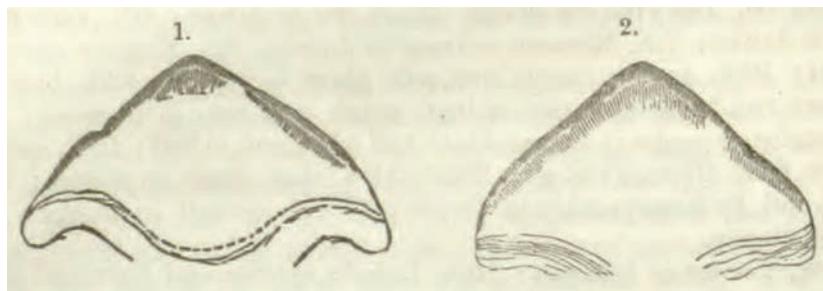




## HIGH-QUALITY CASTS OF THE MISSING HOLOTYPE OF *PETALODUS OHIOENSIS* SAFFORD 1853 (CHONDRICHTHYES, PETALODONTIDAE) AT THE FIELD MUSEUM OF NATURAL HISTORY AND THEIR BEARING ON THE VALIDITY AND PRIORITY OF THE SPECIES

Wayne M. Itano and Kenneth Carpenter





# GEOLOGY OF THE INTERMOUNTAIN WEST

*an open-access journal of the Utah Geological Association*

ISSN 2380-7601

Volume 7

2020

## Editors

Douglas A. Sprinkel Azteca Geosolutions 801.391.1977 GIW@utahgeology.org dsprinkel@gmail.com	Thomas C. Chidsey, Jr. Utah Geological Survey 801.537.3364 tomchidsey@utah.gov
Bart J. Kowallis Brigham Young University 801.422.2467 bkowallis@gmail.com	John R. Foster Utah Field House of Natural History State Park Museum 435.789.3799 eutretauranosuchus@gmail.com
Steven Schamel GeoX Consulting, Inc. 801.583-1146 geox-slc@comcast.net	

## Production

Cover Design and Desktop Publishing  
Douglas A. Sprinkel

Cover

Top: Drawings of (1) the labial (outer) and (2) the lingual (inner) faces of the currently missing holotype of *Petalodus ohioensis* Safford 1853. From the original description. Middle: (A) labial and (B) lingual views of a cast of the holotype of *P. ohioensis* from the collections of the Yale Peabody Museum of Natural History. Scale bar = 1 cm. Bottom: Three casts of the holotype of *P. ohioensis*. Left to right: cast of labial side, three-dimensional cast, cast of lingual side. From the collections of the Field Museum of Natural History.



This is an open-access article in which the Utah Geological Association permits unrestricted use, distribution, and reproduction of text and figures that are not noted as copyrighted, provided the original author and source are credited.

## UGA Board

2020 President	Leslie Heppler	lheppler@utah.gov	801.538.5257
2020 President-Elect	Riley Brinkerhoff	riley.brinkerhoff@gmail.com	406.839.1375
2020 Program Chair	Paul Inkenbrandt	paulinkenbrandt@utah.gov	801.537.3361
2020 Treasurer	Greg Gavin	greg@loughlinwater.com	801.538.4779
2020 Secretary	Elliot Jagniecki	ejagniecki@utah.gov	801.537.3370
2020 Past President	Peter Nielsen	peternielsen@utah.gov	801.537.3359

## UGA Committees

Environmental Affairs	Craig Eaton	eaton@ihi-env.com	801.633.9396
Geologic Road Sign	Greg Gavin	greg@loughlinwater.com	801.541.6258
Historian	Paul Anderson	paul@pbageo.com	801.364.6613
Membership	Rick Ford	rford@weber.edu	801.626.6942
Outreach	Greg Nielsen	gnielsen@weber.edu	801.626.6394
Public Education	Zach Anderson	zanderson@utah.gov	801.537.3300
	Matt Affolter	gfl247@yahoo.com	
Publications	Paul Inkenbrandt	paulinkenbrandt@utah.gov	801.537.3361
Publicity	Paul Inkenbrandt	paulinkenbrandt@utah.gov	801.537.3361
Social/Recreation	Roger Bon	rogerbon@xmission.com	801.942.0533

