Stratigraphy and Paleontology of Late Cretaceous to Paleocene strata on the Western Rosillos Mountain Ranch, Brewster County, Texas

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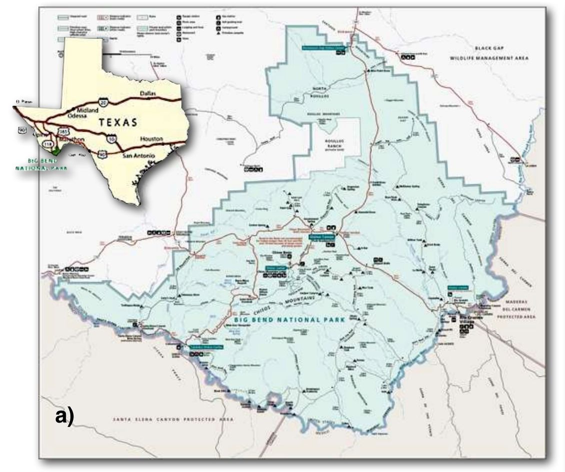
Introduction

The region encompassing modern Big Bend National Park (BBNP) in West Texas (Fig. 1) has been the subject of geologic study since the late 19th century. The Rosillos Mountain Ranch (RMR) lies just north of BBNP, and contains exposures of Cretaceous- to Paleocene-aged rocks that are also found in BBNP, including the Aguja, Javelina and Black Peaks Formations (Fig. 2). The 2007 USGS geologic map of BBNP, which includes the RMR, relied heavily on aerial photos and older maps (Maxwell *et al*, 1967) for contact boundaries in remote areas, including the RMR. Unfortunately, many of these boundaries are incorrect. One purpose of this study is to correct these lithologic contacts, in the southwest of the RMR, with detailed field mapping, including the rather new technique of using plentiful high resolution georeferenced images. Additionally, detailed lithostratigraphic descriptions will be used further establish the distinctiveness of the formations, as there is some confusion in the current literature. Field work has augmented the current vertebrate collection from the area and established more accurate contact locations between these formations, allowing for the production of a more accurate geologic map.



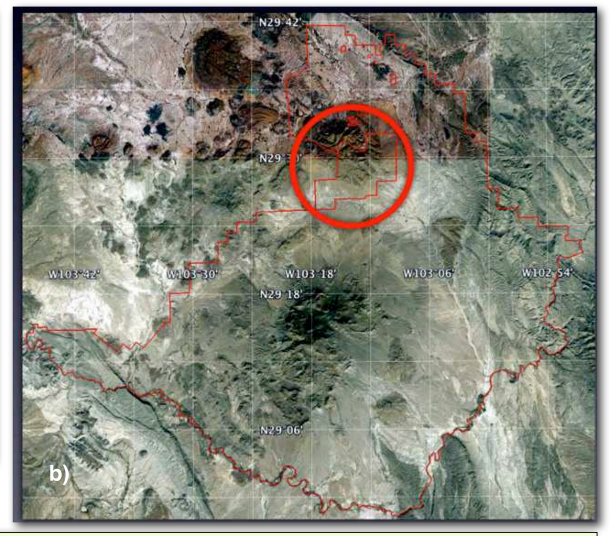


Figure 1 a) Map of Big Bend National Park (National Park Service), b) Location of Rosillos Mountain Ranch in relation to Big Bend National Park (Google Earth image).

