Mapping shear zones geometry across Eastern Africa.

Martelat Jean-Emmanuel (Univ. Grenoble); Randrianasolo Brice (Univ. Grenoble); Lardeaux Jean-Marc (Univ. Nice); Nicollet Christian (Univ. Clermont-Ferrand); Schulmann Karel (Univ. Strasbourg); Cardon Hervé (ENS Lyon); Delacourt Christophe (UCBL & ENS Lyon); Pili Eric (CEA. Paris); Rakontondrazafy Raymond (Univ. Tananarivo); Vidal Gérard (ENS Lyon).

Kilometer scale vertical shear zone networks are visible today at the Earth surface in recent orogens (India - Asia, Leloup et al., 1995) as well as in Precambrian shields where they are equilibrated in granulite facies metamorphism (800°C 0.8-1.2 GPa, late Archean Striding-Athabasca shear zone, Hanmer, 2000; Neoproterozoic Madagascan shear zones, Martelat et al., 2000). In Madagascar and Kenya exist one of the best example of very large transpressive lithospheric shear zone system: many shear zones of 100 km long by 3-20 km wide anastomosing in space. The best exposed may be the Ampanihy ductile shear zone where rigid anorthositic massifs behave as rigid garnets in a micaschist (plate 1 and 3 in de Wit et al., 2001; figs. 3 and 4 in Martelat et al., 1997). New survey in Madagascar is an opportunity to collect new data within a well constrained geometry. Progress in technology, free and easier access to large amount of data set combined with G.I.S. techniques allow easy comparison between precise tectonic framework and various other data: lithologies, ages, metamorphism, mineral microstructures, specific mineralization, geochemistry, regional other kilometric shear zones in India or Kenya... Moreover geophysical data provide indirect information on shear zone extension to depth. This presentation will show different example that integrate these types of data.

Following the previous work of Christian Nicollet in Madagascar (1988) and Gérard Vidal (1986) in Kenya using satellite imaging (LANDSAT, SPOT, ASTER, Fig. 1A) combined with topographic models (Fig. 1B) we mapped 3D geometry of linear anomalies such as brittle faults, lithological boundaries, and metamorphic foliation trends. Note that the two kinds of structures, brittle and ductile, interact (fig. 4 in Martelat et al., 2000, fig. 20 Chapt. I in Martelat, 1998). These approaches give us a regional pattern of lineaments. The second step is to examine their organisation and evolution in space (Fig. 1C) and to verify it on the field.

