ESF LESC Exploratory Workshop on

"Neotectonics and Mantle Dynamics (PLATEC)"

(LESC Priority Theme "Mantle dynamics, plate tectonics and earthquake prediction")

From June 28th to July 1st 2001, about 40 scientists met in Waldshut-Tiengen (southern Germany) to discuss a new solid earth science collaborative research initiative.

During the Exploratory Workshop it was decided that we will propose a new Earth Science ESF Programme focusing on the **four themes**:

(A) Intra-continental dynamics
(B) Deformation at irregular plate boundaries-the Africa-Europe convergence zone
(C) Evolution of subduction zones
(D) Seismogenic zones

The leitmotiv of the new programme regards the quantification of interactive processes between the lithosphere and the (deeper) mantle, in particular but not exclusively, on a recent time scale. Also it includes regions of Europe which obtained little attention during previous ESF-programmes in geodynamics. The proposed new programme builds on experience and tradition of the successful EGT (N-S Geoscience Transect through Europe) and EUROPROBE (Distributed targets in Eastern and Western Europe) programmes by ESF. While these two previous ESF-programmes each had their own characteristic focus, they shared two common features as basis of their success: 1) field operations and subsequent research included a large number of European countries; 2) a sufficiently large scientific community in almost all member countries of ESF convinced their respective funding agencies to join EGT or EUROPROBE even though the transect or the targets were not directly on their territory.

The programme's focus is the multi-Earth science study of the lithosphere in areas of tectonic and seismic activity, with the objective to improve our knowledge and understanding of Earth processes that create tectonic, seismic, and volcanic activity. As a key element in global plate tectonics, the lithosphere both influences and is influenced by mantle processes. Incorporating the effects of processes in the deeper mantle on the overlying lithosphere is a novel and challenging feature of the programme.

As the new programme will concern the multidisciplinary analysis of surface tectonics in the context of deep lithospheric and mantle processes, it should involve a wide range of geological, geochemical, geophysical, and geodetic expertise. To link surface observations (neotectonics, uplift, etc.) with mantle observations (velocity structure, seismicity, geochemistry, thermometry, petrology, etc.) and to connect these observations with models of local and regional scale processes, a close interaction between researchers in a series of sub-disciplines is needed and the new programme will provide the platform for this cooperation.

The European lithosphere is characterised by three distinctively different realms: The old, thick, and stable continental lithosphere in the N and NE encompasses the Baltic shield and the East European Platform. With its great equivalent elastic plate thickness, this lithosphere reacts to plate forces significantly different than the mid-aged, thinner, and warmer continental lithosphere in Central Europe. In both environments (**theme A**), however, tectonic activities are strongly linked to local lithosphere structure and to mantle dynamics. The wider Mediterranean-Alpine region (**theme B**) may be viewed as a great natural laboratory where new continental lithosphere is currently being formed in a micro-plate environment that provides almost unique opportunities to study specific combinations of currently active plate tectonic processes. There is good reason to believe that the underlying upper mantle beneath all these realms shows also significant lateral variations though not necessarily in a one-to-one correlation with lithosphere structure.

The European system offers the unique opportunity to study on a very small spatial-scale a continuum of subduction stages - from incipient to mature subduction to slab break off and subsequent collision (**theme C**). The spatially closely packed European system also represents a scientific challenge and calls for development of interdisciplinary dynamic interpretation and modelling tools. It is obvious that owing to the proximity of slabs, having additional vertical space restriction by the 660 km discontinuity and triggered mantle flow by the retreating motion of the slabs, the problem of plate-mantle interaction is a core project to be addressed.