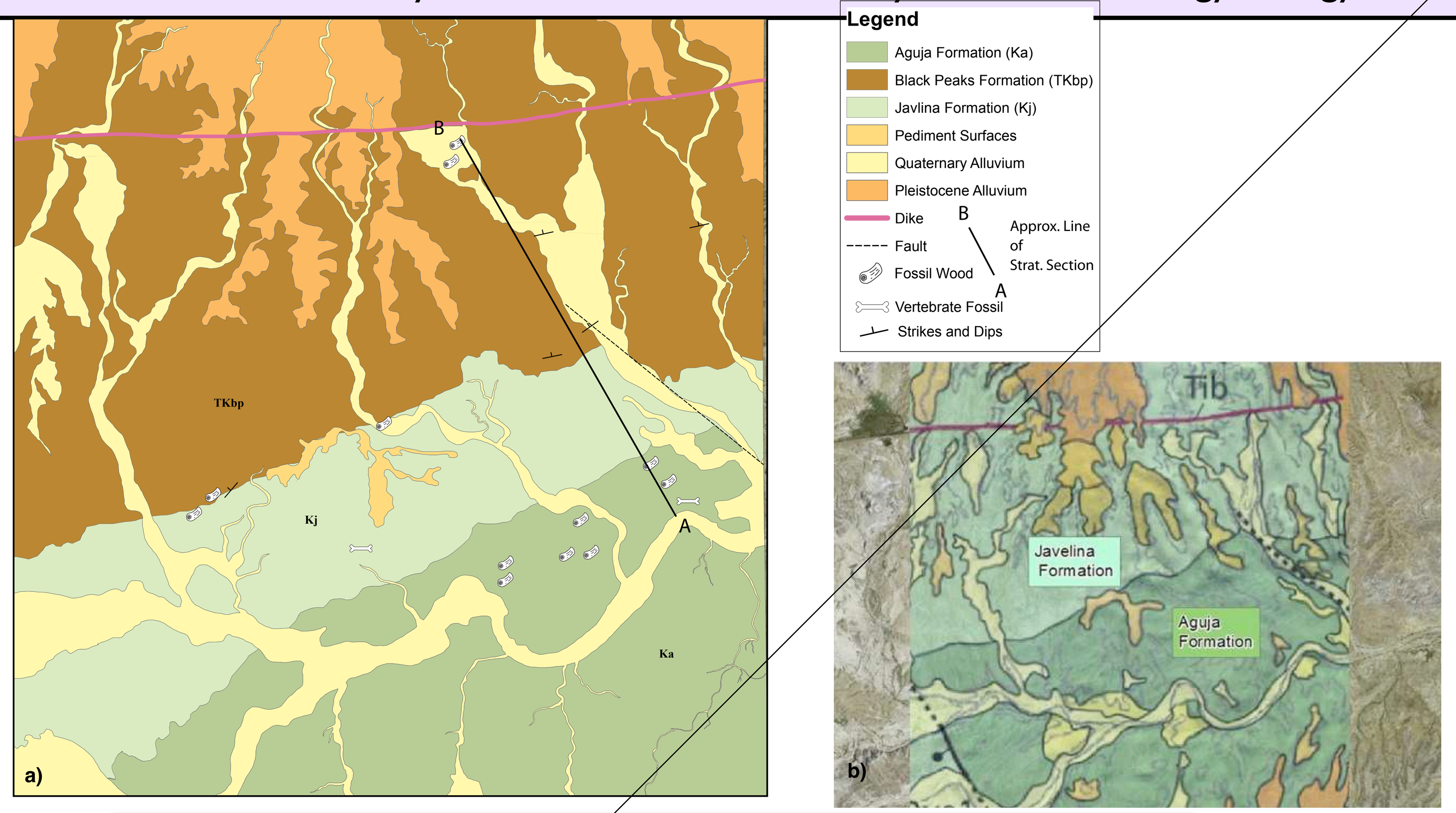


Figure 4. a) Updated field map of the project site, including the Aguja, Javelina, and Black Peaks Formations, the prominent igneous dike in the area, and alluvial and pediment surfaces. Strikes and dips, fossil and wood localities, the fault on the east side of the project area, and the approximate line of stratigraphic section are also shown. b) 2011 USGS map of the same area. Mapped area is approximately 6.0 km^2.

Geology

The field area includes exposures of three vertebrate-bearing formations, the Aguja, Javelina and Black Peaks Formations (AJBp). According to the original description by Maxwell *et al* (1967), the Aguja Formation includes lower marine sand and clay beds grading up into lacustrine and lagoonal terrestrial strata. The terrestrial layers include sandstone, shale, thin limestone and thin lignitic seams. Knebusch (1981) and Lehman (1986) suggested that the Aguja Formation represents a fluvial-dominated delta system, as indicated by paralic deposition, representing two regressive-transgressive cycles. The Aguja Formation is Campanian and includes fossil assemblages of marine mollusks, crocodilians, turtles, dinosaurs, mammals and silicified wood (Maxwell, et. al, 1967).

The Javelina Formation consists of yellow-brown fluvial sandstones separated by varicolored, bentonitic shales. The shales represent poorly drained overbank, paleosol and lacustrine deposits. Calcareous pedogenic concretions are common in the paleosols. The Javelina Formation is Maastrichtian and contains crocodilians, turtles, dinosaurs, pterosaurs, mammals and fossil wood (Wheeler and Lehman, 2005).

