Introduction

The Devonian period is one of the most interesting systems in Earth history. It is widely considered as a time of global greenhouse climates, lacking any significant ice shields, even when recently a discussion on icehouse-related sea-level fluctuations – not only near the Devonian/Carboniferous boundary – has evolved (Elrick et al., 2009, Joachimski et al., 2009). In any case it was characterized by extensive shallow marine and continental lowland areas yielding a wide range of different habitats. Following the work of numerous individuals and regional groups which have been established within IGCP 421, led by John Talent and Raimund Feist, a group of scientists proposed a new successor project (IGCP 499) in order to develop a better understanding of marine and terrestrial ecosystems, and the influence on sedimentation in both the terrestrial and marine realms. Within the marine realm this included the neritic-pelagic correlation. An important focus of the project concerned the interrelated evolution of terrestrial and marine palaeoecosystems with respect to biotic and abiotic factors requiring high-resolution stratigraphic control and detailed analysis of different facies settings. The work on the rapid evolution of early ecosystems on land and their interaction with sedimentary processes, climate, and palaeogeography, both on land and in marine settings, was scheduled for the duration of the project (2004 – 2009). For that reason studies included individual palaeoecosystems and their components as well as their palaeo-biogeographic distribution which should provide a better understanding of the Devonian system with respect to the evolution of palaeoecosystems and to palaeogeographical and palaeoclimatic changes. The project was developed in close collaboration with the Sub-commission on Devonian Stratigraphy (SDS) and many workshops were organized worldwide (Fig. 1), some of them as joint IGCP 499/SDS meetings.

IGCP 499 meetings and workshops

The inaugural meeting took place in Rabat, Morocco, in conjunction with the Subcommission on Devonian Stratigraphy (SDS). The meeting was connected with the 11th International Palynological Congress in Granada, Spain; the 32nd International Geological Congress, Firenze, Italy; the Geological Society of America in Denver, a field workshop in the Dra Valley of the Anti Atlas Mountains. Both were perfectly organized by Ahmed El Hassani, Rabat (El Hassani, 2004). As a result of this meeting a Special Volume was published on "Devonian events and correlations" edited by Becker and Kirchgasser (2007). In October 2004 the first business meeting of the project was held at the University of Göttingen, Germany, during the annual meeting of the Paläontologische Gesellschaft, and was attended by about 40 colleagues from 9 countries. Presentations and discussions focused on the activities during the initial phase of the project and how forthcoming activities can be coordinated. In order to channel the work within IGCP 499 which covered a wide range of scientific disciplines, guidelines were established providing different working groups/regional coordinators which provided a better coordination of forthcoming field meetings and workshops. Furthermore, in the first year we presented the new project in conjunction with several conferences, such as the 11th International Palynological Congress in Granada, Spain; the 32nd International Geological Congress, Firenze, Italy; the Geological Society of America in Denver,
USA, and we organised a joint meeting with IGCP 503 at the University of Erlangen in Erlangen, Germany.

In the following years numerous workshops and conferences took place in different countries (Fig. 1). In the tradition of successful joint meetings and field trips of Devonian IGCP projects and the SDS a meeting was held at the Institute of Petroleum Geology, United Institute of Geology and Mineralogy of the Russian Academy of Sciences, Siberian Branch in Novosibirsk on “Devonian terrestrial and marine environments: From continent to shelf”. The meeting which included a splendid field trip to the South of Siberia (July 26 – August 6, 2005) and well-organised technical sessions (August 7 – 8, 2005) was organised by a great group from Novosibirsk under the guidance of E.A. Yolkin, A.V. Kanygin, N.K. Bakharev, N.G. Izokh and O.T. Obut (Yolkin et al., 2005a, b). The field trip led the participants to various Devonian outcrops in the Salair, Rudny Altai, and Gorny Altai regions yielding a great variety of rocks in different facies settings (from nearshore/terrestrial to open marine conditions) and from the Lower to the Upper Devonian (Fig. 2). About 75 scientists presented 35 oral lectures and 4 posters during the meeting. Results of the conference are published in a Special Issue of the Bulletin of Geosciences (Königshof et al., 2008). In the same year a workshop was organized in Istanbul (Yalçın et al., 2005). The Devonian of Turkey was of special interest for the IGCP 491. It was focused on mid-Devonian land-sea interaction: evolution of ecosystems and climate (session T7) chaired by D.J. Over in June 2005 at the North American Paleontological Convention in Halifax, Nova Scotia. The next meeting of IGCP 499 was included in the 6th Baltic Stratigraphic Conference, held in St Petersburg, Russia, that was coordinated by Z. Zigaite in the framework of IGCP 491. It was focused on mid-Palaeozoic vertebrates (coordinated by M. Zhu and G. Young). IGCP 499 was represented by J. Lazauskiene who organised a business meeting.

