Proposal for an ESF Exploratory Workshop - Call 2009

Section I: *(1 A4 single page)*

Exploratory Workshop title: ESF Exploratory workshop on GEOthermal EXploration and Coupled solid Earth System modeling (GEO-EXCES)

Proposed dates and location:
(a workshop must take place between 1 February and 31 December of the year following application and be located in a ESF Member Organisation Country)

The workshop will be held june 14th to 16th 2010 in the vicinity of Barcelona.

Name and full coordinates of principal applicant(s):

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Gerardo de Vicente, Departamento de Geodinámica, Universidad Complutense de Madrid, 28040 Madrid, Spain, Tel +34913944827, E-mail: gdv@geo.ucm.es

Manel Fernandez, Institut Earth Sciences 'J. Almera' – CSIC, Sole Sabaris s/n, 08028, Barcelona, Spain. Phone: + 34 934095410, Fax: + 34 934110012, email: mfernandez@ija.csic.es

David Bruhn, International Center for Geothermal Research, Deutsches GeoForschungsZentrum – GFZ, 14473 Potsdam, Germany, Tel +49 331 2881374, E-mail: dbruhn@gfz-potsdam.de

Albert Genter, GEIE EMC, Route de Soultz, BP40038, 67250 Kutzenhausen, France, Tel. +33 388 80 99 13, E-mail: genter@soultz.net

Sierd Cloetingh, Faculty of earth and life sciences, Vrije Universteit Amsterdam De Boelelaan 1085, 1081 HV Amsterdam, Phone: + 31 205987300, email: sierd.cloetingh@falw.vu.nl

Keywords relating to the topic of the proposal:

Geothermal exploration, seismicity, stress field, coupled processes, fractured reservoirs and fluid flow

Abstract of the proposal (*max. 50-100 words*):
(Indicate the topic(s) of the workshop and clearly demonstrate the exploratory /innovative nature of the event as well as its potential for future collaborative activities)

The workshop aims to develop an interdisciplinary research framework for the development of next generation geothermal resource concepts and exploration workflow approaches. Key is a unified system earth coupled process approach in which observations are linked to coupled modeling of deep subsurface and surface processes. The workshop:

- Transfers fundamental knowledge and experience from brown field to green field areas
- Sets a research framework for a next generation of integrated earth system scientists for geothermal
- Conceptualises a white paper
- Develops a research network to apply joint research ideas to EU funding programs

Section II: *(not more than 7 A4 single pages)*

The case for an exploratory workshop *(max 3 pages)*

The share of renewable energy sources in the European energy balance can be increased significantly by a meaningful contribution of geothermal energy for both heat and electricity production. Geothermal resources comprise hot water bearing aquifers, fault zones which can be accessed directly or through engineering of the reservoir, leading to Enhanced Geothermal Systems (EGS). Experts from MIT estimate that EGS may well provide 10% of the electricity supply in the US in 2050 (Tester et al., 2006). In Germany alone experts estimate that electricity production can grow from ca 8 MWe at present to 1000 Mwe in 2030. Electricity produced from geothermal resources has large benefits compared to alternative energy sources such as solar and wind, as it serves as base load (24/7) and takes little space at the surface.

Currently geothermal exploration for electricity production is in an embryonic state. Until now exploration and production areas have been selected largely on the basis of observations of high near surface temperature gradients derived from surface heat flow values (e.g. volcanic areas such as Iceland and Tuscany in Italy) and or relative high temperatures assessed in deep boreholes drilled mainly for hydrocarbon exploration and production (e.g. Soultz) and near field exploration (e.g. Landau) based on local successes as made in Soultz.

Critical system earth conditions for geothermal exploration and production success are currently poorly constrained. This situation is similar to the initial stages of hydrocarbon exploration over 50 years ago. Consequently world class resources are yet to be found, based on yet to be discovered key system earth indicators, to be detected by yet to be defined dedicated exploration workflows and best practices.

