Implications of the stratigraphic results of the Colorado Plateau Coring Project (CPCP): salt vs. plate tectonics vs. eustasy in the Late Triassic Chinle Formation

Olsen, P.E.
Parker, W., Kürschner, W., Huber, P., Geissman, J.
Implications of the stratigraphic results of the Colorado Plateau Coring Project (CPCP): salt vs. plate tectonics vs. eustasy in the Late Triassic Chinle Formation

Olsen, P.E.¹, Parker, W.², Kürschner, W.³, Huber, P.⁴, Geissman, J.⁵

1 LDEO of Columbia University, Palisades, NY, 10968 USA. polsen@ldeo.columbia.edu; 2 Petrified Forest National Park, Petrified Forest, AZ, 86028 USA; 3 University of Oslo, 0316 Oslo, Norway; 4 Geoscience Books, PO Box 1036, Faribault, MN 55021 USA; 5 University of Texas at Dallas, Richardson, TX, 75080 USA.

Understanding of the basic tectonic framework for the deposition of the highly fossiliferous continental Chinle Formation (Fm) of the western US is poorly understood; it is far from clear if the setting was a back arc basin [1], a passive margin [c.f., 2], or something else. In addition, the role of eustasy in driving basin-wide sequences, unconformities, and hiatuses [e.g., 3] is contentious. Analysis of cores from Phase 1 of the CPCP in Petrified Forest National Park, AZ, USA (PFNP) integrated with new field studies suggest that the major control was halokinesis of Paleozoic salt, not tectonics or eustasy. Core 1A spans 520 m of the lower Owl Rock Member of the Chinle Fm to the formation base (L Triassic), as well as all of the Moenkopi Fm (E-M Triassic), with TD in the Permian. While the overall stratigraphy of the major units encountered in the core correspond well to those based on local outcrops [e.g., 4], a major facies complex present in southern part of the PFNP, which we call the “Monitor Butte facies” (MBF) is completely lacking, along with its associated palynologically- and macro-plant-productive levels. Our field studies suggest that MBF is associated with very rapid deposition in localized basins associated with syndepositional tilting and well-developed to profound local, angular unconformities, and extreme development of multi-colored mottled strata (MS), all related to basins produced by salt withdrawal. Halokinesis-related unconformities and basins are well documented in the Chinle Fm in Utah [5] overlying the Paleozoic Paradox Basin, and we argue such features are widespread. In the Fort Wingate NM, USA area, steeply dipping to vertical Chinle strata with recumbent-folded MBF with a major plant locality [USGS 10060: 6] are overlain by a profound angular unconformity by virtually flat, black, lacustrine strata of the “Ciniza Lake Beds” (CLB) [7]. Adjacent undeformed facies include very thick MS. The overlying CLB are consistent with a slightly later and longer wavelength overlying sag. Both facies and geometry are similar to the salt withdrawal basins of Utah [5]. Such features are present not only elsewhere in New Mexico and Arizona, but also in the Dockum Group of Texas (with important plant localities [e.g., 8]), and fossil-fish-bearing lacustrine strata at Lisbon Valley, UT and Dolores Canyon, CO [9] may be in CLB-type sags. Lateral restriction of MBF as seen PFNP and core 1A, at Fort Wingate, as well as the unconformities and lacustrine strata reported elsewhere were not proximally a result of plate tectonic or eustatic processes but rather salt tectonics, which may be the most important control on local facies development other than climatic context for these Triassic strata in the western US. Phase 1 of the CPCP is funded by NSF (SG&P/IF), and ICDP. This is a contribution to UNESCO-IUGS IGCP Project 632.

Basic concept is that the Triassic and possibly Jurassic continental sequences of the Western United States are basically a passive margin sequence in which both reported tectonic and eustatic elements are actually due to underlying Paleozoic salt tectonics.
2. What we were thinking we would get.
3. What we got.
4. Missing “Monitor Butte” facies
5. Lacustrine facies of Paradox Basin salt tectonics
6. Supposed sequence eustatic sequence boundaries in Chinle are salt related unconformities
7. Is there any tectonics or eustacy effects in the Western US Triassic?
Sonsela and Blue Mesa members of the Chinle Formation
Revuelttian
Adamanian

Parker and Martz, 11
Revueltian
Adamanian
Sphenopteris

Ash, 1999
Litwin et al., 1991
CPCP: Phase I, Petrified Forest Core

\[ ^{206}\text{Pb}/^{238}\text{U} \]

209.926 ± 0.072 Ma

Black Forest Bed

Chinde Point, Petrified Forest National Park
Site 1 - Chinde Point
Site 2 – West “Bone Yard”
Owl Rock Mb.
Cores
Recumbant fold in Montior Butte facies - Rt. 400 near Fort Wingate. NM
Profound unconformity within Chinle with overlying Ciniza Lake Bed
Profound unconformity within Chinle with overlying Ciniza Lake Bed
Matthews et al., 2007
MaWhews et al., 2007

- Axial drainage of major fluvial-channel belts (fluvial-channel-fill sandstone fairways)
- Transverse drainage of fluvial tributaries (reworking of sediment from salt-wall flanks)
- Paleosols developed on persistent topographic highs flanking salt walls and above inflating segments of salt pillows
- Localized depocenter above deflating segment of salt pillow
- Along-axis salt movement within salt pillow
- Slumping of material downslopes flanking salt walls and pillows
- Salt walls located over basement faults
- Growth of salt wall by passive diapirism
- Localized depocenters in rim synclines and minibasins maintained by salt withdrawal

Matthews et al., 2007
BANHAM & MOUNTNEY, 2013
MaWhews et al., 2007
Hazel, 1994
Standard model of back arc basin does not resemble Chinle basin.
During Chinle time there may have had a western-dipping subduction zone.

The western subduction occurred later.

Sigloch & Mihalynuk, 2013
Matthews et al., 2007 after Blakey and Gubitosa, 1984 and Hazel, 1994;
Thanks to: