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Report on paleontological discoveries across the Bears Ears Region during the 2016 field season with special emphasis on Comb Ridge and Fry Canyon

Introduction

In 2015 CNHA-funded work conducted by myself and our team began the first detailed, systematic examination of the geology and paleontology of Comb Ridge since the start of scientific investigations in the region. This work was reported on last year to the Board; in 2016 additional work was conducted to tie Comb Ridge into the larger prehistoric picture of the Bears Ears Region. Despite setbacks in planned fieldwork relating to equipment failure (geological transit malfunction prevented us from measuring additional stratigraphic columns, aircraft engine malfunction and subsequent sale prevented aerial photography) this field season was the most productive yet. The number of specimens recovered from Comb Ridge and the surrounding area exceeded that of all previous years, and the new specimens particularly from the Hills Have Teeth site and the new Portal to NeCrocPolis locality (in Fry Canyon) are nationally significant.

The Chinle Formation forms roughly half of the vertical height of Comb Ridge north of the San Juan River, where most of the fieldwork authorized under this grant has occurred. Previous authors have suggested that the upper portion cannot be differentiated from the lower unit (Chinle Undifferentiated, Petrified Forest Member (Bennett, 1955)), while later authors have parsed out that the upper unit is a distinct rock group, sharing many commonalities with units in northwestern New Mexico and elsewhere in southeastern Utah (Rock Point Member (Lucas, 1997), upper unnamed member (Murry & Kirby, 2002), Owl Rock Member (Molina-Garza, Geissman, & Lucas, 2003), and the Church Rock Member (Martz, Irmis, & Milner, 2014)). The lower unit has barely been described by prior workers and is discussed here further in the Geology section.

Since May of 2014 fieldwork has been carried out by high school student crews at Comb Ridge, resulting in a significant increase in the number of localities and specimens discovered (Figure 1, compare to Figure 2). In 2016, work continued at Comb Ridge and expanded in scope to other exposures of the Chinle Formation in the Bears Ears region. New discoveries from 2016 include the first fossil horsetail remains from Comb Ridge, the oldest vertebrate traces from Comb Ridge (Gay, Jenkins, & Lepore, 2016), new fossil vertebrate remains from the prolific Hills Have Teeth locality ((Gay & St. Aude, 2015), (Gay R. J., Jenkins, St. Aude, & Azouggagh, 2016), (Gay & Jenkins, In review)), and a new, significant bonebed of several articulated individuals from Fry Canyon (Gay R. J., et al., 2017). What follows is a systematic report of the discoveries from fieldwork conducted in 2017, funded by a Discovery Pool Grant from the Canyonlands Natural History Association.

