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.

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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).

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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 'sheepback' 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