ELSEVIER

Marine and Petroleum Geology 20 (2003) 861–882

Marine and Petroleum Geology

www.elsevier.com/locate/marpetgeo

Marine hyperpycnal flows: initiation, behavior and related deposits. A review

Thierry Mulder[a,*], James P.M. Syvitski[b], Sébastien Migeon[c],
Jean-Claude Faugères[a], Bruno Savoye[d]

[a]*Département de Géologie et d'Océanographie, UMR 5805 EPOC, Université Bordeaux I, Avenue des Facultés, 33405 Talence cedex, France*
[b]*Department of Geological Sciences and Institute of Arctic and Alpine Research, University of Colorado, Box 450, Boulder, CO 80309-0450, USA*
[c]*Geological Survey of Canada Atlantic, Bedford Institute of Oceanography, P.O. Box 1000, Dartmouth, NS, Canada B2Y4A2*
[d]*IFREMER, DRO/GM, BP 70 29280 Plouzané, France*

Received 1 July 2002; accepted 9 January 2003

Abstract

Hyperpycnal flows form in the marine environment when river discharge enters the ocean with suspended concentrations in excess of 36 kg m^{-3} due to buoyancy considerations, or as little as 1–5 kg m^{-3} when convective instability is considered. They form at a river mouth during floods of small to medium size rivers including extreme events such as jökulhaups, dam breaking and draining, and lahars. Associated with high-suspended concentration, they can transport considerable volume of sediment to ocean basins. The typical deposit or hyperpycnite sequence is a compound of a basal coarsening-up unit, deposited during the waxing period of discharge, and a top fining-up unit deposited during the waning period of discharge. Hyperpycnites differ from other turbidites because of their well-developed inversely graded facies and intrasequence erosional contacts. These observations lead to a complete redefinition and interpretation of fine-grained turbidites. Hyperpycnite stacking can locally generate high-sedimentation rates, in the range of 1–2 m per 100 year. Because hyperpycnites are related to climate through flood frequency and magnitude, their record should vary with sea level and climate change. They can also be associated with proximal ice-melting settings. Hyperpycnal flows could also be involved in the formation of meandering canyons and channels.

Keywords: Hyperpycnal flows; River load; Canyon; Turbidite deposit; Floods; Climate

1. Introduction

In the past 30 years, offshore mass wasting processes and gravity flows have been widely studied, stimulated by the needs of deep-water reservoir characterization and other offshore industries needing protection against natural hazards. The importance of gravity processes is associated with new exploration of deep-marine environments including ODP drilling on the Amazon Fan (Hiscott, Pirmez, & Flood, 1997; Normark & Damuth, 1997) or industrial–academic surveys of the Zaire turbidite system (Savoye et al., 2000).

Following pioneer work of Kuenen and Migliorini (1950), early classifications of offshore gravity processes arose in the 1970s (Lowe, 1982; Middleton, 1976, 1993; Middleton & Hampton, 1973; Nardin, Hein, Gorsline, & Edwards, 1979). These classifications underlined the existence of two major processes in the marine environment: mass flows and turbidity currents. Mulder and Cochonat (1996) and Shanmugam (1996) discussed the complexity of a classification, since one single event may involve several processes from the failure to final deposition. Turbidity flows (Kneller & Buckee, 2000; Lowe, 1979, 1982; Middleton & Hampton, 1973, 1976; Nardin et al., 1979; Stow, 1996) result from slide transformation, continuation of a fluvial flow or concentration processes. Ignitive transformation of a submarine slide into a flow in which turbulent energy substantively increases (Emms, 1999; Fukushima, Parker, & Pantin, 1985; Parker, 1982; Parker, Fukushima, & Pantin, 1986) has been described worldwide, including the 1929 Grand Banks event (Hughes-Clarke, 1990; Hughes-Clarke, Shor, Piper, & Mayer, 1990; Piper, Cochonat, Ollier Le Drezen, Morrison & Baltzer, 1992), and the 1979 Nice event (Gennesseaux, Mauffret, & Pautot, 1980; Malinverno, Ryan, Auffret, & Pautot, 1988; Piper & Savoye, 1993).

---

* Corresponding author. Tel.: +33-556648845.
E-mail address: t.mulder@geocean.u-bordeaux.fr (T. Mulder).

0264-8172/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpetgeo.2003.01.003