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Convenor

Wolfgang Bach

Wednesday PM Session

OS03 : WEpm25 : F1
The Equatorial Atlantic 'Cold Spot': Constraints from Osmium Isotope Composition, Plate Kinematics and Tomography

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The existence of cold upper mantle beneath the equatorial Mid-Atlantic Ridge (MAR) was first inferred from the analysis of ridge axis morphology and the petrology of both basalts and uplifted abyssal peridotites. A survey using the submersible NAUTILE was undertaken in the Saint Paul fracture zone. Eleven samples of abyssal peridotites were analysed for Re-Pt-Os, and Os isotopic composition. Preliminary results suggest a Re-depletion model age of 560 Ma to 1.1 Ga for some subchondritic samples. Because the majority of the samples have gamma Os equal to below chondritic values they are unlikely to have originated simply by depletion of recent MORB-type mantle. These data also show a good correlation between $^{187}Os/^{188}Os$ and Pt/Os that is also consistent with a source that preserves chemical characteristics of an older depletion event.

Global upper mantle tomographic models show a significant increase in the velocities of seismic waves beneath the equatorial MAR. These whole mantle models show high velocities observed for the upper mantle that apparently continue into the lower mantle, analogous to the pattern seen for some present day subduction zones. The tomographic evidence supports the geochemical information that 'cold' lithosphere, perhaps a fossil subducting slab is present in the region. The existence of a fossil subduction in the Equatorial Atlantic is corroborated by paleo-reconstructions for the period between 460 and 300 Ma. The equatorial area may have corresponded to a region of subduction, initiated around 460 Ma by the convergence of a main continental block, located in the Southern Hemisphere, towards a smaller block located slightly north of the Earth's equator. This old subduction remained active until the final collision, around 300 Ma. Os isotopic compositions obtained for many of the peridotites require slightly older ages for depletion of the sampled mantle but are consistent with the incorporation of fragments of a fossil subducted slab. The closing of the continental blocks at 300 Ma around the present day Equatorial Atlantic, followed by the subsequent opening of the Atlantic could have left behind a fossil slab that is presently imaged in the lower mantle. The subducted lithosphere could have been created in a previous divergent period prior to 460 Ma. These age estimates for the fossil subducted slab are in good agreement with the residence time required for the unradiogenic $^{187}Os/^{188}Os$ isotopic compositions of the abyssal peridotites.

OS03 : WEpm26 : F1
High-Temperature Alteration in Pillow Basalts from Slow Spreading Ridges: Hydrothermal Upflow Zones or Shallow Convection Systems?

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Pillow basalts metamorphosed under greenschist facies conditions have been recovered from the Western Kane Fracture Zone (23°50'N, 46°23.5'W) on the Mid-Atlantic Ridge (MAR). The secondary mineral assemblage, consisting of chlorite, epidote, plagioclase (An_{2-21}), and amphibole (actinolite to magnesio-hornblende), as well as fluid inclusion evidence suggest alteration temperatures between 250 and 400°C. Such high alteration temperatures are atypical for normal (i.e., layer-cake) sections of ocean crust and ophiolites where alteration temperatures in the extrusives are commonly below 150°C.

High alteration temperatures and greenschist facies assemblages have been reported for rocks representing the narrow upflow zones of high temperature hydrothermal fluids. Unlike rocks from upflow zones, the greenschist facies pillow basalts (GSPB) described here lack significant silicification and sulfide mineralization. The alteration assemblage is more similar to that observed in oceanic diabases, which are believed to represent the deepest parts of the recharge zone and the reaction zone of hydrothermal fluids. However, in contrast to the majority of oceanic diabases, the GSPB were altered at high fluid-to-rock ratios (>50) and, consequently, they exhibit significant chemical modifications (gains in H_2O, MgO, FeO, ^{87}Sr; losses in CaO, SiO_2). The similarity in mineral assemblage to diabases leads us to propose that the GSPB decribed here represent the lowest parts of the recharge zone and reaction zone of a hydrothermal system. In addition, the high temperatures and high fluid-to-rock ratios of alteration imply a shallow circulation system driven by a shallow heat source. This is in contrast to the common perception (derived from studying large hydrothermal deposits at the MAR) of deep penetration of fluids at slow spreading ridges facilitated by low magma supply, faulting, and cracking.

Similar GSPB have been reported from at least 14 locations along the MAR and Central Indian Ridge with the majority of them having been recovered in the vicinity of transform faults. We suggest that GSPB may be limited to the segment ends of slow spreading ridges, where magma production rates are too small to support the construction of a layered crust with a km-thick sheeted dike complex. In this setting circulation of seawater deep into gabbros or ultramafics is possible if faulting generates fluid pathways. In periods of tectonic quiescence, hydrothermal circulation may be confined to the highly permeable extrusive layer, which may directly overlie gabbros or ultramafics. The heat source driving this kind of convection is likely shallow intrusions of basaltic magma in the lithospheric mantle. This type of hydrothermal system may not be represented by the presently known large hydrothermal deposits along the Mid-Atlantic Ridge the formation of which requires deep circulation and reaction of the fluids with large volumes of rocks.

