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Seismic Activity in Madagascar

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ICTP WORKSHOP On EARS Trieste Italy August 2009

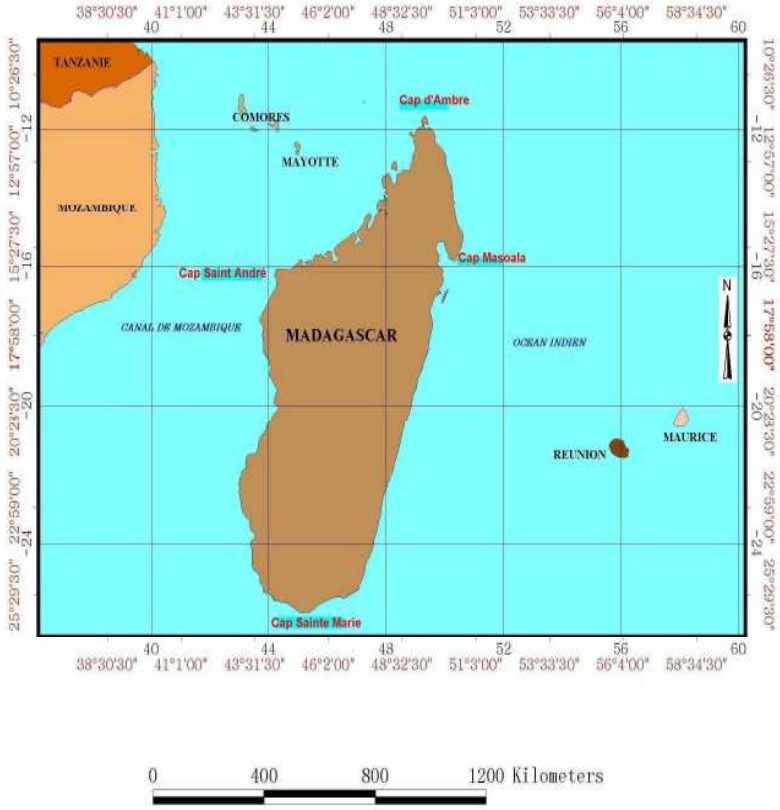
SISMICITY OF MADAGASCAR IN RELATION WITH GEOLOGY AND TECTONIC

Rambolamanana Gerard - Rakotomalala Juliana Mireille

OUTLINE

1. Background
2. Geological and Tectonic Situation Of Madagascar
3. Data Used
4. Method
5. Results And Interpretation

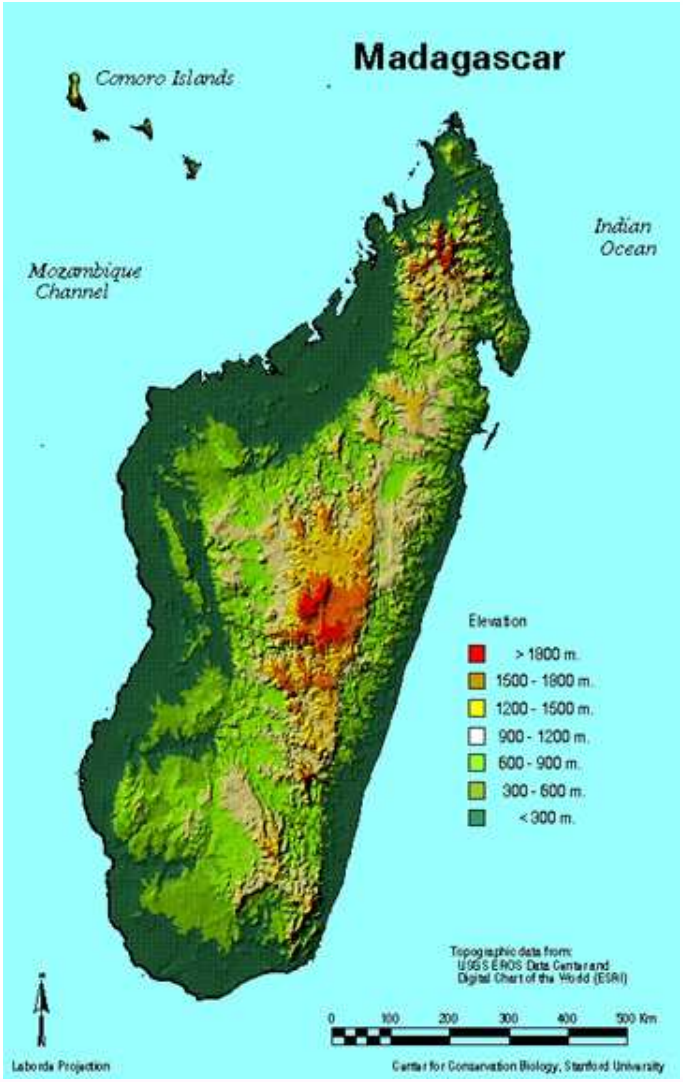
Geographical Situation



-Separated from the great continent Gondwana there is 165 million years, Madagascar arrives at its current position there is 121 million years.
-Madagascar is situated in the southern hemisphere between the latitudes 11,6 ° and 25,3 ° and the longitudes 43,5 ° and 50,3 °. The tropic of Capricorn crosses it in the South.
-It is separated from Africa by the Mozambique Channel off 400 km and Mauritius and Reunion by the Indian Ocean.

Background

Madagascar Landscape



From the Cape Ambre to the Cape Sainte Marie, the length of Madagascar is 1590 km and 620 km from Cape Saint André to Cape Masoala. The total surface is 592000 km ²

The relief of Madagascar divides the country into three bands:

- A narrow coastal band in the East

- High plateau in the centre which contains three main massifs: in the North, the massif of Tsaratanàna who possesses the highest summit of the island (a volcanic peak of 2876 m of height), in the center Ankaratra (2643 m) and in the South Andringitra (2658 m).

- A zone of lower trays and plains on the West

Background

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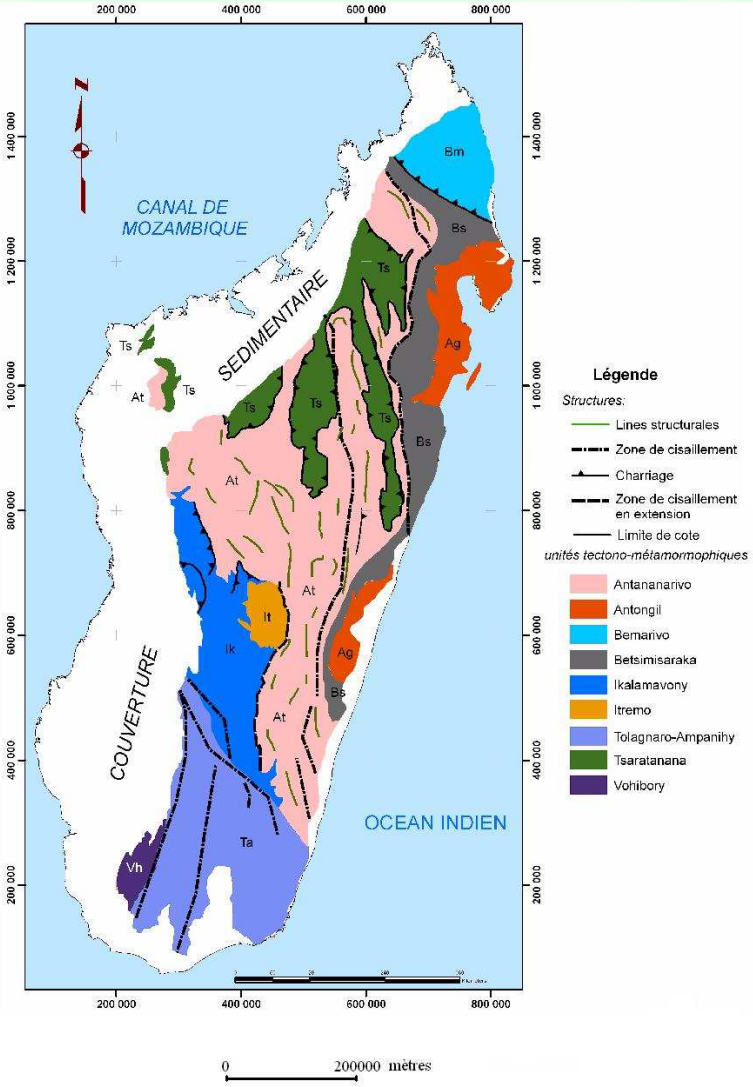
TECTONO-METAMORPHIC MAP (Collins (2002))