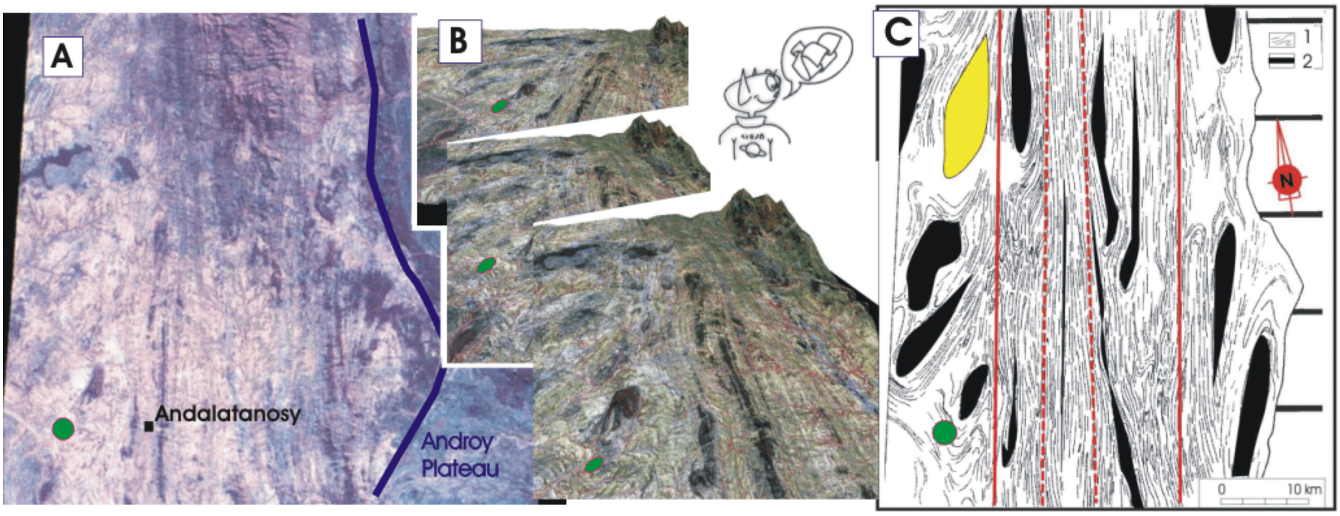

Fig. 1A. XS - Spot images. B. Satellite images projected on topography. C. Simplified interpretation. Images correspond to the south of Madagascar (northern limit of Antanimora village). On each image green circles correspond to the same place.

Yet what is a cartographic ductile shear zone? Tilted monoclinal block could produce regular linear features misinterpreted as shear zone. Ductile shear zones correspond to domains where strain is concentrated with respect to their surrounding that must be mapped as a surface and not only as a line, even at lithospheric scale. At regional scale we use the evolution in space of elliptic geometry of kilometric fold interferences and diapirs (Fig. 1C) to emphasize strain evolution and refine geometry of ductile shear zone. We also compare regional scale geometry with macro to microstructures in the field: the finite strain pattern. However structures are very large (up to 100 km * 3-20km) and in field it is difficult to map continuously such large are. Another less evident difficulty arises from the pervasive granulitic context in these Precambrian outcrops. Under high temperature, with large amount of fluid and melt, strain mechanisms are associated with “mass transfer” giving high strain rocks without mylonitic texture (large grain size up to 1 mm). The latter is classical in supracrustal levels where strain mechanisms are associated with "dilsocation creep " (subgrain rotation and grain size diminution way to fine grain, 10 microns in size, Hanmer, 2000, Martelat et al., 1999). Therefore, a macro to micro - scale study of mineral shape must also complete satellite imaging. At microscopic scale our studies of deformation mechanism constrain rheology of the crust. At regional scale we evidenced a complex network of transpressive ductile shear zones developed by general Est-West flattening in eastern Africa. In Madagascar geometry is relatively homogeneous despite the complex geological evolution (the last D2 finite strain pattern in fig. 13 of Martelat et al., 2000, plate 1 and fig 3D in de Wit et al., 2001, figs. 7 and 9 Chapt. III in Fernandez, 2003, figs. 2 and 3, 12 in Goncalves et al., 2003, fig. 8 in Nédélec et al., 2000).

A shear zone may be lithospheric, that means rooted in the mantle. Such lithospheric shear zones have been documented by gravimetric and seismic data (Poudjom Djomani et al., 1996; Teyssier and Tikoff, 1998). Recent works suggest the existence of shear zones associated with mantle anisotropy (Heintz et al., 2003). Geochemical and gravimetric data from Magadascar and Kenya suggest that these shear zones are of lithospheric character (Pili, 1997; Pili et al., 1997a; Pili et al., 1997b, Cardon, 1998).

Inherited lithospheric anisotropies may control the break-up of continents. Moreover they could constitute pathway for chanalized fluids or magmas. This last phenomenon is a first-order parameter controlling the thermomechanical evolution of the crust. So Madagascar and Kenya are exciting fields, which allow comprehension on the 3D geometry of the crust with numerous implications (Martelat, 1998): implication for lithospheric control on mineralization (fig. 5 Chapt. II); rheological behaviour (fig. 14 Chapt. III); palaeogeographic reconstruction (fig. 14 Chapt. IV) and thermal budget of the crust. (fig. 17 Chapt. IV).

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Web site

Other informations are avalable on

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Nicollet. C. http://christian.nicollet.free.fr/
Martelat. J.E. http://martelat.free.fr/