http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/

http://www.oagsafrica.org/

http://ccgm.free.fr/index_fr.html

Seismotectonic Map of Africa

- Explanatory Notice -

Prepared by the IGCP-601 Project working group(*)

http://eost.u-strasbg.fr/~igcp601/Index.html

FOREWORD

The African continent is made of various geological structures that include zones of active deformation. Seismically active regions are primarily located along rift zones, thrust and fold mountain belts, transform faults and volcanic fields. Several tectonic structures may generate large earthquakes with significant damage and economic losses in Africa. The development of thematic mapping with the identification and characterization of seismically active zones constitutes the framework for the seismic hazard assessment and mitigation of catastrophes.

Following the initiativeshown by the OAGS*, the project titled "Seismotectonics and Seismic Hazard in Africa" has been supported by the UNESCO-Paris - SIDA/IGCP** (Project 601) and UNESCO Nairobi from 2011 to 2016. Among the objectives previously defined by the OAGS is the preparation and implementation of the "Seismotectonic Map of Africa" with the assistance of the CGMW***.

Along with the map preparation, a major objective is the constitution of a database in historical and instrumental seismicity, active tectonics, stress tensor distribution, earthquake geology, paleoseismology, active deformation and earthquake geodesy (GPS), crustal structure and seismic tomography, gravity, magnetic and structural segmentation, volcanic fields, rifting processes and geodynamic evolution. Guidelines for the seismotectonic map preparation and related data analysis are necessary to obtain homogeneous results. An important step is the database harmonization (e.g., earthquake intensities, magnitudes, fault parameters, etc.) at the local, regional and continental level. The data collection and storage are organized under geo-referenced feature using GIS.

A synthesis of earthquake studies and active deformation exposed in theseismotectonic map hitherto serves as a basis for hazard calculations and the reduction of seismic risks. Any large and small infrastructure project needs a seismic hazard and risk assessment due to its significant implications in the socio-economic impact. The Global Earthquake Model**** has set-off regional programs in sub-Sahara Africa and provides supports for implementing seismic zoning and probabilistic applications for large ground motions. The NAGET***** for North Africa and

AfricaArray****** for sub-Sahara bring the necessary scientific knowledge and expertise to achieving the tasks.

Although the grasp of the seismotectonic framework of Africa is a difficult task, several previous and ongoing projects provide wealth of data and outstanding results. The occurrence of large and moderate earthquakes in different geological domains, their related aftershocks and surface faulting revealed the complex nature of the active tectonics in Africa. Earthquake catalogues and developed local and regional seismotectonic maps already exist and need to be integrated into a continental framework. Hence, a first edition of the map is prepared to be presented at the 35th IGC (Cape Town, 27 August – 4 September, 2016; http://www.35igc.org/)where a symposium titled **"**Crustal deformation and seismotectonics in Africa: Active faulting and earthquake hazard assessment" is planned under the theme Geohazards (Geoscience for Society).

* OAGS: Organisations of African Geological Surveys http://www.oagsafrica.org/
** IGCP/SIDA: International Geoscience Program/Swedish International Cooperation Authority http://www.unesco.org/science/IGCP
*** CGMW: Commission for Geological Map of the World http://ccgm.free.fr/
**** The GEM Foundation http://www.globalquakemodel.org/

***** NAGET: North African Group for Earthquake and Tsunami studies http://naget.ictp.it/
****** AfricaArray: A program to promote geoscience in Africa http://www.africaarray.psu.edu/

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The preparation of the seismotectonic map of Africa is a multidisciplinary task that requires the definition of scientific and technical characteristics and the organisation of a working group able to conduct the analysis of existing data.

The Seismotectonic Map of Africa is among the official projects of the Organization of the African Geological Surveys (OAGS). The UNESCO (Paris and Nairobi offices) – International Geological Program (IGCP) supports the project "Seismotectonic and Seismic Hazards in Africa" under the IGCP – Project 601 from 2011 to 2016.

The NAGET (North African Group of Earthquake and Tsunami studies), the Global Earthquake Model (GEM Foundation), the Commission of Geological Map of the World (CGMW), the International Union of Geological Sciences (IUGS) and the Geological Society of Africa have given their support to the project. The CGMW takes in charge the map edition andprovides access to the *Tectonic Map of Africa* at 1:5 000 000 (2010)as a background to the mapping project.

The map has been the subject of a publication with the reference:

Meghraoui, M., P. Amponsah, A. Ayadi, A. Ayele, B. Ateba, A. Bensuleman, D. Delvaux, M. El Gabry, R.-M. Fernandes, V. Midzi, M. Roos, Y. Timoulali, 2016, The Seismotectonic Map of Africa, *Episodes Vol. 39, no. 1, DOI:10.18814/epiiugs/2016/v39i1/89232*

I - Scale and limits:

The Seismotectonic Map of Africa will consist of **1/12 000 000** scale map with data extracted from a synthesis of the **1/1 000 000** to **1/5 000 000** scale regional maps.

The map will have the following characteristics:

1. **Projection:** WGS84 - Transverse Mercator (Mo: 16º East, Latitude: 0º).
2. **Limits:** To be adjusted according to the format envisaged for the map, which will be comparable to the *Tectonic Map of Africa* (i.e., Latitude: 40º N - 40º S, Longitude: 60º E -30º W).

II - Seismotectonic provinces:

Based on the local and regional studies, the seismotectonic map is constructed addressing the following issues:

1. Building a homogeneous database of seismic parameters,making distinction between historical and instrumental data. Location and source parameters are revisited according to new information and the use of routine softwareespecially for past earthquakes.
2. Prepare a database of neotectonic structures with Quaternary faulting; we emphasize the identification of active faults that are the source of significant seismicity.
3. Improving the seismotectonic database in regions with low level seismicity and slow active deformation.
4. Building a GIS interface for the geologic and geophysical database.

The map also uses a synthesis of the main geological background excerpted from the Tectonic Map of Africa (CGMW, 2010), geophysical data (e.g.,gravity, stress field, heat flow), geodynamic movements derived from GPS survey and previous works on plate boundaries (Hartnady, 1990; Calais et al., 2008; Meghraoui and Pondrelli, 2012; Fernandes et al., 2013).