Understanding earthquake behaviour and mitigating seismic risk are central problems in geosciences. Clearly, understanding seismicity is important in itself but it also contributes key data for understanding subsurface structure and dynamics. Thus seismogenic zones (**theme D**) present special tasks for earth scientists but also unique potential for scientific understanding of the dynamics of earth's interior. Seismicity occurs over a wide range of scales, from very large and destructive earthquakes down to microseismicity which is not felt but shows up only on sensitive seismometers. Seismogenic areas abound in Europe, especially in the Mediterranean region, the eastern part of which is one of the most seismogenic areas on Earth. A prominent example is the North-Anatolian Fault Zone (NAFZ). This 900 kilometer-long fault has many similarities to California's San Andreas fault: both are right lateral faults with similar lengths and similar long-term rates of movement. During the last century the seismicity of the North Anatolian fault has been larger than on the San Andreas with seven MS 7 earthquakes in the period from 1939 through 1999 alone.

Recent advances in computational geodynamics give directions to solving the coupled lithosphere deformation/convecting mantle problem. At the heart of this are the "subduction" and "continental collision" problems. The former deals with cold solid lithosphere plunging into a convecting fluid like substance and the latter with mutual or one sided impingement of buoyant lithosphere blocks deforming on top of a fluid-like layer. Activation of the continental intraplate domain and the triggering of mantle plumes are possible consequences of such an interaction. Lithosphere dynamicists assume that to first order the problems can be solved by considering deformation of the lithosphere itself as well as buoyancy forces arising from lithosphere readjustments and rate sensitive coupling from an otherwise passive "asthenosphere". Convection dynamicists solve the problem more comprehensively by acknowledging deformation within the lithosphere as well as flow in the deeper mantle. Presently, the solid mechanical database is neglected in those more comprehensive approaches. Within this framework the Mediterranean subduction-/collision system of highly

irregular 3-D plates, its intraplate deformation and mantle plume activity provides an ideal testing ground for deciphering lithosphere from mantle controlled processes and assessing their mutual importance.

Suggestions and discussions during and after the workshop led to the conclusion that the acronym PLATEC and the title Neotectonics and Mantle Dynamics should be replaced by a title that puts the emphasis more on lithosphere and mantle as the two key elements in the geodynamic framework. Hence, a new title is suggested **MANTLE and LITHOSPHERE DYNAMICS**, leading to the acronym **MELODY**.

Potential PROJECTS

The programme is expected to play a special role in establishing a framework within which a considerable number of hitherto separated European projects can scientifically be connected. In fact, our plans for a broad European programme have been received very positively by researchers active within specific focused projects. Examples of such separate projects are two drilling projects of the International Continental Drilling Program (ICDP) - Gulf of Corinth and Crete – which study fundamental tectonic processes in the lithosphere from seismicity, fluid transport, stress distribution to subduction of continents and subduction zone roll-back. The linking of the two drill sites with a major international Earth science project on neotectonics and mantle dynamics is strengthening both the investigation of the crust by drilling as well as the neotectonics studies: drilling will provide in situ parameters which are required for modelling processes derived from neotectonic observations.

The wealth of observations acquired in previous activities in greater Alpine-Mediterranean region together with new data (regarding, f.e., lithospheric and mantle structure and crustal strain field) will allow to test hypotheses linking three-dimensional deformations of the Earth's surface to the structure and dynamics of the lithosphere/asthenosphere system. What has been missing so far is a rigorous multidisciplinary analysis of the geophysical, geologic, space-geodetic, and neotectonic data sets. For example, in the **Aegean** (proposed **project** relating to themes B, C, and D), a region of key interest and efforts due to large seismic hazard and of significantly fast relative plate motions, most of the current deformation processes are not yet understood. The height components of recent plate tectonic movements and deformations on a regional scale are to this date almost completely unknown. New space-geodetic techniques (interferometric SAR, continuous GPS monitoring) allow for the determination of space and time variations of the regional strain and stress tensors.

Other potential projects have been identified. This list below is preliminary and certainly incomplete.

Theme	Project (main proponents)
(A)	"Mantle fingers" and lithosphere response: The European upper mantle (M. Wilson, U. Achauer et al.)
(B)	Final stages of slab break-off (F. Wenzel et al.)
(A)	Topography, lithospheric structure and mantle processes in Scandinavia (N. Balling et al.)
(A, B)	Black Sea region (R. Stevenson et al.)

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