INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)

Annual Report of IGCP Project No. 497 for 2004/2005

IGCP Project short title: "IGCP 497 - The Rheic Ocean: Its Origin, Evolution and Correlatives"

Duration: **2004-2008**

Project leader(s):

1. Ulf Linnemann (Germany)
State Collections of Natural History Dresden, Museum of Mineralogy and Geology, A.B. Meyer-Bau, Königsbrücker Landstrasse 159, Dresden, D-01109, Germany.
Tel: 0049-351-8926402
Fax: 0049-351-8926404
ulf.linnemann@snsd.smwk.sachsen.de

2. Richard Damian Nance (U.S.A.)
Department of Geological Sciences, 316 Clippinger Laboratories, Ohio University, Athens, Ohio 45701, U.S.A.
Tel: 740-593-1107
Fax: 740-593-0486
nance@ohio.edu

3: Maarten de Wit (South Africa)
Department of Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa
Tel: +27-21-6502921/31
Fax: +27-6503783
maarten@cigces.uct.ac.za

4. Erdin Bozkurt (Turkey)
Department of Geological Engineering, Middle East Technical University, Ankara, TR-06531 Turkey.
Tel: 90-312-2105725
Fax: +90 - 312 - 210 12 63
erdin@metu.edu.tr

5. Petr Kraft (Czech Republic)
Institute of Geology and Palaeontology, Charles University, Albertov 6, 12843 Prague 2, Czech Republic
Tel. +420-221951459
kraft@natur.cuni.cz

6. Francisco Pereira (Portugal)
Departamento de Geociências, Centro de Geofisica de Évora, Universidade de Évora, Apartado 94, 544-7001 Evora, Portugal.
Tel: 00 351 266 74461
Fax: 00 351 266 744971
mpereira@uevora.pt

7. Robin A. Strachan (UK)
School of Earth & Environmental Sciences, University of Portsmouth, Burnaby Building, Burnaby Road, Portsmouth, PO13QL, United Kingdom.
Tel: 44 (0) 23 92842259.
Fax: 44 (0)23 92842244.
Rob.Strachan@port.ac.uk

Project Secretary:
Kerstin Drost (Germany)
State Collections of Natural History Dresden, Museum of Mineralogy and Geology,
A.B. Meyer-Bau, Königsbrücker Landstrasse 159, Dresden, D-01109, Germany.
Tel: 0049-351-8926402
Fax: 0049-351-8926404
kerstin.drost@snsd.smwk.sachsen.de

Date of submission of report: December, 5, 2005

Signature of project leader:

Ulf Linnemann

Short introduction to the Rheic Ocean

The Rheic Ocean was the dominant ocean during Palaeozoic times. Its initial development can be traced back to the plate tectonic situation in the Late Neoproterozoic due to Cadomian orogenic processes culminating around the Precambrian-Cambrian boundary (Fig. 1). The opening of a proto-Rheic ocean between northern continents such as Baltica and Avalonia is assumed to have occurred in Cambro-Ordovician times (Fig. 2). The Rheic Ocean was widest during the Silurian, whereas the Iapetus Ocean finally closed (Fig. 3). The closure of the Rheic Ocean started in the Lower Devonian (Fig. 4) and was completed in the Carboniferous (Fig. 5). The result was the formation of the supercontinent Pangaea (Fig. 5).
Continental blocks such as North and South America, Africa, Baltica and numerous peri-Gondwanan terranes were involved in the development of the Rheic Ocean. The birth, life and death of the Rheic Ocean was a chain of worldwide events that resulted in many orogenic processes like the Ouachita-Alleghanian-Variscan orogen ranging from the Appalachians in North America to the easternmost outcrops in the Dobrogea (Romania) and in Turkey. The history of the Rheic Ocean also affected strongly the history of life, the palaeoclimate, the formation of different sedimentary basins and the environmental conditions on the planet.
The fields of research therefore include stratigraphy, sedimentology, palaeontology, palaeogeography, palaeooceanography, igneous and metamorphic petrology, tectonics, structural geology, geochemistry, geochronology and geophysics (especially palaeomagnetism).
The thematic frame around the Rheic Ocean is therefore worldwide and international and covers nearly all aspects of the geosciences.

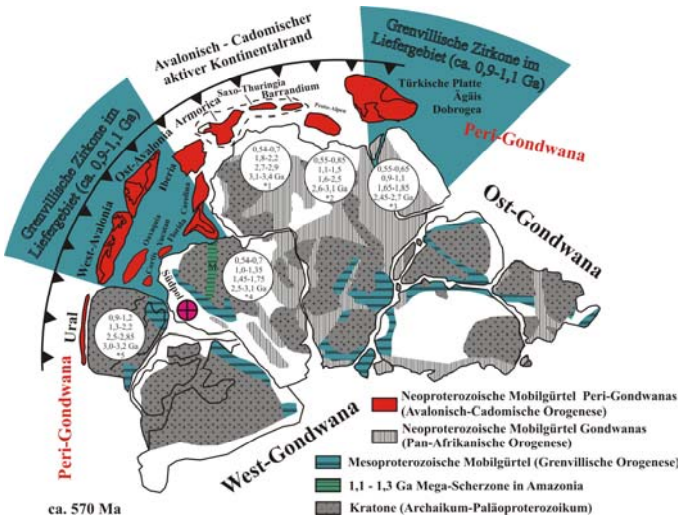


Fig. 1: Palaeogeography of the Cadomian - Avalonian Arc and related prominent peri-Gondwanan terranes including the palaeoposition of Saxo-Thuringia based on the age spectra (modified after NANCE & MURPHY 1994, LINNEMANN et al., 2000, MURPHY et al. 2000, LINNEMANN & ROMER 2002, NANCE et al. 2002; palaeogeography of the Gondwanan continental plates after UNRUG 1996). In the circles are given the known age spectra of the relevant cratons: *1-compilation of NANCE & MURPHY (1994 and references therein), *2-after ABDELSALAM et al. (2002), *3-after AVIGAD et al. (2003); *4-nach SCHNEIDER SANTOS et al. (2000), *5-compilation of ZEH et al. (2001) (Figure taken from Linnemann et al. 2004, "Das Saxothuringikum").

