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Palaeotectonic and palaeogeographic evolution of the western Tethys and PeriTethyan domain (IGCP Project 369)

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Project No. 369 ("Comparative Evolution of PeriTethyan Rift Basins") of the International Geological Correlation Program produced a new palaeotectonic-palaeogeographic atlas of the western PeriTethyan domain. The atlas contains more than two hundred new maps and documents grouped in nine regional sets (Iberia, Polish Trough, Eastern European and Scythian Platforms, Moesian Platform, Levant, Arabian Platform, Northern Africa, NE Africa-NW Arabia, Libya-Pelagian Shelf) plus a set of reconstructions for the whole western Tethys. The area considered in the atlas stretches, from west to east, from the eastern Atlantic shores to the Urals and, from north to south, from the Baltic shield to equatorial Africa; the time span covered extends from the Late Carboniferous to the Present.

The dataset, resulting from an extensive cooperation between industrial and academic sources, is accessible interactively on a CD-ROM (Stampfli et al., 2001a) and includes legend, timetable, short explanatory notes, full references and additional supporting data. This dataset provides information on the development of the Tethyan realm in space and time. In particular, the relation between the Variscan and Cimmerian cycles in the Mediterranean realm is illustrated by numerous palaeogeographic and palaeotectonic maps.

Introduction

The PeriTethyan domain, i.e. the broad regions north and south of the Alpine thrust fronts, is a proxy of the processes which governed the break-up of Pangea, the opening of Tethyan oceanic basins and their subsequent closure and suturing. In spite of such significance, intra-plate rift/wrench basins and passive margins located on the cratons of Africa-Arabia and Europe have been neglected by most Tethyan syntheses, which instead focused on the compressional orogenic zones. The goal of IGCP Project No. 369 "Comparative Evolution of PeriTethyan Rift Basins" (1994–1999) was an integrated geological-geophysical study of rift/wrench and passive margin basins located on the northern and southern Tethyan platforms, aimed to improve constraints on the overall tectonic evolution of the Tethys orogen. More than two hundred researchers from thirty-six

countries actively took part in IGCP 369. These participants came from academia, the oil industry, geological surveys and other institutions. More than one hundred scientific publications have stemmed directly from the activities of this project. Eight independent meetings and five symposia at large international congresses were organized within the framework of the project.

The palaeotectonic-palaeogeographic atlas of the western PeriTethyan domain (Stampfli et al., 2001a), represents one of the two main end products of IGCP Project No. 369. The other one is a companion volume (Ziegler et al., 2001a) outlining the structure, stratigraphy and evolution of a number of rift/wrench basins and passive margins, which developed through time within and along the northern and southern margins of the Tethyan belt, and on the adjacent cratonic platforms. The starting assumption was that the extensional basins on the Tethyan margins preserved a detailed record of Tethyan processes. Considering that the evolution of these basins was governed by stress systems related to the opening as well as to the closure of the western Tethyan realm, and that some of them were not directly involved in the Alpine orogeny, their tectonostratigraphic record provides valuable information on the evolution of the Tethyan domain through time. The results of basin analyses carried out in the framework of IGCP 369, integrated with supplementary data from surrounding regions, provided a base for the development of a set of new plate reconstructions and supporting palaeotectonic-palaeogeographic maps contained in the CD-ROM (Stampfli et al., 2001a).

Ziegler et al. (2001a) presents the foundations upon which the atlas presented in this paper was constructed; it includes contributions on western Tethyan basin development related to processes controlling the break-up of Pangea, the progressive opening of the Tethyan system of oceanic basins and their closure during the Cimmerian and Alpine orogenic cycles. It addresses, as well, extensional tectonics that accompanied the Neogene suturing of Africa-Arabia and Eurasia. The tectonostratigraphic record of these basins, which hitherto has not been fully taken into consideration, provides new and more accurate information on the interaction between the Eurasian and African-Arabian plates through time. Opening chapters on "Dynamics of Rifting and Basin inversion" and the "Evolution of the Western Tethys Realm", presenting a timetable for rifting activity and the opening and closure of oceanic basins and revised plate kinematic reconstructions, are followed by twenty-two papers discussing the evolution of specific basins or regions. Areas addressed range from Iberia to the Black Sea and the Uralian foreland and from North Africa to the Gulf of Aden and Northern Arabia. All papers are based on a thorough analysis of data acquired by the petroleum industry, scientific research programs and geological surveys. Much of the data presented in this author compendium have previously not been published or were not readily accessible to the general international reader.

