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INSIDE: SEDIMENT GRAVITY FLOWS

PLUS: UPCOMING SEPM RESEARCH CONFERENCES
PROGRAM UPDATE FROM NSF - PRESIDENT'S OBSERVATIONS

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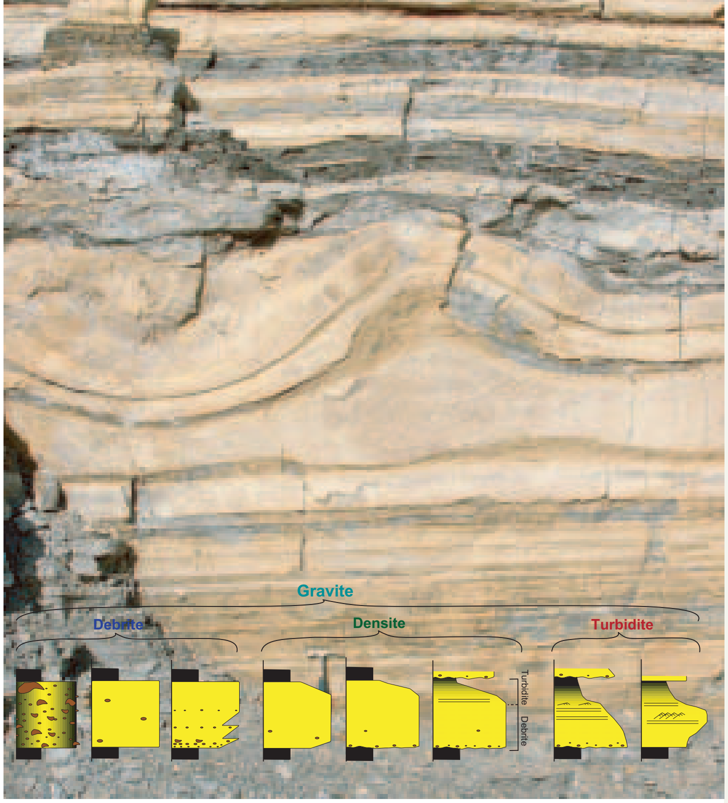

On the Cover: *Simplified model for gravites (deposits of sedimentary gravity flows) and a gravite from a submarine fan deposit in the Permian Brushy Canyon Formation of west Texas. See the article by Gani, this issue.*

CONTENTS

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CORRECTION:

In the Field Notes article of the June, 2004 issue, the following references were omitted:

Mann, K.O. and H.R. Lane, 1995, Graphic Correlation, SEPM (Society for Sedimentary Geology), Sp. Pub. 53, 263 pp.

Olson, H.C., A.C. Gary and G.D. Jones, 2003, Similarity curves as indicators of stratigraphic discontinuities, in H.C. Olson and R.M. Leckie (eds.), Micropaleontologic proxies for sea-level change and stratigraphic continuities, SEPM (Society for Sedimentary Geology), Sp. Pub. 75, p. 89-96.

O'Neill, B.J., A.E. DuVernay and R.A. George, 1999, Applied palaeontology: a critical stratigraphic tool in Gulf of Mexico exploration and exploitation, in R.W. Jones and M.D. Simmons (eds.), Biostratigraphy in Production and Development Geology, The Geological Society (London), Sp. Pub. 152, p. 303-308.

Russell, R.D. and R.C. Tener, 1981, SEPM The First Fifty Years, J. Sed. Pet., v. 51, 1401-1432.

Shaw, A.B., 1964, Time in Stratigraphy, McGraw-Hill, New York, 365 pp.

Wakefield, M.I., 2003, Bio-Sequence stratigraphic utility of SHE diversity analysis, in H.C. Olson and R.M. Leckie (eds.), Micropaleontologic proxies for sea-level change and stratigraphic continuities, SEPM (Society for Sedimentary Geology), Sp. Pub. 75, p. 81-97.

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From Turbid to Lucid:

A Straightforward Approach to Sediment Gravity Flows and Their Deposits

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ABSTRACT

Deepwater sediment gravity flows are categorized on the basis of a combination of four parameters – sediment concentration, sediment-support mechanism, flow state (laminar or turbulent), and rheology. Because there is no agreement among sedimentologists about which of these parameters should be the decisive one, one school's turbidites become another school's debrites, and vice-versa. Except for rheology, all of these parameters change gradationally from one end member to another. Therefore, rheological classification of sediment gravity flows should be the most straightforward and the least controversial. These flows can be either Newtonian (i.e., turbidity currents), or non-Newtonian (i.e., debris flows). However, identification of flow rheology by examining the deposits may not be easy. Although we may confidently identify some rocks as turbidites and others as debrites, there are some transitional deposits, here called densites, that share both the characteristics of turbidites and debrites. Densites are the deposits of dense flows, which are rheologically stratified flows having a composite rheology of Newtonian fluids and non-Newtonian fluids. Moreover, the absence of a general term for all types of sediment gravity flow deposits has resulted in overuse and misuse of the term turbidite. The term 'gravite' is proposed here for deposits of any kind of sediment gravity flow, irrespective of their depositional environment.

INTRODUCTION

The term 'turbidity current' was introduced by Johnson (1938) and applied to a current generated due to turbid or muddy water. Later, Kuenen (1957) introduced the term 'turbidite' for the deposit of a turbidity current, and Bouma (1962) introduced a classic five-fold vertical facies model for turbidites. Soon, the terms 'turbidites,' 'Bouma sequences,' and 'deepwater deposits' became almost synonymous in many published accounts. Although the overuse and misuse of the terms 'turbidity current' and 'turbidite' was first indicated by Sanders (1965), the turbidite controversy has recently caught wide attention (e.g., Shanmugam, 2000; Lowe and Guy, 2000; Kneller and Buckee, 2000; Mulder and Alexander, 2001).