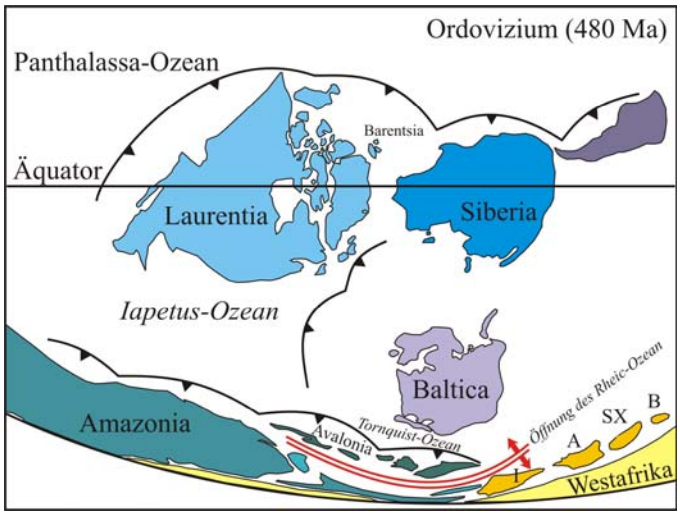


Fig. 2: Palaeogeography in the lower Ordovician (480 Ma) (modified after C.R. SCOTESE: Paleomap web site: www.scotese.com). I-Iberia, A-Armorica (Brittany, Normandy, Massif Central), SX-Saxo-Thuringia, B-Barrandian. (Figure taken from Linnemann et al. 2004, "Das Saxothuringikum").

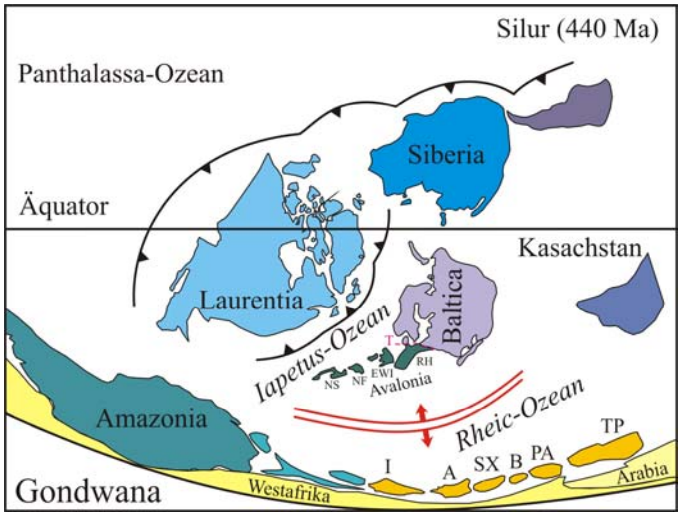


Fig. 3: Palaeogeography in the lower Silurian (440 Ma) (modified after C.R. SCOTESE: Paleomap web site: www.scotese.com). I-Iberia, A-Armorica (Brittany, Normandy, Massif Central), SX-Saxo-Thuringia, B-Barrandian, PA-Proto-Alps, TP-„Turkish plate", RH-Rheno-Hercynian, EWI-England, Wales, Southern Ireland, NF-Newfoundland, NS-Nova Scotia, T-Tornquist Line. (Figure taken from Linnemann et al. 2004, "Das Saxothuringikum").

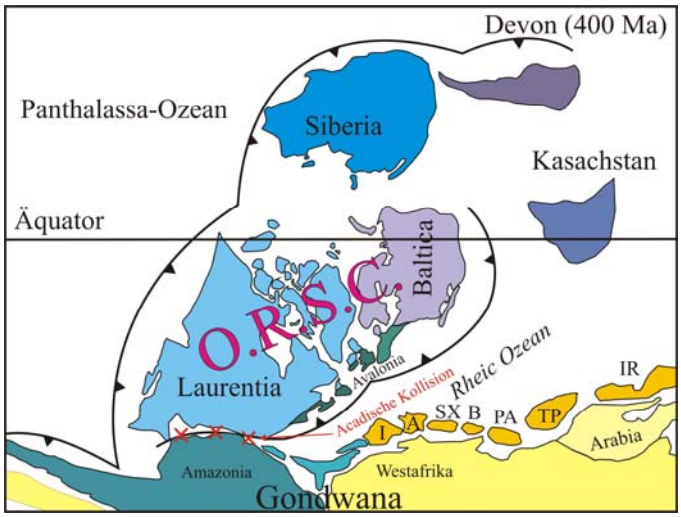


Fig. 4: Palaeogeography of the lower Devonian (400 Ma)(modified after C.R. SCOTESE: Paleomap web site: www.scotese.com). I-Iberia, A-Armorica (Brittany, Normandy, Massif Central), SX-Saxo-Thuringia, B-Barrandian, PA-Proto-Alps, TP-„Turkish plate“, IR-Iran, O.R.S.C.=Old Red Sandstone Continent. (Figure taken from Linnemann et al. 2004, “Das Saxothuringikum”).

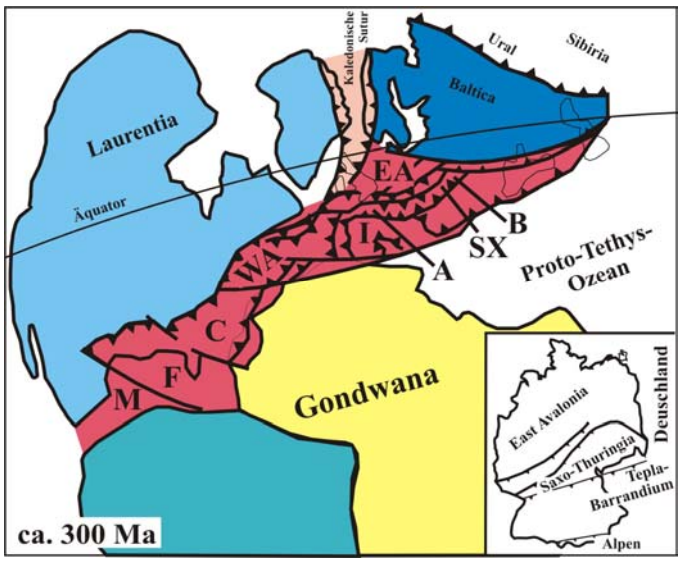


Fig. 5: Part of the Pangaea configuration at the Carboniferous-Permian boundary (c. 300 Ma) (modified after MATTE 1991). Little inset after LINNEMANN & ROMER (2002). I-Iberia, A-Armorica (Brittany, Normandy, Massif Central), SX-Saxo-Thuringia, B-Barrandian, EA-East Avalonia, WA-West Avalonia, C-Carolina, F-Florida, M-Mexican terranes. (Figure taken from Linnemann et al. 2004, “Das Saxothuringikum”).