In order to intensify cooperation between China and Germany a session on “Devonian land-sea interaction: evolution of ecosystems and climate” (session T7) was held on June 17, 2006 in conjunction with the 2nd International Palaeontological Congress (IPC) in Beijing, China. The successful and enjoyable session (21 oral and poster presentations) took place in the Yingsjie Conference Centre. There was a large positive response to our call, and the convenors of the session (Peter Königshof and Xueping Ma) could welcome more than 30 colleagues from Australia, Canada, China, European countries and the USA. Far more talks were offered than could be accommodated in the single-session programme. Finally, 15 talks on a wide range of topics with numerous new data and stimulating scientific ideas, e.g. on carbon isotope stratigraphy, climate fluctuations, sedimentology and microfacies, palaeoecology and mass extinction events were presented. The abstracts of the contributions to the T7 session are published in the IPC abstract volume (Quan Yang et al., 2006). Other workshop activities have been incorporated in smaller congress events. Embedded in the meeting of the “Commission International de Microflore du Paléozoïque” (CIMP) that took place in Praha 2006, a symposium was held on “Palaeozoic Palynology” (Bek et al., 2006) as some of the palynological topics of the meeting appeared to be very important for recognition of marine – non marine sequences and for correlation between different shallow water areas.

Several other field meetings and workshops followed and in 2007 two meetings were organized. A workshop was held from May 14th to 22nd in San Juan, Argentina. The Devonian of the San Juan and Mendoza Precordillera and the San Rafael Block was also a focus of the project regarding the palaeogeographic and biostratigraphic importance in the Devonian Malvinokaffric realm, but also in terms of the tectonic-sedimentary evolution of the Precordillera terrane. A two-day symposium in San Juan was followed by excursions to Western Argentina covering stratigraphic sequences from the Early to Middle Palaeozoic (Fig. 4). The workshop was organized by colleagues of the Facultad de Ciencias Exactas, Fisicas y Naturales, Universidad Nacional de San Juan, Instituto de Geología “Dr. Emiliano Pedro Aparicio” (INGEO), Instituto Superior de Correlacion Geología (INSUGEO) of the Facultad de Ciencias Naturales e I.M.L. Universidad National de Tucumán, Consejo Nacional de
Investigaciones Cientificas y Tecnicas (CONICET). A 120-page abstract volume and a field guide book was published, edited by G. Acenolaza et al. (2007). As a result of this meeting, many papers from different palaeogeographic settings have been published in a special volume of the Geological Society of London (Königshof, 2009).

As in previous years, a joint meeting of IGCP 499 and the Subcommission on Devonian Stratigraphy (SDS) was held in September 2007 in Nevada. Three days of technical sessions took place in the historical Opera House of Eureka, Nevada (Over and Morrow, 2007). A pre-conference field trip led to sections spanning most of the Devonian in northeastern Nevada and western Utah. The meeting in Eureka was well-organized by D.J. Over, Dept. of Geological Sciences, SUNY Geneseo, New York, and J. Morrow, Dept. of Geological Sciences, San Diego State University, California. The field trip was perfectly arranged by J.R. Morrow and the co-leaders C.A. Sandberg, J.E. Warne, M.A. Murphy, and D.J. Over. The meeting in Eureka was attended by about 45 colleagues from 11 countries who presented 40 oral and 12 poster contributions which covered the whole array of Devonian research topics. Among those papers dealing with sea-level changes and/or cyclic sedimentation, stratigraphy, regional geology, palaeontology as well as land-sea interactions were strongly represented. On September 17th the annual SDS meeting was held, followed by a business meeting of IGCP 499. The six days field trip (Morrow, 2007), representing an essential part of the entire conference, started in Las Vegas on September 9th. Various Devonian successions in different areas were demonstrated, highlighting some of the classical as well as recently studied sections.

The field trip route within the Great Basin region (Basin and Range province) covered primarily carbonate shelf settings including reefs, and slope to basinal deposits of different areas such as the Confusion Range and Burbank Hills in Utah, Lincoln County and Antelope Range in Nevada (Fig. 5). Special attention was paid to the impact related Alamo Breccia and to several sections spanning the Frasnian/Famennian boundary (besides others the classical locality at Devil’s Gate near Eureka). Furthermore, Lower to Middle Devonian strata including the Silurian/Devonian boundary were demonstrated. It was especially impressive for the participants to visit sections which whee initially introduced by some of the pioneers of western US Devonian research (e.g., C.A. Sandberg).