Sediment gravity flows play a major role in transporting and depositing sediments in deepwater environments, and can be defined as a complex mixture of sediment and fluid that flows down slope due to the action of gravity. Sediment gravity flows are different from fluid gravity flows, because in the latter, fluid is moved by gravity dragging the sediment along, whereas in former gravity moves the sediment, which drags the fluid along. A turbidity current is only one type of sediment gravity flow. The center point of the turbidite controversy lies in the classification scheme of sediment gravity flows, which is so far poorly constrained and a bit ambiguous. This controversy can lead to erroneous numerical modeling of sediment gravity flows frequently used in submarine construction and hydrocarbon exploration because specific mathematical formulae govern specific types of sediment gravity flows. Therefore, it is felt that this classification scheme needs to be reviewed to clarify the controversy. In this paper, I take a simple and straightforward approach to classifying sediment gravity flows. I also suggest some key depositional features on which flow types can be interpreted least equivocally. Although the suggestions made here are applicable irrespective of depositional environments, this paper mainly deals with deepwater sediment gravity flows and their deposits.

CLASSIFICATION OF SEDIMENT GRAVITY FLOWS: BACKGROUND AND REVIEW

The initial definitions of turbidity currents and debris flows were purely descriptive, without being specific about the physical properties of the current. Therefore, from the beginning, questions revolved around what should be the main basis of classification of sediment gravity flows. Different authors emphasized different parameters in their classification schemes (sediment concentration: Bagnold, 1962; rheology: Dott, 1963; fluid turbulence: Sanders, 1965; sediment-support mechanisms: Middleton and Hampton, 1973; combination of rheology and sediment-support mechanism: Lowe, 1982; combination of physical flow properties and sediment-support mechanism: Mulder and Alexander, 2001). Among the four most important parameters (sediment concentration, sediment-support mechanism, flow state, and rheology) of sediment gravity flows, sediment concentration (by volume) directly affects other three parameters. Therefore, sediment concentration appears to be the most pragmatic parameter for defining the various types. Unfortunately, we can not establish specific threshold values for various types of sediment gravity flows (Shanmugam, 1996) because grain size and concentration of clay minerals offset these threshold values.

Sediment-support mechanisms include matrix strength, dispersive grain pressure, escaping pore fluid, and fluid turbulence. These mechanisms may change gradationally with increasing fluid content, and more than one support mechanism may operate simultaneously for a specific type of sediment gravity flow. Similarly, the flow state may change gradationally and back-and-forth between a laminar state and a turbulent state with the change of sediment concentrations or basin slopes. On the other hand, the rheology of sediment gravity flows is expressible in a straightforward and simplified mathematical way in a 2-D graph (Fig. 1). Most importantly, the rheological types do not vary gradationally among each other. Therefore, rheology may be the one parameter that can be used least ambiguously to define various types of sediment gravity flows.

According to Figure 1, there are only two basic types of rheology in sediment gravity flows – Newtonian and non-Newtonian. If a sediment gravity flow deforms instantly with applied stress and develops a linear relationship between shear stress and strain rate, it is called a Newtonian fluid. Any deviation from this characteristic results in non-Newtonian

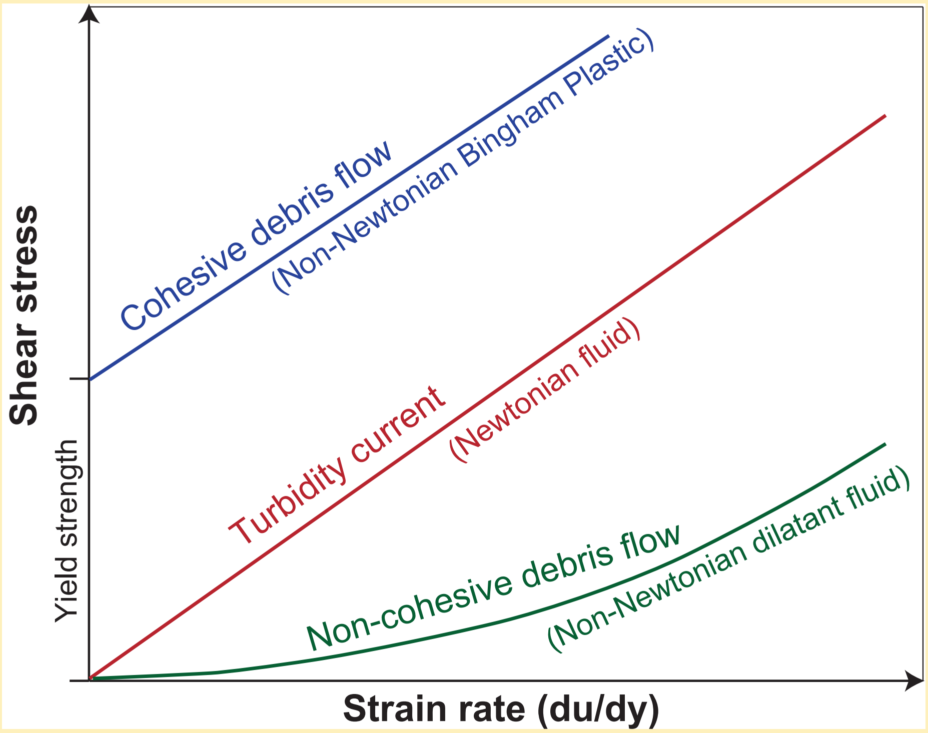

Figure 1. Basic types of rheology in sediment gravity flows. According to this diagram, turbidity currents are Newtonian fluids, whereas debris flows are not. Debris flows can be either non-Newtonian Bingham plastics (cohesive debris flows; e.g., mud flows) with a certain yield strength, or non-Newtonian dilatant fluids (non-cohesive debris flows; e.g., grain flow) without any yield strength.

