U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Petrified Forest National Park

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Petrified Forest National Park

pefo_geology.pdf

Version: 9/3/2020

Geologic Resources Inventory Map Document for Petrified Forest National Park

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Geologic Resources Inventory Map Document

Petrified Forest National Park, Arizona

Document to Accompany Digital Geologic-GIS Data

pefo_geology.pdf

Version: 9/3/2020

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Petrified Forest National Park, Arizona (PEFO).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Map and Source Citation** – The GRI digital geologic-GIS map produced for this project along with source map used in its completion. In addition, a brief explanation of how the source map was used is provided.

3) **Map Unit List** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.

4) **Map Unit Descriptions** – Descriptions for all geologic map units.

5) **Ancillary Source Map Information** – Additional source map information presented by source map. Includes a correlation of map units, map legend and a geologic report.

6) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

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About the NPS Geologic Resources Inventory Program

Background

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm

Geologic Reports: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: https://go.nps.gov/gripubs. GRI digital geologic-GIS data is also available online at the NPS Data Store: https://irma.nps.gov/DataStore/Search/Quick. To find GRI data for a specific park or parks select the appropriate park(s), enter “GRI” as a Search Text term, and then select the Search button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://www.nps.gov/subjects/geology/gri.htm. At the bottom of that webpage is a “Contact Us” link if you need additional information. You may also directly contact the program coordinator:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division. Learn more about I&M and the 12 baseline inventories at the I&M webpage: https://www.nps.gov/im/inventories.htm.

GRI Digital Map and Source Map Citation

The GRI digital geologic-GIS map for Petrified Forest National Park, Arizona (PEFO).

Digital Geologic-GIS Map of a portion of Petrified Forest National Park, Arizona (*GRI MapCode PEFO*)

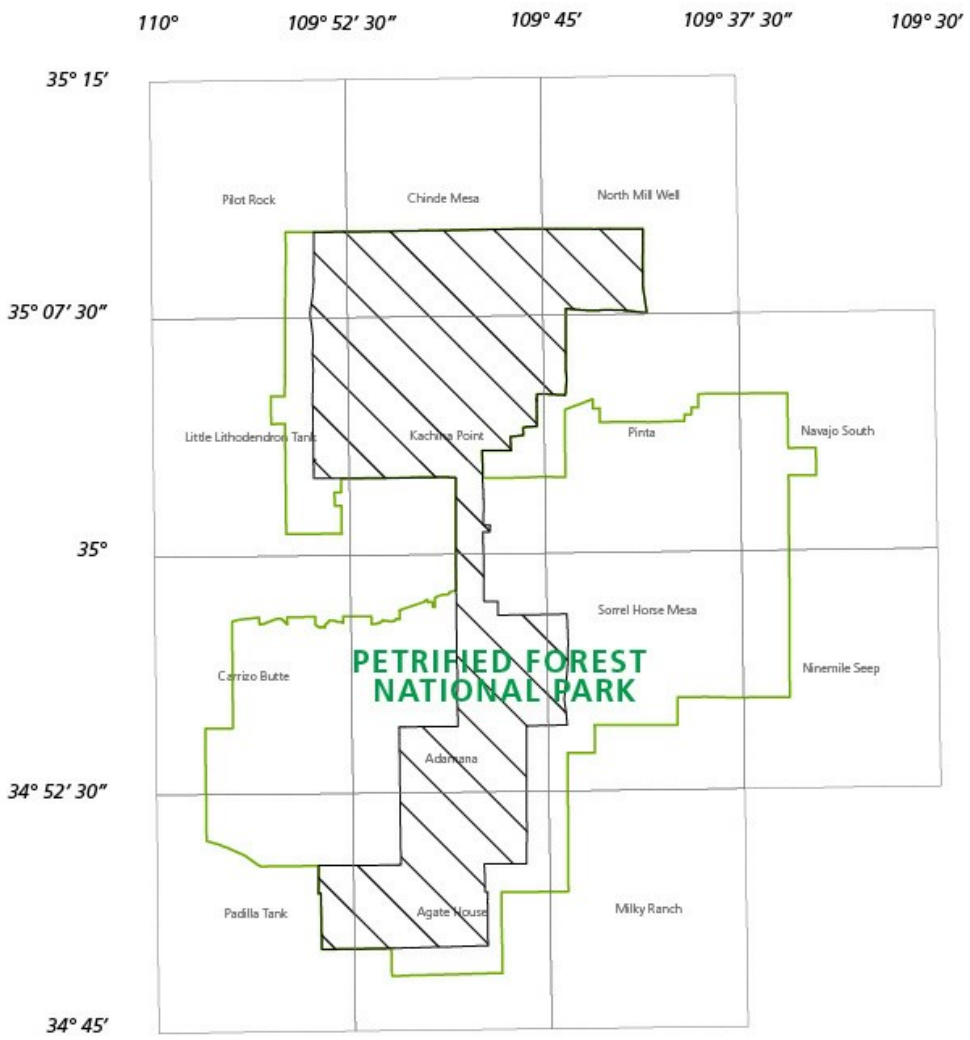
The digital geologic-GIS map was produced from the following source:

> Martz, J., Parker, W., Thompson, L. and Raucci, J., 2012, Geologic Map of Petrified Forest National Park, Arizona: Arizona Geological Survey, Contributed Map Series, CM-12-A, scale 1:50,000 (Petrified Forest National Park). (*GRI Source Map ID 75663*).

The full extent of this source map was used, and all geologic features within the map extent were captured. See index map below to view difference between the source map extent and the expanded Petrified Forest National Park boundary. Additional information pertaining to this source map is also presented in the GRI Source Map Information (PEFOMAP) table included with the GRI geologic-GIS data.

Petrified Forest National Park Index Map

The following index map displays the extents of the GRI digital geologic-GIS maps produced for Petrified Forest National Park (PEFO). The boundary for Petrified Forest National Park (as of August, 2020) is outlined in green. The 1:50,000 scale source map extent is shown in the black hatch pattern. 7.5' quadrangles intersected by the current park boundary are shown in light gray.



Index Map by Jake Suri (Colorado State University).

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Petrified Forest National Park, Arizona (PEFO) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qd - Quaternary eolian dunes and sand sheets). Units are listed from youngest to oldest. Information about each geologic unit is also presented in the GRI Geologic Unit Information (PEFOUNIT) table included with the GRI geologic-GIS data.

Cenozoic Era

Quaternary Period

Qd - Quaternary eolian dunes and sand sheets
Qsu - Quaternary surficial deposits, undifferentiated

Tertiary Period

Mibv - Miocene/Pliocene volcanic rocks of the Bidahochi Formation
Mibs - Miocene sedimentary rocks of the Bidahochi Formation

Meoszoic Era

Triassic Period

TRcuo - Chinle Formation, upper Owl Rock Member
TRclo - Chinle Formation, lower Owl Rock Member
TRcopg - Chinle Formation, Owl Rock Member, purple-gray bed
TRcpf - Chinle Formation, Petrified Forest Member
TRcpfbf - Chinle Formation, Petrified Forest Member, Black Forest bed
TRcpd3 - Chinle Formation, Petrified Forest Member, Lithodendron Wash bed (Painted Desert sandstone 3)
TRcpff4 - Chinle Formation, Petrified Forest Member, Flattops bed 4
TRcpff3 - Chinle Formation, Petrified Forest Member, Flattops bed 3
TRcpff2 - Chinle Formation, Petrified Forest Member, Flattops bed 2
TRcspd1 - Chinle Formation, Sonsela Member, Martha's Butte beds, Painted Desert sandstone 1
TRcsmb - Chinle Formation, Sonsela Member, Martha's Butte beds/Flattops One sandstones
TRcsjc - Chinle Formation, Sonsela Member, Jim Camp Wash beds
TRcsb - Chinle Formation, Sonsela Member, Jim Camp Wash beds, brown sandstones
TRcsrf - Chinle Formation, Sonsela Member, Rainbow Forest bed/Jasper Forest bed/Kellogg Butte bed
TRcslw - Chinle Formation, Sonsela Member, Lot's Wife beds
TRcscb - Chinle Formation, Sonsela Member, Camp Butte beds
TRcbm - Chinle Formation, Blue Mesa Member
TRcbnr - Chinle Formation, Blue Mesa Member, Newspaper Rock Bed
TRcbls - Chinle Formation, Blue Mesa Member, lower "quartz overgrowths" sandstone unit
TRcmr - Chinle Formation, Mesa Redondo Member

