TOWARDS A DEPOSITIONAL MODEL OF COARSE-GRAINED DELTA DRIFT DEPOSITS, MAIELLA, ITALY

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PROJECT OBJECTIVES

- Test the hypothesis that stratal succession of the delta drift in the Maiella is the combined product of hyperpycnal flow originating from the semi-continuous current flowing through the feeder channel and supercritical flow in the adjacent basin.
- Visualize the distribution of clasts in 3D to better elucidate erosion and transport mechanisms.
- Document the proximal to distal facies trends within the delta drift of the Maiella and assess the flow conditions necessary for producing the observed facies distribution.

PROJECT RATIONALE

The Orfento Formation in the Maiella Mountains (Italy) is a largely mud-free succession with sedimentary structures that indicate deposition from a variety of subaqueous high-density sediment flows. Yet, the succession does not fit in any of the existing turbidite models, and as a result has, hitherto, been variously interpreted as a succession of sea-level controlled slope deposits, a shoaling shoreface complex, or a carbonate tidal delta. Due to the similarities in geometry and facies of the Orfento Formation to the contourite delta drift in the Maldives (Fig. 1), these deposits are now recognized as a Cretaceous delta drift (Eberli et al., 2019).

What is still underexplored are the flow mechanisms that act within a current-controlled delta drift. Contourite drift deposits are typically fine-grained but the carbonate delta drifts in the Maldives and the Maiella are, especially in the proximal parts, coarse-grained nearly mud free deposits. Many beds display

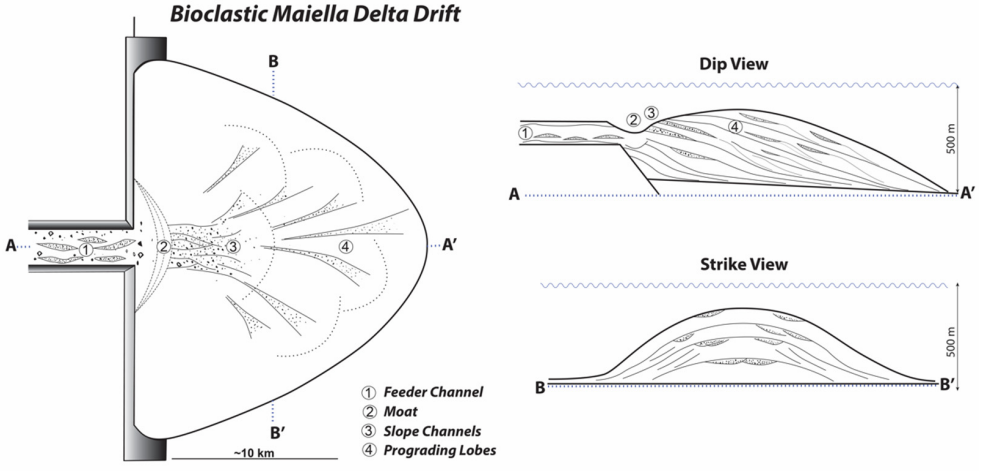

Figure 1: Schematic display of the Maiella drift delta as plan view and dip and strike cross-sections (from Eberli et al. 2019).

characteristics of highly-concentrated turbidity current deposits. Other elements, like scours filled with pebble- and gravel-sized bio- and lithoclasts and erosive surfaces are typical expressions of transitions from supercritical to subcritical flow (Postma & Cartigny, 2014). Other beds display structures that are associated with hyperpycnal flow.

Hyperpycnal flow is produced when water with higher density - commonly associated with sediment laden river water - flows into a basin. Isolated carbonate platforms, like the Apulian platform was, do not have fluvial transport and thus hyperpycnal flow characteristics must have been produced by another continuous flow, thought to be an ocean current flowing through the feeder channel. The large scale geometry of downlapping coarse-grained lobes as observed in the delta drift are reminiscent of homopycnal jet outflow causing deposition in a Gilbert-type delta (Fig. 2). Thus it is likely that, depending on the sediment load, both flow mechanisms are recorded in the bedsets of the delta drift.

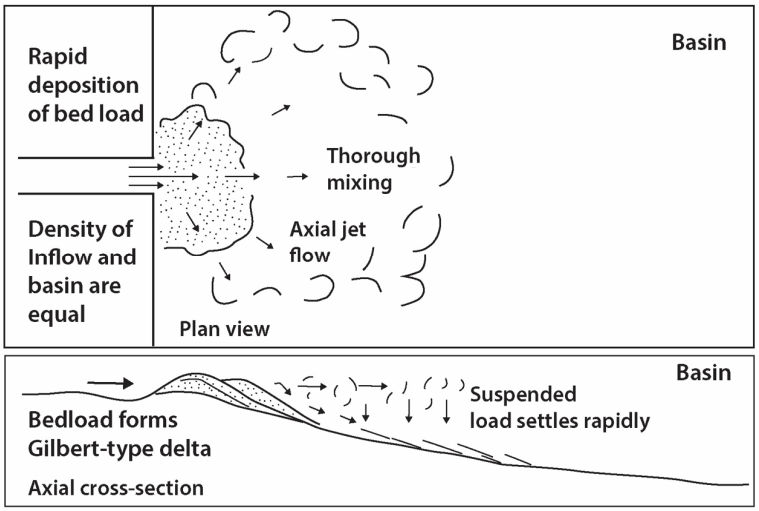

Figure 2: Homopycnal flow model redrawn from Boggs (1987) based on Bates (1953). Homo-pycnal flow leads to rapid deposition of sediment load. The jet outflow causes the formation of Gilbert—type deltas that display topset, foreset and bottomset arrangements of beds.

