

REVIEW OF THE PALAEOICHTHYOLOGICAL RECORDS FROM THE PERMIAN PHOSPHORIA, PARK CITY AND SHEDHORN FORMATIONS AT FORELLEN PEAK, GRAND TETON NATIONAL PARK, WYOMING

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Abstract—A review of the samples collected during the 1950's USGS geologic survey and additional field work in 2022 by the National Park Service Paleontology Program at Forellen Peak within Grand Teton National Park, Wyoming, demonstrates an important record of Permian fish assemblages from the Permian Park City, Shedhorn, and Phosphoria formations. New records of the ctenacanthiform *Glikmanius* is presented here for the Shedhorn and Phosphoria Formations. In addition, a large ctenacanthiform taxon and a large coelodontiform taxon are also documented from the Phosphoria Formation. Evidence of large bobasataniid fishes is also documented. The presence of the ctenacanth *Glikmanius*, the large ctenacanth, the holocephalan *Deltodus*, and large bobasataniid fishes suggest faunal similarities with the southern equivocally aged Kaibab Formation in northern Arizona.

INTRODUCTION

The paleontological resources of Grand Teton National Park (GRTE) are extensive. Fossils dating from the lower Paleozoic to the Quaternary are known throughout the 125,470 ha (310,044.036 acres) park boundary (Tweet et al., 2013). Of interest here are the marine vertebrate records documented within the upper Permian rocks in the northwestern corner of GRTE in the Berry Creek region of the park at Forellen Peak. In the early 1950's to 1960's, a United States Geological Survey team began surveying the Permian rocks of Idaho, Montana, and Wyoming that was conducted on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission between 1950 and 1954 (Sheldon, 1963). The purpose of these surveys was to help unravel the stratigraphic problems of the Permian rocks in western Wyoming, to better understand the genesis of the rocks, and to calculate resources of phosphate rock and uranium during the Cold War (Sheldon, 1963).

The USGS surveys of the Phosphoria, Park City and Shedhorn formations exposed at Forellen Peak resulted in the documentation of Permian invertebrate and vertebrate fossils, including a note of a horizon with significant fish fossil remains (Sheldon, 1963; Yochelson and Van Sickle, 1968). These fossils, consisting of mostly vertebrate specimens, were sent to the Smithsonian Paleobiology Department at the National Museum for identification and publication of the biostratigraphy of the Permian formations in the region (Yochelson and Van Sickle, 1968). The Forellen Peak vertebrate fossil collection from the Retort Phosphatic Shale, Park City Grandeur Member and Shedhorn Sandstone units consists of a small number of important cartilaginous and bony fish specimens. However, the reports by Sheldon (1963) and Yochelson and Van Sickle (1968), along with the specimen information at the Smithsonian Paleobiology Department lacked more precise information of the location of the fossil locality other than "Southwest Phosphoria outcrop, Forellen Peak".

The Phosphoria, Park City and Shedhorn formations has long been known to contain Permian fish fossils and a number of small but important collections have been described or mentioned in the early to mid-twentieth century from western Wyoming, Idaho, and Utah (Branson 1916; Branson 1933;

Bendix-Almgreen, 1966; Yochelson and Van Sickle, 1968). Additional early work noted similarities of the Phosphoria fish assemblages with the lower Permian fish (Cisuralian) assemblages of the Kaibab Formation at Grand Canyon National Park (McKee, 1938) and the Martinia Limestone in eastern Greenland (Nielson, 1932; Branson, 1934). However, since the publication of above reports, little to no new work on these older or more recently made collections from the Phosphoria, Park City and Shedhorn formations has been published. One notable exception was recently published by Tapanila et al. (2020) who described the presence of *Sinohelicoprion* sp., an edestid eugeneodont (whorl-toothed) chondrichthyan known previously only from the Permian of Asia, from the USGS 1950's survey at Forellen Peak.

In 2022, from interest in comparing the Kaibab fish assemblage with the Phosphoria fish assemblage, a survey of the 1950's USGS collections made at Yellowstone and Grand Teton held within the fossil fish collections at the Department of Paleobiology at the National Museum of Natural History was conducted to get a sense of the condition and amount of material studied by Yochelson and Van Sickle (1968). In August 2022, a NPS Paleontology field team returned to Forellen Peak to relocate the original fossil horizons reported during the 1950's USGS surveys. Presented here is a summary of the new information gathered from the review of the Smithsonian fossil collections and the new fossil specimens collected during the field inventories undertaken in 2022.

GEOLOGICAL AND GEOGRAPHICAL SETTING

The lower Permian (Cisuralian) Phosphoria, Park City and Shedhorn formations occurs in Utah, Idaho, Montana, and Wyoming and consist of phosphorites, shales, sandstones, cherts, and limestones (McKelvey et al., 1959; Sheldon, 1963). The Phosphoria Formation is subdivided into 5 units, from bottom up: the Lower Chert Member, consisting of dark cherty shales; the Meade Peake Phosphatic Member, consisting of interbedded brown to black shales, gray dense limestones, dark brown oolitic phosphorite, and minor white calcareous sandstones; the Rex Chert Member consisting of a basal gray limestone, black cherts, and black cherty shale; the Retort Phosphatic Member

consisting of phosphorite, dolomite, and siltstone; and the Tosi chert member which consists of a basal limestone and cherts above (McKelvey et al., 1959). The Park City Formation consists of non-carbonates such as chert and dolo-shales, sand and siltstones, conglomerates, wackestones, and carbonate mudstones (McKelvey et al., 1959). The Shedhorn Formation is extensive in the region and consists primarily of well sorted coarse-grained sandstones that interfinger with the Phosphoria Formation (McKelvey et al., 1959). The marine depositional setting for the Phosphoria and Shedhorn formations is considered to represent a foreland basin between the Paleozoic continental margin and the North American cratonic shelf (Maughan, 1984). The age of the Phosphoria and Shedhorn formations, based on the conodont assemblages, is considered Leonardian (Kungurian/Roadian) (Behnken et al., 1986).