rheology. Sediment gravity flows can show two types of non-Newtonian rheology (Fig. 1). In a non-Newtonian Bingham plastic, a critical value of shear stress (called yield stress) has to be crossed before there is any deformation, after which the deformation is linear (i.e., a Bingham plastic is a combination of an ideal plastic and a Newtonian fluid). In a non-Newtonian dilatant fluid there is no yield strength, but the deformation is nonlinear with applied stress in such a way that it becomes progressively harder to deform the fluid (Fig. 1). Applying the above concepts, I recommend that sediment gravity flows with Newtonian rheology should be called 'turbidity currents,' and those with non-Newtonian rheology should be called 'debris flows' (Fig. 1). Debris flows can be divided further into 'cohesive debris flows' (non-Newtonian Bingham plastics), and 'non-cohesive debris flows' (non-Newtonian dilatant fluids) (Fig. 1). This 'cohesiveness' of debris flows generally depends on the clay concentration of the flows. Although some workers (e.g., Hampton, 1975; Baas and Best, 2002) showed that as little as 2-4% clay (by volume) can generate yield strength in the flows, further research is needed to clarify the matter. So far, we know the least about the numerical and experimental modeling of non-Newtonian dilatant sediment gravity flows (e.g., grain flows) and their deposits. I suspect that it is a critical loophole in understanding the evolution of sediment gravity flows; hence it is an issue of turbidite controversy.

It may be easy to determine the rheology of flows in the laboratory. However, interpreting the flow rheology of a deposit by examining its depositional features may be challenging. There are sediment gravity flow deposits that share both the characters of turbidites and debrites (deposits of debris flows). If we follow the turbidite controversy for the last ten years, it becomes obvious that these hybrid deposits are the main issue of debate. A plethora of terminology (e.g., high density turbidity currents, sandy debris flows, slurry flows, concentrated density flows) has been applied to these rocks. Most of these deposits originate from rheologically stratified (or bipartite) sediment gravity flows (e.g., Sanders, 1965; Tinterri et al., 2003) with commonly a lower zone of non-Newtonian dilatant fluid (non-cohesive debris flow) overlain by a Newtonian fluid (turbidity current). Because these types of flows can frequently change the intra-flow rheological boundaries, and can generate a single event bed, a separate name is needed for these flows and their deposits. In this study, these flows are called 'dense flows' (after Allen, 1997), as they show an intermediate density (due to intermediate sediment concentration) between turbidity currents and debris flows (Fig. 2A), and their deposits are named 'densites.' However, it is emphasized that according to rheology there are only two basic types

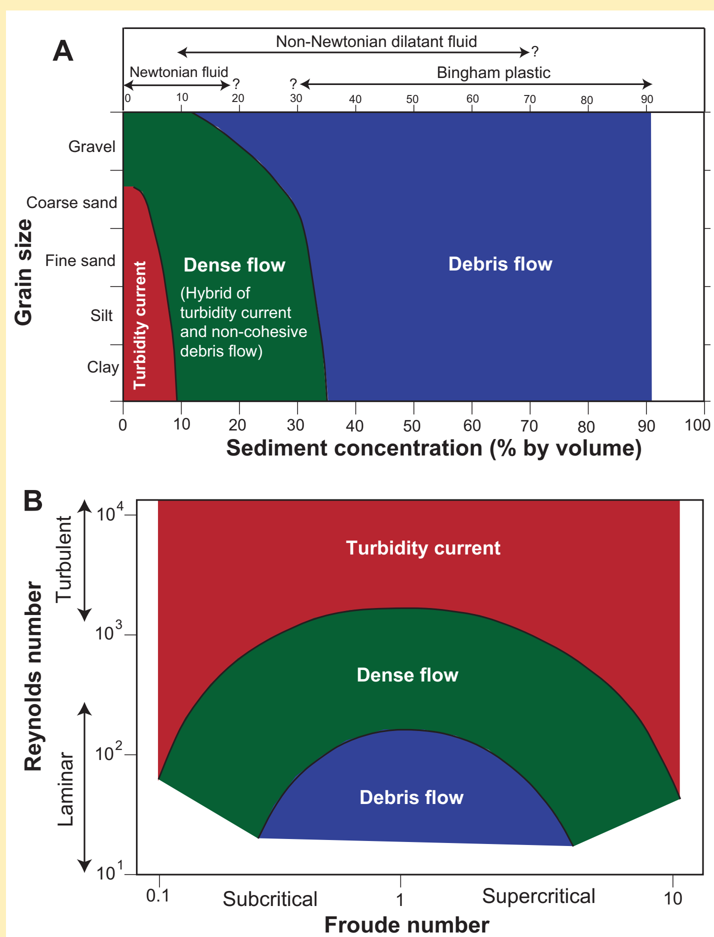

Figure 2. Distribution of different types of sediment gravity flows in 2-D space of sediment concentration vs. grain size (A), and Reynolds number vs. Froude number (B). Note that dense flows (rheologically stratified sediment gravity flows) occupy an intermediate position between turbidity currents and debris flows. For convenience, rheological types are shown for possible operational ranges of sediment concentrations; however, the percentage of clay within the bulk sediments (not shown in Fig. 2A) is an important factor controlling the flow rheology (after Allen, 1997).