OS03 : WEpm27 : F1
Cenozoic Contourite Drift Development in the Northern Norwegian Sea

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Based on high-resolution and multichannel seismic profiles different types of contourite drift development have been identified in the northern Norwegian Sea: i) mounded elongate drift, ii) intercalated contourite and debris flow sediments, and iii) in-filling drift. Re. i): The Lofoten Contourite Drift is a mounded elongate drift located on the steepest part of the continental slope off northern Norway, from about 1000 m water depth and downslope. The internal seismic signature is characterised by layered, continuous, parallel or slightly divergent internal reflections of medium amplitude. This reflection configuration reveals a progressive upslope accretion onto the continental slope. The Lofoten Drift developed from the Miocene. The geometry of the uppermost part of the drift is characterised by maximum thickness at the mound crest, which implies that it is probably presently active. Most of the Norwegian Sea continental slopes are covered by downslope transported sediments derived from former ice sheets covering the shelves. The Lofoten Drift owes its existence to the sparse downslope sediment input. The reason for this is that the Lofoten Islands acted as a sediment barrier for the fluvial and glacial transport. Large fluvial and/or glacial drainage systems from central Fennoscandia were routed south and north of the study area. As a result, alongslope sediment transport has provided the main sediment input to this part of the continental slope. Re. ii) Further south, on the continental slope outside a large transverse shelf trough intercalated contourite and glacigenic debris flow sediments have been identified. The internal seismic signature is similar to the Lofoten Drift and the youngest drift unit is up to 200 m thick. Late Weichselian glacigenic debris flow deposits cap this drift. Here, drift development occurred intermittent to episodes of downslope glacigenic transport. Re. iii): The in-filling drift is in-filling a large slide scar on the upper continental slope. On downslope oriented profiles the seismic signature is characterised by layered, continuous, parallel or slightly divergent internal reflections of medium amplitude. Alongslope profiles display sets of stacked, lens-shaped subunits. In total the drift is up to 200 m thick. It probably originated from sediments derived from winnowing of the shelf and upper slope and is younger than 350 ka implying rapid slide scar infilling.

OS03 : WEpm28 : F1
Chirp Sonar Mapping of Gas Seepage and Gas Bearing Sediments in a Fine-Grained Thick Holocene Sequence in Skagerrak

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High resolution chirp sonar data was collected from northeastern Skagerrak in 1998. The investigated area is characterised by high sedimentation rates and intense water mass mixing, as a branch of the North Atlantic Current turns anticlockwise, slows down and blends with other waters to form the Norwegian Coastal Current. Present day SSTs in Skagerrak are strongly linked to the NAO-index.

The seismic profiles show 40-70 m thick, well-laminated neatly draped Holocene sediments overlying till deposited during the last glacial. In the present data set, extensive areas of these Holocene sediments are clearly distinguished by their acoustic turbidity. This acoustic blanking is interpreted as gas of shallow origin embedded in the sediment. Within these gas-bearing areas, plumes where gas have escaped to the sediment surface are common. Pockmarks have developed in some locations. A detailed bathymetric model and 3D seismic interpretation of the investigated area is shown together with a map of the gas bearing areas and pockmark positions.

A long piston core (MD992286) was retrieved from the investigated area in Skagerrak in 1999 during leg 3 of the IMAGES V cruise. The coring site was determined with respect to the depositional environment interpreted from the seismic profiles. The sediments in the core consist of homogenous silty clay with a slight coarsening upwards. The 32.5 m long core spans over a time interval of ~8000 years, based on the sediment thickness in seismic profiles and a sedimentation rate of about 4 mm/yr (Bøe et al., 1996).

Bøe R, Rise L, Thorsnes TH, de Haas H, Saether OM & Kunzendorf H, *Nor. geol. unders. Bull*, **430**, 75-84, (1996).

OS03 : WEpm29 : F1
Trapped Shallow Gas above BSR?

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Scientific exploration cruises were conducted between 1998 and 2000 to explore the offshore Congo and Angola in the framework of the ZaiAngo project. The main goal of the project is the study of the present and recent Zaire submarine fan. Meanwhile the use of very high resolution seismic methods allowed us to characterise typical facies and detect gas in deep sea superficial sediments. For the first time, the 3.5 Khz echosounder profiles acquired during these cruises, were recorded on board under a numerical format (as seismic lines) instead of an analogical format (paper profiles usually) ; thus we were able to process them as classic seismic lines. Due to the high frequency of the 3.5 kHz echosounder, it is possible to analyse the seismic reflectors signal analysis with a metric resolution, and to determine whether or not gas is present into superficial sediments. A very special facies identified as the 'sheep-back' facies on the 3.5 kHz profiles presents some enigmatic characteristics. It appears like a very regular hyperbolic facies, situated at about 30 m under the seafloor. Very well marked on the echosounder profiles it is localised in the diapiric area, between 1300 m and 2 000 m of water depths. The signal inversion tends to prove that there is some gas at this level. The problem is that this 'sheepback' reflector is situated above a BSR, situated 60 m below, which normally determines the limit of the gas hydrates stability zone, preventing any occurrence of free gas above

it. Does this 3.5 kHz facies correspond to a superficial BSR described by Mienert, 1998 ? Several explanations will be proposed.

Mienert J., Posewang J., Baumann M., *Gas hydrates along the northeastern Atlantic margin. In: Geological society, London special publication*, **137**, 275-291, (1998).

OS03 : WEpm32 : F1
Regional Multiscale Synthesis of Recent Tectonics and Mud Volcanism over the Central and Eastern Mediterranean Ridge, from New Geophysical Data

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More than 70000 km^2 of complete multibeam bathymetric and backscatter coverage were recorded in early 1998 (Prismed 2 survey) across the Central and Eastern Mediterranean Ridge (MR), a pre-collision accretionary wedge lying between the Aegean and Libyan margins in the Eastern Mediterranean. These data, combined with previous multichannel seismic profiles (Prismed cruise, 1993) and bathymetric transits (Seamewe, 1993) allow a better assessment of the complex deformational styles and sedimentary patterns over two large areas of the MR, and the characterization of their lateral evolution. Mainly from swath-bathymetry and backscatter data, abundant subcircular, highly reflective, features commonly known as 'mud volcanoes' have been recognized on the top of the ridge and strong evidences of genetic relationships with tectonic features are inferred from the seismic data. Four major mud fields have been mapped and their morphologic and acoustic characteristics analyzed in detail, as well as their tectonic control, especially for the Olimpi mud field south of Crete where clear relationships with transcurent features are confirmed by deep-tow side scan sonar records from Medineth cruise (1999) and deep dives carried out on the more characteristic mud volcanoes (Medinaut expedition, 1998). Two main morphostructural domains have been identified across the sedimentary wedge, from integration of swath-mapping and seismic data in both Central and Eastern Domains. An Outer Domain, characterized as a narrow belt of stacked thrusts north of the Libyan promontory, widens progressively eastward into a large domain composed of three successive folded belts, disconnected by strike-slip features The sedimentary pile of this domain is formed by a thick PQ partly Nile-derived sediments (reaching 2 km north of the Nile deep-sea fan) and resting on Messinian ductile layers acting as probable decollement levels. To the north, the MR Inner domain appears as an almost reflection free area with the exception of narrow tectonic corridors and argilo-kinetic manifestations (mud volcanism), identified in both Central and Eastern domains in close connection with backthrusts and transcurrent fractures. The integrated data sets illustrate strong lateral contrasts in structural patterns. West of 24°10E, facing a tilted Cyrenaica promontory, the MR is characterized by complex compressive structures explained by an incipient collision between African and Cretan margins. Eastwards, the MR displays a better organized structural pattern, with widening folded belts and strike-slip lineaments related to lateral escape or regional strike-slip tectonics east of 26°E, where the structural pattern of the MR seems to be controled by dominant oblique tectonics.