## AAPG House of Delegates

2020–2023 Term	David A. Wavrek	dwavrek@petroleumsystems.com	801.322.2915
----------------	-----------------	------------------------------	--------------

## State Mapping Advisory Committee

UGA Representative	Bill Loughlin	bill@loughlinwater.com	435.649.4005
--------------------	---------------	------------------------	--------------

## Earthquake Safety Committee

Chair	Grant Willis	gwillis@utah.gov	801.537.3355
-------	--------------	------------------	--------------

## UGA Website — [www.utahgeology.org](http://www.utahgeology.org)

Webmaster	Paul Inkenbrandt	paulinkenbrandt@utah.gov	801.537.3361
-----------	------------------	--------------------------	--------------

## UGA Newsletter

Newsletter Editor	Bill Lund	uga.newsletter@gmail.com	435.590.1338
-------------------	-----------	--------------------------	--------------

Become a member of the UGA to help support the work of the Association and receive notices for monthly meetings, annual field conferences, and new publications. Annual membership is \$20 and annual student membership is only \$5. Visit the UGA website at [www.utahgeology.org](http://www.utahgeology.org) for information and membership application.

The UGA board is elected annually by a voting process through UGA members. However, the UGA is a volunteer-driven organization, and we welcome your voluntary service. If you would like to participate please contact the current president or committee member corresponding with the area in which you would like to volunteer.



## High-quality Casts of the Missing Holotype of *Petalodus ohioensis* Safford 1853 (Chondrichthyes, Petalodontidae) at the Field Museum of Natural History and their Bearing on the Validity and Priority of the Species

Wayne M. Itano and Kenneth Carpenter

Museum of Natural History, University of Colorado, Boulder, CO 80309, USA

Wayne.Itano@aya.yale.edu

Kenneth.Carpenter-1@colorado.edu

### ABSTRACT

The validity of the chondrichthyan species *Petalodus ohioensis* Safford 1853, has long been in doubt due to the poor quality of the published figures and the unknown whereabouts of the holotype. That situation changed with the discovery of casts of the holotype in the collections of the Yale Peabody Museum of Natural History. The quality of the casts is poor, but sufficient to establish *P. ohioensis* as a valid species and as a senior synonym of *P. alleghaniensis* Leidy 1856. Recently, casts of the holotype of much better quality were found in the collections of the Field Museum of Natural History, accompanied by documentation indicating that they were likely obtained directly from Safford by O.P. Hay in 1896. The Field Museum casts clearly show the bands of ridges at the base of the crown on the labial and lingual sides, which are not visible on the Yale Peabody Museum casts.

### INTRODUCTION

The holotype of *Petalodus ohioensis* Safford 1853, is a tooth from the Cambridge Limestone Member of the Glenshaw Formation of the Conemaugh Group, Guernsey County, Ohio. *Petalodus* is an extinct genus of cartilaginous fishes related to sharks and the Cambridge Limestone is Upper Pennsylvanian (Missourian) in age (Martino, 2004). Safford (1853) published rough drawings of the holotype (figure 1) and a brief description in a short note. That note seems to have been unnoticed by other researchers for decades. During that period of neglect, *P. alleghaniensis* Leidy 1856 and *P. destructor* Newberry and Worthen 1866 were described, based

on teeth very similar to the holotype of *P. ohioensis*. In the description of yet another species of *Petalodus*, *P. securiger*, Hay (1895) noted Safford's description of *P. ohioensis* and raised the possibility that some or all of the later-described species, *P. alleghaniensis*, *P. destructor*, and *P. securiger*, might be junior synonyms of *P. ohioensis*. However, Hay (1895) hesitated to formally synonymize these species with *P. ohioensis*, in part because Hay questioned the accuracy of Safford's figures. Hay (1895, p. 563) remarked that "It would be interesting to know whether or not the type of Professor Safford's specimen is yet in existence." Hay later reconsidered the status of *P. ohioensis*, since *P. alleghaniensis*, *P. destructor*, and *P. securiger* (as *P. securis*) are all listed as

Citation for this article.