Increasing fluid content ↑

Rheology	Flow Type		Deposits		Dominant sediment-support mechanism
Newtonian fluid	**Turbidity current** (mostly turbulent)	Subcatagories: - Low-concentration (<1%) & muddy (e.g., fluid mud ?) - Low-concentration (0.2-3%) & medium-grained (Hyperpycnal flow: Mulder et al., 2003) - Low-concentration & fine-grained (Stow & Shanmugam, 1980) - Medium-grained classic (Bouma, 1962)	**Turbidite**	**Gravite** (Gani, 2003)	Fluid turbulence
Variable (Partly non-Newtonian fluid, partly Newtonian fluid)	**Dense flow** (partly laminar, partly turbulent)	Variously named as: - High-density turbidity currents (Lowe, 1982) - Sandy debris flows (Shanmugam, 1996) - Slurry flows (Lowe & Guy, 2000) - Concentrated density flows (Mulder & Alexander, 2001) - Liquified flows /fluidized flows	**Densite** (This study)		Dispersive grain pressure, fluid turbulence, escaping pore fluid, matrix strength
Non-Newtonian dilatant fluid	**Debris flow** (mostly laminar)	Non-cohesive debris flow (e.g., grain flow)	**Debrite**		Dispersive grain pressure
Bingham plastic		Cohesive debris flow			Matrix strength
Bingham plastic	Slide and slump		Slide and slump depostis		Matrix strength

Figure 3. Classification of sediment gravity flows with a simplified nomenclature for the flow types as well as their deposits. Flow rheology is the basis of this classification (Fig. 1). Direction of increasing fluid content is roughly analogous to the down-slope evolution of sediment gravity flows. Flow states and sediment-support mechanisms are incorporated to give a comprehensive picture of the nature of these flows. For the range of sediment concentrations of these flows, see Fig. 2A.

of sediment gravity flows – turbidity currents and debris flows.

As mentioned earlier, there are no threshold values of sediment concentration (by volume) in constraining the types of sediment gravity flows. A range of sediment concentration values, which can vary according to grain size, is suggested for turbidity currents, dense flows, and debris flows (Fig. 2A). In general, with increasing sediment concentration, a turbidity current can transform into a dense flow, and then into a debris flow. Similarly, depending on the Froude numbers, these three flows can be both turbulent and laminar (Fig. 2B). However, turbidity currents are mostly turbulent, whereas debris flows are mostly laminar.

Based on flow rheology and incorporating the concept of dense flows, a simplified tabular classification of sediment gravity flows is generated (Fig. 3). Because most of the sediment gravity flows originate from slides and slumps, these are included at the bottom of this classification. The classification also shows the dominant sediment-support mechanism and flow state for each of the types to give a comprehensive picture about the nature of these flows.

DIAGNOSTIC FEATURES OF DIFFERENT SEDIMENT GRAVITY FLOW DEPOSITS

One reason for the turbidite controversy is the lack of consensus among sedimentologists about which depositional features are the key in determining the types of sediment gravity flows. While dealing with rocks, sedimentologists deduce the processes of depositions based on observable criteria of the deposits. Therefore, successful interpretation of sediment gravity flow deposits depends on how accurately we can establish a link between physics (of the process) and sedimentology (of the product). Rheology and sediment-support

Figure 4. Links between physics (of processes) and sedimentology (of products) of sediment gravity flows. Different rheological properties and sediment support mechanisms can generate depositional features diagnostic to specific types of sediment gravity flows.

Physics (of flows)		**Link**	**Sedimentology** (of products)
Rheology	Newtonian fluid	No yield strength; no freezing	Well sorting with no 'floating' clasts; top part always shows normal distribution grading
	Non-Newtonian dilatant fluid	Frictional freezing but no yield strength; freezes from the bottom up	No normal distribution grading; layer by layer accretion
	Bingham plastic	*En masse* freezing due to yield strength; plug flow; freezes from the top down	Poor sorting; preserved flow morphology; sharp upper boundary; boulder projecting through the top
Sediment-support mechanism	Fluid turbulence	Differential grain settling from suspension	Normal distribution grading; well sorting
	Escaping pore fluid	Leaves escape marks	Dish and pillar structures; convolution
	Dispersive grain pressure	Larger the grain, greater the liftoff	Inverse grading
	Matrix strength	Supports large/outsized clasts	Matrix-supported 'floating' clasts; poor sorting

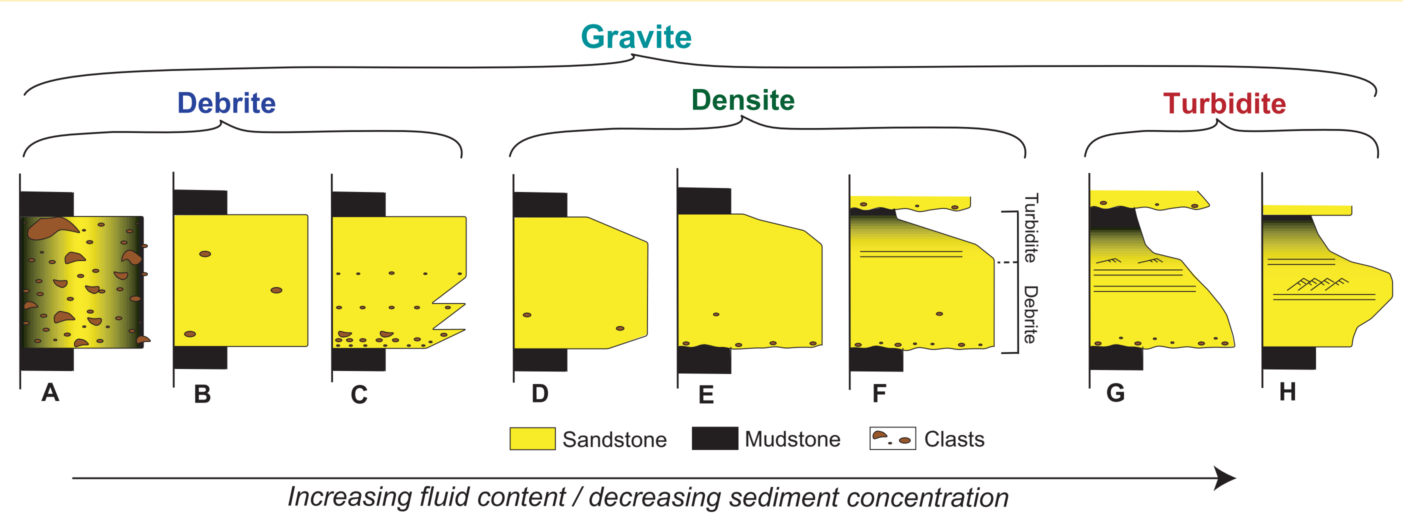

Figure 5. Simplified lithologic models for gravites (deposits of sediment gravity flows). A: cohesive debrite; B-C: non-cohesive debrites; D-F: densites (deposits of bipartite sediment gravity flows); G: turbidite (Bouma sequence); H: turbidite (deposit of hyperpycnal flow). Note that the arrowed direction is analogous to the down-slope evolution of sediment gravity flows. See text for discussion.

