Project Details

Name of project: **Subaqueous Landslide Morphometrics Database and Website for Global Outreach and Data Collection**

Project lead and contact details: Zane Jobe, Colorado School of Mines zanejobe@mines.edu

Project partners and contact details:

- Jason Chaytor, USGS Woods Hole Coastal and Marine Science Center, jchaytor@usgs.gov
- Lorena Moscardelli, S4SLIDE IGCP/UNESCO-640, lorena.moscardelli@utexas.edu
- Lesli J. Wood, Colorado School of Mines, lwood@mines.edu
- Davide Gamboa, British Geological Survey, davide@bgs.ac.uk
- Roger Urgeles, Institut de Ciències del Mar, CSIC, Spain, urgeles@icm.csic.es
- William Meservy, Institut de Ciències del Mar, CSIC, Spain, william.meservy@icm.csic.es
- Wylie Walker, Encana Corporation, wylie.walker@gmail.com
- Alexis Wright, Colorado School of Mines, alexiswright@mines.edu
- Sebastian Cardona, Colorado School of Mines, scardona@mines.edu
- Maxwell M. W. Silver, Colorado School of Mines, mmsilver@mines.edu
- Yizhaq Makovsky, University of Haifa, Israel, yizhaq@univ.haifa.ac.il
- Joshu Mountjoy, NIWA, New Zealand joshu.mountjoy@niwa.co.nz
- Sally Watson, NIWA, New Zealand sally.watson@niwa.co.nz
- Aaron Micallef, GEOMAR, Germany amicallef@geomar.de
- Sebastian Krastel, Kiel Univesity, Germany, sebastian.krastel@ifg.uni-kiel.de
- Christopher Jackson, Imperial College, c.jackson@imperial.ac.uk
- Michael Steventon, Imperial College, michael.steventon13@imperial.ac.uk
- Ricardo León, IGME, r.leon@igme.es
- Michael Strasser, University of Innsbruck, michael.strasser@uibk.ac.at

Proposed start and end date: September 1, 2019 to May 1, 2020

Budget Requested: $8,000

Budget Summary:

$4,500 Salary for codebase and website development ($15/hr, total of 300 hours)

$1,000 Present results at ESIP Summer 2020

$2,500 9th ISSMMTC in Dublin 2020 Workshop to teach methodologies and convey database standards and contribution pathways

Project Outline

Project description: Subaqueous landslides are common deposits occurring in environments ranging from lakes and coasts to deepwater ocean basins. Their occurrence can trigger destructive tsunamigenic waves affecting coastal populations, damaging and disrupting communication and other industrial infrastructure (e.g. oil and gas, offshore wind farms, etc), and upsetting biotic communities. In addition,

ancient subaqueous landslides play an important role in the development and distribution of non-renewable natural resources (i.e., oil and gas), and impact the safety of exploring for deep subsurface resources. Despite recognizing the broad scientific importance of subaqueous landslides, most of the research has concentrated on the qualitative description of these events/deposits. Most recently, the subaqueous landslide community has come to a consensus to standardize the collection of quantitative data associated with the morphometry (e.g., length, area, volume, runout distance, etc.), setting and physical nature of these deposits (Clare et al., 2018). *This proposal aims to develop an online, interactive, user-friendly, and robust web platform to host this burgeoning community database as well as promote collection of standardized, quantitative data for subaqueous landslide deposits using criteria defined by the community consensus* (Clare et al., 2018). We will also provide a set of Python-based tools for subaqueous landslide analysis that can be ultimately used for a variety of modeling efforts including tsunami and geohazard risk assessment, paleoclimate and organic carbon modeling, and many other applications. We see this database and analysis toolset as a bridge to better data collection practices, modeling efforts, and collaborations not only within the subaqueous landslide community, but also with the subaerial landslide community.

Project objectives, significance, and impact:

Objectives: Our objective is to consolidate subaqueous landslide data ranging from modern to ancient timescales across lacustrine to marine settings into a simple, open-access platform that is interactive, evergreen, and filterable. This effort will standardize measurement of landslide characteristics and metadata using community-derived guidelines (Clare et al., 2018). Numerous researchers have been actively employing the Clare et al approach for new data collection, and their efforts will form the initial database. The end result will be a website where researchers can explore this global database as well as populate the database with new data. Tools allowing users to query, filter, plot, run statistics, visualize and export data will allow researchers and political decision-makers to access the necessary data to assess hazards and model impact scenarios for subaqueous landslide occurrence.

