Earthquake frequency, distribution and the seismic hazard of Massawa

- Eritrea

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Abstract

The city of Massawa, hit by destructive estimated magnitude 6.2 and 5.8 earthquakes in 1884 and 1921, hosts Eritrea’s largest port and is administrative capital of the Northern Red Sea-region. The city´s population experience occasional tremors annually, and studying entries in earthquake catalogs there are events of close to moderate magnitude-range with epicenters in the greater area. Through a process in collecting and comparing data from different sources on seismic activity and plotting these events in GIS. Areas of where seismic activity have originated considering a period of up to fifty years back is displayed in cartographic material, this considering a study area covering Eritrea and the southern Red Sea. It appears none of these more recent events of activity in the region have posed threat to Massawa city, or met magnitude ranges equivalent to the quakes of 1884 and 1921. Through a review of the structural outlne; the conclusion is that the perception of the seismic hazard could still be regarded high. This if one takes into consideration the national importance of present day Massawa in terms of lifeline utilities present, and in some areas regarding the construction methods used.

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1. Introduction

1.1 Background

Earthquakes becomes a hazard when it through primary or secondary effects pose threats to humans or human activities. Earthquakes of course vary both in intensity and distribution, thus they occur in regions as well in size , where the effect and outcome do not pose such threat.

Understanding the occurrence of natural earthquakes in a geographical context, one must have an insight to the geological background to understand a relationship between the spatial distribution of seismic events, and the region in which they frequent. It has to be stated that though earthquakes can be the result of many different factors, most are of natural processes which occur within the lithosphere.

A common earthquake is the result in an abrupt release of elastic strain accumulated in bedrock. The internal strength within rock, or the frictional resistance between blocks of previously fractured rock in relation to the amount of strain implemented, is what decides time until- and size in an oncoming offset. The point of rupture is considered the earthquakes origin and is identified as the *focus* or *hypocenter*. When rupturing, accumulated strain within or between the blocks of rock is transformed into released energy. The energy leaves the point of rupture in form of seismic waves and these will cause an impact, depending on the amount of energy released, the type of seismic wave, and the medium in which they travel. This is what could cause the earth to quake. (*Kearny & Vine 1996, p. 8-10, Ogubazghi & Woldehaimanot 1998, p. 68-71*)

Earthquakes of natural origin are commonly divided into two groups, tectonic driven and those of volcanic origin. According to Kearny and Vine (*1996, p.76*), a view upon a global distribution in earthquake *epicenters*, the point at the earth´s surface right above the focus, one could roughly define boundaries between tectonic plates, and Ogubazghi and Woldehaimanot (*1998, p. 5*) states that up to 90% of all natural earthquakes are those of tectonic origin.

Earthquakes of tectonic origin is the result of stress built up by the same forces that cause the relative movement of tectonic plates, thus earthquakes are common features in margin areas and for example around zones of plate divergence, convergence or strike-slip motion. Though most earthquakes actually occur in the vicinity and/or along margins of large-scale tectonic features, the presence of intra-plate earthquakes concludes that natural seismic events by no means are bound to such areas. (*Kearny & Vine 1996, p.78*)

Natural intra-plate earthquakes can have a tectonic origin as stress in plate interiors could derive from its margins spread horizontally, or vertically driven by a regional rise in the underlying asthenosphere. (*Weiran, Zuoxun, Dewei, Jishan, Jie & Wenxing 2009*). Earthquakes on plate interiors could as well be a result of volcanism, though areas of volcanic activity are often found along margin-areas and plate boundaries.

Volcanic driven earthquakes is considered of different nature but have similar characteristics as those driven by the mechanisms of plate tectonics. Eggert and Walter (*2008*) states there are indications on a relationship between tectonic earthquakes and volcanic activity. Though the origin of stress built up in rock in the case of volcanic seismicity is often a result of migrating magma, inflating chambers and dikes, which creates and accumulates strain and further could cause sudden rupture of surrounding bedrock. Sequences of seismicity around volcanic centers are thus often a precursor to an oncoming eruption at the site (*Roman & Cashman 2006*).

1.2 Area description

The area studied; constituted by Eritrea and its adjacent coastal waters, is located on the north-eastern peninsula of the African sub-continent known as Africa´s horn (figure 1). Liberated in 1991 and internationally recognized as a sovereign state in 1993, Eritrea on the political map shares its national boundaries with the countries of Sudan, Djibouti and Ethiopia. Across the Red Sea-divide it borders Yemen and Saudi-Arabia.