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. All unit descriptions were taken from the source map Petrified Forest National Park (Martz, J. et. al., 2012). Figures referenced in the descriptions below can be found in the attached report for Petrified Forest National Park (CM-12-A).

Qd - Quaternary eolian dunes and sand sheets (Quaternary)

Unconsolidated sand, deposited in dunes by eolian processes or in extensive sand sheets by mixed alluvial and eolian processes. Deposits are commonly heavily vegetated.

Qsu - Quaternary surficial deposits, undifferentiated (Quaternary)

Unconsolidated sand, silt, mud, and gravel; includes alluvial surfaces (slopewash and sheet-flow deposits), active stream channels (ephemeral and perennial), colluvium, floodplain deposits, and in-situ soil development. Also includes some areas that may be superficially modified by eolian processes, and deposits of indeterminate origin.

Mibv - Miocene/Pliocene volcanic rocks of the Bidahochi Formation (Miocene to Pliocene)

Basaltic lava and tephra deposits, equivalent to the informal Member 5 of the Bidahochi Formation (Dallegge, 1999). Restricted to Headquarters Mesa and Pilot Rock north of the Puerco River (Figures 2, 3, 10E).

Mibs - Miocene sedimentary rocks of the Bidahochi Formation (Miocene)

Mudstone and minor siltstone, crudely stratified in beds 0.5 – 1 m thick. Outcrops are generally medium tan to yellow and locally difficult to distinguish from overlying Quaternary deposits. Sedimentary units of the Bidahochi Formation are present as cut-and-fill deposits atop the Petrified Forest and Owl Rock members of the Chinle Formation, usually preserved by capping volcanic rocks. Limited outcrops occur at Headquarters Mesa and in the general vicinity, on Pilot Rock, and in the northeast corner of the Park (Figures 2, 3, 10E). The Bidahochi sedimentary rocks within PEFO are likely equivalent to Members 1 and 2 of Dallegge (1999).

Chinle Formation, Owl Rock Member

Heterolithic interval of sandstone and mudstone with minor limestone and siltstone (Figure 11); the base is defined by a subtle change in mudstone color and composition (Stewart et al., 1972), and by the appearance of laterally extensive well-calcified beds (Dubiel, 1993). Mudstones are bentonitic and generally lighter pastel colors compared to the deep reddish mudstones of the underlying Petrified Forest Member; sandstones are pale reddish-brown, fine grained, well-sorted litharentites with common trough cross-strata. Pedogenic carbonate nodules are common and often much more massive (more than 10 cm in diameter) than seen lower in the Chinle Formation. Except for the basal purple-gray bed (see below), the Owl Rock Member is exposed only at Chinde Mesa and Pilot Rock along the northern boundary of PEFO (Figures 2, 3, 11B), where 80 meters are present (Ash, 1992; Dubiel, 1993); the overlying section is truncated by erosion at Chinde Mesa (Figure 11B), and overlain unconformably by the Bidahochi Formation at Pilot Rock. The Owl Rock Member is mapped as three informal sub-units listed below.

TRcuo - Chinle Formation, upper Owl Rock Member (Triassic)

Contains ledge-forming limestones (Figure 11B). Limestones are generally light colored, mottled, pisolithic, and massive. Limestone beds are laterally persistent, and locally show internal brecciation and re-cementation, dissolution zones and secondary silica, suggesting a high degree of pedogenic modification (e.g., Dubiel, 1993; Tanner, 2003).

