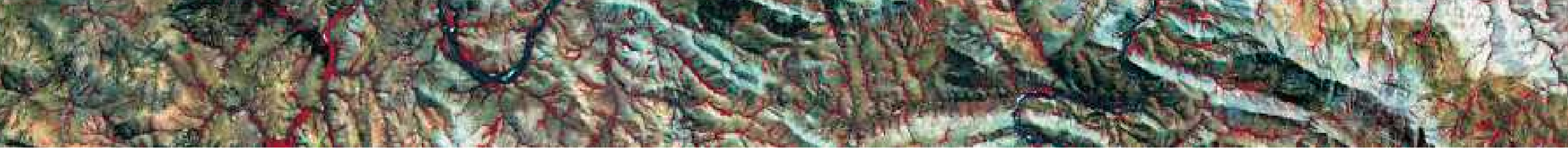


Our work to date has shown that previous models for Gondwana assembly are invalid, but also that data collected so far are insufficient to propose a new model. This project will fill the most prominent gaps in our knowledge of Gondwana assembly, and develop an all-embracing model for the Proterozoic evolution of the southern continents. Such a model is a pre-requisite for any reconstruction of Rodinia, since the continental blocks that assembled to form Gondwana are the fragments produced by Rodinia breakup. Our work will constrain the size, shape and geological character of the Neoproterozoic pieces from which we must reconstruct the Rodinia puzzle, and thus clearly lies at the core of the TSRC's goals.

Project 2.4.1: The Irumide Belt of Zambia

Project Co-ordinator: Ian Fitzsimons

Aims:

The Mesoproterozoic Irumide Belt (area 1, Fig. 1) occupies a central position in an intersecting network of orogenic belts that characterizes south-central Africa, and it provides a unique opportunity to study the tectonic history of the "African" margin of the Mozambique Ocean prior to its closure during the Neoproterozoic East African Orogeny. The belt trends northeast-southwest and comprises granites and metasedimentary rocks. It is truncated to the northeast by the reactivated Palaeoproterozoic Ubendian Belt, and to the southwest by the Neoproterozoic Lufilian Arc and Zambezi Belt terranes, whilst to the northwest the granite, metavolcanic rock and undeformed sedimentary units of the Bangweulu Block are assumed to represent a foreland to the orogen. To the east it is progressively overprinted by the Mozambique Belt. The Irumide Belt has previously been correlated with other Mesoproterozoic metamorphic belts of central Africa on the basis of equivocal and imprecise isotopic age data, and these correlations have been used to argue that much of the Proterozoic tectonism in Africa is intracratonic in nature.

The aim of this project is to determine the tectonic setting, internal structure, and tectonothermal evolution of the Irumide Belt and surrounding terranes, and use these data to develop new models for the tectonic architecture of south-central Africa.

Progress:

Bert De Waele is now in the final year of his PhD project, and has completed all the U-Pb zircon SHRIMP and whole-rock geochemical analyses of samples collected from three field seasons in the Irumide belt (2000, 2001 and 2002). In addition, 19 samples have been analysed for Sm–Nd isotopic composition.

1050–980 Ma SHRIMP zircon crystallization ages for syn-tectonic granite plutons coupled with c. 1015 Ma metamorphic overgrowths on zircon grains from migmatites have provided the first precise age constraints on the age of Irumide tectonism. These data indicate that the Irumide Orogeny occurred at 1050–980 Ma, which is significantly younger than previous estimates of 1400–1100 Ma based upon Rb-Sr techniques. These results have important implications for the regional geology, since they indicate that previous correlations across the Zambezi Belt between the Irumide Belt and the 1350 Ma Choma-Kalomo Block are invalid. These correlations have been used to argue that the Zambezi Belt was intracratonic, but the new SHRIMP data imply that the Zambezi Belt is a Neoproterozoic suture that juxtaposes two unrelated continental blocks.

