

The Cretaceous of Shandong Province

Yongqing Liu^{1*}, Hongwei Kuang¹, Kemin Xu², Zhenguo Ning², Nan Peng¹, Shengxian Du³, Jun Chen³

¹Geology Institute, Chinese Academy of Geological Sciences, Beijing, China

²Shandong Institute of Geological Survey, Shandong, China

³Shandong Institute of Geological Sciences, Shandong, China

Email: *liuyongqing@cags.ac.cn

How to cite this paper: Liu, Y.Q., Kuang, H.W., Xu, K.M., Ning, Z.G., Peng, N., Du, S.X. and Chen, J. (2019) The Cretaceous of Shandong Province. *Open Journal of Geology*, 9, 646-649.

<https://doi.org/10.4236/ojg.2019.910064>

Received: August 16, 2019

Accepted: September 21, 2019

Published: September 24, 2019

Copyright © 2019 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

A well preserved terrestrial Cretaceous succession outcrops in Shandong Province. Although previous studies have conducted much work on the geochronology, subdivision of stratigraphic units, regional correlation and paleontology, high controversies remain about geochronology, subdivision of stratigraphic units and sedimentology. Here, we report a synthesized study of the Cretaceous successions and stratigraphy in Shandong based on the new results. Accordingly, reconstruction of framework of the Cretaceous stratigraphy in Shandong is summarized as, in descending order, the Mengyin Group of the Jurassic/Cretaceous transition, the Lower Cretaceous Laiyang Group, Qingshan Group, Dasheng Group and the Upper Cretaceous Wangshi Group.

Keywords

Terrestrial, Cretaceous, Shandong Province, China

Terrestrial Cretaceous in Shandong Province is, in ascending order, the Mengyin Group of the Jurassic/Cretaceous transition, the Lower Cretaceous Laiyang, Qingshan, Dasheng groups and the Upper Cretaceous Wangshi Group. The Mengyin Group consists of the lower Santai Fm and the upper Fenshuiling Fm. The former is mainly eolian deposits of the purple red sandstone with giant inclined beddings and interbedded interdune fluvial conglomerates [1], which yields the youngest detrital zircons of 164 - 146 Ma [2], suggesting its age of the earliest Cretaceous. The Fenshuiling Fm is chiefly composed of calcareous siltstone with intercalations of tuffs or tuffaceous siltstones and sandstones. Sauro-poda dinosaur tracks are present within the Santai Fm [3] and particularly both skeleton fossils and foot prints of *Euhelopus zdanski* [4] are well preserved in the Fenshuiling Fm. The Lower Cretaceous Laiyang Group, being estimated of an

age interval of 132 - 124 Ma dated by interbedded tuffs and volcanics, is composed of the fluvial conglomerates on the bottom with an unconformity separating the underlying Precambrian basement, the middle lacustrine siltstone and shale, indicating vast lacustrine expanding and fluvial sandstones and conglomerates in the top, implying the evolution end of lacustrine basin of the Laiyang Group age. A spectacularly soft sediment deformation occurred within the middle Laiyang Group in Lingshan island, Qingdao. It is very important yet that vertebrate tracks including dinosaur, bird, turtle and pterosaur and invertebrate traces are very common in the middle-upper Laiyang Group [1] [5] [6] except for plenty of fish and insect fossils in lacustrine sediments of the Shuinan Fm in the middle Laiyang Group. One of the quarries of the middle-upper Laiyang Group displays spectacular dinosaur tracks, including tens of giant Sauropoda tracks and thousands of Theropoda foot prints and tracks [7] [8], indicating a favorable palaeoecology environment at that time. The Qingshan Group with an age interval of 124 - 118 Ma is located between the underlying Laiyang Group and the overlying Dasheng Group and a series of intermediate and acid volcanic interbedded fluvial sediments formed in rift basins. The Dasheng Group with the oldest age of 118 Ma and the youngest age estimated as 99.5 Ma is the terminal units of the Lower Cretaceous and dominantly calcareous mudstone and the fluvial sandstones and conglomerates in the bottom. There are a lot of sedimentary structures formed in arid, hot and shallow lacustrine environment as ripples, cracks, salt and gypsum pseudocasts in the Dasheng Group. In addition, a lot of vertebrate tracks of giant Sauropoda and Theropoda, particularly well-preserved bird footprints are widely and well preserved in lacustrine sediments of the Dasheng Group [3] [5] [9]. The Wangshi Group consists of the lower Hongtuya Fm of the Upper Cretaceous and the upper Jiaozhou Fm of a K/T transition age. The former consists mainly of purple red and cyclic deposits of fluvial sandstone and conglomerates, indicating a warmer and arid palaeoclimate environment. The Jiaozhou Fm consists chiefly of gray-green fluvial and shallow lacustrine deposits implying a reduced arid and hot setting. A diabase sill of (Ar-Ar) 73.2 Ma age [10] separates the lower and middle of the Hongtuya Fm. In addition the Jiaozhou Fm shows signs of the potential K/T boundary in term of positive gamma anomaly [11] and possible impact glass balls (Master dissertation, Ding Chong, 2016), there are at least three horizons of mass death of dinosaurs on the bottom of the Hongtuya Fm, e.g., one of the quarries of dinosaur fossils in Zhucheng displays ten thousands of dinosaur bone fossils in the bottom bonebed [1]. In the meantime, five horizons with mass burials of both dinosaur bones and egg fossils were present within the upper Hongtuya Fm [12], which records a co-evolution between dinosaur extinction and environmental change. In perspective of palaeoclimate, all palynological assemblages within the Cretaceous successions show that palaeoclimate changed periodically from hot and arid to subarid and semihumid in tropical to subtropical zones. But an extreme drought and hot palaeoclimate in the Late

Cretaceous supposed by palynological assemblages may be responsible for the extinction event on the K/T boundary [13].