For improved assessment of the exploration potential of continental regions for geothermal energy we need to look beyond depths of temperatures known from wells and need capability to predict temperatures at depth in areas where no well control is available. To assess the potential for natural fracture-driven permeability and for enhanced flow rates generated by hydraulic fracs we need to be capable to predict the stress field orientation for potential fluid conduits and critically stressed conditions, and for optimizing well planning and exploitation for a safe operation with acceptable levels of induced seismicity.

Leading edge earth system science, alongside industrial techniques and experience will play a critical role in developing geothermal exploration (geothermal resources) concepts. Developments on geothermal exploration on one hand rely on adaptation of state-of-the-art geophysical imaging and drilling techniques used in the capital-intensive mining and oil and gas industries. On the other, in-depth understanding of deep earth system processes down to the reservoir scale is required to develop a rationale to define critical conditions for geothermal resource systems.

At present research networks and programs focused on fundamental understanding of deep system earth processes, such as TOPO-EUROPE, have not been defined with a geothermal scope. Apart from leading countries such as France, Germany and Switzerland, deep geothermal exploration for electricity production has until now hardly received attention from leading solid earth scientists, with regional expertise, and capable to make a major contribution to enhance the development of geothermal play concepts, specific to particular regions in Europe

Aim of the workshop

In the proposed ESF Exploratory workshop on GEOthermal EXploration and Coupled solid Earth System modeling (GEO-EXCES**)** we aim to develop an interdisciplinary research framework for the development of next generation geothermal resource concepts and exploration workflow approaches.

Approach

Key to the framework will be a unified system earth coupled process approach in which observations from state-of-the-art geophysical acquisition techniques for deep basin and basement temperatures, stress and flow conditions at target resource locations are linked to coupled modeling of deep subsurface and surface processes. This approach allows to discriminate between large and local scale processes and feedback loops therein responsible for the success of particular resource locations. Consequently it allows to test existing and new concepts for dominant geological, structural, hydrological and tectonic processes responsible for world class geothermal resources. It provides a generic process-oriented framework which can be applied beyond proven success areas, and which can be easily adapted to deviating conditions in other areas.

Novel developments in the framework are arranged along three major challenges, addressed as workshop themes, to be elaborated during the workshop:

1. *Imaging and detecting resources*: Subsurface Imaging techniques aim to improve the detection, prior to drilling, of high temperature fluid bearing zones in naturally and/or artificially fractured geothermal reservoirs. Over the recent years it has well been recognized that geothermal exploration can take large benefit from geophysical acquisition and drilling research developed over many decades in the capital intensive Hydrocarbon industry. However geothermal play systems are distinctly different from oil and gas, requiring different techniques. Recent state-of-the-art overviews generated by EU projects ENGINE and I-GET have shown that imaging and detection of geothermal resources requires a novel multidisciplinary approach, linking thermal, geochemical and fluid flow process to imaging temperature and flow conduits. Up till now the focus has been on imaging at target (reservoir) level, whereas in-depth knowledge and linkage with deeper lithosphere and surface processes, data and crustal fabric can greatly enhance our imaging resolution and robustness of interpretation. In this theme multi-discplinary (qualitative) conceptual frameworks for geothermal resource detection are developed and tested in natural laboratories, linking experience developed in brown field areas (e.g. Italy, Germany) to promising green field areas such as Iberia, the Lower Rhine Graben (Netherlands) and the Panonian Basin (Hungary).
2. *From large scale to reservoir scale: integrated model strategies for temperature and stress from Lithosphere Astenosphere Boundary (LAB) to surface*. Temperature and stress are critical conditions for exploration success. This theme addresses the development of next generation regional stress and temperature models, which provide important constraints for geothermal exploration. The models take into account state-of-the-art modeling technologies currently developed by leading solid-earth scientists in the ongoing TOPO-EUROPE research project funded by ESF and focused on topography development. TOPO-EUROPE affiliated research demonstrates that temperature and stress field in Europe is subject to strong spatial variations which can be linked in part to polyphase extensional and compressional reactivation of the lithosphere, in different modes of deformation. The development of innovative combinations of numerical and analogue modeling techniques is key to a thorough understanding of the spatial and temporal variations in crustal stress and temperature. Integrated basin studies show that rheological layering and strength of the lithosphere play an important role in the spatial and temporal distribution of stress-induced vertical motions, varying from subtle faulting to basin reactivation and large wavelength patterns of lithospheric folding, demonstrating that sedimentary basins are sensitive recorders to the intraplate stress field. The long lasting memory of the lithosphere, in terms of lithospheric scale weak zones, appears to play a far more important role in basin formation and reactivation than hitherto assumed. A better understanding of the 3-D linkage between basin formation and basin reactivation is, therefore, an essential step in research that aims at linking lithospheric forcing and upper mantle dynamics to crustal vertical motions and stress, and their effect on sedimentary systems and heat flow. Vertical motions in basins can become strongly enhanced, through coupled processes of surface erosion/sedimentation and lower crustal flow. Furthermore patterns of active thermal attenuation by mantle plumes can cause a significant spatial and modal redistribution of intraplate deformation and stress, as a result of changing patterns in lithospheric strength and rheological layering. In this theme, we aim to extend developed modeling and inversion strategies -complementary to ongoing TOPO-

EUROPE research- to test and validate their predictive power in brownfield and promising Greenfield areas. Furthermore, this theme will address the potential quantitative incorporation of these models to improve imaging resolution and robustness of interpretation of geothermal resources (theme 1)

3. *High resolution temperature, geomechanics and fluid flow feedback loops* Many geothermal resources are located in active fault zones serving as hydrological corridors of hot fluids connected to convection cells at larger scale. At the reservoir scale, fractures have a decisive influence on permeability anisotropy and usually control flow rates even for high-porosity reservoir rocks. Out of the many fracture systems co-existing in many rocks, those activated by the current in-situ stress field serve as main conduits for fluids. Strain and stress models based on GPS measured plate motion velocities will define regional stress fields on a continental scale and help to discriminate major geothermal systems with their main fault inventory in different stress regimes. Influenced by fault zones the stress field can vary locally thus small scale fractures can exhibit anomalous behavior in terms of reactivation potential and fluid flow within a geothermal reservoir. Geomechanical structural models and predictive stress models shall describe and characterize fault patterns of geothermal systems to assess natural seismicity and preferential fluid flow due to stress partitioning. The interaction of active fault zone and basin system architecture, its influence on the in-situ stress field and the resulting geomechanic, fluid flow and geochemical processes are not well understood, but critical to targeting and exploiting geothermal resources. This theme serves for detailed and qualitative understanding of coupled processes, which are critical to exploration success. Further, as these processes overprint and influence the large scale models of theme 2, they will provide high resolution geothermal exploration models

In order to be successful we bring together a multidisciplinary team of leading experts in imaging and modeling of deep solid earth temperature, stress, flow properties complemented by leading regional (geothermal) experts. The team is interdisciplinary ranging form geothermal exploration and production experts to leading solid earth scientists in a broad spectrum of disciplines including structural geology, hydrology, geophysics. The scope of the workshop is truely Pan-European in linking experiences in brownfield natural laboratories (e.g. Tuscany, Upper Rhine Graben) to promising Greenfield natural laboratories (e.g. Lower Rhine Graben, Iberia, Panonian Basin)

Deliverables

- Transfer of fundamental knowledge and experience from brown field to green field areas
- Set a research framework for a next generation of integrated earth system scientists focused on exploration of geothermal resources
- Conceptualise a white paper and publish results in thematic volume of a leading international journal
- Develop a research network and apply joint research ideas to EU funding programmes (e.g. ITN, ESF)

Preliminary Workshop Programme:

In the proposed ESF Exploratory workshop on GEOthermal EXploration and Coupled solid Earth System modeling (GEO-EXCES**)** we aim to develop an interdisciplinary research framework for the development of next generation geothermal resource concepts and exploration workflow approaches. Key to the framework will be a unified system earth coupled process approach in which observations from state-of-the-art geophysical acquisition techniques for deep basin and basement temperatures, stress and flow conditions at target resource locations are linked to coupled modeling of deep subsurface and surface processes

The workshop will be aligned along three themes supporting the framework, to demonstrate current state of the art and challenges which need to be addressed

1. *Imaging and detecting resources*
2. *From large scale to reservoir scale: Integrated model strategies for temperature and stress from Lithosphere Astenosphere Boundary (LAB) to surface*
3. *High resolution temperature, geomechanics and Fluid flow feedback loops*

The workshop is setup as follows:

Day 1 (morning) : arrival

Day 1 (afternoon - evening): transfer of knowledge through plenary sessions on the above themes. Papers are approximately 30 minutes, leaving ample time for discussion. About 12 papers

-state of the art deep data-acquisition – characerisation –reconstruction

6 papers, focus on natural laboratories, aspects covered: lithosphere/thermal structure, structural setting, stress, flow properties

-state-of-the-art Coupled process Thermal-mechanical-chemical- fluid flow

6 papers

Day 1 (early morning): transfer of knowledge continued

Day 2 (late morning): break-out sessions on the themes to discuss framework components

Theme 1 *Imaging and detecting resources*: discussion in this theme to develop multi-discplinary (qualitative) conceptual frameworks for geothermal resource detection and testing in natural laboratories, linking experience developed in brownfield areas (e.g. Italy, Germany) to promising green field areas such as Iberia and the Panonian Basin. how in-depth knowledge and linkage with deeper lithosphere and surface processes, data and crustal fabric can greatly enhance our imaging resolution and robustness of interpretation.

Theme 2 *From large scale to reservoir scale: Integrated model strategies for temperature and stress from Lithosphere Astenosphere Boundary (LAB) to surface*.

This theme addresses to develop next generation regional stress and temperature models, which are required for geothermal exploration and production. In this theme, we aim to extend developed modeling and inversion strategies -complementary to ongoing TOPO-EUROPE research- to test and validate their predictive power in brownfield and promising Greenfield areas. Further this theme will address how these

models can be quantitatively incorporated to improve imaging resolution and robustness of interpretation of geothermal resources (theme 1)

Theme 3 *High resolution temperature, geomechanics and Fluid flow feedback loops* allows to discriminate between large and local scale processes and feedback loops therein responsible for the success and failure of particular resources locations. Consequently it allows test existing and new concepts on dominant geological, structural, hydrological and tectonic processes responsible for world class geothermal resources. It provides a generic process-oriented techno-economic framework which can be applied beyond proven success areas, and which can be easily adapted to deviating conditions in other areas.

Day 2 (afternoon)

Plenary discussion and development of scientific roadmap, including

- Summary of state-of-the-art on geothermal potential of brown and green field areas in relation to tectonic setting – role of local vs regional coupled process feedback loops
- Identification of research gaps, impact of knowledge barriers to geothermal exploration and production in brown and green field areas
- Layout for white-paper and/or thematic set of papers
- Sketch proposal to 7th framework ITN and ESF for funding of exploration research
- Embedding of added value of state-of-the-art coupled process understanding, bridges in academic and applied science questions to geothermal exploration in the European academic research agenda (e.g. TOPO-EUROPE)

Day 3 (morning)

visit to Caldas de Montboi thermal springs

departure

List of proposed participants:

Netherlands

1. Jan-Diederik van Wees (thermo-mechanics of lithosphere, reservoir modeling, TNO-Geological Survey of the Netherlands Utrecht/Vrije Universiteit Amsterdam)
2.Sierd Cloetingh (tectonics, Vrije Universiteit Amsterdam)
3.Marlies ter Voorde (thermal and fluid flow processes, Vrije Universiteit Amsterdam)
4.Fred Beekman (geomechanics, Vrije Universiteit)
5.Jan ten Heege, (coupled fluid flow and geomechanics of fault zones, TNO Utrecht)

Spain

6. Gerardo de Vicente (Active tectonics Universidad Complutense de Madrid-IGEO-CSIC)
7. Gabriel Gutierrez-Alonso (Variscan basement Universidad de Salamanca)
8. Manel Fernàndez (Lithosphere structure and geodynamics, Instituto Jaume Almera CSIC Barcelona)
9. José Fernández (Numerical modeling Universidad Complutense de Madrid-IGEO-CSIC)
10. Pilar Grau (Applied economy Universidad Rey Juan Carlos, Madrid)

Portugal

11 Joao Cabral (Neotectonics, Faculty of Sciences, Lisbon University)
12 Fernando Santos (Geophysics, Geophysical Centre of Lisbon University)
13 Fernando Ornelas, (Geology, Geophysical Centre of Lisbon University)
14 Elsa Ramalho (Geothermal exploration, Laboratório Nacional de Energia e Geologia, Lisbon)

Germany

15. David Bruhn (Rock Physics and Geothermal Exploration, GFZ Potsdam)
16. Leni Scheck-Wenderoth (Tectonics and Basin Models, GFZ Potsdam)
17. Oliver Ritter (Magnetotellurics, GFZ Potsdam)
18. Oliver Heidbach (Stress measurements, stress pattern, 3D geomechanical models, GFZ Potsdam)
19. Inga Moeck (Structural Geology, Geothermal exploration, GFZ Potsdam)

France

20. Albert Genter (scientific Director Soultz, GEIE)
21. Vincent Bouchot (BRGM, Structural Geologist, Geothermal energy fields)
22. Philippe Calcagno (BRGM, Geophysist, 3D Modelling)
23. Judith Sausse (University of Nancy, 3D Modeling at Soultz)

Italy

24. Adelle Manzella, geophysics and geothermal exploration, CNR-IGG, Pisa
25. Ruggero Bertani, geothermal business development, ENEL, Rome

Switzerland

26. Keith Evans, seismology and induced seismicity, ETH

27 Thomas Kohl, geothermal exploration and production research, GeoWatt

Hungary

28. László Lenkey, geophysics and geothermal exploration, ELTE

From Outside ESF eligable countries

Australia

29. **Richard Hillis**, Head of the Australian School of Petroleum Geology, University of Adelaide.
Specific expertise in Exploration Geophysics, Tectonics, Geomechanics (Present-Day Subsurface Stresses), Sedimentary Basin Tectonics, Pore Pressure, Naturally Fractured Reservoirs and Hot Rock Geothermal Energy.

Nelson, E.J., Chipperfield, S.T., Hillis, R.R., Gilbert, J., McGowen, J. and Mildren, S.D., 2007. The relationship between closure pressures from fluid injection tests and the minimum principal stress in strong rocks. *International Journal of Rock Mechanics & Mining Sciences*, **44**, 787-801.

Hillis, R.R., 2003. Pore pressure/stress coupling and its implications for rock failure. In: Van Rensbergen, P., Hillis, R.R., Maltman, A.J. and Morley, C.K. (eds.) Subsurface Sediment Mobilization. Geological Society of London Special Publication, 216, 359-368.

USA

30. **Steve Hickman**, USGS Menlo Park, CA, USA

Top expert in geomechanical properties from laboratory to reservoir and larger scale: Mechanical involvement of fluids in faulting (pore pressure, permeability and stress measurements; fracture and fault geometry from geophysical logs). Scientific director of SAFOD.

Hickman, S., C.A. Barton, M.D. Zoback, R. Morin, J. Sass, and R. Benoit (1997) In situ stress and fracture permeability along the Stillwater fault zone, Dixie Valley, Nevada: International Jour. of Rock Mechanics and Mining Science, v. 34, p. 414.

Hickman, S., M.D. Zoback, and R. Benoit (1998) Tectonic Controls on Reservoir Permeability in the Dixie Valley, Nevada, Geothermal Field. PROCEEDINGS, Twenty-Third Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 26-28, 1998; SGP-TR- 158

Zoback, M.D., S. Hickman and W. Ellsworth, The role of fault zone drilling, in Earthquake Seismology - Treatise on Geophysics Vol. 4, ed. H. Kanamori and G. Schubert, Elsevier Ltd., Amsterdam, 649-674, 2007.