Geological structure

The geology of Madagascar is formed by two main groups:

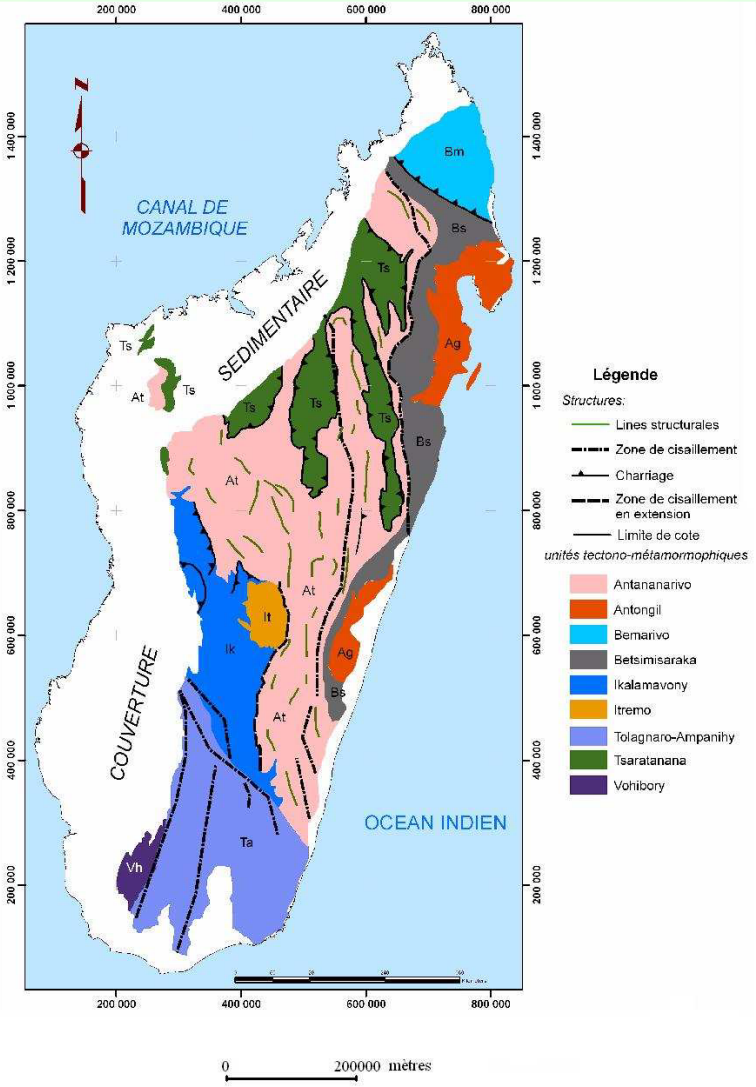
The crystalline basement is dated from the PreCambrian to Devonian. This formation extends in the oriental and central zones which is 2/3 of its surface.

The sedimentary is 1/3 of the island. This formation extends over three major basins such as the Morondava basin, Mahajanga basin and the Antsiranana Basin.

The Morondava basin is the most important and dated from the Carboniferous period superior to the Quaternary whereas both last ones are from the Permian to the Quaternary.

Geological and Tectonic Background

TECTONO-METAMORPHIC MAP (Collins (2002))



Tectonic

Major tectonic events affected the Malagasy PreCambrian basement since Katarchean. We distinguish:

- *The formation of the massifs of Antongil in the Northeast, Ankazobe on the West, Angavo in the Center East, Behara in the South (Katarchean).*
- *Deposits of the graphitic series and calco-ferro-magnesian drawing furrows.*
- *Synclinorial: Andriamena, Alaotra, Manampotsy, Ambatolampy, Maevatanàna as well as deposits migmatitics: Mangoro, Vondrozo, Anjafy, Famoizankova (Archean).*
- *Orogenesis Shamwaian accompanied by metamorphism and with mass wrinkling: Alaotra, Beforona and graphitic series: Manampotsy, Ambatolampy (Archean).*

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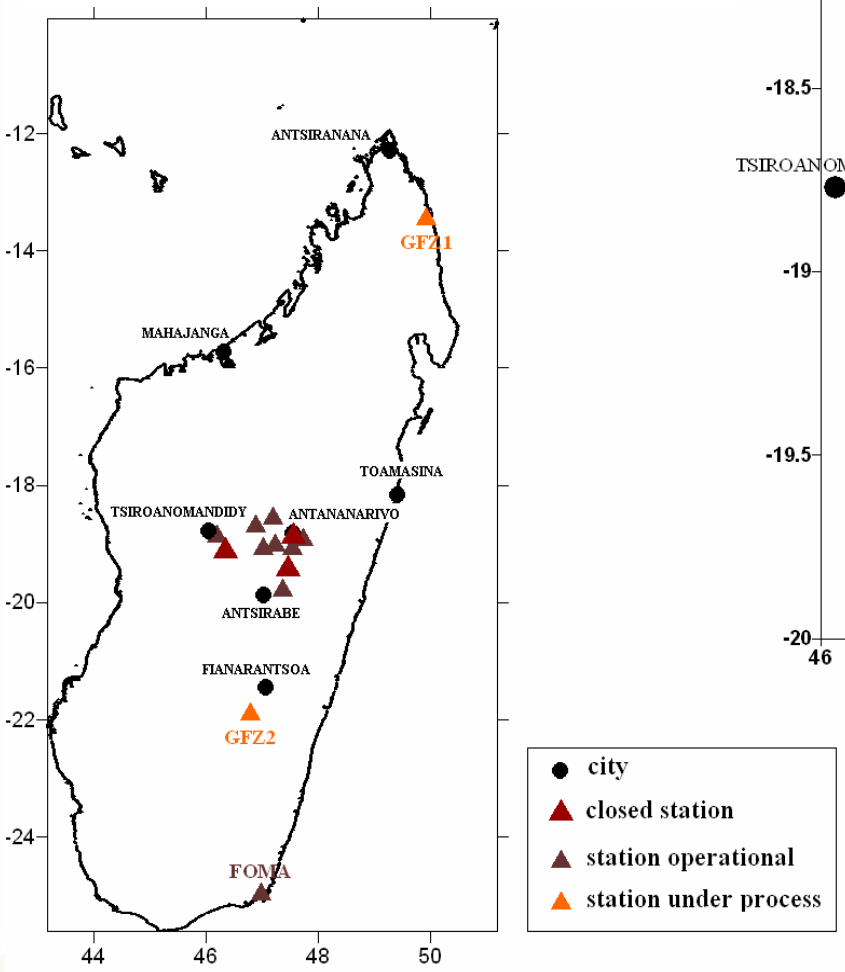
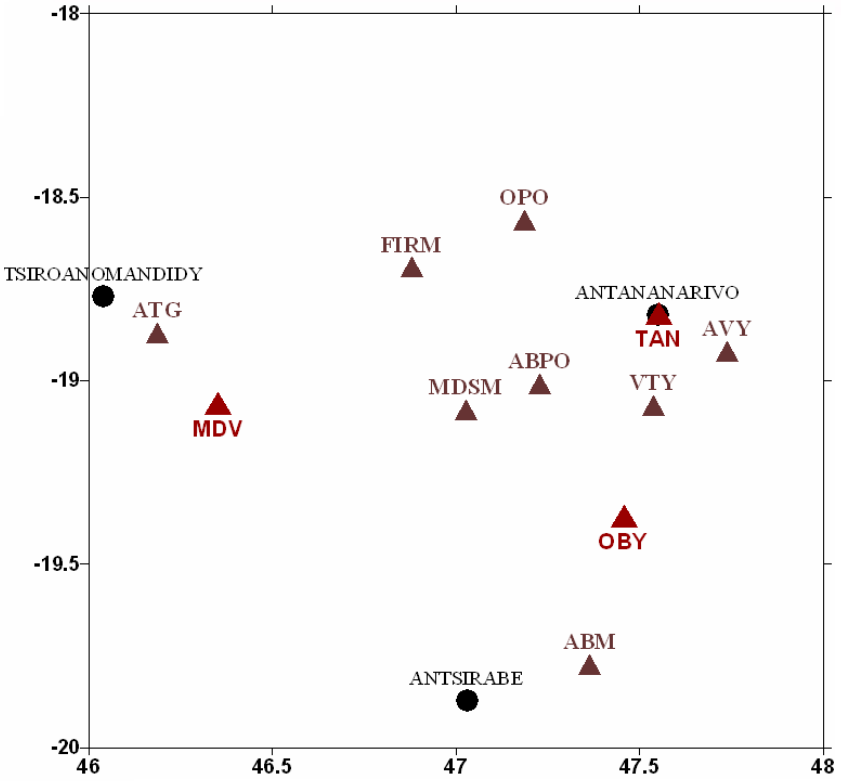
MALAGASY SEISMIC NETWORK