Forellen Peak is located in the Berry Creek region of the northwestern corner of Grand Teton National Park, Wyoming (Fig. 1). The Phosphoria Formation as surveyed by the 1950's USGS team is exposed on the southwestern slope of Forellen Peak forming a stratigraphically thick crescent-shaped outcrop (Fig. 2). McKelvey et al. (1959) mapped the stratigraphy showing that the Phosphoria Formation was inter-tongued with the upper and lower Shedhorn Sandstone, and the Grandeur Member of the Park City Formation at the base of the outcrop, with the fossil fish bed occurring in the lower Retort member. The 2022 NPS field team was able to relocate the field area of the USGS survey and confirmed the presence of largely abundant, though many highly weathered, vertebrate fossils within the Retort Member (Fig. 3). This outcrop is approximately 1.8 meters at its thickest margin (Fig. 3A-B) and extends approximately 400 meters. Large pelletal tubular nodules are common in the upper sections of the Retort Member, near the contact with the Tosi Member above (Fig. 3D). Exposed *in situ* vertebrate fossils in the Retort

Member consist of weathered teeth, dermal spines, and bones of large and small chondrichthyans and actinopterygian fishes. Isolated teeth and dermal spines of fish were also collected in the Tosi Member (McKelvey et al., 1959), the lower Shedhorn Formation and the Grandeur Member of the Park City Formation at the base of the outcrop (Yochelson and Van Sickle, 1968). Geospatial locality data is on file with the Grand Teton National Park and National Park Service Paleontology Program.

MATERIALS AND METHODS

The 2022 NPS Paleontology assessment of Forellen Peak occurred on August 16th, 2022 under permit GRTE-2022-SCI-0048. As most specimens were embedded in the hard phosphorite matrix, only a few fossil samples were collected from outcrops that were loosely attached from the rock by use of small hand tools or collected as float. All 2022 fossil samples collected were reposit with the Grand Teton National Park Museum Collections. All photos were taken with an iPhone 12 Pro. Figures were created with Adobe Photoshop and Illustrator, respectively.

Institutional Abbreviations—GRTE, Grand Teton National Park, Wyoming; USNM PAL, Smithsonian National Museum of Natural History Paleobiology Collections, Washington, D.C.

SUMMARY OF THE PALAEOICHTHYOLOGY FROM THE PHOSPHORIA FORMATION AT FORELLEN PEAK

Yochelson and Van Sickle (1969) summarized the Forellen Peak fossil fish assemblages from six sample sites from the 1950's USGS survey. One horizon is listed as the Grandeur Member of the Park City Formation which they listed "*Helodus* sp." and "fairy-collar buttons," which refer to isolated blunt and rounded actinopterygian teeth that are usually identified as isolated teeth of platysomid fishes (Johnson and Zidek, 1981; Fracasso and Hovorka, 1987), which are now considered to represent bobasataniid fishes (Schultze et al., 2022). Four sites are recorded from the lower member of the Shedhorn Sandstone

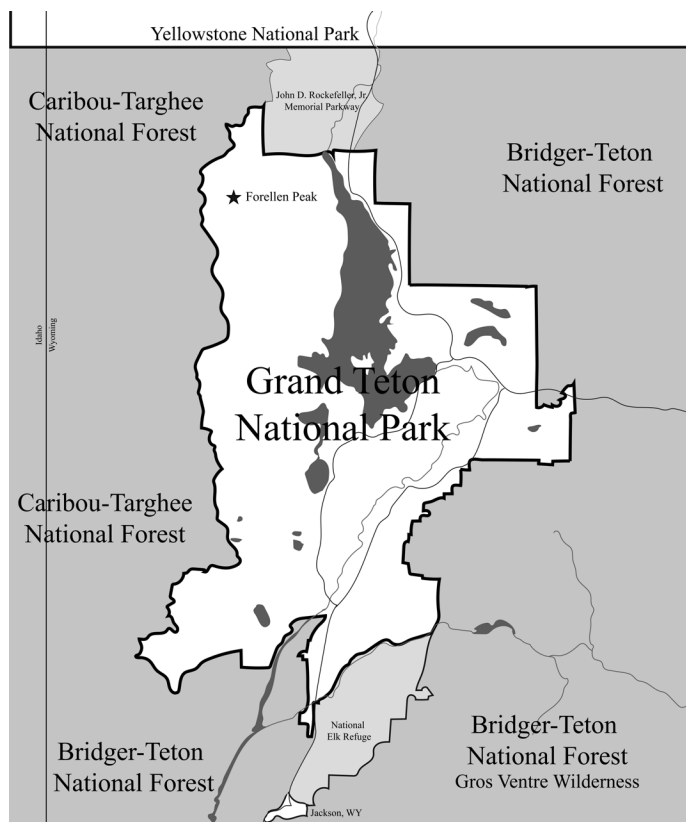


FIGURE 1. Map of Grand Teton National Park, Wyoming. Star representing the approximate location of Forellen Peak.