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Combined Thin-Skinned and Thick-Skinned Tectonics in the Eastern Nile Deep-sea Fan, Eastern Mediterranean: Results from the Recent 'FANIL' Survey

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Deformation in the Nile deep-sea fan results from the combined influences of (1) deep-seated, thick-skinned tectonics and (2) thin-skinned tectonics due to loading of the Messinian evaporites by the Nile's sediments. Our survey focused on a NW-SE deformation belt located in the fan's eastern region. The belt is more than 200-km long and comprises NW-SE narrow lineaments, interpreted as transtensional structures caused by regional tectonics, and SW-NE-trending, sigmoidal crestal grabens and underlying salt ridges, interpreted as resulting from thin-skinned gravity spreading of the sediments above the salt.

The 'Fanil' survey (onboard R/V "Le Suroit"; october 2000) allowed us to image the southern extension of these spectacular structures using multibeam bathymetry, backscattering imagery and HR seismic. The new data clearly show the southern extension of this structural belt progressively curved towards the N-S direction and image remarquable spatial changes of salt-tectonics style in the area. - Upslope, listric normal growth faults, sub-parallel to the coastline, terminate against narrow arcuate grabens, corresponding to the southern part of the belt. - Downslope, within the belt, we evidenced a network of polygonal sediment depocenters bounded by radial and concentric normal faults and grabens, a pattern very similar to that observed above the Sigsbee salt nappe in the deepwater US Gulf of Mexico. - Toward the abyssal plain, normal faults progressively disappear whereas arcuate salt ridges and short-wavelength folds dominate. Against the Eratosthenes Seamount, a >400-m-high bathymetric scarp represents the distal tip of a nappe of salt that has been thickened and expelled seaward by sediment loading of the evaporites.

This downslope progression from growth faults, to polygonal depocenters, to folds is common along salt-bearing passive margins, where gravity spreading of the salt-sediment system causes proximal thin-skinned extension on the shelf and upper slope, and distal contraction along and in front of the lower slope.

To conclude, the Eastern Nile Cone displays within the structural belt (1) Upslope, radial and concentric structures, associated with polygonal mini-basins, mainly created by the spreading of sedimentary lobes above Messinian salt; (2) Downslope, this 3D structural pattern is progressively relayed first by 2D-type extensional deformation, then by contractional features.

OS03 : WEpm34 : F1
Pock-Marks, Mud Volcanoes and Gas Chimneys: Evidences from the Nile Deep-Sea Fan

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The Nile deep-sea fan's physiography and shallow structure, have recently been imaged in detail during two recent scientific surveys (Prismed II in 1998, and Fanil in 2000). Multibeam swath bathymetry and acoustic imagery, seismic reflection data, HR seismic profiling and a few piston-cores have allowed to discover numerous sea-bottom fluid and gas escapes. - Pock-marks have been imaged by backscatter data (highly reflective patches) in two domains: Firstly, within the Central deep-sea fan's province between the Rosetta and Damietta onshore areas. There, they chiefly characterize the upper slope, between 1000 and 2500 meters where they are related to slope destabilization processes and huge debris flows. Pock-marks have also been detected along the upper slope of the Eastern Nile deep-sea fan, at water depth ranging from 750 to 1000 meters. - Several features, similar to gas chimneys described by Barsoum et al.(2000), have also been observed, chiefly in the Eastern Nile deep-sea fan upper slope, where they show as sub-circular and flat bathymetric features reaching diameters up to 4.5 kilometers. They are clearly related to nearby tectonic trends that bound thickly sedimented grabens. - Finally, numerous sub-marine conlets (300 to 1000 meters in diameter on average) have been discovered along the lower slope, within the Western Nile deep-sea fan's province. These features are not randomly distributed, but appear clearly located at the foot of growth fault systems that characterize most of the middle slope domain in this area. Within this sub-domain, huge sub-circular depressions, 5 to 10 kilometers in diameter, where several mud cones are emplaced, look like 'calderas'. We suspect that these features reflect areas of intense fluid and mud escape (mud volcanoes), that may be due to sedimentary overload itself resulting from the activity of growth faults rooting within underlying Messinian salt layers.

The Nile deep-sea fan appears thus as an area releasing huge quantities of fluids (may be chiefly gas) as a consequence of several concurrent mechanisms such as sedimentary overload, growth faults activity, and potentially deep-seated tectonics.

Barsoum K, Della Martera & Menardi Noguera A, *EAGE conference on geology and petroleum geology*, **1**, (2000).