TRclo - Chinle Formation, lower Owl Rock Member (Triassic)

Contains slightly resistant pinkish and purplish calcareous paleosols developed in siltstones, sandstones and conglomerates, but no ledgeforming limestones (Figure 11A). Calcareous paleosols locally contain carbonate nodules and deep vertical fissures usually filled with clastic sediments. Large scours filled with clastic sediments also occur in this part of the member.

TRcopg - Chinle Formation, Owl Rock Member, purple-gray bed (Triassic)

Well-calcified purple-gray siltstone bed 2-4 meters thick, full of small carbonate nodules, locally abundant gastropods (Dubiel, 1993), and vertebrate fossils, also contains deep vertical fissures filled with darker clastic sediments and silica, probably representing in-filled desiccation cracks. This bed is extensively exposed in the northern part of the Petrified Forest Wilderness area, and often forms resistant steep faces on low cliffs and mesas (Figure 11A), including the divide between the Lithodendron Wash and Digger Wash drainages (Figure 2).

TRcpf - Chinle Formation, Petrified Forest Member (Triassic)

Approximately 130 meters (Parker and Martz, 2011, fig. 5) of mudstone with minor sandstone and siltstone (Figure 10). The most prominent and laterally persistent sandstones have been granted formal bed status (see below). Consists primarily of pale red to purple mudstone with common, thin sandstone interbeds; commonly bright reddish orange. Large-scale scours are common in the upper part of the unit (Kraus and Middleton, 1987; Johns, 1988; Zuber, 1990). Bedding in the mudstones is typically 1-3 m thick and tabular, and mudstones contain abundant pedogenic carbonate nodules and vertic paleosols, especially greenish-gray mottling (Johns, 1988; Zuber, 1990; Tanner, 2003; Dubiel and Hasiotis, 2011).

TRcpfbf - Chinle Formation, Petrified Forest Member, Black Forest bed (Triassic)

Up to 12.6 m of calcrete-nodule conglomerate and reworked tuffaceous sandstone, with finer-grained 0.1- to 0.2- m- thick sandstone and mudstone interbeds (Figure 10E-F). Conglomerate is basal, conformably overlain by finer-grained tuffaceous interval. Unit is rich in petrified wood (Figure 10F), as well as invertebrate and vertebrate remains (Ash, 1992; Riggs et al., 2003; Ash and Creber, 2000; Creber and Ash, 2004).

TRcpd3 - Chinle Formation, Petrified Forest Member, Lithodendron Wash bed (Painted Desert sandstone 3) (Triassic)

Generally fine-grained sandstone with minor conglomerate, coarse-grained sandstone and interbedded mudstone. Sandstones are pale gray to tan on fresh surfaces, often with gray and brown candy striping, but commonly weather to medium brown. The base of the unit is erosive and irregular, with local relief commonly exceeding 1 m, and up to 6 m (Johns, 1988). Internal cross-stratification is ubiquitous,

including trough and planar cross-sets, lateral accretion sets, and rare channel forms. Conglomerates are generally intra-formational, composed primarily of re-worked pedogenic carbonate nodules, and extra-basinal clasts are rare. The unit may be single-storied or multi-storied (Figure 10D) with a total thickness up to 11 m. Vertebrate fossils are extremely common in uppermost part of the unit, and in the beds immediately above it (Parker and Martz, 2011). In the northern part of PEFO, the Lithodendron Wash Bed is present throughout southern part of the Petrified Forest Wilderness area, and along the south side of Lithodendron Wash, commonly as a cap on cliffs and mesas (Figures 2, 10B).

TRcpff2-4 - Chinle Formation, Petrified Forest Member, Flattops beds 2-4 (Triassic)

Generally fine- to medium- grained, moderately to well- sorted brownish-gray sandstones (Figure 10A). Planar and trough cross-strata are common, as well as horizontal and ripple laminae. Intraformational conglomerates composed predominantly of reworked pedogenic carbonate are common, especially as lags at the base of scours. Extra-basinal clasts are rare (Espregen, 1985). Fossils are most commonly local beds of unionid bivalves, although vertebrate fossils are also known. Flattops Bed 2 is laterally extensive, but Beds 3 and 4 are restricted to the Flattops Mesas area along the main park road (Figures 2, 10A). Unit thicknesses are laterally variable, but are typically less than 10 m. Flattops Bed 2 is the thickest, being thicker than 10 m in some locations.

