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A new amber outcrop from the Lower Cretaceous of northeastern China

DANY AZAR[1], SIBELLE MAKSOUD[1, 2], CHENYANG CAI[3, 4] & DIYING HUANG[2*]

[1] *Lebanese University, Faculty of Sciences II, Department of Natural Sciences, P.O. Box: 26110217, Fanar–Matn, Lebanon.*
[2] *State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, and Center for Excellence in Life and Paleoenvironment, Chinese Academy of Sciences, Nanjing, Jiangsu 210008, China.*
[3] *CAS Key Laboratory of Economic Stratigraphy and Palaeogeography, Nanjing Institute of Geology and Palaeontology, and Centre for Excellence in Life and Paleoenvironment Chinese Academy of Sciences, Nanjing 210008, China.*
[4] *School of Earth Sciences, University of Bristol, Life Sciences Building, Tyndall Avenue, Bristol, BS8 1TQ, United Kingdom.*
** Corresponding author. E-mail: dyhuang@nigpas.ac.cn*

The amber is a fossilized vegetal resin ranging from a few millions to more than 300 million years (mid-Carboniferous) in age (Sargent Bray & Anderson, 2009). It constitutes a superb material for the conservation of biological inclusions in their minute three-dimensional details (Poinar, 2003).

Amber has been known from China for about 2000 years and are produced from different regions and geological ages such as Fushun of Liaoning (Eocene), Xixia of Henan (Late Cretaceous), Zhangpu of Fujian (Miocene), Lunpola of Tibet (Oligocene-Miocene) (Hong, 2002; Shi *et al*., 2014; Wang *et al*., 2018). Modern amber inclusion study originated in the 1970s and 1980s in studying the Fushun amber deposits (*e.g*., Hong *et al*., 1974; Hong, 1981). The study of the Fushun amber by Chinese pioneer of palaeoentomology, Prof. You-Chong Hong, culminated in his major contribution to the study of Chinese amber (*e.g*., Hong, 2002).

In recent years, amber from the West Opencast Coalmine situated in the south of Fushun City in the Liaoning Province in Northeast of China raised new attention (Wang *et al*., 2014; Azar *et al*., 2018). After the 6th International Congress on Fossil Insects, Arthropods and Amber that took place in Byblos (Lebanon) in 2013, scientific interest on amber and its inclusions has grown significantly in China. Consequently, Chinese institutions (especially the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences) have acquired huge collections of amber inclusions from northern Myanmar, and has become a major destination for study for most of international palaeoentomologists.

We report herein the discovery of a new Cretaceous amber deposit from the Lingquan Coal Mine at Zhalainuoer (Jalainur) in the Inner Mongolia Autonomous Region (Northeast of People's Republic of China). As of this writing, only a single amber piece of millimetric size has been found and this amber is located in layers belonging to the Damoguaihe Formation. The amber from this outcrop is characterized then analyzed using Fourier Transform Infrared (FT-IR) spectroscopy.

