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Tectonics, sedimentation and volcanism in the East African Rift System: introduction

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This special issue of the Journal of African Earth Sciences is the second publication of the IGCP400 project "Geodynamics of Continental Rifting", the first being the proceedings of the Dublin meeting (Jacobs *et al.*, 1997). This issue presents new results mainly from geological investigations concentrated in the western branch of the East African Rift System and conducted in the framework of different research projects on the East African Rift. An additional paper is related to the seismicity of the southern part of the Kenya Rift.

IGCP400 PROJECT "GEODYNAMICS OF CONTINENTAL RIFTING"

Rationale

The presence of active intracontinental rift systems with deep water basins, such as those of East Africa and Baikal, gives rise to several problems regarding the mechanism of basin formation in plate interiors. For example, one of the most important results of the ILP World Stress Map project is that the interior of continental lithospheric plates are under compression (Zoback, 1992). Central Asia is under compression resulting from the India-Eurasia convergence and collision; and Africa is surrounded by mid-oceanic spreading ridges and a continental collision to the north. A fundamental question therefore is how do such deep extensional rift basins develop in a compressional environment? To address this problem, it is necessary to investigate not only the rift basins themselves, but also their lithospheric structure and their general intraplate tectonic setting.

The aim of IGCP400 (1996-2000) "Geodynamics of Continental Rifting" is to understand the causes and effects of continental rifting by making comparisons of the deep structure and the geophysical, tectonic, kinematic and magmatic processes responsible for the initiation and development of intracontinental rifts, particularly the Afro-Arabian, East African, Baikal, Rio Grande and European Cenozoic Rift Systems. For a better understanding of the evolution of rifting processes with time, the project also includes the North Sea Rift and rifted passive margins.

Present-day knowledge of rifts is uneven and it is necessary to promote further investigation where information is lacking, and also to develop new ideas and methodologies to address crucial rift problems. Models of origin resulting from the comparative studies can be tested using data from geodesy, tectonics and seismology for kinematics; gravimetry, seismic tomography, and heat flow for rheology; and gravimetry and fission tracks for the thermomechanical behaviour of the lithosphere. The project also addresses related topics including environmental issues, natural hazards, palaeoclimatic and palaoenvironmental changes, and lacustrine environmental protection. It also promotes multinational north-south and east-west scientific and technological cooperation.

Recent activities

The IGCP400 project officially started in July 1996. Three business meetings were organised during the first six months to disseminate information on the new project, to recruit members and to assemble a pool of specialists. Business meetings were held during the 21th EGS General Assembly in The Hague, The Netherlands (6-10 May 1996), during the scientific meeting of the INTAS-93-134 project "Continental rift tectonics and sedimentary basin evolution", in Novosibirsk, Russia (22-24 May

1996) and during the 30th International Geological Congress in Bejing, China (4-14 August, 1996). A total of 60 scientists from 17 different countries attended to these three different meetings. As the major activity for 1996, IGCP supported the participation of delegates to the third annual meeting and field trip of IGCP 369 project "Comparative Evolution of PeriTethyan Rift Basins" in Cairo.

The scope of IGCP400 is now global and multidisciplinary and covers many more rifts than Africa and Baikal, as in the original proposal. Although there are many active rift researchers, most work in a single discipline and few have seen more than one rift. The pooling of knowledge and expertise requires regular multidisciplinary workshops and field meetings in different rifts. The first annual meeting of IGCP400 was held in Dublin (Ireland), 20-23 March, 1997: Lithospheric Structure, Evolution and Sedimentation in Continental Rifts. This launched the project by assembling a representative set of experts on the East African, Afro-Arabian, Baikal, European and Rio Grande Rift Systems, and on rifted passive margins. It allowed the exchange of information and ideas on the state of knowledge of each of the rifts in geophysics, geology, tectonics, sedimentation and neotectonics, to identify research priorities for the future. About 60 people attended the meeting from 17 different countries. The proceedings of this meeting are available as a Bulletin of the Dublin Institute for Advanced Sciences, including extended abstracts, synthesis and recommendations for each rift systems (Jacobs *et al.*, 1997).