mechanisms of flows suggest a number of links, which, in turn, point to a set of key depositional features for each type of sediment gravity flow deposits (Fig. 4). Based on these diagnostic features, the concepts described in the previous section, and on numerous published works, I suggest the following terminology be applied for the deposits of different sediment gravity flows.

Gravite

Gravite is defined as a sediment or rock deposited from a sediment gravity flow (Gani, 2003). It is an umbrella term that incorporates all sediment gravity flow deposits (including slide and slump deposits) irrespective of their depositional environment (Fig. 5). The absence of such a concise, general term resulted in overuse and misuse of the term 'turbidite' in geological literature. For example, although submarine fans consist of different types of sediment gravity flow deposits, the term 'turbidite systems' has been used interchangeably with 'submarine fan systems' (e.g., Bouma and Stone, 2000). When the assignment of sediment gravity flow deposits to any particular types is either problematic (due to preservational bias, poor outcrop quality, etc.) or unnecessary, the term gravite can be used conveniently without creating any debate of the recent kind. Gravites exclude deposits of fluid gravity flows.

Debrite

Debrites, a class of gravites, are deposits of debris flows. Traditionally, debris flows are regarded as moving mass of rock clasts, clay minerals, and water. Although debris flows are commonly regarded as plastic flows (e.g., Lowe, 1982), there are other views that support non-Newtonian fluid rheology (e.g., Allen, 1997). In this study, for the sake of simplicity, I consider debris flows as sediment gravity flows whose rheology is not Newtonian (Fig. 1). Therefore, debrites can include both cohesive debrites (Bingham plastic rheology) and non-cohesive debrites (non-Newtonian dilatant fluid rheology). In general, a gravite bed that does not show any distribution grading even in the uppermost part is a debrite (Fig. 5). Cohesive debrites are relatively easy to identify. Most importantly, because of the yield strength of the flow, they contain 'floating,' outsized clasts in a muddy matrix (Figs. 5A, 6A). These deposits show poor sorting with rare, if any, coarse-tail grading. On the other hand, non-cohesive debrites are relatively mud-free sandstones (e.g., grain flow deposits) that show inverse grading because of the dispersive grain pressure (Fig. 5C). Generally, non-cohesive debrites aggrade layer by layer (~ <few cm) because they do not freeze en masse due to lack of yield strength (Fig. 5C). If we accept the notion that it takes little clay (~2%) for debris flows to develop yield strength, then debrites like Figure 5B are hard to classify further.

Densite

In this study, the term 'densite' is introduced for deposits of dense flows (Fig. 2). A densite is a hybrid gravite, consisting commonly of a lower debrite (mostly non-cohesive) layer and an upper turbidite layer without developing any bedding plane between these two layers (Figs. 5D-F, 6B). In geologic literature, these deposits have been identified frequently as turbidites with Bouma T_a or $T_{a\text{-}b}$ divisions. However, these beds show distribution grading only at the top parts, and the rest of these beds are either massive or inversely graded (Fig. 5D-F). As part of the turbidite controversy, various flow names have been proposed in explaining the depositional mechanism of these deposits (Fig. 3). The features of these beds are diagnostic of rheologically stratified/bipartite sediment gravity flows (i.e., dense flows) and are here called densites.

Turbidite

When the term 'turbidite' was introduced (Kuenen, 1957) for deposits of turbidity currents, it became popular in geological literature. I propose using turbidity currents only for sediment gravity flows with Newtonian rheology. Therefore, I recommend restricting the term turbidites to only those gravites that suggest a Newtonian rheology of the depositing currents. Turbidity currents have long been regarded as surge-type waning currents. These types of currents with Newtonian rheology, unlike other currents, should produce a diagnostic distribution grading (due to differential grain settling) from the bottom to the top of the deposits (i.e., Bouma sequence; Figs. 5G, 6C). However, Kneller and Branney (1995) introduced the concept of waxing, steady, and waning turbidity currents, which may produce reverse grading, non-grading, and normal grading, respectively. To explain the depositional mechanism of ungraded, massive sandstones Kneller and Branney (1995) advocated sustained 'high-density turbidity currents,' with a lower non-Newtonian rheology and an upper Newtonian rheology. Therefore, according to this study, the deposits of these 'high-density turbidity cur-