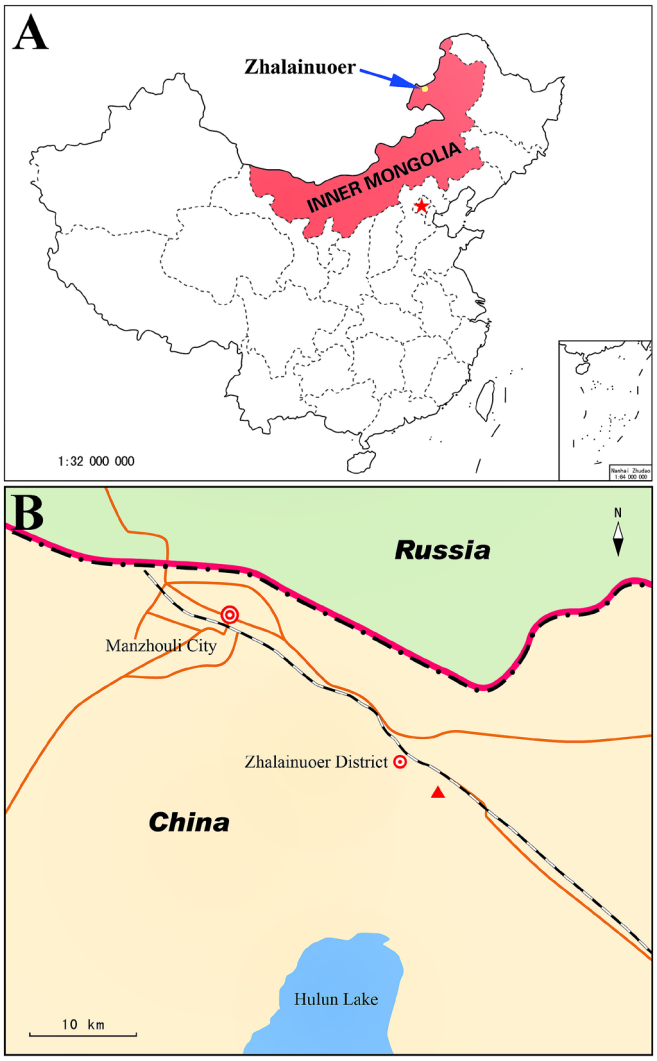

FIGURE 1. Map of amber locality. **A**, Map of China showing the locality of Zhalainuoer (Inner Mongolia, China). **B**, The detailed locality.

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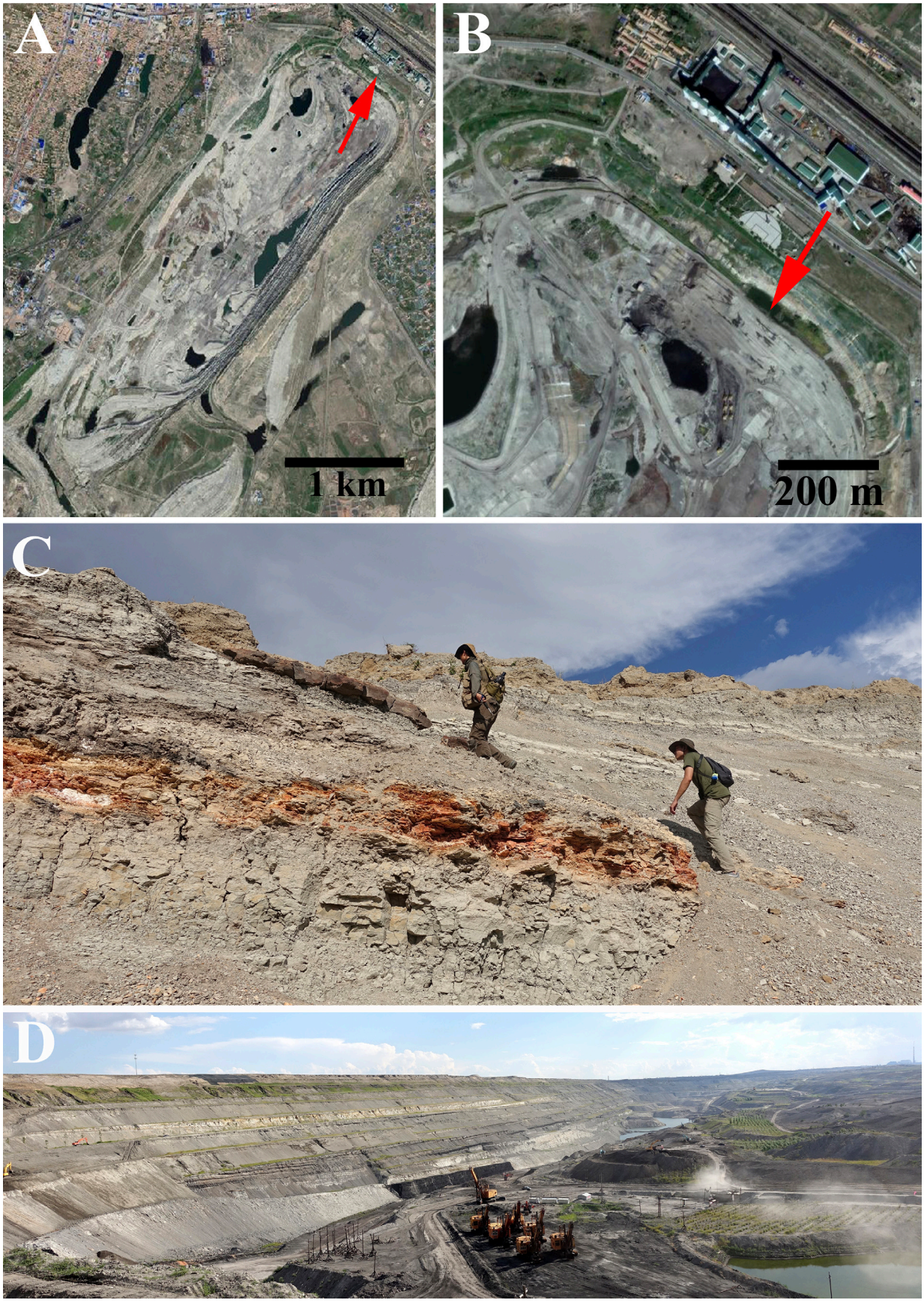