The Black Peaks Formation spans the latest Cretaceous and oldest Paleogene time, and consists of alternating sandstone and varicolored shales Lehman (1986). Some of the sandstones contain cannonball-sized concretions. The paleosols of the Black Peaks appear dark gray to black and red in color, and the K-Pg boundary lies within the Black Peaks Formation. Though both the Javelina and Black Peaks Formations have fluvial channel and floodplain deposits, the Javelina Formation is more sandstone dominated and does not contain the distinct black paleosols found in the Black Peaks (Lehman and Busbey, 2007).

Maxwell *et al* (1967) placed the contact between the Aguja and Javelina Formations above the last sandstone at which the shales change from 'yellow' to predominately varicolored. Additional features are now used to distinguish the two formations near their contact, including "sick" green and blue paleosols, the presence of highly silicified wood near the top of the Aguja Formation (Figure 3), and sometimes the presence of tiny chert pebbles in the lowest Javelina sandstone (Lehman and Wick, *pers comm.*). The contact between the Javelina and Black Peaks Formations is more gradational, but is generally placed above the last major Javelina sandstone before the transition to a section dominated by varicolored paleosols. The Cretaceous/Paleogene boundary occurs some 50 to 60 meters above the Javelina/Black Peaks boundary and may occur at thin, slightly ferruginous sandstones.

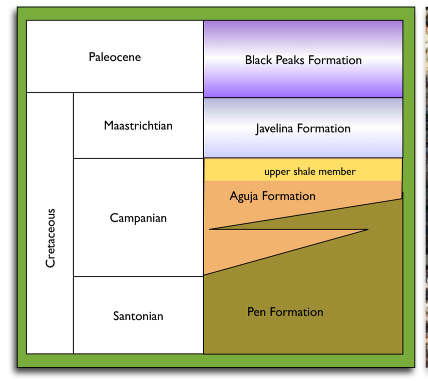


Figure 2. Chronostratigraphy of Late Cretaceous and Early Paleogene stratigraphic units near Big Bend National Park.

Figure 3. Silicified wood (a) and distinct pea green shale (b) found in the upper shale member of the Aguja Formation, just below the contact with the Javelina Formation.

Problems to be addressed

The field site is located north of Big Bend National Park on the RMR. The area has well-exposed, but unstudied, sections of the vertebrate-bearing Aguja, Javelina and Black Peaks Formations (AJBp) (Campanian through Danian). Though the area, or portions of the area, have appeared on published geologic maps (Bloomer, 1949, Maxwell *et al*, 1967, USGS, 2011) these maps either predate current lithostratigraphic unit definitions or were mapped by airphoto without 'field truthing'. Current field mapping of the area has revealed major discrepancies between field contact locations and contact locations on published maps. In this project, we address these discrepancies and use these excellent exposures to help resolve lithostratigraphic definition problems between the three formations. In addition, similar exposures in the park show different facies between the east and west sides. As the field site lies near the middle, we hope to use these excellent exposures to help explain this facies difference. Finally, we hope to add to the fossil collections ranging from Late Cretaceous to Paleocene by thoroughly prospecting these exposures.

Methods and Results

Field mapping of the area was conducted using current lithostratigraphic definitions of Lehman and Wick (*pers comm*). Georeferenced pictures were taken using a 16 mpx Casio GPS camera, with high density along contacts and the detailed measured section. Contacts were drawn on printed aerial photos and then transferred to ArcGIS. Polygons were drawn for the formations over an aerial photo and compared to the 2011 USGS map of the area. A stratigraphic section was measured using a Jacob staff, and was documented with georeferenced pictures.