If Richard Hillis or Steve Hickman are not available, a suitable (and superb) candidate might be

Alan Morris, Southwest Research Institute, San Antonio, TX, USA

Expertise in the analysis of the slip tendency for faults and fractures to slip or dilate, based on the three-dimensional (3D) stress state. Developed specific approaches to help understand and predict fault reactivation, earthquake hazard, fault and fracture transmissivity, fault and fracture mineralization paths, fault-sealing behaviour, well-bore stability, structural geology interpretations.

The participation of Richard Hillis, Steve Hickman, and Alan Morris from outside ESF countries is highly desirable, as they have made the transfer of outstanding expertise collected in the hydrocarbon industry (Hillis and Morris) to the specific needs of geothermal exploration, and because they connect geomechanical properties to reservoir properties (Hickman), which is one of the core issues of the planned workshop, combined with unrivalled experience in scientific drilling and geothermal exploration in the USA. There is no one with this specific combination of expertise and scientific standing in the geothermal sector in Europe.

Estimated budget (ESF support up to a maximum of 15 000 €):

(Indicate (in Euros) the breakdown for travel, accommodation, meals and any other expenses, in compliance with the ESF exploratory workshop budget guidelines. Indicate, if applicable, any financial support awarded or foreseen from sources other than the ESF. Any request for funding for participants based outside countries with ESF membership (maximum 2-3 participants) must be justified on scientific grounds)

Travel costs of participants (inside ESF countries)	€5,000
accommodation	€5.000
subsistence	€3,500
Travel costs of Hillis and Hickmann	€1,500
total	€15,000

The workshop will take place in a hotel in the vicinity of Caldas de Montboi, which is located ca 30 km from Barcelona.

Section III: *(not more than 2 A4 single pages in total)*

Brief curriculum vitae of the principal applicant(s):

Curriculum Vitae of Prof. Dr. Jan-Diederik van Wees
Position: head geothermal technology TNO, professor Integrated Basin Information Systems
Coordinates: Princetonlaan 6, P.O. Box 80015, 3508TA Utrecht, The Netherlands, Tel +31302564931, E-mail: jan_diederik.vanwees@tno.nl
Qualification: is director of the TNO-VUA knowledge centre 'Integrated basin tectonics' and head geothermal technology development at TNO. He has published over 40 papers in leading international journals. He has worked extensively on developing quantified models on European intraplate tectonics, with particular focus on lithosphere rheology, geomechanics and thermo-mechanical aspects on basin modelling. Further he is an expert on developing techno-economic models for oil and gas and geothermal purposes and has been WP leader of risk analysis in the Enhanced Geothermal energy in Europe EU-Project (ENGINE)
Key Publications:

Abadi, A., J.D. van Wees, P. van Dijk and S. Cloetingh, (2008): Tectonic evolution of the Sirt Basin. *AAPG bulletin*. V 92, no. 8, pp. 993–1027

Cloetingh, S., and Van Wees, J.D (2005). strength reversal in Europe's intraplate lithosphere: Transition from basin inversion to lithospheric folding. *Geology*, 33, No. 4, pp. 285–288.

Van Wees, J.D., H. Mijnlieff, J. Lutgert, J. Breunese, C. Bos, RosenKrantz, P. and F. Neele, (2008). A new method for assessing the impact of exploration prospect inter-dependency: an application to predicted gas discoveries in the Netherlands. AAPG Bulletin., v. 92, no. 10 (October 2008), pp. 1315–1336

Van Wees, J.D.,Van Bergen, F., David, P., Nepveu, M., Beekman, F., Cloetingh, S. (2009) Probabilistic Tectonic heat flow modelling for basin maturation: method and applications. Journal of Marine and Petroleum Geology. DOI 10.1016/j.marpetgeo.2009.01.020

