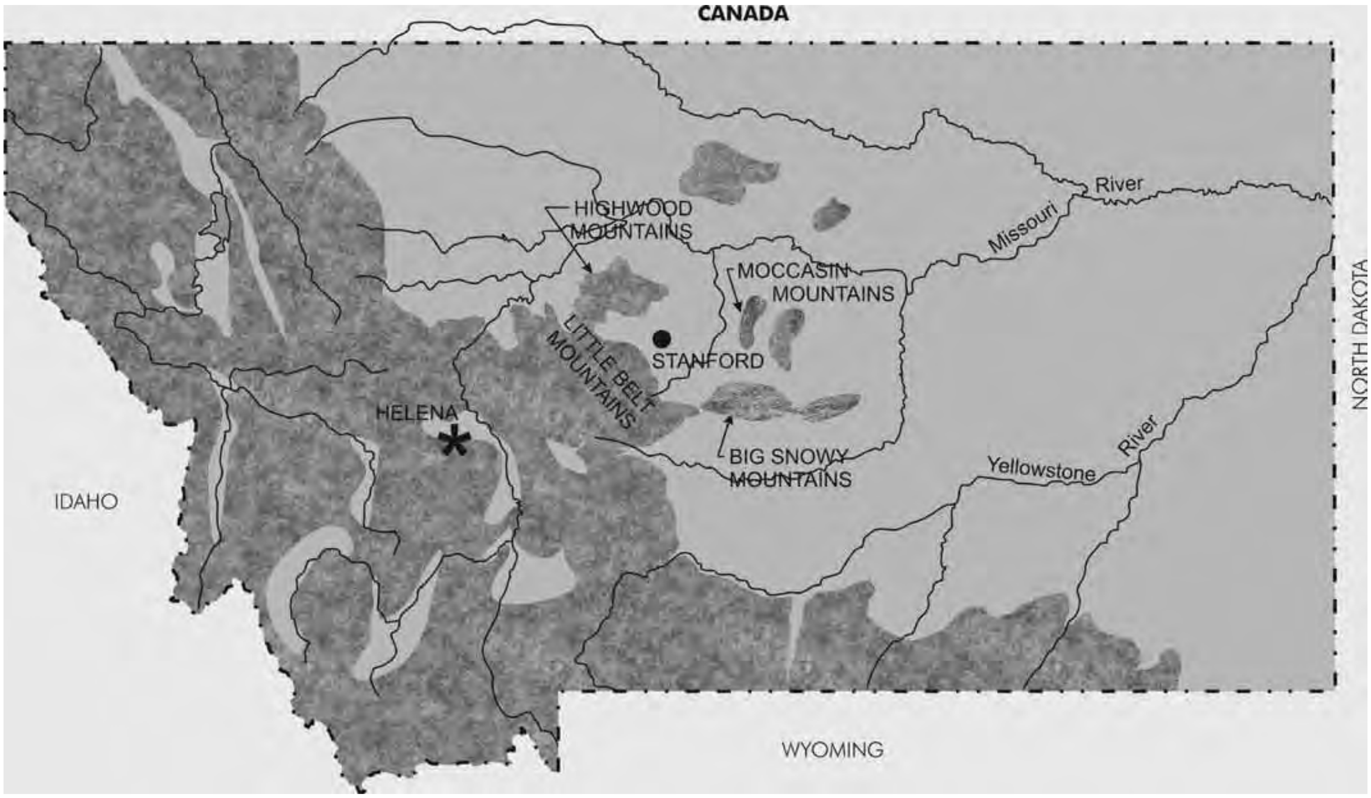

Figure 1. Map of Montana showing major rivers, mountains, the capital (Helena) and Stanford, seat of Judith Basin County. Cayuse Basin is four miles southwest of Stanford.

out to do. The idea of an impact crater had occurred to Mike O'Brien when he flew over Cayuse Basin and to me when I saw it on Google Earth®. But as Acrey (1968, p. 120) pointed out, "Scientists must always be mindful of the fact that deficiencies in present knowledge will be reflected in our interpretations of past events." We needed to investigate in person.

Investigation

The principle of multiple working hypotheses (Chamberlin, 1890) is a good one. It facilitates an open mind and sharpens observational skills. I thought of four potential origins for Cayuse Basin:

1. Impact crater
2. Volcano
3. Dome
4. Other

Each generates a set of predictions (Table I). While the hypotheses themselves belong to the field of history, their predictions can be investigated via geology. They therefore qualify as "mixed questions" (Adler, 1965; Reed and Klevberg, 2017, 2018). Hypothesis #4 should always be included per Acrey (above), but it is nebulous and would be favored by a failure to find supporting evidence for the first three.

Observations in the Basin

We started on the east side of Cayuse Basin and headed straight toward the rim. I took measurements of bed attitudes with a Brunton compass and examined the scattered outcrops. What we observed is summarized in Table II.

The entire rim, except where it is breached on the northeast side (Figure 3), consists of limestone (micrite). The limestone resists erosion (Figure 4). The attitude of the beds is uniformly dipping away from the center of Cayuse Basin. Most of my dip measurements were in the range 22±5° away from the center of the basin. The steepness of the slope on the outside of the rim or crest reflects the bedding plane attitude of the limestone (Figure 5). At the northeast side of Cayuse Basin, the rim, here a medium-grained sandstone, is cut by Skull Creek (Figure 6).

The outside slopes are well vegetated, making identification of contacts dif-

Figure 2. What could be better proof that Cayuse Basin is an impact crater than this Google Earth image?

ficult (Figure 7). The interior is similar. Less-resistant strata formed regolith, the parent material for the soil of well-developed grassland. Isolated outcrops were observed; most sandstones (Figure 6), but a few locations along Skull Creek exposed dark gray fissile shale. The mounded center (Figure 3) appears to be primarily composed of this shale, while sandstone outcrops form the lower slopes of the rim. The lowest part of

Table I. Working Hypotheses and Their Predictions

Hypothesis	Predictions
Impact Crater	coesite, stishovite, shatter cones, shocked quartz, rebound structure, ejecta
Volcanic Crater	extrusive rocks, contact aureole, ejecta (pyroclastics), dikes
Dome	upwarped sedimentary rocks, possible igneous core with contact aureole at bottom
Other	none of the above evidence, various other phenomena than the above

Table II. Comparison of Hypotheses and Observations

Hypothesis	Observations
Impact Crater	no quartz, high pressure minerals, rebound structures, or metamorphism of basal shale
Volcanic Crater	lack of igneous rocks, lack of contact metamorphism
Dome	upwarped sedimentary rocks, eroded core with unaltered shale in bottom, nearby domes
Other	no unusual phenomena observed

Cayuse Basin is the toe of these slopes (Figure 8).

