220 teleseismic events with even azimuthal distribution recorded at permanent and temporary seismic networks in the greater Alpine area. The tomographic study consists of these components: (1) Corrections for the contribution of the Alpine crust to travel-times of incoming wave fields that may account for up to 50% of the observed travel-time residuals. The 3-D crustal model established from controlled-source seismology data represents the large-scale Alpine crustal structure which clearly reflects the effects of the African-European plate collision. (2) Tests with synthetic data document that the combination of non-linear inversions, high-quality teleseismic data, and usage of an a priori 3-D crustal model allows reliable resolution of cells at 50km*50km*30km with a velocity variation in the order of ± 3% in the upper mantle. (3) Our tomographic images illuminate the structure of the uppermost mantle to depth of 400 km reflecting the complex processes that formed the Alpine orogen when three different plates were amalgamated (European, Adriatic, and Ligurian plates). In the western Alps, the inversion results show a steep W-E dipping high-velocity anomaly which we interpret as the subducting European plate. In the eastern Alps we find high-velocity anomalies in a depth range of 150 km to 300 km beneath the axis of the orogen. At present, the relation of this material with European or Adriatic lithosphere remains unclear. Our results are in general agreement with earlier lithospheric studies. However, the increase in resolution illuminates significantly more complex lithospheric slab geometries, which vary along the axis of the orogen, than assumed in previous geologic models.

T52B-0949 1330h POSTER

Analytical Modeling and Space-Geodetic Observation of Post-Seismic Deformation After the 1997 Umbria-Marche (Central Italy) Earthquake

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In the fall of 1997 a moderate size ($M_w = 6$) and shallow earthquake struck Central Italy. According to recent deep seismic reflection studies, surface-wave tomography and depth distribution of the related aftershock sequence, the seismogenic layer in that region appears to be thin (8-9 km) and decoupled from the lower part of the crust. Within this particular setting, which includes the presence of a low-viscosity transition zone and lower crust, viscoelastic relaxation is expected to be a major term in governing postseismic deformation.

Viscoelastic deformation is quantified following a normal mode approach for a stratified, self-gravitating and viscoelastic Earth; particular care is taken in reaching the high-resolution required by the small scale of this event. We focus our attention on the two main shocks that occurred on September 26, 1997, and after obtaining a good agreement with the observed coseismic displacement, we study the viscoelastic relaxation expected in the first 10 years after the earthquake. For reasonable viscosity values in the transition zone and lower crust ranging between 10^{18} and $10^{19} Pa \cdot s$, relatively high deformation rates are expected to occur at the surface. Both vertical and horizontal rates between 1 and 5 $mm \cdot yr^{-1}$ are possible to occur in a region of a few tens of km around the epicentre, depending on the chosen viscosity values and observation times.

The modelled deformation pattern for the years 1998-2001 is compared with measurements obtained by means of space geodetic techniques, namely GPS and InSAR and also to the seismic strain pattern revealed by the aftershock sequence. GPS data, coming from a local network installed across the fault and occupied on a yearly basis since the fall of 1999, are analysed by means of two different techniques: a multibase mode using the software package Bernese and Precise Point Positioning with ambiguity fixing using GIPSY. For the SAR Interferometric measurements of the area, we considered a set of interferograms covering different time spans within the years 1998-2000. Merging the redundant information from these partially overlapping interferograms helps to reduce the effects of temporal decorrelation on the whole two-year period. Additionally, GPS data are integrated in the interferometric measurements in order to check phase unwarpping errors. We show that the layered viscoelastic structure of the crust and mantle imposes a pattern and scale on the modelled coseismic and postseismic deformations with a major contribution from the transition crustal zone and low-viscosity lower crust, stress relaxation in the mantle being negligeable. We analyse the relation between the deformation fields averaged over different temporal and spatial scales and discuss the mechanical behavior of moderate-magnitude earthquake faults.

T52C MC: Hall D Friday 1330h

Continental Rifting and Passive Margin Development: Rift to Drift *(joint with S, V)*

Presiding: **N Morewood,** Univ College Dublin

T52C-0950 1330h POSTER

Crustal Structure and Continental Margin Development Within the Svalbard Caledonide Terrain Based on Modeling of Ocean Bottom Seismometer Data