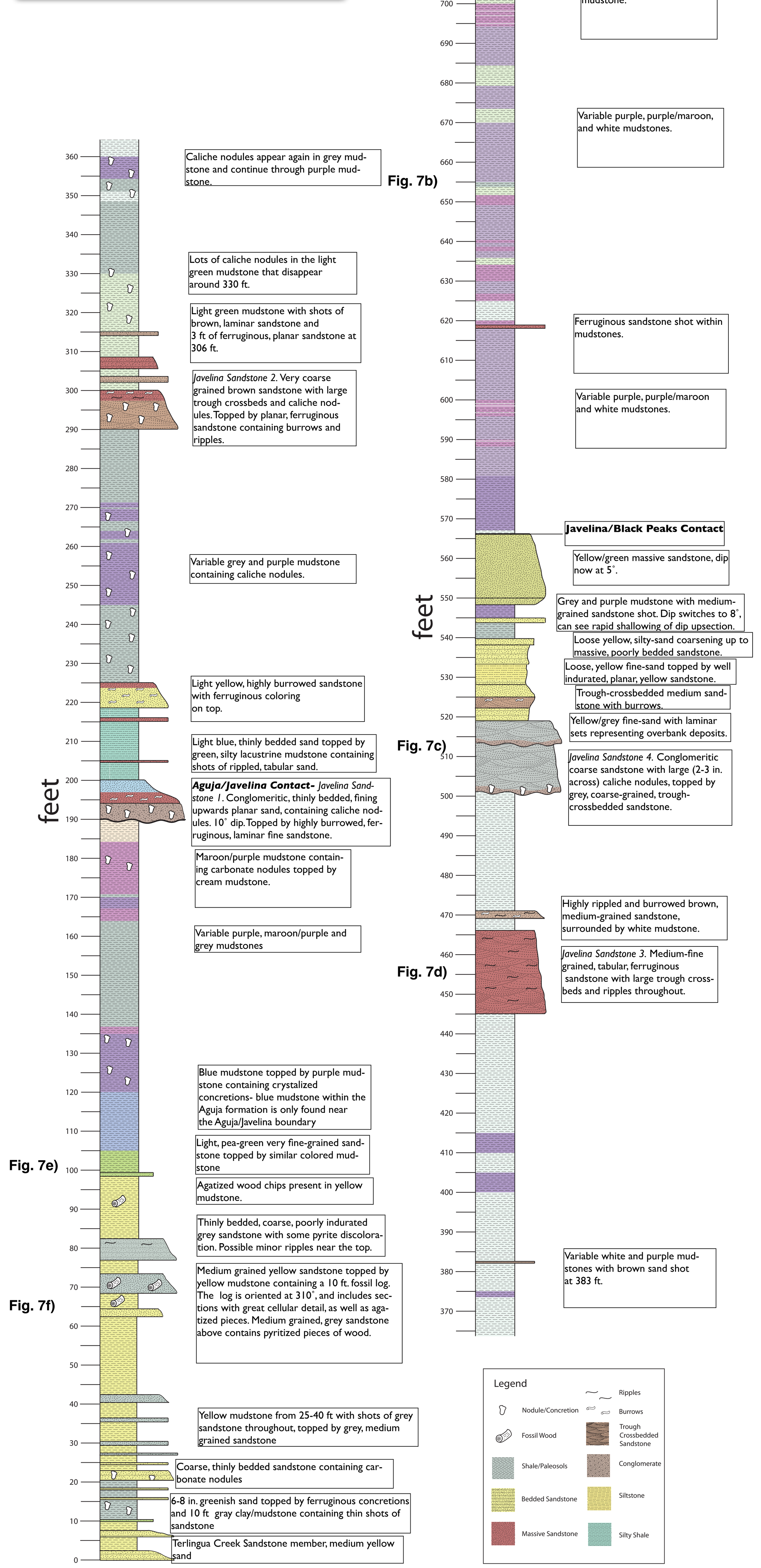
Field mapping revealed large disparities in the location of the contacts as compared to previously published maps of the area that relied heavily on aerial imagery for mapping. Figure 4 displays these maps, with a) representing the new, "field-truthed" map, including fossil wood and fossil vertebrate localities and strikes and dips in the area. The USGS 2011 Big Bend map only shows two formations, the Aguja and Javelina, and completely eliminates the Black Peaks. In the USGS 2011 map, the mapped contact between the Aguja and Javelina formations is placed at the actual Javelina and Black Peaks contact.

Prospecting has revealed an abundance of fossil plant material. In addition to the silicified wood found in the uppermost Aguja, the Aguja Formation has horizons with entire logs of fossilized wood, including a range of preservation from petrified pieces still showing vascular structure to fully silicified sections. These "log jams" represent cupresoid and podocarpoid log types (Wheeler and Lehman, 2005). Farther up in the Aguja, isolated cupresoid and podocarpoid *in situ* stumps are present, again with a variety of preservation. Isolated petrified wood is found in the Javelina, but not in nearly of the same abundance as the Aguja. Within the Black Peaks Formation, a major "log jam" assemblage is present, but is made up of almost exclusively *Paraphyllanthoxylon*. Representative "log jam" examples are shown in Figure 5.

Prospecting of the area, during mapping, revealed four vertebrate specimens, a small turtle in the Upper Aguja, hadrosaur material including a distal tibia and juvenile ilium, and an *Alamosaurus* ulna (Figure 6). Similar exposures within Big Bend National Park have a range of vertebrates, including dinosaurs (*Alamosaurus, Torosaurus, Tyrannosaurus*), pterosaurs (*Quetzalcoatlus*), and early Paleocene mammal assemblages.

