Supplementary Material for

Calcitic shells in the aragonite sea of the earliest Cambrian

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GEOLOGICAL SETTINGS

The Zavkhan Basin in southwestern Mongolia preserves complete Cryogenian to early Cambrian marine deposits (MacDonald et al., 2009; Bold et al., 2016). Sedimentary sequence consists of the carbonate dominated Tsagaan-Olom Group and overlying Zuun Arts Formation, followed by the mixed carbonate-siliciclastic Bayangol Formation and massive limestones of the Salanygol Formation (Smith et al., 2016). The Ediacaran-Cambrian boundary occurs at the top of the Zuun Arts Formation recognized by a large negative carbon isotopic excursion interpreted as the BAsal Cambrian carbon isotope Excursion (BACE) by Smith et al., (2016). This region has been the focus by a number of scientific studies since the 1960s (Bezzubtsev, 1963; Voronin et al., 1982; Brasier et al., 1996), and particularly received great interests in recent palaeontological and geological studies (Pruss et al., 2019; Adachi et al., 2019, 2021; Yang et al., 2020; Steiner et al., 2021). Please refer to Topper et al. (2022) for a comprehensive review with respect to the biostratigraphy, lithostratigraphy and (carbon and oxygen isotope) chemostratigraphy of the region.

The Bayangol Formation in the studied BAY2 section (GPS: N46°42'11.0"/ E96°18'44.5", true thickness 359m) is a mix of siliciclastic-carbonate unit of sandstones, mudstones and three distinct limestone intervals. Based on the presence of three massive limestone units, the strata of the Bayangol Formation in the BAY2 section could be correlated to the lower parts, the named BG2 and BG3 members of the formation in Smith et al., (2016). Its boundary to the underlining Zuun Arts Formation in the BAY2 section, however, is not exposed, and strata of middle/upper part of the formation is heavily disturbed by complex thrust faults.

Previous palaeontological studies have yielded a diverse assemblage of small shelly fossils, and two shelly biozones: *Anabarites trisulcatus* Zone and *Purella* Zone were recognized, indicating a Fortunian age of the formation (Brasier et al., 1996). However, the

boundary between the two shelly biozones is poorly constrained. In the BAY2 section, the first appearance of scaly maikhanellid *Purella antique* for defining the base of the *Purella* Zone is at 335m above the base of the section. Abundant and diverse coiled, conical and cyrtoconic helcionelloids mollusk shells occur within the *Purella* Zone, especially at the 340/341/342m limestone beds. In the lower parts of the formation belonging to the *Anabarites trisulcatus* Zone, no convincing helcionelloid shell were discovered, but some different scaly maikhanellid shells dose occur, which is also the same case in many other areas such as Siberia and South China (Kouchinsky et al., 2012, 2017).

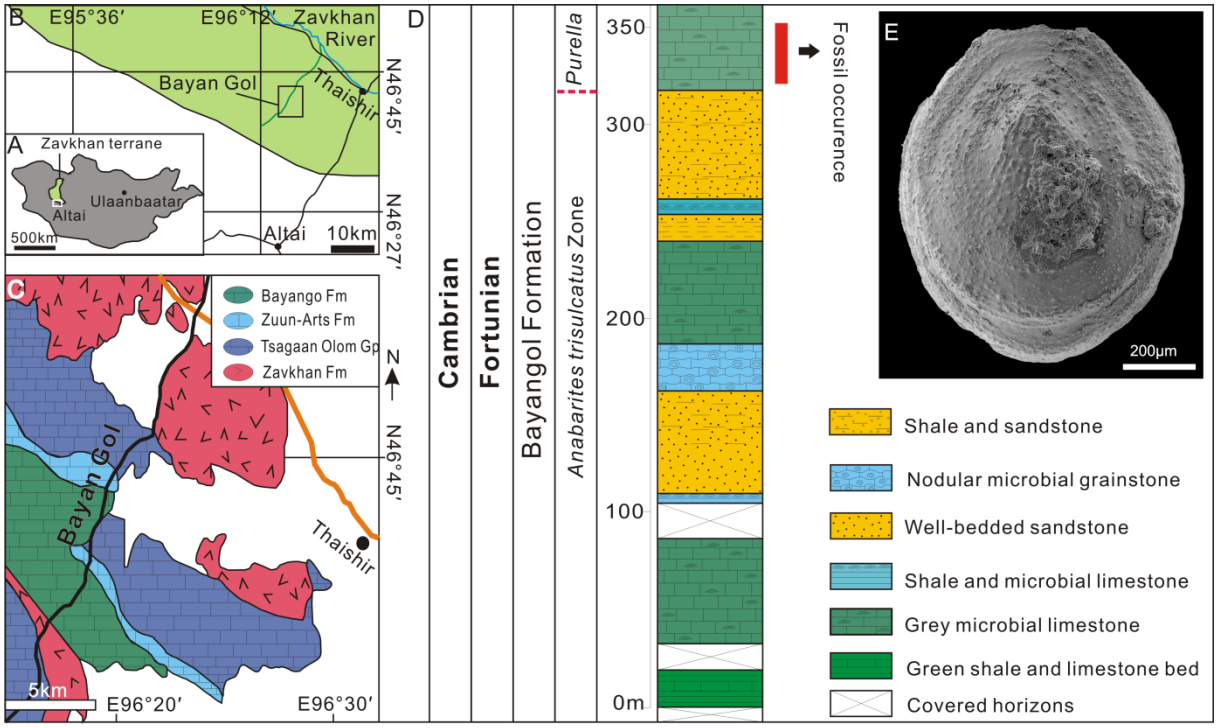

Figure 1. Geological setting, lithostratigraphy and biostratigraphy. (A) Locality map of the Zavkhan terrane, southwestern Mongolia. (B) Location of Bayan Gol in the Zavkhan Basin. (C) Geological map of Bayan Gol and the location of section BAY2, GPS: N46°42'11.0"/ E96°18'44.5". (D) Lithostratigraphic columns of the Bayangol Formation in the BAY2 section and fossil occurrence horizon. The boundary of the small shelly fossil *Anabarites trisulcatus*

Zone and *Purella* Zone is temporarily placed at the 335m above the base of the section. (E) NRM.XXX. Overall morphology of cap-shaped helcionelloid *Postacanthella voronini* Zhegallo in Esakova and Zhegallo, 1996.

METHODS

Our Mongolian mollusk materials presented in this paper were collected from the 341m limestone bed of the formation. Rock samples were macerated in diluted 5% acetic acid. Acid-resistant residues were washed, sieved carefully, and air-dried at room temperature. Mollusks together with other skeletal fossils were manually picked under stereomicroscopy. Fragments of modern bivalve *Pinctada* shells were chemically etched using 0.5% hydrochloric acid (HCL) for 1-5 minutes, rinsed with tap water for 1 minute, air-dried at room temperature. Then specimens of both fossils and modern shells were mounted, sputter-coated with gold and examined with a FEI Quanta FEG 650 SEM at an accelerating voltage of 15 KV at the Swedish Museum of Natural History. All imaged fossil material is stored at the Swedish Museum of Natural History (NRM).

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