Estimating the velocity of ancient bottom currents using grain size distributions measured in thin sections of contouritic rocks with siliceous cements

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Paleocurrent problem

The quantification of **paleocurrent speed** of ancient contourites is notoriously difficult. Modern contourite deposits are often calibrated against actual current measurements, whereas ancient contourites require a proxy to estimate current speeds.

Cementation problem

The grain size of the coarse mud fraction of contourites is often measured and used as a proxy for bottom current velocity. This **sortable silt** proxy (McCave et al. 2017) requires sediments to be disaggregated, which is difficult to achieve in well-lithified Mesozoic and Paleozoic deepwater rocks.

Take home message

Image analysis on micrographs of well-lithified contourites can be used to acquire grain size distributions, which can be used to quantify paleocurrent speeds. Key uncertainties of this workflow are the **representativeness** of the micrograph for the sample and **grain recognition**.

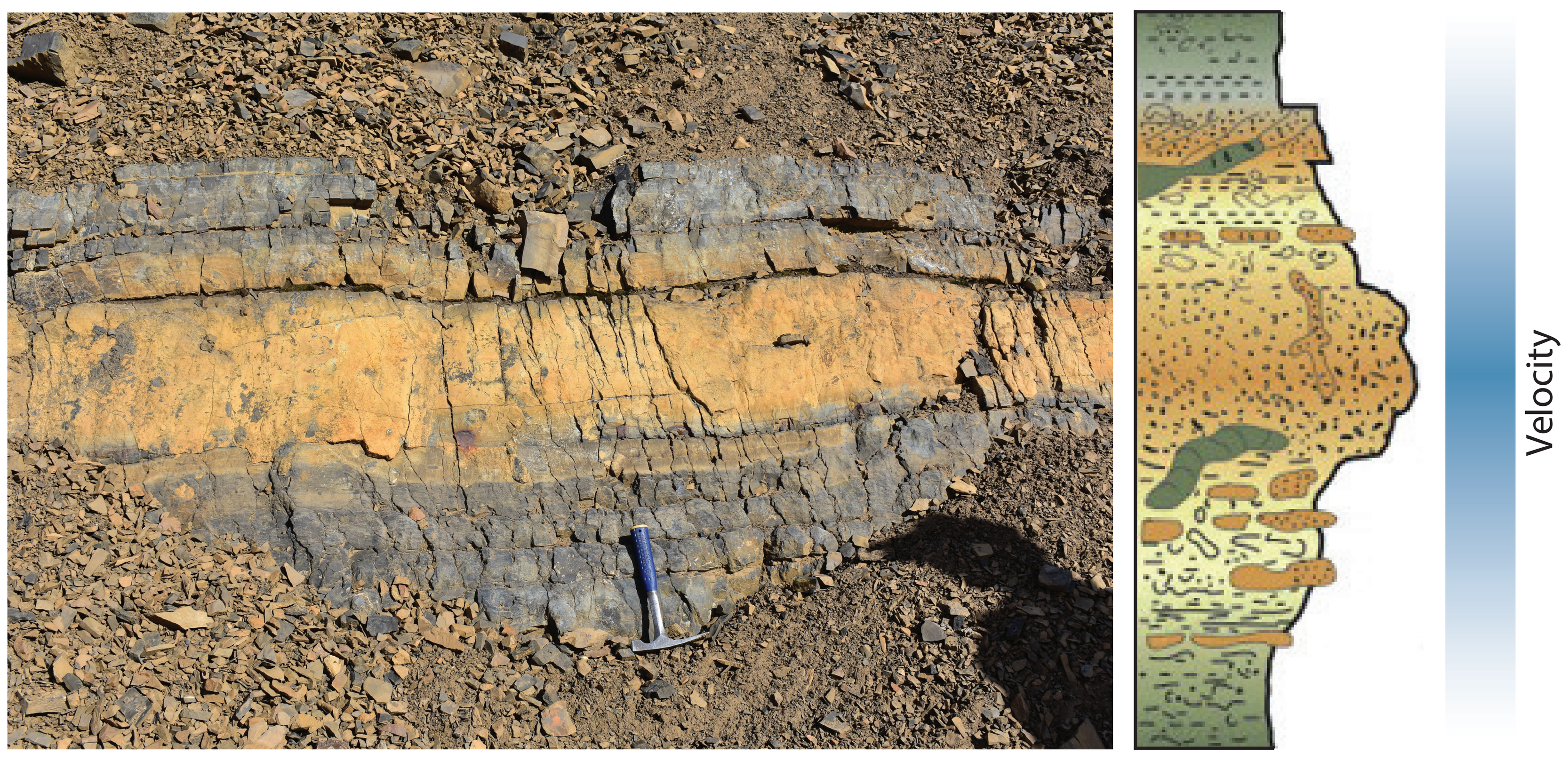

Figure 1 | Bigradational bed, typical for silty contourite deposits, as apparent from the comparison with the facies model. The bigradational bedding is indicative of an increasing and then decreasing paleocurrent velocity (modified from Rebesco et al. 2014).