Significance: Subaqueous landslides can affect coastal communities by triggering tsunamis, as witnessed during the devastating 1998 Papua New Guinea event that resulted in ~2,200 deaths (Tappin et al., 2001) and the 1958 subaerial rock fall and associated subaqueous landslide in the Lituya Bay that triggered the highest tsunamigenic wave runup in recorded history (524 m) resulting in infrastructural damage and five human casualties (Fritz et al, 2009). Most recently, two deadly subaqueous landslides in 2018 occurred, with varied causal mechanisms: on 28 September 2018, a 7.5 magnitude earthquake near Palu, Indonesia triggered multiple coastal landslides that transitioned into the marine realm, triggering the 6 m high Sulawesi tsunami that caused 384 deaths and devastated coastal communities along its path (Sassa and

Takagawa, 2019); on 22 December 2018 the eruption of the Anak Krakatau volcano, located in the Sunda Straits of Indonesia, resulted in subaerial-to-subaqueous landslides and a resultant 13 m high tsunami that killed 437 people and displaced 33,000 (Tappin et al., 2019). Unfortunately, these recent events have demonstrated that the deployment and maintenance of tsunamigenic detection and warning systems have been deficient in these regions in part due to lack of technical resources and the high cost of equipment and technology. A more efficient way to tackle this problem would be to highlight and prioritize areas of increased risk for the occurrence of subaqueous landslides and then concentrate resources to those areas. The proposed dataset containing standardized measurements of worldwide subaqueous landslide measurements represents a first step to provide an open access data repository to tsunami modellers working in refining prediction efforts.

Impact: This project will lead to the formation of an open-access online database, where users will be provided a template and guidelines for submitting their own data. Interactive maps and catalogs will be available to assist in stochastic and probabilistic modeling of subaqueous landslide events, model potential tsunamigenic forces and impacts, facilitate research and education efforts, and investigate both marine and coastal geohazard linked to these events. Access to this database by the global community will provide a comprehensive, global, and curated database to solve global problems of seafloor dislocation and its impact on seafloor installations, resource extraction, biotic communities, and enable paleoclimate studies. Finally, knowledge provided to the community through this database will assist with de-risking of drilling hazards for subsurface energy resource extraction.

Description of key project steps and timeline:

Timeline:

Phase One: September-December 2019: The standardized methods developed by Clare et al. (2018) will be implemented into a GitHub backend (a database structure and analysis tools) and an Azure hosted frontend, a website with database exploration tools and a webform for adding data to the database. We will employ student software developers at Mines with knowledge of Java, JSON, html5, and Python to build the software stack. At the end of Phase One, we will have a complete beta software stack.

Phase Two: January-June 2020: Testing and further development of the frontend and backend, with the project partners acting as beta testers. Workshop as part of the 9th International Symposium on Submarine Mass Movements and Their Consequences in Dublin, Ireland June 20th-27th, 2020 (link)

Phase Three: Summer 2020: Deployment of website and initiation of community outreach efforts to promote crowd-sourcing of data.

Description of additional funding currently supporting this work:

- $32,000 from S4SLIDE IGCP/UNESCO-640 in planning workshops, meetings, etc. since 2015; this money funded the workshop that resulted in the Clare et al. (2018) paper.
- $10,000 from Lesli Wood (through the SAnD consortium) to host planning S4SLIDE Workshop and travel to meetings since 2015.

Outreach

What groups/audiences will be engaged in the project?

- S4SLIDE IGCP-640 Project - Significance of Modern and Ancient Subaqueous Slope Landslides
- USGS Woods Hole Coastal and Marine Science Center
- British Geological Survey
- Geological Survey of Canada
- University of Haifa, Israel
- Colorado School of Mines SAnD (Sedimentary Analogs Database)
- SLATE - Submarine landslides and their impact on European continental margins
- National Institute of Water and Atmospheric Research (NIWA). Wellington, New Zealand
- GEOMAR, Germany
- Geological Survey of Spain (IGME)

How will you judge that project has had impact?