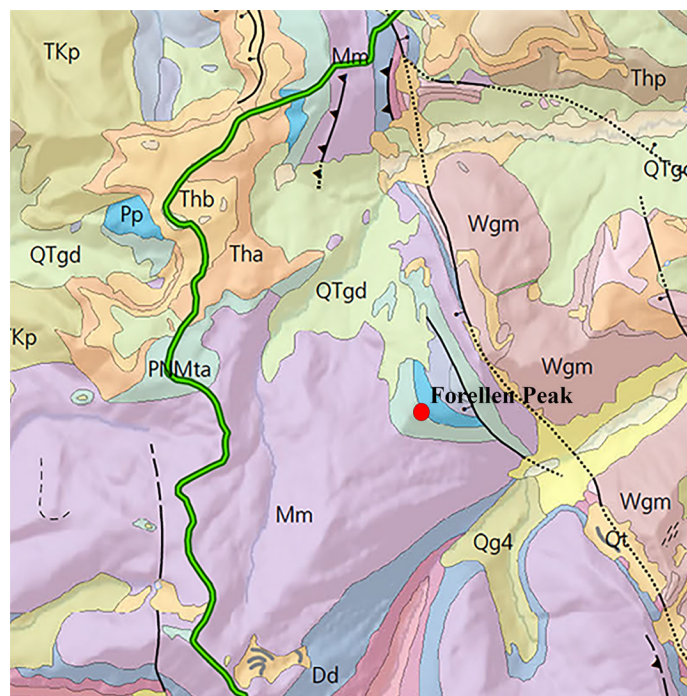


FIGURE 2. Geologic Map of Forellen Peak region. Red dot representing the approximate location of the USGS 1950's and 2022 NPS Paleo surveys of the Phosphoria Formation (blue crescent). Modified from USGS and GRI, 2010.



FIGURE 3. Photos of the fossiliferous ridge of the Retort Member of the Phosphoria Formation at Forellen Peak. **A**, the top of the thickest section of the Retort Member with James Bovis and Sam Timko in the background looking at exposed fish fossils. **B**, view of the approximately 1.8 meters thick section of the Retort Member of the Phosphoria Formation at Forellen Peak. **C**, outcrop of the Retort Member from the thinning northwest section of the outcrop. **D**, pelletal tube from the Retort Member of the Phosphoria Formation at Forellen Peak.

where Yochelson and Van Sickle (1969) listed “*Cladodus* sp.”, “*Ctenacanthus* sp.”, “*Crassidonta* sp.”, isolated bobasatraniiform teeth, and indeterminate bony fossils. The Retort Member of the Phosphoria Formation was listed to have “*Cladodus* sp.”, “*Ctenacanthus* sp.”, “*Helicoprion* sp.”, “*Dolophonodus* sp.”, “*Deltodus* sp.”, “*Crassidonta* sp.”, “bradydont indeterminate”, “*Ancistriodus* sp.”, “palaeoniscoid fragments”, bobasatraniid isolated teeth, indeterminate actinopterygian scales, and

indeterminate bony fragments. Most of the above identifications are now considered antiquated and our survey of the USGS survey collections within the Smithsonian Paleobiology Collections offers new identifications based on more recent work on Paleozoic fishes. Below is a summary of our survey of the USGS samples and our observations of new fossil materials of fishes collected and encountered during the 2022 NPS Paleontology Survey (Table 1).

TABLE 1. Vertebrate fauna of the early Permian formations at Forellen Peak Grand Teton National Park.

Taxonomy	Locality	
	Forellen Peak	
	USGS 1950's USNM PAL Collections	2022 Grand Teton NP Paleontological Resource Inventory
Class Chondrichthyes		
Subclass Elasmobranchii		
Order Ctenacanthiformes		
Family Indeterminate		
<i>Glikmanius occidentalis</i>	x	x
large ctenacanthiform (? <i>Kaibabvenator</i> sp.)		x
Subclass Euchondrocephali		
Order Orodontiformes		
Family Orodontidae		
<i>Orodus</i> sp.		x
Order Eugenodontiformes		
Family Edestidae		
<i>Sinohelicoprion</i> sp.	x	
Family Caseodontidae		
genus and species indeterminate (? <i>Fadenia</i> sp.)		x
Order Helodontiformes		
Family Helodontidae		
cf. <i>Helodus</i> sp.	x	x
Order Cochliodontiformes		
Family Psephodontidae		
genus and species indeterminate		x
Family Cochilodontidae		
<i>Deltodus</i> sp.	x	x
genus and species indeterminate (small form)	x	
Class Actinopterygii		
Order "Palaeonisciformes"		
Family Indeterminate		
genus and species indeterminate		x
Order Bobasatraniaformes		
Family Bobasatraniaidae		
genus and species indeterminate 1 (large broad toothed form)		x
genus and species indeterminate 2 (large fine toothed form)	x	
genus and species indeterminate 3 (small form)	x	x

Chondrichthyes

Fossils of cartilaginous fishes are well documented from the Phosphoria, Park City and Shedhorn formations. Branson (1916) described a rich assemblage from near Lander Wyoming that included ctenacanth, eugeneodont, petalodont and coeliodont chondrichthyans. Branson (1933) added additional new taxa from the Wind River and Owl Creek Mountains regions of Wyoming. Most iconic of the chondrichthyans of the Phosphoria Formation is the eugeneodont *Helicoprion* which has been extensively described from specimens collected in Idaho and Wyoming (Bendix-Almgreen, 1966; Tapanila and Pruitt, 2013; Tapanila et al 2020).

