FIRST KNOWN POST-TRIASSIC OCCURRENCE OF THE PALM-LIKE PLANT FOSSIL *SANMIGUELIA* BROWN

by
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ABSTRACT

In this article, the remains of a nearly complete specimen of the enigmatic *Sanmiguelia* Brown plant (narrow stem and attached palm-like leaves) are described from the Early Jurassic (Hettangian) in the uppermost part of the Whitmore Point Member of the Moenave Formation in southwestern Utah. Previously, the fossil was only known from Upper Triassic strata at ten localities found in all but the lowest members of the Chinle Formation of Late Triassic age and equivalent units in the American Southwest. A small isolated fragment of the palm-like leaf of the *Sanmiguelia* plant is also described here for the first time from the Church Rock Member of the Chinle Formation in Lisbon Valley, southeastern Utah. The twelve localities (counting those described here) extend from west Texas to Zion National Park in southwestern Utah and range in age from Late Triassic (Norian) to Early Jurassic (Hettangian).

INTRODUCTION

The recent discovery of the fossilized remains of a specimen of the enigmatic palm-like plant *Sanmiguelia* Brown in the Early (Hettangian) Jurassic at a locality in Utah's far south warrants description. The reason for this is that the fossil continues to be one of the few putative pre-Cretaceous angiosperms (flowering plants) that has not been totally discounted since it was first described from the Upper Triassic of Colorado, nearly six decades ago (Brown, 1956). Since that time, the fossil has been found at additional Late Triassic localities in the American Southwest (Ash and Hasiotis, 2013). The new discoveries reported here extend its geographic range from western Texas to southwestern Utah and east-central Arizona (figure 1) and its stratigraphic range from the Norian Stage of the Late Triassic into the Hettangian Stage of the Early Jurassic. Furthermore, and of particular importance, if one of the new localities were to be recollected, it might yield additional specimens of the *Sanmiguelia* plant that would finally clarify the systematic relationships of the fossil and help elucidate the origin and early development of the angiosperms.

Since at least three nearly complete specimens of the *Sanmiguelia* plant have been found in the Late Triassic of the southwestern United States (see Tidwell and others, 1977; Cornet, 1986), its growth form is reasonably well known. These fossils indicated that it was a low plant (up to 0.6 meters tall), which had a narrow (~30-40 millimeters) upright, monopodial stem that bore many large, distinctive, oval to elliptical, spirally attached leaves. The leaves range up to 60 centimeters in length and 40 centimeters in width. They are longitudinally pleated and narrowed apically to form acute to acuminate apices and contracted basally to form clasping bases. At most localities, the *Sanmiguelia* plant is only represented by fragments of the distinctive pleated leaves (see figure 3A, 3B). Although they somewhat resemble the leaves of certain palms, there are impor-

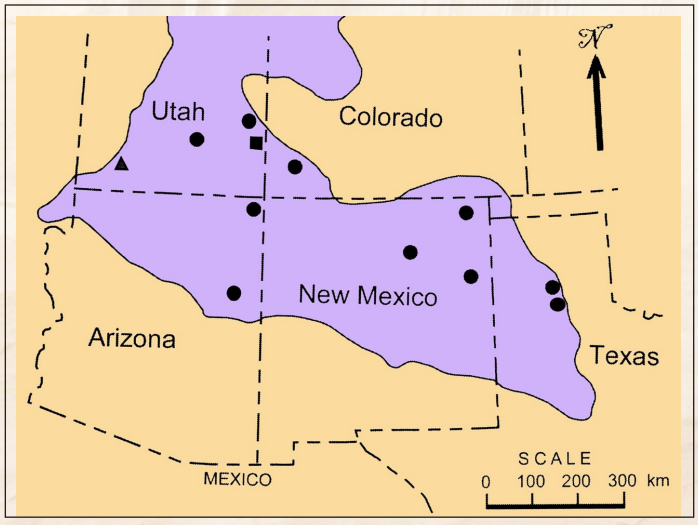

Figure 1. *Index map of American southwest showing the distribution of* Sanmiguelia *localities (solid circles) known before the current research began. The solid square in southeastern Utah represents Lisbon Valley and the solid triangle in southwestern Utah represents Zion National Park. The purple color shows the distribution of the Chinle Formation, and by inference the minimum size and location of the Chinle-Dockum basin. Adapted from Ash and Hasiotis (2013) and sources cited therein.*

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tant differences and it is apparent that *Sanmiguelia* is not closely related to the modern palms although it might be distantly related to the angiosperms, especially the monocotyledons.