1.Website address related to the project

http://www.snsd.de/igcp497/

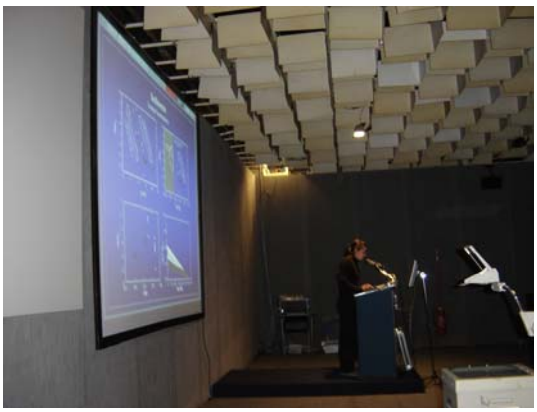
2. Summary of major past achievements of the project (2004)

(i) **Opening Meeting (2004):** The opening meeting of the IGCP 497 ***"Gondwanan margin of the Rheic Ocean in the Bohemian Massif"*** was held in Prague on September, 20, 2004. The meeting was organized by Petr Kraft form the Department of Palaeontology and Geology of the Charles University of Prague (see abstract volume and excursion guides in the attachment of this report). The pre-conference fieldtrip (September 16-19, 2004) to the Sudetes was organized by Stanislaw Mazur, Richard Kryza and Pawel Alexandrowski (Geological Institute, Wroclaw University). The post-conference fieldtrip to the Barrandian and the Saxothuringian in the Bohemian Massif (September 21-25, 2004) was guided and organized by Petr Kraft, Vaclav Kachlik (Department of Palaeontology and Geology of the Charles University of Prague), Uwe Kroner (Department of Geology, Mining Academy of Freiberg) and Ulf Linnemann (Staatliche Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie). 30 scientists from Poland, Czech Republic, Spain, France, U.S.A., UK and Germany participated at the meeting. All the presentations and the fieldtrips were relevant to the topic of the project.

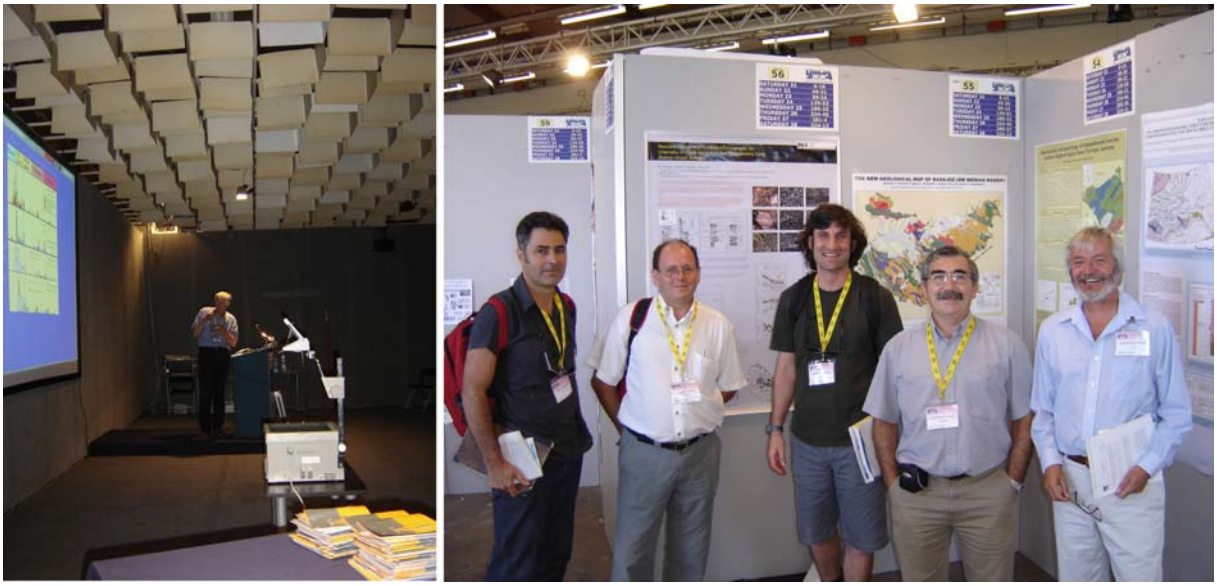
Logo of the post-conference fieldtrip of the opening meeting of IGCP 497.

Post-conference fieldtrip of the opening meeting of IGCP 497.

(ii) **Session at the IGC in Florence (2004):** During the International Geological Congress in Florence, the special symposium "T31.03: Neoproterozoic to Early Paleozoic orogenic processes at the northern margin of Gondwana (Avalonian-Cadomian Orogenic Belt)" was organized by Ulf Linnemann (Staatliche Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie) and Gernold Zulauf (Geologisches Institut der Universität Frankfurt/M.). The meeting was held on August, 28, 2004 and sponsored by IGCP 497 and the International Association of Gondwana Research (IAGR). The keynote address was given by Damian Nance (USA). In the session 9 oral presentations and 12 posters were involved. The IGCP 497 project was introduced to the international audience and the geological community in Florence.



Kerstin Drost (secretary of IGCP 497) at the session T 31.03 in Florence (Aug. 2004).



Impressions from the IGCP 497 session in Florence (Aug. 2004).

(iii) **Symposium in Mexico:** J. Duncan Keppie and R. Damian Nance organized a special symposium in Mexico that was linked to IGCP 497. The symposium was involved in the conference "IV. REUNIÓN NACIONAL DE CIENCIAS DE LA TIERRA" (31 October – 5 November de 2004, home page: http://geminis.geociencias.unam.mx/IVRNCT.htm, title of the symposium: S 01 Acatlan Complex, southern Mexico: part of the Iapetus, Rheic or paleo-Pacific Ocean?, Chairmen: J. Duncan Keppie (duncan@servidor.unam.mx) - Instituto de Geología, UNAM, R.D. Nance (nance@ohio.edu) - Ohio University). The Symposium is sponsored by: IGCP 497 "The Rheic Ocean: its origin, evolution and correlatives" (The Acatlan Complex has previously been attributed to both the Iapetus and Rheic Oceans. This symposium concentrated on new data on the geological history of the Acatlan Complex and its relevance to global reconstructions).

(iv) **Joint meeting of IGCP 497 with IGCP 453 (2004):** A joint meeting of IGCP 453 "Ancient and Modern Orogens" (Brendan Murphy and Duncan Keppie) and IGCP 497 was held in the Urals (August 3-12, 2004) organized by Dennis Brown (Spain) and Victor Puchkov (Russia).