TRcspd1 - Chinle Formation, Sonsela Member, Martha's Butte beds, Painted Desert sandstone 1 (Triassic)

Localized ledge-forming sandstone lenses, generally 1-5 meters thick, which occur at the top of the Martha’s Butte beds/Sonsela Member (Figure 10B). This sandstone is probably equivalent to the highest Flattops One sandstones in southern PEFO (Figure 10A). It is mapped due to historical confusion about its stratigraphic equivalence to beds in southern PEFO (Billingsley, 1985a, b; Heckert and Lucas, 2002) and its geographic separation from most Sonsela Member exposures further west in Devil’s Playground. The unit was previously correctly mapped and correlated by Johns (1988, fig. 2).

TRcsmb - Chinle Formation, Sonsela Member, Martha's Butte beds/Flattops One sandstones (Triassic)

Sandstone and conglomerate complexly interbedded with mudstone (Figures 8, 9B, 10A-B); the top of the Sonsela Member in the nomenclature of Martz and Parker (2010). Resistant ledge-forming sandstones within this interval in southern PEFO are called Flattops One sandstones (following Billingsley, 1985a, b) and include the type “Agate Bridge Bed” of Heckert and Lucas (2002; Figure 8A), which they erroneously correlated with the Jasper Forest bed. Lithologically similar sandstones (including Painted Desert 1 sandstone; Figure 10B) cap the member in Devil’s Playground in northern PEFO. Flattops One sandstones are medium to coarse-grained, moderately to well-sorted, pale yellow-brown to dark brown (lighter on fresh surfaces), compositionally immature, and are commonly multi-storied with thin mudstone interbeds. Conglomerates are commonly carbonate nodule lags at the base of sandstone beds, as well as discrete lenses of pebble-size clasts. However, gravel-sized clasts of extra-basinal volcanic rock and chert are also common, as are beds composed almost entirely of unionid bivalves, often coated with layers of calcium carbonate. Structures consist of horizontal planar bedding, trough and planar cross-bedding, ripple bedding, lateral accretion beds, and ridge and swale topography (Espregen, 1985; Woody, 2006). A dark silicified horizon similar to that seen in the Jim Cap Wash beds and Lot’s Wife beds occurs locally near the base of this unit (Martz and Parker, 2010). Vertebrate fossils, as well as white and orange petrified logs are locally abundant in this unit. Individual Flattops One sandstones are generally 2-6 meters thick, although multi-storied units may achieve a maximum thickness of 25 m and make up almost the entire thickness of the Martha’s Butte beds (Figure 3). Due

to the discontinuous nature, complex interbedding, and variable thickness of the Flattops One sandstones, they have not been individually mapped. Although mudstones are usually purple, they sometimes have a distinctive pale blue color in northern PEFO, and are full of pedogenic carbonate nodules in both areas (Figure 8C). Some mudstones interbedded in this unit are locally well-lithified and possibly represent playa lake deposits (Espregen, 1985).

TRcsjc - Chinle Formation, Sonsela Member, Jim Camp Wash beds (Triassic)