The specimen of *Sanmiguelia* that was collected in Lisbon Valley has been deposited in the Natural History Museum of Utah in Salt Lake City (UMNH) and the specimen found in Zion Canyon has been deposited in the collection of Zion National Park, Utah.

STRATIGRAPHIC SETTING

In the far south of Utah the Moenave Formation, which contained the stem and attached leaves of the specimen of a *Sanmiguelia* plant that is described here, is a continental deposit that ranges from 71-118 meters in thickness in Zion National Park (Milner and others, 2012). It is divided into the Dinosaur Canyon Member at the base and the largely lacustrine Whitmore Point Member at the top (figure 2C, D). In Zion National Park the Dinosaur Canyon Member rests unconformably on the "undifferentiated" Petrified Forest Member of the Chinle Formation of Late Triassic age in most places according to Milner and others (2012). These authors also consider this unconformity to be the boundary between the Upper Triassic Chinle Formation and the Lower Jurassic Moenave Formation and it was designated the J-0 regional unconformity by Pipiringos and O'Sullivan (1978). The Dinosaur Canyon Member is made up predominantly of reddish-brown sandstones that represent fluvial and floodplain environments (Milner and others, 2012). DeBlieux and others (2006) reported plant remains from the upper part of the Dinosaur Canyon Member in the Kolob Canyon area of Zion National Park, which in terms of preservation resemble those from the upper Dinosaur Canyon Member at the St. George Dinosaur Discovery Site at Johnson Farm (SGDS) in nearby St. George (Tidwell and Ash, 2006), but none of this material has been formally identified (DeBlieux and others, 2006). The overlying Whitmore Point Member is a distinctive unit that contains reddish-brown sandstone and siltstone beds similar in appearance to the Dinosaur Canyon Member, but also contains reddish-purple to greenish-gray well laminated siltstone and shale beds and thin, dolomitic limestone beds that are sporadically stromatolitic (Biek and others 2003; Kirkland and Milner, 2006; Milner and others, 2012). The only plant megafossils positively identified from the Whitmore Point Member besides the *Sanmiguelia* plant that is described elsewhere in this article are *Equisetum* sp. and *Pagiophyllum* sp. described by Tidwell and Ash (2006) from the SGDS and elsewhere. The Whitmore Point Member was deposited in transgressive and regressive marginal lacustrine and floodplain environments that also include deeper water lacustrine facies although it is dominated by shoreline deposits, particularly at the SGDS (Kirkland and Milner, 2006).

The Chinle Formation in the Utah's far south was deposited during the Late Triassic by a major river system that occupied the vast Chinle-Dockum basin that extended westward to northwestward from western Texas to Utah at the time (Dickinson and Gehrrels, 2008) (figure 1). In Lisbon Valley, Utah, the formation was deposited some distance northeast of the mainstem of the river system, and as a consequence is only about 112-122 meters thick (Martz and others, this volume) compared to a thickness of as much as 500-600 meters in northeastern Arizona (Stewart and others, 1972). In the Lisbon Valley area the Chinle Formation rests unconformable on the Lower Permian Cutler Group and is unconformably overlain by the Upper Triassic-Lowerr Jurassic Wingate Sandstone (figures 2A and 2B). Here the formation is divided into the Kane Springs beds below and the Church Rock Member above. In this area the Chinle is considered to be late Norian to early Rhaetian in age (Martz and others, this volume). The Church Rock Member ranges in thickness from about 60-90 meters, with an overall average thickness of 80 meters and consists mostly of orange-red and reddish-brown siltstone, sandstone and conglomerate (Martz and others, this volume). It contains *Sanmiguelia* and a few other plant fossils including *Neocalamites, cf*. *Cynepteris*, *Pelourdea*, and *cf. Zamites* (Andrew Milner, affiliation personal communication date). The *Sanmiguelia* specimen described herein came from a distinct ledge-forming unit informally referred to as the "Red Ledge", which varies in thickness from 5.5-30.4 meters and is composed principally of reddish sandstones, with a local fossiliferous conglomerate interpreted as a braided-stream deposit (Martz and others, this volume).