(v) **First IGCP 497 book-project "Das Saxothuringikum" (2004)**: The first book project of IGCP 497 was finished in the spring of 2004 in German with with a synthesis and figure captions in English ("Das Saxothuringikum", edited by Ulf Linnemann, 159 p., ISBN: 3-910006-28-0). The book is focused on the history of the Rheic Ocean preserved in the

Saxothuringian Zone at the NW unit of the Bohemian Massif and is written for a German audience (students of geosciences, teachers, scientists and all people interested in geology). The book contains an English summary and subchapters of headings, figure captions, diagrams and tables to make it readable also to the international audience. An English version is in preparation and planned for late 2006 or early 2008 at the publisher E. Schweizerbart´sche Verlagsbuchhandlung (Stuttgart, Germany).

(vi) **Second IGCP 497 book project: GSA-Book (planned for 2006):** The presentations of the opening meeting in Prague, of the session in Florence and of the symposium in Mexico will be published by the Geological Society of America in 2006 (GSA Special Publications, working title: "The Geology of Peri-Gondwana: Avalonian-Cadomian terranes, adjoining Cratons, and the Rheic Ocean", edited by Ulf Linnemann, Petr Kraft, Damian Nance and Gernold Zulauf). The papers for this book are currently in review.

(vii) **Co-operation and planned joint meeting with IGCP 485 (planned for 2007)**: Participation of Ulf Linnemann on the annual meeting and the field trip of IGCP 485 "Boundaries of the West African Craton" in December 2004 in Nouakchott (Mauritania). Planning of a big joint meeting by Jean-Paul Liégeois (IGCP 485), Nasser Ennih (IGCP 485) and Ulf Linnemann (IGCP 497) in El Jadida (Morocco) in 2007. This joint meeting is extremely important for the IGCP 497, because most of the peri-Gondwanan terranes in Europe are related to the periphery of the West African Craton.

Impressions from the meeting of IGCP 485 in Mauritania (Dec. 2004).

3. Achievements of the project this year

2005-I:

IGCP 497 conference and field workshop in Portsmouth, UK: "Devono-Carboniferous evolution of the northern margin of the Rheic Ocean" (organised by Rob Strachan, John Whalley & Kevin Jones, University of Portsmouth, UK)

The annual meeting including a field workshop took place at the University of Portsmouth in the UK and was organized by Rob Strachan, John Whalley and Kevin Jones. The very successful conference was held at the campus of the University on July, 5 followed by a marvelous and very informative field trip July, 6-11th 2005. The field trip was guided by Rob Strachan, John Whalley, Kevin Jones (Portsmouth) and Robin Shail (Exeter).
Unfortunately the fantastic meeting was embittered by the terrible terrorist attack in London at July, 7.
We had 30 registered participants at the meeting with 17 oral presentations and 9 posters. The aims of this annual IGCP 497 meeting and the fieldworkshop were:

- the presentation of new data concerning the Rheic Ocean
- the introduction into the geological history of the Lizard Ophiolite and adjoining crustal units especially consideration of the of the closure mechanisms and the tectonothermal events of the Rheic Ocean
- the planning of the next meetings and the strategy concerning data processing and publications (especially book projects and special volumes)
- introduction of the next meetings in 2006 by Erdin Bozkurt (Turkey) and Francisco Pereira (Portugal) and Cecilio Quesada (Spain)

Registered participants:

Kerstin Drost (Germany), Yelena Gorozhanina (Russia), Ulrich Jens (Germany), Pawel Aleksandrowski (Poland), Markus Pracht (Ireland), Damian Nance (USA), Gutiérrez-Alonso (Spain), Kaveh Khaskar (Iran), Joachim Neugebauer (Germany), Petr Budil (Czech Republic), Allen Dennis (USA), Michiel van Noorden (Belgium), Koen van Noten (Belgium) José R. Martínez-Catalan (Spain), Sonia Sánchez Martínez (Spain), Ricardo Arenas (Spain), Francisco Pereira (Portugal), Barry Long (Ireland), Antoneta Seghedi (Romania), Ulf Linnemann (Germany), Nigel Woodcock (UK), John Whalley (UK), Rob Strachan (UK), Brendan Murphy (Canada), Steve Johnston (Canada), Christian Pin (France), Erdin Bozkurt (Turkey), Victor Puchkov (Russia), Cecilio Quesada (Spain), Kevin Jones (UK).

Programme of the conference:

A) Oral presentations:

Origin of the Rheic Ocean: rifting along a Neoproterozoic suture? (Murphy)

LA-ICPMS-U-Pb dating of detrital zircons of Precambrian and Early Palaeozoic rock units of the West African Craton and Gondwanan Europe: Constraints to Provenance and Palaeogeography (Linnemann)

Provenance of Neoproterozoic and Palaeozoic sedimentary rocks of the Teplá-Barrandian (Bohemian Massif) as indicated by U-Pb LA-ICP-MS data of detrital zircons (Drost)

The rift-drift transition of the Rheic Ocean in the Ossa-Morena Zone (SW Iberia)(Quesada)

The building of the Gondwanan margin: detrital mica ages tell their tale (Gutiérrez-Alonso)

Provenance of an exotic Neoproterozoic microconglomerate of the Lausite block – evidence from detrital modes and U-Pb zircon ages (Jens)

Dalmanitoidean and acastoidean trilobites as indicators of faunal exchanges between the Prague Basin, Czech Republic (Budil)

Occurrences of MORB-type magmatism in the northern Gondwana margin and their geodynamic significance: the case of the Ossa-Morena Zone (SW Iberian Massif)(Pereira)

The Acadian deformation in Britain: a result of Iapetus or Rheic closure? (Woodcock)

Contraction-dominated Variscan geodynamics in Central Armorica: evidence from the Menez Are slate belt (Brittany, France)(van Noorden)

The Vila de Cruces Ophiolite: A remnant of the early Rheic Ocean in the Variscan suture of Galicia (NW Iberian Massif)(Arenas)

The upper allochthon of NW Iberia: structural constraints to a polyorogenic peri-Gondwanan terrane (Martínez-Catalan)

The Palaeozoic basement of the North Dobrogea Orogen: Variscan history based on the sedimentary and magmatic record (Seghedi)

Structural connections between the Rheic and Uralian oceans and subsequent orogens (Puchkov)

The Acatlán Complex, southern Mexico: vestige of the Rheic Ocean in North America (Nance)

B) Posters:

Syntectonic sedimentary sequences in Devono-Carboniferous evolution of the south-western margin of the Uralian Ocean (Gorozhanina)

Tectonic contact of the Western and Eastern Kaczawa Complexes (West Sudetes, northern Bohemian Massif): a boundary between the Saxothuringian passive margin and Rheic oceanic successions (Aleksandrowski)

A late Namurian (318 m.y.) 40Ar/39Ar age for kaersutite megacrysts from the Black Ball Head diatreme: an age limit for the Variscan deformation in SW Ireland (Pracht)