Sandstone, siltstone and mudstone; mudstones are pale gray, purple and less commonly red (Figures 8-9). Sandstones are typically fine- to medium-grained and poorly sorted; chert, calcareous nodules and unionid bivalve fragments are locally abundant. Sandstones are generally not laterally continuous and ribbon architecture is common; however, thicker, more resistant, and more laterally continuous sandstone beds are locally present (Martz and Parker, 2010; Parker and Martz, 2011), though only one, the “Brown sandstone” of Billingsley (1985a, b) is mapped here (see below). Sandstones in the Jim Camp Wash beds in Devil’s Playground (Figure 9) are generally thicker, more laterally persistent, and contain more extra-basinal chert, quartzite, and volcanic clasts than normally seen in southern PEFO. Bedding thickness varies throughout the Jim Camp Wash beds. Contacts are usually erosive and sharp and dominated by cut-and-fill architecture, and heterolithic intervals are locally common (Woody, 2006). As with the Martha’s Butte beds, interbedded mudstones are rich in pedogenic carbonate nodules (Herrick, 1999; Woody, 2006; Martz and Parker, 2010). A distinctive reddish or orange horizon composed of silicified plant material occurs low in the unit (Creber and Ash, 1990; Martz and Parker, 2010; Driese et al., 2010), just below the level where pedogenic carbonate and unionids become abundant, and is associated with important faunal and floral overturns (Parker and Martz, 2011; Reichgelt et al., in press). Vertebrate fossils are extremely abundant. Total unit thickness is generally 25-30 m, but is thinner locally.

TRcsb - Chinle Formation, Sonsela Member, Jim Camp Wash beds, brown sandstones (Triassic)

Sandstone and minor conglomerate (Figure 9), restricted to Devil’s Playground area north of I-40 (Figure 2), where it forms prominent blocky ledges. Although Billingsley (1985a, b) only identified a single “brown sandstone”, two closely associated sandstones with unusual dark chocolate brown or reddish brown colors occur in Devil’s Playground; the upper sandstone is usually thicker and more laterally persistent and is probably the unit Billingsley (1985a, b) was referring to. Sandstones are generally fine- to medium-grained, but coarser intervals are common, especially near the base of scours. Gravel-sized clasts are predominantly extra-basinal chert and volcanic clasts; pedogenic carbonate and unionids become abundant slightly higher than the Brown sandstone, suggesting that the Brown sandstone is correlative with the red silicified horizon in the Jim Camp Wash beds in southern PEFO. Sandstone is pale tan or gray on fresh surfaces but weathers to medium brown across most of the exposed area (Figure 9A), although the upper Brown sandstone is locally white (Figure 9B). Internal structure ranges from massive or weakly laminated to complex cross-stratification. Total unit thickness ranges up to ~6 m, but lateral changes in thickness can be abrupt.

TRcsrf - Chinle Formation, Sonsela Member, Rainbow Forest bed/Jasper Forest bed/Kellogg Butte bed (Triassic)

Sandstone and conglomerate, with common cobble-sized clasts of extrabasinal volcanic rocks, chert, and quartzite; clasts of re-worked intrabasinal bluish mudstone often dominating the lower part of the unit. These sandstones are usually multi-storied, with the dominant bedform being planar cross-bedding with lesser trough cross bedding and horizontal planar bedding (Espregen, 1985; Deacon, 1990). Reddish and multi-colored petrified logs are abundant in these units (Figure 7D; Heckert and Lucas,

1998; Ash and Creber, 2000; Ash, 2005), as are vertebrate fossils. The Jasper Forest bed (Figure 7B) and Rainbow Forest Bed (Figure 8A) are names for equivalent units respectively exposed north and south of the Flattops in southern PEFO, while the Kellogg Butte bed is the equivalent unit in Devil's Playground (Figure 9). The Jasper Forest bed becomes a thinner and more friable unit just north of the Flattops (Herrick, 1999; Martz and Parker, 2010). The Kellogg Butte bed also varies greatly in thickness and lithology, and is locally completely truncated by the Brown sandstones.

TRcslw - Chinle Formation, Sonsela Member, Lot's Wife beds (Triassic)

Sandstone, siltstone and mudstone; mudstones are purple and less commonly bluish or gray (Figure 7B-C). In southern PEFO, exposures north of the Flattops mesas can locally be roughly divided into upper beds dominated by gray and reddish sandstone and conglomerate with minor purple and bluish mudstone, and lower beds dominated by purple mudstone interbedded with discontinuous gray and dull pinkish ribbon and sheet sandstones which are not usually very conglomeratic (Figure 7B; Martz and Parker, 2010). Conglomerates in the upper Lot's Wife beds are dominated by clasts composed of chert, quartzite, volcanic rock, and intra-basinal mudstone rip-ups similar to those in the Jasper Forest bed. As with the Jim Camp Wash beds, contacts are usually erosive and sharp, and dominated by cut-and-fill architecture. Locally, a horizon of orange silicified plant material, similar to that in the lower Jim Camp Wash beds, is developed in the upper Lot's Wife beds (Creber and Ash, 1990; Woody, 2006; Martz and Parker, 2010).