In this paper we present black and white versions of some material coming from the atlas (Stampfli et al., 2001a), which can be subdivided into two types of information: (i) regional paleogeographic maps and associated data, and (ii) a set of plate-tectonic reconstructions from Carboniferous to Cretaceous times and terrane maps, covering the entire western Tethyan realm. The CD-ROM allows switching from one type of information to the other and maps can be zoomed using Acrobat Reader(TM), which is provided in the CD. Selected material from Stampfli et al. (2001a) can be previewed at http://www.sst-unil.ch/IGCP_369.

Plate-tectonic versus continental drift

Contrary to continental drift models, which only consider displacement of continents on a sphere and so do not take into account plate boundaries, our goal during the elaboration of these new palaeotectonic reconstructions was to develop plate-tectonics constrained models. We integrated ocean spreading rates, plate buoyancy, dynamic plate boundaries, pelagic series and ophiolites occurrences and major tectonic and magmatic events.

The subsequent procedure was applied during the reconstructions of the western Tethyan realm:

- Continents: present shape and size and/or geological boundaries when applicable
- Terranes: when possible present shape was kept for geographical identification
- Continental fit: tight fits were used systematically to take care of crustal extension during rifting
- Oceanic pseudo-anomalies: for disappeared oceans and reconstruction of plate boundaries
- Spreading rates: in line with geodynamic context
- Baltica palaeo-poles: as reference for palaeo-latitudes
- Euler Poles of rotation: for each continent
- Europe as reference: fixed on the globe in its present day position

The use of Euler poles for each continent has numerous consequences, one of them being the geometry of transform boundaries; when they are known (e.g. Levant transform) the chosen Euler pole has to conform with this geometry. The other point is the maximum spreading rate that a chosen pole implies along its equator, what appears as an acceptable spreading rate close to the Euler pole is sometimes unacceptable a few thousands of kilometers away. Spreading rates were systematically calculated at the Euler equator of PaleoTethys and NeoTethys in order to check whether the figures were acceptable (below 20 cm/y).

We have combined stratigraphic, sedimentary and palaeontological data to produce subsidence curves in some key areas (Stampfli, 2000; Stampfli et al., 2001b). Subsidence analysis is a powerful tool to compare different basin histories particularly passive margins, because it allows us to characterize and constrain the timing of major geodynamic events. Palaeomagnetic and palaeobiogeographic information was also incorporated to the limit of our knowledge to constrain the location of older continents, whilst magnetic anomalies were used to constrain younger reconstructions. This multidisciplinary approach was applied to the entire globe in order to become self constrained. Nearly a hundred continents and terranes were used to elaborate the reconstructions (orthographic projection) on the GMAP Software package (Torsvik and Smethurst, 1994). We focussed our attention particularly on the Tethyan realm for which numerous continental drift models have been presented in the last thirty years, in order to see if plate-tectonic models including dynamic plate boundaries could solve some of the main geological issues. Alternate proposals were tested prior to making a selection. In the process of this we discovered that dynamic plate boundaries reported from one reconstruction to the next, give a high level of constraint, not reached by continental drift models proposed so far.

Based on the fact that a continent is nearly always attached to a larger plate, it is not a sound approach to move this continent and ignore at the same time what is happening to its plate boundaries.

Figure 1 Late Carboniferous (Westphalian) reconstruction of the western Tethyan realm (orthographic projection, 20N/20E entered).

Figure 2 Late Triassic reconstruction of the western Tethyan realm (orthographic projection, 20N/20E centered).

Figure 3 Early Cretaceous reconstruction of the western Tethyan realm (orthographic projection, 20N/20E centered).

areas can be traced and defined in such a way that their drift history will help to constrain this model. So this model is a plate tectonic model (with built-in plate boundaries geodynamically consistent from one reconstruction to the next) and not a continental drift model, any new kinematic information (e.g. onset of rifting, onset of subduction) places additional constraints and allows elimination of alternate solutions. The sets of regional palaeogeographic maps presented in the CD and the information used to construct them (stratigraphic charts, subsidence curves, sedimentological analysis, etc.) provided very useful information to constrain the plate tectonic models. In this scheme, all the Cimmerian terranes (from Apulia to South Tibet) are regarded as Gondwana derived and devoid of any Variscan deformation. Up to their Permian detachment from Gondwana, they represent the northern passive margin of this continent. During the Triassic they were involved in the Eocimmerian phase of Paleotethys closure and were subsequently dispersed creating an apparent duplication of the Paleo-Tethys northern margin during the Alpine orogenic events.