Mississippian-Devonian dextral collision in the Central Appalachians: evidence from the Catskill-Pocono clastic wedge and the Southern Appalachians Inner Piedmont (Dennis)

Textural record of the Rheic closure: the Careón supra-subduction ophiolite under SEM-EBSD perspective (Martínez-Catalan)

Geochemistry and tectonic setting of the Careón Ophiolite (NW Iberian Massif): Implications for the final Devonian evolution of the Rheic Ocean (Sánchez Martínez)

Epi-Gondwanian terrains in the structure of the southern Urals frame of Baltica: new data (Kuznetsov)

A hydrofracturing event in the Ardenne-Eifel area (Belgium, Germany): does it reflect the onset of the closure of the Rheic-Rhenohercynian ocean? (Sintubin)

Early Palaeozoic geodynamics in the Rhenohercynian passive continental margin in the Ardenne-Brabant area (Belgium)(Sintubin)

C) Field workshop at the Lizard ophiolite and adjoining crustal units:

The field workshop was ran over 6 field days and took the form of a geotraverse from the external margins of the Variscan fold and thrust belt in North Devon southwards to the allochthonous oceanic rocks of the Lizard and Start complexes ("Lizard Ophiolite") in Cornwall.

The annual meeting is documentet in the following publications:

Strachan, R.; Whalley, J. & Jones, K. (ed.): IGCP 497: The Rheic Ocean – It´s origin, evolution and correlatives – Project Meeting: July 5´th 2005, University of Portsmouth-Conference Abstracts and Programme.

Strachan, R.; Whalley, J. & Jones, K.: IGCP 497: The Rheic Ocean – It´s origin, evolution and correlatives – Field Excursion: July 6-11´th 2005, SW England, Fieldguide.

Impressions from the meeting of IGCP 497 in the UK ("Lizard Ophiolite") (Jul. 2005).

2005-II:

Special session and joint meeting of IGCP 453 and IGCP 497 during the *Annual Meeting of the Geological Association of Canada 2005:*

Special session: SS-20 "Assembling Avalon and Other Peri-Gondwanan Terranes"

Field trip: FT-B1 "Accretion of peri-Gondwanan terranes, northern mainland Nova Scotia and southern New Brunswick"

During the GAC-MAC – Meeting in Halifax (Canada, May, 2005) the Special Session SS-20 "Assembling Avalon and Other Peri-Gondwanan Terranes" (May, 17, 2005) was organized by Brendan Murphy (Canada), Margaret Thompson (USA), Jim Hibbard (USA) and Cees van Staal (Canada). This session was sponsored by the IGCP 453 and 497. A number of very good contributions concerning peri-Gondwanan terranes were presented by active colleagues of both IGCP´s:

Presentations:

De Wit, M.J, Bowring, S., Dudas, F. and Kamga, G. The great Neoproterozoic central Saharan Arc and the amalgamation of the North African Shield

Evans, D.A.D. Do Avalonian terranes contain the lost Grenvillian hinterland?

Rogers, N. and van Staal, C. Clues to the origin and tectonic evolution of Ganderia from Neoproterozoic and Cambrian magmatism in central Newfoundland

Horák, J.M., Evans, J.A. and Zalasiewicz, J. Provenancing limestone megaclasts from Palaeozoic melange, N. Wales, UK

Zagorevski, A., van Staal, C.R., Rogers, N. and McNicoll, V. Journey of a leading peri-

Gondwanan crustal fragment across Iapetus: Constraints on the arrival of Ganderian crust at the Laurentian Margin from Newfoundland

van Staal, C.R., Valverde-Vaquero, P., McNicoll, V., Rogers, N. and Zagorevski, A. Ordovician-Devonian accretion of Ganderia, Avalonia and Meguma to Laurentia in the Northern Appalachians

Hibbard, J.P. and van Staal, C.R. Relationships between crustal blocks in the Appalachian peri-Gondwanan realm

Wintsch, R.P., Aleinikoff, J.N., Unruh, D.M. and Walsh, G. Evidence for crustal-scale delamination of Gander basement from cover by tectonic wedging of the Avalon terrane, southern New England

Kroner, U., Linnemann, U. and Romer, R. From Cadomian accretion to Variscan collision: A synthesis of the geological record of Saxo-Thuringia

Linnemann, U., Drost, K., Jeffries, T., Gehmlich, M., Storey, C. and Garcia-Sanches, R. LA-ICPMS-U/Pb dating and provenance studies of glaciomarine tillites from Late Neoproterozoic rock units of Germany, the Czech Republic and France (Bohemian and Armorican Massifs)

Keppie, J.D., Nance, R.D., Miller, B.V., Murphy, J.B., Dostal, J. and Ortega-Rivera, A. Acatlán Complex, southern Mexico: a vestige of the Rheic Ocean

Murphy, J.B., Middleton, M., Keppie, J.D., Nance, R.D., Miller, B.V., Dostal, J., Fernandez-Suárez, J. and Jeffries, T.E. Asis eclogitic band, Piaxtla Suite, Acatlán Complex, southern Mexico: evidence for Ordovician rifting, and Mississippian subduction and exhumation of the Rheic Ocean

Nance, R.D., Fernández-Suárez, J., Keppie, J.D., Storey, C., Jeffries, T.E. and Murphy, J.B. Correlation and provenance of the Granjeno schist and Cosoltepec Formation, Mexico: Implications for Paleozoic paleogeography

McClelland, W.C., Roeske, S.M., Vujovich, G.I, Mulcahy, S.R. and Ellis, J.R. U-Pb SHRIMP evidence for additional allochthonous elements between the Precordillera terrane and Gondwana margin, Sierra de la Huerta, northwest Argentina

Ellis, J.R, McClelland, W.C, Roeske, S.M, Mulcahy, S.R and Naipauer, M. New U-Pb (SHRIMP and LA-ICP-MS) detrital zircon ages from metasedimentary rocks along the eastern margin of the Cuyania terrane, San Juan Province, Argentina

Field trip:

In addition to the session a related field trip "FT-B1 "Accretion of peri-Gondwanan terranes, northern mainland Nova Scotia and southern New Brunswick" was organized and guided by Sandra Barr, Susan Johnson, Brendan Murphy, Georgia Pe-Piper, David Piper and Chris White. This very successful and excellent field workshop ran between May 19 and May 21.

Impressions from the joint meeting of IGCP 453 and IGCP 497 in Atlantic Canada (Halifax, Nova Scotia, southern New Brunswick) ("Avalonian ide of the Rheic Ocean") (May 2005).