Additional Information

After field investigation, I sought additional information from published sources. In the years since, work on water well projects in the area supplied more knowledge of the subsurface.

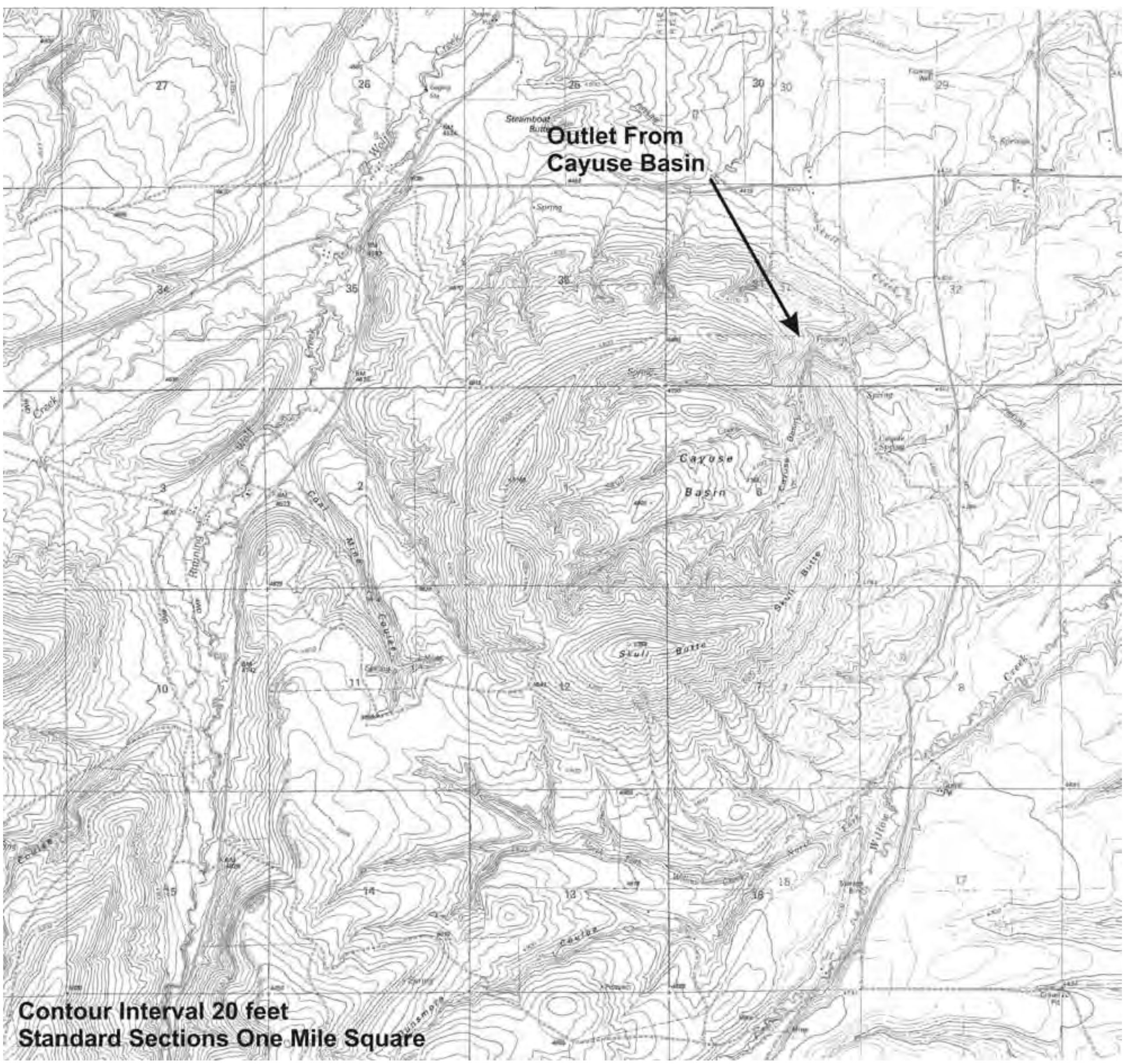

Figure 3. U.S. Geological Survey topographic map of Cayuse Basin with 20-foot contour interval. Interior of basin is roughly one mile in diameter, rim is two miles in diameter, exterior roughly three miles in diameter. South rim abutting spur ridge from Little Belt Mountains is known as Skull Butte. Coal mines operated on its southwest flank a century ago.

Figure 4. View southwest from east rim of Cayuse Basin. Michael J. O'Brien, trip instigator, stands on outcrop of Alaska Bench limestone. While over half of the geologic contacts are obscured by soil and vegetation, Alaska Bench outcrops provided many good opportunities to measure bed attitudes all the way around the basin.

Figure 5. View north from just below east rim toward Stanford, Montana, and Square Butte. Rocks in foreground are in situ slabs of Alaska Bench limestone. This resistant formation forms most of the basin rim. Stanford is 5 miles (8 km) northeast of Cayuse Basin at an elevation of 4,285 feet (1,303 m) above sea level.

Figure 6. Ephemeral drainages converge at the northeast side of Cayuse Basin where Skull Creek flows through a gash in the rim. Slow erosion of the interior of the basin under present climatic conditions could be expected to produce topography more like the Arrow Creek Badlands several miles to the northwest rather than the slit in the northeast rim and rounded, much lower interior topography seen here.

Geologic setting

Skull Butte is a northeastern foothill of the Little Belt Mountains (Figure 1), northeast of the mountain ranges and intermontane valleys that form the edge of the Basin and Range Province of Southwestern Montana. The geography changes markedly to the north and east. The Highwood Mountains, Bears Paw Mountains, Moccasin Mountains, and Judith Mountains (Figure 1) are "island mountains" cored by igneous rocks (Woodward, 2010). Isolated buttes, such as Round Butte and Square Butte (Figure 9) resemble the buttes of the Little Belt foothills except for their shapes and full exposure of the igneous rocks. The only exception to these igneous cores is the great anticline of the Big Snowy Mountains. Between these "island

Figure 7 *(left above)*. Many of the geologic contacts are obscured by soil and grass but are discernable with scrutiny. Here the author shows companion Mark Nelson a contact. Dotted line added to image to indicate approximate location of Kootenai-Morrison contact.