Ziegler, P., Schumacher, M., Dèzes, P., van Wees, J.D. and Cloetingh , S. A.P.L. (2004). Post-Variscan evolution of the lithosphere in the Rhine Graben area: constraints from subsidence modelling. In: M. Wilson et al. (Editors), Permo-Carboniferous Magmatism and Rifting in Europe. Geological Society Special Publications, London, V. 223, pp. 289-317

Curriculum Vitae of Prof. Dr. Gerardo de Vicente Muñoz
Position: Professor, Geodynamics Department University Complutense of Madrid
Coordinates: Departamento de Geodinámica, Universidad Complutense de Madrid, 28040 Madrid, Spain, Tel +34913944827, E-mail: gdv@geo.ucm.es
Qualification: Prof. Dr. G. de Vicente is head of the Applied Tectonophysics group of the Universidad Complutense de Madrid and teacher/ researcher of Tectonics and Seismotectonics. He has published over 30 papers in leading international journals and more than 80 in Spanish journals. He has worked extensively on the Cenozoic Iberian Foreland Ranges (Central System. Iberian Chain, Duero and Tagus Basins) and on inversion of active stresses from focal mechanism population data at an Iberian Peninsula scale. He is currently IP of one of the groups of the Consolider Ingenio 2006 Project TOPO-IBERIA (Proj J. Gallart Coordinator) and is the head of a coordinated project (TOPO-IBERIA FORELAND) to analogue and numerical modeling of lithospheric folding.
Key Publications:

G. de Vicente, R. Vegas, A. Muñoz Martín , P. G. Silva, P. Andriessen, S. Cloetingh, J. M. González Casado, J. D. Van Wees, J. Álvarez, A. Carbó and A. Olaiz.*Cenozoic thick-skinned deformation and topography evolution of the Spanish Central System*.Global and Planetary Change, **2007**,, 58: 335-381. doi: 10.1016/j.gloplacha.2006.11.042

Cloetingh, S.A.P.L et al., 2007. TOPO-EUROPE: The geoscience of coupled deep Earth-surface processes. Global and Planetary Change, 58: 1-118.

G. de Vicente, Cloetingh, S.; Muñoz-Martín, A.; Olaiz, A.; Stich, D.; Vegas, R.; Galindo-Zaldívar, J. y Fernández-Lozano, J. Inversion of moment tensor focal mechanisms from active stresses around Microcontinent Iberia: Tectonic implications.Tectonics, 27. **2008**. 20pp.doi:10.1029/2006TC002093

G. de Vicente and R. Vegas. Large-scale distributed deformation controlled topography along the western Africa–Eurasia limit: Tectonic constrains.Tectonophysics (TOPOEUROPE Special Volume), **2009**, 465 24pp..doi: 10.1016/j.tecto.2008.11.026

*G. de Vicente, Vegas, R. Muñoz-Martín, A. Van Wees, J.D. Casas-Sáinz, A. Sopeña, A. Sánchez-Moya, Y. Arche, A. López-Gómez, J. Olaiz, A. and Fernández-Lozano, J. Oblique strain partitioning and transpression on an inverted rift: The Castilian Branch of the Iberian Chain. Tectonophysics. **2009**, 465. 31 pp.doi: 10.1016/j.tecto.2008.11.003*

Curriculum Vitae of Prof. Dr. Manel Fernandez
Position: Director of the Institut de Ciencies de la Terra 'J. Almera'- CSIC
Coordinates: : Institut Earth Sciences 'J. Almera' – CSIC, Sole Sabaris s/n, 08028, Barcelona, Spain. Phone: + 34 934095410, Fax: + 34 934110012, email: mfernandez@ija.csic.es
Qualification: Prof Dr. Manel Fernandez is professor in geodynamics with more than 70 research papers published in peer-reviewed international Journals. He is a specialist in deep lithosphere structure and geodynamic processes, with emphasis on the Western Mediterranean. He has been PI and coordinator of a large number of EU funded R&D programs, including the WESTMED project in the EUROMARGINS program. He is coordinator for the Crustal and Mantle Structure module in the TOPOIBERIA program.
Key Publications:

J. Fullea, M. Fernàndez, H. Zeyen and J. Vergés. A rapid method to map the crustal and lithospheric thickness using elevation, geoid anomaly and thermal analysis. Application to the Gibraltar Arc System, Atlas Mountains and adjacent zones. Tectonophysics, 430, 97-117, 2007.