OS03 : WEpm35 : F1
Pyroclastic Diapirs in the Bay of Naples, Eastern Tyrrhenian Sea

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Diapiric structures, mostly consisting of volcanoclastic deposits ('pyroclastic lumps') have been recently discovered beneath the sea floor a few kilometers off the town of

Naples (Eastern Tyrrhenian Sea). Swath bathymetry data, side scan sonar sonograms and high-resolution seismic reflection profiles show these pyroclastic diapirs uplift through the uppermost Pleistocene - Holocene and deform the sea bed over a quasi-circular area of ca. 2 km in diameter. Individual diapir crests produce mound-like features at the sea floor which are several meters high and several tens of meters wide. The pyroclastic lumps of the Naples Bay are rooted in the uppermost layers of a large volcanic unit, several tens of meters beneath the sea floor. Core-log analysis coupled with chemical study of the enclosed pumice fragments collected from core samples and radiometric dating suggest that pyroclastic deposits forming the diapirs derive from widespread eruptions of Latest Pleistocene-Earliest Holocene, associated with the deposition of the 'Neapolitan Yellow Tuff' (ca. 12 Ky BP) in the volcanic district of Phlegrean Fields. Seismic stratigraphic analysis of sparker profiles 1 kJ and 4 kJ confirms the rooting of the pyroclastic lumps in the upper part of the 'Neapolitan Yellow Tuff' deposits, overlying another large volcanic unit attributed to the 'Campanian Ignimbrite' pyroclastic flow (ca. 35 Ky BP), widely occurring in the south-eastern area of the Gulf of Naples. A numerical model is presented in order to explain the origin and mechanism of the diapirism. According to our model the key factors controlling the dynamic system include: a) the viscosity of the ascending pyroclastic material; 2) the density of the overlying deposits; 3) the density contrast between these structures and the overlying sediments; 4) the initial width and height of individual diapiric structures; 5) soft-sediment deformation due to lithostatic load under water-saturated conditions. The calculated rates of uplift of pyroclastic lumps are in the order of several mm/year.

OS03 : WEpm36 : F1
Stratigraphic Signatures of the Late Quaternary Sequence off the Salerno and Naples Bays, Eastern Tyrrhenian Sea

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This study is based on the interpretation of ca. 800 km of very-high resolution single-channel seismic profiles (sub-bottom CHIRP) acquired on the continental shelf of Salerno and Naples Bays, Eastern Tyrrhenian Sea. Stratigraphic reconstruction and mapping of the Late-Quaternary sequence in the study area allowed for recognition of thickness and stacking patterns of latest Pleistocene-Holocene stratigraphic units (continental-deltaic/paralic deposits) and associated erosional features (incised valleys and channel fills) which record the relatively slow sea level drop between ca.100 ky BP and 18 ky BP. In the Salerno bay, stacking transgressive units and progradationl paralic deposits locally preserved along morphological terraces associated with clear-cut steps can also be recognized. These features record the rapid sea level rise that occurred between ca 18 ky BP and 7-5 ky BP. Conversely, the average thickness of the Late Quaternary sequence is significantly lower in the Bay of Naples where faint evidence exists, (mostly in the Sarno-Castellammare area) of continental-paralic deposits that formed on the present-day continental shelf during the last regression.

OS03 : WEpm37 : F1
Stratigraphy, ^{14}C and $^{40}Ar/^{39}Ar$ Geochronology, and Petrochemistry of Holocene Deposits in an Active Volcanic Area: The Pozzuoli Bay, Southern Italy

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The tectono-volcanic activity of Phlegrean Fields, a Late Quaternary volcanic district of the Eastern Tyrrhenian margin, had significant impact on the evolution of the Holocene coastal zone in the area of Pozzuoli, west of Naples. A classic section of the Holocene stratigraphic succession of the Pozzuoli Bay is exposed along the cliff of the erosional terrace known as 'La Starza', represented by transgressive-regressive marine parasequences interbedded with volcaniclastic deposits. We discuss here the results obtained by the study of five cores sampled nearshore in the Port of Miseno Bay. The drillings reached a maximum depth of 40 meters beneath the seafloor. The stratigraphic succession is characterised by shallow marine sand interbedded with two pumice layers (namely level S and level I). The pumice beds are bounded by two peat layers which have been sampled and processed for radiometric age determination. Their absolute ages (^{14}C) are 3.6 and 7.8 ka B.P. respectively; they have been correlated with two resting periods in the volcanic activity of the Phlegrean Fields during the last 10 ka (Rosi & Sbrana, 1987; Di Vito et al., 1999). Preliminary $^{40}Ar/^{39}Ar$ data on sanidine crystals, picked up from fresh pumices, yielded an age of 7 ka for the level S; it is to be noted that there are no already known eruptions on land during this period. Major elements analysis, carried out on pumice samples, indicate a trachytic and trachyphonolitic composition; furthermore, the content of immobile trace elements like Zr and Nb may offer an excellent criterion to refine correlation with dated volcanic events documented onland. Basement tuff (ca. 11 ka), which makes up the majority of land outcrops in this area, was not reached by drilling and this suggests high sedimentation rates during the Holocene. Red surfaces, peat and marine sand in the Holocene sequence indicate short sea level oscillations accompanied by episods of emersion and development of restricted lagoons or marshes overlain by beach deposits during transgressive episods. Preliminary results of this work indicate a possible correlation of the studied succession with that exposed along 'La Starza' terrace where the Holocene sequence has been uplifted about 40 m above the sea level in the last thousand years (Barra, 1991).

Rosi M, Sbrana A, *Phlegrean Fleds, C. N. R. , Quaderni de "La ricerca scientifica"*, **114-9**, pp. 176, (1987).
Di Vito M, Isaia R, Orsi G, Southon J, de Vita S, D'Antonio M, Pappalardo L, Piochi M, *Journal of Volcanology and Geothermal Research*, **(91)2-4**, 221-246, (1999).
Barra D, *PhD thesis, Università di Napoli Federico II*, pp.298, (1991).

OS03 : WEpm38 : F1
SEISCAN and SEISTRANS: The Creation of SEG-Y Files from Images of Paper Seismic Records

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The SEISCAN project enabled preservation of old marine seismic reflection records by digital scanning. It was a EC Supporting Initiative 'no cost' service aimed at rescuing data not backed-up by digital or magnetic media and many of Europe's marine institutes submitted seismic records to be archived via the A0 scanners. They benefited by both transferring data to CD as images and through informing the scientific and industrial communities of the information they hold. This unlocked their commercial re-use value in areas of new scientific and resource interest. It also avoided the cost of re-acquiring some of the 1,000,000 line kilometres of survey.