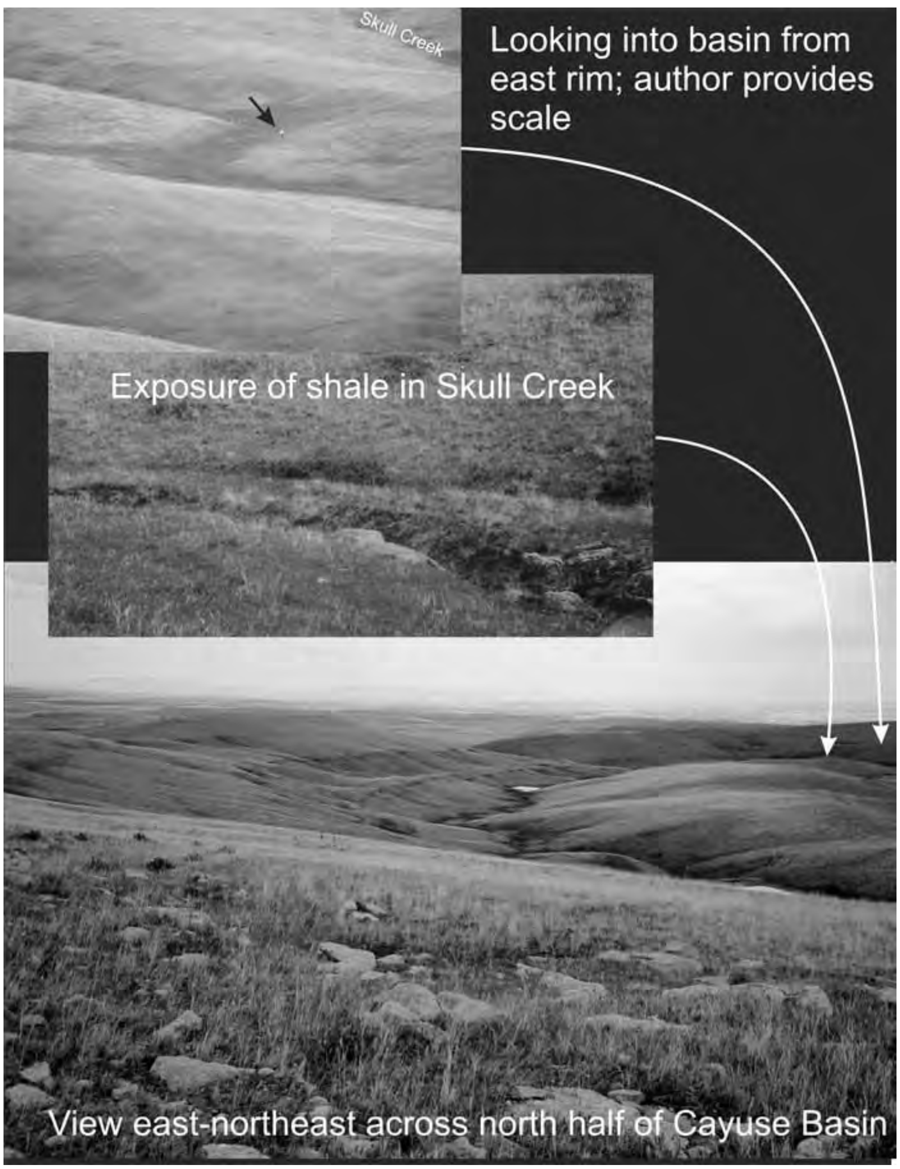

Figure 8 *(left below)*. The bottom of Cayuse Basin is a broad, grass-covered dome with minor gullies. Isolated small outcrops reveal the lithology to consist of unmetamorphosed black or dark gray shale. Black arrow points at author for scale.

ranges" stretch the nearly horizontal sedimentary strata of the Judith Basin.

Cayuse Basin has a circumference of approximately 9 miles (15 km) (Figure 3). A spur ridge from the prominent Little Belt Mountains to the south encounters the south rim of Cayuse Basin and is called Skull Butte. Coal mines operated on its southwest side and a few miles east of it until about a century ago. I did field work on these abandoned mines years ago but had never been in Cayuse Basin before 2012. Skull Creek originates in the basin, and the structural dome is often referred to as Skull Creek Dome (Vine, 1956).

Lithology

Sedimentary rocks outcrop in and around Cayuse Basin. The prominent rim (Figure 9) is light gray micrite. Sandstones (Figures 6 and 8) are primarily thin- to medium-bedded, fine-to-medium-grained, medium hard, and gray weathering to a reddish brown. Incom-