TRcscb - Chinle Formation, Sonsela Member, Camp Butte beds (Triassic)

Sandstone and conglomerate; the unit is the basal beds of the Sonsela Member, and includes the conglomeratic sandstone capping Camp Butte (Figure 7A-B; Murry, 1990; Woody, 2006). Sandstones are fine- to medium-grained, moderately well sorted, pale gray, and locally trough and planar cross-stratified. Conglomerates are rich in white and orange petrified wood, and pebble-sized clasts of andesite, rhyolite, chert, and quartzite, as well as bluish mudstone rip-ups. Individual beds are generally 1-4 m thick, and the total unit varies from multi-storied conglomeratic sandstones to thin sandstone ribbons interbedded with mudstones of the upper Blue Mesa Member (Woody, 2006; Martz and Parker, 2010). Total unit thickness is 0-15 m.

TRcbm - Chinle Formation, Blue Mesa Member (Triassic)

Mudstone with minor siltstone and sandstone; banded dark blue, gray, yellow and red; structureless beds generally >2 m thick with diffuse boundaries; locally fossiliferous, with abundant wood and vertebrate remains. The upper part of the unit is dominated by greenish-gray, dark blue, and dark purple mudstones with thin, discontinuous ribbon sands (Figure 7A), and has the densest concentrations of vertebrate fossils in PEFO (e.g., Long and Murry, 1995; Therrien and Fastovsky, 2000). The lower part of the unit below the Newspaper Rock Bed (Figures 5B, 6) is composed of interbedded mudstone and sandstone, locally with minor conglomerate. Unit thickness is approximately 50 m, although the base is only exposed between the Tepees and Haystacks, south of Newspaper Rock (Figures 2, 3, 5).

TRcbnr - Chinle Formation, Blue Mesa Member, Newspaper Rock Bed (Triassic)

Sandstone with interbedded conglomerate and mudstone; the unit possesses complex internal geometry and strong lateral variation in lithology, color, and overall appearance. Around Newspaper Rock (Figure 6A), the unit is up to 10 m of yellow-brown, fine to medium-grained, well-sorted sandstone interbedded with thin layers of conglomerate composed of re-worked mudstone clasts, in which the sandstones contain small-scale trough cross beds, ripple cross-laminations, and lateral accretion bedding (Demko,

1995). Approaching the Tepees area, the unit becomes more complex (Figure 6B) and is composed of stacked fining-upward sequences of reddish, grayish, and greenish beds composed of fine- to very fine-grained sandstone with small trough cross beds and ripple cross-laminations, and mudstones locally containing abundant plant fossils and invertebrates (Stagner, 1941; Demko, 1995; Ash, 2005; Parker, 2006). In the Tepees and Blue Mesa areas (Figures 2, 6B, 7A), this unit grades laterally into a thin reddish paleosol generally not more than about 1 m thick (Demko, 1995; Parker, 2006) which is not mapped.

TRcbls - Chinle Formation, Blue Mesa Member, lower "quartz overgrowths" sandstone unit (Triassic)

Discontinuous sandstone (Figure 5B); coarse-grained, quartzose with significant quartz overgrowths; irregular and lenticular bedding 0.5-1 m thick, trough cross-strata in 20-40 cm sets; unit is up to 2 m thick, locally exposed capping low mesas east of the Haystacks, and along cliffsides southeast of Newspaper Rock (Figure 2). The unit is only mapped where it is relatively coarse and resistant; elsewhere it thins into a more friable and finer-grained sandstone.