The seismotectonic sub-division of the continent is made taking into account the geodynamic context, the tectonic domains and structures, the seismic activity and the level of active deformation. The IGCP-601 working group conducted the map preparation of the following six different seismotectonic provinces (Figure 1):

1. The **Western-Central Africa** “stable” tectonic zones and related islands.
2. The **Northwest African** fold-and-thrust belt (Atlas Mountains),
3. The **Northeast African** tectonic zones of Libya, Egypt and northern Sudan,
4. The **Central Africa** fault systems of DRCongo, Cameroon, Nigeria, Chad,
5. The **East African** Rift (from Madagascar, Malawi to the Red Sea and Gulf of Aden Oceanic rifts),
6. The **Southern African** shield (includes Mozambique to Namibia and Angola) and the Cape fold belt.

Province 1 covers West Africa from Nigeria to Senegal and is presumably considered as a stable part of Africa, although several major historical and recent earthquakes struck the region. The Guinea earthquake of 22nd December 1983(Mw 6.4) is a good example as an event of intraplate seismicity which occurred on a stable West African craton (2.2-1.8 Ga). The seismicity in this province is not frequent according to the geological context.

Province 2 includes Northwest Africa from Tunisia to Mauritania, and is well known for its recent large thrust and strike-slip earthquakes along the plate boundary between Africa and Eurasia. The plate boundary is diffuse but it joins to the west in the Atlantic the Gloria transform fault system. The region experienced one of the largest earthquakes in Africa, the Mw 7.2 El Asnam seismic event in 10^{th} October 1980, with surface faulting and folding.

Province 3 encompasses Libya and Egypt and is characterized by infrequentlarge and moderate normal faulting earthquakes. This area is also prone to two distinct tectonic regimes, collision of Africa-Eurasia plates and the rifting of the red sea.

Province 4 covers Central Africa that includes the Cameroun Volcanic Line (CVL), Angola, Chad the Congo basin and its seismically active East African Rift System (EARS) margin.

Province 5 includes the most active part of the EARS and related volcanic and normal faulting system that extends from the Red Sea and Gulf of Aden oceanic rifts, the Afar triple junction through the Rukwa-Tanzania rift Valley down to the Zambezi Valley;the province includes the Madagascar Island where the seismicity is also associated with the rifting process and the breackup of the African lithosphere.

Province 6 covers the southern regions of Africa, which have also been struck by large and moderate intraplate earthquakes and includes Mozambique, Botswana, Zambia, Zimbabwe, Angola, Namibia and South Africa. The region is made up of major shield structures, the Kaapvaal and Zimbabwe cratons, which are separated by mobile belts. The north eastern part of the region encompasses the southern extension of the EARS where the major Machaze earthquake of magnitude M 7.0 occurred in 2006.

Other major islands as La Réunion, Mauritius, Comoros in the Indian Ocean, and Cape Verde, Canaria, Madeira and Azores Islands in the Atlantic Ocean, are also included in the seismotectonic analyses and the study of crustal deformation.

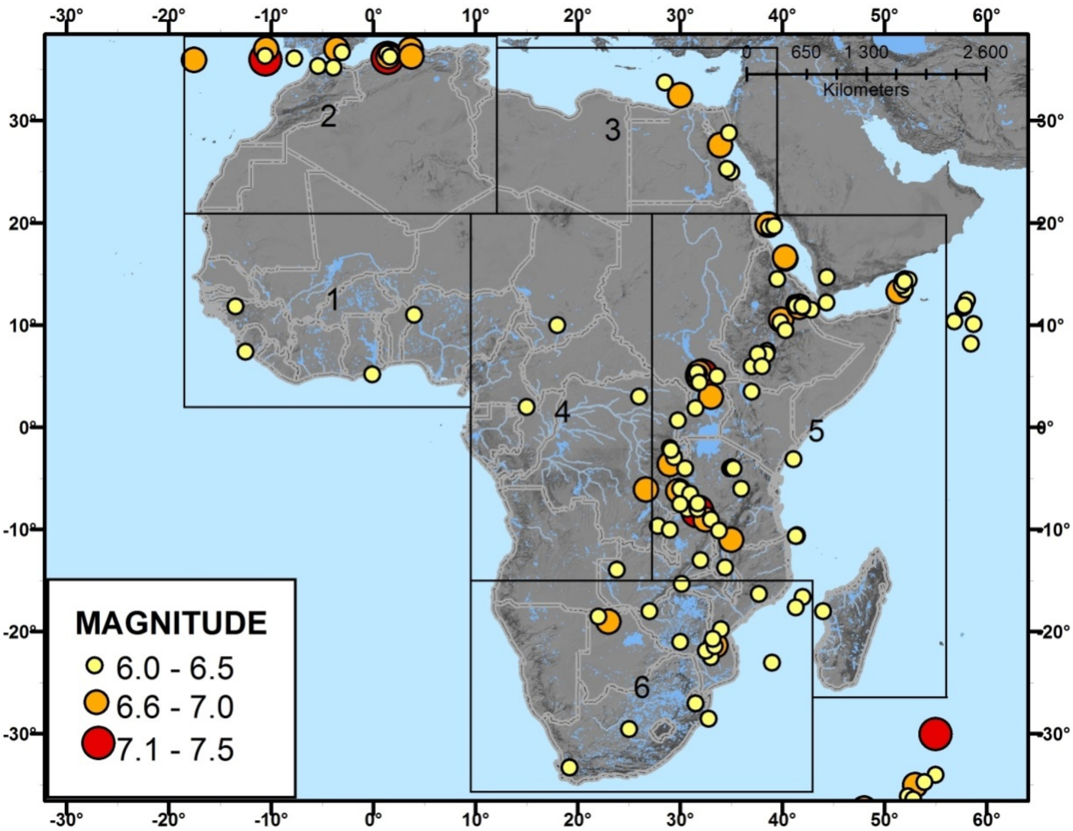

Figure 1: Seismotectonic provinces (1 to 6) and major recent earthquakes of the African continent.