Access to these data required disseminating knowledge of their existence and this has been achieved through the SEISCAN Web Viewers: http://cats.u-strasbg.fr/seiscan.html & http://www.soc.soton.ac.uk/CHD/seisweb/index.html. Navigation and seismic image thumbnails are available for browsing and mid-resolution images accessible for reference. Access to full images is through data owners. The potential re-acquisition cost of these surveys would run to tens of millions of Euros.

In scanning some 7000 images of various EPC and wiggly trace record sections off European margins it became apparent that there was a need for digital versions of the old data, even though most were only ever recorded on now unusable analogue media. SEISCAN realised that commercial digital translation of data was too expensive for most academic applications and that these jobs were also often too small a task to interest processing companies. Therefore in association with the project Associate Partner company Caldera Graphics, SEISCAN designed a new software module - SeisTrans - that creates a SEG-Y file of almost any scanned seismic image.

SeisTrans uses an interactive procedure to first register the image in time and source space. This process depends on the original data acquisition parameters but does permit generalised assignment necessary when processing poorly annotated record sections. Based on these parameters the record is partitioned into sample patches nominally appropriate to 4 ms sampling (variable) and removes any traveltime lines. The translation process evaluates the ratio of black to white pixels in each patch to give a digital value. These sample values, with optional header information, are then written to a SEG-Y file fully compatible with seismic processing packages such as Seismic Unix (Colorado School of Mines) and ProMAX (Landmark). The module is integrated in the Caldera Graphics 'Cameleo' imaging software. It brings seismic translation into the academic budget, is particularly suitable for small data sets, training and project compilation and forms part of a project technology transfer.

Wednesday PO Session

OS03 : WEpo01 : PO
Deformation Processes at the Fast to Ultrafast Oceanic Ridges: Analog Modeling Constrains

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We report the results of analog experiments performed to constrain the deformation processes of the crestal region of fast spreading ridges. The axis of the fast to ultrafast East Pacific Rise (EPR) is characterized by an elongated dome 5-15 km wide and 0.2 to 0.5 km high. This axial high is bounded by 2-5-km-wide lateral troughs that develop 2-8 km off-axis. In addition, along 15-20% of the length of the ridge, the axial high is notched by a summit trough 40-110 m deep and 200 to 2000 m wide (an order of magnitude wider than the elongated lava lakes and eruptive fissures which frequently mark the axis of accretion). It has been proposed that such large axial troughs represent elongated collapse calderas that form when the melt supply to formerly inflated axial magma chambers wanes or nearly ceases. Our analog experiments are designed to examine the combined effect of a magma reservoir deflation and a steady-state seafloor spreading. An inflatable elongated balloon filled with water is used as an analogue of magma reservoir (including magma lens and crystal mush). The balloon is capped with a silicone layer representing hot rocks below the brittle/ductile transition, and is covered by a sand layer representing the upper brittle crust. The sand surface was given a dome shape that approximates the morphology of a fast spreading ridge. Mobile walls activated by a stepping motor combine the deflation experiments with continuous extension. Results suggest that the EPR axial morphology is a combination of horizontal and vertical movements, in relation with two different processes. The regional continuous extension generates the lateral grabens that are bounded by normal faults rooted at the base of the brittle crust, at the boundary of a free stress area corresponding to the top of the magma reservoir. The second process is the subsidence of the magma reservoir top that yields, with a sufficient subsidence amount, to the development of the axial summit caldera and its associated ring fault located on the flanks of the dome. The subsidence also emphasizes the development of lateral grabens. An original model that integrates tectonic extension and lost of volume at depth is proposed, integrating for the whole fast to ultra fast EPR: 1) the systematic presence of lateral grabens and their formation mode; 2) the conditions for the development of a summital trough as a collapse caldera process.

OS03 : WEpo02 : PO
The Connection of Zones of Hydrothermal Activity and Petrochemical Zoning within the Scope of the Mid-Oceanic Ridges with Deep-Seated Geophysical Anomalies (An Example of the Mid-Atlantic Ridge)

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We was undertake the approachs to study the deep seated structure under Mid-Atlantic ridge by the seismical tomography method. The difficulties connected with installation of the seismological networks in the regions of Mid-Oceanic ridges have resulted in, that an exploration of these locations in global practice to last moment was limited. Only the development of inverse-teleseismical scheme (Koulakov, 1998) has allowed to receive detailed patterns of the seismical heterogeneities under any seismically-active areas, including a parts under the Mid-Oceanic ridges. The main idea of inverse-teleseismical scheme consists in use of information about earthquakes, that located inside of investigated area, registered by stations of the global seismologycal network. The tomographycal inversion is based on so-called, nodal parametrization (Kulakov et al., 1995). According to it the significances of high-speed anomalies are calculated in units of certain grid. The high-speed distribution between units is approximated by certain simple priciple (constant gradient's of speed, slowness or other). The units inside of investigated areas are distributed non-uniformly, pursuant to density of beams, on the basis of which the inversion is executed. Present moment receives the preliminary results, showing the seismical heterogeneity under Mid- Atlantic ridge (from 10° to 33° N) on depth from 100 to 300 km. It is possible to see, that positive and negative anomalies are interleaved lengthways of the Mid-Atlantic ridge, and period of alternation on qualitative level corresponds to the distance between main transform faults. Lowered seismical speed on depth below 100 km. usually connect with anomalous-high temperature. However it is necessary to mean, that besides temperature, on the seismical speed can also act the considerable influence the next criteria: variation of real structure, rock fracture system, saturation by fluids. All these factors should have the reflection in processes, being present on the surface. The comparison of seismical patterns received in MAR region with distribution of zones of magmatism and hydrothermal ore formation shows the definite conformity. The further researches of connection of deep seated seismical heterogeneities and surface processes on quantitative level probably allows to predict the location of the ore mineralization development on base of the topographical patterns. This work was supported by the RFBR (grant 01-05-65226) and UIGGM-VMTK(grant 1753).