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The Barents Sea is located in the northwestern corner of the Eurasian continent, where the crystalline basement was assembled in the Caledonian orogeny during the Silurian period. Multichannel reflection seismic lines mostly do not resolve the structure well below the Permian sequence, and the post-orogenic development is not well known. Four ocean bottom seismometer (OBS) profiles that were collected in 1998 south of Svalbard is presented here. One profile was shot across the continental margin, and two profiles were shot as tie-lines on the continental shelf, together with one short profile to the north not crossing the others. P-wave modeling of the OBS profiles supports the presence of a Caledonian suture as previously proposed from interpretation of a deep seismic reflection line coincident with one OBS profile. The suture is associated with a small crustal root and westward dipping mantle reflectors. It also forms a boundary between two different crystalline basement terrains; the western part with low (6.2-6.45 km/s) P-wave velocities, the eastern part with higher (6.3-6.9 km/s) velocities. Gravity modeling supports a change in crustal terrain, as a higher density is needed in the eastern block. The results of the modeling of the S-wave data were not so clear on this, but very variable results indicate a strongly heterogeneous basement terrain. Immediately east of the suture zone there is a 15 km deep, early post-Caledonian sedimentary basin, restricted to the west and north. These observations can be explained by a model assuming westward dipping Caledonian subduction and collision, followed by post-orogenic extensional collapse mainly to the southeast. Subduction erosion may explain the missing lower crust in the western block. The outer 30 km of the continental margin is dominated by two large rotated fault blocks with throws of 2-3 km each, apparently formed during the Tertiary transform margin development and opening of the Norwegian-Greenland Sea. Due to the very low tectonic thinning of the continent at the margin, the continent-ocean boundary can be located to within 5 km. On the oceanic side, a top basement velocity of 6.55 km/s shows a missing oceanic layer 2, though the high (7 km/s) velocity reported earlier from expanding spread profiles is not observed.

T52C-0951 1330h POSTER

Tectonic Evolution of the Svalbard Continental Margin - Results from Seismic Refraction Experiments -

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In 1997 and 1999 the western and northern continental margins of Svalbard were geophysically explored by a German/Polish/Japanese scientific team. Main target of the surveys was the determination of the crustal seismic velocity structure. Therefore four seismic refraction profiles, with a total length of 1300 km were carried out across the continental margin. On the northernmost profile across the southern Yermak Plateau stretched continental crust is present up to 81 N. Seismic velocities vary between 5.1-6.9 km/s, therefore we exclude a rifted-volcanic evolution for the southern part, as supposed for the origin of the entire Yermak Plateau. The E-W striking profiles from Knipovich Ridge across the western continental margin of Svalbard show local zones with slightly elevated seismic velocities up to 7.2 km/s in various depths within continent-ocean transition zone (COT). The structure of the adjacent continental crust is similar to that on Yermak Plateau. Thinned oceanic crust with a thickness of 2-4 km is oberserved westwards of the COT. The deeper structure within the COT shows strong variations along the western margin. A 180 km broad COT is found at 79.8 N (northern Svalbard). Approximately 100 km further to the south at 79.0 N (Kongsfjord) the COT narrows to 40 km followed by the abrupt termination of continental crust to the adjacent oceanic crust. We interprete this part of the margin as a sheared continental margin. Off Van Mijenfjord at 77.8 N the width of the COT broadens again to 80 km and forms a normal stretched non-sheared part of the margin, as observed in the north. It seems that the Spitsbergen Fracture Zone of the complex Fram-Strait MOR-system was active while to the north and south normal stretching of continental crust occurred. The occurence of bodies of higher seismic velocity between 77.8 N and 79.8 N might be explained by the close distance of the newly developing margin to active spreading center segments. A limited amount of mantle derived melts was injected into the COT.

T52C-0952 1330h POSTER

RAPIDS 3: Imaging Beneath the Southern Rockall Trough Using Wide-Angle Seismics

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The Rockall And Porcupine Irish Deep Seismic (RAPIDS 3) project, funded by the Petroleum Infrastructure Programme, Rockall Studies Group, involved the acquisition of four wide-angle reflection/refraction seismic profiles in the Irish sector of the Rockall Trough. 2-D travel-time modelling has been completed and indicates typically a 4 – 5 km thick sedimentary succession within the central part of the basin thinning to c. 1 km on the surrounding basement highs. Significant topography modelled on the crystalline basement most likely represents a series of rotational fault blocks. Three main seismic packages have been identified within the sedimentary succession which is thought to be of Late Palaeozoic to Recent age. A 3-layer crust of c. 30 km thickness is modelled beneath the Porcupine and Rockall Highs thinning to 6 – 8 km beneath the basin with maximum thinning occurring beneath the edges of the basin. The three intra-crustal layers also thin and merge together such that beneath the centre of the basin a 1 or in some places a 2-layer crust is observed. Sub Moho velocities are lower than would be expected beneath the centre of the basin suggesting that some form of alteration of the upper mantle may have occurred.