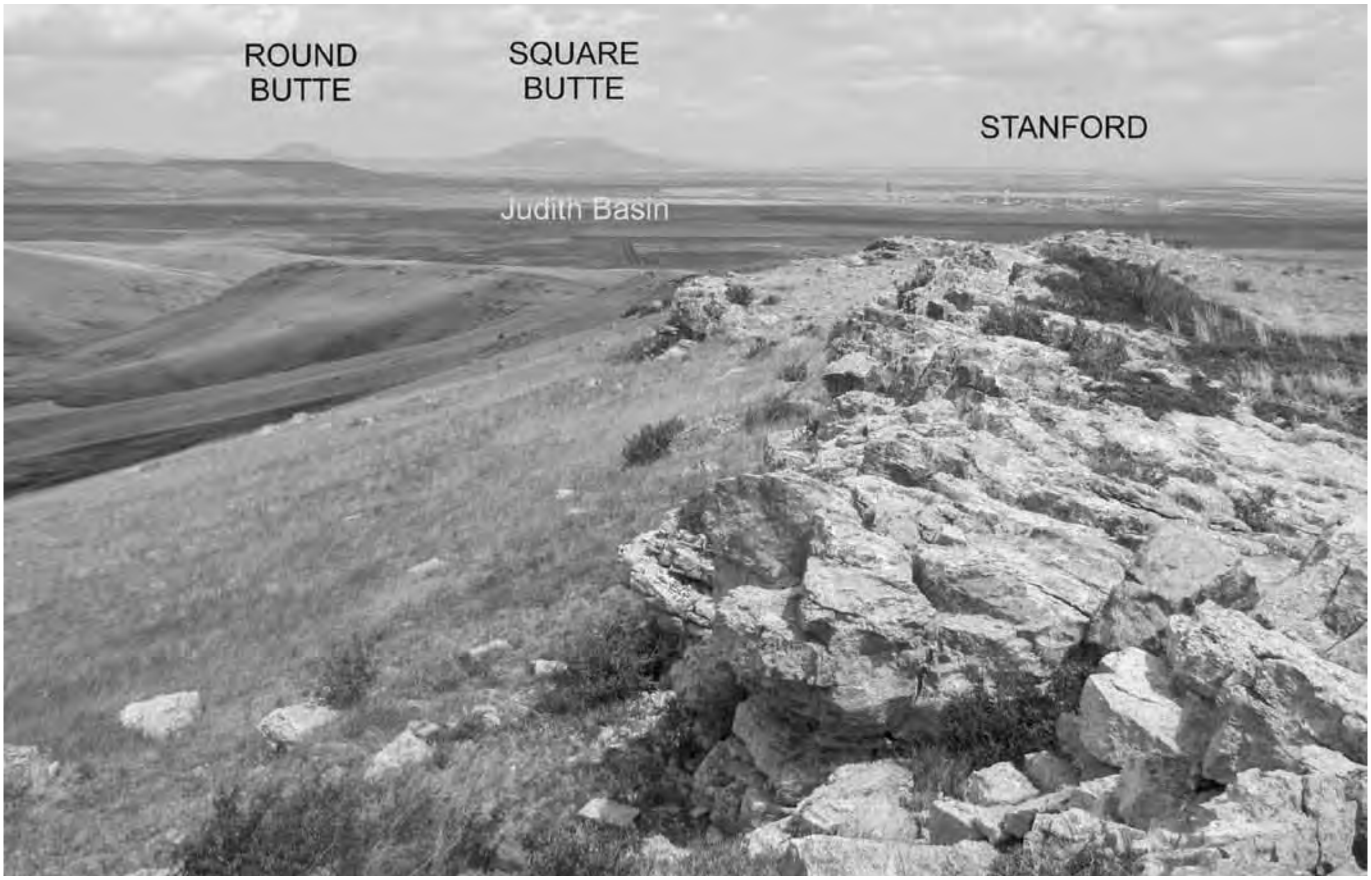

Figure 9. View north-northeast from east rim of Cayuse Basin showing the nearby town of Stanford, with Square Butte and Round Butte in the distance. These buttes are the nearest exposed igneous rocks and are mapped among the laccoliths in the area (Raymond, 1995), though Round Butte appears to be sheeted dikes, and Square Butte appears topped by flows. The top of Square Butte is 1,419 feet (433 m) higher than Stanford and 27 miles (44 km) north-northwest of the town.

petent rocks are difficult to examine due to the development of soil on them, but fissile, thin-bedded dark gray shale was observed (Figure 8). According to Vine (1959) and Vuke et al. (2007), the predominant lithology is shale (Figure 10).

Igneous rocks are common in the mountain ranges ringing the Judith Basin. Laccoliths are present west of Cayuse Basin along the front of the Little Belt Mountains, in the Highwood Mountains, and in scattered locations east of the Highwoods. These are mostly plutonic rocks, with some volcanics, and are principally mafic phonolite or shonkinite with associated syenite (Vuke et al., 2007). Quartz latite porphyry is mapped at Windham Dome approximately 7 miles (12 km) northeast of Cayuse Basin (Figure 11), but this is covered by a sheet of surficial gravel. Other igneous lithologies outcrop several miles to the southwest in the Little Belt Mountains. These rocks are part of the Central Montana Alkalic Province (Raymond, 1995; Woodward, 2010), and a quick look for shonkinite in the index of nearly any textbook on igneous petrology will take one to a description of the Highwood Mountains' main claim to fame.

Metamorphic rocks have been observed by the author as very thin zones at contacts of sedimentary rocks with flows and dikes of shonkinite in the Highwood Mountains and buttes farther east. I have seen them nowhere else in the area. Metamorphic rocks are not described proximate to Cayuse Basin by Vuke et al. (2007). High grade metamorphic rocks do occur far to the southwest in the central Little Belt Mountains.

Stratigraphy

Figure 10 shows a composite column for the rocks at Cayuse Basin derived from Vine (1959) and Vuke et al. (2007). The stratigraphic nomenclature is shown in Table III. The uppermost consolidated formation is the Kootenai, and the lowest exposed at Cayuse Basin is the Otter Formation or possibly the Kibbey Forma-