DESCRIPTION AND AGE OF FOSSILS

Zion National Park Specimen

The fossil described here represents a large portion of the stem and attached leaves of a large *Sanmiguelia* plant, which is embedded in a cubical block of pinkish fine-grained sandstone that is about 17 centimeters thick in lateral-view (figure 3C) and about 33 centimeters x 41 centimeters in plan view (figure 3B). When found, the block was resting on a bench that had developed at the top of a steep northwest facing cliff in the Whitmore Point Member of the Moenave Formation of Early Jurassic age in Zion Canyon, Zion National Park, Utah (figure 2C). Judging by its lithology and color, the block had probably fallen from the side of the low ledgy cliff of regressive shoreline deposits at the top of the Moenave Formation and just below the Springdale Sandstone Member of the Kayenta Formation (Kirkland, personal communication). The site has been assigned locality number 42Ws294P in the Utah paleontological locality data base managed by the Utah Geological Survey.

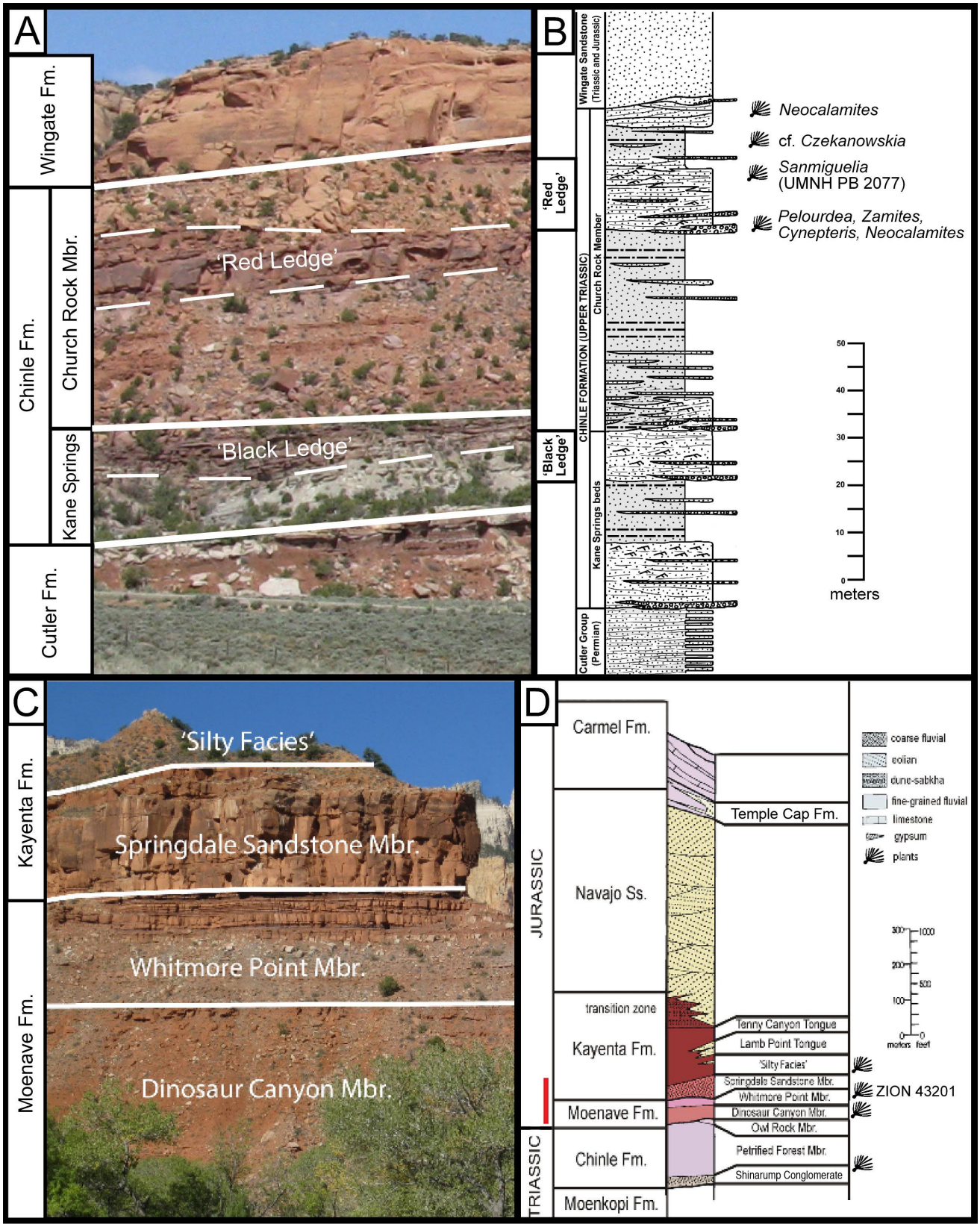

Figure 2. Sanmiguelia *stratigraphy in the far south of Utah. (A) Photograph of the stratigraphic section in Lisbon Valley, Utah area showing Chinle Formation and relevant subunits. (B) Matching composite stratigraphic section of the Upper Triassic Chinle Formation in the Lisbon Valley area. The approximate position of the* Sanmiguelia *leaf described here is shown together with other identifiable plant fossils found in the region. Note that the specimens mostly came from the "Red Ledge." Image courtesy Jeff Martz. (C) Photograph of the geologic section exposed on the eastern side of Zion Canyon in Zion National Park. The approximate positions of stratigraphic boundaries are indicated for the Moenave and Kayenta Formations. The* Sanmiguelia *fossil came from the ledgy beds in the uppermost part of the Whitmore Point Member. Photograph courtesy David Taralio. (D) A generalized stratigraphic section of the rock formations exposed in Zion National Park (after Kirkland and others, 2006). The red line indicates the approximate stratigraphic section shown in the photo in C. The location of significant and identifiable plant fossils found in the Chinle, Moenave (Dinosaur Canyon and Whitmore Point Members), and Kayenta Formations in southwestern Utah are shown.*