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T52C-0953 1330h POSTER

RAPIDS 3: Seismic Stratigraphy of the Southern Rockall Basin from Wide-Angle Seismic Modelling and Normal Incidence Reflection Data

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The Rockall And Porcupine Irish Deep Seismic (RAPIDS 3) project, funded by the Petroleum Infrastructure Programme, Rockall Studies Group, involved the acquisition of wide-angle reflection/refraction seismic profiles in the Irish sector of the Rockall Basin on the NE Atlantic continental margin. A comparison has been made between one of the RAPIDS profiles (profile 33) and a coincident high quality normal incidence reflection profile, both of which traverse the entire width of the Rockall Basin. Conversion of the RAPIDS model to two-way travel-time has enabled the positions and geometries of the packages defined by the wide-angle velocity modelling to be directly compared with those interpreted from normal incidence reflection data. The independently derived layers and geometries show a generally very close comparison between the two data sets. A seismic stratigraphy for profile 33 is presented, based on correlation between the wide-angle and normal incidence data, shallow seismic site surveys, shallow borehole cores and tectonostratigraphic studies. A Late Palaeozoic to Recent age is interpreted for the sedimentary succession.

T52C-0954 1330h POSTER

Gravity Variations in the Rockall and Porcupine Basins West of Ireland: Evidence for a Linked Structural Development

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The crustal structure of the large Mesozoic Rockall and Porcupine basins west of Ireland determines the broader scale behaviour of the free air gravity field in the region. Marine gravity surveys in the shallow shelf seas around Ireland together with satellite gravity data from the deeper ocean to the west are used to investigate the larger-scale crustal structure of these major basins. Crustal structure derived from wide-angle and vertical incidence seismic data is used to control the interpretation and modeling of gravity data. The Porcupine Basin is situated between the highly stretched crust of the Rockall Basin (where β = 5 to 6) and the thicker Proterozoic crust of the Irish mainland and shelf area, where the crust approaches 30 km in thickness. The crust of the south Porcupine Basin has undergone similar amounts of bulk stretching to that of the southern Rockall Basin and has very similar gravity patterns. The crust of the northern Porcupine Basin is less severely stretched and an axial gravity high is present due to anomalous density variations in the crust or upper mantle. The change in crustal geometry and gravity properties occurs across a distinctive set of NW-trending gravity lineaments, which may correlate with cross-basin crustal faults, controlling large-scale basin segmentation. Lithospheric stretching south of these gravity lineaments involved a large anticlockwise rotation of the southern part of the Porcupine High, while to the north the stretching involved a smaller antipathetic clockwise rotation of the northern Porcupine High. This pattern of tectonic block rotation controls the southward broadening of the Rockall Basin and suggests a strong structural linkage between these two large basins.

T52C-0955 1330h POSTER

A New Deep Seismic Reflection Profile From the SCREECH Project, Newfoundland Basin, NW Atlantic Margin

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As part of the SCREECH project (Study of Continental Rifting and Extension on the Eastern Canadian sHelf), we present a complete, deep seismic reflection profile along the southernmost of three data-acquisition corridors crossing the Newfoundland passive margin into the Newfoundland Basin. The corridors were chosen to provide (with corresponding transects from the Iberian margin) complete images of the non-volcanic conjugate margins of the Atlantic that evolved as seafloor spreading jumped northwards from its initiation between North America and NW Africa.

We present data for seismic profile 3MCS-2 recorded on R/V Ewing. The profile extends more than 500 km across the rifted Grand Banks continental shelf, the continental slope and into the deep water Newfoundland basin. At the seaward end, it crosses a 150-km-wide transition zone containing crust of uncertain origin and it ends on undisputed oceanic crust. Coincident seismic wide-angle recordings provide seismic velocity constraints that are of primary importance to interpreting lithospheric structure, particularly in the transition zone.

Images presented show the nature of crustal thinning below the shelf, slope and rise. The transition zone is characterized by angular basement blocks. On the inboard two-thirds of the slope and rise these blocks have internal layering dipping inboard. This is suggestive of sedimentary rocks originally deposited over continental basement during pre-rift or syn-rift stages. There is no clear reflection Moho, and the base of the crust may be disrupted by intrusions or alteration (serpentinization) of ultramafics.