III – The database

Several major earthquakes of the continent (Figure 1, Table 1) were the site of detailed field investigations using geological and geophysical data analysis, including space-based geodesy (GNSS and InSAR). Previous studies of major earthquakes emphasized the study of seismic strain release using mainshock and aftershocks with focal mechanisms including field studies of earthquake faulting, GNSS measurements and SAR interferometry.

1. Seismicity catalogue

Taking into account the different catalogues of the 6 seismotectonic provinces (Amponsah et al., 2012; Ayadi and Bezzeghoud, 2015; Ayele et al., 2007; Benouar, 1994; Harbi et al., 2015; Hussein et al., 2006; Midzi et al., 2013; Soumaya et al., 2015) the seismicity database is prepared in order to:

1. Compile the historical seismicity catalogue that covers the period before the 1st January 1900.
2. Implement the instrumental seismicity catalogue for the period from the 1st January 1900, up to the Present-day.
3. To homogenize the seismicity catalogue both for instrumental and historical data with a threshold of Magnitude 4.0

4. To separate historical from instrumental data in the map but display all seismicity using the same homogeneous scale.
5. Present the seismicity catalogue as an Excel Table.

A careful study and compilation of data is devoted to the collection of the historical and instrumental seismicity catalogues of African countries. Regional and local maps may include earthquake magnitude as low as M 1 but the final seismotectonic map (Figure 2) will have to consider magnitudes larger than or equal to M 4. An example of parametric catalogue is as in the following table:

Year	Mo	Day	Hr	Mn	S	Lat	Lon	D	mb	Ms	Mw	Md	Ml	Io	NS	Site	Ref.
1900	04	25	18	00	00	35.70N	0.60W	1	0.0	0.0	0.0	0.0	0.0	6	0	Oran. AL	MEZ
1901	01	13	00	00	00	36.62N	4.68E	0	0.0	0.0	0.0	0.0	0.0	9	0	SidiAich. AL	ROT
1901	03	09	22	26	00	35.73N	0.55E	0	0.0	4.6	5.0	0.0	0.0	6	0	Relizane. AL	NNA
1902	05	05	06	00	00	38.00N	1.20W	0	0.0	0.0	0.0	0.0	0.0	6	0	Sabla. MO	KAR
1902	07	09	03	44	06	35.30N	3.00W	0	0.0	0.0	0.0	0.0	0.0	5	0	Mellila. MO	MEZ
1903	07	28	00	00	00	36.70N	3.20E	0	0.0	0.0	0.0	0.0		6	0	-	EC
1903	09	23	01	55	00	36.00N	2.83E	0	0.0	5.5	5.4	0.0	0.0	7	0	Mudjebeur. AL	BEN
1903	11	24	00	00	00	37.60N	2.00W	0	0.0	0.0	0.0	0.0	0.0	7	0	Huercal. SP	KAR
1903	11	25	00	00	00	37.60N	2.00W	0	0.0	0.0	0.0	0.0	0.0	7	0	Huercal. SP	KAR
1904	04	05	21	01	00	36.92N	7.75E	0	0.0	0.0	0.0	0.0	0.0	4	0	Bone. AL	-
1904	08	23	05	59	00	35.40N	0.10E	0	0.0	0.0	0.0	0.0	0.0	5	0	Mascara AL	-
1905	02	14	04	00	00	38.00N	1.20W	0	0.0	0.0	0.0	0.0	0.0	6	0	Nora. SP	-

Table representing an extract of the parametric seismic catalogue
(Africa IGCP-601 database)

The building of a reliable seismicity catalogue needs the following :

1. Parametric earthquake catalogues must have been checked for completeness (completeness model)
2. False events must be avoided,
3. Standard approaches to regional catalogue processing and interpretation,
4. Controlled intensity scales and correspondence,
5. Standard magnitude measures for large and moderate events (Mw, Ms),
6. Magnitude conversion for smaller events,
7. Methodology to estimate location, magnitudes and associated uncertainties for historical events,

Other types of information:

1. Focal mechanism with detailed solutions presented (whenever possible)
2. Upper seismogenic depth estimate
3. Lower seismogenic depth estimate
4. Tomography and crustal structure
5. NB: Recent earthquakes in the catalogue can also be presented as an individual study.

2. Magnitude homogenization

Recent approaches were put forward for magnitude conversions into a homogeneous moment magnitude Mw using standard relations. Locally defined empirical relations are preferred but if no local studies are available the following relations, from Scordilis (2006).

Conversion Ms-Mw (Surface wave magnitude into Moment magnitude):

$Mw = 0.67\ (\pm 0.05)\ Ms + 2.07\ (\pm 0.03)$ for $3.0 \leq Ms \leq 6.1$

$Mw = 0.99\ (\pm 0.02)\ Ms + 0.08\ (\pm 0.13)$ for $6.2 \leq Ms \leq 8.2$

Conversion Mb-Mw (Body wave magnitudes into Moment magnitude):

$Mw = 0.85\ (\pm 0.04)\ Mb + 1.03\ (\pm 0.23)$ for $3.5 \leq Ms \leq 6.2$

Conversion ML-Mw (Local magnitude into Moment magnitude)

$Mw = 0.722\ ML + 0.743$ (from $ML > 2$ for intraplate domains)

3. Digital fault mapping

- **Active – Seismogenic Faulting**(Figure 3)**:**

The digitization of already mapped active faulting is an important step of the seismotectonic map preparation (Hill et al., 1988; Goedhart, 2006; Fenton and Bommer, 2006; Delvaux and Barth, 2010; Meghraoui and Pondrelli, 2012). Therefore, the working group decided to take the following actions:

1. Collect the digitized earthquake fault traces and Holocene fault in the format .xy or prepared drawings for digitization (Figure 3).
2. Maps should be indicated following the fault classification as seismogenic sources (see below).
3. Use Google Earth, GIS and the STRM DEM (3”) as a basis for digitizing and referencing the mapped faults.
4. Consider only fault segments of min. 5 km long.
5. Compile the existing literature (fault characteristics, name, age of activity, ..) for each province but re-digitize them into GIS from Google Earth and the STRM DEM for homogeneity.