The fossils of chondrichthyans were the most common vertebrate component encountered within the museum collection and in the field for Forellen Peak. The majority of the cartilaginous fish fossils from the 1950's USGS Forellen Peak Survey consist of either teeth or spine fragments or unprepared teeth and spines in rock hand samples. In the field, the 2022 survey encountered mostly highly weathered teeth and spines that were difficult to collect without damage to the fossil sample. We were unable to locate the specimens of "*Dolophonodus* sp." and "*Ancistriodus* sp." listed by Yochelson and Van Sick (1969) within the Smithsonian Paleobiology collections. Both taxa were described by Branson (1933) based on fragmentary material and their relationship to the chondrichthyans is considered dubious by one of us (JPH) and thus excluded from our summary.

Elasmobranchii

Ctenacanthiformes—Ctenacanthiform chondrichthyans are early elasmobranchs that had well developed ornamented dorsal fin spines and cladodont-grade dentitions (Hodnett et al. 2021; 2024). Ctenacanths have an extensive fossil record with origins at least within the early Late Devonian and they extend up into the middle to late Permian (Guadalupian-Lopingian) (Ginter et al., 2010; Hodnett et al. 2024). The Forellen Peak sample of ctenacanthiforms are found throughout the Permian geologic sequence. A single fragmentary ctenacanth tooth (USNM PAL 235398) is from the lower Grandeur Member of the Park City Formation, but it is too fragmentary for identification at the genus level. The lower member of the Shedhorn Formation has a single hand sample (USNM PAL 235387) of sandstone that contains a partial dorsal fin spine and a partially exposed tooth that can be attributed to *Glikmanius* (Fig. 4). Additional samples of *Glikmanius* were encountered within the Retort Member of the Phosphoria Formation, mostly consisting of partial weathered teeth (Fig. 5C-D). Larger ctenacanthiform teeth were identified within the Retort Member of the Phosphoria Formation (Fig. 5B and E). Though fragmentary, these teeth are similar in size and morphology to *Kaibabvenator swiftae*, a middle Permian (Guadalupian) ctenacanthiform from the Kaibab Formation in Arizona (Hodnett et al., 2012). An over 15 cm long weathered dorsal fin spine of a ctenacanth was also encountered in the Retort Member of the Phosphoria Formation at Forellen Peak (Fig. 5F).

The samples of *Glikmanius* from Forellen Peak are the first definitive record of this ctenacanth taxon for the Shedhorn and Phosphoria formations respectively. *Glikmanius* has an extensive fossil record extending from the Middle Mississippian to middle Permian (Guadalupian) (Hodnett et al., 2024). For the Permian, *Glikmanius* is known from two species, *G. occidentalis* and *G. myachovenski* from the equivocal Kaibab Formation in northern Arizona and *G. culmensis* from the late Permian (Lopingian) of Oman (Hodnett et al., 2012; Koot et al. 2013). The approximate size of the Forellen Peak *Glikmanius* fits within the range seen in *G. occidentalis* but the preservation prevents confirmation at the species level. Until more complete teeth can be identified, we presently refer the Forellen Peak *Glikmanius* samples to *Glikmanius* sp. The larger ctenacanthiform teeth



FIGURE 4. USNM PAL 235387, ctenacanthiform dorsal fin spine and tooth of *Glikmanius* sp. from the lower member of the Shedhorn Formation at Forellen Peak. **A**, the fossil sample with tooth and spine. **B**, close up of the *Glikmanius* sp. tooth exposed lingually. **C**, close up of the ctenacanthiform spine. Scale equals 1 cm.

are too fragmentary to confirm the presence of *Kaibabvenator* in the Phosphoria Formation, although a *Kaibabvenator*-like tooth is figured by Branson (1916) from Lander Wyoming. However, these fragmentary teeth do confirm that a large-bodied ctenacanthiform shark did occur in the Phosphoria Formation.

Euchondrocephali

The Euchondrocephali are chondrichthyans more closely related to extant ratfish/chimeras than to sharks and rays (Stahl, 1999; Ginter et al., 2010). This subclass of cartilaginous fishes has their origins in the Late Devonian but their greatest diversification took place during the Mississippian (Stahl, 1999; Ginter, et al., 2010). From Forellen Peak, at least three orders have been identified.

Orodontiformes—Orodontiform chondrichthyans are best known from the Mississippian and Pennsylvanian and are represented mostly by short to elongated crushing teeth, typified by the genus *Orodus* (Ginter et al. 2010). The few body fossils of *Orodus* preserved demonstrate these chondrichthyans had short broad crania with elongated bodies (Zangerl, 1981). The Permian record of orodontiforms was unknown, but a single tooth encountered in the Retort Member of the Phosphoria Formation at Forellen Peak (Fig. 7A) shared various features with *Orodus* such as an elongate blunt cusp on a narrow vascular tooth base. This sample may be the first record for a Permian *Orodus*. Unfortunately, this specimen was deeply embedded in the matrix and was not able to be collected for further scrutiny.