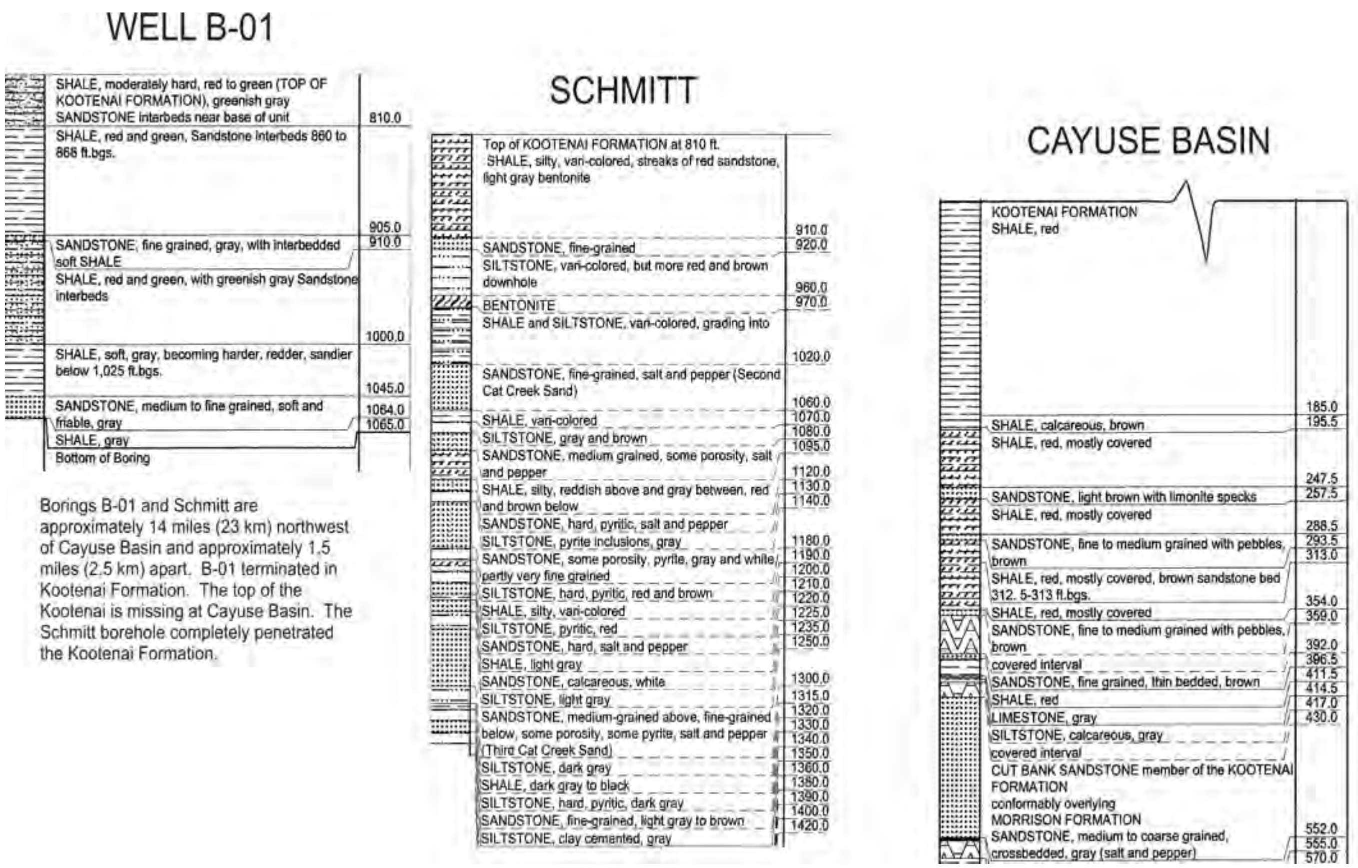

Figure 10. Bottom portion of log from well B-01, a water well completed in the Kootenai Formation 24 km (15 miles) northwest of Cayuse Basin, and a portion of the log from the Schmitt wildcat well drilled 2.5 km (1.5 miles) southeast of B-01, compared with top portion of log from east side of Cayuse Basin derived from Vine (1959) and Vuke et al. (2007). Numbers are depths in feet (precision varies from 0.5 to 5.0 ft.). Tracing or correlating formations such as the Kootenai laterally can be difficult, and workers rely heavily on a few key marker beds.

tion. For readers who prefer traditional geochronologic designations, I recommend instead using the Sloss sequence terminology (Table III) for its more empirical basis (Dott, 2014).

The Kibbey Formation was mentioned in Vine (1959) and Vuke et al. (2007) but not observed by the author. Shale observed resembled instead the Otter Formation (Figure 8).

The inside of the rim exhibits prominent sandstone (Figure 6) of the Tyler Formation, the basal formation of the Amsden Group. On the outside of the rim, similar sandstones are mapped as the Swift Formation of the Ellis Group (the only Ellis formation present), then Morrison Formation, overlain by Kootenai Formation. The Swift and Morrison together are approximately 200 feet (63 m) thick, and an unconformity is thought to exist in the Morrison (Vuke et al., 2007). The Ellis Group farther west consists of generally three formations, the Swift being the uppermost. An unconformity is thought to exist at the base of the Ellis Group, but Ellis strata pinch out rapidly eastward, and exhibit lateral facies changes.

Between the Tyler and Swift is the prominent limestone of the Alaska Bench Formation, the upper formation of the Amsden Group. The unconformity described between the Amsden and Ellis Groups is a major sequence boundary (Absaroka to Zuni) but was not observed in the field despite supposedly 100 million years (or *mega annum*, Ma) of allegedly missing time (Carstarphen et al., 2011). Unfortunately, traditional ages are often cobbled to the Sloss sequences, undermining their empirical status. This apparent conformity and lack of transgressive-regressive cycles between the Swift and Alaska Bench Formations makes this sequence boundary designation inapplicable in the Cayuse Basin. An intraformational unconfor-

Table III. Stratigraphic Nomenclature

Sequence	Group	Formation	Remarks
Zuni		Kootenai	
		Morrison	Unconformity posited within formation
	Ellis	Swift	Unconformity posited at base
Absaroka	Amsden	Alaska Bench	Unconformity posited at top
		Tyler	
Kaskaskia	Big Snowy	Heath	
		Otter	
		Kibbey	Unconformity posited at base
Sequences correlated with Williston Basin, but originally traced from Rocky Mountains by Sloss.	Madison Group, Lodgepole Formation, underlies Kibbey. Petroleum geologists in author's acquaintance may refer to Madison as "Mississippian" and Kootenai, the shallower production zone, as "Lower Cretaceous" without referencing lithologies or formations or even supposed ages. "Second Cat Creek Sand" and "Third Cat Creek Sand" are drillers' terms for locally important aquifers and sometimes oil producing zones within the Kootenai Formation.		

mity is speculated for an uncertain location within the Morrison Formation.

Early on, the Morrison and Kootenai Formations were biostratigraphically determined (Fisher, 1909). These were assembled like a culch bin: as any potentially useful machine part or scrap is tossed into the bin, so strata "dated" by fossils were "tossed" into the "bins" corresponding to "Morrison time" or "Kootenai time." This imaginative departure from science to create a chronologic geologic column has unfortunately not been limited to Central Montana (Woodmorappe, 1999). Imaginary time makes a poor field marker for drillers, so the top of the Kootenai came to be recognized as the first red bed (hematite rich unit). The first coal was originally classified as basal Kootenai but later assigned to the upper Morrison.

The Kootenai portion of Figure 10 is compared with portions of logs from water well B-1 and wildcat well Schmitt (1.5 miles or 2.5 km apart) approximately 14 miles (24 km) northwest of Cayuse Basin. As with most of the formations both up and down section, the Kootenai strata are dominated by shale and claystone with significant amounts of siltstone and sandstone, and minor bentonite and limestone. Subjectivity and technology could explain some differences but there is a lack of lateral continuity. This is considered the consequence of a continental depositional environment, though similar formations deeper in the section are marine.