The addition of third-party data into this database and the use of data obtained from this database in academic publications and geotechnical papers. Community feedback from related conferences (e.g., 9th ISSMMTC 2020, SEPM 2020 Symposium). Increase in community involvement in S4SLIDE.

How will you share the knowledge generated by the project?

- The resulting database will be open access via a publicly accessible website and related GitHub repository
- ESIP-hosted webinar(s) to showcase the product and encourage crowd-sourcing of database development
- 9th International Symposium on Submarine Mass Movements and Their Consequences 2020
- ESIP Summer meeting 2020
- Workshop at SEPM 2020 with the goal of community knowledge building around methodologies in subaqueous landslide interpretation and data collection and analysis.

Description of *who* (agencies/individuals) should be aware of this project, i.e. potential outreach targets:

- The subaqueous landslide research community
- The earthquake history research community
- The tsunami history research community
- Oil and gas industry exploration, development and geohazards communities.
- Coastal territory risk assessors (e.g., government agencies, city planners, insurance agents).
- Offshore geotechnical contract companies
- International geological surveys (e.g., USGS, BGS, GSC, Funvisis, etc.)

Project Partners

Description of project partners (agencies/individuals) and their involvement:

- Zane Jobe is a research professor at Colorado School of Mines, who will provide oversight, mentor web developers, and manage the budget
- Jason Chaytor is a research geologist at USGS Woods Hole Coastal and Marine Science Center; Jason will provide input on the implementation of the Clare et al (2018) framework and validate the database outputs for research community goals.
- Lorena Moscardelli is the chair for S4SLIDE IGCP/UNESCO-640 Project; she will ensure that the findings of the project are communicated and shared with the broader S4SLIDE community by directing IGCP/UNESCO resources to plan workshops associated with this effort
- The other project partners will provide input for the development of the database and act as beta testers for the website and analysis codebase.

How will this project engage members of the ESIP community: ESIP members can be engaged in multiple ways including population and mining of the database for purposes of research leading to publications, workshops, and special sessions as part of major scientific conferences. Outreach activities can include interactions with the ESIP marine science community via webinars, hackathons and other interactive activities. We are also interested to utilize ESIP expertise and resources in order to (1) create a database structure and web deployment mechanism for perpetual use and support, and (2) interact with the subaerial landslide community to build collaborations and best data-recording practices.

Citations:

Clare, M., Chaytor, J., Dabson, O., Gamboa, D., Georgiopoulou, A., Eady, H., Hunt, J., Jackson, C., Katz, O., Krastel, S., León, R., Micallef, A., Moernaut, J., Moriconi, R., Moscardelli, L., Mueller, C., Normandeau, A., Patacci, M., Steventon, M., Urlaub, M., Völker, D., Wood, L., Jobe, Z., 2018, A consistent global approach for the morphometric characterization of subaqueous landslides *in* Lintern et al. (*eds.*) Subaqueous Mass Movements. Geological Society, London, Special Publication, 477, SP477-15, https://doi.org/10.1144/SP477.15

Fritz, H. M., Mohammed, F., & Yoo, J., 2009, Lituya Bay landslide impact generated mega-tsunami 50th Anniversary. In *Tsunami Science Four Years after the 2004 Indian Ocean Tsunami* (pp. 153-175), https://doi.org/10.1007/978-3-0346-0064-4_9

Sassa, S. and T. Takagama, 2019, Liquified gravity flow induced tsunami: First evidence and comparison from the 2018 Indonesia Sulawesi earthquake and tsunami disaster: Landslides, v.16, 1, pp. 195-200, https://doi.org/10.1007/s10346-018-1114-x

Tappin, D. R., Watts, P., McMurtry, G. M., Lafoy, Y., & Matsumoto, T., 2001, The Sissano, Papua New Guinea tsunami of July 1998—offshore evidence on the source mechanism. *Marine Geology*, *175*(1-4), 1-23, https://doi.org/10.1016/S0025-3227(01)00131-1

Tappin, D., Grilli, S., Ward, S., Day, S., Grilli, A., Carey, S., Watt, S., Engwell, S., and Muslim, M., 2019, The devastating eruption tsunami of Anak Krakatau - 22nd December 2018. *Geophysical Research Abstracts*, 21, EGU2019-18326-1.