In addition to the field activities in Turkey and the lab work in Turkey and Germany, a joint fieldtrip led four Turkish colleagues to the Devonian of the Rheinisches Schiefergebirge and the tidal flats of the German North Sea. These activities in Germany gave important support for a better understanding of the Turkish sections studied within the frame of the DEVEC-TR Project.

In 2008 IGCP 499 went again to North-Africa. A meeting was organized in Libya (April 23rd - 30th, 2008). The workshop (Belgasem, 2008) and the field trip (Ben Rahuma et al., 2008) were devoted to the stratigraphic evolution of Devonian sequences in the Awaynat Wanin area, Southern Ghadamis Basin with a focus on sequence stratigraphy, sedimentology and facies, and palaeoecology (Fig. 6). The Devonian of Libya was of special interest due to the excellent sequences mainly representing very shallow water environments, but also including fluvial sequences (land-sea transitional settings). The workshop was held at the Libyan Petroleum Institute (LPI) in Tripoli with an opening ceremony, which included the welcome adresses by the General manager of LPI, B.A. Belgasem, and the coordinator of the meeting, A.D. El Mehdawi. A 43-page abstract volume and a 67-pages field guide book have been published. Scientists from seven countries attended the meeting.

Another joint SDS/IGCP 499 meeting took place in Uzbekistan from August 24th and September 03rd, 2008. The meeting was entitled “Global alignments of Lower Devonian carbonate and clastic sequences” and colleagues from nine countries attended
the meeting. The main focus has been on the revision of the GSSP at the base of the Emsian Stage and on stratigraphy, sedimentology and facies development in the classical area of the Kitab State Geological Reserve. Other subjects emphasized in the conference and the field trip concerned cyclicity and sedimentary markers for intra- and inter-basinal correlations, neritic/pelagic associations and their interrelations as well as global sedimentary and biotic events. The scientific session included 30 oral presentations and 18 posters. A 97-pages field guidebook (Yolkin et al., 2008) and a 122-pages abstract volume (Kim et al., 2008) has been published.

Finally, a conference at the end of the regular term of IGCP 499 and IGCP 497 (on the Rheic Ocean) was held in Frankfurt, Germany. As orogenic events involved in the history of the Rheic Ocean range from the Avalonian-Cadomian orogenies in the Latest Neoproterozoic up to the formation of Pangaea in the Devonian-Carboniferous time. These incising events within the Devonian played a major role for the evolution of life, climate, palaeogeography, and environmental conditions. This was the main reason to combine the final meetings of IGCP 497 and of IGCP 499 under the heading “From Gondwana and Laurussia to Pangaea: Dynamics of Oceans and Supercontinents”.

Scientific session were related to the following topics:
- Palaeogeography and Supercontinents during Late Precambrian and Palaeozoic times
- Palaeobiodiversity and Palaeoecology
- Past climate and sea-level changes
- Neritic-pelagic correlation
- Land-Sea interactions
- Diversification of early terrestrial ecosystems
- Palaeozoic orogenic processes at the northern margin of Gondwana
- Birth of the Rheic Ocean: Avalonian-Cadomian orogenic processes and Early Palaeozoic rifting at the northern Gondwana margin
- Closure of the Rheic Ocean: Palaeozoic drift and the Alleghanian-Variscan orogenic processes during the Pangea configuration
- Geochronology, Isotope Geology and Provenance Analysis in Late Neoproterozoic and Palaeozoic times

The conference took place from September 30th to October 04th, 2008 at the Senckenberg Natural History Museum, Frankfurt am Main, Germany, followed by a 6 day post-conference field trip (Fig.7) displaying a cross section through the Rheno-Hercynian Zone (Rhenish Massif, Avalonia, Laurussia), the Mid-German Crystalline Zone (suture zone of the Rheic Ocean), the Saxo-Thuringian Zone (Bohemian Massif, Cadomia, Gondwana). 130 participants from 26 countries attended the meeting. This meeting was of international interest and we are proud that the meeting was co-sponsored by the German Science Foundation. A 241-pages abstract volume and a 159-pages field trip guidebook have been published (Königshof and Linnemann, 2008a, b). A special volume of “Gondwanan Research” devoted to that meeting was published recently, edited by Damian Nance (D. Nance, 2010).