Workflow

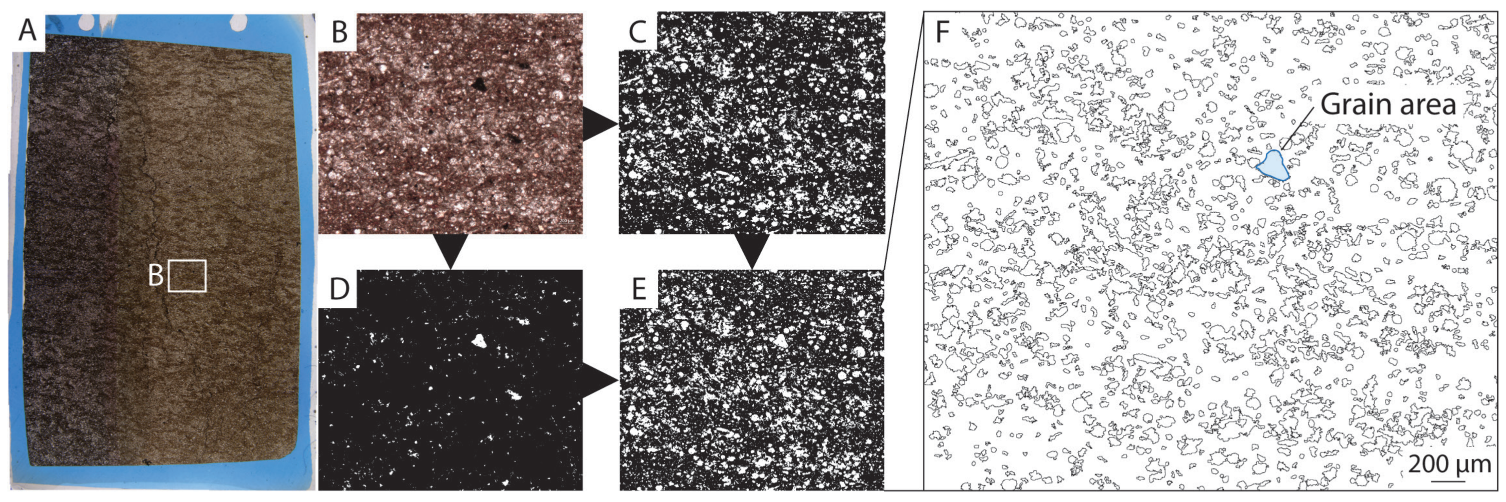

Figure 4 | ImageJ workflow: A micrograph (B) is taken from a thin section (A) using a petrographic microscope. Brightness thresholds are then applied to extract light and dark grains (C, D). The images are subsequently spliced (E). Finally, the area of each grain is measured (F).