Tectonic Map of Africa*(see background tectonic faulting in Figures 2 and 3)****:*** For regions with no specific mapping or studies on late Quaternary and/or active faults, it was decided to use the background mapping of the recently published Tectonic Map of Africa (CGMW, 2010, Tectonic Map of Africa, CGMW General Assembly / UNESCO, Paris, France). The GIS version of the map is accessible on internet through a server.

The aim of the map is to characterize the potential of faults as seismogenic Sources

I: Faults

• We consider only Quaternary faults (maximum date 1.8 Ma) and proceed with :

1. Quaternary faults with lower and middle Pleistocene tectonic movement (1,8 Ma to 130 ka),
2. Quaternary faults with upper Pleistocene (150 ka to 11 ka) tectonic movement,
3. Quaternary faults with Holocene (11 ka to present-day) tectonic movement,
4. Quaternary faults with historical or recent coseismic surface ruptures.

The map preparation takes into account the following items:

1. Digital Elevation Models (GEBCO digital Atlas, SRTM3+, Alos prism &TerraSARxproducts),
2. The major faults with tectonic activity during the Quaternary period,
3. The major active faults with tectonic activity during the late Pleistocene and Holocene (< 150 ka),
4. The major faults with recently recorded coseismic activity,
5. The major faults of the oceanic domains,
6. Characteristics of active volcanoes,
7. Geodetic maps (conventional geodesy, GPS data, InSAR)
8. The background seismicity from 1900 up to the present-day,
9. The historical seismicity up to 1900,
10. Major tsunamis and their impact on the African coastlines,
11. The focal mechanisms of earthquakes and related stress distribution,
12. Geophysical maps (gravity, magnetic, heat flow, seismic profiles and tomography).

List of Parameters for the Active Fault traces and fold axes:

Fault (or fold) name: In the original language and an English translation, and an ID#.
Fault patch coordinates: At endpoints of every straight segment or patch. Fault breaks and echelons needto be represented down only to a certain scale (5 km for fault traces).
Fault or Fold age: Time since last movement, time of fault formation.
Fault rake: Thrust, normal right-lateral, left-lateral, oblique right-thrust, right-normal, left-thrust, leftnormal,if available from focal mechanism, seismic inversion, slickensides, with citation.
Fault dip and rake: Azimuth and dip. This could include full information if available (e.g., on faults that have slipped inwell-recorded earthquakes), or there could be a default of vertical, NW/NE/SE/SW. Dip should be able toinclude a citation. We may have default dips for new (30° for thrust, 60° for normal, 90° for strike-slip) and
reactivated faults. For cases in which no clear dip information is available, then rely on the identification of therelatively upthrown side of the fault.
Rake is defined from slickenside (striation) measurements on a fault plane, or from focal mechanisms of earthquakes
Fold crest (anticline axis); or tip line.
Fault slip rate: Would include the dated geological offsets rather than simply estimated long term slip rate.
Aseismic component of slip: Should include basis for this assessment, with citation.
Credibility of the fault parameters: Peer reviewed publication, consistency with instrumental or historicalseismicity and geodetic strain rate, consistency with recent moderate-large earthquake source parameters.

Paleoseismic data

1. Slip per event (size of paleo-earthquake)
2. Mean Recurrence Interval estimate and location on fault where measured
3. Number of paleoseismic events

4. Date of last event
5. Correlation with historical seismic events

Other types of database can be:
1. Stress field distribution (see Figure 4)
2. Geodetic strain measurements (see Figure 5)
3. Gravity, magnetic, seismic profiles and tomography
4. Volcanic fields and date of eruptions
5. Tsunami catalogue, …

4. Focal mechanisms and stress field (Figure 4)

The kinematics of faulting and related stress distribution requires:
1. The use of the Harvard CMT (Aki seismic source) format convention (see table below).
2. The compilation of the different CMT catalogues and published data.
3. The building of a master table of all focal mechanism parameters.
4. The construction of focal solutions (beach balls) of selected earthquakes in EPS format and include them in the GIS database.
5. The plot of the stress indicators (P and T kinematic axes) using the World Stress Map representation and legend.
6. Collect the available stress tensors and calculate σ (1) whenever possible.

Long_E	Lat_N	Mag	Mag-Type	Location	Method	Strike1	Dip1	Slip1	Strike2	Dip2	Slip2
1.3600	36.2500	7.10	Mw	Algeria	CMT	247	30	105	050	61	81
1.3100	35.7200	6.20	Mw	Algeria	CMT	058	43	81	250	47	98
2.0700	36.5300	5.20	Mw	Algeria	CMT	063	42	69	271	51	108
1.3200	36.0200	5.20	Mw	Algeria	CMT	270	45	126	044	55	59
1.6800	35.8700	5.30	Mw	Algeria	CMT	112	61	-179	021	89	-29
0.9400	36.0200	5.60	Mw	Algeria	CMT	277	40	140	039	66	57
1.3800	36.3800	5.00	Mw	Algeria	CMT	181	53	29	072	67	139
1.9000	36.2700	5.60	Mw	Algeria	CMT	210	43	64	064	52	112
1.7600	36.0800	5.20	Mw	Algeria	CMT	026	67	-18	124	73	-156
41.6200	-10.2500	5.30	Mw	Mozambique	CMT	148	38	-104	345	53	-80
42.9300	11.3100	5.10	Mw	W-Arabian	CMT	149	54	-27	256	69	-140
41.2300	-10.6860	5.60	Mw	Madagasca	CMT	346	44	-93	169	46	-87
28.9440	-2.3720	4.90	Mw	Tanganyik	CMT	211	45	-090	031	45	-090
35.9600	5.7200	5.40	Mw	Ethiopia	CMT	258	31	-045	029	68	-113
48.4410	-18.2940	5.50	Mw	Madagasca	CMT	147	32	-115	357	61	-75

Table of focal mechanisms and active fault parameters
(extract from the Africa-IGCP-601 database)

Building the stress field: For areas with homogeneous stress field, a formal stress inversion should be done to retrieve the stress tensors (Delvaux and Barth, 2010;

Ousadou et al., 2014). This work can be consigned in a scientific publication that will update the existing databank and scientific information.