There is no precisely collinear equivalent on the Iberian conjugate margin. Iberia profile IAM-9, offset some 100 km north, shows some similarities with 3MCS-2 but also significant differences. Both show a transition zone 120-150 km wide, and 50-70-km-wide zones of thinned continental crust adjacent to the shelf edges. Dips in fault blocks are predominantly landward. There is no unequivocal evidence of peridotite ridges in the Newfoundland Basin, similar to those off Iberia, but the Newfoundland Basin does exhibit a clear basement-capping reflection (U) - absent on the conjugate margin - that can be correlated with rift-drift unconformities on the adjacent Grand Banks. Thus, despite gross similarity between the conjugates, there are significant differences in detail. Seismic velocity characterization will enable us to test alternative interpretations of structures observed on the Newfoundland margin. Interpretation of the complete SCREECH data set will lead to attractive targets for the Integrated Ocean Drilling Program.

T52C-0956 1330h POSTER

Crustal Structure and Composition of the Newfoundland Nonvolcanic Rifted Margin on the Future ODP Leg 210 Drilling Transect

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The Newfoundland side of the Newfoundland/Iberian conjugate margin pair is an excellent place to study continental extension and rifting. The SCREECH study area is conjugate to drilling transects and seismic data sets collected on the Iberian margin. Lingering questions concerning the symmetry of rifting processes and architecture and the lack of magmatism on nonvolcanic margins can be addressed by obtaining high-quality images of the Newfoundland margin to complete the picture. We present a preliminary velocity model and processed, time-migrated, multi-channel seismic reflection lines collected during the SCREECH survey. These lines include Transect 2, one of three primary transects collected offshore Newfoundland in July-August 2000, and a network of grid lines that cross Transect 2 at proposed drill sites for upcoming ODP leg 210 in 2003. Transect 2 extends from continental crust on the outer edge of the Grand Banks southeast across extended continental crust, "transitional" crust of unknown origin, and 60 km seaward of magnetic anomaly M0. Three major basement types are observed on Transect 2: (1) block-faulted continental crust with abundant lower-crustal and Moho reflections, (2) a 70-km-wide zone of enigmatic origin, showing relatively smooth, transparent basement beneath the "U" reflector, and (3) a wide zone characterized by significant basement topography (>1.5 km) straddling M0. The basement highs and intra-basement reflections observed on the seaward end of Transect 2 strongly resemble serpentinite ridges imaged and drilled on the Iberian margin. Crustal domain (2), however, is dissimilar from any basement type imaged on the conjugate margin. Additionally, no reflectors comparable in strength and continuity to the "S" reflector, identified as a possible decollement fault on the Iberian margin, are observed on Transect 2. One possible explanation of these asymmetries is a model that invokes a rolling hinge to exhume mantle from beneath continental crust. Other observations on Transect 2 support this assertion. A bright landward-dipping reflector located between crustal domains (1) and (2) at Moho depths might represent the rolling-hinge. Basins in crustal domain (3) appear to deepen and contain older sedimentary sequences seaward, suggesting a landward younging of the "transitional" crust. Although basement types (2) and (3) have different topographic expressions, the transition from smooth to high relief basement is gradual. These observations suggest that all basement seaward of block-faulted continental crust may be serpentinized, continental mantle exhumed from beneath North America by a fault located at the edge of the continent. This interpretation is supported by our velocity model, which shows a high velocity gradient in both crustal domains (2) and (3), with velocities increasing from 5.0 km/s to >7 km/s.

T52C-0957 1330h POSTER

Origin of an Eastern North America Great Escarpment, Based on (U-Th)/He Dating and Geomorphic Analysis

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Many passive margin great escarpments have been interpreted as the result of slow, steady erosional processes following continental rifting. Rugged escarpments may be maintained by parallel slope retreat and drainage divide migration, driven by flexure of the lithosphere associated with rift flank uplift and the isostatic response to denudation and mass transfer from thickened mountain belts to offshore basins. In eastern North America, an escarpment bounding the eastern limit of the southern Appalachian Mountains stands high and rugged, despite a prolonged period of time since cessation of tectonic activity along this passive margin. Whether this feature is the product of slow, steady erosional processes along the continental margin since rifting in the early Mesozoic and cessation of orogenesis in the late Paleozoic, or the result of recent rejuvenation, has been the subject of debate. To investigate this, we have constrained the erosional kinematics of the Blue Ridge Escarpment in Virginia and North Carolina using radiogenic helium thermochronometry and other geomorphic data. Helium ages from rocks above and extending west of the escarpment are old (157-197 Ma), consistent with very slow cooling and denudation since the early Mesozoic. In contrast, helium ages are younger along the Piedmont surface, 500