Eugeneodontiformes—Eugeneodontiform chondrichthyans have their origins in the Early Mississippian and are characterized by having a median tooth whorl at the end of the lower jaw and



FIGURE 5. Field samples of ctenacanthiform spine and teeth from the Retort Member of the Phosphoria Formation at Forellen Peak. **A**, large weathered ctenacanthiform spine, **B**, large weathered ctenacanthiform (?*Kaibabvenator* sp.) tooth, **C**, GRTE 3792, *Glikmanius* sp. tooth in matrix, **D**, large weathered ctenacanthiform tooth, **E**, large weathered ctenacanthiform (?*Kaibabvenator* sp.) tooth. Scale in millimeters.

batteries of smaller crushing teeth in the upper and lower jaws (Ginter et al., 2010). Some lineages developed crushing median tooth whorls, while in others, the lower median whorl developed more blade-like cusps (Ginter et al., 2010; Tapanila et al., 2020). At Forellen Peak eugeneodont fossils were encountered only within the Retort Member of the Phosphoria Formation. The 1950's USGS survey collected a relatively complete tooth whorl (USNM PAL 235953; Fig. 6) that they originally referred to *Helicoprion*, a taxon well known from the Phosphoria



FIGURE 6. USNM PAL 235953, *Sinohelicoprion* sp. symphyseal whorl from the lower member of the Shedhorn Formation at Forellen Peak. Scale 1 cm.

Formation elsewhere (Bendix-Almgreen, 1966; Yochelson and Van Sickle, 1969). Tapanila et al. (2020) reviewed this specimen and concluded that it represented a new distribution record of *Sinohelicoprion*, an edestoid eugeneodont known primarily from China. The 2022 NPS Paleontology survey encountered additional eugeneodont teeth from the Retort Member of the Phosphoria Formation. These eugeneodont teeth are more enlarged and bluntly shaped (Figs 7C and E), similar in morphology to the genus *Fadenia*, which is well known from the Permian Martinia Limestone in eastern Greenland (Nielsen, 1932, 1952). Unfortunately, the weathered and fragmentary nature of the specimens encountered renders the identification to a questionable placement with *Fadenia*.

Helodontiformes—The Helodontiformes are a group of chondrichthyans that have multiple teeth that grow into fused whorls over its life time, and are primarily known from genus *Helodus* (Stahl, 1999; Coates et al., 2021; Johnson et al., 2021). Fossils of *Helodus* are known from the Upper Devonian to lower Permian (Cisuralian) worldwide (Stahl, 1999). Yochelson and Van Sickle (1969) listed a sample of *Helodus* from the Grandeur Member of the Park City Formation. However, our survey of the USGS collections demonstrated this specimen is a ctenacanthiform. The 2022 NPS Paleontology survey encountered isolated *Helodus* sp. teeth from the Retort Member of the Phosphoria Formation at Forellen Peak (Fig 7B and D).

Cochliodontiformes—The Cochliodontiformes are chondrichthyans that are most closely related to extant ratfish/chimaeras, and characterized by dentitions consisting of specialized dental plates in the upper and lower jaws (Stahl, 1999). Fossils of Cochliodontiforms are known from the

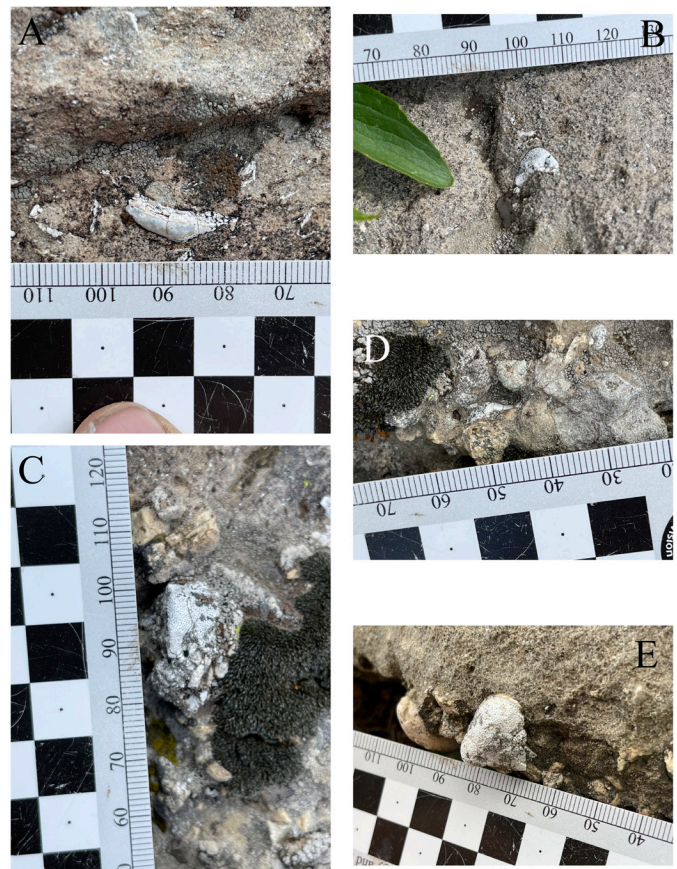


FIGURE 7. Field samples of euchondrocephalan teeth from the Phosphoria Formation at Forellen Peak. **A**, tooth of *Orodus* sp., **B** and **D**, teeth of *Helodus* sp., **C** and **E**, teeth of eugeneodontiforms (?*Fadenia* sp.) Scale in millimeters.

Upper Devonian to middle Permian (Guadalupian) (Stahl, 1999). Yochelson and Van Sickle (1969) listed two species of cochlodontiforms, *Deltodus* and *Crassidonta*, from the lower member of the Shedhorn Formation and the Retort Member of the Phosphoria Formation. Both taxa were also identified by Branson (1916) from the Lander (Wyoming) area. Most of the specimens collected by the USGS survey are very fragmentary and we would argue that these samples (USNM PAL 235406, 235408, and 235409) would be best classified as indeterminate cochlodontiforms.