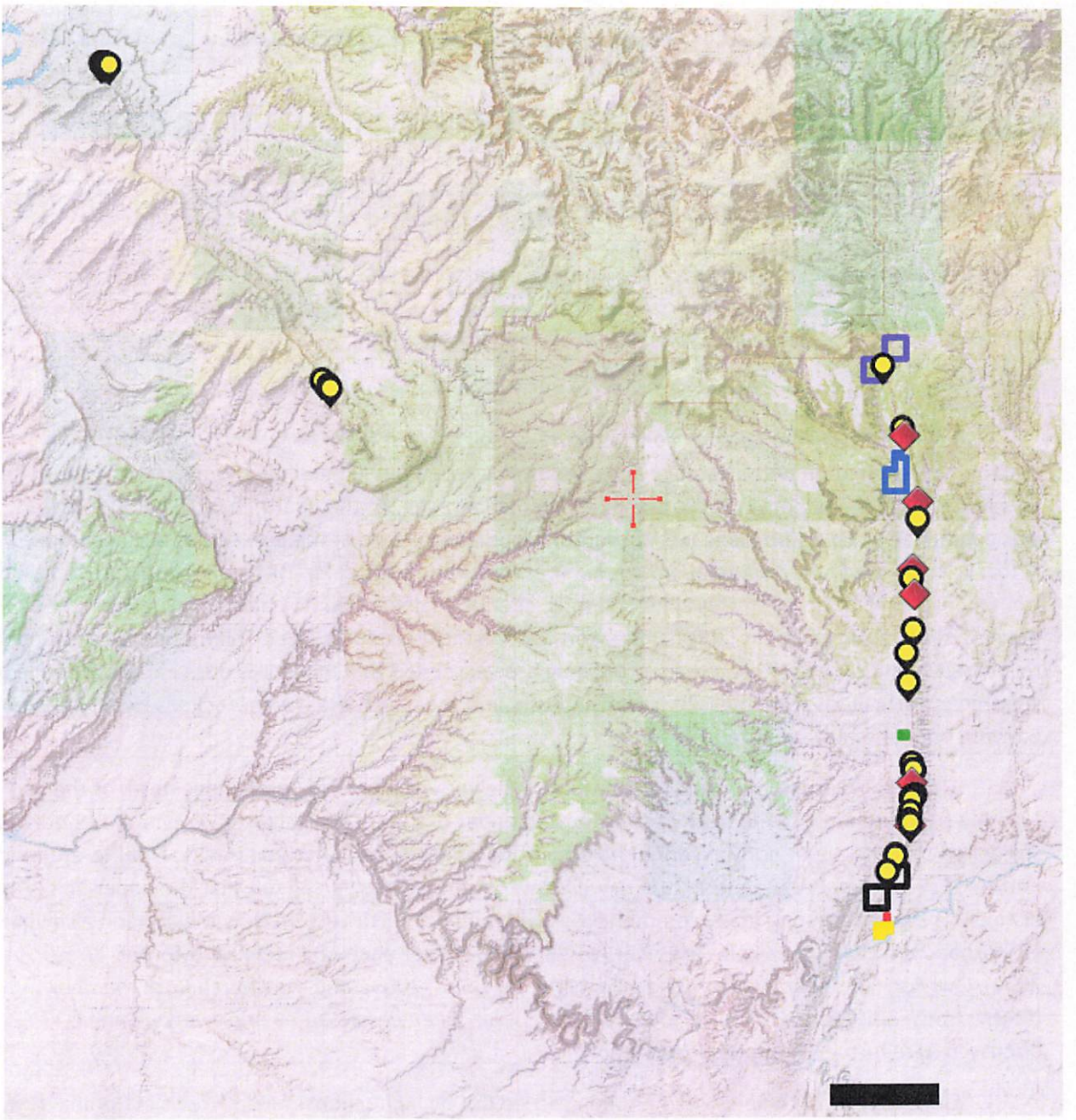

Figure 1: Sites discovered by CNHA-funded High School Field School teams in the Bears Ears region since 2014. Boxes along Comb Ridge indicate private or state ownership. Red diamonds indicate areas that were investigated with no fossils. Scale = 5 miles.