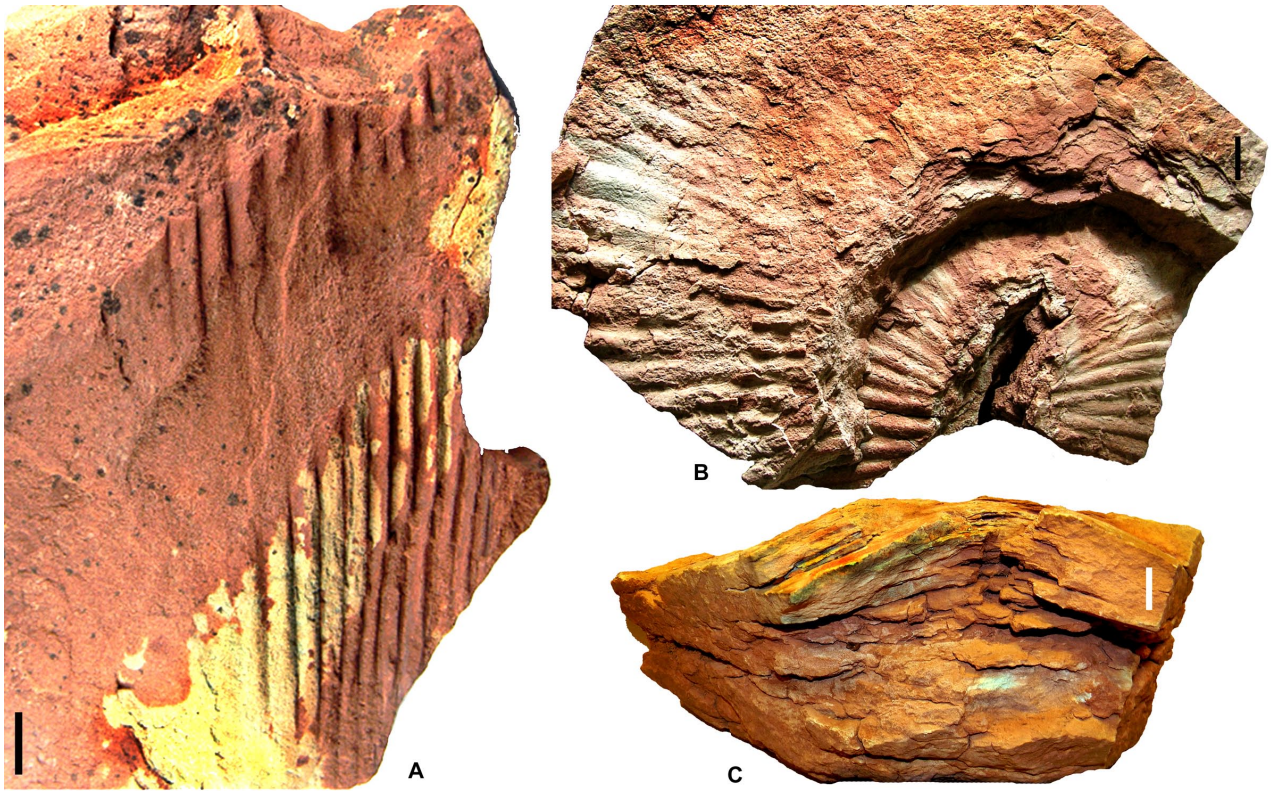

Figure 3. *(A) Fragment of a large leaf of* Sanmiguelia lewisii *from the Chinle Formation in Lisbon Valley, Utah. Courtesy of NHMU, UMNH PB 2077. Scale bar = 2 centimeters. (B) Top of block containing fragments of an in-situ specimen of a* Sanmiguelia lewisi *plant from the Whitmore Point Member of the Moenave Formation in Zion National Park, Utah. Portions of two whorls of leaves are exposed on the top of the block surrounding the plant axis which is represented by a narrow oval cavity in the lower right. Scale Bar = 5 millimeters. (C). View of the front of the block in Figure B showing edges of the two leaf whorls. Scale bar = 5 millimeters.*

The block was discovered in November 2012 by David Tarailo who was then a paleontological intern at Zion National Park. After the significance of the fossil was pointed out by James Kirkland and the senior author, the block was collected by David Sharrow, Hydrologist at the park on March 3, 2013 and placed in their collections where it has been assigned specimen number ZNP 43201.

The age of the Moenave Formation and the position of the Triassic-Jurassic boundary have not yet been settled after many years of work by geologists, stratigraphers, vertebrate and invertebrate paleontologists, palynologists, ichnologists, magnetostratigraphers, etc. It is beyond the scope of this article to review the various lines of evidence and their implications, but readers are directed to the recent summary by Milner and others (2012). Currently, however, there seems to be general agreement among most workers that the upper part of the Whitmore Point Member of the Moenave Formation including the interval where *Sanmiguelia* was found is Early Jurassic (Hettangian) in age. The strongest evidence supporting this conclusion is based on the palynomorphs obtained from the Whitmore Point Member of the Moenave Formation (Olsen and Galton 1977; Litwin, 1986). Illustrations of the palynoflora are given by Cornet and Waanders (2006). These authors agree that the palynoflora is dominated by the Early Jurassic palynomorph *Classopollis* spp. and lacks any taxa that are restricted to the Late Triassic.