SEISMIC STATION IN MADAGASCAR





Data Used

DATA

- **Local earthquakes: Magnitude ≥1**
- **April 1975 < Date< January 2009**
- **Data : 13492 events**

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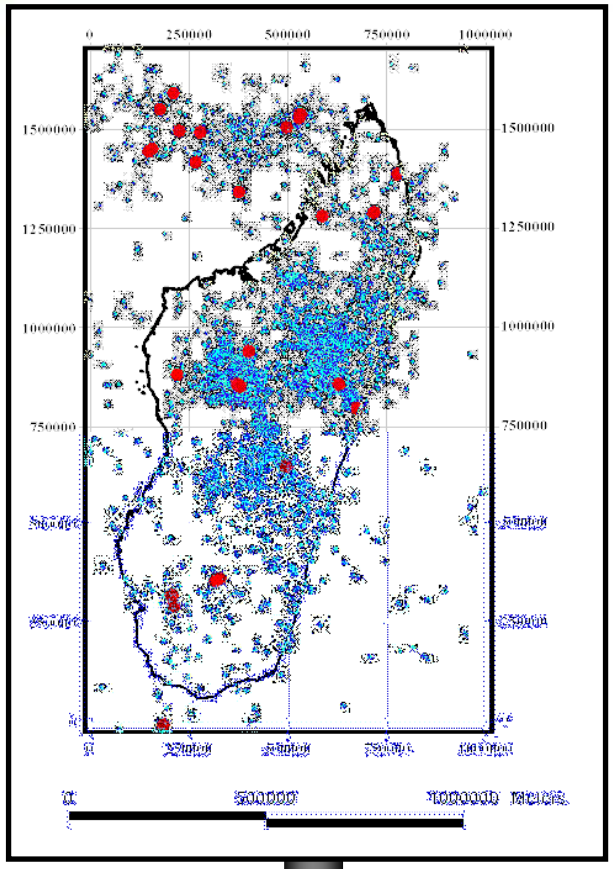
Data Process



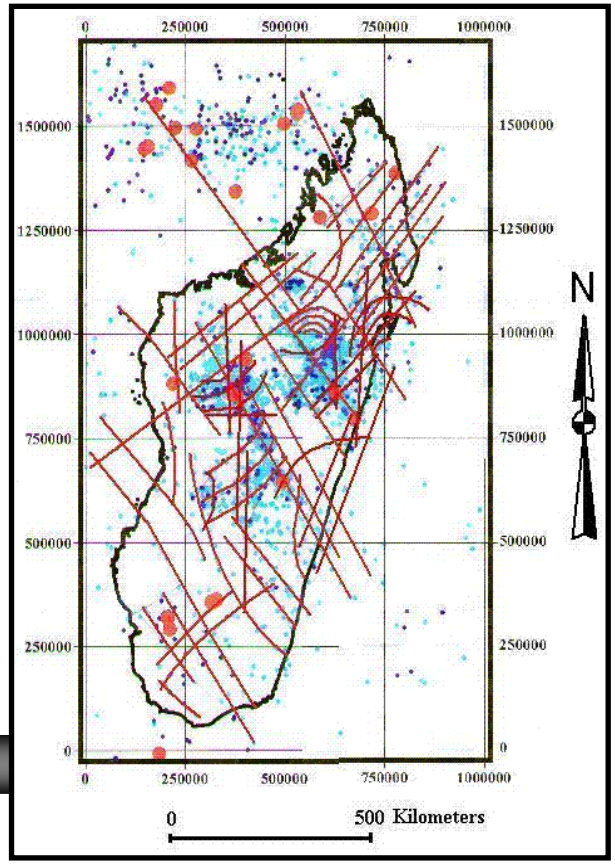
Sismic data

ArcView

Sismicity map

MapInfo

Sismicity lines



Method

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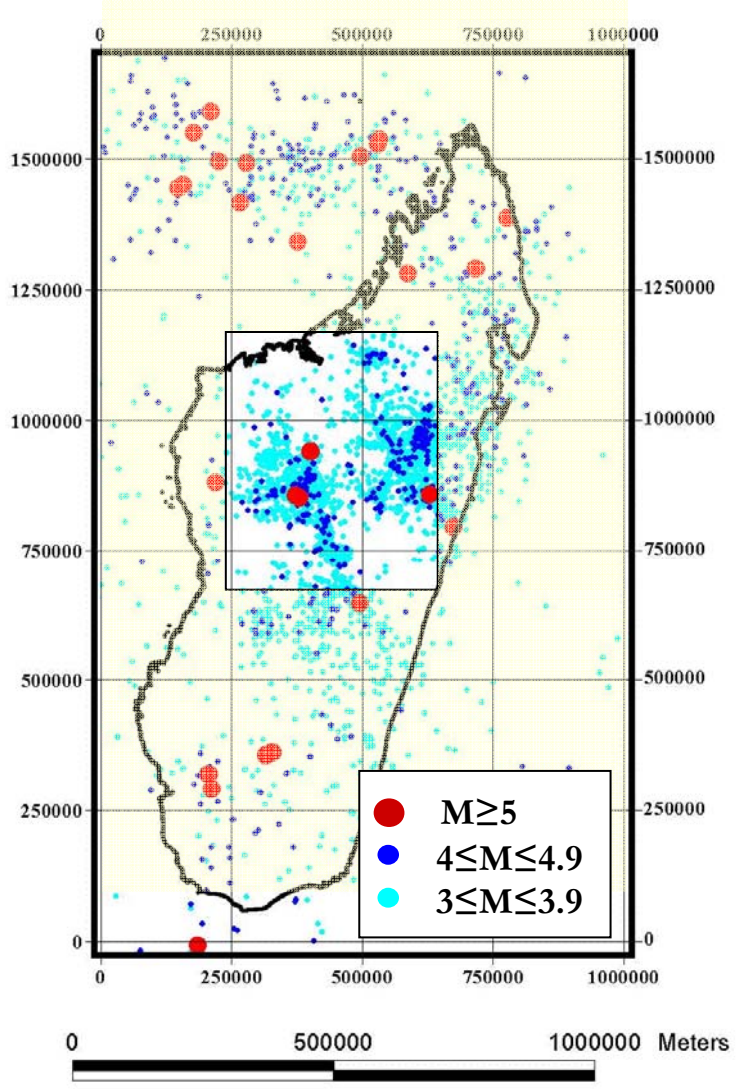
Seismicity of MADAGASCAR