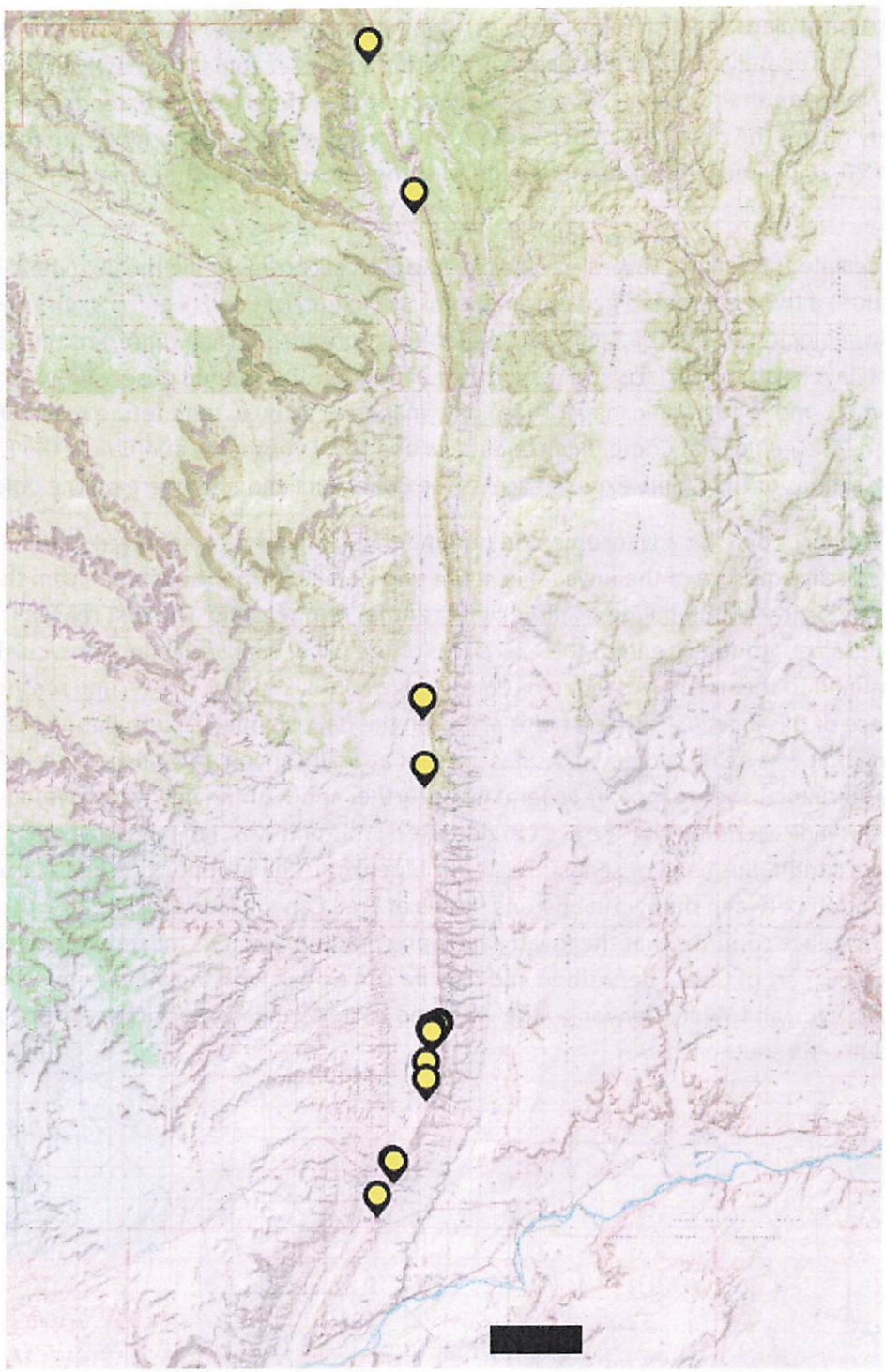

Figure 2: Topographic map of Comb Ridge with localities discovered by the end of the 2015 field season highlighted. Scale bar = 3 miles

Geology

As discussed in the introduction, the geology of Comb Ridge has been examined in a minimal fashion by previous workers. During the 2015 field season, new stratigraphic sections were measured

and there were plans to finish these sections, along with several new sections, during the 2016 field season. Unfortunately, when crews began measuring a new section at the newly discovered Bloody Cut locality, alongside Utah Highway 95 the geological transit suffered a failure, rendering it unable to accurately record the dip of the beds. As the formations present at Comb Ridge dip to the east at between 20-25 degrees, this failure prevented us from measuring further stratigraphic columns in the area.

Despite this failure, several geological advances occurred during the 2016 field season. First was the creation of two generalized geologic maps for use in publications (Figures 3, 4). These are the first fine-scale geologic maps of the Bears Ears region to be produced. They represent the generalized geological layout on the surface and were created using on-the-ground observations, aerial photography, and topographic maps. These new maps will allow us, and future researchers, to better understand the geology at Comb Ridge and make and test hypotheses about how the rocks here relate to other sections of the Chinle exposed across the Bears Ears and elsewhere on the Colorado Plateau.

The second major advancement in our understanding of the geology at Comb Ridge is the discovery of an exposure of the lower sandstone unit ('Trail Canyon Sandstone' from the 2015 report) in the central portion of Comb Ridge. This is significant for two reasons. The first reason is that it establishes a new southern end to the exposures of the lower sandstone unit; previously this unit has been confined to the northern section of Comb Ridge near Elk Ridge. The second reason for the significance of this location is that it helps establish the depositional pattern during the time the lower sandstone unit was being laid down. As it is present at Trail Canyon and pinches out before the Utah Highway 95 roadcut, yet reappears several miles further south at the newly discovered White Rocks locality, this indicates that that the system depositing this unit was a meandering river; otherwise there would be a continuous band of sandstone at the Moenkopi/Chinle contact. While this was hinted at by the separation between the two sandstone lenses at Trail Canyon (see 2015 report) this independent piece of evidence confirms that the lower sandstone unit represents a meandering river system present at the earliest part of Chinle deposition and may be correlative with the Shinarump Sandstone reported from Fry Canyon and White Canyon to the west and better-studied deposits in Arizona and New Mexico to the south and southeast.

