Complementary Results on Experiment-Derived Classification of Submarine Sediment Gravity Flows*

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Abstract

A sequence of ten fully-equipped experiments of continuous flows of sediment gravity flows (SGF) was conducted in a long-glass flume (15 × 0.4 × 0.6 m) in order to identify variations in their depositional and hydrodynamic behavior in function of increments in sediment concentration and/or clay content. Mineral Coal (D50 = 55μm, density = 1,190 kg/m³) Kaolin (D50 = 6 μm, density = 2,600 kg/m³) mixtures were prepared to constitute distinct SGF with volumetric concentrations ranging from 2 and 40% and clay contents of 5, 12.5, and 50%. The mixture volumes were 200 and 400 liters, and the discharge varied from 50 to 60 l/min. Images of all simulated SGF were obtained using two video cameras and two medical ultrasound scanner. Velocity and concentration data were also collected using, respectively, 24 UVP probes and 6 UHCM probes. Results showed that significant changes occurred in the dynamics of flow as well as in the deposits generated as concentration/clay content increases. Low concentration flows (Cv < 7.5%) were thicker; lower velocity, and turbulence keep sediments in suspension. In line, more concentrated flows (CV > 10%), a bipartite flow stratification was observed. In the top layer, the predominant sediment-support mechanism was turbulence. However, in the basal layer, mass transport became predominant (Cv > 20%). When the clay content was greater than 12.5%, the formation of a mixed layer was fully inhibited. The Sediment-support mechanism also drives the depositional process: the sediment transported by turbulent flows was deposited grain by grain as flow decelerates, whereas the mass transported sediment was deposited just after an abrupt stop (injection stop), characterizing to a frictional (no clay) and/or cohesive freezing (with clay). The slicing analysis of the non-cohesive flow deposits showed that the amount of material deposited (thickness) and the grain size decreasing along the channel. In addition, increase in concentration provided greater flows competence, which can be identified by the larger sediment size in the most distal part of the channel. The increase in clay content, in turn, reduced the flow capacity of transport causing the formation of thicker deposits. Rheological aspects of these distinct flows can also explained the differences between SGF simulated. Finally, those new results can complement/better conception previous experiment-derived classification models for submarine sediment gravity flows.
References Cited


A sequence of ten fully-equipped experiments of continuous flows of sediment gravity flows (SGF) was conducted in a long-glass flume (15 x 0.4 x 0.6 m) in order to identify variations in their depositional and hydrodynamic behavior in function of increments in sediment concentration and/or clay content. Mineral Coal (0.02 = 55 μm, s.g. = 1.19) and Kaolin (D50 = 6 μm, s.g. = 2.6) mixtures were prepared to constitute distinct SGF with volumetric concentrations ranging from 2 and 40% and clay contents of 5, 12.5 and 50%. The mixture volumes were 200 and 400 liters, and the discharge varied from 50 to 60 liters. Images of all simulated SGF were obtained using two video cameras and two medical ultrasound scanners. Velocity and concentration data were also collected using, respectively, 24 UVP probes and 6 UHCM probes.

**EXPERIMENTAL SETUP**

- **RESERVOIR 2.5 m²**
- **Inlet Diffuser**
- **UVP**
- **ADV**
- **UHCM**
- **Video camera**
- **ULTRASOUND**

**EXPERIMENTS DATA**

<table>
<thead>
<tr>
<th>RUN</th>
<th>CV</th>
<th>SEDIMENTS CONTENT</th>
<th>Volume [ℓ]</th>
<th>Q [litres/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>11.9</td>
<td>100% C</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>E2</td>
<td>30.6</td>
<td>100% C</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>E3</td>
<td>29.28</td>
<td>50% C, 50% K</td>
<td>500</td>
<td>70</td>
</tr>
<tr>
<td>E4</td>
<td>53.12</td>
<td>87.5% C, 12.5% K</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>E5</td>
<td>31.8</td>
<td>95% C, 5% K</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>E6</td>
<td>7.7</td>
<td>100% C</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>E8</td>
<td>1.84</td>
<td>100% C</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>E9</td>
<td>18.98</td>
<td>100% C</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>E10</td>
<td>37</td>
<td>100% C</td>
<td>200</td>
<td>50</td>
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</table>

**EXPERIMENTAL-DERIVED CLASSIFICATION - MANICA (2009)**

**INTRODUCTION & BACKGROUND**

**COMPLEMENTARY EXPERIMENTS OF SEDIMENT GRAVITY FLOWS**

- Continuous Flows experiments
- Long Flume (> 15 m)
- Multi equipped experiments
- Spatial data analysis – 2 sets (proximal and distal)
- Rheology of the mixtures used (coal and kaolin from Castro 2016)
- Inner visualization of the – (medical ultrasound)
- Dip and strike section of the deposit
- Process-Based analysis

**FACILITÉS & EXPERIMENTAL SETUP**

**SEDIMENTS CARACTERIZATION**

<table>
<thead>
<tr>
<th>Sediment</th>
<th>K</th>
<th>KAOLIN</th>
<th>COAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol</td>
<td>K</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Cohesive</td>
<td>YES</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>D50 [μm]</td>
<td>1.09</td>
<td>2.72</td>
<td></td>
</tr>
<tr>
<td>D40 [μm]</td>
<td>6.55</td>
<td>4.14</td>
<td></td>
</tr>
<tr>
<td>D30 [μm]</td>
<td>29.45</td>
<td>155.74</td>
<td></td>
</tr>
<tr>
<td>D20 [μm]</td>
<td>13.23</td>
<td>49.95</td>
<td></td>
</tr>
</tbody>
</table>

**EXAMPLES OF SGF CLASSIFICATION**

- **SGF CLASSIFICATION**
- **Rheology**
- **Flow Regime**
- **Matrix Strength**
- **Yield Strength**
- **Clay/Mud WAVY REGION**
- **ALMOST RIGID REGION**
- **DEFORMATION REGION**
- **DISPLACEMENT REGION**
- **FLOW REGIME**
- **DEFORMATION REGIME**
- **FINAL DEPOSITION**

**EXPERIMENTS TABLE**

**SEDIMENT GRAVITY FLOWS PROPERTIES - MANICA (2009)**

**INLET DIFUSER**

**video camera**

**ULTRASOUND**

**Flume (>)**

**FACILITÉS & EXPERIMENTAL SETUP**

**COMPLEMENTARY EXPERIMENTS OF SEDIMENT GRAVITY FLOWS**

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Experiments increase the understanding on High-Density currents like flow (with a little clay on it < 12%) is governed by other sediment support
mechanism than Turbulence (hindered settling). Yet, Rheology behavior of the mixtures confirmed as a key aspects on the flow deposits model.

Classical low-density flows and debris flows behavior were also confirmed.

This Experimental-Derived classification aims no create other synonyms, but keep focus on the hydrodynamic and depositional processes based only.