Acknowledgements

This research is supported by the National Natural Science Foundation of China (41688103, 41672111, 41272021, 41372109), China Geology Survey (DD20190005), the National Key Research and Development Program of China (2018YFC0604201). This is a contribution to UNESCO-IUGS IGCP Project 679.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Liu, Y.Q., Kuang H.W., Ji, S.A., Lv, J.C., Liu, Y.X., Jiang, X.J., Peng, N., Chen, M.P. and Li, J.H. (2009) The Biotic and Environmental Response to the Geological Event on the Earth during the Late Mesozoic. *Earth Science Frontiers*, **16**, 37-47.
- [2] Yang, D.B., Xu, W.L., Xu, Y.G., Pei, F.P. and Wang, F. (2013) Provenance of Sediments from Mesozoic Basins in Western Shandong: Implications for the Evolution of the Eastern North China Block. *Journal of Asian Earth Sciences*, **76**, 12-29. <https://doi.org/10.1016/j.jseae.2013.07.027>
- [3] Li, R.H., Liu, M.W. and Matsukawa, M. (2002) Discovery of Fossilized Tracks of Jurassic Dinosaur in Shandong. *Geological Bulletin of China*, **21**, 596-597. (In Chinese)
- [4] Wilson, J.A. and Upchurch, P. (2009) Redescription and Reassessment of the Phylogenetic Affinities of *Euhelopus zdanskyi* (Dinosauria: Sauropoda) from the Early Cretaceous of China. *Journal of Systematic Palaeontology*, **7**, 199-239. <https://doi.org/10.1017/S1477201908002691>
- [5] Kuang, H.W., Liu, Y.Q., Wu, Q.Z., Cheng, G.S., Xu, K.M., Liu, H., Peng, N., Xu, H., Chen, J., Wang, B.H., Xu, J.L., Wang, M.W. and Zhang, P. (2013) Dinosaur Track Sites and Palaeogeography of the Late Early Cretaceous in Shuhe Rifting Zone of Shandong Province. *Journal of Palaeogeography*, **15**, 435-453.
- [6] Xing, L.D., Marty, D., Wang, K.B., Lockley, M.G., Chen, S.Q., Xu, X., Liu, Y.Q., Kuang, H.W., Zhang, J.P., Ran, H. and Persons, V.W.S. (2015) An Unusual Sauropod Turning Trackway from the Early Cretaceous of Shandong Province, China. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **437**, 74-84. <https://doi.org/10.1016/j.palaeo.2015.07.036>
- [7] Xu, H., Liu, Y.Q., Kuang, H.W., Wang, K.B., Chen, S.Q., Zhang, Y.X., Peng, N., Chen, J., Wang, M.W. and Wang, B.H. (2013) Middle Early Cretaceous Super-Large Scale Dinosaur Tracks in Zhucheng Area, Shandong Province, and Their Palaeogeography and Palaeoecology. *Journal of Palaeogeography*, **15**, 467-488. (In Chinese)
- [8] Lockley, M.J., Li, R.H., Matsukawa, M., Xing, L.D., Li, J.J., Liu, M.W. and Xu, X. (2015) Tracking the Yellow Dragon: Implications of China's Largest Dinosaur Tracksite (Cretaceous of the Zhucheng Area, Shandong Province, China). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **423**, 62-79. <https://doi.org/10.1016/j.palaeo.2015.01.028>

- [9] Li, R.H., Lockley, M.G., Matsukawa, M. and Liu, M.W. (2015) Important Dinosaur-Dominated Footprint Assemblages from the Lower Cretaceous Tianjialou Formation at the Houzuoshan Dinosaur Park, Junan County, Shandong Province, China. *Cretaceous Research*, **52**, 83-100. <https://doi.org/10.1016/j.cretres.2014.08.004>
- [10] Qin, H.F., Pan, Y.X., He, H.Y., Yang, L.K. and Zhu, R.K. (2016) Paleomagnetism of Early Cretaceous Volcanic Rocks at Huangya Section in Jiaodong Peninsula and Implications for Tectonics. *Acta Petrologica Sinica*, **32**, 3205-3213.
- [11] Xu, K.M., Kuang, H.W., Qin, J., Wang, Y.P., Peng, N., Ning, Z.G., Zhang, F.Z. and Liu, Y.Q. (2017) New Discovery of Terrestrial K-Pg Boundary from Jiaolai Basin of Shandong Province. *Geology in China*, **44**, 94-195.
- [12] Wang, X.L., Wang, Q., Jiang, S.X., Cheng, X., Zhang, J.L., Zhao, Z.K. and Jiang, Y.G. (2012) Dinosaur Egg Faunas of the Upper Cretaceous Terrestrial Red Beds of China and Their Stratigraphical Significance. *Journal of Stratigraphy*, **36**, 401-416.
- [13] Kuang, H.W., Liu, Y.Q., Dong, C., Peng, N., Wang, B.H., Zhang, P., Wang, K.B., Chen, S.Q. and Zhang, Y.X. (2014) Research on Taphonomy of Late Cretaceous Dinosaurs in Zhucheng, Eastern Shandong, China. *Acta Geologica Sinica*, **88**, 1353-1371. <https://doi.org/10.1111/1755-6724.12269> 19