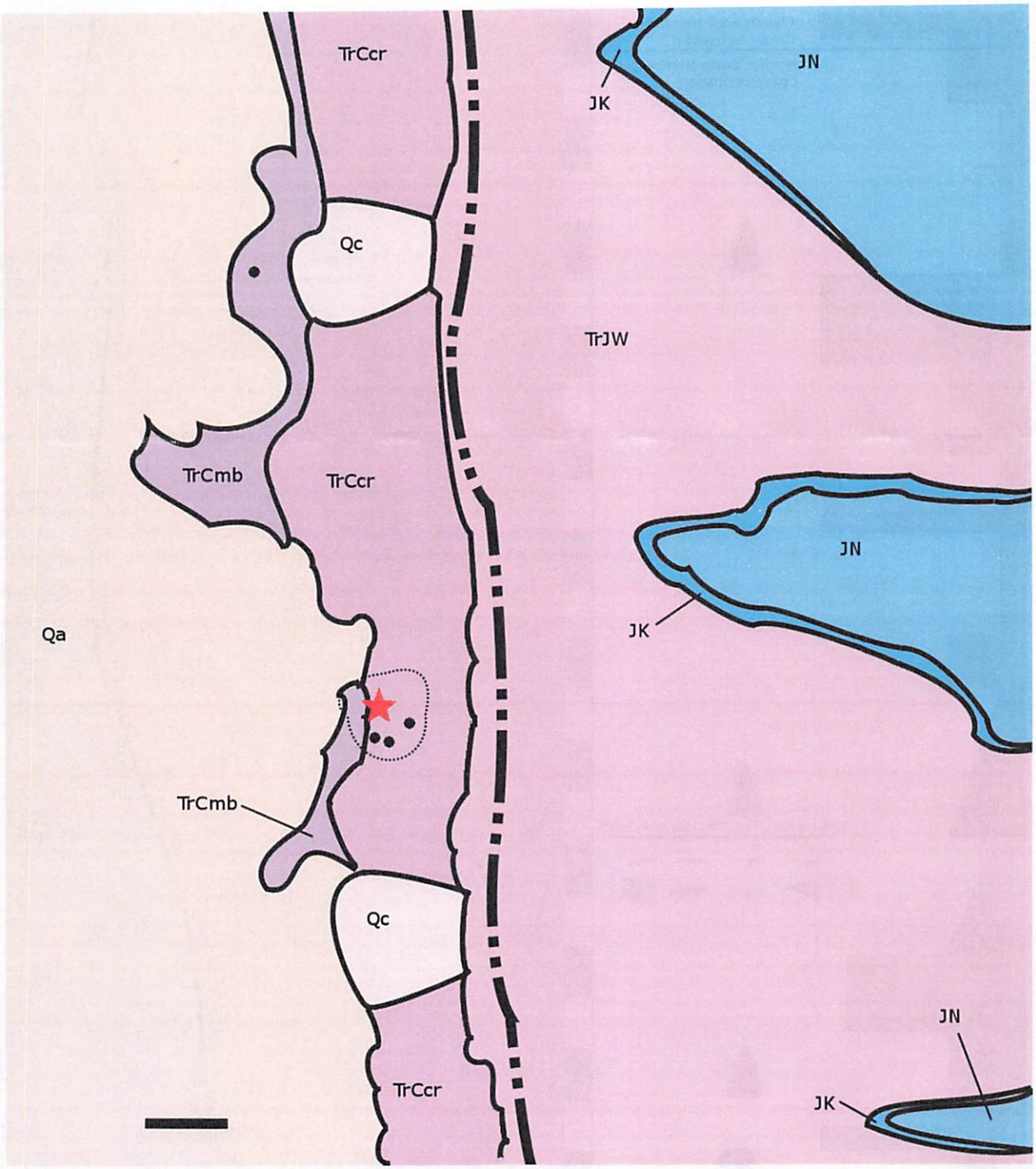

Figure 3: Geological map showing the generalized geology at the Bread Bowl region of Comb Ridge. Scale bar = 0.1 km.