First rate marker beds are not common in the study area. There are color changes evident with the Kootenai and Otter Formations, and the presence of coal is used to infer Morrison. As shown in the logs, there is repetition in some lithologies, but poor lateral correlation. For example, medium grained sandstones (litharenites) with limonite flecks are not uncommon in the Kootenai but may occur elsewhere too. Whether the light gray micrite of the Alaska Bench Formation differs lithologically from the light gray micrite of the deeper Madison Group or the thin unit in the Kootenai Formation is unclear. What is evident is this: the source materials for these various lithologies were available throughout the depositional history of the section, appearing virtually identical at various points throughout the rock column, a supposed span of over 200 Ma. This episodic deposition and the subtlety of the unconformities–or paraconformities–appears more compatible with a relatively quick depositional history with few hiatuses—or none.

Structure and geomorphology

Sedimentary strata in the Judith Basin dip northeast at a very slight angle. Their dip becomes steeper against the north side of the Little Belt Mountains, and they form a dome at Cayuse Basin (Vine, 1956; Vuke et al., 2007). While my bed attitude measurements were more numerous and scattered than those on Figure 11, they were similar.

Knife Edge Ridge, the flat, narrow top of the Big Snowy Mountains flanked by dry cirques, is approximately 8,500 ft. (2,620 m) above sea level and truncates the top of the anticline. In my youth, I

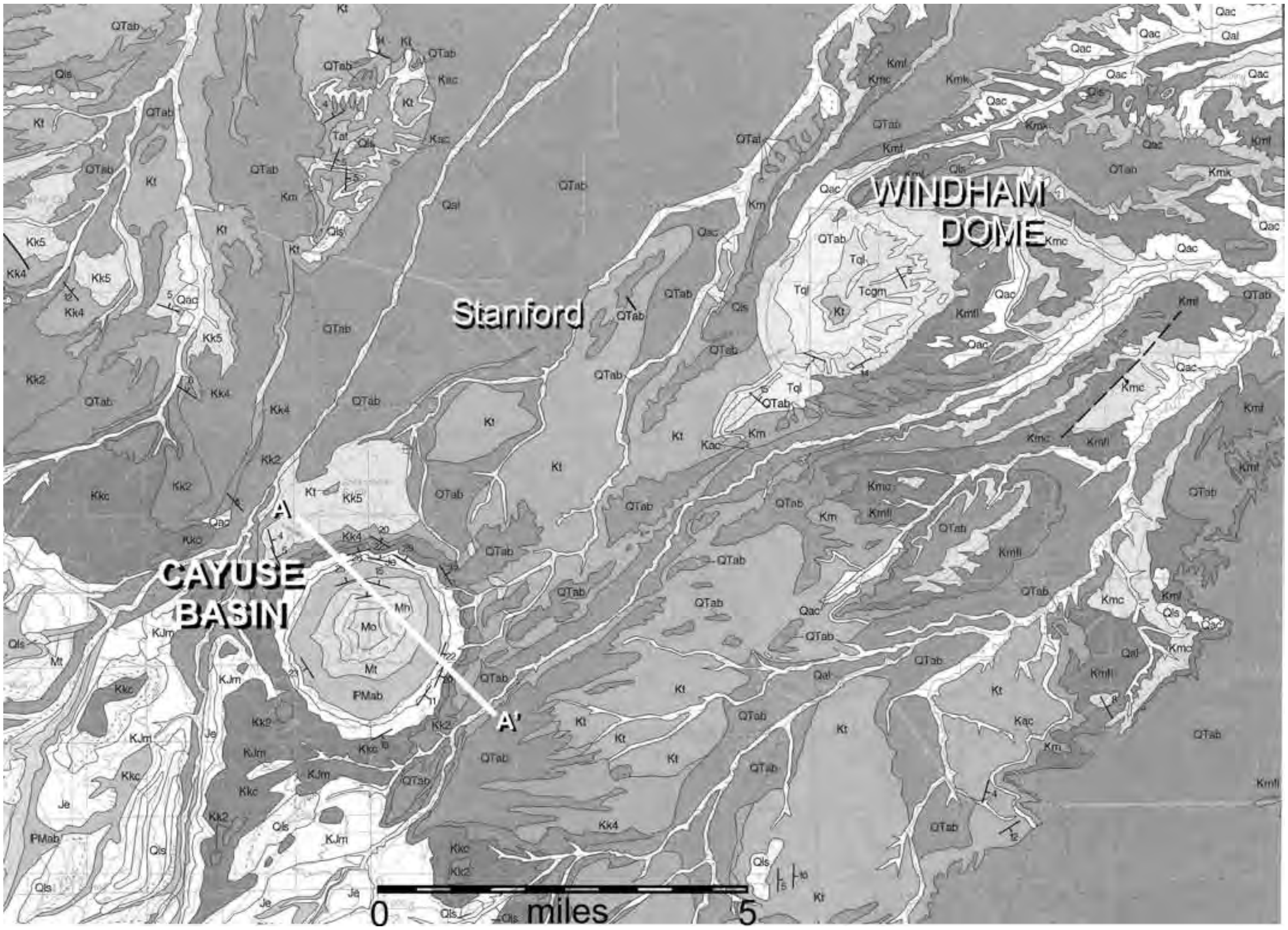

Figure 11. Portion of geologic map (Vuke et al., 2007) showing Cayuse Basin and Windham Dome. Line A–A' is location of cross section in Figure 13.

was taught this was a peneplain, a now discredited concept (Oard and Klevberg, 1998). High planation surfaces such as this are seen at the tops of other Montana mountain ranges, such as the Beartooth Plateau and the Highland Mountains. Planation surfaces occur in a smaller, more channelized form at lower elevations; the Judith Basin is an excellent example (Figure 12). These lower surfaces, called "benches," are generally smaller and ramp into each other. The Judith Basin planation surfaces are mantled by coarse gravel sheets (Klevberg and Oard, 1998; Oard and Klevberg, 1998), but here the predominant lithology is limestone from nearby mountains, not quartzites from halfway across the continent.

