Process-Oriented Experiments Working Group

Proposed Program Format

- 2/3: Ten large, coordinated, interdisciplinary OBS programs agreed upon by the OMD community.
- 1/3: Essential related studies: laboratory, theoretical and/or field-based studies that address major goals of OMD

Ancillary Goals

- Community building through workshops, short courses etc.
- Data visualization improvements
- Data archives to handle large 3D data base
- Links to MARGINS, RIDGE2K, GERM, etc.

Distribution, scale, nature and origin of mantle heterogeneities

Scientific Questions:

- Temperature distribution in upper mantle
- Relation between surface chemistry and mantle
- Pattern and mechanisms of large-scale chemical transport: reservoirs
- Seismological constraints on physical/chemical/lithological properties
- Seismic anisotropy as indicator of mantle flow
- Electrical conductivity as an indicator of mantle fabric
- Oceanic upper mantle vs. cont. upper mantle
- Composition of the mantle including lithologic heterogeneities
- Volatiles in the mantle
- Mantle discontinuities and phase transitions
- Nature of oceanic Moho

Possible Field Experiments

- Superswell survey
- Survey geochemical boundary in order to compare with seismic and electromagnetic anomalies as well as small-scale scattering
- Compare mantle in regions of different subsidence rates and different residual gravity anomalies
- Tomographic imaging across the transition zone

Essential Related Studies

- Seismic resolvability of heterogeneity
- Properties of polyphase and polycrystal rocks
- Calibration experiment of anisotropy at ϕ=0 (LPO equilibrated)
- Calibration: do shear-wave splitting and Rayleigh waves give the same anisotropy?
- Numerical modeling/testing of anisotropy calibrations
- Experimental constraints on sources of anisotropy
- Full scale mantle geodynamic models combined with regional scale models and integrating observations
- Geochemical/petrological direct observations of abyssal peridotite and oceanic melt compositions
- Additional physical properties measurements at seismic frequencies; attenuation
- Simulate full-wavelength propagations

Mantle plumes

Scientific Questions:

- Where do plumes originate? Lower mantle? Upper mantle?
- Fine-structure
- Plume-ridge interactions
- Fate of plume material
- Differences between hotspots
- Time variability of hotspots/plume flux
- Superswells

Possible field experiments

- Study a hot hotspot and a wet hotspot.
- Hotspots beneath both young and old plates
- Seismological constraints on selecting best site for imaging a plume
- Image plumes from top down, to the lower mantle

Essential Related Studies:

- Field study on age-progressive hotspots
- Fluid-dynamical modeling of plumes in conjunction with specific field experiments

Relationship of plate tectonics to mantle dynamics

Scientific Questions:

- Driving force of plate tectonics (mantle/lithosphere coupling)
- Cooling of thermal boundary layer
- Small-scale convection
- Rheology of oceanic lithosphere and mantle
- Plate boundary formation and evolution
- Deep structure of transform faults
- Steering of plates by transform faults
- Relationship between present tectonics and past geology
- Transition between tectonic provinces.
- Origin of ridge segmentation
- Crustal structure
- Earthquake dynamics in oceanic vs. continental lithosphere (including seismic cycles and stress triggering)
- Mass balance of oceanic upper mantle between slabs, ridges and hotspots, lower mantle
- Comparative planetology and mantle dynamics

Possible Field Experiments

- Major fracture zone with lots of earthquakes; using OBS, EM, and seafloor geodesy
- Ridges – width of melting zone, mantle anisotropy
- Survey trench environment
- Lithosphere/mantle structure/fabric ahead of propagating rift
- Anisotropy beneath rotating microplates
- Contrasting earthquakes at different transforms
- Relative motion between plates and mantle using anisotropy
- Seismic experiment near gravity lineations (rolls)
- Survey across dead fracture zone
- Survey across ridge-transform intersection
- Transect across continental margin
- Seismic reflection measurements of old ocean basins

Essential Related Studies

- Gravity and subsidence associated with heterogeneities
- Linking anisotropy-inferred flow with geodynamic models
- Seafloor geodesy

Subduction zones and fate of slabs

Scientific Questions:

- Initiation and development of subduction
- Fate of subducted material
- Dynamics; flow and temperature structure at subduction zones
- Dynamics of back-arc spreading centers and relation to island arcs
- Slab/trench rollback

Possible Field Experiments

- Seismic anisotropy in subduction zones
- Survey of oceanic subduction zone – trench, arc and back-arc
- Velocity anomalies of slabs in transition-zone (slab-flattening vs penetration)
- Comparison of hot and cold mantle wedges

Essential Related Studies

- Laboratory studies of origins of anisotropy
- Theoretical models to examine origin of anisotropy
- Elastic properties of slabs
- Rheological properties of slabs passing through trenches
- Rheological properties of deep slabs through the seismogenic zone (deep earthquakes)
- Laboratory investigation of the effects of temperature and melt and chemistry on seismic velocities

Melt distribution and dynamics

Scientific Questions:

- Melt distribution and migration in the mantle
- Ridge dynamics and variables: spreading rate, mantle temperature and their effects on the melting regime beneath the ridge.
- Nature of mantle and melt flow at ridges.
- Origin of intra-plate volcanism and anomalous near-ridge volcanism.
- Focusing of melt and origin of volcanoes
- Large igneous provinces
- Is there melt everywhere in the low-velocity zone?

Possible Field Experiments

- Seismic study of ultra-slow spreading ridge (esp. magmatic center surrounded by amagmatic region)
- Combined attenuation and tomography (Q, Vp, Vs) and electrical conductivity to look for melt away from hotspots (intraplate/nonplume volcanic island chains)

Essential Related Studies

- Laboratory studies on attenuation (Q) with and with out melt at seismic frequencies
- Attenuation in areas of anomalous anisotropy ostensibly due to melt
- U-series complementing seismic studies of crustal thickness
- Seismic imaging before and after volcanic eruption