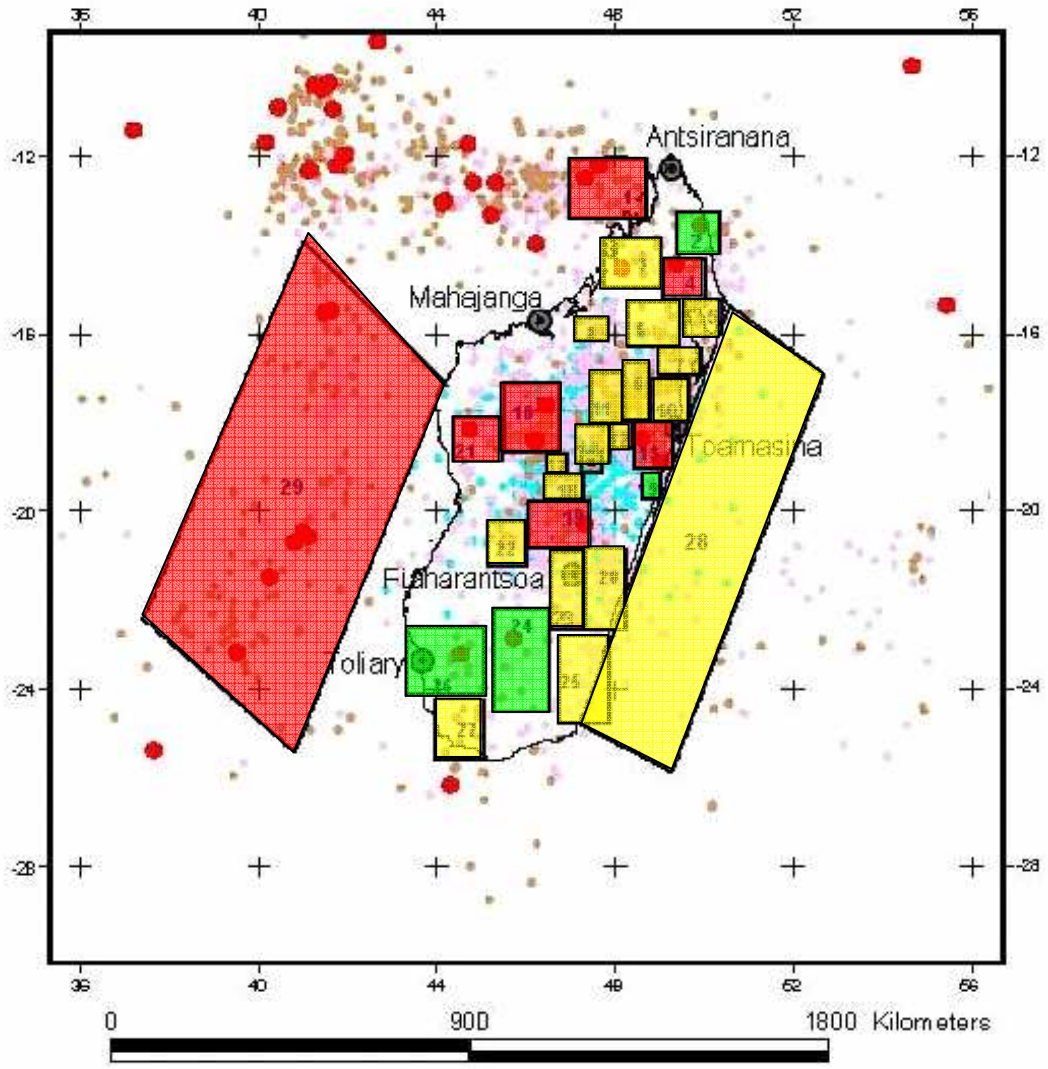
➢Sismic activity everywhere.

➢Epicenters in the central part.

Cause: detectability of the malagasy sismic network.

Results

Seismic Zones



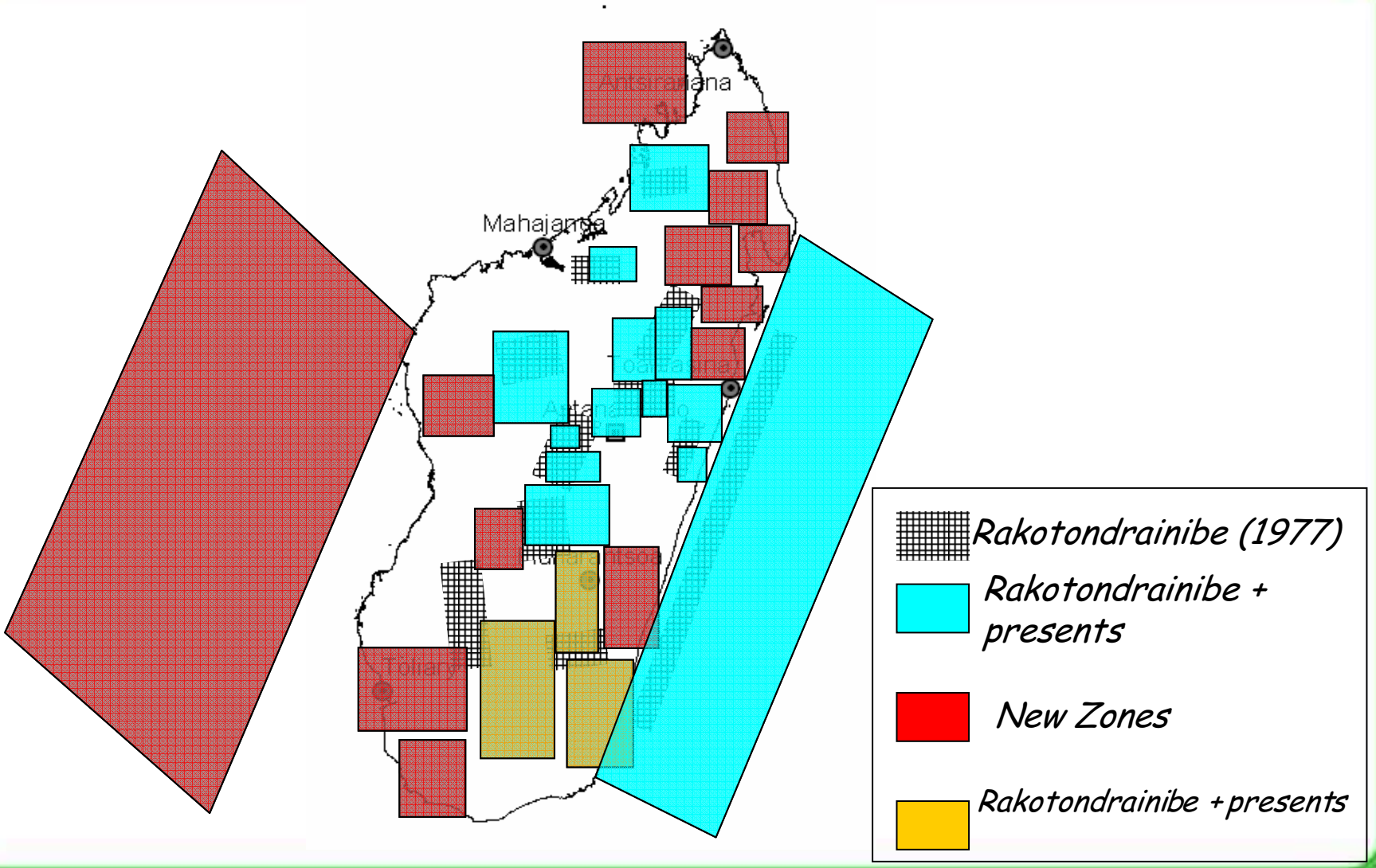
Zones 2,15,24,26: low density, high magnitude

Zones 3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 17, 18, 20, 22, 23, 25,27 et 28: high density, low magnitude

Zones 1, 4, 16, 13, 19, 21 et 29: high density, high magnitude.