The center of Cayuse Basin consists of soft shale. The rim is hard sandstone capped by limestone. Only a slit in the northeast rim affords drainage, yet its erosional history is problematic. Much material appears to have been removed from Cayuse Basin. Slow erosion over deep time would have resulted in a very different topography. Hard blocks of sandstone and limestone would have accumulated on the basin floor and hindered erosion of the soft underlying shale. Yet above the shale inside the basin, these hard lithologies are absent. Not only are the planation surfaces testimony to the violent sheet flow of a megaflood, but Cayuse Basin itself appears to have been scoured out, exposing the softer shale. Similar is Windham Dome (Figure 11), which was razed to the level of the surrounding plain and covered with a sheet of gravel. Planation surfaces often cut indiscriminately through hard and soft strata, the opposite of what would be expected from uniformitarian erosion (Oard and Klevberg, 1998).

Interpretation

Meteor Crater, Arizona, is perhaps the most famous obvious impact crater. Chicxulub is famous for the dinosaur extinction theory, but many others have

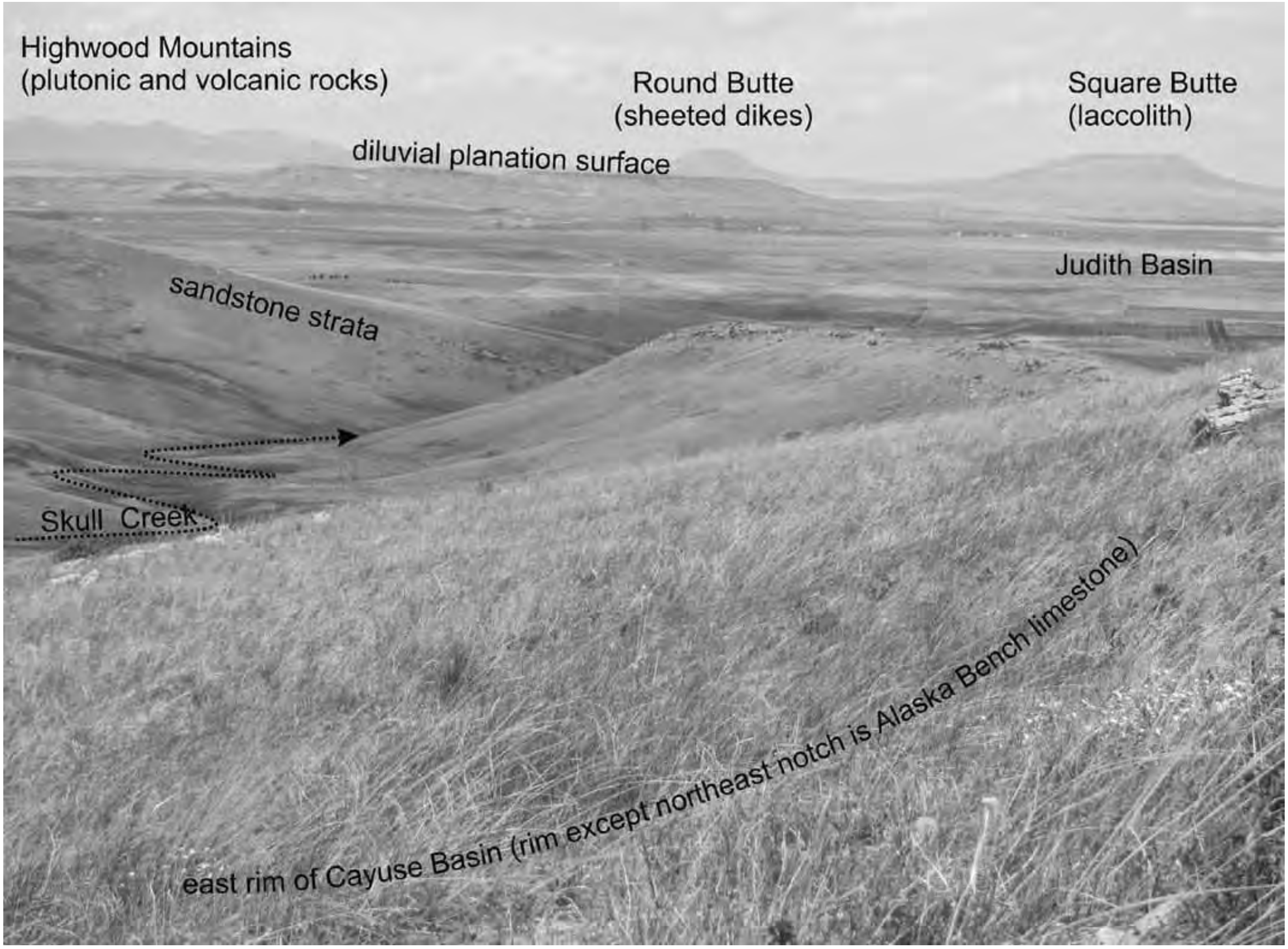

Figure 12. View north-northwest from east rim of Cayuse Basin showing various plutons on northern horizon beyond high bench that is a gravel-capped planation surface (diluvial). Like Cayuse Basin, the Judith Basin is a topographic basin, but whereas Cayuse Basin is a couple of miles across, the Judith Basin is twenty times that broad.

been imaged in the subsurface. There are sites where the evidence shown in Table I is found, but not Cayuse Basin. Furthermore, the undisturbed fissile shale in the bottom of the basin is hard to reconcile with an impact.

Cinder cones often look like Figure 3. Volcanic rocks are present north and northwest of Cayuse Basin (Figure 9). However, the basin contains only sedimentary rocks. It is clearly not a volcanic feature.

The geologic map of Vuke et al. (2007) was vindicated by field evidence. Cayuse Basin is a sedimentary dome (Figure 13). It appears likely that a laccolith underlies Cayuse Basin, causing the dome. Drainage of Floodwaters late in the Deluge (Abative Phase per Walker, 1994) could readily explain removal of debris from the interior of Cayuse Basin, planing of the Windham Dome flush with the bench, and its decreasing flow forming benches in the Judith Basin.

Catastrophic Plate Tectonics

Central Montana is believed by some to have been a foredeep at the northwest end of the Wyoming Craton and the south end of the Medicine Hat Block as part of the Rodinian supercontinent (Sims et al., 2004). It is distant from subduction zones and well over one hundred miles (200 km) north of Yellowstone. Cayuse Basin has no obvious connection to plate tectonics, catastrophic or otherwise.