According to the National Statistics Office of Eritrea, the country host an estimated population of 4,106,168 inhabitants (population figure as of 2010), and according to FAO (*web; 2011*) it is by land area constituted of approximately 124,000 km^2.

Located in the Sahel-region of Africa largely presenting a semiarid climate, climatic changes with topography relates to a population divide where Eritrea largely present higher concentrations in the less dry highland-areas. The topography of Eritrea presents a steep gradient with elevation ranging from areas below sea level to up to 3000 m s l. After the physical outline, the country have been commonly divided into three sub-regions; the central highlands and the eastern- respectively western lowlands.

Eritrea acts the northernmost outpost of the East African Rift-system, also known as the *Great rift valley*, and with its approximate 1.000 km long coastline it borders the Red Sea. When located, in terms of plate tectonics; *a triple-junction area*, where the East African-, the Red Sea- and the Gulf of Aden-rifts meet, the country face presence of associated phenomena such as events of volcanism and seismic activity.

Overlooking figure 1, the region in the African context stands out as one of the most probable to be struck by destructive earthquakes on the continent.

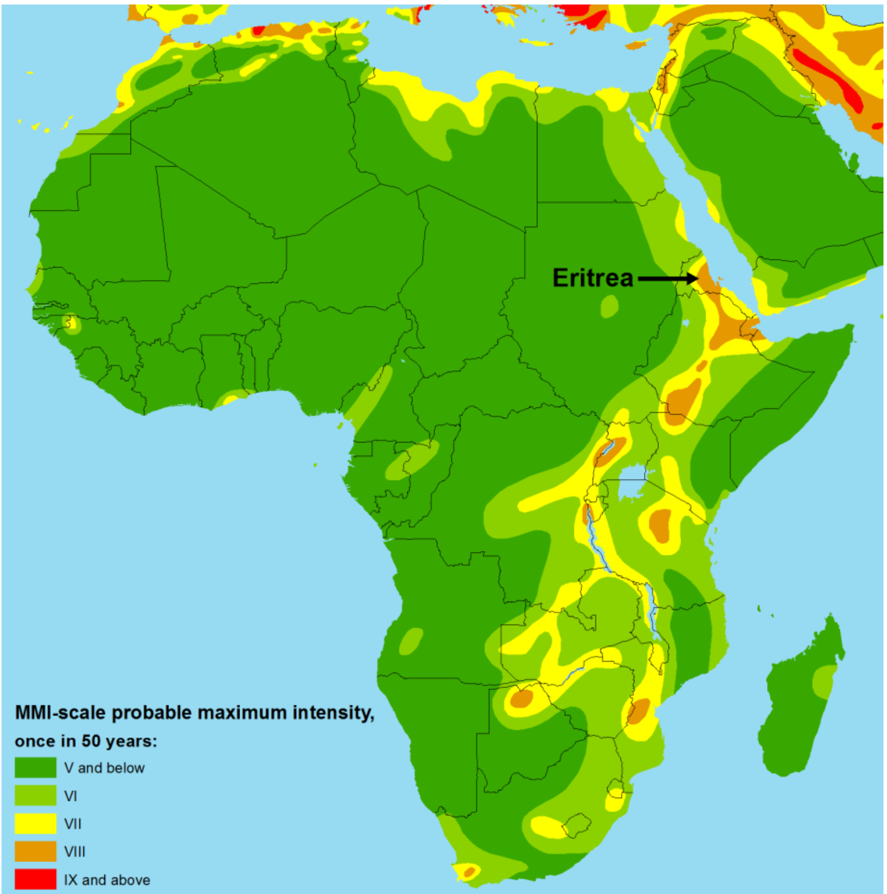

Figure 1. Zoning of Africa after the 1956 version of the Modified Mercalli Intensity-scale, data based on the 1988 Munich Re publication; *world map of natural hazards*.

Thus, the country does have a history of earthquakes, some with severe outcomes considering damage to the built environment as well as loss of human lives.

Tough Eritrea's location in a seismic prone region and earth-tremors historically have frequented the country, damage and destruction caused by earthquakes seem to have been rather uncommon and events recorded instrumentally mainly seem to fall in minor- up to moderate-magnitude ranges. More so, areas actually affected by tremors and the locations of estimated epicenters seem in general to be constituted by either adjacent coastal waters, or sparsely populated arid lands perhaps of less interest in the viewpoint of human settlement or future development.