The plant fossil is preserved perpendicular to the bedding in the block in growth position. The axis of the plant is represented by a laterally compressed perpendicular hole that extends downward for about 8 centimeters from the top of the block and disappears. The hole is about 1.2 centimeters x 1.8 centimeters and incompletely preserved because it is located toward the "front" side of the block and about one third of its vertical thickness and associated leaves have been lost to weathering prior to collection of the block. Several curving bedding planes that follow the *Sanmiguelia* leaves are visible in cross-section on the side of the block that may have been exposed on the cliff face before it fell.

The remains of the leaves of this specimen of the *Sanmiguelia* plant occur at about six levels but are best exposed on only two of the broad curving bedding planes that dip at about 20° from the horizontal on either side of the axis and at two superposed levels in the block. The layer of rock between these two fossil-bearing bedding planes is about 1.8 centimeters thick. The leaves radiate outward from the area of its axis on these bedding planes. Neither the bases nor apices of the leaves are present and their lateral margins are not clearly delimited except at one place because the leaves overlap each other near the stem where they are attached. The impressions on the lower level represent the basal regions of the leaves and only a few extend out as much as 11 centimeters from the stem region but

most are only about 6 centimeters long. The pleats of these leaves have a maximum width of about 1 centimeter and taper gradually toward the base. Impressions on the upper level represent a somewhat higher region in the leaves and once extended outward from the axis as far as an estimated 25 centimeters. On these leaves the pleats have a maximum width of about 2 centimeters and gradually taper toward the top of the leaves. The other levels only show a few square centimeters of individual leaves. There is no evidence of veins in any of the leaves in this fossil, as is typical of most *Sanmiguelia* leaves that have been discovered at other localities and probably indicates that the veins are quite narrow.