5. Volcanoes

A review of Quaternary, Holocene and historical volcanoes with the most recent eruptions is attached to the map database (see also Figure 2). These crustal structures may be accompanied by a significant active deformation and seismic activity (Calais et al., 2008). Their representation in the map is as following:

1. Provide coordinates of craters and the age of volcanic fields (check the Global Volcanism Program in http://www.volcano.si.edu and http://web.ics.purdue.edu/~ecalais/teaching/gmt/world_volcanoes)
2. Use the work of Simkin and Siebert (1981): Volcanoes of the World. Other references are in Google Scholar.

6. Geophysical data

A large number of projects have been conducted recently to study the crustal thickness and structure of the African continent. The contribution to the seismotectonic map of Africa includes:

1. Database of the thickness of the seismogenic layer for each province.
2. Determine the Moho depth from the compilation of published studies
3. Compile receiver functions from publications

Tomography

Use the global tomographic model of J.B. Montagner and Eric Debayle (0 – 40 km depth).

Heat flow data

Exploit the Global Heat Flow database.

Gravity data:

Use data from the World Gravity Map (WGM) with the leaflet and gridded data from the Bureau Gravimétrique International (Bonvalot et al., 2010).

7. Geodetic data (Figure 5)

The IGCP-601 Project also includes the current status of the determined strain distribution using present-day GNSS velocity field of Africa, with respect to the latest global reference frame ITRF2008 and AFREF in perspective (Bos et al., 2013; Fernandes et al., 2013). The existing number of sites (~100 CGPS stations) and a threshold value of 2.5 years data already permit to compute a velocity field that can be used to obtain the general pattern of the current strain field for Africa. This constraint of active deformation provides us with an assessment of the main seismotectonic hazards areas of Africa.

In order to proceed with the evaluation of the strain velocity field, the working group put forward the following objectives:

1. Continue to collect the available GPS data for all GPS station in Africa.
2. Compute reliable uncertainties associated with the GNSS velocity solutions.
3. Increase the number of stations in regions with limited CGPS (e.g., Sahel and North Africa),
4. Compute solutions for convergence (North Africa Atlas Mountains, Cape Town Mountain Ranges), extension (East African Rift System), transform faults and intraplate deformation (West Africa, Central Africa and Southern Africa).

8. Tsunami data

Following the 2004 Sumatra and 2011 Tuhoku earthquake tsunamis, several EC-funded projects (TRANSFER, ASTARTE) were recently launched in order to assess the tsunami hazards and risks in the Indian and Atlantic Oceans, and in the Mediterranean Sea regions.

One may remember that the 2003 Zemmouri earthquake generated a tsunami in the western Mediterranean Sea and the 2004 Sumatra tsunami that affected the eastern coast of Africa. Other Tsunamis that devastated North African coastal cities (e.g., Alexandria, and Benghazi) were reported along the eastern Mediterranean coast such as the event related to the AD 365 giant subduction zone earthquake. Another important event is the Lisbon earthquake of 1755 which also generated a tsunami that affected the north western African coasts.

Tsunami data are collected from catalogues and exposed areas are the Mediterranean, South, West and East Africa coastlines.

9. Leaflet

The IGCP Working Group agreed that the leaflet consists of a minimum number of pages including figures and pictures. As proposed in the guidelines, the map will be prepared at 1/5 000 000 and edited at 1/10 000 000 scale. The leaflet will include:

1. An introduction that explains the used criteria for the map and a simple list of used data and their sources with references.
2. The map legend of used symbols.
3. Explanations on the harmonization and the homogenization of the data
4. Examples of seismotectonic features and crustal deformation for each province.
5. Include a seismic signal of an African earthquake and pictures to illustrate damages caused by earthquakes in Africa.
6. Present the geophysical maps such as gravity, tomography, Moho depth, etc.
7. Produce a CD that contains all maps and the leaflet:
   a. The CD will contain the GIS products relative to our map with all thematic layers.
   b. In parallel, a compilation of all published papers (in pdf) on seismotectonic studies in Africa with a related list will be continuously updated and added to the leaflet.

Database and final product

The data compilation is complemented by a detailed study of the related scientific literature and an analysis of the seismotectonic characteristics with fault and earthquake parameters at a regional level. The credibility of the information should be tested through peer-reviewed publication, un-reviewed publication, unpublished report, reconnaissance study, etc.

Thefinal map productwill include:

1. A leaflet that supplements the map and includes the detailed legend with explanations of the seismotectonics of each province. Tectonic cross sections joined with geophysical profiles and kinematic models will illustrate the geodynamic structure at the crustal and lithospheric level.
2. Tables of tectonic and seismic parameters (fault dimensions and mechanism, physical properties) following a specific format (MapInfo, ArcInfo) that can be useful for subsequent seismic hazard and risk studies.

The insets of the seismotectonic map will include:

1. Plate movement sketch (with kinematic indicators).
2. Major historical and instrumental seismicity distribution
3. Plate sketch map with principal stress direction.
4. Neotectonic and Quaternary faults
5. Explanatory notes with legend of symbols.

Accompanying products:

In addition to the seismotectonic map, the following will be prepared:

1. An accompanying Compact Disc with the digital seismotectonic map on 1:5 000 000-scale to be accessed with easily readable Geographic Information System (GIS) software.
2. A GIS software and databank for the “Seismotectonic Map of Africa” comparable with those developed in the frame of the CGMW.

Acknowledgements:

We are thankful to Margaret Patzak, Patrick McKeeverand Marie-Laure Faber (Unesco-Paris), and Felix Toteu (UNESCO Nairobi) for their constant interest and support to the project.We also thank the Swedish International Development Agency for funding the project from 2011 to 2016.

The project on the Seismotectonic Map of Africa was initiated and encouraged thanks to LhacenBitam, RamontjaThiebedi, Mxolisi Kota, Peter Zavada and FhatuwaniRamagwede from the Organisation of African Geological Surveys (OAGS). We also appreciate the support of Philippe Rossi, Manuel Pubellier and Jean Paul Cadet from the Commission of Geological Map of the World (CGMW). We thank all colleagues from AfSC, NAGET, GSAf, Africa-Array, IASPEI, and GEM for discussions and support of meetings during the 4-year preparation of the map.