Figure 5A presents a general Late Permian palaeogeographic map for North Africa. It shows the rift, which opened between

Africa and East Gondwana (Somalia Basin) in Permian times, linking southward with the Karroo system. This rift was an aborted branch of NeoTethys whereas another westward branch extended up to the East-Mediterranean area where the rift shoulder is transgressed following the onset of its thermal subsidence. Figure 5B shows in more detail the development of the passive margin on the same shoulder during the Early Ladinian in the Levant-Egyptian region, where transgression of the shoulder is even more evident.

Figure 6 presents a palaeogeographic map for the Arabian peninsula for Late Jurassic times. It shows a more mature NeoTethys passive margin development around this area, as well as active rifting in Yemen linked to sea floor spreading processes in the Mozambique-Somalia areas and the onset of separation of Western and Eastern Gondwana.

Figure 7 presents an example of supporting data attached to palaeogeographic set of maps for the Moesian platform. It shows the complex and multistage development of the Balkan rift zone and its inversion in Cretaceous time. The Balkan rift is an aborted branch of the Meliata back-arc basin, which separated the Rhodope (Strandzha) block from Moesia in the Middle Triassic. Inversion of

Figure 5 A—General palaeogeographic map for North Africa for the Late Permian (orthographic projection 15N/20E centered); B—Early Ladinian map of the Levant-Egyptian region. 1, Deep basin; 2, carbonate platform; 3, mixed platform (carbonate and siliciclastic facies); 4, fluvial-lacustrine environment; 5, exposed land; 6, volcanics; 7, depocenter; 8, uplifted arch; 9, active normal fault; 10, fault; 11, alkaline anorogenic complex; 12, present-day Precambrian basement-sedimentary cover limit; 13, political boundary.

Figure 6 Palaeogeographic map for the Arabian peninsula for Late Jurassic times.

Figure 7 Main tectono-stratigraphic units of the Balkan domain.

this rift started during the Late Jurassic due to the closure of the Meliata ocean and the collision of the oceanic Vardar plate with Moesia. The subsequent northward subduction of the Vardar ocean created the Late Cretaceous Srednogrie volcanic arc, extending eastward to the Black-Sea, regarded as a back arc basin due to the northward subduction of the Izmir-Ankara-Vardar oceanic slab. Closure of the Vardar ocean occurred in Paleogene times and a new phase of inversion created the final structure of the Balkan chain.

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Hutchison 'Young Scientist' Fund

William Watt Hutchison, "Hutch" to his many friends around the world, was a Scots-born Canadian geologist who served Canada and the IUGS in myriad dynamic and creative ways. Most notably, he served as the IUGS Secretary General (1976–1980) at a pivotal time in its history, and as IUGS President (1984–1987). The same boundless energy, enthusiasm, skill in communications, and ability to foster teamwork that characterized his work with the IUGS also carried him to preeminent scientific administrative positions in the Canadian Government, where he served as Director General of the Geological Survey of Canada and as Assistant Deputy Minister of Earth Sciences. His distinguished career was terminated in 1987 by his untimely death at the age of 52, following a painful struggle with cancer.

One of Hutch's last wishes was to establish under IUGS auspices a memorial foundation intended to promote the professional growth of deserving, meritorious young scientists from around the world by supporting their participation in important IUGS-sponsored conferences. The first 3 beneficiaries of the Hutchinson "Young Scientist Foundation" attended the 28th International Geological Congress (IGC) in Washington, D.C., in 1989. However, income earned as interest on the Hutchison fund is insufficient to sustain comparable grants every four years without seriously eroding the principal. For that reason, the IUGS made no grants from the fund for the 29th and the 30th IGCs, preferring instead to strengthen the fund by allowing it to earn interest for a longer period of time and by appealing for donations from the international geologic community. And in 2000, 6 awardees received financial support from the Fund to attend the 31st IGC in Rio de Janeiro, Brazil.

The Hutchison "Young Scientist Foundation" is a worthy cause that honors a fine, caring man and a distinguished, public-spirited scientist and administrator. The foundation also celebrates and promotes those things that gave Hutch the most professional satisfaction: geology, international scientific collaboration, and stimulating young minds.

The IUGS welcomes contributions to the Hutchison "Young Scientist Foundation." Please send donations to:

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