Itano, W.M., and Carpenter, K., 2020, High-quality casts of the missing holotype of *Petalodus ohioensis* Safford 1853 (Chondrichthyes, Petalodontidae) at the Field Museum of Natural History and their bearing on the validity and priority of the species: *Geology of the Intermountain West*, v. 7, p. 197–203, <https://doi.org/10.31711/giw.v7.pp197-203>.

© 2020 Utah Geological Association. All rights reserved.

For permission to use, copy, or distribute see the preceding page or the UGA website, [www.utahgeology.org](http://www.utahgeology.org), for information. Email inquiries to [GIW@utahgeology.org](mailto:GIW@utahgeology.org).

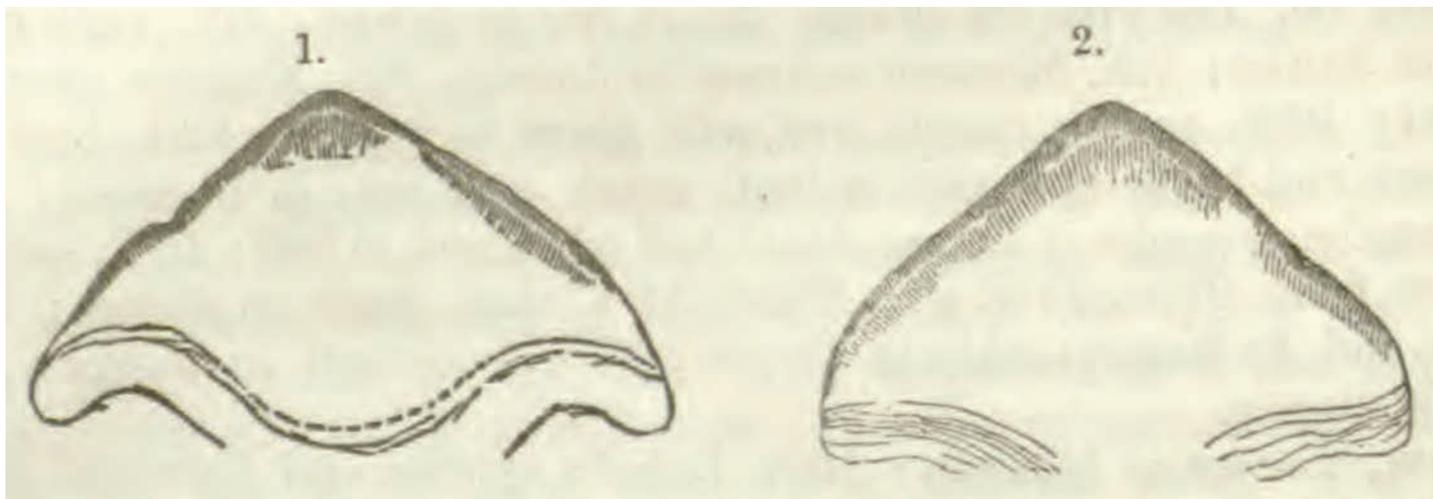


Figure 1. *Petalodus ohioensis* from Safford (1853, p. 142) in (1) labial and (2) lingual views.

junior synonyms of *P. ohioensis* in the bibliography of fossil vertebrates of North America (Hay, 1902).

Whereas some researchers (Hansen, 1985, 1996; Dalla Vecchia, 1988; Ramovš, 1997a, 1997b; Lucas and Estep, 2000; Robb, 2003; Elliott and others, 2004; Hamm and Cicimurri, 2005; Brusatte, 2007; Ginter and others, 2010; Carpenter and Ottinger, 2018) have followed Hay in regarding *P. ohioensis* as the senior synonym, others (Miller, 1957; Miller and Mann, 1958; McNulty, 1963; Zidek, 1976; Goto and Okura, 2004; Monson, 2010) have followed Eastman (1896) in giving priority to the name *P. alleghaniensis*, apparently regarding *P. ohioensis* to be a nomen dubium, due to the inadequacy of Safford's description. The status of *Petalodus ohioensis* is difficult to resolve without having access to its holotype or even to an accurate illustration of it.