FIGURE 2. Lingquan Coal Mine at Zhalainuoer. **A**, Aerial photography of Lingquan Coal Mine; the arrow indicates the locality where the amber was found. **B**, A close up aerial photography of the site; the arrow indicates the locality where the amber was found. **C**, The outcrop of the amber locality. **D**, The overview of the coal mine.

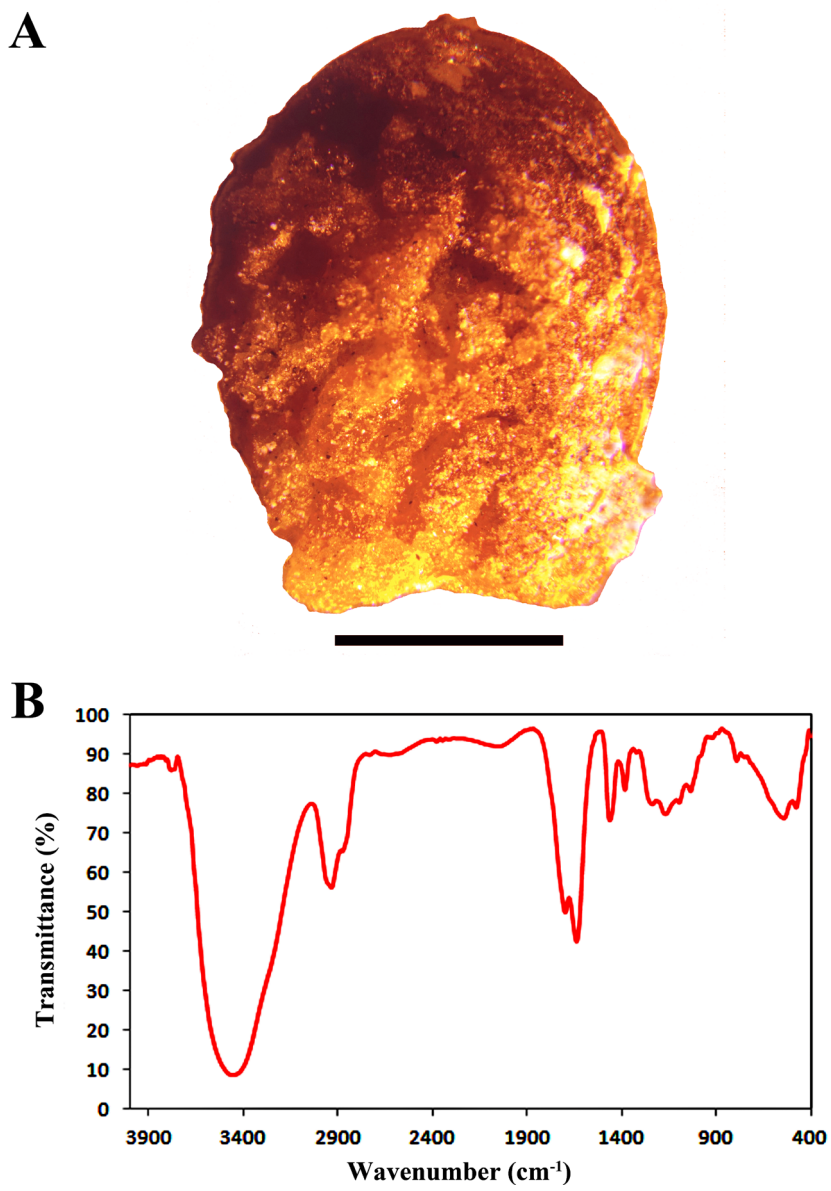

FIGURE 3. Amber of Lingquan Coal Mine. **A**, The amber piece; scale bar = 1 mm. **B**, FT-IR spectrum.

Geological settings

A few years ago, our colleague Dr. Yaqiong Wang (NIGPAS) provided us a significant information that she had found a few small amber grains from the Lingquan Coal Mine of Zhalainuoer but they did not collect them. During our field trip on 29 July 2017, a small piece of amber was discovered in the lower section of Lingquan Coal Mine of Zhalainuoer (Jalainur) District of Hulunbeier (Hulunbuir) City (49°26′53″N, 117°44′26″E) (Figs. 1 and 2), Inner Mongolia, northeastern China. The locality is close to Manzhouli (Manchuria) City and about 10 km from the boundary with Russia. Amber from this site is translucent to opaque with shades of colour ranging from pale yellow to dark orange (Fig. 3A).

The amber has been yielded from the Damoguaihe Group that is divided into a lower part named the Damoguaihe Formation and an upper part named the Yimin Formation. The Lingquan Coal Mine mainly produce coal from the Yimin Formation, but the amber came from the Damoguaihe Formation. The Damoguaihe Formation is a set of clastic rock deposits with a few layers of coal or shed coal that are comprised of conglomerate, glutenite, sandstone, siltstone, mudstone, and tuff. The Yimin Formation is a coal-bearing deposit that successively overlies Damoguaihe Formation. Sometimes a set of basalt occurs in between the above stratum and is named the Ganhe Formation (Inner Mongolia Autonomous Regional Bureau of Geology and Mineral Resources, 1996).