m below and to the east of the escarpment (94-137 Ma). Although this difference may partly represent an age-elevation gradient associated with either slow exhumation and cooling or an exhumed helium partial retention zone, it cannot be fully explained without lateral variations in exhumation rate. Our working interpretation is that the western Piedmont has experienced as much as several km more exhumation than the Blue Ridge upland since samples cooled through their closure temperatures, effectively bending isochrons upwards to the east. The greater magnitude of denudation east of this east-facing escarpment is not consistent with escarpment formation by rejuvenated uplift of the Blue Ridge; it invokes the wrong sense of vertical motion than expected if the escarpment and highlands to the west had been recently uplifted by faulting or rebound associated with accelerated valley incision tied to climate change. Instead, it is more simply explained by retreat of an asymmetric divide, possibly formed by flexure and isostatic rebound in response to rift-flank uplift or offshore loading. This is consistent with other evidence for westward divide migration in the form of fluvial deposits atop the Blue Ridge highland and the character of stream networks throughout the region.

T52C-0958 1330h POSTER

The nature of a serpentinite-hosted detachment fault underlying the Cretaceous proto-Atlantic: Evidence from the Iberia non-volcanic rifted margin.

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This study documents the footwall succession of a low angle normal (detachment) fault, drilled by The Ocean Drilling Program (ODP) leg 173, Site 1068 beneath the Southern Iberia Abyssal Plain (IAP). The fault zone is comprised of carbonate-altered, rodingitized, and albitized metabasite-rich sedimentary breccias, with serpentinized mantle peridotites. The brittle infrastructure of the detachment consists of a mesh of mineralised extensional and shear veins, mineralised high-dilation breccias, cataclasite and gouge, underlain by cohesive serpentinite. The later shows kernel textures disrupted and offset by small-scale fractures and faults.

The distributions of serpentine polytypes, carbonates, Fe-Ni alloys, sulphides, oxides, and other silicate phases vary across the fault zone, in patterns consistent with mineralization and replacement from solutions derived from two end member components: seawater, and CH4-bearing calcium-hydroxide enriched hydrothermal solutions. The later evolve from seawater where serpentinization proceeded at low water to rock ratios. Serpentine minerals also show chemical changes with fracture-controlled recrystallization, consistent with the fault zone having experienced contact with solutions derived from an antigorite forming prograde metamorphic event.

Hydrothermal mineralization, rock volume expansion accompanying serpentinization reactions with associated changes to solution mass density in the vicinity of the serpentinization front promoted high fluid pressures. In the wake of the front, the production of chlorite and serpentinite gouges, rodingitization, and hydrothermal carbonate precipitation provided fault seals.

Fluid pressure within the fault zone was regulated by fault-valve action, in the course of which serpentinization-related hydrothermal solutions were intermittently discharged. Inter-seismic periods were marked by pre-failure draw down of seawater, into the fault zone, at low water to rock ratios. Co-seismic failure also gave rise to suction pump effects within the rupturing fault seals. Asthenospheric mantle dome ascent and migration away from the continent most likely contributed to the overall intensity of coupled hydrothermal-fault-tectonic activity during the very final stages of non volcanic rifting. Consequently, evidence suggests that the northern reaches of the Early Cretaceous proto-Atlantic may have been subject to pulsed mass additions of serpentinite-related hydrothermal solutions, from extensional faults, occurring on a regional scale.

T52C-0959 1330h POSTER

Along-Strike Variation in the Ocean-Continent Transition off Iberia From Seismic Reflection Profiles

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The nature of the ocean-continent transition along the West Iberia margin varies significantly from north to south between latitudes 42.25°N and 40.83°N. Nine seismic reflection lines collected in 1997 record east-west dip sections across the margin. From north to south, large tilted blocks of continental crust give way to diffractive basement with no tilted fault blocks. The diffractive basement suggests that oceanic crust may be present landward of the peridotite ridge, which is commonly taken to mark the landward extent of oceanic crust.

The northernmost lines image large tilted blocks of continental crust, separated by faults that sole into a detachment referred to as the S reflector. The most seaward blocks of continental crust are adjacent to segments of the peridotite ridge. The nature of the peridotite ridge varies from a fairly flat diffractive top, suggesting that it was eroded significantly during exposure at the seafloor, to a more symmetric ridge that is currently exposed at the seafloor.

Line 15 is about 50 km south of the northernmost line. It is the southernmost line to image the S reflector, which is shallow in the section beneath extremely thin continental crust. There are only two large tilted fault blocks toward the landward end of the line. This line images two segments of the peridotite ridge with fairly symmetrical shapes. Since this line contains the southernmost extent of the S reflector and the large tilted crustal fault blocks, as well as an offset zone between two segments of the peridotite ridge, it may mark the boundary between two different phases of rifting.