TECTONICS, SEDIMENTATION AND VOLCANISM IN THE EAST AFRICAN RIFT SYSTEM

Rift basin evolution and tectonic stages in the Western Rift Branch

The Tanganyika-Rukwa-Malawi segment of the East African Rift System has been submitted to repeated tectonic reactivations since the Proterozoic (Theunissen *et al.*, 1996). These reactivations controlled the development of several stages of sedimentary basin formation (**Klerkx *et al.***, 1998). The timing of the Mesozoic and Cenozoic events have been constrained using apatite fission track thermochronology (**van der Beek *et al.***, 1998). This allowed the identification of several stages of rapid cooling and denudation of the Malawi and Rukwa Rift flanks. These can be related to changes in the plate tectonic setting of Africa and modifications in the kinematics of the surrounding oceanic plates. The discovery and identification of a fossil wood sample in the Red Sandstone Formation of the Songwe-Kiwira coal field in the north Malawi Rift (**Damblon *et al.***, 1998) has important stratigraphic and tectonic implications. It was identified as *Pahudioxylon* (Chowdhury *et al.*, 1960), which has so far been strictly restricted to the Cenozoic. This supports a Cenozoic (Miocene) age for the Red Sandstone Formation rather than a Mesozoic age. It also suggests the existence of an Early Tertiary phase of rifting in the North Malawi-Rukwa Rift, coeval to a cooling stage evidenced by fission track data (**van der Beek *et al.***, 1998).

The structural framework and Late Quaternary tectonic activity of the Rukwa Rift Basin is examined in **Delvaux *et al.*** (1998). More detailed results on palaeoseismic activity along the Kanda Fault System have been published elsewhere (Vittori *et al.*, 1997). Also, the investigation and dating of palaeolacustrine terraces and delta fans around the Rukwa Basin reveal lake level fluctuations up to 200 m above the present-day lake level (**Delvaux *et al.***, 1998). The lake highstand occurred in the Early Holocene and was controlled by the altitude of the watershed between the Rukwa and Tanganyika hydrological systems. At that time, the excess water from Lake Rukwa was flowing into Lake Tanganyika.

Volcanism and rifting in the Western Rift Branch

The investigation of volcanism in a rift setting gives valuable information on the evolution of rifting. In particular, the dating of the lavas helps to calibrate the stratigraphy of rift sediments (**Yamba and Boven**, 1998). Volcanic activity is controlled by tectonic activity (**Kampunzu *et al.***, 1998; **Boven *et al.***, 1998), and the investigation of volcanic rocks may also provide information on the deeper processes (**Boven *et al.***, 1998). New K-Ar geochronological data for the Virunga, Bukavu and Mwenga-Kamituva Volcanic Provinces are used by **Kampunzu *et al.*** (1998) to infer the space-time evolution of volcanism and tectonic activity in the Western Rift Branch. In particular, they support and develop the idea of along-axis propagation of lithospheric extension proposed by Ebinger (1989).

The precise K-Ar and Ar-Ar dating of the Toro-Ankole volcanics in the northern sector of the Western Rift Valley suggests that these volcanics have been erupted prior to 50 ka (**Boven *et al.***, 1998). Comparison with the Virunga and Kivu volcanic fields suggests a Late Quaternary volcanic pulse, coeval to plate-scale crustal stress field changes inferred by Delvaux (1993) and Bosworth and Strecker (1997). Specificities of the Toro-Ankole volcanism are discussed in relation to reworked lithosphere at the margin of the Tanzanian Craton and as potential diamontiferous rocks.

Seismicity and rifting

An important addition to understanding the seismicity of the Kenya Rift is provided by **Hollnack and Stangl** (1998) from a temporary network at the southern end of the rift. Most of the high magnitude ($M_L \geq 3$) events recorded came from the Tanzanian extension of the Rift Valley and in the Nyanzan Rift System. The seismic activity suggests that the Nyanza Rift continues to the southwest, through Lake Victoria. Activity around Mount Kilimanjaro was low at this time. The work helps to fill the gap between studies relating to the North Malawi-Rukwa Rift segment in southwestern Tanzania from the Mbeya Seismic Network (Camelbeek and Iranga, 1996; Tongue *et al.*, 1992) for central and northern Kenya. The work of **Hollnack and Stangl** (1998) gives another detailed outlook of the seismicity in the East African Rift.

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