The age of the Damoguaihe Formation is attributed to the Early Cretaceous based on the contained animal fossils probably indicating a correspondence to the late assemblage of the Jehol biota (*i.e.*, Barremian to early Aptian) such as the bivalves *Sphaerium* sp., the ostracods

Cypridae spp., the conchostracans *Eosestheria* sp. and *Liograpta* sp. and the plant fossils more like the assemblage of the Fuxin flora (*i.e*., Aptian) (Inner Mongolia Autonomous Regional Bureau of Geology and Mineral Resources, 1996). By some studying of palynological assemblages the age of the Damoguaihe Formation was attributed to Valanginian-Barremian (Pu & Wu, 1985; Cheng & Shang, 2015). More authors believe that the age of the Zhalainuoer Group should be attributed to middle-late Early Cretaceous (*e.g*., Wu *et al*., 2006). Recent study of ostracods indicates the age of the Damoguaihe Formation is mainly Aptian (Wang *et al*., 2012). Some authors even believe the age of the underlying Nantun Formation is Aptian-Albian (Han *et al*., 2019). Isotopic dating (U-Pb La-ICP-MS) indicates the age of the overlying Ganhe Formation to be nearly 114.3 Ma as the latest Aptian (Zhang *et al*., 2017). Therefore, we agree the age of the Damoguaihe Formation would be Barremian-Aptian (mainly Aptian) and the Yimin Formation would be Albian. The present discovered amber grain collected from the middle-upper part of the Damoguaihe Formation thus would be Aptian.