H. Zeyen, P. Ayarza, M. Fernàndez and A. Rimi. Lithospheric structure under the western African-European plate boundary: A transect across the Atlas Mountains and the Gulf of Cadiz. Tectonics, 24, TC2001, doi:10.1029/2004TC001639, 2005.

Fernàndez, M., M. Torne, D. Garcia-Castellanos, J. Vergés, W. Wheeler and R. Karpuz. Deep structure of the Vøring Margin: the transition from a continental shield to a young oceanic lithosphere. Earth Planet. Sci. Lett., 221, 131-144, 2004..

M. Torne, M. Fernàndez, M.C. Comas and J.I. Soto. Lithospheric strcuture beneath the Alboran basin: Results from 3D gravity modelling and tectonic relevance. J. Geophys. Res., 105, 3209-3228, 2000.

Fernàndez, M., I. Marzán, A. Correia and E. Ramalho. Heat flow, heat production, and lithospheric thermal regime in the Iberian Peninsula. Tectonophysics, 291, 29-54, 1998.

Curriculum Vitae of Dr. David Bruhn
Position: Project Manager, International Center for Geothermal Research at Deutsches GeoForschungsZentrum – GFZ Potsdam
Coordinates: International Center for Geothermal Research, Deutsches GeoForschungsZentrum – GFZ, 14473 Potsdam, Germany, Tel +49 331 2881374, E-mail: dbruhn@gfz-potsdam.de
Qualification: Dr. D. Bruhn. Research scientist at GFZ Potsdam in the field of rock physics, with special emphasis on experimental research on the influence of liquid phases on the physical properties of rocks and on rock deformation. Project manager of EU project I-GET on geothermal exploration, editor of special volume on I-GET in *Geothermics*.
Key Publications:

Milsch, H., L. H. Kristinsdóttir, E. Spangenberg, D. Bruhn, and Ó. G. Flóvenz (2009) Effect of the water-steam phase transition in porous rocks on their electrical conductivity; Geothermics vol. 38, no.4 (in press)
Blöcher, G.; Bruhn, D.; Zimmermann, G.; McDermott, C.; Huenges, E. (2007): Investigation of the undrained poroelastic response of sandstones to confining pressure via laboratory experiment, numerical simulation and analytical calculation, Rock physics and geomechanics in the study of reservoirs and repositories, The Geological Society, 71-87.
Bruhn, D. and L. Burlini (2005): High-Strain Zones: Structure and Physical Properties, Geological Society Special Publication ; 245, The Geological Society.London, UK.
Burlini, L. and Bruhn, D. (2005): High-strain zones: Laboratory perspectives on strain softening during ductile deformation - In: Bruhn, D.; Burlini, L. (Eds.), High Strain Zones: Structure and Physical Properties, The Geological Society, 1-24.
Bruhn, D.; Groebner, N.; Kohlstedt, D. L. (2000): An interconnected network of core-forming melts produced by shear deformation, Nature, 403, 6772, 883-886.

Curriculum Vitae of Dr. Albert Genter
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Key Publications:

Genter, A. Evans, K.F. Cuenot, N. Fritsch, D. Sanjuan, B., (2009). The geothermal Soultz adventure: 20 years of reconnaissance and research for exploring deep crystalline fractured rocks, Geoscience, submitted.
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Key Publications:

Cloetingh, S., Beekman, F., Ziegler, P., Van Wees, J.D., Sokoutis, (2008) D. Post-rift compressional reactivation potential of passive margins and extensional basins. JOHNSON, H., DORE´, A. G., GATLIFF, R. W., HOLDSWORTH, R., LUNDIN, E. R. & RITCHIE, J. D. (eds) The Nature and Origin of Compression in Passive Margins. Geological Society, London, Special Publications, 306, 27–70. DOI: 10.1144/SP306.2.
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