Figure 5. a) Cupresoid/podocarpoid log from "log jam" assemblage of the Upper Aguja. b) *Paraphyllanthoxylon* log from the "log jam" bed of the Black Peaks Formation. c) Turtle specimen, Upper Aguja. d) Distal hadrosaur tibia, Javelina. e) Juvenile hadrosaur ilium, Javelina. f) *Alamosaurus* ulna, Javelina.

Figure 6) Stratigraphic section of Upper Aguja Formation, Javelina Formation, and Lower Black Peaks Formation. Locations from Figure 7 are indicated.



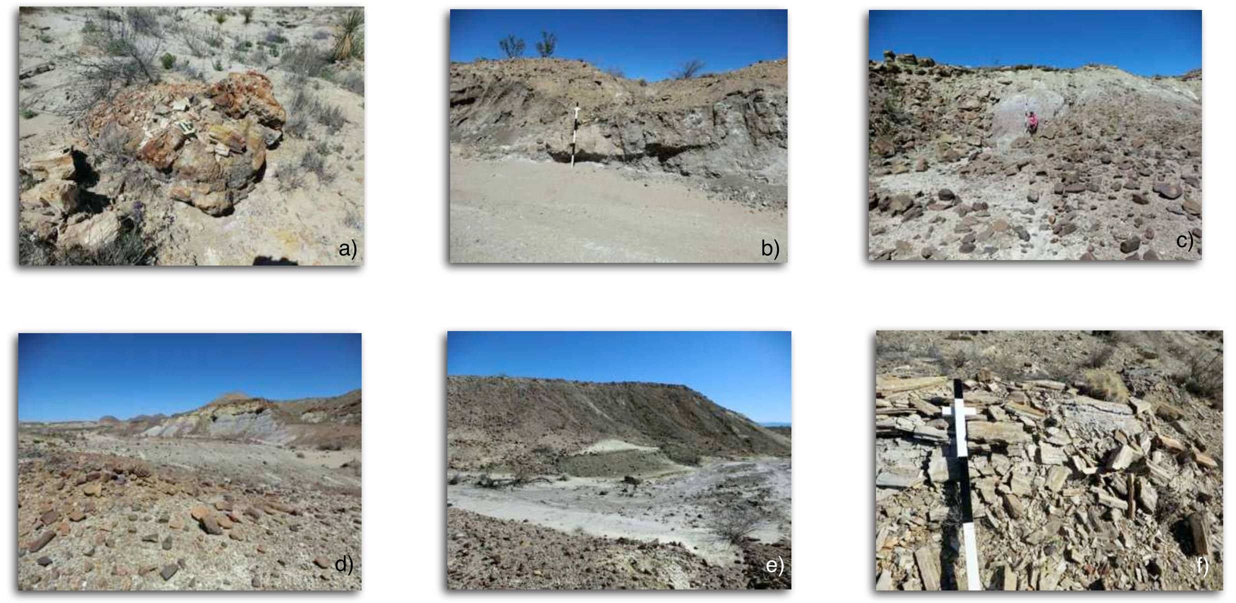


Figure 7 Georeferenced pictures labeled in stratigraphic column a) Petrified wood from the Black Peaks "log jam" at the top of the section. b) Black Peaks paleosols. c) Top (Fourth in stratigraphic column) sandstone in Javelina Formation. d) Ferruginous sandstone overlying Javelina paleosols. e) Pea green color found at the top of the Aguja, near the contact between the Aguja and Javelina Formations. f) petrified log in the Aguja Formation