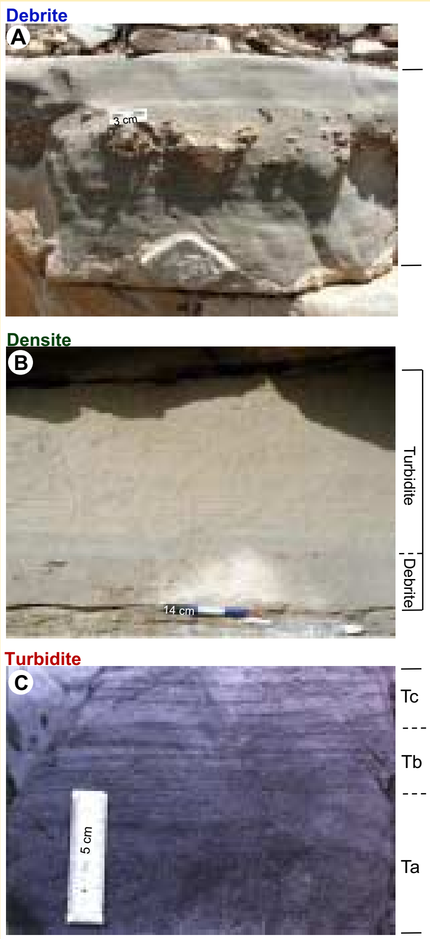

Figure 6. (A) Wackestone cohesive debrite in the base-of-slope deposits of Permian Lamar Limestone Member, Guadalupe Mountains, west Texas. Poorly sorted skeletal grains floating within matrix mud along with ungraded and sharp upper boundary indicate a Bingham plastic rheology of the depositing flow. Compare with Fig. 5A. (B) Delta front densite in the Upper Cretaceous Wall Creek Formation of central Wyoming. The lower layer of this bed is ungraded with floating mud clasts, hence indicates non-Newtonian flow rheology. The upper layer shows distribution grading with flat stratification indicating Newtonian flow rheology. Note that as bedding plane has not developed between these two layers, the entire bed is called a densite (hybrid of debrite and turbidite; compare with Figs. 5E-F). (C) Turbidite in Miocene base-of-slope deposits of the Bengal Basin, Bangladesh (modified from Gani and Alam, 1999). The entire bed shows distribution grading with the development of Bouma T_{abc} divisions and without any floating clasts in T_a division. These indicate differential grain settling from a Newtonian fluid. Compare with Fig. 5G.

rents' are densites (Figs. 5D-F). However, the top part of these deposits should show normal grading (e.g., Baas, 2004), otherwise they are debrites. The only real-world example of quasi-steady turbidity currents are the hyperpycnal flows produced during river floods. These hyperpycnites show reverse-then-normal grading analogous to a waxing-then-waning flood hydrograph (Mulder et al., 2003; Fig. 5H). Hyperpycnal flows are regarded as low-concentration (0.2-3% by volume) and medium-grained turbidity currents (Fig. 3). Therefore, their deposits (Fig. 5H) should not be confused with deposits of dense flows (Figs. 5D-F). However, more study is needed for successful identification of ancient hyperpycnites. Future research is also necessary in order to identify deposits of fluid muds commonly developed on modern continental shelves (Traykovski et al., 2000) from ancient records. Because sediment concentration of fluid muds is very low (<<1% by volume), it is debatable whether these should be regarded as fluid gravity flows or sediment gravity flows. Nonetheless, if these mudrock beds show normal grading they are best identified as turbidites. Alternatively, if these beds are ungraded they are debrite, in which case the sediment concentration of fluid muds should exceed 2% (cf. Baas and Best, 2002).

CONCLUSIONS

The overuse and misuse of the term 'turbidite' for many types of sediment gravity flow deposits has resulted in what I refer to here as the turbidite controversy. This controversy is rooted in the classification scheme of sediment gravity flows, which is poorly constrained and somewhat contradictory. I suggest a simple but well-constrained classification of sediment gravity flows based on flow rheology. Turbidity currents are Newtonian fluids, whereas debris flows are not. Debris flows can be of two types: a cohesive debris flow (a non-Newtonian Bingham plastic) or a non-cohesive debris flow (non-Newtonian dilatant fluid). Some sediment gravity flows may be rheologically stratified (or bipartite) in nature, so that commonly a lower layer of non-Newtonian rheology is overlain by a layer of Newtonian rheology. These types of flows are called dense flows and their deposits are named densites. Identification of flow rheology from ancient deposits may not be an easy task. Nonetheless, there are some diagnostic depositional features of debrites, turbidites, and densites that relate to the physics of corresponding flows. In order to avoid confusion, if it is not possible to determine the category of a sediment gravity flow deposit, we should simply call the deposit a gravite.

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SEPM MEMBERS:
READERS OF THE ROCKS

Summertime always causes me to think about the field with anticipation and nostalgia. Sedimentary geologists are, in large measure, field-based geoscientists. We are the few people on the planet who interpret the rocks, be they on Earth, the Moon, or Mars. By doing this, we have a distinct role to play in many of modern life's critical endeavors. My doctoral advisor, Lloyd Pray, would always tell us that if we could "read the rocks", we would always make a contribution and better yet keep a job. Whether our professional lives involve academia, government, or industry, and irregardless of whether it is in energy, minerals, water resources, or the environment, the ability to decipher the origin and history of the sedimentary rocks is a critical element of our work. Understanding the environments of deposition, the stratal geometries, diagenetic alterations, and structural configuration of the rocks is basic to our jobs.

As past-president, John Anderson, stated in an earlier letter, the first principles of science and mathematics are absolutely essential to modern geoscience and it's increasing quantification. There is also no substitute for field experience. It provides the context and ground truth for our ideas and for our interpretations of the subsurface. The field is where we go to test our ideas and concepts. It provides scale relationships from the seismic scale (10's-100's-m) to the reservoir flow unit scale (m's). Having just spent ten days in the field in Australia with our regional exploration team in Melbourne has reminded me once again of the value of this experience. The focus of the trip was to introduce a very experienced exploration group to ancient carbonate platforms using the classic outcrops of the Devonian of the Canning basin, and to expose them to the modern carbonate environments of the Shark Bay region. Observing the platform lithofacies, stratal architecture, and paleogeography of these different carbonate settings has enhanced their ability to interpret the subsurface by giving them visual images of scale and geometry, and by giving them insight into the lateral and vertical stratigraphic and lithofacies relationships present in carbonate sequences.