The southern lines are very different from the lines to the north. No large tilted fault blocks are visible. The basement is very diffractive toward the landward end of the lines and could represent small wavelength faulting caused by an extremely thin crust (either continental or oceanic). The diffractive nature of the basement suggests oceanic crust, although it is landward of the peridotite ridge.

The southernmost line in the survey images diffractive basement that is located shallow in the section, immediately underlying the oldest post-rift sedimentary unit. The peridotite ridge segment on this line is fairly symmetrical. Basement blocks landward of the peridotite ridge also appear symmetrical, as opposed to the more typical asymmetrical fault blocks to the north. Several of these blocks are similar in appearance to the peridotite ridge, suggesting that some of the blocks may in fact be mantle-derived peridotite rather than crustal blocks.

T52C-0960 1330h POSTER

Description of Along Strike Structural Styles and Implications of Deep Crustal Reflections in the Galicia Segment of the Offshore Iberia Margin

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The offshore Iberia passive margin is recognized as an ideal location for studying the evolution of rifting because of its thin sedimentary cover, absence of salt and limited magmatism, which often make imaging crustal and sub-crustal reflections difficult. Seismic line ISE 5, which was shot in 1997 as part of the Iberia Seismic Project, images some deep crustal reflection geometries that might have important consequences with regard to understanding the evolution of rifting that broke up Pangea.

Based on reflection character, the upper sedimentary section can be divided into two parts: an upper, uniformly dipping, sub-parallel post-rift sedimentary section and an underlying transparent post-rift sedimentary section. Beneath the post-rift sedimentary section, syn- and possible pre-rift, sedimentary rocks are imaged on top of crystalline basement and between apparent "pods" of crystalline basement bounded by faults on all sides.

A bright sub-parallel reflection regarded locally as the S reflector images the detachment upon which most of the extension occurred. Refraction modelling results from OBS data suggest Moho velocities below this horizon. Several reflections that splay from S dip northward into the mantle. This geometry is probably related to northward propagation of the rift, which is consistent with radiometric analyses of localized intrusives that finds younger 40Ar-39Ar ages progressing from Gorringe Bank northward to Galicia Bank. Alternatively, these reflections are related to multiphase rifting along the margin.

Most interesting are 1 second (3.5 km) thick subparallel reflections that might be part of a shear zone associated either with horizontal displacement along the S detachment or from the northward dipping splays. Alternatively, these reflections might represent underplating of upwelling mafics, which rose during decompression as continental crust attenuated along the relatively flat sub-horizontal S reflector. This interpretation supports the observed lack of magmatism along the Iberia Margin. Underplating most likely occurred as a result of cooler than normal crustal temperatures that made for rapid cooling of upwelling asthenosphere. However, underplating also suggests that early rifting along this part of the margin was relatively slow, which seems contrary to observations of limited syn-rift sedimentation.

Future work will focus on pre-stack depth migrating the seismic data in order to evaluate our preliminary interpretations. In addition, gravity and magnetic data will be used to constrain our kinematic model.

T52C-0961 1330h POSTER

Balanced Profiles across the Iberia Rifted Margin

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We have interpreted 4 seismic reflection profiles crossing the entire Iberia/Atlantic rifted margin, and 5 additional profiles crossing the outer, highly extended, part of the rifted margin. The profiles were collected in 1997 using the R/V Ewing, and span the southern part of the Galicia Bank margin segment and the northern part of the Iberia Abyssal Plain margin segment. We have identified the boundaries of the faulted continental crustal blocks rifted during the formation of the margin. We have palinspastically restored the faulted blocks to their apparent pre-rift geometry. We did this assuming that the upper parts of the blocks were not deformed during rifting and that we can estimate the effects of post-extensional erosion on the tops of the blocks. From the interpreted displacements of the blocks we have calculated and mapped estimates of upper crustal extension during rifting. We find that the amounts of extension inferred from the palinspastic restoration are less by a factor of 2 or more than estimates based on observed crustal thickness over most of the rifted margin studied. We argue that this difference is greater than can be accounted for by the assumption that there are faults smaller than we can observe. It is possible that this discrepancy means that there was a period of significant extension that occurred prior to any of the faulting that we observe. If this is true, then the faulting we see has completely obliterated the earlier faulting. We suggest that the difference may be more easily accounted for by detachment style rifting.

