COST action FLOWS

Report on Workshop on drilling from the Sea of Marmara seafloor
19th – 20th March 2015

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Meeting host: Prof. Dr. Heinrich Villinger
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Meeting Agenda

19th March 2015

10:00	Heinrich Villinger (Department of Geosciences, Host), Pierre Henry (CEREGE):	Introduction MeBo visit
11:00	Tim Freudenthal (MARUM)	Presentation of MeBo capabilities
11:10	Achim Kopf (MARUM)	MeBo observatories
11:20	Cecilia McHugh (LDEO)	Submerged continental boundaries: tectonic evolution and geohazard
11.30	Namik Çağatay (ITU)	Correlating and dating paleoceanographic records in the SoM
11:40	Kürsad Kadir Eriş (ITU)	Turbidite homogeneites in long cores: small, big, and huge
11:50	Gülsen Uçarkuş (ITU)	Fault slip rates, horizontal and vertical
12:00	Pierre Henry (CEREGE)	Cyclicity of slope instability beyond the earthquake cycle
12:10	Lunch	
13:15	Christian Hensen (Geomar)	Strike-slip faults and the rise of crustal-derived fluids and mud volcanism in the deep sea

13:25	Louis Geli (Ifremer)	Fluid emission sites on the NAF/Ifremer's experience with MeBo in Niger Delta
13:35	Catherine Pierre (LOCEAN)	Records of cold seep activity
13:45	Barbara Teichert (Munster)	Linking the C, S and Ca cycle and lipid biomarkers associated to methane turnover at Marmara Sea fluid emission sites
13:55	Volker Liebetrau (Geomar)	Geochronology of authigenic carbonates
14:05	Julia Kende (CEREGE):	ArcGIS and openDTect projects of Marmara Sea target areas
14:15	Coffee break	
14:30	Discussion on proposal	Scientific objectives Targets of interest Observatory components
19:00	Dinner	Ratskeller, Bremen

20th March 2015

9:00	Working groups (fluids and early diagenesis/stratigraphy, tectonics and geohazard)	Selection of sites, evaluation of site survey material
11:00	Plenary session	Round-up and writing assignments
12:00	Lunch	
13:00	Working groups	writing assignments

Workshop Conclusions

At the workshop held in Bremen, it was decided to develop a drilling proposal in the Sea of Marmara within the Framework of IODP, with the aim to submit a pre-proposal for the April 2016 deadline. The name of the proposal will be « BAsin growTH and fluid activity along a continental TrAnsform Boundary », abreviated as BATHTAB. The MeBo appeared as an efficient and cost effective way to reach the coring targets and install instrumentation, but the choice of drilling platform cannot be made at this stage.

A) Background and drilling objectives

The purpose of drilling is (1) to acquire stratigraphic records over the last 100.000 to 500.000 years on topographic highs and ponded basins within the Sea of Marmara Trough (2) to collect cores and install borehole monitoring instruments at a fluid emission site within an active fault zone. The Sea of Marmara Trough occupies the northern part of the Sea of Marmara and is composed of several rapidly subsiding basins

along the northern branch of the North Anatolian Fault, which accommodates a majority of the Eurasia-Anatolia plate motion. The Sea of Marmara is here considered as a generic case example of strike-slip basin within continental crust, and is also representative of the early stages of oblique rifting and transform type continental margin formation. Strike-slip basin structure and formation processes are still poorly understood compared to that of rift basins. A classical schematic representation is as a "pull-apart" connecting two parallel fault branches. Another class of models proposes to explain the formation of asymmetric basins in strike-slip shear zones by geometrical complexities along a continuous principal fault. Moreover, the role of ductile deep crustal (and/or mantle) deformation is generally overlooked, although it may be important in redistributing crustal thinning and thus influence the long-term tectonic evolution of transtensional systems.

The sedimentary basin and crustal structure in the Sea of Marmara is well known from a wealth of geophysical data acquired over a wide range of scales. These geophysical studies were primarily motivated by the earthquake and tsunami risk that the North Anatolian Fault system presents for this highly populated area, which includes the city of Istanbul. However, many of the conclusions regarding long term fault rates, seismotectonics and related geohazards, are suspended to seismostratigraphic interpretations of sequences that were never drilled nor cored and to basin modeling, in which the principal constraint on timing is heat flow. Between 15 000 years ago and the initiation of basin growth in the Sea of Marmara area during the Pliocene, the only stratigraphic control is a single industry borehole drilled on the southern shelf, for which no samples remain.

The proposed drilling will address the following themes:

1) Strike-slip basin growth and geological fault slip rate variability.

One question in debate is whether the presently active fault system could be considered as nearly steady state since its inception during the Pliocene or, on the contrary, has been subject to major reorganizations, the last one possibly as recently as 200.000 years ago.

Another problem of interest is the partitioning of deformation. Current estimates for the geological strike-slip rate on the main fault vary widely from 10 mm/yr to about 20 mm/yr, which would allow secondary faults to play a significant role, including as potential sources for damaging earthquakes. Moreover, the spatial distribution of extensional strain appears to differ from that of the strike-slip component. What fraction of the basin subsidence should be attributed to slip on master faults? What fraction of extension is distributed by flow in the ductile lower crust? Did shear partitioning vary in time?

The strategy we propose is to ground truth the ages of key horizons that have been correlated over large portions of the Sea of Marmara, including the deep basins, and used as markers to infer fault slip rates and subsidence rates. The hypothesis that the Main Marmara Fault and syn-tectonic basins have functioned in steady state over at least the last 500.000 years will be tested. The significance of observations indicating some variability of fault activity and distribution of subsidence within this time frame will also be clarified.

