A NEW TECTONIC FRAMEWORK FOR NORTHERN MOZAMBIQUE

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The bedrock geology of Northern Mozambique has been investigated as part of an infrastructure development program funded by the World Bank and other donors. The project has a significant component of technology transfer and training. The work involved reconnaissance geological mapping at 1:250.000 scale over 31 degree square sheets, acquisition of structural, petrographic, mineralogical, geochemical and geochronological data, and a survey of mineral resources. The maps integrate results from new airborne magnetic and radiometric surveys over key areas.

The region can be subdivided into a number of gneissic complexes characterized by distinct lithological, structural, geochronological and geophysical signatures. They are listed hereafter from west to east. The northwestern most Ponta Messuli Complex, along Lake Niassa, exposes a 1.95 Ga Paleoproterozoic basement and is overlain by the Txitonga Group, dominated by low-grade metasediments. The Unango, Marrupa and Nampula Complexes consist mainly of 1.1-1.0 Ga granitoid gneisses, associated with slivers of metasediments. These complexes were affected by Pan-African metamorphism and deformation associated with their juxtaposition and subsequent reworking between 580 and 520 Ma, commonly at granulite facies in the Unango Complex and upper amphibolite facies in the other two. The Unango and Nampula Complexes show fairly widespread Pan-African granitic plutonism and are separated by a complex NE-trending zone of structural discontinuities. The Marrupa and Unango complexes are juxtaposed along NW-verging tectonic contacts, which we interpret as a NW-directed nappe sequence. The Xixano complex includes granulites juxtaposed with various metasedimentary rocks along greenschist- to amphibolite-facies shear zones. It records an early granulite-facies metamorphic event dated at 735 ±4 Ma. The Lalamo and Montepuez Complexes include abundant metasediments and felsic metavolcanic rocks.

In the southern part of the area, the prominent WSW-ENE trending Lurio belt separates the Nampula Complex in the south from the Marrupa and Montepuez Complexes to the north. It is cored by lenses of granulite, which decrease in abundance to the west. Much of the southern margin of the Lurio belt is marked by a characteristically highly sheared leucogneiss. These lithologies have been assigned to the newly established Ocua Complex. Granulite-facies metamorphism and deformation in the Lurio belt is bracketed between 580 and 530 Ma. The Lurio belt does not always correspond to a major lithological break between the Nampula, Marrupa and Montepuez Complexes, and consequently we do not interpret it as representing a Pan-African suture zone.

High-resolution geophysical data, in combination with field structural observations and geochronology, leads to a new, large-scale, comprehensive tectonic framework for the Pan-African orogeny in Northern Mozambique.

We envisage the following possible chronological sequence of events and structures:

1) An early granulite-facies metamorphic event is recorded at 735 ±4 Ma in the Xixano Complex. Preservation of these granulites suggests a phase of NW-SE crustal extension after 735 Ma, responsible for their partial exhumation. Due to the subsequent strong structural reworking, we were able to identify only a limited number of structures associated with this exhumation event.

2) Structures from the western sector of the Lurio belt (Ribaue-Malema area) differ remarkably from those observed in its eastern sector (Montepuez region). In the east, the structure is intense and linear, whereas in the west it becomes wider and less belt-like in character. Nevertheless, throughout the structure, tight to isoclinal folds with NNW-dipping axial planes and roughly down-dip plunging axes are common and are often associated with down-dip stretching lineations. We refer to these features as "Proto-Lurio". No clear kinematic

indicators could be identified, which precludes assigning of these structures to a specific tectonic phase. Nonetheless, the Proto-Lurio event can be envisaged as being responsible for the exhumation of early Pan-African granulites. The youngest of these granulites are reported in the Mugeba Klippe, to the south of the Lurio Belt, and have a published age of ca. 614 ±8 Ma. Therefore, the Proto-Lurio tectonic event probably post-dates 615 Ma.

3) A post-615 Ma top-to-NW directed nappe-stacking episode juxtaposed the tectonic slices of the Ponta Messuli, Txitonga, Unango, Marrupa and Xixano Complexes, listed from west to east with increasing structural level in the nappe stack. Field evidence strongly supports the tectonic origin of the terrain contacts and confirms their NW-directed thrusting kinematics.

4) New high-resolution geophysical data allows the identification of a crustal-scale set of E/ENE-W/WSW trending upright, open to tight folds that can be followed from the Tanzanian border southward, to the southernmost boundary of the high-resolution geophysics dataset coincident with the location of the Lurio belt and even further south within the Nampula Complex. Fold axes plunge moderately to the W/WSW. Field observations confirm the geometry of the folds and their importance. Numerous meso-scale folds are observed throughout the area, often with leucosomes injected parallel to the upright axial planes. The Lurio belt (especially its eastern sector) is part of this geometrical framework, with its mylonitic foliation folded isoclinally around E/ENE-W/WSW trending axes. The belt underwent strong flattening with granulite bodies highly attenuated, segmented and retrogressed in response to the extreme pure-shear strain that affected the whole region. The isoclinal folds that characterize the belt reached a stage of strain hardening, which resulted in the strain being accommodated by crustal-scale sets of conjugate ductile shear zones. These are identifiable from the outcrop to the regional scale, based on geophysical data. The eastern sector of the Lurio belt, where the overall structural grain swings to an E-W orientation, reflects indeed the local, strong control of such an E-W-trending ductile shear zone. Strain-accommodation within the Lurio belt (via isoclinal folding and conjugate shear zones) is more intense than in the surrounding blocks (open to tight folding and conjugate shear zones) because of the existence of the Proto-Lurio structure that acted as a zone of mechanical weakness, leading to preferential strain accommodation. Nonetheless, evidence of the S/SSE-N/NNW directed regional compression is found throughout the region, leading not only to the above-mentioned crustal-scale E/ENE-W/WSW-trending folds, but also to intense structural reworking of pre-existing tectonic features. Clear examples are the attenuation (for example via asymmetric boudinage) and shear reworking, both sinistral and dextral, of pre-existing tectonic contacts (e.g. Xixano-Marrupa) along fold limbs in response to flexural flow folding mechanism and development of widespread strike-slip imbricate structures to the N of the belt. Geochronological results constrain the age of the regional compression to between 580 and 530 Ma.

5) 530 Ma monazite ages from mylonitic fabrics associated with top-to-NW extensional structures constrain a renewed phase of crustal extension co-axial with the prior compressional event. Field evidence of extensional structures deflecting and cutting through folds of the previous compressional event were found within the eastern sector of the Lurio Belt as well as to the north, at least as far as the Tanzanian border.

6) Pan-African granite intrusions are widespread and follow specific structural trends. Ring complexes and alkali granite intrusives within the Lurio belt have been assigned to the Malema Suite. The emplacement of such magmatic complexes was most likely facilitated by the crustal thinning starting at 530 Ma.

7) NE-SW-trending sinistral shear zones to the NW of the Lurio belt record late Pan-African ages ranging from 480-445 Ma. We interpret these to be lateral ramps defining the western margins to the displaced blocks that accommodated the overall crustal thinning.

In summary, we believe the present-day structural architecture of northern Mozambique to record a long-lived deformation history during which phases of compression have alternated with phases of extension and crustal thinning along a coaxial NW-SE trend. In this perspective, the Lurio belt is interpreted as a belt of repeated tectonic activity and structural reworking, whereby the latest strain increment reflects pure shear bulk flattening of the belt and localized extension, lacking significant amounts of regional, belt-parallel simple shear.