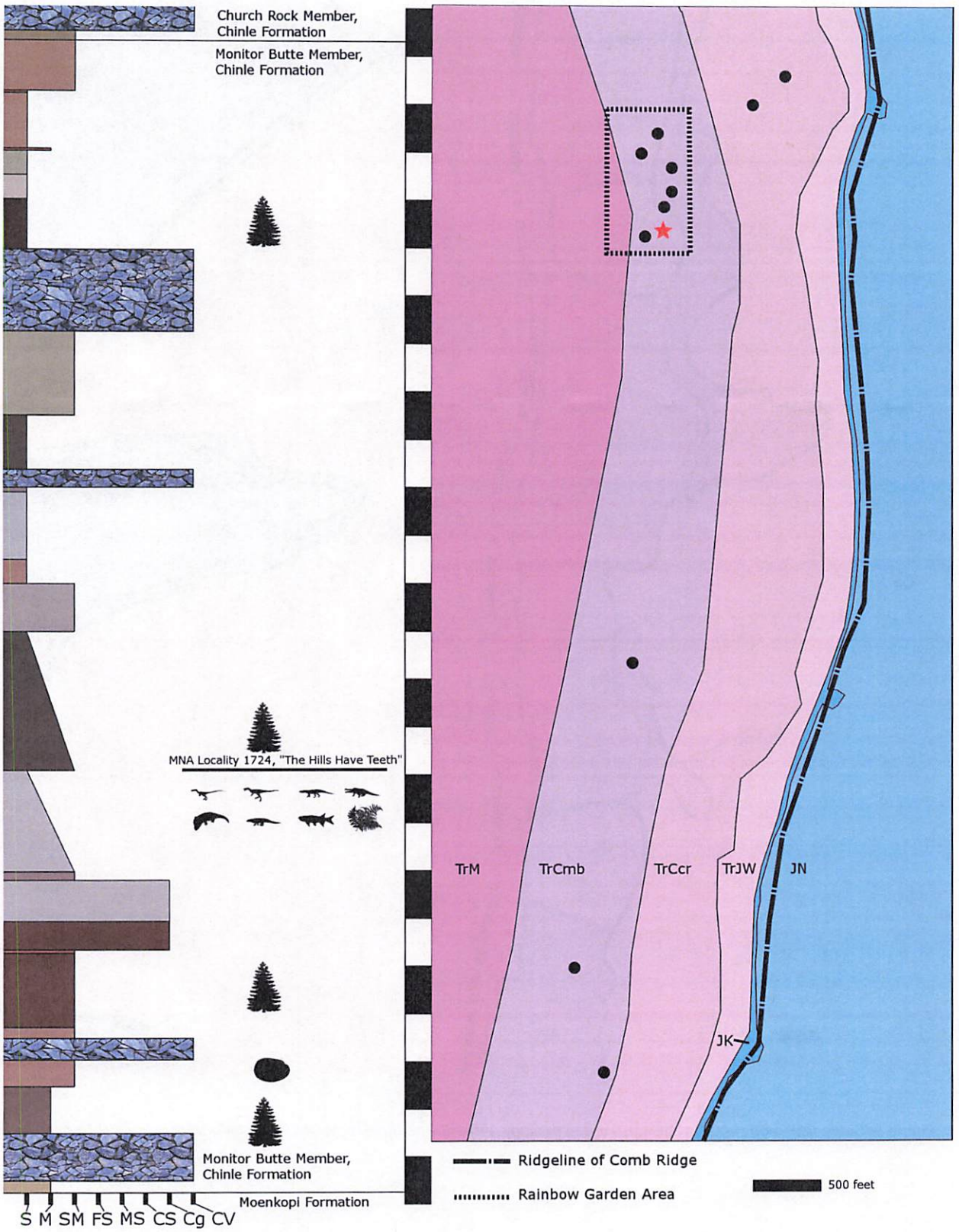

Figure 4: Stratigraphic column and geologic map of the Rainbow Garden area of Comb Ridge.

Paleontology

The 2015 field season added significantly to our understanding of the paleontology and paleoecology of Comb Ridge. Although flash flooding during June limited prospecting to the Rainbow Garden area and immediately foot-accessible vicinity, a number of new and significant fossils were recovered both from existing localities and from newly discovered sites. These are discussed below.

New Archosauromorph Tooth Taxon (*Crosbysaurus n. sp.* From 2015 report)

As stated in the 2015 report, *Crosbysaurus sp.* has been identified from Comb Ridge (Gay & St. Aude, The first occurrence of the enigmatic archosauriform Crosbysaurus Heckert 2004 from the Chinle Formation of southern Utah, 2015) (Figure 5) and the specimens recovered since 2014 show taxonomically significant differences between them and the holotype of *Crosbysaurus*; specifically the Comb Ridge teeth lack of compound mesial denticles and a mesiobasal edge that lacks denticles completely. A manuscript describing these specimens as a new species of *Crosbysaurus* was submitted to PLoS ONE in the spring of 2016. Reviews came back suggesting that the teeth were so different they warrant the erection of a completely new genus as well. In addition to these comments, several new specimens were discovered at 'The Hills Have Teeth' during the 2016 field season. As a result, my coauthor and myself have completely overhauled the manuscript and have named these tall, recurved, laterally compressed teeth as a new genus and species (Figure 6). It is in the second round of review currently and we hope to see it published before the end of 2017.