2005-III

Special session of IGCP 497 "Cadomines/Variscides" organized by Ulf Linnemann and Gernold Zulauf at the International Conference and Annual Meeting of the Deutsche Gesellschaft für Geowissenschaften (DGG) and the Geologische Vereinigung (GV) in Erlangen (Germany)

During the International Conference and Annual Meeting of the Deutsche Gesellschaft für Geowissenschaften (DGG) and the Geologische Vereinigung (GV) in Erlangen (Germany) on September, 28, 2005, the Special Session of IGCP 497 "Cadomides/Variscides" was organized by Ulf Linnemann (Dresden, Germany) and Gernold Zulauf (Frankfurt/M., Germany). The very successful session was a real international one with many contributions concerning the history of the Rheic Ocean:

Presentations:

Armendariz, M., Quesada, C., Gabaldón. V. and Gómez, J.J.
Destruction and resedimentation processes of carbonate platforms in the Carboniferous Guadiato basin (Córdoba, SW Iberian Massif)

Dietl, C., Finger, F. and de Wall, H.
The nature and meaning of microdiapir structures in granite massifs: results from the Fürstenstein Intrusive Complex (Bavarian Forest, Germany)

Galadí-Enríquez, E., Zulauf, G., Heidelbach, F., Dörr, W. and Rohrmüller, J.
Variscan dyke emplacement and sinistral strike slip in the Bavarian Forest (SE Germany): Constraints on the evolution of the Bavarian Pfahl
shear zone

Romano S.S., Brix, M., Dörr, W., Krenn, E. and Zulauf, G.
The evolution of the Cretan pre-Alpine basement

Schulz, B., Finger, F., Brätz, H. and Klemd, R.
Cadomian and Variscan metamorphic events in the Léon Domain and their dating by trace element analysis in monazite and garnet (Armorican Massif, France)
Teipel, U., Rohrmüller, J., Eichhorn, R., Loth, G., Höll, R. and Kennedy, A.
Implications for Upper Vendian and Lower Ordovician magmatism in the Bayerischer Wald (South-western Bohemian Massif) from U-Pb SHRIMP dating

von Raumer, J.F. and Stampfli, G.M.
Gondwana derived basement - searching for lost Palaeozoic seas

Xypolias, P., Dörr, W. and Zulauf, G.
Late Carboniferous plutonism within the pre-Alpine basement of the External Hellenides (Kithira, Greece): implication for the tectonic evolution of northern Gondwana

Doublier, M.P., Potel, S., Franke, W. and Wemmer, K.
Metamorphic evolution of southern flank of Montagne Noire (Variscan
belt, France) and its implications

Doublier, M.P., Potel, S., Franke, W., Wemmer, K. and Brandt, I. "From
compression to extension in an external part of the Variscan belt:
new geochronological and tectonometamorphic data (S French Massif Central) "

Blatt, A. K. H., Dörr, W. and Stein, E.
Neoproterozoic Basement in the metasedimentary Envelope of the Zone
Axial of the Montagne Noire (S-France)

Kraft, P., Lehnert, O., Fr_da, J., Rajchl, M. and Verner, K.
The developement of the Prague Basin as a part of a rift-basin system at
the southern margin of the Rheic Ocean

Kroner, U., Hahn, T, Linnemann, U. and Romer, R.
"The three principal domains of Saxo-Thuringia – Result of heterogenous Variscan overprint of Cadomian / Paleozoic Peri-Gondwana crust"

Rotthaus, B., Franke, W. and Dörr,W.
Where did the heat come from? - U-Pb zircon ages of granitoids in the Frankenwald Transverse Zone (Saxothuringia)

Brennholt, N., Schreiber, U. and Simon, J.
Neogene tectonics in the Rhenish Massif in special consideration of earthquake-relevant fault zones and their indication by hill-building forest ants (Formicinae)

Koch, M., Muench, T. W. and Schlittenhardt, J.

Simultaneous inversion for 3D crustal and lithospheric structure and regional hypocenters beneath Germany in the presence of an anisotropic upper mantle

3.1. List of countries involved in the project

Austria, Brazil, Canada, China, Columbia, Czech Republic, France, Georgia, Germany, Ireland, Italy, Kazakhstan, Mexico, Morocco, Mauritania, Poland, Portugal, Romania, Russia, South Africa, Spain, Slovakia, Switzerland, Turkey, U.K., Ukraine, U.S.A., Venezuela.

3.2. General scientific achievements (including societal benefits)

(i) The opening of the Rheic Ocean in the Late Cambrian/Early Ordovician (stage 1-"Birth"), the evolution of the Rheic Ocean during the Mid-Ordovician/Mid-Devonian (stage 2-"lifetime"=drift of Avalonia and the closure of the Iapetus Ocean) and the closure of the Rheic Ocean (stage 3-"death") accompanied by the formation of Pangea in the Late Devonian/Carboniferous are the general topics of our IGCP (see also chapter "Short introduction to the Rheic Ocean).
The Opening meeting in the Bohemian Massif and the other field workshops in 2004 (Mexico, Urals) each have shown aspects of all three stages. In 2005 the annual meeting in Portsmouth (UK) and the related field workshop ("Lizard Ophiolite") was more focused on stage 3 (closure of the Rheic Ocean). In contrast the meeting and the field trip in Halifax 2005 have shown aspects of all three stages.
Our aim is to combine a new data set to all three stages from all significant plates which were involved in the geological history of the Rheic Ocean.

(ii) In our meetings a lot of young geologists and students are involved.

3.3. List of meetings with approximate attendance and number of countries

2004-I: Opening Meeting IGCP 497: *"Gondwanan margin of the Rheic Ocean in the Bohemian Massif"*, held in Prague Sept. 2004, organized by Petr Kraft, pre-conference field trip (Sudetes): post-conference field trip (Tepla-Barrandian, Moldanubian, Saxothuringian).

2004-II: Session at the IGC in Florence (2004): special symposium "T31.03: Neoproterozoic to Early Paleozoic orogenic processes at the northern margin of Gondwana (Avalonian-

Cadomian Orogenic Belt)", organized by Ulf Linnemann (Dresden) and Gernold Zulauf (Frankfurt/M.).

2004-III: Symposium in Mexico: J. Duncan Keppie and R. Damian Nance organized a special symposium in Mexico that is linked to IGCP 497. The symposium was involved in the conference "IV. REUNIÓN NACIONAL DE CIENCIAS DE LA TIERRA".

2004-IV: Joint meeting of IGCP 497 with IGCP 453 (2004): We had a joint meeting of IGCP 453 "Ancient and modern Orogens" (Brendan Murphy and Duncan Keppie) and IGCP 497 in the Urals (August 3-12, 2004) organized by Dennis Brown (Spain) and Victor Puchkov (Russia).