Large-scale isoclinal fold in quartzite of the Kanona Group at Kundalila Falls, Irumide belt, Zambia [Photo: B. De Waele]

SHRIMP analysis has also been used to determine the age of pre-Irumide protoliths within the orogen and the basement of the adjacent Bangweulu foreland. Zircon cores in the Irumide migmatite yield protolith ages of 2000 Ma, which correspond to U-Pb zircon ages for the Mkushi Gneiss basement to the Irumide Belt in central Zambia. The undeformed Luwalizi granite at the northwestern limit of the Irumide Belt has a SHRIMP U-Pb zircon crystallization age of c. 1940 Ma. Granitoids and metavolcanic rocks of the Bangweulu Block, northwest of the Irumide Belt, yielded U–Pb zircon ages of 1870–1860 Ma, confirming earlier estimates based on Rb–Sr whole-rock dating. These results confirm that the basement to the Irumide Belt and the adjacent Bangweulu Block is dominated by Palaeoproterozoic granite with an identical age range to basement in the Ubendian and Usagaran belts of Tanzania. However, our study has also identified previously unrecognized 2730 Ma and 1670–1640 Ma granitic basement terranes within the Irumide Belt. The former age represents the oldest protolith yet identified in Zambia, and is interpreted as an old segment of the cratonic foreland, whilst the younger ages probably reflect a period of late Palaeoproterozoic magmatism within the foreland prior to the Irumide Orogeny. Abundant 2700 and 2000 Ma xenocrysts in younger granitoids and aplites suggest that Neoarchaean and Palaeoproterozoic basement underlies much of the Irumide Belt.

Bangweulu Block granites and volcanic rocks have remarkably consistent whole-rock geochemistry, and eNd(T) values ranging from –3.6 to –2.9 with TDM crustal residence ages of 2.3 to 2.2 Ga. Two samples of 2000 Ma protolith within the Irumide belt yielded eNd (T) of –6.4 and –5.2 with TDM crustal residence ages of 2.5 Ga, whilst two samples of the 1600 Ma protoliths had eNd (T) values of –12.0 and –5.0 with TDM ages of 3.1 and 2.4 Ga. Volcanic rocks in the Irumide belt have strongly negative eNd (T) values of –14.8 to –2.0 and TDM crustal residence ages of 3.1 to 2.5 Ga, and two samples of the 1000 Ma Irumide granitoid suite yielded eNd (T) of –19.4 and –14.5 with TDM ages of 2.9 and 2.8 Ga. These data confirm that the basement immediately beneath and reworked within the Irumide Belt includes components that are older than those exposed to the northwest in the Bangweulu Block.

SHRIMP work has also been undertaken on the Muva Supergroup, a quartzite-pelite dominated passive margin sedimentary sequence that comprises the undeformed Mporokoso Group lying on the Bangweulu Block foreland, the deformed Manshya River Group within the Irumide belt, and the Kasama Formation that lies between the two. Two samples of rhyolitic tuff from the Manshya River Group yielded SHRIMP U–Pb zircon ages of c. 1880 and 1860 Ma, indicating that sedimentation was contemporaneous with the closing stages of magmatism in the underlying Bangweulu basement. Detrital zircon in both the Mporokoso and Mansyha River groups is dominated by 2100–1800 Ma age populations, consistent with the two sequences being stratigraphic equivalents. Quartzite from the Kasama Formation is dominated by detritus of a similar age, but a single zircon grain aged c. 1440 Ma implies that it is a much younger unit. This confirms previous interpretations based on sedimentological characteristics that the Kasama Formation was derived by reworking of the Mporokoso Group. Our data show that all of these sedimentary units were locally derived by erosion of Bangweulu Block protoliths, and indicate that much of the present exposure of the Irumide Belt represents the reworked margin of the Congo Craton. Rare detrital grains as old as 2800 Ma provide further evidence of Neoarchaean basement in the Irumide foreland.

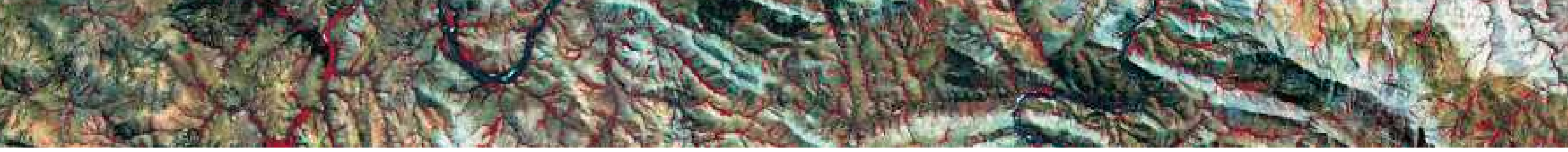
Huntly Cutten is in the final stages of finishing his PhD thesis on the regional geology and Neoproterozoic assembly of the Mozambique Belt.

Aims for 2004:

All field and most analytical components of this project are now complete, and work during 2004 will focus on data synthesis and interpretation as De Waele and Cutten finish their PhD theses.