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TABLE

Earthquakes	Dates	Latitude	Longitude	Mw
Lac Tanganyika	1910 Dec. 13	-6.5	29.5	7.4
El-Asnam, Algeria	1980 Oct. 10	36.23	1.32	7.2
Nuweiba, Egypt	1995 Nov. 22	28.81	34.80	7.2
Juba, South Sudan	1990 Mai 20	5.11	32.18	7.1
Mt. Kenya	1928 Jan. 6	0.4	36.11	7.0
Al-Qadahia, Libye	1935 Apr. 19	31.38	15.4	7.0
Machaze, Mozambique	2006, Feb. 22	-21.32	33.58	7.0
Kalemie, Congo-Tanzania	2005 12 5	-6.25	29.79	6.8
Zemmouri, Algeria	2003, May 21	36.83	3.65	6.8
Orleansville, Algeria	1954 Sep. 9	36.28	1.47	6.7
Salima, Malawi	1989 Mar. 10	-13.71	34.49	6.6
Accra, Ghana	1939 Jun. 22	5.18	0.13	6.5
El-Hoceima, Morocco	2004, Feb. 24	35.14	-4	6.4
Dobi, Ethiopia	1989 08 20	11.75	41.96	6.4
Ceres, West Cape, S. Africa	1969 Sept. 29	-33.36	19.31	6.3
Kivu, DR Congo	2002 Oct. 24	-1.905	29.013	6.2
Karonga, Malawi	2009 Dec. 19	10.108	33.81	6.2
Gaoual, Guinea	1983 Dec. 22	11.95	-13.6	6.2
Mascara, Algeria	1994 Aug. 18	35.45	0.08	6.0
Bukavu, DR Congo	2008Fev. 2	28.74	-2.45	6.0
Rukwa, Tanzania	1994 Aug. 18	6.5	29.5	6.0
Agadir, Morocco	1960 Fev. 28	30.41	-9.6	6.0
Cairo, Egypt	1992 Oct. 12	29.78	31.14	5.8

Table 1: List of major earthquakes in Africa that were the subject of detailed studies.

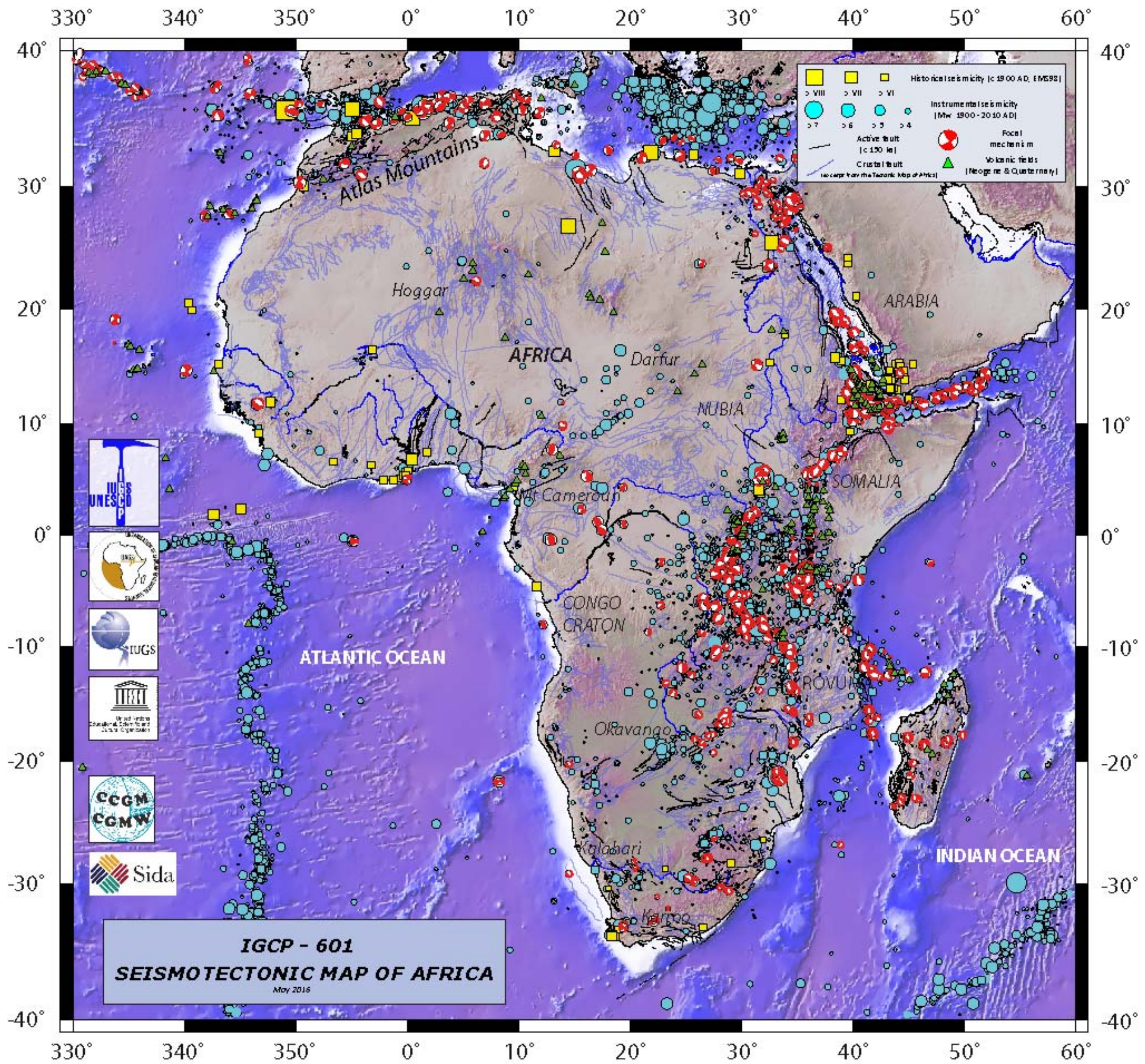

Figure 2. TheSeismotectonic Map of Africa (December 2015).
Database Africa-IGCP-601
The map background topography and bathymetry is reproduced from the GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003.