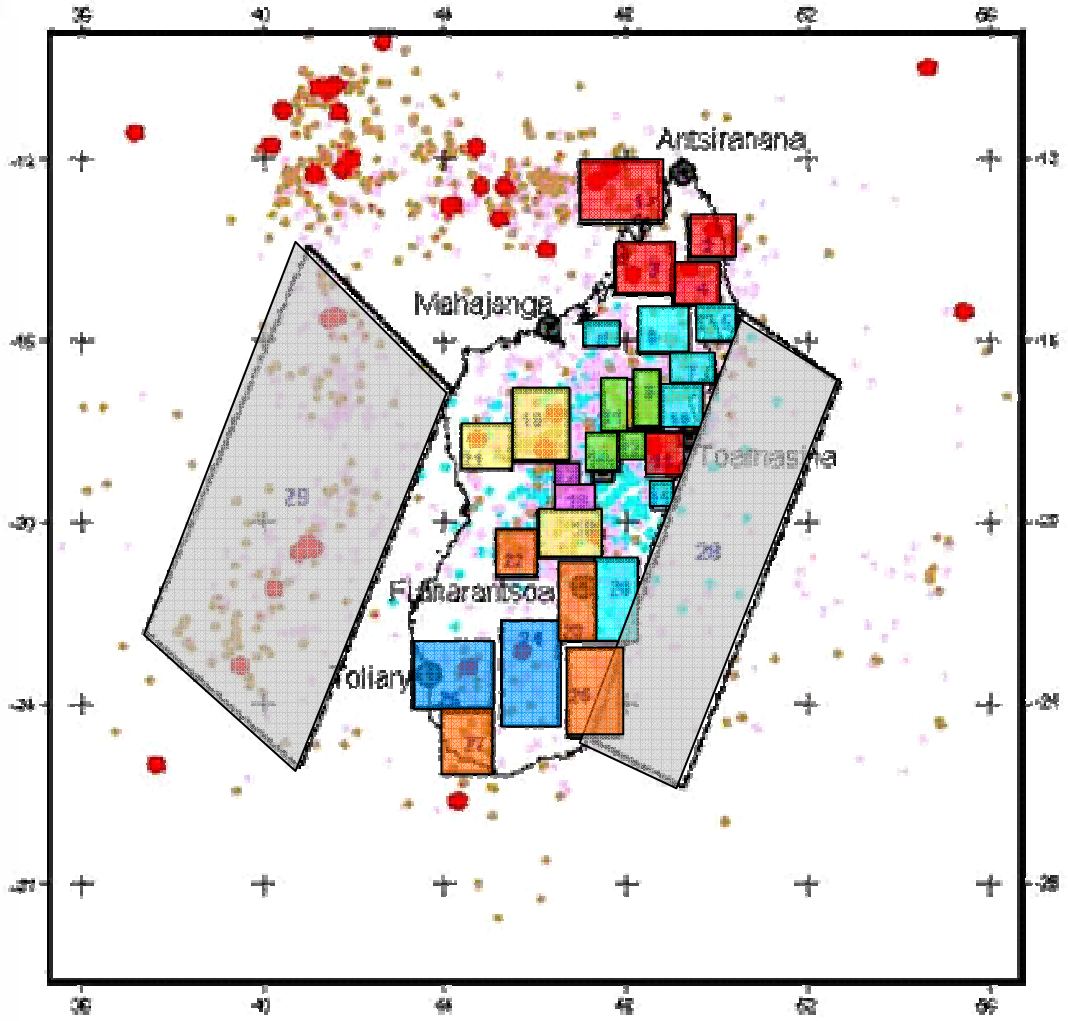
Criteria of classification: Density and Magnitude

COMPARAISON



Previous Results ≠ Present Results

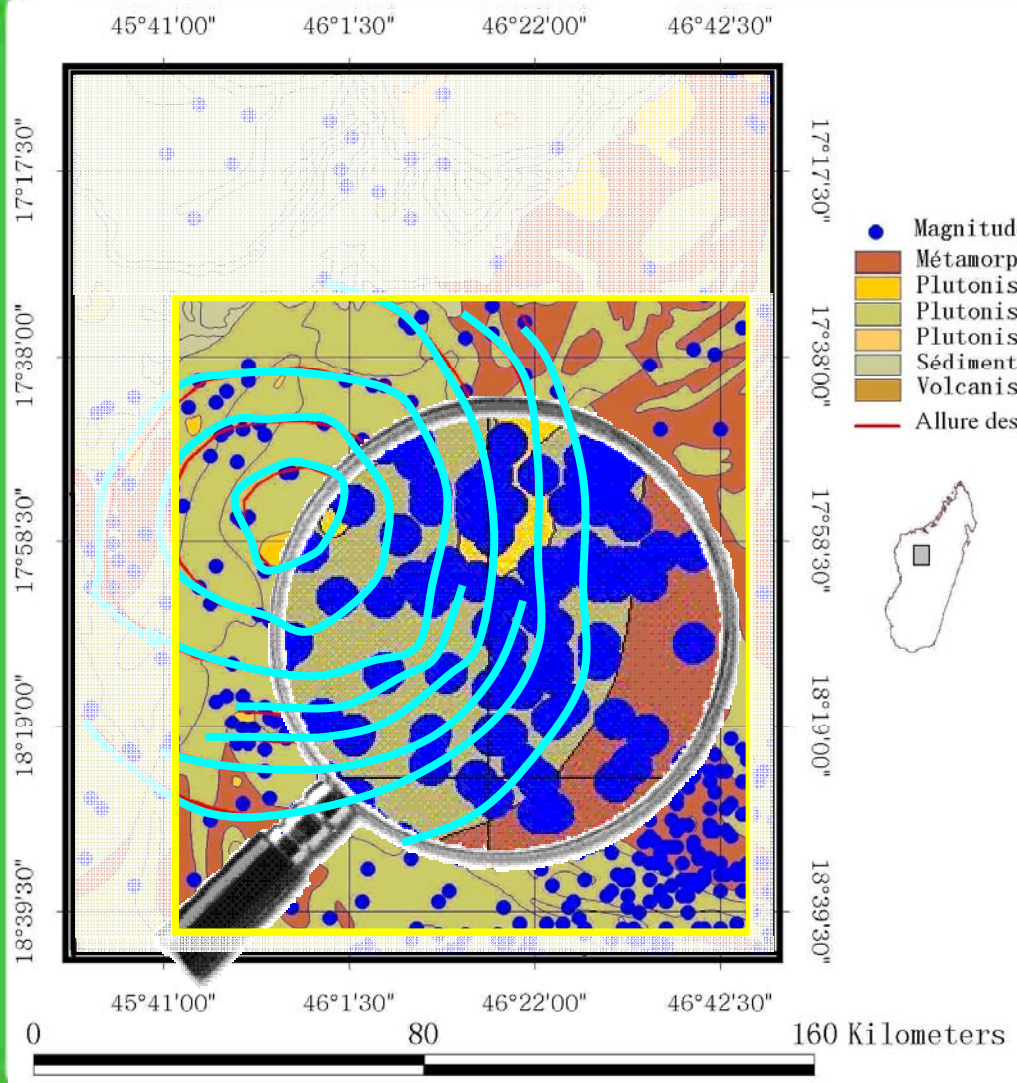
Seismic Zones



- Category 1
- Category 2
- Category 3
- Category 4
- Category 5
- Category 6
- Category 7
- Category 8

Criteria of classification: Geology

GEOLOGIC CHARACTER



- Plutonique body.