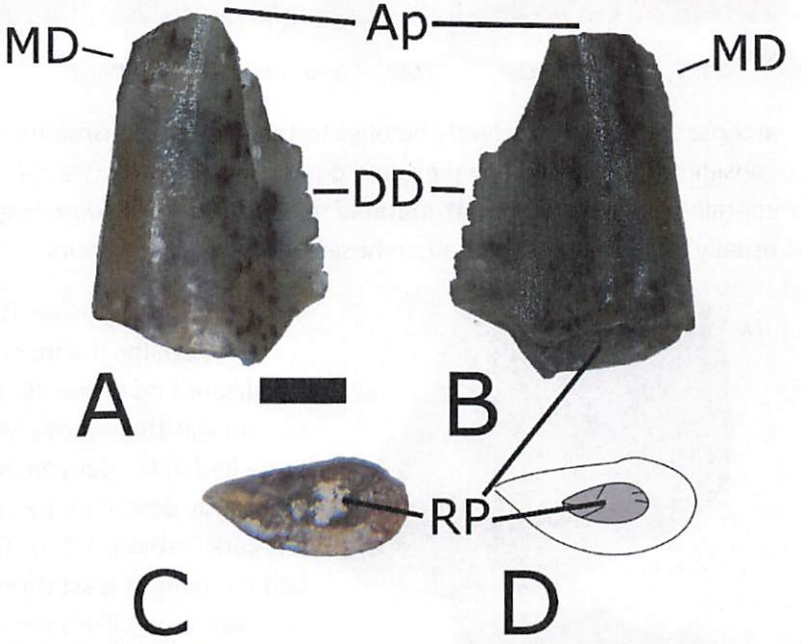

Figure 5: Archosauriformes n. gen et sp., figure from Gay and St. Aude, 2015.

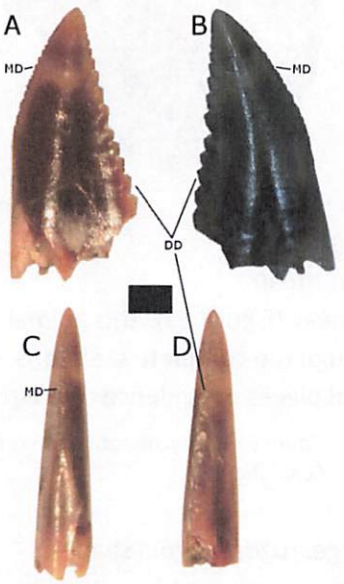

Figure 6: Holotype of Archosauriformes n. gen. et sp. from the Monitor Butte Member, Chinle Formation.

Vertebrate Traces from the Chinle Formation at Comb Ridge

Another significant find from the 2016 field season was the discovery of the first identifiable vertebrate trace fossils from the Chinle Formation at Comb Ridge. While vertebrate fossils are well known from the younger Navajo Sandstone, none have been previously reported from the older sections of Comb Ridge. The team discovered two definitive and one probably type of vertebrate trace at the 'Bread Bowl' area. The first type of trace was

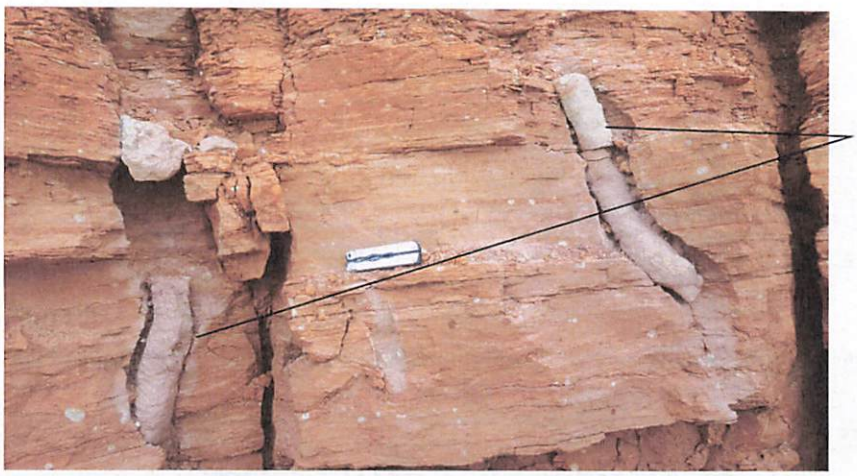

Figure 7: Vertebrate burrows in red channel sand at the 'Bread Bowl' area.

a series of burrows, approximately 7-10 cm in diameter through a red channel sand and infilled with white sand (Figure 7). These are likely vertebrate burrows, based on lungfish and temnospondyl burrows from Colorado, though the possibility remains that they are crayfish burrows.