OS03 : WEpo03 : PO
Conditions of Rift Magmatism within the Central Part of the Knipovich Ridge

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Norwegian-Greenland basin is the youngest region of the Atlantic Ocean. Knipovich Ridge situated in its northern part belongs to slow-spreading zone with complicated history of its development. Beginning from the early stages of spreading (about 66-57 m.y. ago) the position of the spreading zone was not constant (Crane et al., 2000) undergoing the axis shifting with direction under an angle to the previous strike. The peculiarity of the northern part of the ridge is its close position to the continental margin of Svalbard Archipelago. Series of volcanic axial mountains from 600 to 1000 m are situated along the rift valley, the maximum depth of which is 3700 m. The ridge is cut by the system of oblique faults. According to geological and geophysical investigations there are several segments about 30-140 km long within the ridge (Crane et al., 2000).

The study of magmatism of the central part of Knipovich Ridge segment 76°38' - 77°25' 85 km long and average rift valley width about 10 km in the region of 76°45' n.l. has been carried out. Fresh basalts with quenched zone have been taken from different depth with the help of submersible apparatus "Mir"(r/v "Mstislav Keldysh") and dredging (r/v "Professor Logachev", 1996). These melts belong to middle-enriched tholeiite types with K_2O/TiO_2 up to 0.3. H_2O content in the glasses reach 0.24 and H_2O/K_2O ratio is 0.3 which is close to similar ratios for enriched tholeiites (Danyshevsky, 2000). Distribution of lithophile elements with respect to their content in primitive mantle demonstrates the certain peculiarity of positive Zr anomaly, and considerable negative Th anomaly and not so well obvious Sr which is similar to distribution of these elements in tholeiites of the Gakkel Ridge (Muhe, 1997). Studied isotope composition (Sr, Nd, Pb) and values of characteristic ratios (Sr/Sm - La/Sm, Yb/Sm) evidence that the glasses in the region (70°-77°n.l.) form the single mixing trend with the end members of depleted MORB source and enriched source close to the source of the Jan Mayen basalts.

By composition of the main elements the melts pouring out within the Knipovich Ridge belong to the less deep tholeiite type, the primary melts of which are rather enriched in Na, Si and poor in Fe. Such type of melts is characteristical to colder regions of the oceanic lithosphere. Its presence within the Knipovich Ridge and perhaps development till the Gakkel Ridge evidence that here magmatism is formed under conditions of passive spreading as against the MAR near Iceland and the Azores where the influence of upraise of hotter substance of deep plume is more considerable.

OS03 : WEpo04 : PO
The Chemical Consequences of Late-Stage Hydrothermal Circulation in an Uplifted Block of Lower Ocean Crust at the SW Indian Ridge: Results from ODP Hole 735B (Leg 176)

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Mid-ocean ridges with slow spreading rates are characterized by lithologically complex lithosphere that generally lacks a well-organized layer-cake structure. The low magma budgets of slow spreading ridges lead to periods of amagmatic extension, during which lower crust and upper mantle are exposed. Lower crustal lithologies form a significant fraction of the flanks of slow spreading ridges, and must be subjected to off-axis seawater circulation.

We examined whole rock chemical and isotopic (Sr and O) data for '"fresh"/"altered" sample pairs from Ocean Drilling Program (ODP) Hole 735B at the Southwest Indian Ridge. The compositional data are combined with estimated extents of low-grade background alteration to derive the magnitude of chemical changes related to subgreenschist-facies alteration. We then compare the style and intensity of chemical alteration, together with flux estimates, to data for ridge flanks in layer-cake crust.

ODP Hole 735B penetrates more than 1500 m into lower ocean crust that was generated at the very slow spreading Southwest Indian Ridge and later formed the 5-km high Atlantis Bank on the inside corner high of the Atlantis II Fracture Zone. The gabbroic rocks recovered from Hole 735B preserve a complex record of plastic and brittle deformation and hydrothermal alteration. High-temperature alteration is rare below 600 meters below seafloor (mbsf), but the lowermost section of the hole (500-1500 mbsf) has been affected by a complex and multi-stage low-temperature (<250°C) alteration history probably related to the tectonic uplift of the basement. This low-T alteration is localized and typically confined to fractured regions where intense alteration of the host rocks can be observed adjacent to veins/veinlets filled with smectite, smectite-chlorite mixed layer minerals, or chlorite ±calcite ±zeolite ±sulfide ±Fe-oxyhydroxide. We have determined the bulk chemistry and O and Sr isotope compositions of fresh/altered rock pairs to estimate the chemical fluxes associated with low-temperature interaction between the uplifted and fractured gabbroic crust and circulating seawater. The abundant low-temperature alteration in the lower 1000-m of Hole 735B significantly changed the chemical composition of the basement. The magnitude of these changes is large enough to render low-T alteration of uplifted and fractured lower crust a significant sink for H_2O, $CO_2$2, S, Li, U, P, ^{18}O, and ^{87}Sr.

O and Sr isotopic compositions of calcites reflect very low fluid temperatures and overall little exchange of Sr between basement and circulating seawater. A number of calcites, however, appear to have been formed from a fluid that had exchanged Sr with the rock. This observation suggests that fluid circulation in exposed lower oceanic crust may be a source of mantle Sr to the oceans.

OS03 : WEpo05 : PO
Evidence for Intraplate Deformation in the Southern Central Indian Basin from a Swath-Bathymetry Survey (MD118-DEFLO Cruise)

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In August 2000 during the DEFLO cruise, R/V Marion Dufresne collected ~10.000 km of geophysical data in the diffuse plate boundaries between the Indian, Capricorn and Australian plates (southern Central Indian and Wharton basins). These data include multibeam bathymetry, seafloor reflectivity, magnetic, and gravity data, and few single-channel seismic profiles. Basement rocks were also recovered from an isolated seamount 500 km north of Amsterdam Island.