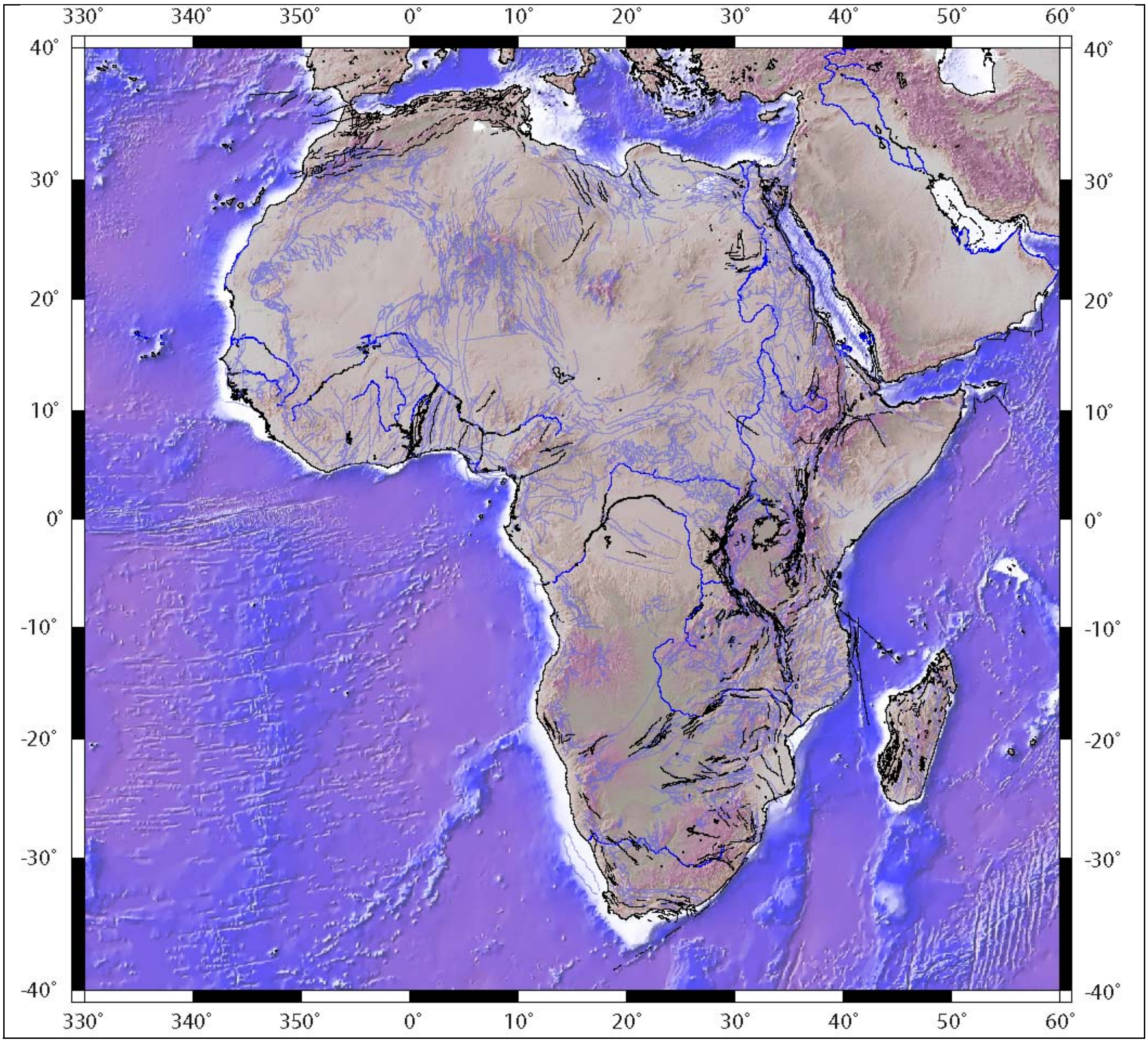

Figure 3. The Neotectonic and Quaternary Fault Map of Africa (December 2015).
Database Africa-IGCP-601
The map background topography and bathymetry is reproduced from the GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003.