## INSTITUTIONAL ABBREVIATIONS

FMNH = Field Museum of Natural History, Chicago, Illinois; YPM = Yale Peabody Museum of Natural History, Yale University, New Haven, Connecticut.

## CASTS AT THE YALE PEABODY MUSEUM OF NATURAL HISTORY

Recently, the present authors located two casts at the Yale Peabody Museum, accompanied by a label stating

that they were copies of the holotype of *Petalodus ohioensis* and that they were received from the Museum of Comparative Zoology, Harvard University (Carpenter and Itano, 2019). Figure 2 shows labial (A) and lingual (B) views of one of the casts. There seems to be no reason to doubt the authenticity of the casts, which correspond closely to the drawings of Safford (1853) (figure 1), even to the slight asymmetries of the crown margins. The casts were catalogued at the Yale Peabody Museum on September 18, 1930, but might have been received at an earlier date (D. Brinkman, Yale Peabody Museum, email communication, June 15, 2018). Currently, neither the holotype of *P. ohioensis* nor casts of it, nor any record of them, can be located at the Museum of Comparative Zoology (J. Cundiff, Museum of Comparative Zoology, email communication, June 15, 2018). Despite their low quality, the casts at the Yale Peabody Museum are sufficiently detailed to establish the validity of *P. ohioensis*. They confirm that *P. alleghaniensis* is a junior synonym of *Petalodus ohioensis* (Carpenter and Itano, 2019).

It seems possible, even likely, that Safford would have sent a cast of the holotype to L. Agassiz, then at the Museum of Comparative Zoology, whom Safford (1853) credits with identifying the genus of the tooth. The poor quality of the Yale Peabody Museum casts might be a result of their being copies of a cast, once



Figure 2. Cast of the holotype of *Petalodus ohioensis* in (A) labial and (B) lingual views. Specimen number YPM PV 2861 from the collections of the Yale Peabody Museum of Natural History. Scale bar = 1 cm.

held by the Museum of Comparative Zoology, rather than being copies of the original specimen.

### CASTS AT THE FIELD MUSEUM OF NATURAL HISTORY

Recently, one of the authors (Itano) noticed the following entry in a catalogue of type specimens in the Field Museum of Natural History (Bruner, 1992):

*Petalodus ohioensis* (Safford, 1851)  
= Originally described as *Getalodus ohioensis* Safford 1851  
PF 673 Casts of holotype. Casts of 3 teeth.  
Pennsylvanian.  
Ohio: Guernsey County: Near Cambridge.  
Collector: J. M. Safford.  
Safford, J. M. 1853. Tooth of *Getalodus ohioensis*.  
*American Journal of Science*, 2nd ser., 16: 142. Desc. (p. 142) & fig. Figs. 1, 2.

The description leaves no doubt that the tooth referred to is the holotype of *P. ohioensis*. The date 1851 should be corrected to 1853, the date of Safford's publication. One of the authors (Itano) requested information from the Field Museum as to the status of the casts and received a photograph (figure 3) and registration information (figure 4) (W. Simpson, Field Museum of Natural History, email communication, January 21,

2020). Simpson also clarified that, although the entry in Bruner (1992) refers to “casts of 3 teeth,” there are actually three casts of the same tooth: one of the entire tooth and one each of only the labial or lingual side. The Field Museum casts are of better quality than those of the Yale Peabody Museum and reinforce the conclusions of Carpenter and Itano (2019) as to the validity and priority of *Petalodus ohioensis*. That the Field Museum and Yale Peabody Museum casts are of the same tooth is clear by observation. The close correspondence of the asymmetric lingual faces (rightmost cast of figure 3 versus figure 2B) is particularly striking. The Field Museum casts are important because they clearly show the bands of ridges at the base of the crown on the labial and lingual sides. The Yale Peabody Museum casts are too rough to show the ridges, which are a feature of all *Petalodus* teeth (Hansen, 1985). Bands of ridges on both labial and lingual sides distinguish *Petalodus* from similar genera, for example, *Polyrhizodus*, which has ridges only on the lingual side (Hansen, 1985).

