Tales Set in Stone
40 Years of the International Geoscience Programme (IGCP)

Subaqueous mass movements occur in almost all environments in the ocean and lakes, in fjords and along the coastline. They can have volumes of up to several hundred cubic kilometres and are typically at least one order of magnitude larger than their counterparts on land. They are found throughout the geological record right up to the present and are caused by various triggering mechanisms including earthquake, erosion, gas hydrate dissociation, diapirism (a sharply upward fold in rock) and wave action. Like their counterparts on land, subaqueous...
mass movements result from a disequilibrium between resisting forces and stresses. Damage can be huge, extending over more than 1,000 km and threatening underwater communication cables and infrastructure (pipelines, wellheads, fishing habitats, coastal infrastructure and communities). They are also responsible for about 10% of observed tsunamis.

Submarine mass movements of various sizes and styles have shaped the sea floor through geological time; their

The Grand Banks slide and tsunami, off the Newfoundland coast of Canada. (a) Map of slide showing location of the breakage point of the Transatlantic cable within the slump zone (red); (b) a large schooner at anchor with a tsunami-born two-storey house (and an attached shed behind it), in Little Bunn Harbour, floating directly astern of the schooner (A. Ruffman, pers. com.; photo by Father James Anthony Miller). (From Heezen, B.C., and Ewing, M., 1952. Turbidity currents and submarine slumps, and the 1929 Grand Banks earthquake. American Journal of Science, 250: 849-873). © Jacques Locat
Participants of the 3rd symposium of IGCP 511 (Santorini, Greece).
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deposits now play an important role in controlling the location of hydrocarbon reservoirs. In developing our understanding of submarine mass movements and their consequences, there are two milestone examples: the Grand Banks slide of 1929 and the Storegga slide which took place 8,100 years ago.

On November 18th 1929, a M7.2 earthquake shocked the Grand Banks to the southeast of Newfoundland, Canada, triggering a huge (~150 km³ in volume) submarine mass movement; it generated a tsunami which devastated a small village in Newfoundland, killing 27 people. The turbidity current generated by the slide broke submarine cables over a distance of up to 1,000 km. A similar event occurred in Papua New Guinea in 1998 with more than 2,000 casualties.

The large and much older Storegga slide involved a total volume of 2,500 km³ and removed about 300 km of the Norwegian continental margin. Such a massive failure generated a tsunami, evidence of which has been recorded as far south as the eastern coast of Scotland and north-eastern England. Located above one of the major gas reservoirs in the Norwegian Sea, the Storegga slide was the subject of a comprehensive investigation involving a multidisciplinary approach from Earth sciences to engineering.

These milestone cases illustrate clearly that research on subaqueous mass movements has clear societal implications. Such mass movements represent a major geohazard because of their potential destruction of near-shore structures, coastal facilities, seafloor life and offshore seabed structures. Submarine slides can trigger tsunamis and are capable of methane gas release into the seawater and the atmosphere. IGCP 511 was initiated as a community effort originating from the 1st International Symposium on Submarine Mass Movements and Their Consequences (ISSMMTC) held in Nice, France in 2003; it coincided with the conclusion of the COSTA project (COntinental Slope sTAbility), an international investigation of submarine mass movements. Since then, IGCP 511 has promoted many workshops and conferences, including the continuation of the ISSMMTC series, as well as its biennial conferences in Oslo, Norway (2005), Santorini, Greece (2007) and Austin, Texas, USA (2009). On the basis of these conferences alone, more than 220 peer-reviewed papers have been published (also available in electronic format). The ISSMMTC conference series has continued under the IGCP 585 E-MARSHAL project. The various IGCP 511 symposia were in many ways strongly supported by various industrial, governmental and non-governmental organizations.

This IGCP project has brought a worldwide perspective to submarine mass movements and their consequences. The project attracted a broad range of research, covering fundamental as well as site-specific studies from many parts of the world including the Atlantic and Pacific oceans, inner seas like the Mediterranean, fjords and lakes using the most recent technologies from multi-beam sonar imaging and 3D seismic imaging to modelling of slope stability to post-failure evolution and tsunami generation, propagation and run-up. It has also acted as a unique forum to showcase the diversity and complexity of the geomorphology and geology of the subaqueous environment.

One of the main goals of IGCP 511 was to advance science through networking of scientists and engineers from around the world by supporting meetings and
conferences in particular with a large proportion of its budget dedicated to the active participation of students. This goal was achieved by bringing together more than 150 scientists from 17 countries as well as financially supporting a number of students and researchers from developing countries. IGCP 511 was instrumental in securing the inclusion of marine geohazards in the Integrated Ocean Drilling Program (IODP) science plan. It also supported IODP projects aimed at understanding the role of groundwater flow on submarine mass movement initiation.

On the basis of our five years of cooperation on submarine mass movements within the framework of IGCP 511, significant advances have been made on a number of important topics, including groundwater flow along continental margins and slope instabilities, landslides and tsunamis, 3D seismic imagery revealing palaeo-submarine landslides, and mechanisms of transition from slope failure to post-failure evolution.

In conclusion, the advancement in our knowledge of submarine mass movements and their consequences has been greatly enhanced by the sustained support of UNESCO and IUGS. Such support has provided an exceptional framework with which to establish a strong research network for the benefit of society.

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