FT-IR analysis

A Fourier Transform Infrared (FT-IR) spectroscopy spectrum was obtained from the new amber material in order to retain its chemical signature, even if though is known today that such analysis is of very limited importance as most amber FT-IR spectra are more or less similar without providing accurate data for resolving the amber botanical origin of the fossil resin (Azar *et al*., 2010).

For the infrared analysis, less than 0.2 mg of amber was crushed and mixed with potassium bromide (KBr) (FT-IR grade; Merck, Darmstadt, Germany) and pellets were prepared using a manual press. Transmission FT-IR spectroscopy was performed with a Bruker IFS 55 spectrophotometer. The spectrum was acquired between 4000 and 400 cm^{-1} with 40 scans collected at 4 cm^{-1} resolution. The obtained spectrum of the amber from is given in Fig. 3B.

The obtained spectrum could be divided into two areas: transmittance bands between 3700–1350 cm^{-1} are almost shared by all types of amber; transmittance bands between 1350–400 cm^{-1} are considered to be the fingerprint area. Transmittance strong and broad peak at the wavelength 3452 cm^{-1} corresponds to O-H stretching in alcohol and/or carboxylic acid. Transmittance peak at the wavelength 2932 cm^{-1} corresponds to C-H stretching in CH, CH_2 and CH_3. Transmittance peak at the wavelength 1696 cm^{-1} corresponds to C=O stretching in carboxylic acids. Transmittance peak at the wavelength 1460 cm^{-1} corresponds to C-H bending in CH_2 and CH_3 of alkyl groupings. Transmittance peak at the wavelength 1380 cm^{-1} corresponds to C-H bending in CH_3 of alkyl groupings. Transmittance peak at the wavelengths 1166 cm^{-1} corresponds to C-O stretching in carboxylic acids and esters. All the functional groups detected indicate the large dominance of the aliphatic chains in the chemical constitution of the studied amber. It is noteworthy to state that infrared analyses have long been used in amber characterization; however, used only by itself, they cannot be necessarily precise in correctly ascertaining the botanical origin of the amber.

Conclusion

The Damoguaihe Coal Series are widely distributed in western of Daxinganling area (Inner Mongolia and Heilongjiang Province) that have been previously considered as Jurassic strata. From the above analysis, the Damoguaihe coal mine would be contained in the Aptian-Albian deposit like the Fuxin coal mine in Liaoning Province (*i.e*., the Damoguaihe Formation correlates to the Shahai Formation and the Yimin Formation correlate to the Fuxin Formation). Therefore, the amber discovered from the Damoguaihe Formation has potential important significance as its age would fill the gap of the several famous amber deposits, for example the Lebanese amber (Barremian) and the Late Albian-Cenomanian ambers from Spain, France, and Myanmar. Because of the wide distribution of the Damoguaihe Coal Series, the output of ambers should not be poor.

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References

Azar, D., Gèze, R. & Acra, F. (2010) Chapter 14: Lebanese amber. *In*: Penney. D. (Ed.) *Biodiversity of fossils in amber from the major world deposits*. Siri Scientific Press, Manchester, pp. 271–298.

Azar, D., Maksoud, S., Nammour, C., Nel, A. & Wang, B. (2018) A new trogiid genus from lower Eocene Fushun amber (Insecta: Psocodea: Trogiomorpha). *Geobios*, 51, 101–106. https://doi.org/10.1016/j.geobios.2018.02.002

Cheng, J.H., & Shang, Y.K., (2015) Early Cretaceous palynological assemblage sequence and palaeoclimate research in Zhalainuoer Coalmine, Manzhouli, Inner Mongolia. *Acta Geologica Sinica*, 54, 3, 316–341.