The handwritten note in figure 3, with the words, “Casts of *Petalodus ohioensis*, J. M. Safford, Nashville, Tenn., Presented by O. P. Hay,” together with the information from the registration record (figure 4) that the casts were received in 1896 from O.P. Hay, allows one to reconstruct a plausible series of events. James Merrill Safford was a professor at Cumberland University,



Figure 3. Three casts of the holotype of *Petalodus ohioensis*. Specimen number FMNH PF 673. From left to right: cast of labial side, three-dimensional cast, cast of lingual side. Photograph by W. Simpson (Field Museum of Natural History). Used with permission.

Lebanon, Tennessee, from 1848 to 1873. From 1873 to 1900, Safford was a professor at the University of Nashville and at Vanderbilt University, both in Nashville, Tennessee (Stearns, 2018). One can speculate that, after writing the 1895 article, Hay wrote to Safford, who was then in Nashville, enquiring as to the status of the holotype of *P. ohioensis*, received the casts shown in figure 3, and, in 1896, donated them to the Field Museum of Natural History, which was then called the Field Columbian Museum. Based on the evidence of the casts,

Hay might then have concluded that *P. ohioensis* was the senior synonym of *P. alleghaniensis*, *P. destructor*, and *P. securiger*, as is reflected in Hay (1902). Attempts by the present authors to locate the original holotype have so far been unsuccessful.

## CONCLUSIONS

The casts of the holotype of *Petalodus ohioensis* Safford 1853, FMNH PF 673, in the collections of the Field Museum of Natural History, show details not present on

1 of 1    Axiell EMU IRN: 2408107    Primary Key: PF673    Next Available No: 17546    MASTERFILE INPUT SCREEN    VP Coll F

Synonyms:

Higher Taxon 3: Chondrichthyes  
Higher Taxon 2: Holocephali  
Higher Taxon 1: [Holocephali]  
Superorder: Paraselachimorpha  
Order: Petalodontiformes  
Suborder: [Petalodontiformes]  
Infraorder: [Petalodontiformes]  
Family: Petalodontidae  
Subfamily: [Petalodontidae]

**CANCEL**    **SAVE**    MANUAL Only for changes to pre-existing record  
**FIRST**    Save #1 Save new record & update machine number  
**PREVIOUS**    Save #2 Copy from query, save under next machine #, update machine #  
**NEXT**    Save #3 FOR FILLING IN GAPS. saves, copies under incremented user-supplied # (w/o updating machine #)  
**LAST**    Invenoried by (+ prior dates):    Inventory Date: WFS    01/21/2020  
**DELETE**    Specimen Location: Fossil Fish Rnage

Location On Loan:   
Cabinet/Drawer:  Edited by:  Edit Date: 00/00/00

Exhibit Name:  Exhibit Hall:   
Exhibit Section:  Exhibit Code:  Exhibit Case:   
Print Note:  2nd Print Note:  3rd Print Note:  4th Print Note:   
jf    sharks

Desc. and fig'd by J.M. Safford, 1853: Am. Journ. Sci., (2), 16, p 142, fig. 1-2

Catalogue No: PF 673    prep status    disposition    status F    Cast of Holotype ?

Genus: Petalodus  
specific epithet: ohioensis  
Author / Year: Safford    1853  
Morphology: casts of 3 teeth  
entry date: 2/14/1952    # of individuals: 1    pieces: 3  
Period: Pennsylvanian    Epoch:   
Age:   
Group:   
Formation:   
Member:   
Horizon:   
Coal measures:   
Continent: North America    State:     County:   
Country: USA    Ohio    Guemsey County  
Location: near Cambridge  
Locality Name:   
Township + range:   
Quad Map:   
Lat/Long:     UTM Co-ords:   
Centroid Coords:     Elevation:   
Remarks:   
Collector: J.M. Safford  
Field #    MADsub#    MADconcat  
Date Collected: 0    Year modifier    corcat    Year  
Old Cat # (entry fields): P 5307    P    5307  
Accession#: G-310    Acc Date    Other Inst#  
Accession Description: Gift, 1896, from O.P. Hay  
Remarks:

Figure 4. Registration information for FMNH PF 673. Courtesy of W. Simpson (Field Museum of Natural History). Used with permission.

the casts in the collections of the Yale Peabody Museum of Natural History, YPM PV 2861. This reinforces the conclusions of the present authors (Carpenter and Itano, 2019) that *P. ohioensis* is a valid species and a senior synonym of *P. alleghaniensis*.