PROJECT OBJECTIVES

This project aims to test the hypothesis that a sediment laden ocean current can yield flow conditions to a long-lived homopycnal and hyperpycnal flow, producing the observed bedload transport by the shear provided by the overpassing hyperpycnal sediment laden ocean current (Fig. 3). In addition,

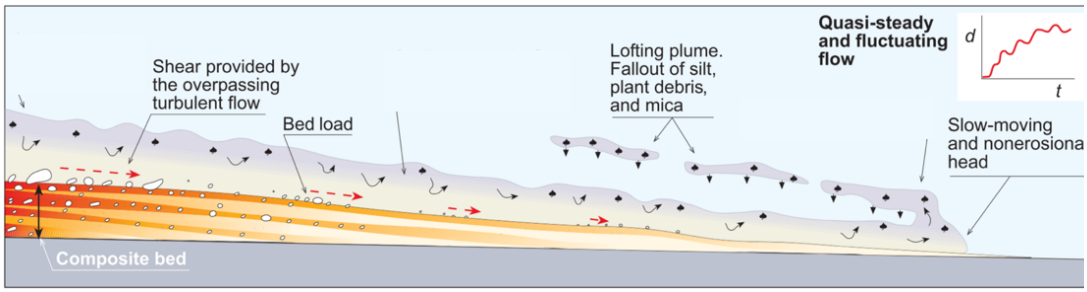

Figure 3: Hyperpycnal flow model Zavala et al. 2011, explaining the coarse-grained composite beds produced by the shear of an overpassing hyperpycnal flow with fluctuating strength. We will test if quasi-steady ocean currents with fluctuating strength results in a similar depositional pattern.

hydraulic jumps caused by the topography are thought to produce transitions from subcritical to supercritical flow and several of the observed sedimentary features.

A second major objective of the project is to use the clast distribution of the delta drift to interpret the depositional process in the more distal portion of the delta drift. The combination of 3D GPR, flattening and thick slice visualization has provided an unprecedented view of sedimentary structures inside the grainstone beds of the Madonna della Mazza quarry (Grasmueck et al., 2019). The random distribution of the clasts indicates a freezing of the dense hyperpycnal flows (Fig. 4). This year we plan to improve the visualization of the clasts in each layer to precisely assess the clasts in various layers.

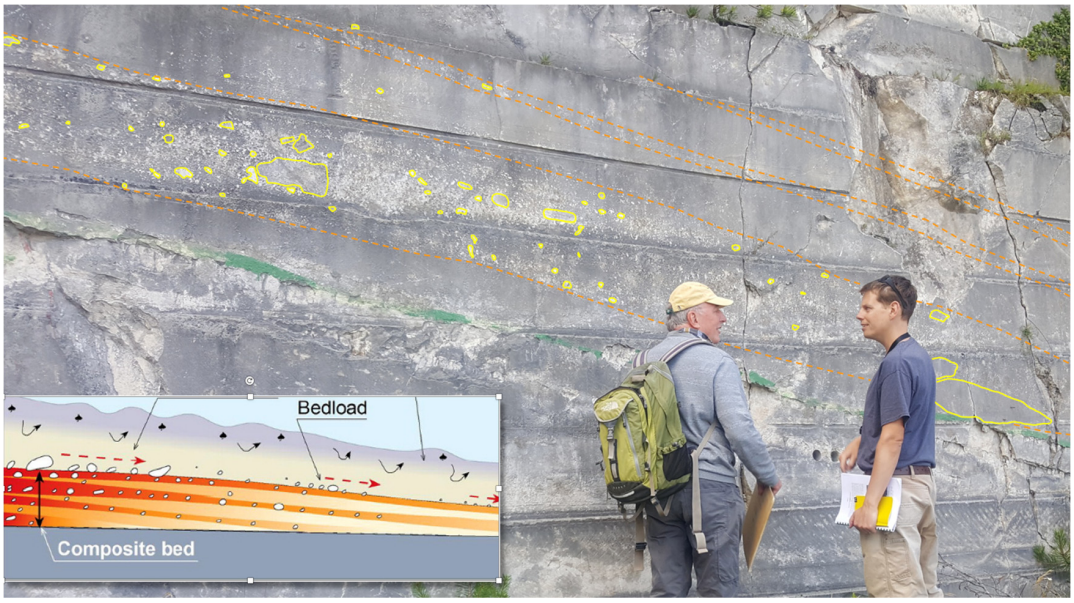

Figure 4: Clast distribution in the strata of the Madonna dell Mazza quarry. Clast appear as white specks in the quarry floor and walls; larger clasts are outlined in yellow. Inset is schematic display of the clasts deposited by hyperpycnal flow (Zavala et al., 2011).