Field mapping is a critical component of the field experience. It forces us to build a three-dimensional picture of the geology of an area. It gives us the knowledge and insight into structure and stratigraphy that are essential to the interpretation of rocks less well exposed, of strata in the subsurface, and now even of the rocks of remote places like Mars. Fieldwork gives us an understanding of sedimentary environments from deepwater to the fluvial siliciclastics, to lacustrine settings, to evaporites, and to the whole world of carbonate platforms and basins. This understanding of the geometry and continuity of sedimentary rocks gives us a predictive framework that among many other things allows us to understand flow through porous media, whether that flow is hydrocarbons, water, or contaminants. Finally, the field is the database for biostratigraphy. It provides the basis for building a time history of the crust of the earth that is essential to our understanding, among other things, the movement of the continents and the origin of life.

As students and professionals, but especially as students, we cannot get enough field time. There is much we, as members of SEPM, can do to promote the field. I strongly encourage you all to take every opportunity to go to the field. Whatever the venue, field camp, field trips, or as part of your research, the more rocks you see the better a reader of those rocks you'll be. Field experience is absolutely essential to the education of a geoscientist, and every SEPM member should encourage their favorite University department to retain and enhance field-based programs. As undergraduate students, seek out Geoscience Departments for graduate work that embrace the field experience. As graduate students make the field part of your thesis. Those of us in the professional ranks should be proactive in taking students to the outcrop. Field-based work is critical to continuing to advance sedimentary geology, and there will always be work for the "reader of the rocks". Have a good rest of the summer, and I know I'll see many of you this fall at the GSA in Denver.

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The Sedimentary Geology and Paleobiology Program Update from NSF

INTRODUCTION

This column is our annual update on activities, opportunities and changes that are happening at NSF that impact the soon to be formalized Sedimentary Geology and Paleobiology Program at NSF. These are divided into Organization, People, Budget, Special Programs/Initiatives, and Program News.

ORGANIZATION

The Geology and Paleontology Program became three programs beginning August 1, 2004. These new programs are the Sedimentary Geology and Paleobiology Program (SGP), Geobiology and Environmental Geochemistry Program (GEG), and the Geomorphology and Land Use Dynamics Program (GLD). Other changes include the establishment of the EarthScope Program, for which a Program Officer has already been hired. Along with these new programmatic additions, there is a new organization for the Earth Science Division. The new organization consists of two sections, the Surface Earth Processes (SEP) Section and the Deep Earth Processes (DEP) Section.

PEOPLE

There have been several changes in staffing this year. SGP is staffed by one full time and one half time Program Director—H. Richard Lane and Paul Filmer, respectively—one science assistant—Shana Pimley—and one program assistant—Lerome Jackson. Felicia Means, who has served the Geology and Paleontology so well for so many years, is now the Administrative Officer for the Division. In the new organization, the EAR Division, directed by Hermann Zimmerman, consists of two sections, SEP and DEP. These are headed by Walter Snyder and Jim Whitcomb, respectively. Currently, the Division is advertising for a temporary two-year appointment to replace Walter Snyder as the Section Head for the Surface Earth Processes Section, with an expected selection after the first of the year. I strongly encourage,…. no plead, for those in our community who are interested and qualified to apply. Without strong scientific leadership in NSF aligned in our area of the science, the exciting progress seen in the last couple years will end. Many other EAR Division staffing changes have occurred in the last couple years and the current staffing can be found on the NSF website at www.geo.nsf.gov/ear/start.htm.

BUDGET

As reported last year, Congress and the President had NSF on track for doubling its budget in 5 years. A number of obvious economic problems have conspired to delay or sidetrack that plan. The overall budget increase declined for NSF and EAR significantly this year to around 1%, for which most increased revenues were applied to Earthscope research fund and the geoinformatics initiative. Bottom line is that the GE and other EAR core programs' budgets were flat for the fiscal year 2004. Budget requests to Congress for GY 2005 represent a 3% increase, but it appears as though the optimistic scenario is for a flat budget.

SPECIAL PROGRAMS

There are numerous NSF special programs that should be of interest to the SGP community as funding sources. These special programs generally last for 3-5 years, require multidisciplinary team approaches, and commonly fund larger requests. Some of these include:

- **Collaborations in Mathematical Geosciences (CMG):** www.nsf.gov/pubs/2004/nsf04508/nsf04508.pdf
- **Assembling the Tree of Life (ATOL):** www.nsf.gov/bio/progdes/bioatol.htm
- **Biocomplexity in the Environment (BE): Integrated Research and Education in Environmental Systems:** www.nsf.gov/pubs/2002/nsf02167/nsf02167.htm
- **Earth System History (ESH):** www.nsf.gov/pubs/2004/nsf04597/nsf04597.htm
- **Research in the Biogeosciences:** www.geo.nsf.gov/cgi-bin/geo/showprog.pl?id=114&div=ear
- **Major Research Instrumentation (MRI):** www.nsf.gov/od/oia/programs/mri/start.htm
- **Margins:** www.nsf.gov/pubsys/ods/getpub.cfm?ods_key=nsf02110
- **Faculty Early Career Development (CAREER) Program:** www.nsf.gov/pubsys/ods/getpub.cfm?ods_key=nsf02111

NSF/SGP SUPPORTED PROJECTS OF INTEREST TO THE SEDIMENTARY GEOLOGY AND PALEOBIOLOGY COMMUNITIES

Geoinformatics: NSF is emphasizing the need for development of a cyberinfrastructure across all of science and engineering. The community has coined the term "GeoInformatics" for cyberinfrastructure applied to the Earth Sciences. GeoInformatics is an information technology system that will provide earth scientists with the tools necessary to conduct the next generation of geoscience research. GeoInformatics is designed to take advantage of powerful new information technologies such as Geographical Information Systems (GIS), remote sensing, scientific visualization, information networks, and wireless applications in a truly integrated manner.