The first part of this cruise focused on the diffuse plate boundary between the Capricorn and Australian plates, that connects with the Southeast Indian Ridge, between 75E and 90E. The deformation in this area is mostly known from its unusual high level of off-ridge seismicity. The pattern of focal mechanisms (Bergman et al. 1984) and plate motion studies (Royer & Gordon 1997) suggest that this plate boundary is made of two disjoint zones, on either side of the Capricorn/Australia rotation pole. South of the pole, predicted motions are consistent with WNW-ESE stretching of the oceanic lithosphere, parallel to the general trend of the Southeast Indian Ridge, and, north of the pole, with NW-SE shortening in the southern Central Indian Basin. In the extensional part of the diffuse boundary, satellite altimetry data reveal many volcanic edifices and intermediate-wavelength undulations of the geoid (lambda 200 km), perpendicular to the direction of extension (Cazenave et al. 1987). The objectives of the DEFLO survey were to test this model and to collect direct evidence of the deformation in this two areas.

Along the northern flank of the Southeast Indian Ridge, swath-bathymetry data revealed some evidence of extension including normal fault scarps, cutting trough the original abyssal hill fabric, and a graben, oblique to the spreading direction. Modelling of a 900 km long profile, perpendicular to the gravity undulations, and comparison with the conjugate flank, will help determining the origin of these undulations (buckling or inverse boudinage). Further north, in the compressive part of the diffuse plate boundary, the seafloor fabric displays a series of different directions, that could be due either to a late deformation of the original fabric or to the change in spreading direction which occured around 40 Ma when India collided with Asia. Close examination of the magnetic anomaly pattern will help discriminating between the two hypotheses.

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OS03 : WEpo06 : PO
Modeling of Aeromagnetic Anomalies of the Chicxulub Crater and its Implications on the Nature of the Yucatan Basement

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Modeling of the aeromagnetic anomaly data from the Chicxulub crater allows us to propose an updated model of the Chicxulub impact structure. Prior studies of the magnetic susceptibility variation along the lithologic column in the crater revealed that the suevite-like breccias may have a stronger magnetic signature than that of the impact-melt. The crystalline component estimated from clasts analyses in the suevite-like breccias has a stronger magnetic susceptibility (up to 1500 x 10^{-6} SI) than that of the impact melt (~500 x 10^{-6} SI) and the crystalline basement (400 x 10^{-6} SI). Using this data, new 2-D magnetic models were developed, which indicate that the central uplift yields an important magnetic anomaly and is about ~ 1000 m deep in the central area. Along with the magnetic analyses, geochemical analyses of samples from the Maya Mountains and from UNAM scientific drilling program were used to investigate on the nature of the Yucatan basement. From this study we find that the Yucatan basement is formed by granodiorites, quartzmonzonites and granites. SiO_2 ranges are 48.5-67.4, 63.3-73.92 and 74.13-75.8 for Yucatan, LGmMPR and LGbMPR respectively, which suggest a calc-alkaline composition from intermediate to acidic with $K_2O > Na_2O$. From the Harker diagrams, we noticed a linear trend with smooth and negative slope for Al_2O_3, Fe_2O_3, TiO_2 and MgO; trends are not very clear for MnO, P_2O_5 and CaO and are not present for K_2O and Na_2O. Th, Y, Hf, Nb and Zr plots show two well defined groups. One group is LGbMPR with almost constant SiO_2 content and higher variation in trace elements. Second group (Yucatan and LGmMPR) has a wider SiO_2 range (48.48 - 73.92) because it includes 3 different lithologies (granodiorite, quartzdiorite and granite). Other factor is that Yucatán samples are altered, the intensity and kind of alteration produced loss of SiO_2. Further evidence is in bulk alkali vs Y+Th+Nb plot. Yucatan samples show lower REE total contents (16.96-116.26) than samples from Belize (73.11-144.09). (La/Lu)* ratio for three out of four samples from Yucatan (1.06- 5.22) are consistent with the Belize samples (5.23-17.9). The slope differences might be a consequence of post impact alteration of the Yucatan samples that produced lost of REE, as well as SiO_2 mobilization. Cloritization, seritization and fenitization are the types of alterations in those samples. Eu anomaly is other indication of alteration effects; in Yucatan samples Eu anomaly is negative but small (Eu/Eu* = 0.67 - 0.98).

OS03 : WEpo07 : PO
Sedimentary Processes in the Naples Gulf, Southern Italy: Results from High Resolution Stratigraphy

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An integrated study of high resolution seismostratigraphy and core analysis, in the western sector of the Naples Gulf (Phlegreand Fields and corresponding marine areas) has been carried out. The petrophysical properties of the cores, mostly formed by muddy marine sediments alternated to sandy pumiceous layers, measured at 2 cm steps by a fully automated Multi Sensor Core Logger, are the base of high resolution correlation. Eight stratigraphical markers (events A to H) characterized petrophysically and sedimentologically have been recognized and correlated two of which (C and F) are present in all cores and one (F) is recognized also in the seismo-acoustic Subbottom-Chirp profiles. A composite stratigraphic section was carried out by mean of interactive Unix Platform Software (Splicer). The 'Spliced' section defines a chronology of the events. Using previous dating it could be possible that the Monte Nuovo (472 B.P) and Averno (3800 B.P.) Phlegreand Field eruptions, and the 79 A.D. and c. 2700 B.P Vesuvian eruptions are recorded respectively in the stratigraphic events A and F, C and D (the last record is yet unknown in marine sediments). Further work will be aimed to understand the significance of the other stratigraphic markers and to build up an Holocene event chronostratigraphy in the Naples and Salerno Gulfs.