TRcmr - Chinle Formation, Mesa Redondo Member (Triassic)

Sandstone and mudstone; mostly brick red with minor greenish-gray mottling, top meter or so of the unit is a well-developed gleyed oxisol with intense reddish, purple, yellow, and gray mottling (Figure 5A; e.g., Dubiel and Hasiotis, 2011, fig. 3D) capped by a horizon of silicified plant material similar to those seen in the Sonsela Member. Only the top of the unit is locally exposed between the Tepees and the Haystacks (Figures 2, 3, 5A); local thickness is uncertain, although the type section south of PEFO is about 40 m thick (Cooley, 1958).

Ancillary Source Map Information

The following section presents ancillary source map information associated with source map used for this project.

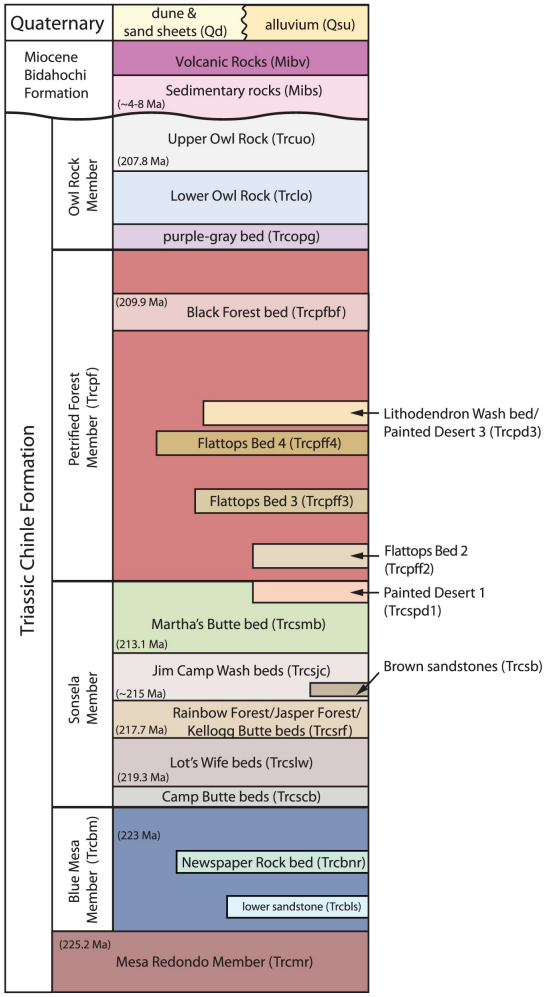
Geologic Map of Petrified Forest National Park

The formal citation for this source.

> Martz, J., Parker, W., Thompson, L. and Raucci, J., 2012, Geologic Map of Petrified Forest National Park, Arizona: Arizona Geological Survey, Contributed Map Series, CM-12-A, scale 1:50,000 (*GRI Source Map ID 75663*).

Prominent graphics and text associated with this source map.

Correlation of Map Units



Map Legend

Folds

——— known

— — — - approximate

—?— — - approximate and queried

····· concealed

·····?··· concealed and queried

Attitudes

⊕ horizontal bedding

→→ monocline

syncline

strike and dip

Geologic Report

The Geologic Report for Petrified Forest National Park (CM-12-A) contains figures referenced in the geologic unit descriptions above as well as discussion of geologic setting, structure, stratigraphy and macro-fossil occurrence.

References

Geologic mapping by Jeff Martz and William Parker, Division of Natural Resources, Petrified Forest National Park.

Digital map by Lisa Skinner, Northern Arizona University, Flagstaff, AZ, and Jason Raucci, Daniel B. Stephens & Associates, Albuquerque, NM.

GRI Digital Data Credits

This document was developed and completed by James Chappell and Jake Suri (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara (Colorado State University).

The information in this document was compiled from the GRI source map, and intended to accompany the digital geologic-GIS map and other digital data for Petrified Forest National Park, Arizona (PEFO) developed by James Chappell and Stephanie O'Meara (Colorado State University) (see the GRI Digital Map and Source Map Citation section of this document for the source used by the GRI in the completion of this document and the related GRI digital geologic-GIS map).

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