Despite above, the port town of Massawa is in the Eritrean context somewhat of an exception. While there is instrumental recordings of earthquakes adjacent to-, and historical reports on earth-tremors from other Eritrean population centers (see appendix 1), none seem to have faced a seismic hazard in terms of damage and destruction comparable to that of Massawa.

EARTHQUAKES IN ERITREA.

People Are Killed and Houses Collapse—Italy to Send Aid.

ROME, Aug. 16.—Serious earthquake shocks are reported from the Italian colony of Eritrea, on the African shore of the Red Sea.

A telegram from Asmara, the seat of the colony, says that four persons have been killed and a score injured at Massowa on the Red Sea coast. Several houses have collapsed and others have been damaged in that town, while other casualties are reported from nearby places.

The Italian Minister of the Colonies has ordered that aid be immediately dispatched to the scene of the earthquake.

Figure 2. Newspaper notice on the 1921 Massawa earthquake (web: New York Times, 2011)

Located along one of the world's busiest waterways regarding trade, the natural deep-water port of Massawa is situated approximately on latitude 15.6° N, longitude 39.5° E at the south wester-section of the African Red Sea-coast. (*the cultural assets rehabilitation project (CARP) 2005, p.16*)

Present day town of Massawa is constituted by the islands of *Massawa*, *Tualu*d and the adjacent mainland area as well as the uninhabitated island of *Sheikh-Seid*. The inhabitated parts of the city is linked by causeways connecting the outermost island of Massawa to Tualud, and Tualud back to the mainland.

Eritrea supports a policy of decentralization and is, since the 1996 reconstruction of a former provincial divide, today constituted by six separate administrative regions. (*web; Eritrean Embassy Stockholm, 2011*)

Massawa is capital city of zoba Semienawi Keih Bahri, *Northern Red Sea-zone* (figure 3). The region cover Eritrea's northeastern lowlands and coastline from the national boundary with Sudan in north-west, toward the northern outpost of the *Danakil*-depression and regional boundary with *Debubawi Keih Bahri* in south-east, including islands of the *Dahlak*-archipelago. Inland, the region is westward flanked by the central highlands stretching from the national boundary with Ethiopia in south-east, along regional boundaries with the *Debub*, *Maakel* and *Anseba* towards the Sudanese border in north-west.

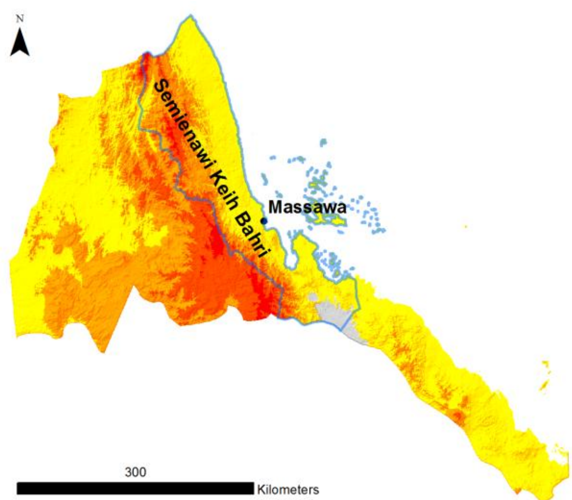

Figure 3. Location of Massawa and approximate regional boundaries of Semienawi Keih Bahri

By area, Semienawi Keih Bahri is Eritrea's second largest region and by population, at an estimated 691.281 inhabitants (considering figures of 2006) it hosts an approximate 16 percent of Eritrea's total population. The town population of Massawa for the same year was 45.798 which count for about 6.6 percent of the regions total population. (*National Statistics Office*),

Compared to more densely populated central highlands of Eritrea, low population figures of Massawa and Semienawi Keih Bahri are probably due to the region largely made up of the eastern lowlands, coastal areas and island hosting a considerably more arid climate. For traditional pastoral and nomadic cultures of the region, historically these ha e probably provided little natural resources to base a livelihood on beside those found at sea. (*Eritrea profile 2011*)

The reason for choice in area of study is due to above historical impacts of seismic activity and the fact of Eritrea being a young nation, twenty years as of 2011, which have left a small time-frame for previous research on the subject in the region. Its also partly due to Eritrea being a developing country, that is a criteria under the Minor Field Studies-scholarship I was granted and has helped fund the study.

1.3 Issues and purpose of study

The object is to give a view of earthquake occurrence, frequency and spatial distribution within Eritrean territory and adjacent south western-section of the Red Sea.