## ACKNOWLEDGMENTS

We thank William Simpson (Field Museum of Natural History) for the photograph of the casts (figure 3) and the registration information (figure 4). We thank

Dan Brinkman (Yale Peabody Museum of Natural History, New Haven, Connecticut) for access to collections and for information on the casts registered as YPM PV 2861. We thank Jessica Cundiff (Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts) for attempting to locate the holotype of *P. ohioensis*, or casts of it, in the museum collections. We thank James Kirkland (Utah Geological Survey) and Spencer Lucas (New Mexico Museum of Natural History and Science) for their constructive reviews.

## REFERENCES

- Bruner, J.C., 1992, A catalogue of type specimens of fossil fishes in the Field Museum of Natural History: Fieldiana Geology, v. 23, p. 1–54.
- Brusatte, S.L., 2007, Pennsylvanian (Late Carboniferous) chondrichthyans from the LaSalle Limestone Member (Bond Formation) of Illinois, USA: Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, v. 244, no. 1, p. 1–8.
- Carpenter, K., and Itano, W.M., 2019, Taxonomic validity of *Petalodus ohioensis* (Chondrichthyes, Petalodontidae) based on a cast of the lost holotype: Geology of the Intermountain West, v. 6, p. 55–60, <https://doi.org/10.31711/giw.v6.pp55-60>.
- Carpenter, K., and Ottinger, L., 2018, Permo-Pennsylvanian sharks from the lower Cutler beds near Moab, Utah: Geology of the Intermountain West, v. 5, p. 105–116, <https://doi.org/10.31711/giw.v5.pp105-116>.
- Dalla Vecchia, F.M., 1988, First record of a petalodont (*Petalodus ohioensis* Safford, 1853) from the Alps: Gortania-Atti del Museo Friulano di Storia Naturale, v. 9, p. 47–56.
- Eastman, C.R., 1896, Remarks on *Petalodus alleghaniensis* Leidy: Journal of Geology, v. 4, no. 2, p. 174–176, <https://www.biodiversitylibrary.org/item/96016#page/188/mode/1up>.
- Elliott, D.K., Irmis, R.B., Hansen, M.C., and Olson, T.J., 2004, Chondrichthyans from the Pennsylvanian (Desmoinesian) Naco Formation of central Arizona: Journal of Vertebrate Paleontology, v. 24, no. 2, p. 268–280, <https://doi.org/10.1671/1978>.
- Ginter, M., Hampe, O., and Duffin, C.J., 2010, Chondrichthyes Paleozoic Elasmobranchii teeth, in Schultze, H-P., editor, Handbook of paleoichthyology, volume 3D: Munich, Verlag Dr. Friedrich Pfeil, p. 1–168.
- Goto, M., and Okura, M., 2004, The chondrichthyan tooth remains from the Carboniferous and Permian of Fukuji, Gifu Prefecture, central Japan: Earth Science (Chikyu Kagaku), v. 58, p. 215–228.
- Hamm, S.A., and Cicimurri, D.J., 2005, Middle Pennsylvanian (Desmoinesian) chondrichthyans from the Lake Neosho Shale Member of the Altamont Limestone in Montgomery County, Kansas: Paludicola, v. 5, no. 2, p. 62–76.
- Hansen, M.C., 1985, Systematic relationships of petalodontiform chondrichthyans, in Dutro, J.T., Jr., and Pfefferkorn, H.W., editors, Neuvième Congrès International de Stratigraphie et de Géologie du Carbonifère, Compte Rendu, vol. 5: Carbondale and Edwardsville, Southern Illinois University Press, p. 523–541.
- Hansen, M.C., 1996, Phylum Chordata—vertebrate fossils, in Feldmann, R.M., and Hackathorn, M., editors, Fossils of Ohio: Ohio Division of Geological Survey Bulletin 70, p. 288–369.
- Hay, O.P., 1895, Description of a new species of *Petalodus* (*P. securiger*) from the Carboniferous of Illinois: Journal of Geology, v. 3, no. 5, p. 561–564, <https://www.jstor.org/stable/30055026>.
- Hay, O.P., 1902, Bibliography and catalogue of the fossil vertebrata of North America: U.S. Geological Survey Bulletin 179, 868 p., <https://www.biodiversitylibrary.org/item/59973#page/9/mode/1up>.
- Leidy, J., 1856, Descriptions of some remains of fishes from the Carboniferous and Devonian formations of the United States: Journal of the Academy of Natural Sciences of Philadelphia, v. 3, p. 159–165, <https://www.biodiversitylibrary.org/item/113477>.
- Lucas, S.G., and Estep, J.W., 2000, Pennsylvanian selachians from the Cerros de Amado, central New Mexico, in Lucas, S.G., editor, New Mexico's fossil record 2: New Mexico Museum of Natural History and Science Bulletin 16, p. 21–27.
- Martino, R.L., 2004, Sequence stratigraphy of the Glenshaw Formation (Middle-Late Pennsylvanian) in the Central Appalachian Basin, in Pashin, J.C., and Gastaldo, R.A., editors, Sequence stratigraphy, paleoclimate, and tectonics of coal-bearing strata: American Association of Petroleum Geologists Studies in Geology 51, p. 1–28.
- McNulty, C.L., Jr., 1963, Teeth of *Petalodus alleghaniensis* Leidy from the Pennsylvanian of north Texas: Texas Journal of Science, v. 15, no. 3, p. 351–353, <https://www.biodiversitylibrary.org/item/249272#page/897/mode/1up>.
- Miller, H.W., Jr., 1957, *Petalodus jewetti*, a new species of fossil bradyodont fish from Kansas: Transactions of the Kansas Academy of Science, v. 60, no. 1, p. 82–85.
- Miller, H.W., Jr., and Mann, R.J., 1958, *Petalodus* (Bradyodont) from the Permian of Kansas and Oklahoma: Transactions of the Kansas Academy of Science, v. 51, no. 1, p. 97–103.