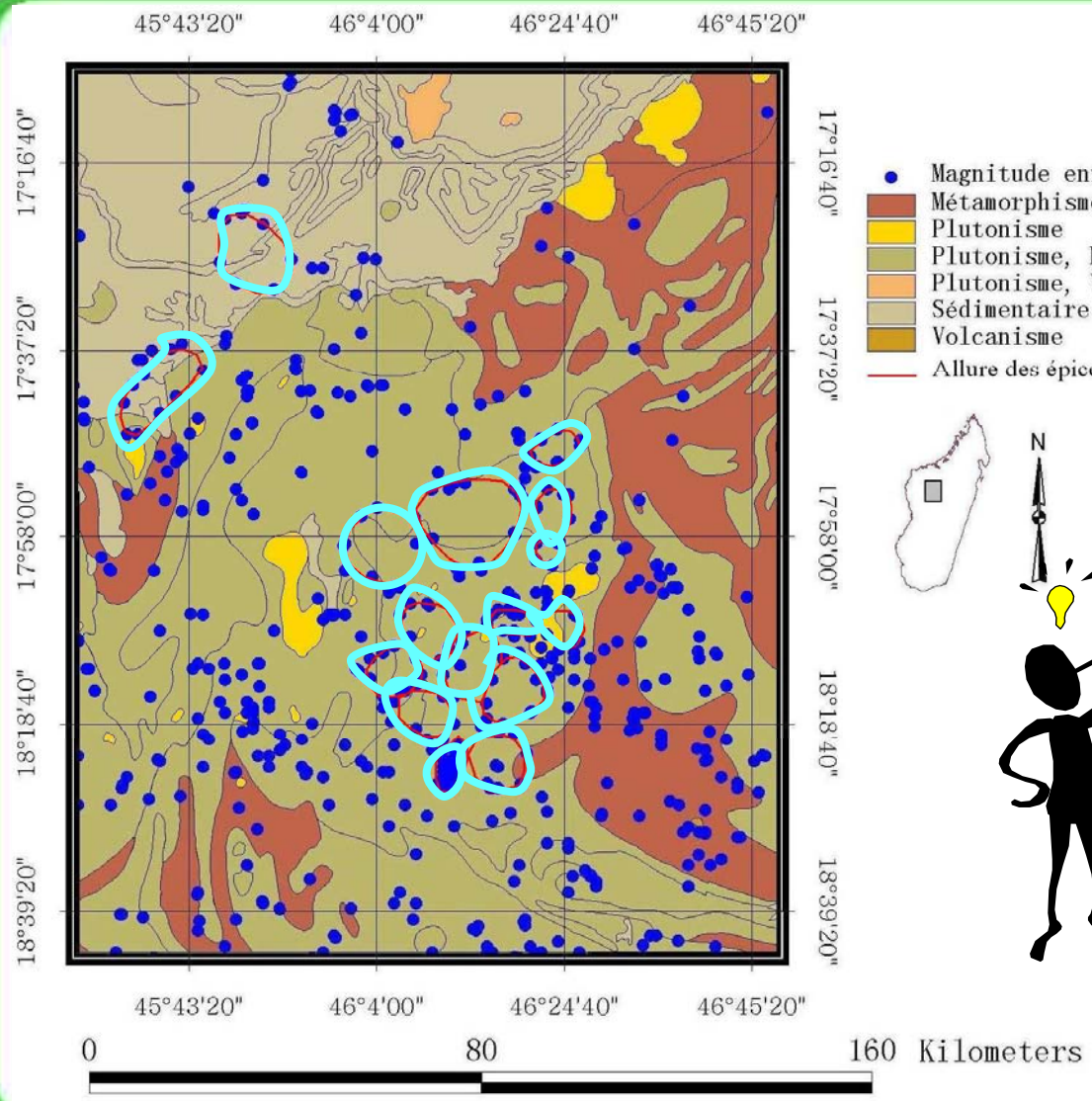
- Contact SE circular Body-basement= Density Higher

WHY ?

⇒ Forced implementation by the circular body in particular in its borders.

Example: Famoizankova (category 1) M<3

GEOLOGICAL CHARACTER



Circular look ⇒ domes and basins are situated in the SE quadrant.

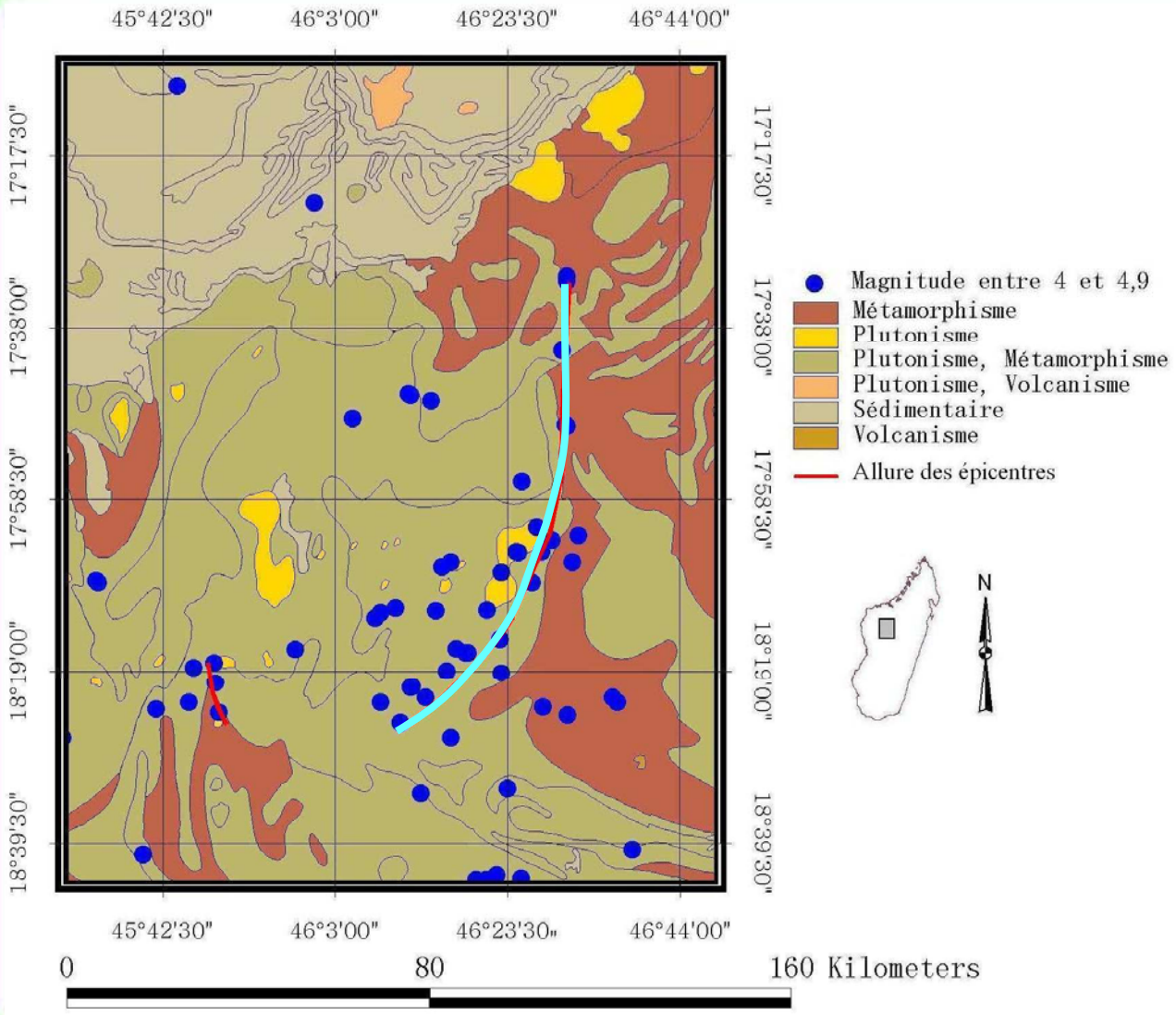
WHY ?

