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Research Advances

A new discovery of The Early Cretaceous Supercritical Hyperpycnal Flow Deposits on Lingshan Island, East China

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Objective

Understanding the dynamics of sediment gravity flows is of great importance to correctly interpret their related deposits. The discovery of supercritical sediment gravity flows provides some new viewpoints for the explanation of controversial sediment gravity flow deposits. However, the dynamics, formation, evolution processes of supercritical sediment gravity flows and their recognition criteria from their associated deposits are still worldwide controversial. The supercritical hyperpycnal flow deposits recognized in the upper part of Early Cretaceous Lingshandao Formation provide a rare opportunity to understand their sedimentary characteristics. This work is aimed at documenting the typical sedimentary structures associated with the supercritical hyperpycnal flow, and discussing the vertical stacking and its relationship with flow evolution.

Methods

The results presented in this work are based on extensive field observations, complemented with photomosaics, stratigraphic columns (1:200), and thin sections analysis.

Results

Our present study shows that the gravity flow deposits in the Beilaishi section on the north end of Lingshan Island are typical supercritical sediment gravity flow deposits, mainly triggered by hyperpycnal flows (Fig. 1).

(1) Hyperpycnal flow deposits. Suspended-load-dominated hyperpycnal flow deposits (hyperpycnites) are characterized by typical inverse then normal grading recognized in siltstones to fine-grained sandstones (Figs. 1a, 1b and 1c). Moreover, climbing ripples can also be observed on both lower and upper part of hyperpycnite beds (Figs. 1b and 1c). Bedload-dominated hyperpycnal-flow deposits are characterized by cut and fill features. The scour filling deposits are dominated by pebbly coarse-grained sandstone with frequent low angle cross stratification (Fig. 1f), showing floating pebbles and mud clasts.

(2) Supercritical gravity flow deposits. The gently dipping fore- and backset laminations in siltstones to fine-grained sandstones are interpreted as the deposits of breaking antidunes (Fig. 1d). The gently dipping concave- to convex-up foresets in siltstone to fine-grained sandstones are interpreted as the deposits of chutes-and-pools (Fig. 1e). The widely distributed scours are interpreted as erosion features resulting from hydraulic jumps of supercritical waxing flows (Figs. 1f, 1g and 1h). The lenticular scours infilled by backset stratification in pebbly coarse-grained sandstone are interpreted as the deposits of cyclic steps (Figs. 1h). The appearance of above sedimentary structures strongly indicated a deposition from supercritical sediment gravity flows.

(3) Vertical organization. Six fining-upward cycles (small scale depositional sequences) can be recognized in the Beilaishi section (Fig. 1a). The deposits of cyclic steps and bedload-dominated hyperpycnal flows are mainly recognized in the lower part of each fining-upward sequence (Figs. 1a, 1f, 1g and 1h), while the deposits of breaking antidunes, chutes-and-pools, and suspended-load-dominated hyperpycnal flow deposits are mainly distributed in the upper part of the sequence (Figs. 1a, 1b, 1c, 1d and 1e). The vertical organization of those deposits indicated a possible bedform evolution process of supercritical gravity flow from cyclic steps into chutes-and-pools, then breaking antidunes, ending with normal deposition.

Conclusions

The outcrops exposed in the Beilaishi section on Lingshan Island are typical supercritical hyperpycnal flows deposits. Deposits with inverse and then normal grading with climbing ripples are considered diagnostic of a hyperpycnal flow origin. The deposits of cyclic steps, chutes-and-pools, and breaking antidunes strongly indicate