2) Paleocenography of the Black Sea-Mediterranean gateway.

The global paleoceanographic importance of the Sea of Marmara resides it is location in the gateway between the Black Sea and the Mediterranean Sea. The timing and hydrology of the reconnection during the last deglaciation has been studied in great details. Understanding the paleoenvironmental and water level changes in the Sea of Marmara during past glacial cycles in response to global sea-level variations as well as to the local and Black Sea hydrological budgets is needed to reliably interpret sedimentary sequences and thus unravel the tectonic evolution of the basins.

The Sea of Marmara sediment cores we will acquire will thus bring new constraints on global sea-level variations, Black Sea hydrology and meltwater flow pathways during previous glaciations, this up to 400-500 ka. However, the conditions for connection or disconnection through the Bosphorus and Dardanelle sills depends of their depth, which changed with time, primarily because of sedimentation during highstands and erosion during lowstands and possibly also from vertical tectonic movements, which appears more progressive at the time scale we consider. The question of the erosion and sedimentation budget of Borphorus and Dardanelle can be addressed by drilling in sediment ponds within the straights.

3) Response of cold seep activity to earthquake processes and to environmental change.

Variation of fluid fluxes, fluid composition and biogeochemical processes at seeps occur on diverse timescales that include the earthquake cycle as well as shorter (days) and longer timescales. We here focus on mobilized sediment conduits within the Main Marmara Fault zone that channel thermogenic hydrocarbons and associated brines to the seafloor. Coring performed on mounds at the conduit outlets recovered interlayered mud and authigenic carbonates that constitute a record of past cold seep activity since the last marine-lacustrine transition Moreover, episodes of gas released in the water column can influence microbiological activity in the water column, which can be tracked with biomarker as well as reodx condionts. Several factors have been shown to influence gas flux and biogeochemical processes: hydrate formation and dissociation in response to temperature and pressure variations at the sea (or lake) floor, sulfate and oxygen concentration in the bottom water. On a shorter time scale, monitoring of seeps on the mounds shown episodic variations of fluid flux and composition and of fluid pressure.

For its location within the MMF zone in an area that also has moderate background seismic activity, this site has remarkable potential for investigating with a long term monitoring strategy the coupling of fluid migration with seismicity and strain in the upper crust and sediments.

On the longer time scale, the record of cold seep activity from authigenic minerals and biomarkers will be extended in the past by coring to at least one glacial cycle, and the occurrence and timing of mud eruptions established.

4) Influence of environmental factors on geohazards and on their sedimentary records

Slope instability in the Sea of Marmara is thought to be earthquake triggered, and associated with the deposition of turbidite-homogenite in the deep basins. Correlations have been established between tubidite-homogeneite and historical events, which brought insight on the seismic segmentation of the North Anatolian Fault in the Sea of Marmara. However, it is difficult, if at all possible, to establish a one-to-one correlation between seismic events and sedimentary deposits. On a longer time scale, it appears that environmental factors influence the occurrence of landslides, debris flows and turbibidite-homogenites as well as the size of the events. For instance, large slope instability events and thicker turbidite-homogeneites are found just before the end of

the lacustrine period (c.a. 15000 a BP). High-resolution seismic studies show that mass transport deposit complexes formed cyclically, but their precise tuning with respect to glacio-eustatic cycles is not known, in particular, they do not appear to form every cycles. Factors influencing slope instability include changes of sedimentation dynamics in response to water level variations, hydrate formation and dissociation and gas volume change in response to water temperature and/or pressure variations, changes in sediment geotechnical properties due to water salinity variations and clay leaching.

What we here aim at is better understanding of the environmental factors influencing slope instability, and particularly, how these factors can influence the paleoseismological interpretation of turbidite-homogeneite sequences, in the Sea of Marmara as well as in other settings. In the Sea of Marmara, the variation of slope instability with time may be influenced both by processes globally synchronized (sea-level and temperature change) and by specific processes such as water salinity variations.

B) Outline of drilling strategy

Drilling of 6 sites (see figure) will be proposed, corresponding to a cruise duration of 3 weeks, including contingency time, if the MeBo is used.

BAT-1 : 200 m reference borehole in ponded basin
Coring and logging of a continuous sedimentary sequence over the last 400 ka
Expected time using MeBo200 : 8 days

BAT-2 : 80 m borehole at carbonate mound above fluid conduit
Coring of authigenic carbonates layers and hemipelagic sediments. Coring of mud breccia. Installation of fluid pressure monitoring and fluid sampling system.
Expected time using MeBo : 4 days
BAT-3 : 80 m borehole near carbonate mound
The aim of coring is to provide a stratigraphic reference for correlation with BAT-2, and biomarker analysis to identify effects of fluid emissions in the water column.
Expected time using MeBo : 2 days

BAT-4 : 150 m borehole on ponded basin with MTD complex
Coring of onlaping sedimentary sequence of presumed MIS 5 age containing mass transport deposits (MTDs). The aim is to determine the age and paleocanographic context of the MTDs.
Expected time using MeBo : 4 days

BAT- 5 and 6: 80 and 80 m holes in sedimented ponds in Bosphorus and Dardanelle straight.
The aim is to determine the maximum age of sediment deposited in these ponds and thus infer the sedimentation and erosion budget in the straights during a glacial cycle and constrain sill depth variations.
Expected time using MeBo : 4 days

The precise location of each site still needs to be specified. Candidate targets BAT-1, 2, 3, 4 are considered within a high-resolution multichannel 3D data set acquired on the Western High in the Sea of Marmara.