Hydroplate Model

The Hydroplate Model may be thought of as catastrophic plate tectonics with a different mechanism and perhaps greater stress on horizontal compressive

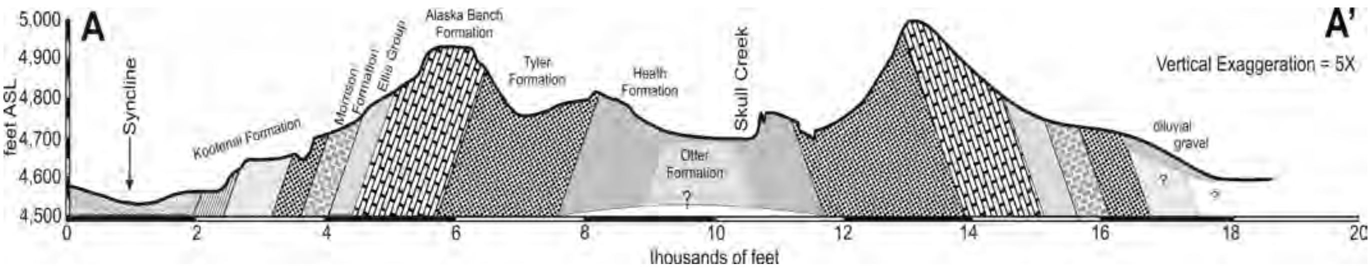

Figure 13. Section through Cayuse Basin as shown on Figure 11. See Vine (1956) and Vuke et al. (2007).

folding. The fold axis for the Big Snowy Mountains (Figure 1) is east-southeast by west-northwest, oblique to many other folds in the area, and the rest of the mountain ranges surrounding the Judith Basin have igneous cores. While this does not disprove the Hydroplate Model, neither does it support it.

Impacts with Vertical Tectonics

Cayuse Basin is not a crater. Other sites (e.g., Meteor Crater, Arizona) show impacts. Vertical motion on normal faults appears to have occurred over much of the study area (Vine, 1956; Vuke et al., 2007). Basement faults inferred from gravity and aeromagnetic data along the north flank of the Little Belt Mountains and the Great Falls Shear Zone do not appear to have been reactivated (Sims et al., 2004). Thus, Cayuse Basin neither refutes nor supports the model combining meteorite impacts with vertical tectonics.

Other Models

Laterally extensive strata with few or subtle unconformities are more readily explained in the diluvial geologic paradigm than uniformitarianism, as are the extensive planation surfaces and “cleaning” of debris from inside Cayuse Basin. Structural effects related to plutons of the Central Montana Alkalic Province indicate this emplacement was contemporary with late diluvial erosion, calling into question the 40-Ma age assigned to the plutons (Woodward, 2010). While good evidence for the Deluge, Cayuse Basin does not appear to provide a strong argument for or against any one model.

Conclusions and Admonitions

If Cayuse Basin does not show us which “Flood Model” is right, does studying it have any value? Much indeed! One of the most important lessons is not to jump to conclusions. Chamberlin (1890) was right. Second, do not rely on Google Earth®. While a useful tool, aerial imagery has inherent limitations, and conclusions should not be based solely on them. Third, do not rely on geologic maps. Even though the maps were quite accurate in this case, they are not always so. Marker beds, geophysical data, or other means of correlation are not always readily available, and mappers are fallible, particularly in stratigraphic interpretation. Rocks with little or no relation to a given type locality may be given a formation name simply to fill a gap in a presumed stratigraphic column. I typically look at the map *after* my first site visit lest I fail to make key observations. Maps are generally more reliable, however, than Google Earth®.

There is no substitute for boots on the ground. It is sometimes surprising what one may notice in the field that could never be learned from published sources. This works both ways relative to models. In the field, observations are readily made at various scales that may not have been made before, or not published.

Geologic research is not dependent on models and does not always validate or invalidate any of the popular geotheories or “Flood models.” These models should be treated as multiple working hypotheses and not as colored glasses or blinders.

Acknowledgements

Thanks to the Hughes Livestock Company for permission to hike on their land. I was accompanied by a couple of fine, science-minded Christian brothers, Mike O’Brien (the pilot) and Mark Nelson. Most of the figures from the east side of the basin in this article were taken by Mike O’Brien. *Deum Laude* (Job 38:4).

Glossary

Bentonite. Earth material composed of at least 90 percent smectite (a physil or "clay mineral" that is very moisture sensitive); bentonite is apparently to a large extent the end product of alteration of volcanic ash in sea water.

Bolide. A large, crater-forming meteorite of unknown composition.

Diluvialist. One who believes the Deluge of Noah's day was the most important geologic event of history and explanative of most geologic phenomena.

Fissile. Readily breaking into thin sheets.

Hydroplate Model. A plate tectonics model formulated by Walt Brown (2008) in which the plates moved on water.

Laccolith. A pluton (igneous intrusion) with a domed top that apparently pushed up the strata above it.

Latite. An extrusive (volcanic) rock in which alkali feldspar and plagioclase feldspar are present in approximately equal amounts.

Limonite. A hydrous iron oxide mineral.

Mafic. Igneous rocks high in magnesium and iron (basic rocks).

Micrite. Limestone with crystals too small to discern with the naked eye.

Paraconformity. An alleged unconformity for which physical evidence is lacking; it is inferred based on stratigraphic interpretation only.

Peneplain. An erosion surface marking the final stage of the cycle of landscape evolution as envisioned by uniformitarians in which a nearly flat surface results from erosion nearly to base level.

Phonolite. An extrusive rock equivalent to trachyte (either a porphyry or a lithology without visible crystals that is dominated by alkali feldspar) except that it includes feldspathoid minerals instead of the more common feldspars.

Porphyry. An igneous rock with relatively large crystals (phenocrysts) in a fine-grained groundmass.

Regolith. Mineral matter composed of weathered bedrock that forms the parent material for soil.

Shonkinite. A mafic intrusive (plutonic) rock that is a mafic syenite composed primarily of augite and alkali feldspar.

Syenite. An intrusive rock dominated by alkali feldspar (mineralogically equivalent to trachyte).

Unconformity. A contact between rock units that is discordant, implying that the top of the lower one was eroded to some degree before the next was deposited.

Wildcat well. A well drilled in search of oil in a location lacking detailed information or previous exploration.

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