IODP Proposal Cover Sheet

NADIR: Nice Amphibious Drilling

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Title	Nice Amphibious Drilling, In situ monitoring & Risk analysis
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Area	Ligurian margin

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Abstract

Submarine landslides, followed by tsunamis, represent a major geohazard and an exciting research target given the wealth of trigger mechanisms and their dynamic interaction. The Ligurian margin, western Mediterranean, is known for its steep topography with numerous landslide scars, however, the cause of these landslides is incompletely understood. Given the geodynamic situation adjacent to the western Alps (with seismicity ranging up to M>6) and the large discharge of water and sediment through the Var River, the lithological variability (coarse sand and conglomerate interbedded with sensitive clay) and different hydrological regimes (coupled to precipitation and seasonal melt-water discharge), as well as the profound human impact on the coast (e.g. collapsed landfill area and construction site in 1979, followed by a tsunami in the Gulf of Antibes), the French portion of the Riviera is an area where various triggers can be studied in a locally confined region.

The fact that the margin comprises permeable delta deposits that underwent transgression calls for an amphibious approach that addresses both the onshore portion of a charged aquifer as well the area into which the fluids are funneled, thus causing elevated pressure in the shallow submarine slope. We here propose to drill two onshore and four offshore holes at the Ligurian margin to characterize the strata of the Plio-Quaternary Var aquifer, and the marine metastable slope E and W of the 1979 collapse structure and its redeposited material downslope. The target depth at each site will provide reconnaissance data to portions already sampled (onshore groundwater wells, offshore gravity/piston coring) and also characterization of the underlying strata down to the Pliocene puddingstones. Since we propose mission-specific amphibious drilling and borehole instrumentation, drill cores and downhole-logging information will identify mechanically weak vs. strong layers, hydraulically active horizons, and zones of overpressure owing to groundwater-charging or rapid vertical loading in the Var delta deposits. The related hypotheses may be tested by drilling, and will be comprehensively answered by long-term monitoring of the physical parameters affecting slope failure. Offshore, borehole observatory installation is effortless given water depths of <50 m and will include multi-parameter instruments.

This proposal is designed to unambiguously test multiple-triggers for landslides at the French Riviera, and although locally restricted, the complexity of the area makes this margin a primary site for time- and cost-efficient operations at a glacially affected margin in the NEAM region.

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Scientific Objectives

Mission-specific amphibious drilling at the Ligurian Margin will answer a large number of questions concerning factors governing slope failure in an area where multiple triggers, most prominently a charged aquifer and dynamic valley-to-canyon system, serve to
•identify permeable layers in PlioQuaternary rocks onshore, glacial and postglacial delta deposits and underlying Pliocene rock offshore to define their role in the aquifer system as well as in slope failure when leaching clayey sediment,
•sample prominent discordant contacts and test whether they may serve as failure and sliding surfaces,
•utilize core samples for deformation and permeability experiments and relate them landslide risk/societal threat.

After drilling, we propose the instrumentation of the boreholes with pore pressure, strain and temperature gauges (and potentially seismometers) using 3rd party funds. Time series by these instruments will allow us to
•use in situ pore pressure as a strain and fluid flow proxy,
•establish a relationship between e.g. seismicity and pore pressure, or sediment permeability and groundwater influence,
•relate precipitation and meltwater supply to temperature, pore pressure, and fluid geochemical transients, and
•measure displacement causing creep, casing deformation and pore pressure transients.

Given that the drill sites are in shallow water, with favorable logistics and good infrastructure at the French Riviera and an EMSO seafloor-cabled node, scuba diving operations to facilitate borehole installations are a feasible way to maximize the success and use the drill holes as a hydrogeophysical monitoring and fluid sampling facility and real-time landslide observatory.

Non-standard measurements technology needed to achieve the proposed scientific objectives.

We propose to use a standard onshore drill rig for the onshore sites and then mount the same system to a pontoon/barge of opportunity to drill the offshore sites, where a three-point anchor (2 at Nice airport, 1 offshore) should suffice. Heave compensation is obsolete given 2 cm tidal range, but weather has to be monitored closely.

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
NA-09	43.6664, 7.2008	0	60	140	200	Alluvial cover of largely sand and gravel overlies Pliocene puddingstones, contact to be recovered (erosional surface? Unknown!) – Secondary aim is to check heterogeneity of puddingstones and abundance in argillaceous interbeds and lenses.
NA-10	43.6736, 7.1919	0	40	200	240	Alluvial cover of largely sand and gravel overlies Pliocene puddingstones, contact to be recovered (erosional surface? Unknown!) – Secondary aim is to check heterogeneity of puddingstones and abundance in argillaceous interbeds and lenses.
NA-02	43.6458, 7.2139	33	110	0	110	Slump material, horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation

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-	-	-	-	-	-	silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-03	43.6469, 7.2175	37	60	0	60	Slump material, horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-07	43.6439, 7.2225	31	150	0	150	Horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-08	43.6431, 7.2228	50	80	0	80	Slump material, horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-01	43.6455, 7.2133	39	100	0	100	Slump material, horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-04	43.6453, 7.2142	50	120	0	120	Horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-05	43.6431, 7.2108	20	130	0	130	Horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties
NA-06	43.6411, 7.2114	104	125	0	125	Horizontally layered shelf deposits, prograding sequences, probably cyclic grain size variation silt/clay, transition Unit B/C, upper part of Unit C with high reflectivity to characterize hydraulic properties

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