The two undisputed traces belong to two different sorts of archosaurs. One track clearly belongs to the ichnotaxon *Grallator* (Figure 8), which is generally considered to be made by theropod dinosaurs. The other trace is a slab containing several tracks attributable to *Brachycheirotherium* (Figure 9), usually attributed to armored archosaurs known as aetosaurs.

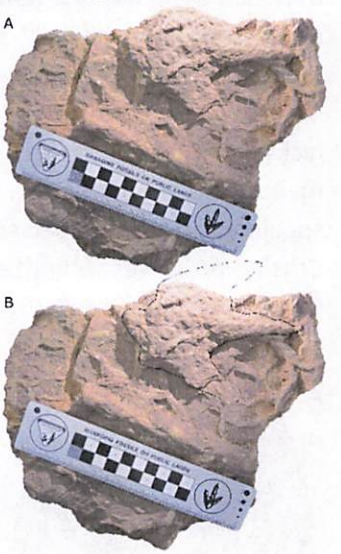

Figure 8: Grallator *track from Comb Ridge.*

Figure 9: Brachycheirotherium *tracks from Comb Ridge.*

Fry Canyon Archosaur Bone Bed

Perhaps the most significant find of the 2016 field season was the discovery of a new bone bed in Fry Canyon, not previously described by earlier workers (Parrish, 1999). This bone bed contains at least three organisms, and likely more, spread across a 67-meter section of exposure. At least one of the organisms is still articulated *in situ* (Figure 10), with parts of a second organism being discovered *in situ* in September of 2016 several meters away (Figure 11). This animal appears to be new to science. Although the complete skeletons have not been excavated yet, several pieces of evidence rule out this specimen belonging to the most common Triassic archosaurs from Utah. Although all parts of the body have been represented with the finds thus-far, no osteoderms have been recovered matching those of aetosaurs (with their highly diagnostic rectangular shape) or phytosaurs (with their large, rugose, ovoid shape). This is despite the fact that osteoderms are the second-most numerous element collected from the Fry Canyon locality. Additionally, we have recovered a half dozen unguals from this organism that are completely unlike any described phytosaur or aetosaur osteoderms, which tend to be mediolaterally compressed. In contrast, the unguals from Fry Canyon are dorsoventrally compressed 'hooves,' similar

to those seen in *Shuvosaurus*, *Poposaurus*, *Effigia*, and other rare Triassic archosaurs (Nesbitt, The anatomy of Effigia okeeffeae (Archosauria, Suchia), theropod convergence, and the distribution of related taxa, 2007), (Nesbitt, 2011) (Figure 12). The few teeth recovered from the Fry Canyon site further support our hypothesis that this animal is neither a phytosaur nor an aetosaur. All teeth recovered thusfar are smaller than would be expected from a phytosaur of this size and have a serration density significantly higher than those of phytosaurs (9/mm vs. ≤2/mm).

Figure 10: Articulated archosaur in situ *at Fry Canyon.*

Fieldwork is currently being planned for summer 2017 to excavate this large bone bed at Fry Canyon. These fossils will be reposited at the Museums of Western Colorado's Dinosaur Journey facility in Fruita, CO for study and publication. In fact, the initial description of the bone bed and a scientific attempt to identify the animal preserved will be presented in Prescott in February, at the annual meeting of the Western Association of Vertebrate Paleontologists (Gay R. J., et al., 2017).

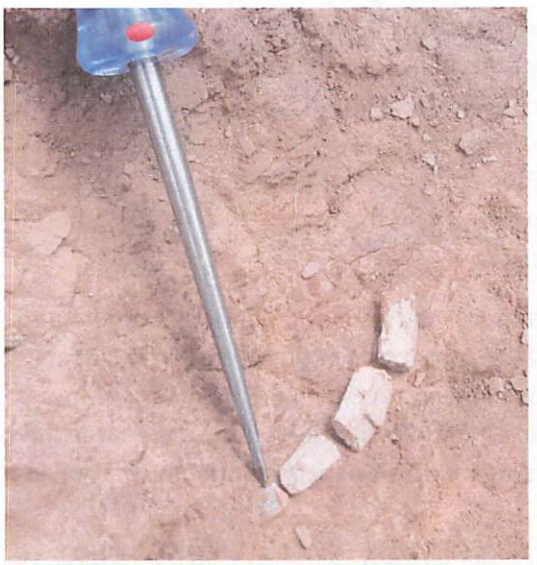

Figure 11: Cervical rib of Fry Canyon archosaur, in situ.