One well preserved tooth plate (GRTE 3782, Fig. 8) was collected during the 2022 NPS Paleontology survey from the base of the Retort Member of the Phosphoria Formation. This specimen is interpreted as a lower right distal tooth plate. The plate is oroaborally thick posteriorly, giving it a *Psephodus*-like appearance. *Psephodus* is known from Upper Devonian to upper Permian (Lopingian) and characterized by relatively thick tooth plates (Stahl, 1999). However, the Forellen Peak specimen lacks medial ridges, a trait usually seen in *Psephodus*, and has a thin labial flange that is present in other cochlodontiforms. Presently, we tentatively identify this taxon as a member of the Psephodontidae due to the robust nature of the tooth plate. A large (approximately 11 cm long) lower medial tooth plate of *Deltodus* was also encountered in situ in the Retort Member of the Phosphoria by the 2022 NPS Paleontology survey (Fig. 9). These two tooth plates demonstrate the presence of large cochlodontiform chondrichthyans occurring in the Phosphoria.

Actinopterygii

The fossil history of the bony “ray-finned” fishes is extensive with the proposed beginning of this subclass occurring during the Late Silurian (Schultze et al., 2022). By the Late Devonian to Mississippian, actinopterygians went through rapid diversification and by the Permian, the ray-finned fishes had already evolved into many niches with corresponding morphologies (Schultze et al., 2022). The 1950’s USGS and 2022 NPS Paleontology surveys documented important records of actinopterygians that have yet to be described in detail. Below is a summary of the specimens encountered.

“*Palaeonisciformes*”—The informal group “Palaeonisciformes” often refers to basal actinopterygians with fusiform bodies and ganoid scales but is largely a taxonomic waste basket (Schultze et al. 2022). Its usage here is in reference to non-platysomid fish material that consists of isolated scales and teeth. Yochelson and Van Sickle (1969)

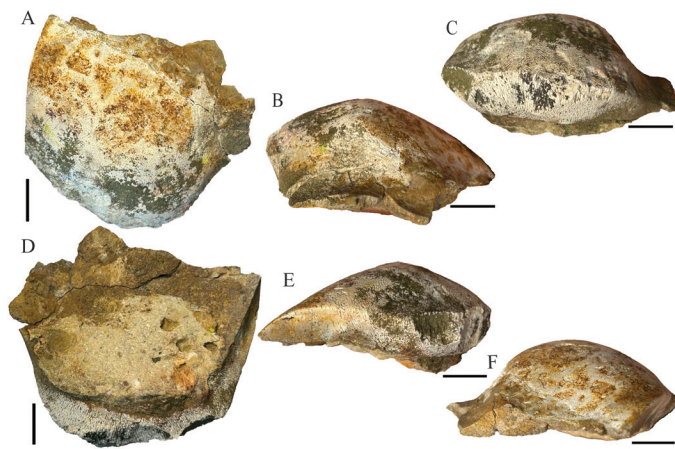


FIGURE 8. GRTE 3782, tooth plate of a *Psephodus*-like cochlodontiform holocephalan from the Phosphoria Formation at Forellen Peak. A, oral, B, aboral, C, distal, D, labial, E, lingual, F, mesial. Scale equals 1 cm.

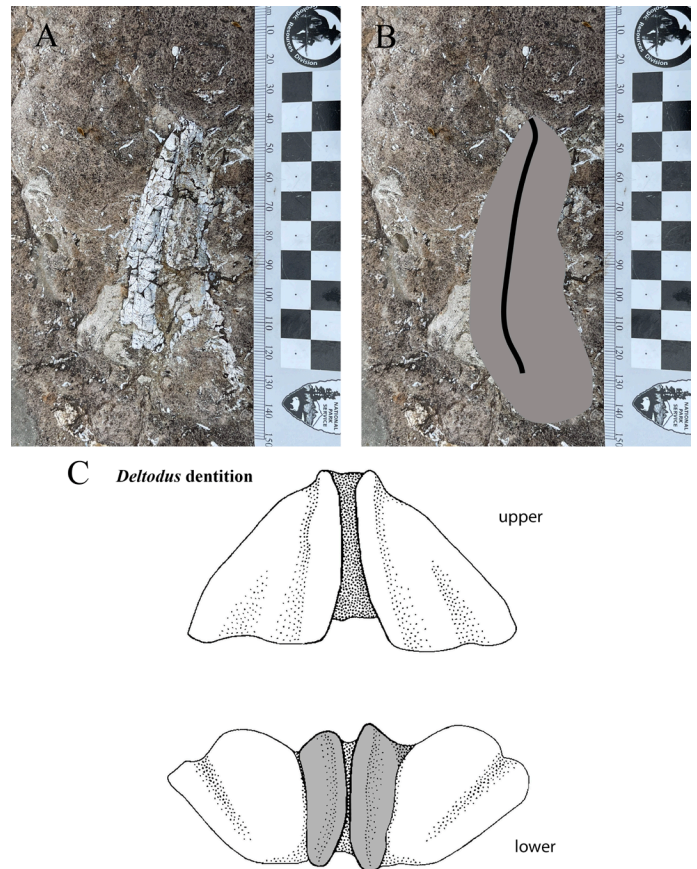


FIGURE 9. Field sample of a weathered lower right mesial tooth plate of a large *Deltodus* sp. from the Retort Member of the Phosphoria Formation at Forellen Peak. A, field photo, B, interpretation drawing of specimen outline in situ, C, Line drawing, of position of tooth plate within the jaws of *Deltodus* (modified from Stahl, 1999). Scale in millimeters.

listed the presence of “palaeoniscoid” fossils from the Retort Member of the Phosphoria Formation. However, our survey of the Smithsonian Paleobiology collections did not identify fossils that would be considered “palaeoniscoid” today. It is most likely that the reference by Yochelson and Van Sickle (1969) to “palaeoniscoid” refers to the platysomid fossils discussed below. The 2022 NPS Paleontology survey did recover a single weathered “palaeoniscoid”-grade scale from the Retort Member of the Phosphoria Formation (Fig. 10A).