The viewpoint in this thesis is on earthquakes in a hazard perspective and as case focus is brought towards the city of Massawa and its relation to the geographical distribution of seismic events.

The intent is to:

- define the spatial distribution, frequency and magnitude of seicmic activity, considering a period of the last 50 years, within Eritrean and the adjacent section of the southern Red Sea.

- determine causes in this geographical distribution, identify patterns and potential seismically active geological structures.

- Regarding the seismic hazard; identify vulnerable elements and structures in present day town of Massawa.

1.4 Delimitation

The intent with this thesis is to describe and consider natural earthquakes in order to give a picture in the geographical distribution of the same in the area of study, the intent is thus not to give a more thorough explanation on driving-mechanisms behind seismicity in the specific area and processes causing this. Further, the presentation of Massawa and its structural outline regarding the hazard of earthquakes is only intended to give a brief description in common vulnerable construction methods- and lifelines present.

2. Methodology

As part of the study I spent the period between the 16th of April to the 29th of May 2011 in Eritrea for field research and to retrieve first hand data from on-location sources. The process included collecting data on seismic events, selecting relevant information (considering events within the area of study), including digitizing data when interpreted from written material and finally made presentable in cartographic material.

As overview of Massawa´s structural environment, a visual identification in common construction methods and lifeline utilities present have been made.

2.1 Seismic data

Collected and and further processed data on seismic events, besides data retrieved from the Eritrean network, has been retrieved through following processes; ISC data was accessed through a search in the ISC on-line bulletin(http://www.isc.ac.uk/search/bulletin/index.html), data from the PDE-catalog was retrieved through a search in the USGS/NEIC (PDE) 1973 - 2011 06 30 database (http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_rect.php) and seismic data from the GCMT-catalog has been retrieved in Global CMT Catalog Search (http://www.globalcmt.org/CMTsearch.html).

Searches in each database were made with the following premises;

ISC:

Bulletin type; comprehensive, format; GSE 2.0. Time-frame; 1961/06/20 00, up to 2011/06/20 00. Rectangular area; latitude 12°N, latitude 18°N, longitude 36°E and longitude 44°E. Magnitude type; mb.

PDE:

Format; spreadsheet. time-frame; 1961 06 20 to 2011 06 20. Rectangular area bound by; latitude 12°N, latitude 18°N, longitude 36°E and longitude 44°E. Since the online database doesn't cover events prior to 1973, data have been added using *CGS* (U.S. Coast and Geodetic Survey, a USGS/NEIC predecessor) entries present in Gouin (1979) counting from 1961 – 06 – 20 up to 1973.

GCMT:

Moment magnitude: 0 <= Mw 10 <=, Surface wave magnitude: 0 <= Ms 10 <=, Body wave magnitude: 0 <= mb 10 <=, Latitude: (degrees) from 12 to 18, Longitude: (degrees) from 36 to 44, Depth: (kilometers) from 0 to 1000. Output type: GMT psvelomeca input. Mw have been manually added the list after reading given events in a second search with above parameters, besides output type where *full format* was chosen.

2.2 Geographic Information System

The spatial distribution of seismic events have been plotted using the ArcGIS-software. *Geographical Information Systems* are computer based software created for the task of managing and handle data with a geographical refrence.

The location of seismic events have been plotted using the Greenwich-coordinate system , this after coordinates either given from source, or determined using the SEISAN-software. The WGS84 refrence-system was used.

All seismic events retrieved from above sources were singled out using ArcGIS via the geographical references given so the display only regards events within the area of study; Eritrean territory including events approximately ~2,5 km adjacent to the national boundary, as well as adjacent coastal waters to an approximate Red Sea-median line.

Seismic events are displayed upon a topographic background based on the ASTER Global Digital Elevation Model, in order to visualize the structural outline of the study area and the regions where seismic events frequent. A 1° latitude by 1° longitude-grid is displayed in order to more precise visualize the geographical distribution in between the maps. Further, all maps beside figure 1 and figure 4 are displayed in a WGS84; UTM-Zone 37N projection.

2.3 SEISAN

Seisan is a computer based software created for the task of analyzing earthquake data, such as locating earthquakes and plotting epicenters. Data retrieved on location in Eritrea considering seismic monitoring stations of Abesalama and Asmara have been analyzed and given new locations and magnitudes considering a pre-programmed model in the software.