In January 2009 the project received the status on extended term (OET). Even if we did not receive funding, the leaders and other colleagues organized two meetings in this year. The first one took place in Cincinnati, Ohio, from June 21-26 in conjunction with the 9th North American Paleontological Convention (NAPC 2009) where two special sessions had been organized. One session was entitled “Rapid evolution of terrestrial ecosystems and their influence on marine realms – land-sea interactions in the Devonian” chaired by R. Brocke, P. Königshof, and J.E.A. Marshall, the other one had the focus on “Biological response to Devonian sea-level and paleoclimate changes”, chaired by R.T. Becker, E. Schindler, and C.E. Brett. A special volume on sea level and climate, cyclicity and bioevents in Middle Devonian marine and terrestrial environments will be published in 2010 (edited by Brett et al. in prep).

In September 2009 a joint meeting of IGCP 497, 499 and 503 entitled “Palaeozoic Seas Symposium” was organized by Th.J. Suttner, H. Hubmann, and W. Piller at Graz, Austria from September 14th –18th. The symposium was followed by a field trip to the Devonian of the Graz Palaeozoic and to Carboniferous localities of the Carnic Alps.

Additionally, there have been many activities in the regional and local working groups in different countries over the past years.

All in all, even if there are many open questions left which especially concern the land-sea transitional settings or sequence stratigraphy vs. global bioevents, it should be stressed that this project has been a highly successful IGCP. Relationships of regional geological features and open questions with respect to biostratigraphy, facies interpretation and depositional environment, especially land-sea transitional settings generated vivid discussions in all of these meetings and workshops mentioned above and helped identify topics requiring future research. They also acted as a catalyst for future collaborative research between

Figure 7. Members of the joint IGCP 497 / 499 field trip in 2008 (Photograph courtesy of P. Königshof)
groups all over the world, as well as offering a network for collaboration between researchers involved in the IGCP 499 and forthcoming activities.

Furthermore, the last six years have shown that successful research is based on multidisciplinary cooperation. On the other hand, there are many open questions left and there are some disciplines where we should concentrate research in the Devonian. Based on a profound knowledge of organisms sequence stratigraphic correlations should be brought into agreement with available biostratigraphic data. Another focal point could be a better correlation between terrestrial events and the correlation with marine realms, and in the neritic settings we need a better biostratigraphic and sedimentary record. Palynomorphs are a useful tool in this context. Another interesting aspect could be the evolution of the terrestrial vegetation and the interaction with the arthropods as well as the evolution of early terrestrial eco-systems. The meetings and workshops of IGCP 499 clearly have shown that there is a huge potential for special topics requiring future research and perhaps successor project of IGCP 499.

Outreach activities

Regarding outreach activities we have improved our main websites (English and German version) and we have also linked our website with other "geo-sites". Additionally, P. Königshof and T. Agricola compiled a touring exhibition (Fig. 8) on German IGCP projects for the general public. In this context, also geological excursions for the general public took place. Several TV reports and numerous reports in newsletters resulted from this initiative. The touring exhibition was a contribution to the International Year of Planet Earth (IYPE). A short exhibition guide as pdf-file is available.

Publications

Since 2004 more than 550 peer reviewed papers (Fig. 9) have been published representing the improved knowledge on the following topics:
- climate change and events during the Devonian
- characterization of facies in marine-terrestrial transitions and their correlation
- sea-level changes in the Devonian on global and regional scale
- rapid evolution on early life on land and its interaction with sedimentary processes
- case studies of complex palaeoecosystems in different palaeogeographic settings and their correlation
- biostratigraphic control in different facies realms

Many more publications are expected in the near future (e.g., edited volumes by Brett et al., 2010). The references contain a list of published conference volumes and field trip guide books as well as Special volumes.

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Peter Königshof, E. Schindler, E. and V. Wilde
Forschungsinstitut und Naturmuseum Senckenberg,
Senckenberganlage 25, 60325 Frankfurt
Email: peter.koenigshof@senckenberg.de
Email:Eberhard.Schindler@senckenberg.de;
Email: Volker.Wilde@senckenberg.de

J. Lazauskiene
Geological Survey, Lithuania,
Konaskio 35, Vilnius, LT-2009;
Email: Jurga.Lazauskiene@lg.tlt

M. Namik Yalçın,
Istanbul University, Engineering Faculty,
Department of Geological Engineering,
TR 34850 Avci lar, Istanbul;
Email: mny@istanbul.edu.tr

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