Bobasatraniaidae?—The majority of the actinopterygian fossils encountered between both surveys belong to indeterminate taxa potentially referable to the Bobasatraniaidae, a group of actinopterygians with laterally compressed and dorsoventrally deep bodies actinopterygians known from the Carboniferous to Triassic (Schultze et al. 2022). These fishes have tooth plates on the pterygoid and coronoid bones consisting of multiple small rounded teeth forming a tear drop shaped crushing surface. Most of these plates are generally small when compared to the body size of the fish. However, multiple large phyllodont plates (originally considered to be platysomid fishes) have been identified from Permian aged sites in the American Southwest (Johnson and Zidek, 1981; Fracasso and Hovorka, 1987). The bobasatraniaid samples from the 1950’s USGS surveys showed that these fishes occurred throughout the Permian stratigraphic sequence. Isolated teeth (USNM PAL 235444) were collected from the lower Grandeur Member of the Park City Formation and two specimens of associated dentitions with fragmentary cranial and appendicular elements (USNM PAL 235386 and

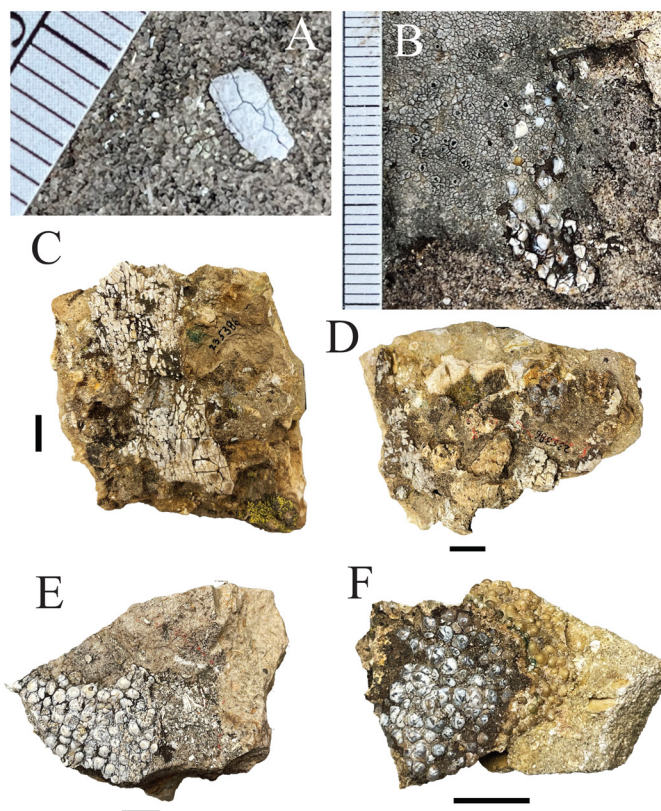


FIGURE 10. Actinopterygii fossils from the Phosphoria and Shedhorn Formations at Forellen Peak. **A**, field specimen of a weathered “palaeoniscoid” fish scale from the Retort Member of the Phosphoria Formation, **B**, field specimen of the coarse tooth morph bobsatraniid fish from the Retort Member of the Phosphoria Formation, **C-D**, USNM PAL 235386, associated skeletal elements of the fine toothed morph bobsatraniid fish from the lower member of the Shedhorn Formation, **C**) ?cleithrium, **D**) ?partial cranium with partial dentition, **E-F**, USNM PAL 235445, associated tooth plates of the fine tooth morph bobsatraniid fish lower member of the Shedhorn Formation. A-B, scale in millimeters; C-F, Scale equals 1 cm.

235445) were collected from the Lower Member of the Shedhorn Formation (Figs 10C-F). The 2022 NPS Paleontology survey also identified isolated bobsatraniid teeth and a weathered tooth plate from the Retort Member of the Phosphoria Formation (Fig. 10B). Comparison of the tooth plates shows great degree of variation in tooth density and tooth size. This suggests that there may have been more than one species of large bobsatraniid occurred within the Permian fish assemblages represented at Forellen Peak.

DISCUSSION AND CONCLUSIONS

The 1950’s USGS and 2022 NPS Paleontology surveys of the Permian Park City, Shedhorn, and Phosphoria formations at Forellen Peak in Grand Teton National Park, Wyoming have important data about the early to middle Permian (Cisuralian-Guadalupian) fish assemblages in the region. Our review of previous USGS collections and the new data gathered in 2022 demonstrates that there is the potential to document successive fish assemblages from the three geologic horizons that show the changes in deposition and environmental shifts recorded in the sediments. Though the present sample size is small, we do see changes in diversity within the stratigraphic succession at the Forellen Peak locality (Fig. 11). Currently the Retort Member of the Phosphoria Formation appears to have both the highest