Representativeness

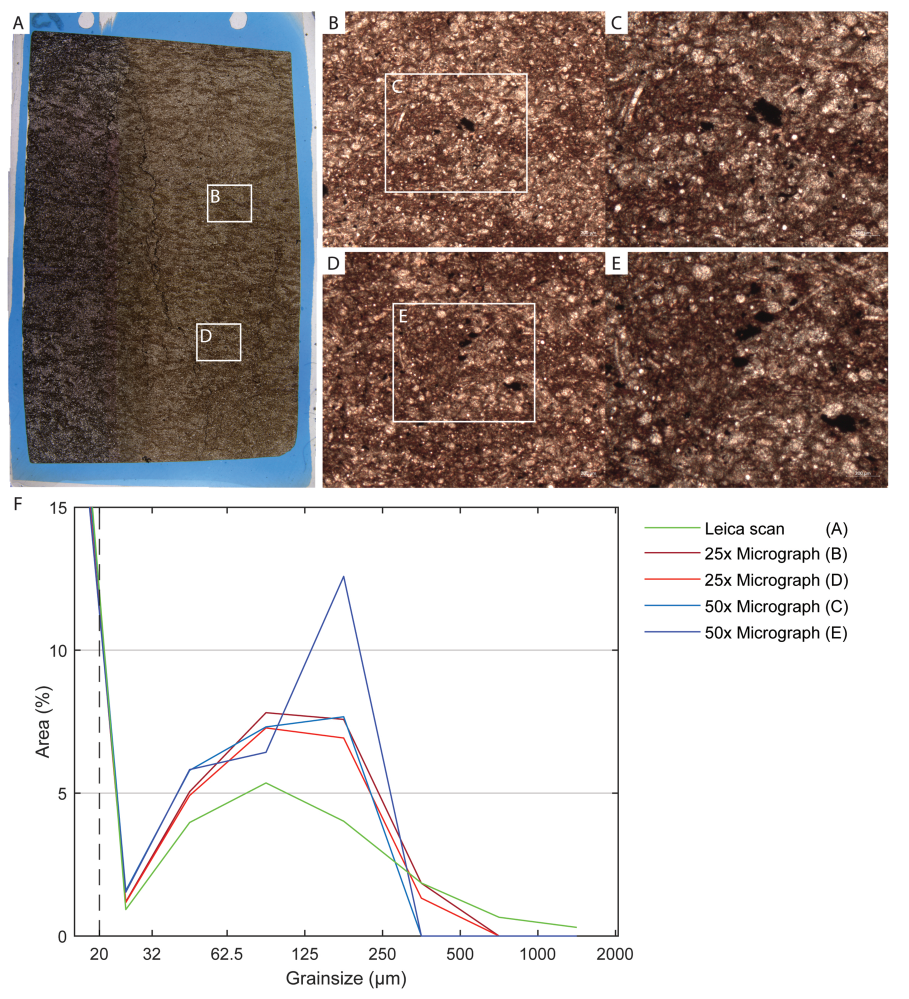

Figure 3 | The grain size distribution of 50× magnification micrographs (C, E) is highly location dependent, as opposed to 25× magnification micrographs (B, D) from the same sample (A). This becomes apparent from differences in the grain size distribution, that are large for the 50× magnification micrographs and small for the 25× magnification micrographs (F). Since the largest grain is medium sand, the error in the coarser fractions is caused by clustering.

Grain recognition

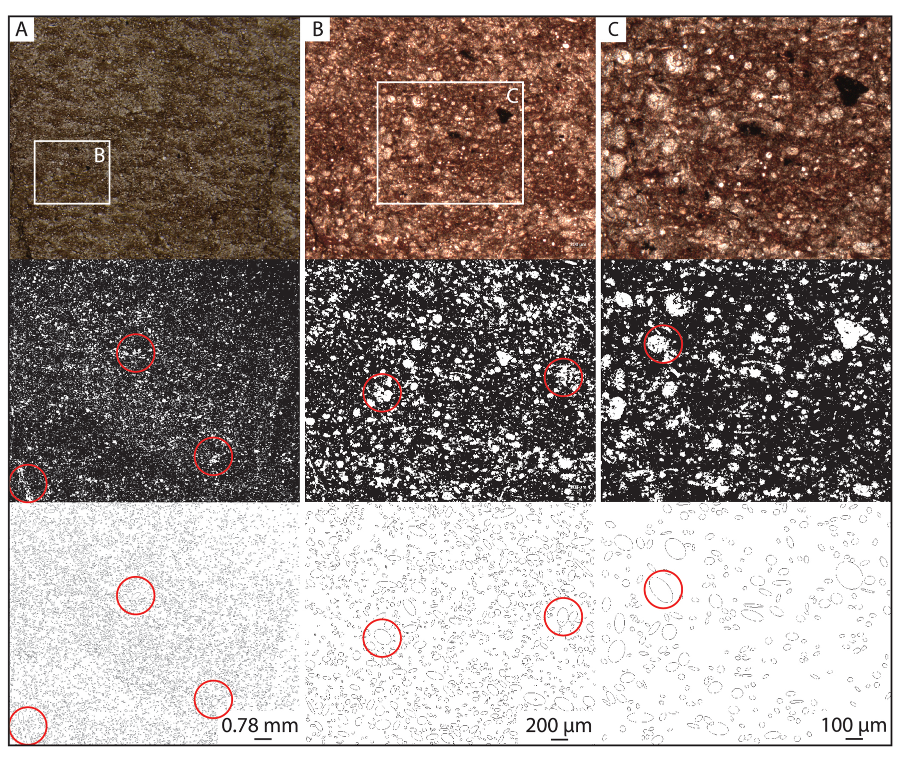

Figure 2 | Three sets of micrographs were produced to test grain recognition by the image analysis software. (A) Leica scan. (B) 25× magnification micrograph. (C) 50× magnification micrograph. The latter results in the most accurate grain recognition, apparent from the small amount of clustering.

Figure 5 | The upper member of the McCarthy Formation, exposed on the slopes of the Chitistone mountain, South-central Alaska, is the record of Jurassic deep water sedimentation (Veenma et al 2022).