The general morphology and size of the leaves on this fossil and their arrangement around the stem matches that of the distinctive leaves that Brown attributed to *Sanmiguelia* (Brown, 1956, p. 206). In addition, the pleats on the leaves of the fossil described here are mostly convex upward and narrow toward the base (figure 3B) comparable to the leaves that Brown (1956) illustrated on plate 32, figure 2. Furthermore, the arrangement of the leaves around the stem in the new specimen of *Sanmiguelia* resembles the arrangement of the leaves in the whole plant that was described earlier by Tidwell and others (1977, plate 2, figures 3, 5) from one of Brown's localities in southwestern Colorado. Also, the basal contracting of the leaves is similar in figure 3B to that in some of the leaves illustrated by Tidwell and others (1977, plate 2, figure 6). There seems to be no question that this fossil should be referred to the only known species of *Sanmiguelia, S. lewisi* Brown (1956).

Lisbon Valley Specimen

This description is based on a single large, linear fragment of a *Sanmigulia* leaf preserved on a piece of sandstone float (figure 3A) discovered by the UMNH museum volunteer Julie Bergene on August 28, 2013, lying loosely on the surface on the eastern side of Redd Ridge (local name), in the Lisbon Valley region. This locality has been assigned the number 42Sa902P in the records of the Utah Geological Survey. The slab is composed of reddish-brown, fine-grained sandstone, which may have come out of the upper part of Red Ledge (figure 2A), or possibly one of the several thin sandstone beds in the slope immediately above the Red Ledge. Either way, the specimen undoubtedly originated from the upper part of the Church Rock Member of the Chinle Formation because that unit is composed dominantly of reddish-brown sandstone. The presence of derived pseudopalatine phytosaurs, particularly "*Redondasaurus*" (=*Machaeroprosopus sensu* Hungerbühler and others, 2013), and the aetosaur *Typothorax* which is found throughout the Church Rock Member, indicates that this specimen of *Sanmiguelia* is from the Apachean biozone (Martz and others, this volume), and is Rhaetian in age (between 208-201.5 Ma).

The leaf fragment of *Sanmiguelia* found on Redd Ridge is about 15 centimeters wide x 24 centimeters long and shows the remains of at least 13 linear, mostly rounded pleats which are typical of this taxon (figure 3A). Most of the pleats on the fragment narrow proximally from a maximum width of about 1 centimeters near the top of the fossil to about 0.5 centimeters on the lower right side of the fossil. There is no evidence of veins on this specimen because they are quite narrow and the fossil is poorly preserved. Although this specimen is incomplete, enough is preserved to show that it closely compares in morphology with those in one of the type specimens illustrated by Brown (1956, plate 32, figure 2) as well as some of the specimens collected from one of Brown's localities by Tidwell and others (1977, plate 2, figures 4-6). Also, the leaf fragment compares with the isolated leaf fragments described from the Upper Triassic of Utah (Ash 1982, text-figure2B) and Arizona (Ash and Hasiotis, 2013, figures 5B, 5E). In the absence of more data the fossil probably should be referred to the only known species of *Sanmiguelia, S. lewisi* Brown, 1956. The fossil has been assigned the number UMNH PB2077 in the records of the Natural History Museum of Utah.

DISCUSSION

It is evident from the stratigraphic location of the *Sanmiguelia* fossil that was described here from the Whitmore Point Member of the Moenave Formation and the eleven other *Sanmiguelia* localities known in the American Southwest (Ash and Hasiotis, 2013) that the stratigraphic range of *Sanmiguelia* extends from near the base of the Norian Stage of the Upper Triassic into the Hettangian Stage of the Lower Jurassic, a range of a little less than 20 Ma. Also, it demonstrates that the geographic range of the genus extends from western Texas into southwestern Utah. Such a widespread distribution of *Sanmiguelia* indicates that it was a characteristic member of the Chinle flora when all the members of the Chinle, except for the lowest members and their lateral equivalent units were being deposited. The whole plants that have been found in growth position such as the specimen described here from Zion National Park, indicate that the plants grew along river and lake margins. At all of the other localities, such as the one described here from Lisbon Valley, the plant is only represented by isolated fragmentary and tattered leaves preserved in fluvial deposits.

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specimen of the *Sanmiguelia* plant that was found there. We also extend our thanks to Brian Axsmith (Mobile, Alabama) and James Kirkland (Salt Lake City, Utah) for their constructive reviews of this article.

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