De Waele and Cutten will also both be working on a collaborative project with Luc Tack to extend the SHRIMP geochronology into the Kibaran Belt of central Africa to be funded from non-TSRC sources.

Outcomes: The first SHRIMP data on the age of Irumide tectonism and their implications for the assembly of southern Africa were published in GEOLOGY in 2003 (TSRC Publl.



#218). A paper on the U-Pb geochronology and metamorphic history of late Archaean gneisses in the Mozambique belt of Tanzania was published in Tectonophysics (TSRC Publ. #214). Another review paper on the Irumide Belt has been submitted to an IGCP 418 special volume on the Mesoproterozoic of southern Africa, and a paper summarizing the U-Pb SHRIMP ages for the Bangweulu basement, and lavas and detrital zircon populations in the Muva Supergroup, has been submitted to Precambrian Research. Other papers are in various stages of preparation. Two papers were presented at the IGCP 440 field meeting in China, October 2003.

Participants: Mr B. De Waele (PhD student), Mr. H. Cutten (PhD student), Drs I. Fitzsimons, A. Nemchin, M. Wingate (TSRC), Professor T. Rivers (University of Newfoundland, Canada), Drs A. Kampunzu (University of Botswana), B. Mapani (University of Zimbabwe), F. Tembo (University of Zambia).

Project 2.4.2: Tectonic Profile through Madagascar

Project Co-ordinators: Ian Fitzsimons and Alan Collins

Aims:

Madagascar has a critical position in Gondwana reconstructions, lying between the cratons in central Africa and India that collided to form the East African Orogen as the intervening Mozambique Ocean closed during the Late Neoproterozoic. The East African Orogen represents the culmination of the transformation from Rodinia to Gondwana, but it remains relatively poorly understood with little consensus on the time of collision or the precise location of the suture that separates crust of essentially African origin from that of Indian origin. Madagascar provides the best-preserved section through the eastern margin of this broad orogenic zone, and as such represents a key area for understanding the evolution of the orogen as a whole.

This project aims to identify and characterize the major lithotectonic units present along an east-west profile through the Neoproterozoic basement rocks of Madagascar, constrain their age of amalgamation, and thereby develop a comprehensive model for the evolution of the East African Orogen.

Progress:

Much of the work on this project was completed during the first two triennia of the Centre (as Project 2.2.2), and the focus during 2003 has been to synthesize and publish our results, and to identify and fill any gaps in this data set.

Bregje Hulscher has continued her PhD studies on the tectonic history of the metasedimentary Itremo Group of central Madagascar and the adjacent granitic basement of the Antananarivo Block (area 2a in Fig. 1, pg. 44). She has completed her SHRIMP and $^{40}Ar/^{39}Ar$ geochronological studies, finalized the GIS database of central Madagascar and conducted a targeted geochemistry analytical program on the newly dated SHRIMP and other samples.

Hulscher's detailed studies of field relationships, coupled with zircon and titanite SHRIMP geochronology on structurally constrained samples, indicate that both the Itremo Group and Antananarivo Block underwent deformation, metamorphism and magmatism during two distinct phases (804--756 Ma and 570--510 Ma). Structural studies by Hulscher, and earlier work by Chris Powell and Ian Fitzsimons, indicate that the Itremo Group can be divided into western and eastern portions with quite different deformation styles. The age of granulite-facies deformation in the western Itremo Group has been constrained at 545 Ma by Fitzsimons using SHRIMP U-Pb zircon dating of migmatites from the Amborompotsy Group, which structurally overlies and has identical structures to the western Itremo Group. In contrast it is the earlier 800 Ma event that is largely responsible for deformation in the low grade eastern Itremo Group. Detrital zircon data collected by Hulscher and Fitzsimons indicate that despite their different metamorphic ages, both the eastern and western Itremo Group are part of a single sedimentary sequence, with identical provenance to the Palaeoproterozoic Muva Supergroup of Zambia (project 2.4.1). 770 Ma U-Pb ages for fabric-parallel titanite in highly deformed amphibolites of the Antananarivo Block basement at the southeastern margin of the Itremo Group indicate that, despite nearby late Neoproterozoic weakly deformed granites, regional temperatures at 550 Ma were insufficient to reset the U-Pb titanite system. Thus, we attribute a large part of cover and basement deformation in east-central Madagascar to the 800 Ma tectonic event, whilst granulite-facies deformation and

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