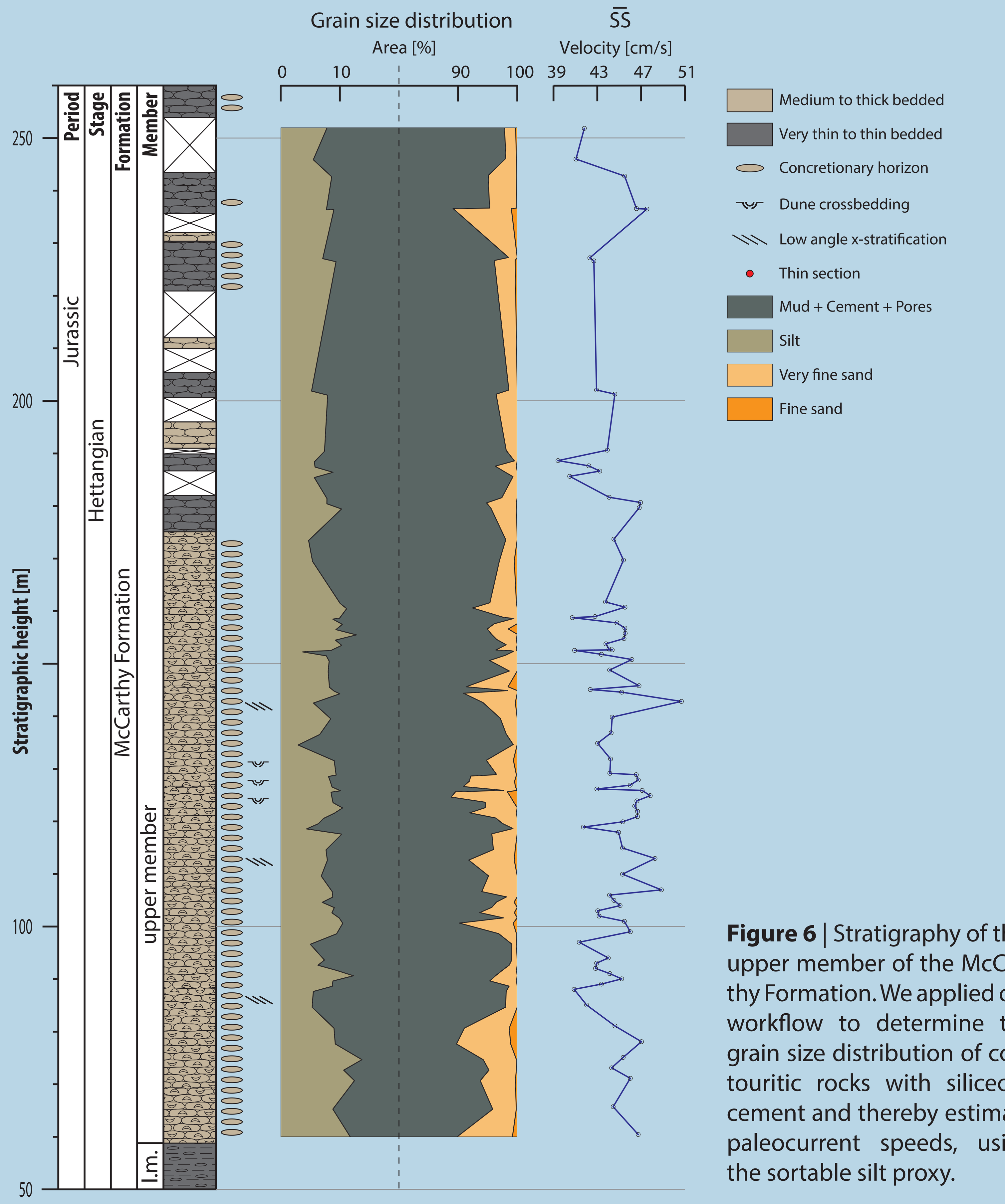

Figure 6 | Stratigraphy of the upper member of the McCarthy Formation. We applied our workflow to determine the grain size distribution of contouritic rocks with siliceous cement and thereby estimate paleocurrent speeds, using the sortable silt proxy.

References

McCave, I.N., Thornalley, D.J.R., and Hall, I.R., 2017, Relation of sortable silt grain-size to deep-sea current speeds: Calibration of the 'Mud Current Meter': Deep Sea Research Part I: Oceanographic Research Papers, v. 127, p. 1–12, doi:10.1016/j.dsr.2017.07.003.

Rebesco, M., Hernández-Molina, F.J., Van Rooij, D., and Wåhlin, A., 2014, Contourites and associated sediments controlled by deep-water circulation processes: State-of-the-art and future considerations: Marine Geology, v. 352, p. 111–154, doi:10.1016/j.margeo.2014.03.011.

Veenma, Y.P., McCabe, K., Caruthers, A.H., Aberhan, M., Golding, M., Marroquín, S.M., Owens, J.D., Them, T.R., II, Gill, B.C., and Trabucho Alexandre, J.P., 2022, The glass ramp of Wrangellia: Late Triassic to Early Jurassic outer ramp environments of the McCarthy Formation, Alaska, U.S.A.: Journal of Sedimentary Research, v. 92, p. 896–919, doi:10.2110/jsr.2022.004.

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