Discussion

The 2016 field season has drastically increased our knowledge of the paleontological story of Comb Ridge. The number of specimens collected during June and September fieldwork outstrips the number collected from Comb Ridge in all previous field seasons combined. The areas of Comb Ridge now covered by scientific survey work has increased greatly, from <1% in 2013 to ~30% in 2016, with the Chinle Formation portion of Comb Ridge now covered by scientific, systematic prospecting near 40%. The large gaps in the rock record between the two highways began to be filled during the 2016 field season, though more work needs to be done there, especially in the tougher-to-access Church Rock Member of the Chinle Formation. The areas between UT 95 and Trail Canyon still need to be surveyed; this has not happened due to the difficulty of access from paved or gravel roads (except for the Old Dugway area). Likewise,

the area south of US 163 needs to be further investigated but owing to the nature of the road (down Comb Wash itself) and the newly-sold section of land formerly belonging to the State of Utah access has remained problematic.

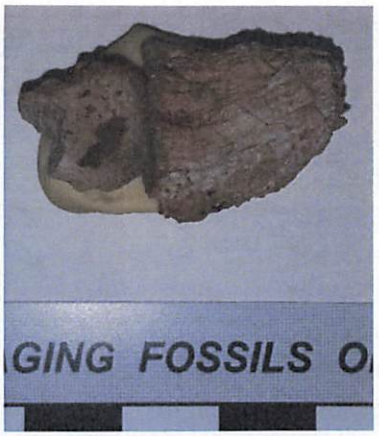

Figure 12: Hoof-like ungula from the Fry Canyon archosaur.

The 2016 field season also allowed us to begin connecting the fauna at Comb Ridge with other areas in the Bears Ears, specifically those in White and Fry Canyons. The discovery of rich fossil-bearing coals in the lower Chinle Formation, stratigraphically equivalent to the Hills Have Teeth beds at Comb Ridge, reinforces our conclusion that the lower portion of the Chinle Formation at Comb Ridge is in fact the Monitor Butte Member, owing to the high quantity of carbonized plant remains found in those beds. The beds in the upper section of Comb Ridge have produced few vertebrate body fossils thus far, but we are hopeful that additional work will help correlated them. One exception to this is a partial phytosaur skull discovered in the center portion of Comb Ridge in the Church Rock Member in late June of 2016. This skull will be excavated during the 2017 field season. As phytosaur skulls are common from Triassic rocks across the globe, we are hopeful that this new piece of data will help us better date the Chinle Formation at Comb Ridge. Additionally, this represents the first phytosaur skull yet discovered at Comb Ridge.

Future Work

Future work will have two primary thrusts. The first goal is further our geological reconnaissance of Comb Ridge. While the areas covered thus far have yielded new information about the paleontology and geology of the area, many areas have received little to no attention due to time, environmental conditions, or access issues. Some of these areas are slated to be investigated during the summer of 2017. Coupled with the completion of stratigraphic work along the western face of Comb Ridge, delayed in 2016 due to equipment failure, this comprehensive study and survey can then be tied in with other works both local (Martz, Irmis, & Milner, 2014) and regional (Stewart, et al., 1972) to greatly expand our understanding of the geologic history of southeastern Utah. This regional synthesis has begun with 2016 fieldwork tying down the Monitor Butte Member at Comb Ridge and correlation between the units at Comb Ridge with those at Red Canyon, Lisbon Valley, Indian Creek, and the Moab area. In 2017 these regional correlations will grow as the gaps at Comb Ridge shrink.

The second main point of 2017 fieldwork in the region will be the excavation, preparation, and description of the Fry Canyon archosaur. This is the first Triassic bone bed yet discovered in the Bears Ears region and, if the initial data from its anatomy turns out to be correct, may be the first new archosaur taxon to be named from the region or will provide an unprecedented look at the anatomy of a poorly known group of organisms. In either case the team is very excited to begin work on this project in May of 2017 and again in September of 2017.

With these avenues of future work, it should not be overlooked that ongoing efforts exist by the team to publish and describe specimens previously uncovered at Comb Ridge. These include the oldest vertebrate traces from Comb Ridge (preprint currently available (Gay, Jenkins, & Lepore, 2016), expected to go to formal review March 2017), the paleontological description of The Hills Have Teeth

locality (SVP 2016 poster (Gay R. J., Jenkins, St. Aude, & Azouggagh, 2016), expected to be in review by Fall 2017), the description of a new genus and species of archosauriform from Comb Ridge (Gay & Jenkins, In review), and a draft geologic map for Comb Ridge (currently in preparation). With the new specimens and data, along with the ongoing publication efforts, it seems likely that 2017 will represent a new benchmark for research at Comb Ridge. The team and myself look forward to the work and to working with Canyonlands Natural History Association going forward with this.

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