Han, G., Cao, Y., Zhang, W.J., Wang, J.Y., Xue, Y.F. & Bao, L. (2019) Stratigraphy and sporopollen assemblages of well Bei 32 from the Nantun Formation in the Hailar Basin, Inner Mongolia. *Geological Bulletin of China*, 38 (6), 916–921. [In Chinese].

Hong, Y.C. (1981) *Eocene fossil Diptera insecta in amber of Fushun Coalfield*. Geological Publishing House, Beijing. vi+166 pp. [In Chinese].

Hong, Y.C. (2002). *Amber insects of China*. Beijing Science and Technology Press, Beijing. 653 pp. [in Chinese].

Hong, Y.C., Yang, T.C., Wang, S.T., Wang, S.E., Li, Y.K., Sun, M.R., Sun, H.C., & Tu, N.C. (1974). Stratigraphy and Palaeontology of Fushun coal-field, Liaoning Province. *Acta Geologica Sinica*, 2, 113–149.

Inner Mongolia Autonomous Regional Bureau of Geology and Mineral Resources. (1996) *Lithologic stratigraphy of Inner Mongolia Autonomous Region.* China University of Geosciences Press, Beijing. 344 pp. [In Chinese].

Poinar, G.O. Jr (2003) Amber. *In:* Resh, V.H. & Cardé, R.T. (Eds.), *Encyclopedia of insects*, Academic Press, [Amsterdam], pp. 9–12.

Pu, R.G. & Wu, H.Z. (1985) The palynological assemblages of the Xinganling and Zhalainuoer in Xinganling region, northeastern China and their stratigraphical significance. *Bulletin of the Shenyang Institute of Geology and Mineral Resources*, *Chinese Academy of Geological Sciences*, 11, 47–113. [In Chinese with English Summary].

Sargent Bray, P. & Anderson. K.B. (2009) Identification of Carboniferous (320 Million Years Old) Classic Amber. *Science*, 326,132–134. https://doi.org/10.1126/science.1177539

Shi, G.L., Dutta, S., Paul, S., Wang, B. & Jacques, F.M.B. (2014) Terpenoid compositions and botanical origins of Late Cretaceous and Miocene amber from China. *PLoS ONE*, 9 (10), e111303. https://doi.org/10.1371/journal.pone.0111303

Wang, B., Rust, J., Engel, M.S., Szwedo, J., Dutta, S, Nel, A., Fan, Y., Meng, F.W., Shi, G.L., Jarzembowski, E., Wappler, T., Stebner, F, Fang, Y., Mao, L.M., Zheng, D.R. & Zhang, H.C. (2014) A Diverse paleobiota in Early Eocene Fushun amber from China. *Current Biology*, 24, 1606–1610. https://doi.org/10.1016/j.cub.2014.05.048

Wang, H, Dutta, S., Kelly, R.S., Rudra, A., Li, S., Zhang, Q.Q., Zhang, Q.Q., Wu, Y.X., Cao, M.Z., Wang B., Li, J.G. & Zhang, H.C. (2018) Amber fossils reveal the Early Cenozoic dipterocarp rainforest in central Tibet. *Palaeoworld*, 27 (4), 506–513. https://doi.org/10.1016/j.palwor.2018.09.006

Wang, Y.Q., Sha, J.G., Pan, Y.H., Zhang, X.L. & Rao, X. 2012. Non-marine Cretaceous ostracod assemblages in China: a preliminary review. *Journal of Stratigraphy* 36, 289–299.

Wu, H.Y., Huang, Q.H., Dang, Y.M., Kong, H. & Wang, L.Q. (2006) Achievements in the study on Cretaceous biostratigraphy of the Hailaer Basin, Inner Mongolia. *Acta Palaeontologica Sinica*, 45 (2), 283–291. [In Chinese with English Summary].

Zhang, C., Wu, X.W., Zhang, Y.J., Guo, W., Qin, T. & Quan, J.Y. (2017) Chronology of Early Cretaceous volcanic rocks from the Longjiang Basin and its tectonic implications. *Geological Review*, 63 (supplement), 295–296. [In Chinese].