After located in SEISAN, events have been plotted and a selection considering only events withind in the area of study have been made in ArcGIS. Events recorded by Eritrean monitoring stations where data was insufficient regarding amount of seismic phases recorded or monitoring stations recording them, was unable to locate by the program and is not considered.

3. Results

3.1 Volcanic- and regional tectonic framework

The region around Eritrea presents three large scale tectonic features which all are known to originate seismicity; The Red Sea-, East African- and Gulf of Aden rifts. These features meet in a trans-boundary area labeled the *Afar triple-junction*(figure 4), partly located within Eritrean territory. (*Kearny & Vine 1996, p. 224-225, Ogubazghi & Woldehaimanot 1998, p.21, Ogubazghi, Ghebreab & Havskov 2003*)

The Red Sea rift, mainly centered on the Red Sea floor, is the axis of spreading in between the divergent tectonic plates of Arabia and Africa. The whole of the Red Sea basin is by Ogubazghi and Woldehaimanot (*1998, p. 10, 18-21*) described a *graben*-structure, and the current area active where seafloor-spreading takes place is bound to a much more narrow axial through located in the southern section of the ocean approxinatley located between latitude 15° N and 20° N. (*Ghebreab 1998*)

Oceanic rifts or ridges are commonly associated with zones of either *transform*- or *transcurrent* faulting. On ocean floor such features could often be easily identified on bathymetric maps in association with large-scale fracturing, displayed as linear features of depression, running perpendicular to the ridge and along the direction of spreading. Such features could in places be even more easily identified where they offset the ridge by great distances. Fracturing will develop along lines of weakness in the crust, and have been suggested to derive from either an initial rifting process in the development of the ridge, changes of direction in spreading, or locational changes of spreading along the ridge (*Kearny & Vine 1996, p.118,119, 122-128*). According to Ogubazghi & Woldehaimanot (*1998, p.21,30-31*) there are indications of such perpendicular faulting in the southern Red Sea and sequences of seismic-activity have been suggested to derive from this.

The East African rift system is located through the eastern section of the African continental plate from the Afar triple junction running SW-ward parallel to the eastern coast of the continent. It's the boundary between what has been labeled the *Nubian*- and the *Somalian*-parts of the African tectonic plate . Though rates of spreading and direction may slightly vary along the rift (*Stamps, Calais, Saria, Hartnady, Nocquet, Ebinger and Fernandes 2008*), the northernmost section of the system adjacent to the Afar-triple junction and the area of study, does present divergent movement, crustal extension and associated seismic activity. (*Ogubazghi et al. 2003*)

While present, and a major feature concerning seismicity in the region, the Gulf of Aden-rift does not enter Eritrean territory or the area of study. Like the Red Sea rift it is an oceanic ridge, presenting a divergent boundary between the Somalian section of the African plate and the Arabian tectonic plate.

Seismicity associated with oceanic ridges, and areas of plate divergence in general, is commonly identified by shallow events either bound to the ridge-crest in association with extensional faulting, where forces of separation accumulate great stress as the plates accrete, or to trans current- or transform faulting in association with fracturing running in line of spreading. *(Kearny & Vine 1996, p.77, Ogubazghi & Woldehaimanot 1998, p.10*)