⇒ Partial cooling of the circular body.

cooled liquid raises in sticky conditions.

Example: Famoizankova (category 1) 3≤M≤3.9

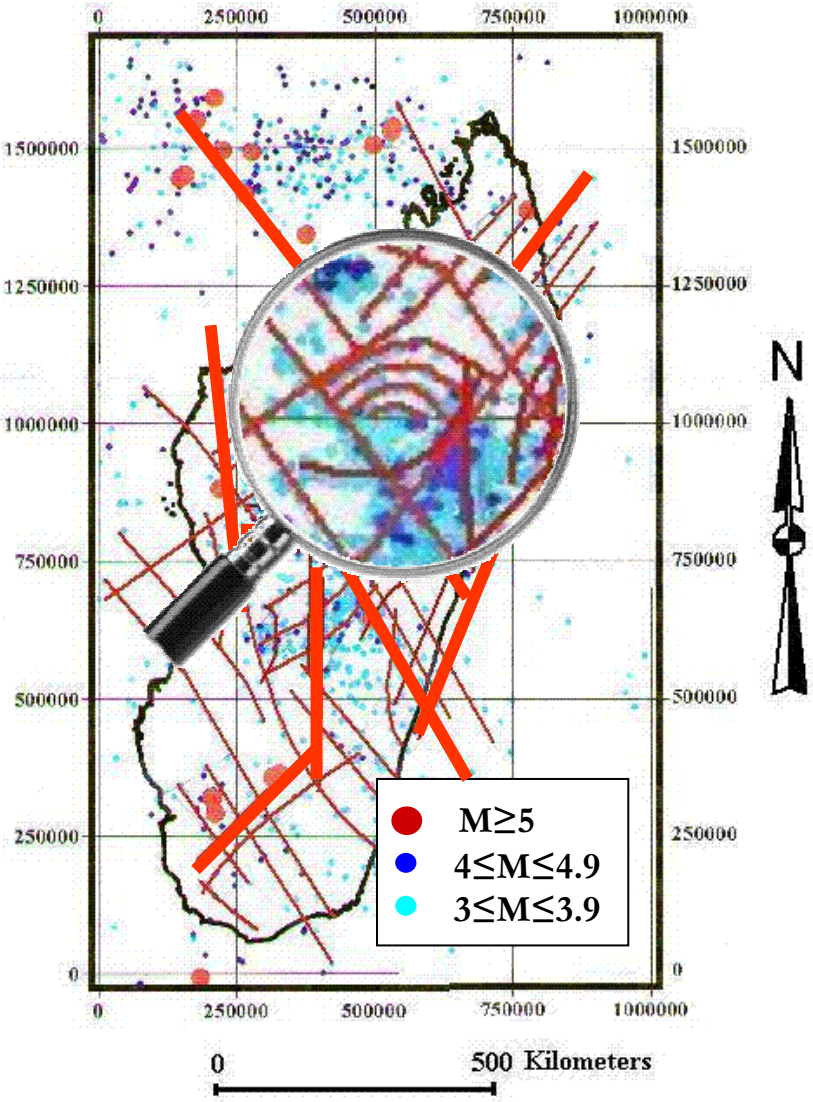
GEOLOGIC CHARACTER



·Outline of the circular body in the SE quadrant

Example: Famoizankova (category 1) 4≤M≤4.9

CORRELATION SEIMICITY - TECTONIC



- Direction of Seismic lines:

N30°W , N35°W, N40°W

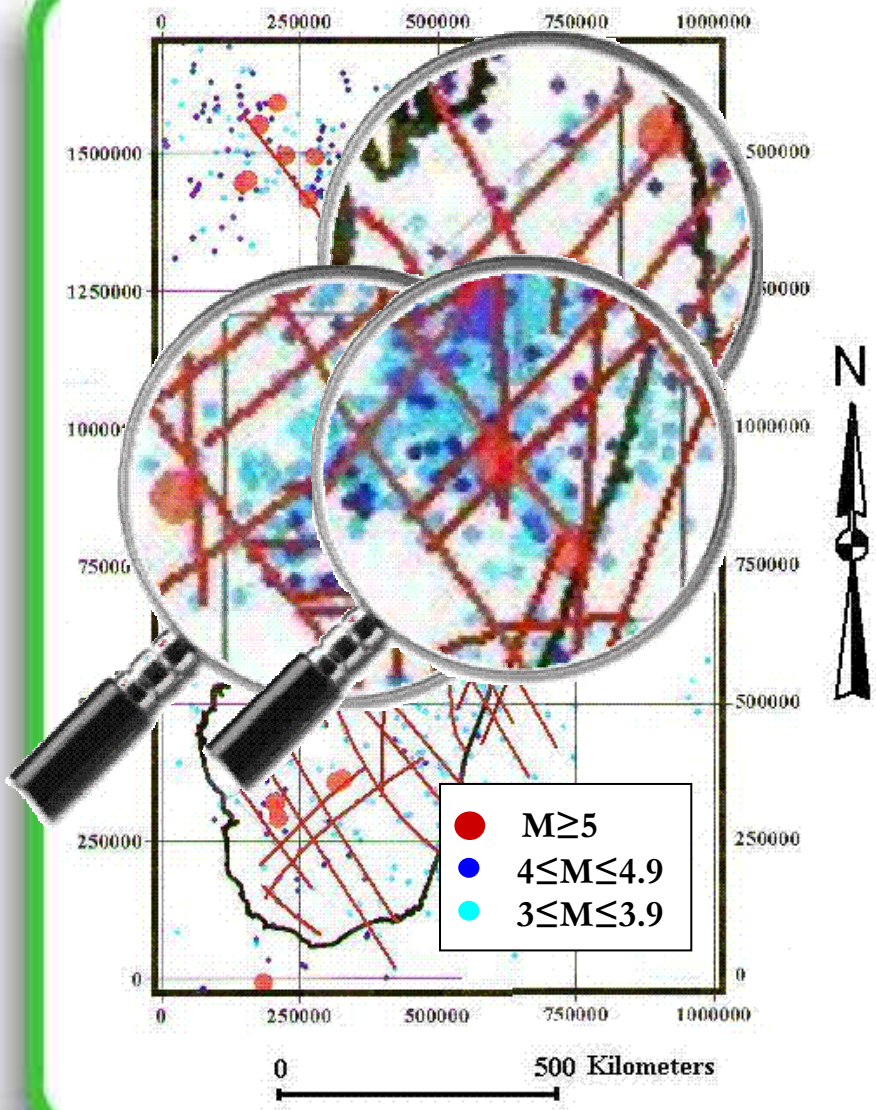
N40°E, N50°E, N0°, N90°

N20°E , N15°W

Concentric circles .