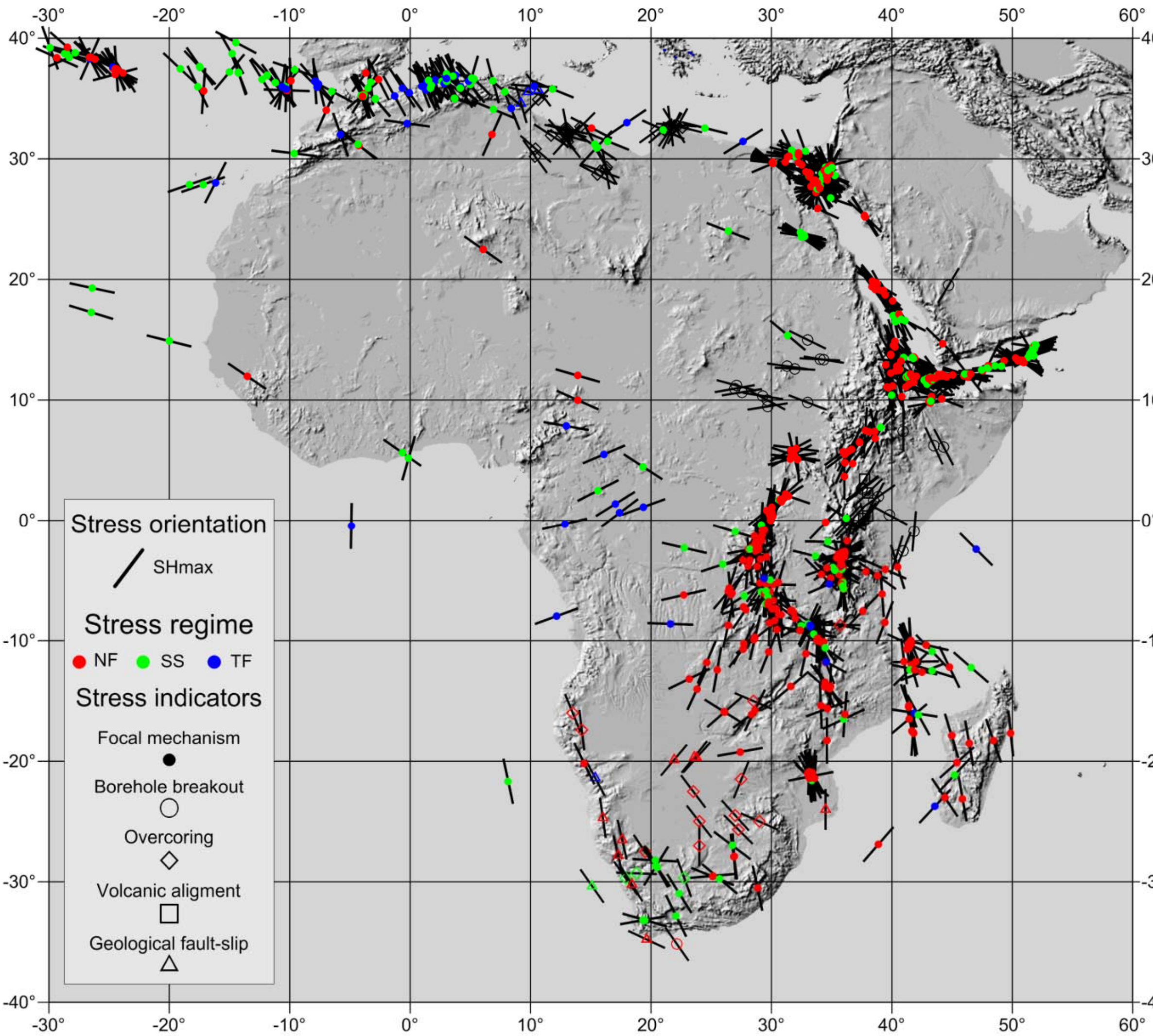

Figure 4. Stress map of Africa (December 2015). Database Africa-IGCP-601

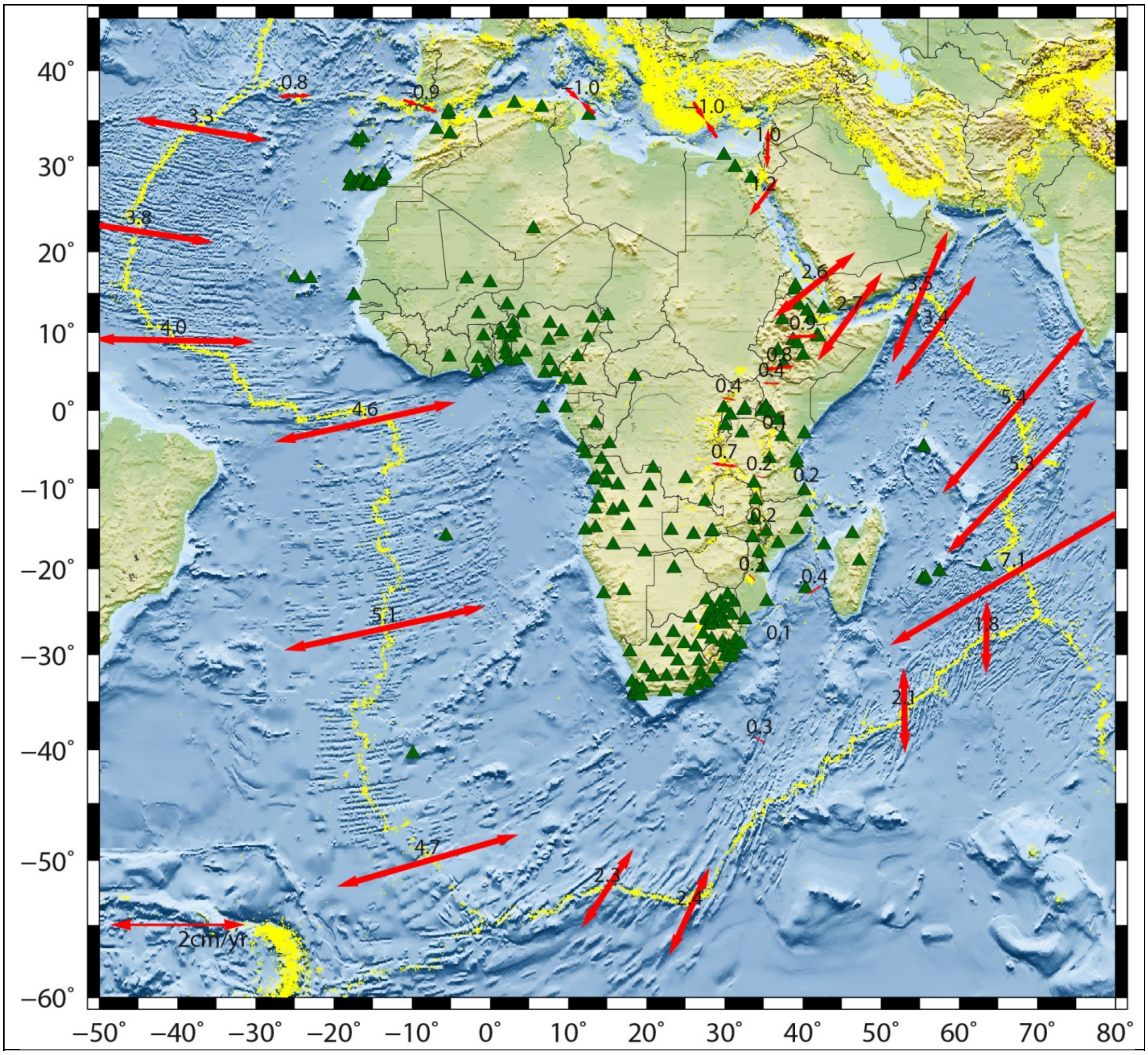

Figure 5. Geodetic velocity rates and GPS stations (triangles) of Africa (December 2015). Yellow dots for seismicity (ISC catalogue). Database Africa-IGCP-601