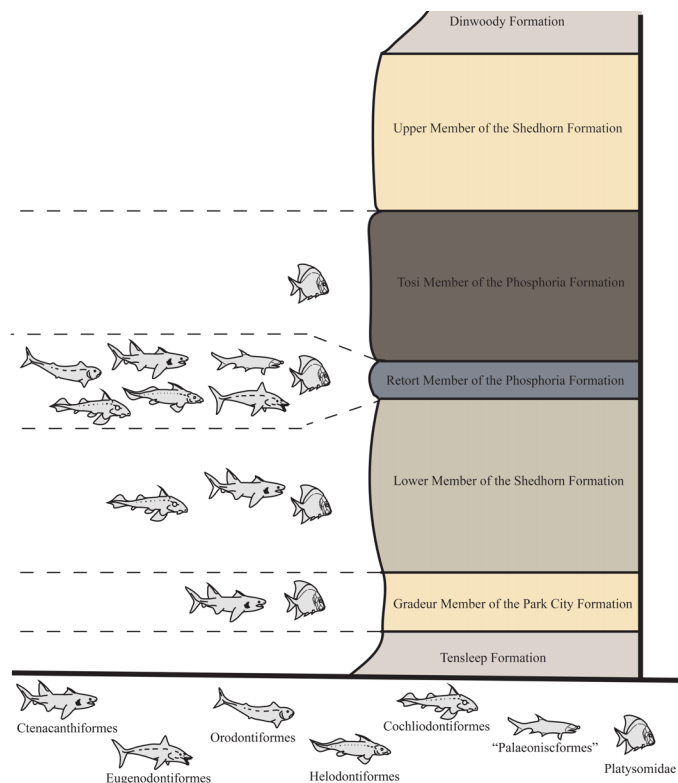


FIGURE 11. Generalized stratigraphic model of the Permian rocks at Forellen Peak with distribution of the fish taxonomic groups mentioned in text.

variety and number of fossil samples for Permian fish at Forellen Peak. The large number of fossil fish remains encountered does raise the question as to why such abundance of vertebrates are found within this horizon and why many of the taxa represent large-bodied fishes (Fig. 12). A comparable scenario for such a large accumulation is seen in the Lower Cretaceous Mowry Shale which is known for large number of isolated fish scales, bones and teeth. Anderson and Kowallis (2005) proposed that this accumulation was deposited by storm action within the

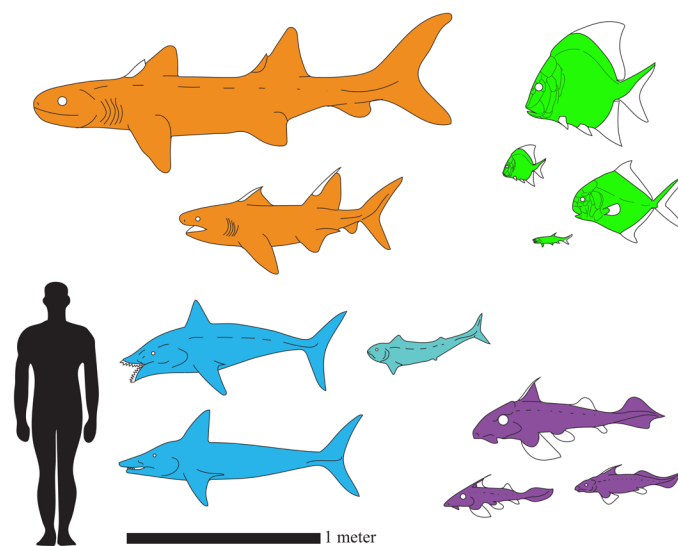


FIGURE 12. Scaled representations of the fish assemblage from the Phosphoria and Shedhorn Formations at Forellen Peak. Orange Ctenacanthiformes, blue Euglenodontiformes, light blue Orodontiformes, purple Holocephali, green Actinopterygii. Human scale approximately 1.8 meters tall.

western coast of the Great Interior Seaway.

Faunal similarities between the Park City, Shedhorn, and Phosphoria formations with the southern equivocally aged Kaibab Formation are noted with the identification of the ctenacanth *Glikmanius* now occurring within the Shedhorn and Phosphoria formations, along with *Deltodus* and *Crassidonta* (Hodnett et al. 2012; Hodnett and Elliott, 2021; Hodnett et al., this volume). Large platysomid fishes are also documented from the Kaibab Formation (Hodnett and Elliott, 2021). At present, only the presence of large eugeneodontiforms (*Helicoprion*, *Sinohelicoprion*, and a *Fadenia*-like taxon) make the Phosphoria unique as these taxa have yet been identified with confidence in the Kaibab Formation. These combined occurrences at Forellen Peak demonstrates this region had a diverse vertebrate assemblage during the Early Permian (Fig. 13).

More field work and sampling will be necessary to assess the true composition of the Permian fish assemblages at Forellen Peak as both surveys collections made by USGS and NPS Paleontology mostly likely document just a fraction of what these deposits may hold.

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FIGURE 13. The visual representation of the Permian palaeoichthyological assemblage of the Retort Member of the Phosphoria Formation at Forellen Peak, Grand Teton National Park, Wyoming. A large ctenacanthiform shark attempts to feed through a “palaeoniscoid” fish bait-ball as *Sinohelicoprion* and large deep bodied actinopterygians feed on stragglers to the left. Small orodontiform chondrichthyans (above) avoid the smaller ctenacanth *Glikmanius* as two duronid *Fadenia*-like eugeneodont come closer to investigate the bait-ball. Small and large bobasatraniaid fishes (center-right) and holocephalans (bottom) look for food sources near the sea floor. Art by Benji Paysnoe

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