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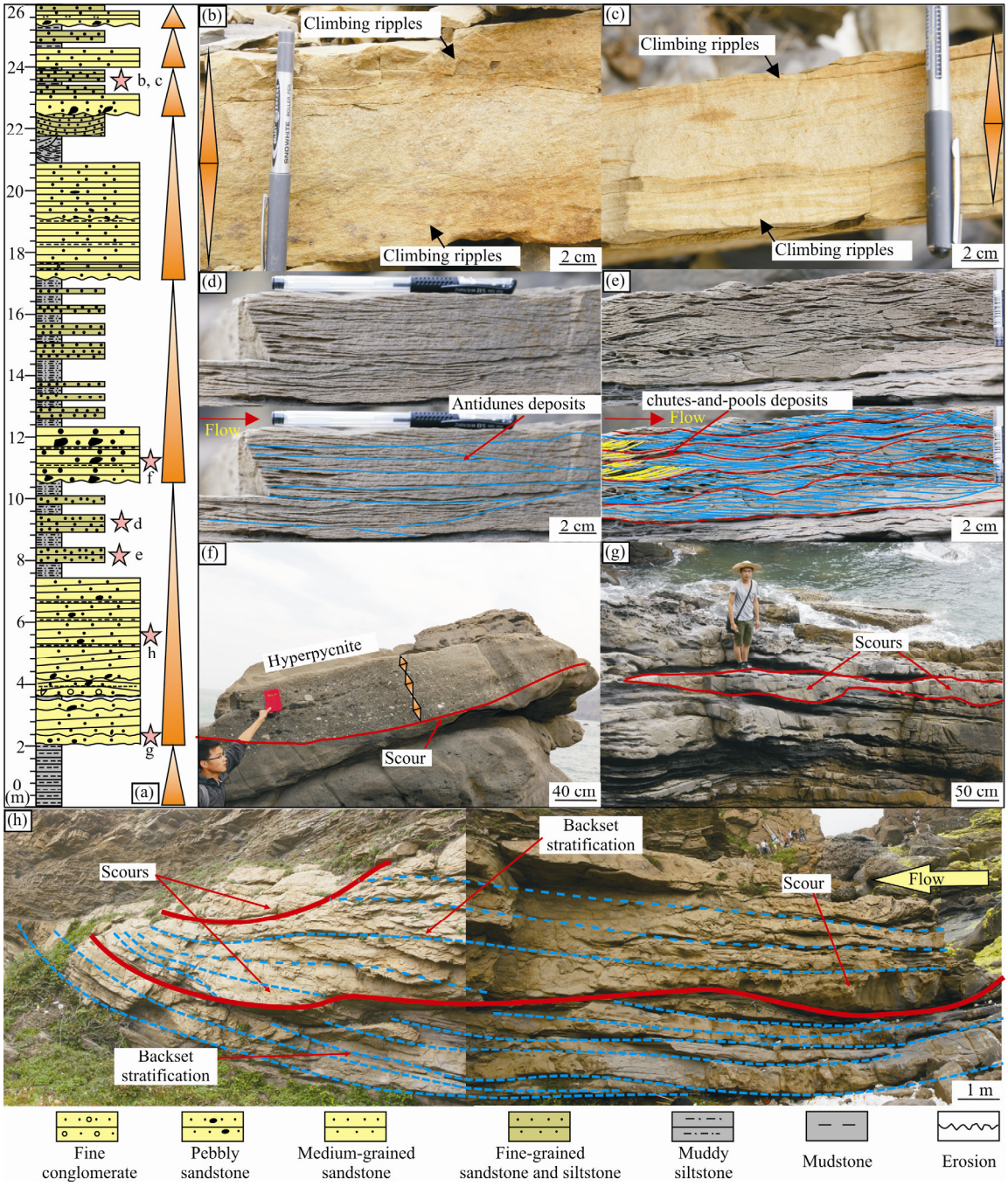

Fig. 1. Supercritical hyperpycnal flow deposits on Lingshan Island.
(a), Vertical succession of sediment gravity flow deposits in the Beilaishi section (after Zhong et al., 2016); (b), Hyperpycnite with inverse and then normal grading with climbing ripples; (c), Hyperpycnite showing inverse and then normal grading; (d), Gently dipping fore- and backsets lamination; (e), Gently dipping concave- to convex-upward foresets; (f), Scour filled with a hyperpycnite, with grain size changes that suggests flow fluctuations; (g), Detail of scour and fill structures; (h), Cyclic steps deposits characterized by backset stratification infilling lenticular scours.

a deposition from supercritical gravity flows. The vertical organization of these deposits indicate a possible bedform evolution with normal deposition process of supercritical sediment gravity flows from cyclic steps into chutes-and-pools, then breaking antidunes, ending with normal deposition.

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