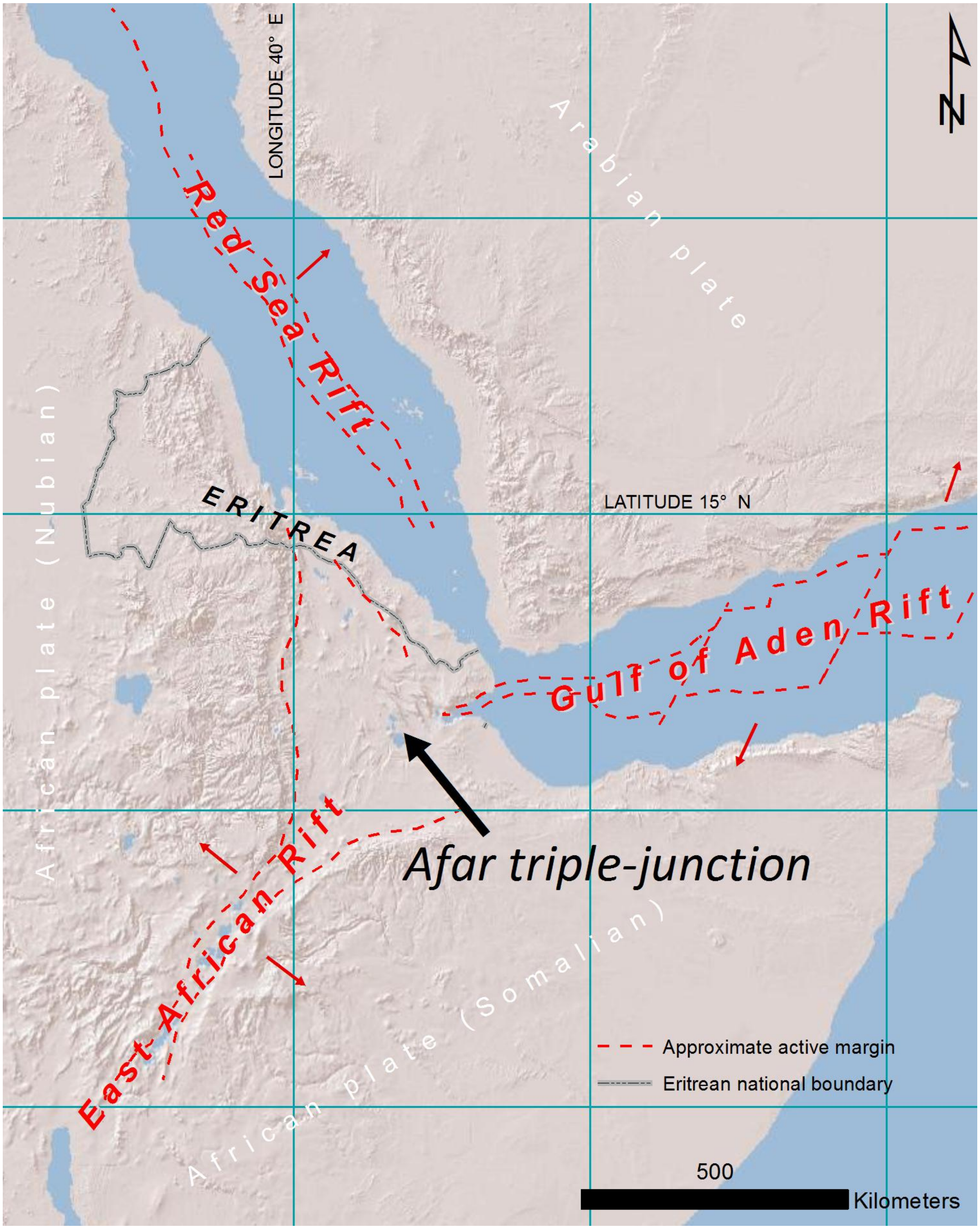

Figure 4. Eritrea´s location on *Africa's horn* and relative location to the Red Sea-, East African and Gulf of Aden rifts. Arrows along margins indicate an approximate direction of spreading (after *Ghebreab 1998)*

Large-scale regional tectonics aside, looking at historical as well as more present studies, there are a number of minor geological structures identified as have been generating earthquake activity in Eritrea.

Figure 5. section of the north eastern scarp of the Sabarguma graben, along the Asmara-Massawa road, 2011

Ogubazghi and Woldehaimanot (*1998, p. 25-26*) and Gouin (*1979, p. 30, 50,51 & 69*) both states that seismic activity in historical time has been identified originating along the *Sabarguma-graben* and the *Nakfa-faults,* located along central- respectively north western-parts of Semienawi Keih Bahri (figure 6).

The *Massawa channel,* located off coast approximately between Massawa and Dahlak Kebir , has on several occasions been inferred as an area originating earthquakes. *(Gouin 1979, p.97, 98, 103, 108, 109, Ogubazghi & Woldehaimanot 1998, p. 24*)