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Drilling the Newfoundland Margin in the Newfoundland-Iberia Rift

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Extension in the Newfoundland-Iberia rift began in the Late Triassic and culminated in seafloor spreading by the mid-Cretaceous. Magnetic anomalies M0-M3 are consistently identified and indicate that seafloor spreading commenced no later than Barremian-Aptian time. On both margins, however, crustal 'transition' zones up to about 150 km wide separate the known ocean crust from clearly continental crust, and the origin of this lithosphere is disputed. Deep-sea drilling (ODP legs 149 and 173) and geophysical work has documented that about half this width on the Iberia margin may be extended continental crust, depending on location along the margin, while the seaward part of the transition zone is unroofed mantle emplaced with apparently little associated magmatism. The Newfoundland side of the rift is undrilled but has significantly different deep structure and basement character across the transition zone. Newfoundland basement averages more than a kilometer shallower (corrected for sediment loading) than the Iberia conjugate, exhibits much less roughness, and is capped by a level and highly reflective sequence (below the 'U' reflection) that is missing off Iberia. These features suggest asymmetry in rift development, with the Newfoundland margin forming an upper plate (thinned continental crust) and Iberia comprising a lower plate (exhumed mantle). Leg 210 ODP drilling to about 2200 meters depth in the transition zone of the Newfoundland Basin is scheduled for 2003. It is intended to sample and log basement, the basement-U interval (pre- to synrift?), and the entire post-rift sequence. Primary objectives are to document the nature of basement, the level of magmatism on the Newfoundland margin, the origin and significance of the sub-U reflection sequence, the post-rift subsidence and sedimentation history, and the history of strain partitioning in the rift.

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Deep Stucture of the Northwestern Atlantic Moroccan Margin Studied by OBS and Deep Multichannel Seismic Reflection.

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The Northwestern Atlantic Moroccan margin, a conjugate of the New Scotland margin, is one of the oldest passive margin of the world. Continental break up occurred at early Liassic time and the deep margin is characterized by a large salt basin. A good knowledge of this basin is of major interest to improve the initial reconstruction between Africa, North America and Iberia (Eurasia). It is also a good opportunity to study a mature passive margin and model its structure and evolution.Moreover, there is a need to assess the geological hazards linked to the neotectonic activity within the Africa-Eurasia plate boundary.

These topics have been adressed during the SISMAR cruise carried out from April 9th to May 4th 2001.During this cruise, 3667 km of multichannel seismic reflection (360 channels, 4500 m long streamer, 4800 ci array of air guns) were recorded together with refraction records by means of 48 OBH/OBS drops. Simultaneously, some of the marine profiles have been extended onshore with 16 portable seismic land stations.

We present the initial results of this study. Off El Jadida, the Moho and structures within the thinned continental crust are well imaged on both the reflection and refraction records. In the northern area, off Casablanca, we follow the deepening of the moroccan margin beneath the up to 9 sec (twtt) allochtonous series forming a prism at the front the Rif-Betic chain. Sismar cruise has been also the opportunity to record long seismic profiles making the junction between the Portuguese margin and the Moroccan one, and crossing the Iberian-African plate boundary. This allows to observe the continuity of the sedimentary sequence after the end of the large inter-plate motion in Early Cretaceous.

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Structural Architecture of the Ocean-Continent Boundary at a Transform Margin, Gulf of Guinea, West Africa

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Migration of the 16sec TWT PROBE seismic reflection dataset provides amongst the clearest images of crustal structure at the ocean-continent boundary of a transform continental margin. Despite this, there is considerable uncertainty as to the structural architecture and composition of the so called transitional crust occupying the zone between the continental shelf and the oceanic crust of the Gulf of Guinea. This uncertainty is due largely to the complex transform nature of the Gulf of Guinea whereby the ocean continent boundary is defined by several fracture zones across a c.60 km wide region. This project uses combined geological interpretation and gravity modelling of new migrations of selected PROBE lines to define the whole-crustal structural architecture and composition of this intermediate crust.

In contrast to classic transform margins elsewhere, the Gulf of Guinea margin is characterised by a series of seaward dipping faults that define deep half graben basins and penetrate to Moho level. Gravity modelling provides a constraint on the complex structure within the fracture zones, resulting in a greater understanding of the transform margin formation. Three fracture zones define two distinctly different blocks of transitional crust formed as a result of small offsets in the Mid-Atlantic Ridge. The density variation between the two blocks indicates that the seaward block is highly deformed continental crust, heavily intruded with dykes. Whereas the landward block is less intruded, deformed continental crust.

T52C-0965 1330h POSTER

Basaltic Volcanic Fields Across the Central Part of the Peninsula of Baja California: Tectonic Implications.