APPROACH FOR VISUALIZATION OF CLASTS

To be able to visualize and quantify the clasts in individual dipping beds several steps are necessary (Fig. 5). First, a geomodel of the 3D GPR datacube has to be constructed that resolves the individual layers of the quarry succession. The geomodel is then used to flatten each lithoclast bed to obtain a contiguous map view of the bed content. We will use the Pondview (Grasmueck and Viggiano, 2018) thick slice method for the visualization of the clast distribution inside the lithoclast beds. The 2D matrix color rendering of Pondview shows the lateral and vertical clast distribution. The goal is to assess the distribution, size, shape, and orientation of the lithoclasts within each layer. This will support the reinterpretation of the flow- erosion- and transport mechanisms operating during deposition of the drift succession of the Madonna della Mazza quarry.

SIGNIFICANCE

This study will provide for the first time an assessment of the sedimentologic processes of jet flow generated by ocean currents in feeder channels and their depositional products. We suspect that some deep-water deposits, in particular coarse-grained beds that hitherto have been assigned to gravitational flow mechanisms, might be better explained within the context of a deep-water delta. The geometry and facies of this thick coarse-grained in contourite drift type points towards a new depositional model in deep-water environments.

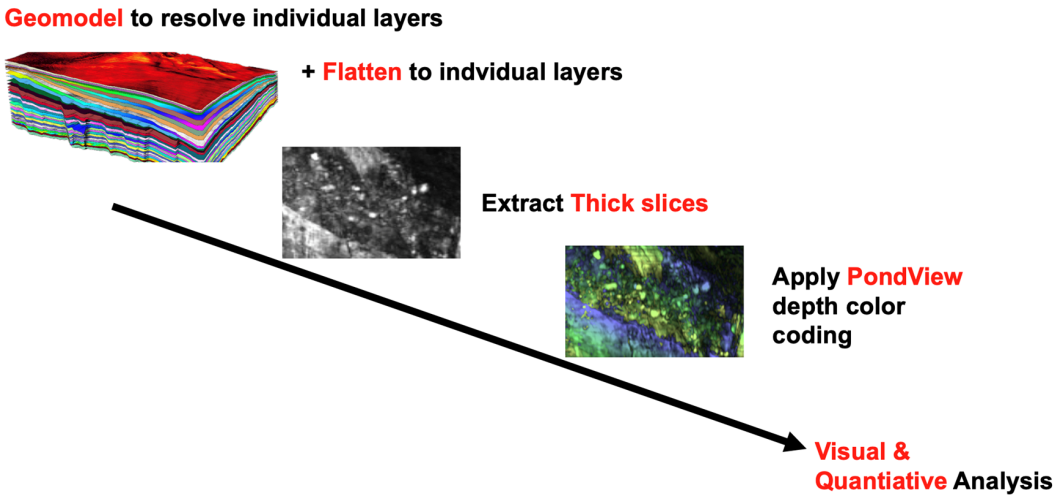

Figure 5: Workflow to visualize and quantify the lithoclast distribution in the Madonna dell Mazza quarry succession of the Maiella delta drift. Geomodel Image from PaleoscanTM interpretation software, Eliis

REFERENCES

Bates, C.C. (1953) Rational theory of delta formation. AAPG Bulletin, 37, p. 2119-2161.

Boggs, S. (1987) Principles of sedimentology and stratigraphy. Merrill Publishing Company, Columbus, Ohio, pp. 784.

Eberli, G.P., Bernoulli, D., Vecsei, A., Sekti, R., Grasmueck, M., Lüdmann, T., Anselmetti, F.S., Mutti, M., and Della Porta, G. (2019) Cretaceous Carbonate Drift Delta in the Montagna dell Maiella, Italy. Sedimentology, v. 66, p. 1266-1301. doi: 10.1111/sed.12590.

Grasmueck, M., and Viggiano, D., (2018) PondView: Intuitive and efficient visualization of 3D GPR Data. Expanded Abstract, IEEE Proceedings 17th International Conference on Ground Penetrating Radar, June 18 -21, 2018, Rapperswil, Switzerland.

Grasmueck, M., Viggiano, D., and Eberli, G.P. (2019) Assessing Lithoclast Distribution in Grainstone Drift Deposits with the Pondview Seismic Attribute. CSL – Annual Review Meeting Abstract Book, p. 99 -102.

Postma, G. and Cartigny, M.J. (2014) Supercritical and subcritical turbidity currents and their deposits—A synthesis. Geology, v. 42, p. 987-990.

Zavala, C., M. Arcuri, M. Di Meglio, H. Gamero Diaz, and C. Contreras, 2011, A genetic facies tract for the analysis of sustained hyperpycnal flow deposits. AAPG Studies in Geology v. 61, p. 31–51.