OS03 : WEpo08 : PO
Evidence of the 79 A.D. Pompei Plinian Eruption in the Salerno Bay, Eastern Tyrrhenian Sea: Stratigraphic and Sedimentological Implications

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Stratigraphic and sedimentological studies carried out on a number of gravity cores and the interpretation of ca. 300 km of high resolution single-channel seismic profiles (Subbottom CHIRP) from the Salerno Bay (Eastern Tyrrhenian Sea) documents the occurrence of a several decimeter-thick pyroclastic fall deposit interbedded with the uppermost Holocene marine strata. Core log description shows this deposit consists of a lower part of white pumice and an upper part of greenish-gray pumice with a variable content of lithic fragments. Major and trace elements analysis carried out on pumice samples indicate a vesuvian origin for this volcanoclastic level which has a phonolitic (white pumice) and tephri-phonolitic (greenish-gray pumice) composition. Furthermore, the content of immobile elements like Zr and Nb are well within the range observed for the plinian eruption that destroyed the roman town of Pompei in 79 A.D. Interpretation of Subbottom profiles shows that the Late Quaternary sequence of the Salerno Bay represents an expanded Holocene section reaching a maximum thickness of ca. 36 meters in the median zone of the continental shelf off Vietri-Cetara area. Seismic interpretation also documents that the tephra layer in study occurs at depths beneath the sea floor varying from a maximum of ca. 16 m in the Holocene depocenter area to a minimum of ca. 2 m towards the shelf edge. The data set allowed us to map this widespread isochronous level whose thickness in the Bay is consistent with the one measured on land. These results provide new constraints concerning the sequence stratigraphic evolution of the area during the Late Holocene.

OS03 : WEpo09 : PO
The Dohrn Canyon (Gulf of Naples): A Drainage System of an Active Volcanic Area

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A detailed mapping of the Dohrn canyon has been carried out in the frame of a national research project aimed to the geological mapping at the scale 1:50.000 of selected areas of the Gulfs of Naples and Salerno, Eastern Tyrrhenian Sea. The Gulf of Naples (South Italy) is an excellent natural laboratory for the study of deep submarine canyons and their relationships to eustasy and sedimentary processes. Tectonism and volcanism in geologically active continental margins can also act as important control factors on morphology and evolution of submarine canyons. The Dohrn canyon expose along its walls hundreds of meters of a Middle-Late Pleistocene prograding wedge, made up by clastic and volcanoclastic sediments and genetically related to the Sarno fluvial system. A major morphostructural high ('Banco di Bocca Grande' or 'Banco di Fuori') separates the Dohrn canyon from the Magnaghi canyon. The width of the Dohrn canyon ranges from a few hundred meters to more than 1 km; its depth from 250 m at the shelf edge to some 1300 m at the base of the continental slope, and the

dip of its walls attains some 35° in the steepest sectors. The Dohrn canyon initiates with two major curved branches. The northern branch merges into the shelf through a 1.5 km wide and 20-40 m deep channel ('Ammontatura' channel) characterized by a curved shape in plan view and a flat bottom and asymmetrical levees, located along the -200 m isobath. The 'Ammontatura' channel probably represents a deeply incised valley later infilled by sediments which predates the onset of the most recent eruptive centres in the Gulf of Pozzuoli, as suggested by its abrupt termination towards the Nisida submarine volcanic edifice. The Dohrn southern branch is fed laterally by a dense network of tributary channels which control the sediment transport from the continental slope. The sedimentological analysis of gravity cores from the southern branch of the Dohrn canyon suggest that the rocks displaced from slide scars and sediment mass transport occurred towards southeast by along-slope turbidity currents and debris flows. Core analysis reveals the presence of pumice-rich sediment flows, corresponding to periods of high volcanoclastic input. Conversely, bioturbated muddy intervals mark phases of quiescence in sediment transport along the canyon.

OS03 : WEpo10 : PO
The Nile Deep-Sea Fan: Main Results of the Fanil Cruise (October-November 2000)

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The general aim of the Fanil cruise (R/V 'Le Suroit', 9 october-6 november 2000), was to complete the knowledge of the Nile deep-sea fan, by extending the Prismed II cruise area (R/V 'L'Atalante', 1998), to the West and the East. The used method was approximately the same ie swathbathymetry, acoustic imagery, and multichannel seismic profiling. In addition, seven piston cores were sampled. Four clearly individualized domains can be identified: A) A western domain, is mainly characterized, in its upper part, by very numerous growth faults responsible for gliding of the plio-quarernary sedimentary cover. Beyond, very numerous mud volcanoes, recognized for the first time in this region, are present. The Nile fan has been recognized from the Rosetta canyon to its most distal part. The network of deep-sea meanderous leveed channels show clear evidence of avulsions and channel migrations. Their sedimentary structure shows, for the first time, clear lense shaped units made of high acoustic reflexions (HAR) in the axis, and transparent to well stratified layers on the lateral levees. On acoustic images, the distal part of this network is marked by high reflectivity areas, corresponding to coarse lobe deposits. Coring shows that these deposits are made of terrigenous sandy sediments. B) A central domain is characterized in its upper part by 1) very huge debris flow deposits associated with pock-marks in the western sector b) very large growth faults in the eastern sector. Offward, salt ridges, approximately oriented N-S, are trapping sediments of probably hemipelagic origin, filling small basins. C) An eastern domain is characterized by more than 150 km long NNW-SSE oriented transtensive faults with a right-lateral horizontal component, bounding thick sediment-filled grabens. Most of the deformation is believed to reflect a salt reactive reponse to regional tensional geodynamics driving or combined with active gravitational gliding. Especially in its upper part, this domain is marked by mud volcanoes and gas seeping tightly associated with faulting. Some deep depressions located at the intersections of the NNW-SSE transtensive faults and associated transtensive grabens, seem to be the locus of salt brines. In both central and eastern areas the Nile meanderous deep-sea channels are still present but highly segmented by tectonis and sedimentary instability. D) More to the east, a fourth domain is characterized by the occurrence of very long and sinuous deep-sea channels, originating from the Damietta branch of the Nile. These channels spread northwardly over a thick nilotic sedimentary formation, appearing deformed and folded by gliding over the underlying messinian salt layer. This Nilotic network merges, east of the Eratosthenes seamount, with another network that seems originate from the Levantine coasts. Both networks outlet in the sedimentary basin located south of Cyprus.