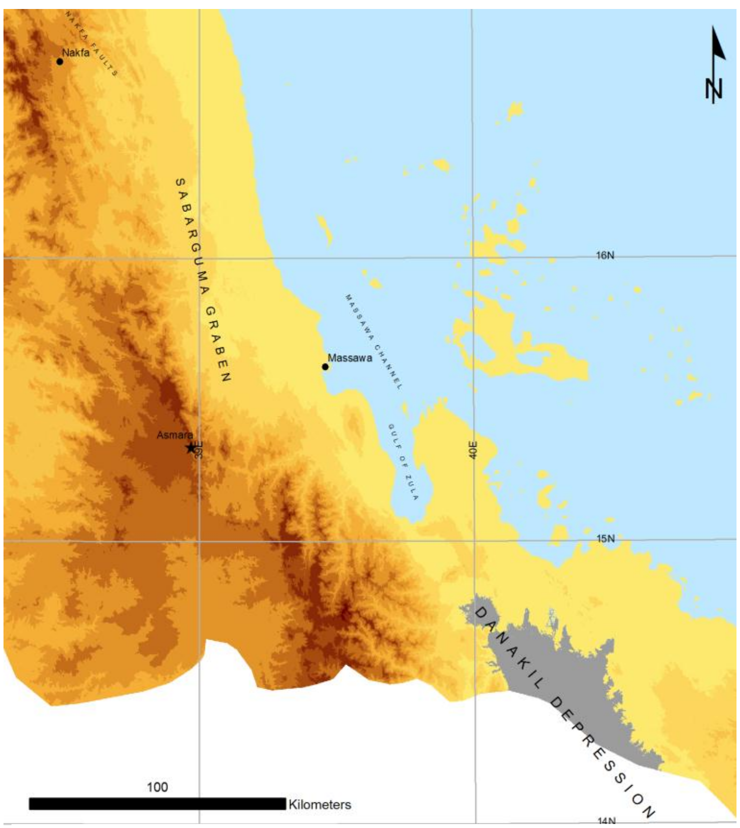

Figure 6. Approximate locations of geological structures

Ogubazghi et al. (2003) cover a sequence of seismic events in the moderate magnitude-range in the region around Bada in 1993, located on the north western outpost of the Danakil-depression.

The Danakil-depression in turn, approximately in line with the Gulf of Zula graben-structure as well as the Massawa channel and the volcanic area around Alid (figure 6 and 7), is considered a zone of crustal extention and spreading described a rift-jump feature part of the Red Sea rifting system. (*Ghebreab 1998*)

Fumarolic-activity aside, considered dormant and without evidence of an eruption occurring in historical time, P. Gouin (*1979, p.106-107*) does present reports on a series of tremors occurring between 1901 and 1902 originally interpreted as activity at and around the volcano of Alid.

The supposedly dormant volcano of *Nabro* erupted on June 12, 2011. Adjacent to this event, several earthquakes was recorded, the strongest reaching a magnitude of 5.7. Prior to the 2011 Nabro eruption, the only considered conclusive evidence of a volcanic eruption in historical time in Eritrea was dated to 1861. (*web; NASA & Shabait, 2011*)

The event of 1861 at *Dubbi*, labeled the single largest historical volcanic eruption on the African continent by Wiart and Oppenheimer (*2000*), was according to Gouin (*1979, p 98-101*) preceded and followed by sequences of earthquakes, some reported felt as far as Massawa approximately 340 kilometers away. Tremors are reported to have been present in the area for up to four months prior to the eruption(*Ambraseys, Melville & Adams 1994, p.70*). Further there exist, though considered inconclusive, reports on previous eruptions at Dubbi in the year of 1203 as well as in 1400.(*Ambraseys et al. 1994, p.39, 47, Gouin 1979, p. 93*)