- Monson, C.C., 2010, Paleontology and paleoecology of the Pennsylvanian in south-central Iowa, in Marshall, T., and Fields, C., editors, The Pennsylvanian geology of south-central Iowa: Geological Survey of Iowa Guidebook 86, p. 27–35, <https://s-iihr34.iihr.uiowa.edu/publications/uploads/GSI-086.pdf#page=33>.
- Newberry, J.S., and Worthen, A.H., 1866, Descriptions of new species of vertebrates, mainly from the sub-Carboniferous limestone and coal measures of Illinois: Geological Survey of Illinois, v. 2, p. 9–134.
- Ramovš, A., 1997a, *Petalodus ohioensis* (Chondrichthyes, Upper Carboniferous) from the Karavanke Mountains, Slovenia: Neues Jahrbuch für Geologie und Paläontologie Monatshefte, v. 1997, p. 109–113.
- Ramovš, A., 1997b, Two new petalodont teeth (Chondrichthyes, Upper Carboniferous) from the Karavanke Mountains, Slovenia: Geologija, v. 40, p. 109–112, <https://doi.org/10.5474/geologija.1997.004>.
- Robb, A.J., III, 2003, Notes on the occurrence of some petalodont shark fossils from the Upper Pennsylvanian rocks of northeastern Kansas: Transactions of the Kansas Academy of Science, v. 106, no. 1/2, p. 71–80.
- Safford, J.M., 1853, Tooth of *Getalodus* [sic] *ohioensis*: American Journal of Science and Arts, v. 16, no. 46, p. 142, <https://www.biodiversitylibrary.org/item/90339#page/149/mode/1up>.
- Stearns, R.G., 2018, James Merrill Safford: Tennessee Historical Society Tennessee Encyclopedia, online access 6 January 2020, <https://tennesseeencyclopedia.net/entries/james-merrill-safford>.
- Zidek, J., 1976, Oklahoma paleoichthyology part 5—Chondrichthyes: Oklahoma Geology Notes, v. 36, no. 5, p. 175–192.