Seismic Lines

CORRELATION SEISMICITY - GEOLOGY

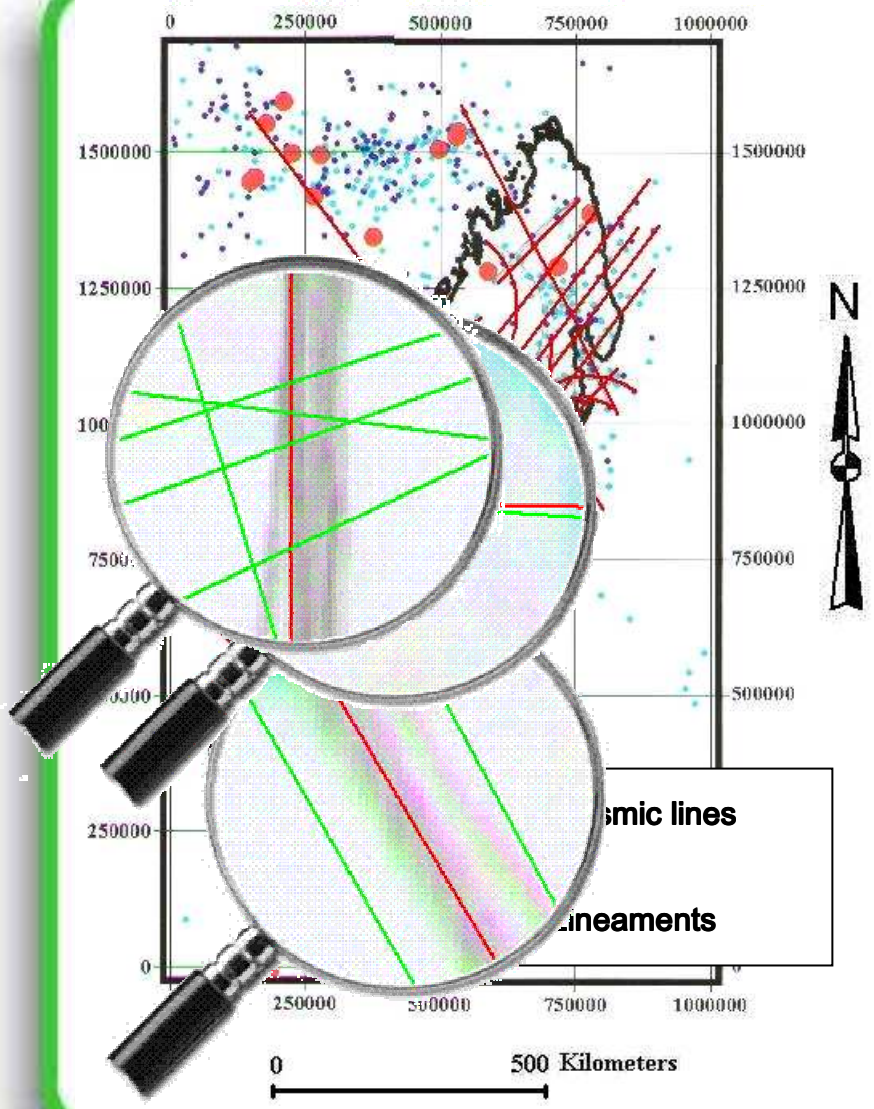


- **High Magnitude Events:**

The intersection of seismic lines.

Seismic Lines

SEISMIC LINES – LINEAMENTS



Lineament directions – Seismic Lines

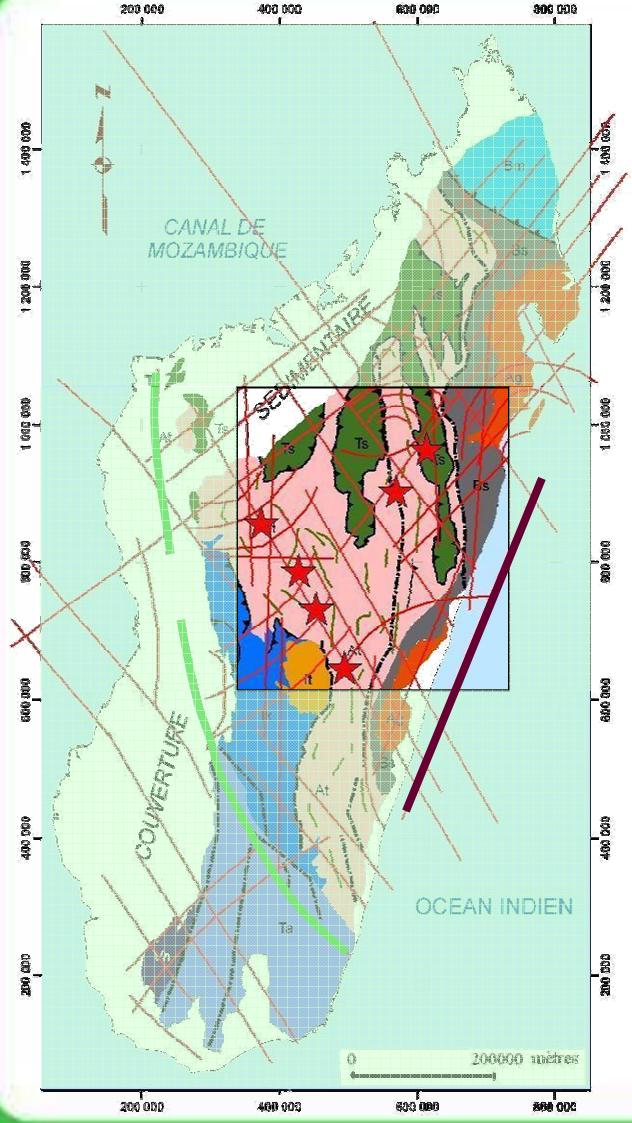
- Centre the seismic lines
- Close to the seismic lines
- directions completly different to the seismic lines

Seismic lines

Linéaments

Results and interpretations

SEISMIC LINES –TECTONO-METAMORPHIC MAP



Zones sismiquement remarquables (Famoizankova, Ankaratra, Alaotra, Itasy, Ambatofinandrahana, Anjafy)

Structures:

- Lines structurales
- Zone de cisaillement
- Charriage
- Zone de cisaillement en extension
- Limite de cote

unités tectono-métamormophiques

- Antananarivo
- Antongil
- Bemarivo
- Betsimisaraka
- Ikalamavony
- Itremo
- Tolagnaro-Ampanihy
- Tsaratanana
- Vohibory

Seismic lines highlighted:

- **the Bongolava-Ranotsara structure.**
- **the main tectonic zones such as: Ankaratra, Itasy, Alaotra.**
- **The Eastern Coastal fault.**

Results and interpretations

CONCLUSION

CONCLUSION

- Only, recent events and mainly from Mesozoic are highlighted by events with magnitude more than 3.9.

- Most geological events, source of the restructuration of Madagascar are highlighted by low magnitude seismicity (less than 3.0).

CONCLUSION

SUGGESTIONS

1/ The ancient deformations and the associated structures are:

- stabilized by mechanical accommodation of their geological components.
- The geological structures are under maturation and not to be any more in search of an equilibrium.

2/ The deformations and the associated structures to the recent geological events, in particular those connected to the various stages of Madagascar (from the separation of the block Madagascar - Antarctica - India - Australia of Africa in the separation of India from

Madagascar) would not still be under maturation and stabilization.

ICTP WORKSHOP I ON EARS August 2009

Misaotra Tompo!

Rambolamanana Gérard - Rakotomalala Mireille

Thank You!

WORKSHP ICTP August 2009

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