NCED: The University of Minnesota's St. Anthony Falls Laboratory (SAFL), Univ. California—Berkeley, the Science Museum of Minnesota, MIT, Princeton University, and Fond du Lac Tribal and Community College have received a five-year (renewable for up to 5 additional years) Science and Technology Center (STC) grant from the NSF for a new National Center for Earth-surface Dynamics (NCED). **www.nced.umn.edu**

CHRONOS: CHRONOS aims to create a dynamic, interactive and time-calibrated framework for Earth history. CHRONOS's main objective is to develop a network of databases and visualization and analytical methodologies that broadly deal with chronostratigraphy. The goal is not only to produce a system for assembling and consolidating such a wide range of Earth history data, but also to provide a platform for modern, innovative Earth science research, and to empower the general public with new knowledge of Earth science facts and issues. **www.chronos.org**

EARTHTIME: Recent developments in geochronology and in stratigraphic correlation suggest that for the first time it will be possible to calibrate the entire geologic timescale to better than 0.1% back at least to the beginning of the Phanerozoic, 542 million years ago. This effort will require about a decade of focused work; unprecedented cooperation between different geochronological laboratories and community-wide involvement of stratigraphers, geochronologists, geochemists, magnetostratigraphers, and paleontologists. The payoff of this effort is enormous. **www-eaps.mit.edu/earthtime/**

THE PALEO PORTAL: This site is a resource for anyone interested in paleontology, from the professional in the lab to the interested amateur scouting for fossils, to the student in any classroom. Many different resources are gathered into this single entry "portal" to paleontological information on the Internet. **www.paleoportal.org**

GEOSYSTEMS: GeoSystems is a developing community-based initiative that focuses on the importance of the deep-time perspective for understanding the complexities of Earth's atmosphere, hydrosphere, biosphere and surficial lithosphere using climate as the focus. The proposed GeoSystems initiative will be able to progress only through data enhancements and modeling collaborations among earth, ocean, and atmospheric-modeling researchers, focusing on the deep-time record to achieve a holistic understanding of Earth's climate and related systems. This effort began with a National Science Foundation-sponsored workshop in May, 2003 that addressed the state of research on Earth's pre-Quaternary climate record. A second workshop is slated for September, 2004. **geosystems.ou.edu**

PALEOSTRAT: PaleoStrat is a non-profit, web-accessible information system currently being developed and as part of a collaborative research effort to help implement web-based tools to deal with stratotype sections and the geologic time scale- specifically for the Carboniferous and Permian intervals. However, its structure will be capable of supporting such data for all of the Phanerozoic. **www.paleostrat.com**

PALEOBIOLOLGY DATABASE: This effort is to provide the public and the paleontological research community with collection-level information on the spatial, temporal, and environmental distribution of fossils, as well as images and taxonomic accounts of fossils and web-based scripts for analyzing large-scale patterns in these data. In the future, phylogenetic and morphometric data also will be collected and provided freely on the web. Any professional paleontologist may volunteer to become a contributor to the database. **paleodb.org**

CSDMS (Community Surface Dynamics Modeling System): A group of Earth system modelers have recently launched an international effort to develop a suite of modular numerical models able to simulate the evolution of landscapes and sedimentary basins, on time scales ranging from individual events to many millions of years. Ideas behind the CSDMS concept were discussed by participants of at several international workshops. The formal CSDMS idea, however, took shape at a panel convened by NSF in March 1999. That panel identified a CSDMS as a high priority NSF research initiative in sedimentary geology, and since then the concept has been widely discussed in the North American sediment-dynamics community.
instaar.colorado.edu/deltaforce/workshop/csdms.html

GEON: The GEON (GEOscience Network) research project is responding to the pressing need in the geosciences to interlink and share multidisciplinary data sets to understand the complex dynamics of Earth systems. The need to manage the vast amounts of Earth science data was recognized through NSF-sponsored meetings, which gave birth to the Geoinformatics initiative. The creation of GEON will provide the critical initial infrastructure necessary to facilitate Geoinformatics and other research initiatives, such as EarthScope. **geongrid.org**

HOUSTON RESEARCH CENTER (HRC): Much material resulting from NSF-funded research never reaches a place that storage and later access is assured in perpetuity. Much of these materials are eventually discarded and many valuable samples and materials are lost forever. Because of this EAR is looking for a place for the community to permanently store such materials. Although not yet definite, the Houston Research Center (HRC) of the Texas Bureau of Economic Geology has come forward to act in this capacity with the help of NSF funding. **www.beg.utexas.edu/crc/houston.htm**

SEDIMENTARY GEOLOGY INITIATIVE: The Sedimentary Geology Initiative is a community-based effort, co-sponsored by NCED, SEPM, and NSF, to build a stronger and more cohesive sedimentary geology community. The first informal meetings in 2003, lead to a desire for a larger open discussion meeting just before the AAPG/SEPM annual meeting in Dallas 2004. This all day meeting took place on April 16, 2004 and another is planned for Saturday, November 6 at GSA meeting in Denver.
www.nced.umn.edu/Sedimentology_Stratigraphy_Initiative.html

EARTHSCOPE: EarthScope is a bold undertaking to apply modern observational, analytical and telecommunications technologies to investigate the structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. EarthScope will provide a foundation for fundamental and applied research throughout the United States that will contribute to the mitigation of risks from geological hazards, the development of natural resources, and the public's understanding of the dynamic Earth. **www.earthscope.org**

CUAHSI: The Consortium of Universities for Advancement of the Hydrologic Science, Inc. is a consortium of 68 universities that was organized to foster advancements in the hydrologic sciences, in the broadest sense of that term. Although there are 68 participating universities at this time, participation is unlimited. Please contact Marshall Moss at **memos@worldnet.att.net** or Rick Hooper at **rhooper@agu.org** if you are interested in your university participating. **www.cuahsi.org**

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