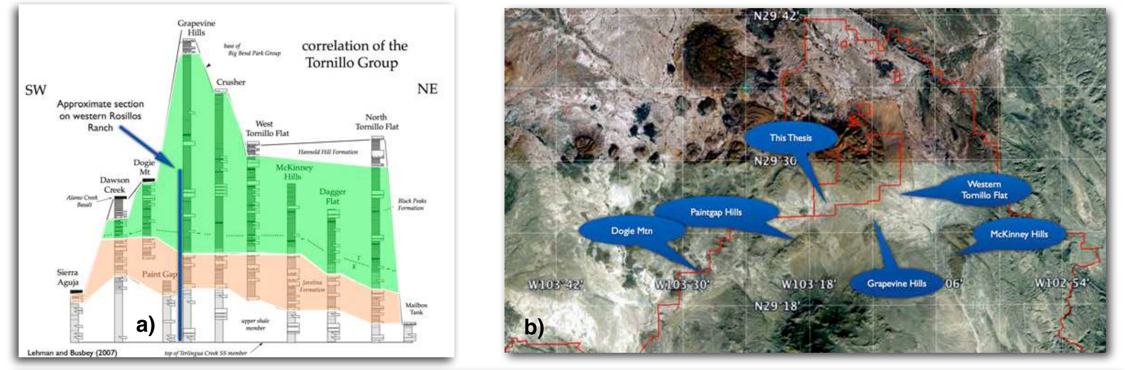


Figure 8 a) Correlated stratigraphic sections in the park with approximate location of field stratigraphic section marked. b) Location of published and field stratigraphic sections.

Conclusions and Further Work

Mapping of the field area revealed major problems with currently published maps and emphasized the problems with a reliance on aerial photos for mapping. Updated lithostratigraphic definitions of the formations, including criteria such as silicified wood abundance and pea green coloration, allowed for confident mapping of the contact boundaries. Georeferenced pictures allowed for accurate documentation of the area, and vertebrate and fossilized plant samples were collected for further analysis.

Further work includes the comparison of the detailed stratigraphic column to others published in and around BBNP, shown in Figure 8, in order to explain facies differences between sections in the East side of the park and the West, as the project area lies near the middle. The section was fully documented with georeferenced pictures, and in the future will be published with a CD including picture documentation along the section.

Fossil preparation still needs to be conducted for the vertebrate samples collected, as well as comparison to vertebrate collections in order to determine the species of the two hadrosaur specimens. Further field collecting would also be beneficial, as the area is very well exposed and should yield more vertebrate specimens with further field work.

Acknowledgements

The authors thank the Dallas Paleontological Society for their scholarship for the support of Ashley Adams, Mr. Roy Pitcock for access to the Rosillos Mountain Ranch and Dr. Tom Lehman and Mr. Steven Wick for their discussions on Big Bend stratigraphic units.

References

Bloomer, Richard Rodier (1949) Geology of the Christmas and Rosillos Mountains, Brewster County, Texas. Dissertation, UT-Austin.

Knebusch, William E. (1981) Evidence for Deltaic Environment of Deposition for Aguja Formation (Upper Cretaceous), *Southwest Texas AAPG Bullentin*, 65:764.

Lehman, T. M. (1986) Late Cretaceous sedimentation in Trans-Pecos Texas: *in* Pause, P. H. and Spears, R. G., *eds*., Geology of the Big Bend area and Solitario Dome, Texas: West Texas Geological Society, 1986 Field Trip Guidebook, pg. 105-110.

Lehman, T.M., and Busbey, A.B. (2007) Big Bend field trip guidebook: *in* Society of Vertebrate Paleontology, 67th Annual Meeting (Austin, TX, Oct. 17–20, 2007), field trip guidebook. Society of Vertebrate Paleontology, Deerfield, IL.

Lehman, T.M., and Wheeler, E.A. (2010) Fossil Palms (Arecacceae, Coryphoideae) Associated with Juvenile Herbivorous Dinosaurs in the Upper Cretaceous Aguja Formation, Big Bend National Park, Texas. Steven R. Manchester, Thomas M. Lehman and Elisabeth A. Wheeler. *International Journal of Plant Sciences* , 171(6): 679-689

Maxwell, R.A., Lonsdale, J.T., Hazzard, R.T., and Wilson, J.A., (1967) Geologic map of the Big Bend National Park, Brewster County, Texas: University of Texas at Austin Bureau of Economic Geology Publication 6711, scale 1:62,500

Maxwell, R. A., Lonsdale, J. T., Hazzard, R. T., and Wilson, J. A. (1967) Geology of Big Bend National Park, Brewster County, Texas: The University of Texas at Austin, Bureau of Economic Geology, Publication 6711, 320 p.

Turner, K.J., Berry, M.E., Page, W.R., Lehman, T.M., Bohannon, R.G., Scott, R.B., Miggins, D.P., Budahn, J.R., Cooper, R.W., Drenth, B.J., Anderson, E.D., and Williams, V.S. (2011) Geologic map of Big Bend National Park, Texas: U.S. Geological Survey Scientific Investigations Map 3142, scale 1:75,000, pamphlet 84 p.

Wheeler, E.A., and Lehman, T.M. (2005) Upper Cretaceous–Paleocene conifer woods from Big Bend National Park, Texas, *Palaeogeography, Palaeoclimatology, Palaeoecology*, 226(3-4): 233-258.