2005-I: IGCP 497 conference and field workshop in Portsmouth, UK: "Devono-Carboniferous evolution of the northern margin of the Rheic Ocean" (organised by Rob Strachan, John Whalley & Kevin Jones, University of Portsmouth, UK)

2005-II: Special session and joint meeting of IGCP 453 and IGCP 497 during the *Annual Meeting of the Geological Association of Canada 2005:*
Special session: SS-20 "Assembling Avalon and Other Peri-Gondwanan Terranes"
Field trip: FT-B1 "Accretion of peri-Gondwanan terranes, northern mainland Nova Scotia and southern New Brunswick"

2005-III: Special session of IGCP 497 "Cadomines/Variscides" organized by Ulf Linnemann and Gernold Zulauf at the International Conference and Annual Meeting of the Deutsche Gesellschaft für Geowissenschaften (DGG) and the Geologische Vereinigung (GV) in Erlangen (Germany)

attendance: 153 scientists
number of countries: 19

3.4. Educational, training or capacity building activities

(i) In our meetings a lot of young geologists and students are involved.

(ii) The first book project of IGCP 497 "Das Saxothuringikum" (edited by Ulf Linnemann, 159 p., ISBN: 3-910006-28-0) is our large contribution to the educational sector in 2004. The book is focused on the history of the Rheic Ocean preserved in the Saxothuringian Zone at the NW´part of the Bohemian Massif and written for the German students of geosciences, teachers, scientists and all people interested in geology.

3.5. Participation of scientists from developing countries

2004: In 2004 from developing countries the following geoscientists were sponsored because of active participation at the meetings: Francisco Pereira (Portugal), Stanisław Mazur (Poland), Pawel Aleksandrowski (Poland), Richard Kryza (Poland), Inma Gil-Peña (Spain), Cecilio Quesada Ochoa (Spain), Ricardo Arenas (Spain), Petr Kraft (Czech Republic), Olda Fatka (Czech Republic), Vaclav Kachlik (Czech Republic), Jaroslav Marek (Czech Republic), Luis Eguiluz Alarcón (Spain), Antonetta Seghedi (Romania), Jose Catalan (Spain), Jacobo Abati (Spain).

2005: In 2004 from developing countries the following geoscientists were sponsored because of active participation at the meetings: Yelena Gorozhanina (Russia), Pawel Aleksandrowski (Poland), Markus Pracht (Ireland), Gutiérrez-Alonso (Spain), Kaveh Khaskar (Iran), Petr Budil (Czech Republic),
José R. Martínez-Catalan (Spain), Sonia Sánchez Martínez (Spain), Ricardo Arenas (Spain), Francisco Pereira (Portugal), Barry Long (Ireland), Antoneta Seghedi (Romania), Erdin Bozkurt (Turkey), Victor Puchkov (Russia), Cecilio Quesada (Spain).

3.6. List of most important publications (including maps)

We have presented international papers in a special volume of the International Journal of Earth Sciences (vol. 93, 2004) and the book "Das Saxothuringikum".

(i) List of online-papers in the International Journal of Earth Sciences (Springer):

New data on the Neoproterozoic – Cambrian geotectonic setting of the Teplá-Barrandian volcano-sedimentary successions: geochemistry, U-Pb zircon ages, and provenance (Bohemian Massif, Czech Republic)

Kerstin Drost, Ulf Linnemann, Neal McNaughton, *et al.*

Neoproterozoic—Early Paleozoic evolution of peri-Gondwanan terranes: implications for Laurentia-Gondwana connections

J. Brendan Murphy, Sergei A. Pisarevsky, R. Damian Nance, *et al.*

The Avalonian-Cadomian Belt and related peri-Gondwanan terranes

W. Dörr, F. Finger, U. Linnemann, *et al.*

Transcurrent continental tectonics model for the Ossa-Morena Zone Neoproterozoic–Paleozoic evolution, SW Iberian Massif, Portugal

J. B. Silva and M. F. Pereira

West African provenance for Saxo-Thuringia (Bohemian Massif): Did Armorica ever leave pre-Pangean Gondwana? – U/Pb-SHRIMP zircon evidence and the Nd-isotopic record

Ulf Linnemann, Neal J. McNaughton, Rolf L. Romer, *et al.*

Cambrian granitoids in pre-Alpine basement of Crete (Greece): evidence from U-Pb dating of zircon

Sandra S. Romano, Wolfgang Dörr, Gernold Zulauf

Pre-Variscan geological events in the Austrian part of the Bohemian Massif deduced from U–Pb zircon ages

Gertrude Friedl, Fritz Finger, Jean-Louis Paquette, *et al.*

Zircon ages, geochemistry, and Nd isotopic systematics of pre-Variscan orthogneisses from the Erzgebirge, Saxony (Germany), and geodynamic interpretation

B. Mingram, A. Kröner, E. Hegner, *et al.*

U-Pb SHRIMP and Nd isotopic data from the western Bohemian Massif (Bayerischer Wald, Germany): Implications for Upper Vendian and Lower Ordovician magmatism

U. Teipel, R. Eichhorn, G. Loth, *et al.*

Neoproterozoic metamorphism and deformation at the southeastern margin of the East European Craton, Uralides, Russia

U. A. Glasmacher, W. Bauer, N. Clauer, *et al.*

The eastern continuation of the Cadomian orogen: U–Pb zircon evidence from Saxo-Thuringian granitoids in south-western Poland and the northern Czech Republic

Andrzej Żelaźniewicz, Wolfgang Dörr, Paweł Bylina, *et al.*

Neoproterozoic and Cambro-Ordovician magmatism in the Variscan Kłodzko Metamorphic Complex (West Sudetes, Poland): new insights from U/Pb zircon dating

Stanisław Mazur, Krzysztof Turniak, Michael Bröcker

(ii) The book “Das Saxothuringikum”

Linnemann, U. (Ed.) (2004): Das Saxothuringikum, published by Staatliche Naturhistorische Sammlungen Dresden and Verlagshaus Bautzen, ISBN 3-910006-28-0, 159 pp. Content:

(iii) Peer reviewed articles in Journals:

Abati, J., and Arenas, R., 2005, Metamorphic evolution of anthopyllite/cummingtonite-cordierite rocks from the upper unit of the Órdenes Complex (Galicia, NW Spain). European Journal of Mineralogy, v. 17, p. 57-68.

