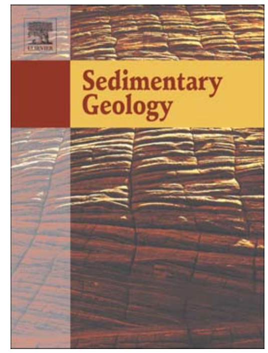
Accepted Manuscript



Supercritical-flow structures (backset-bedded sets and sediment waves) on high-gradient clinoform systems influenced by shallow-marine hydrodynamics

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PII: S0037-0738(17)30192-6
DOI: doi:10.1016/j.sedgeo.2017.09.003
Reference: SEDGEO 5227

To appear in: *Sedimentary Geology*

Received date: 28 June 2017
Revised date: 6 September 2017
Accepted date: 10 September 2017

Please cite this article as: Massari, F., Supercritical-flow structures (backset-bedded sets and sediment waves) on high-gradient clinoform systems influenced by shallow-marine hydrodynamics, *Sedimentary Geology* (2017), doi:10.1016/j.sedgeo.2017.09.003

Supercritical-flow structures (backset-bedded sets and sediment waves) on high-gradient clinoform systems influenced by shallow-marine hydrodynamics.

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Abstract

Inferred supercritical structures and bedforms, including sediment waves and backset-bedded sets, are identified as components of coarse-grained siliciclastic and bioclastic, high-gradient clinoform wedges (Plio-Pleistocene of southern Italy) and canyon head infills (Tortonian of Venetian pre-Alps), showing evidence of having been built out in a setting influenced by shallow-marine hydrodynamics. The facies identified are dominated by a range of traction carpets, formed after segregation of coarser particles in the lower part of bipartite density underflows. The generation of backset-bedded sets is thought to imply scouring due to impact of a submerged hydraulic jump on the bed, and upstream migration of the jump, concomitant with the deposition of backset beds on the stoss side of the developing bedform. Submerged hydraulic jumps apparently formed spontaneously and in any position on the foreset and toeset, without requiring any precursor bed defect. The mostly solitary, non-cyclical character of the bedforms prevents their attribution to cyclic steps. The sets of backset beds are locally underlain by chaotic infills of deep, steep-sided scours attributed to vigorous erosion at the hydraulic jump, accompanied by instantaneous loss in transport capacity which results in rapid plugging of the scour (hydraulic jump facies of Postma et al., 2014). Gravel waves have a distinct internal stratigraphy, and their length to amplitude ratios show lower mean values and higher variability when compared to sediment waves consisting of sand. The presence of supercritical bedforms on steep foreset slopes of the studied clinoform systems, even in proximity to the topset-foreset rollover, is believed to reflect high inefficiency of mud-poor and short run-out bipartite underflows episodically transporting relatively small volumes of coarse-grained sediment. This may also account for common solitary, non-cyclical bedforms. It is proposed that during intense oceanographic events, such as coastal storms, seaward sediment entrainment, assisted by gravity, was very effective on the gently sloping subaqueous topset, and that, beyond the topset-foreset rollover, the flows evolved to high-concentration turbidity underflows with supercritical Froude numbers. The flows are inferred to have been sustained, probably lasting for the duration of the meteorological events, and to have commonly been unsteady in discharge, fluctuating in concentration and size of transported sediments, and subject to peaks in velocity. The characteristics of the structures are regarded as typical of the systems fed by oceanographic processes, and may fall into the class of coarse-grained “small sediment waves with mixed relief” of Symons et al. (2016), formed from a combination of erosion and deposition, and by the action of stratified flows depositing from denser basal layers, and typically restricted to small-scale shallow-marine slope systems.

Key words: Supercritical flow, hydraulic jump, backsets, sediment waves, high-gradient clinoforms, shallow-marine hydrodynamics

1. Introduction

Bedforms and structures originating from supercritical flow conditions have been identified from a large range of present-day natural environments (Kostic et al., 2010), including rivers (e.g., Fralick, 1999; Fielding, 2006), glacial lake outburst flood successions (e.g., Gorrell and Shaw, 1991; Russell and Arnott, 2003; Russell et al., 2003; Hornung et al., 2007; Duller et al., 2008; Lang and Winsemann, 2013), high-angle clinoform delta wedges (e.g., Gobo et al., 2015), prodelta slopes (e.g., Hughes Clarke et al., 2014), and deep-water environments such as canyon floors and turbidite overbank areas, where they have mainly been observed and documented by means of bathymetric and high-resolution seismic data (e.g., Piper and Savoye, 1993; Wynn and Stow, 2002; Fildani et al., 2006, 2013; Lamb et al., 2008; Heiniö and Davies, 2009; Normark et al., 2009; Maier et al., 2011; Armitage et al., 2012; Gong et al., 2012; Covault et al., 2014;; Zhong et al., 2015; Lang et al., 2017). They have also been successfully reproduced in both flume and numerical