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Based on a combination of photo interpretation and field work, new evidence has been gathered that shows that the lava flows that cover part of northern Baja California Sur form at least one basaltic field on the region. The area of study, extending from latitude 27° 30' N to 26° 08' N and longitude 112° 20' W to 113° 20' W can be divided in four zones, each having distinctive characteristics of the volcanic record. Most of the 120 volcanic vents identified on this work are located in two of these zones, whereas the two other zones are characterized by a gap on the volcanic cover that can be interpreted as the boundaries between adjacent volcanic fields. The identified vents include cinder cones, small shield volcanoes and eroded remains of volcanic conduits (necks and dikes), that erupted both alkaline and tholeiitic lavas. The identification of monogenetic fields on the region yields a different tectonic scenario than the one used to explain the volcanic record without the recognition of the fields. Specifically, the previously proposed association of the tholeiites with the initial stages of the rifting that resulted on the opening of the present-day Gulf of California is not longer supported. Rather, the volcanism on the region suggests the existence of zones of crustal weakness that have been overlooked until now. Further, the presence along the Peninsula of basaltic rocks that roughly have the same age and overall characteristics than the lavas of the area of study, suggests that such zones of crustal weakness might have been common on the past 10 Ma, and were especially important on controlling the stress redistribution that occurred from the end of the subduction to the west to the establishment of rifting to the east of the present-day Peninsula. Thus, although much is still unknown about the majority of these rocks, this work highlights the importance of the positive identification of miocenic volcanic fields on Baja California in clarifying the tectonic evolution of the region at that time.

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The Baja California Borderland and the Neogene Evolution of the Pacific-North American Plate Boundary

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New observational data on Neogene faulting in the borderland of Baja California places important constraints on tectonic models for the evolution of the Pacific-North American (P-NA) plate boundary and rifting in the Gulf of California. Neogene faults in the borderland range from strike slip to normal slip and accommodate integrated transtension. Most have east-facing escarpments and likely reactivate the former east-dipping accretionary complex. Numerous lines of evidence indicate that Neogene faults are still active and accomplish a significant component ($\sim$1-5 mm/yr) of Pacific-North American shearing. Quaternary volcanoes are found offshore and along the Pacific coastal margin, Quaternary marine terraces are warped and uplifted as high as 200 masl. Many of the offshore faults have fresh escarpments and cut Holocene sediments. Extensive arrays of Quaternary fault scarps are found throughout the coastal region and in Bahia Magdalena they are clearly associated with major faults that bound recently uplifted islands. A prominent band of seismicity follows the coast and eight earthquakes (Ms>5.0) were teleseismically recorded between 1973 and 1998. This evidence for active shearing indicates that the Baja microplate has not yet been completely transferred to the Pacific plate.

The best lithologic correlation that can be used to define the total Neogene slip across the borderland faults is the offset between the Magdalena submarine fan and its Baja source terrane. The distal facies of the fan drilled during DSDP leg 63 is dominated by mudstone and siltstone that contain reworked Paleogene cocoliths derived from strata correlative with the Tepetate formation found throughout the borderland and fine-grained sandstone derived from a source terrane of granitoid basement. The Middle Miocene La Calera formation of the Cabo trough is one of many granitoid-clast syn-rift alluvial deposits that could form the continental counterpart of the submarine fan near the mouth of the proto-gulf. However, regardless of the exact source, the Magdalena fan must have been transported beyond a major submarine canyon system south of Todos Santos by 13.5 Ma when sedimentation rates significantly diminished. This places a maximum of $\sim$200 km total slip on the borderland faults since 13.5 Ma. Alternatively, all components of the Magdalena fan could have been derived from reworking Cenozoic strata within the borderland. The sandstone facies could be derived from the Oligocene El Cien Fm., which is a granitoid clast conglomerate that overlies the Tepetate Fm. and crops out $\sim$100 km west of La Paz. If true, the total slip across borderland faults may be only a few tens of kilometers. Key structural relations along the submarine Tosco-Abreojos fault system support this lower slip estimate including: relatively short ($\sim$30 km width) pull-apart basins, correlative strata on either side of the fault, and a strong pattern of splaying, which indicates a lateral termination only $\sim$50 km to the SE of the Magdalena fan.

These new observations require significant modifications to existing tectonic models, which usually assign $\sim$300 km of offset to the borderland. Lower finite slip estimates suggest that the borderland may not have formed the main P-NA plate boundary and long-term Neogene slip rates need not be significantly different from Quaternary slip rates. Lower finite slip estimates also allow stronger correlations between Farallon derived microplates and the patterns of Neogene faulting, volcanism, topographic variations, and surface heat flow in the overlying continental crust of Baja California.