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3.7. Activities involving other IGCP projects or the IUGS

- **(i)** Session at the IGC in Florence (see point 3.2) (linked to IUGS, IGCP 453, IAGR)
- **(ii)** Symposium in Mexico (linked to IGCP 453)
- **(iii)** Joint meeting of IGCP 497 with IGCP 453 in the Urals (linked to IGCP 453)
- **(iv)** Special session and joint meeting of IGCP 453 and IGCP 497 during the Annual Meeting of the Geological Association of Canada, Halifax, 2005.

4. Activities planned

4.1. General goals

The evolution of the Appalachian-Caledonide Orogen is commonly described in terms of the Iapetus Ocean whose opening produced the rifted margin of eastern Laurentia and whose closure resulted in the collision of this margin with Baltica and a variety of peri-Gondwanan terranes. However, the climactic collision in the Appalachian Orogen and much of Eastern and Central Europe was not that of Iapetus closure but that of its immediate successor, the Rheic Ocean. Closure of the Rheic Ocean produced the vast Ouachita-Alleghanian-Variscan Orogen and was one of the principal events in the Late Palaeozoic assembly of the supercontinent Pangaea.

The Rheic Ocean is generally held to have opened between Gondwana and a number of terranes that rifted from the Amazonian-West African margin of Gondwana. Its growth occurred at the expense of the Iapetus Ocean and its closure brought Gondwana into collision with Laurussia during the assembly of Pangaea. Despite its importance during the Palaeozoic, however, the history of the Rheic Ocean has not received the same attention as that of its better-known forerunner, and much controversy surrounds its origin, palaeogeography and evolution. These controversies result from uncertainties in the identification of its rifted margins, in the timing of its initial rifting and rift-drift transition, in its size and geography, and in the geodynamics of its final closure. Lying behind these uncertainties is the broad

geographic area to which regions of Rheic geology were scattered following the breakup of Pangaea, including North and Central America, Western, Central and Eastern Europe (including former "Eastern-Block" countries), and Northwest Africa, and the widely varying disciplines involved in its study. As a result, communication between interested geoscientists is impeded by language and cross-disciplinary barriers. To remedy this, we believe it is timely to bring together geoscientists of varying disciplines from each of these areas in order that a more comprehensive understanding of the evolution of this important ocean can be developed. In particular, scientists from less developed nations and former "Eastern-Block" countries will be invited in order to promote information and technology transfer that will both promote the goals of the project and enhance the development of the geosciences in their own countries. The fields of expertise involved (stratigraphy, sedimentology, palaeontology, igneous and metamorphic petrology, geochronology, geochemistry, structural geology, tectonics, palaeogeography, palaeoceanography, geophysics, etc.) span the entire discipline and, because of the vagaries of Pangaea breakup, are developed to differing degrees amongst the countries in which the story of the Rheic Ocean is recorded. Thus, the Czech Republic, for example, possesses vital expertise on the stratigraphy, sedimentology and palaeontology of the Rheic Ocean because of the superb sedimentary record preserved in the Prague Basin, the palaeoecology of which has been used to trace the radiation and extinction events that chart the ocean's evolution. Poland, Germany and Slovakia, on the other hand, possess well-exposed records of the collisional processes that accompanied ocean closure, while Spain and Portugal possess records of its initial rifting, and the United Kingdom preserves vestiges of the ocean itself. The transfer and exchange of this expertise with that from other areas of Rheic geology, for example, the sedimentary records preserved in Morocco and South Africa, the rifting and ophiolitic records preserved in Mexico, and the collisional histories preserved in Turkey, eastern North America and northern South America are central to resolving the ocean's origin and evolution, and its relationship to correlative oceanic tracts, such as proto-Tethys, Tornquist, Aegir and other unnamed seaways in Europe, the Middle East, Kazakhstan, Ukraine, Russia and China, with which it played a collective geodynamic role in the assembly of Pangaea.

General frame work: The opening of the Rheic Ocean in the Late Cambrian/Early Ordovician (stage 1-"Birth"), the evolution of the Rheic Ocean during the Mid-Ordovician/Mid-Devonian (stage 2-"lifetime"=drift of Avalonia and the closure of the Iapetus Ocean) and the closure of the Rheic Ocean (stage 3-"death") accompanied by the formation of Pangea in the Late

Devonian/Carboniferous are the general topics of our IGCP (see also chapter "Short introcuction to the Rheic Ocean).

The Opening meeting in the Bohemian Massif and the other field workshops in 2004 (Mexico, Urals) each have shown aspects of all three stages. In 2005 the annual meeting in Portsmouth (UK) and the related field workshop ("Lizard Ophiolite") was more focused on stage 3 (closure of the Rheic Ocean). In contrast the meeting and the field trip in Halifax 2005 have shown aspects of all three stages.

Our aim is to combine a new data set to all three stages from all significant plates which were involved to the geological history of the Rheic Ocean.

*4.2. Specific meetings and field trips (*please indicate participation from developing countries)*

2006-I:

IGCP 497 conference and field workshop in Turkey: "The remnants of the Rheic Ocean in the Turkish plate: Neoproterozoic and Palaeozoic terranes in Northwest Turkey"
(June, 23-30, 2006) (responsibility: Erdin Bozkurt, Ankara, Turkey).

(*Turkey is a developing country)

2006-II:

IGCP 497 conference and field workshop in Portugal and Spain *(Iberia I)*: "The Rheic Ocean in Iberia: Ediacaran to Visean crustal growth processes in the Ossa-Morena Zone (SW Iberia) and the Ossa-Morena Zone" (Sept. 20-27, 2006) (responsibility: Francisco Pereira, Portugal; Cecilio Quesada, Spain; et al.).

(*Portugal and Spain are developing countries)

2007-I

IGCP 497 conference and field workshop in NW-Spain *(Iberia II)*: "The rootless Variscan suture of NW Iberia (Galicia)" in NW-Spain (responsibility: Ricardo Arenas, José Ramon Martinez Catalan, Jacobo Abati).

(*Spain is a developing country)

2007-II:

Joint Meeting of IGCP 485 and IGCP 497 including field workshop in El Jadida, Antiatlas, Morocco) (IGCP 485-board: Jean-Paul Liégeois & Nasser Ennih, responsibility for IGCP

497: Francisco Pereira, Scott Samson, Richard D`Lemos, Ulf Linnemann).

(*Morocco is a developing country)

2008-I

IGCP 497 conference and field workshop in South Africa: "The Rheic Ocean and the Cape Fold Belt" (responsibility: Maarten de Wit et al., South Africa).

(*South Africa is a developing country)

2008-II

Final IGCP 497 conference and field workshop in Mexico: "The Rheic Ocean and the peri-Gondwanan terranes of Mexico" (responsibility: Duncan Keppie, Mexico, & Damian Nance, USA)

(*Mexico is a developing country)