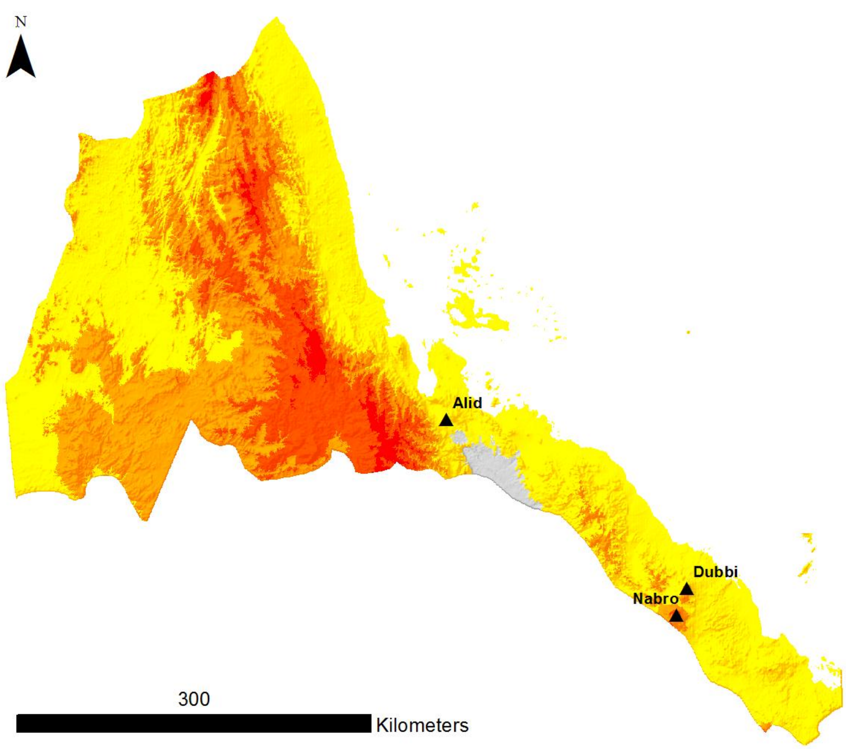

Figure 7. Location within Eritrea of volcanic-ranges where reports on, or presumable seismic activity, in historical time have been present.

Though volcanic peaks and calderas are rather common geomorphologic features in areas of Eritrea´s eastern lowlands, historical reports and documentations on volcanic activity from this area are sparse and nothing points to events of volcanism have been frequent in Eritrea during historical time.

Identified areas of potential activity seem restricted to volcanoes of two trans-boundary ranges (figure 7).

One, as previously mentioned, located along an axis of spreading (*Lowenstern, Janik, Tesfai & Fournier 1997, Ogubazghi & Woldehaimanot 1998, p. 22,23, Gouin 1979, Figure. 69*) enter the administrative region of Semienawi Keih Bahri via the Danakil depression, is in the Eritrean context constituted by *Alid*. A second range is located along a transverse fracture (*Ogubazghi & Woldehaimanot 1998, p.33, Gouin 1979, Fig. 69*), cross the administrative region of Debubawi Keih Bahri, is in the Eritrean context constituted of the area around volcanic peaks *Dubbi* and *Nabro*.

3.2 Spatial distribution of seismic events

Seismic activity and earthquakes is instrumentally monitored via equipment able to pick up and register the seismic waves released when a quake occur, though such instruments are only able to recognize an event if the amount of energy released at the events is enough to make travelling waves reach the location of the monitoring station. (*Båth 1970, p.53*)

Accessing conclusive data and records on seismic events considering the specific region and Eritrea from the early years of instrumental monitoring is difficult, partly due to limitations in early monitoring equipment, often found at distant locations, as well as loss of local records from the earliest seismic monitoring stations in the region (*Ogubazghi & Woldehaimanot 1998, p. 92-93*)

For an historical overlook and distribution on seismic activity in Eritrea, Gouin (*1979, p.189-238*) present an extensive catalog including historical reports on tremors as well as instrumental recordings regarding activity in the horn of Africa with entries dating from 1400 and up to the 1970's. an Intrepetation of this catalog covering events in the area of study is considered in appendix 1.

Overlooking the data present in Gouin (*1979*), see Appendix 1, documentation on seismic activity in Eritrea have a history stretching over a hundred years back. Prior to independence, Ogubazghi and Woldehaimanot (1998, p.92) concludes that instrumental monitoring was conducted in Eritrea in as early as 1913, and from 1980 and forward the former University of Asmara did, though not continuously, keep an instrumental record.

Post Eritrean independence in 1991, a national network of monitoring stations has been developed (figure 8). The ASME-station in Asmara was the first operating in 1992, followed by ABSE (Abaselama) in 1998, SHBE (Sheeb) 2003 and GELE (Gelaalo) 2004.

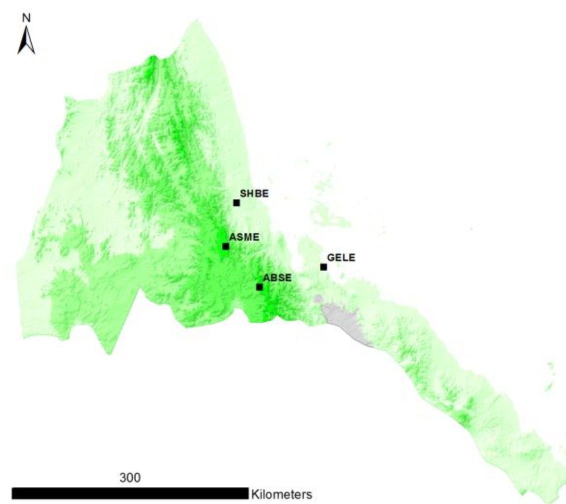

Figure 8. Location of monitoring stations in the Eritrean network, stations are labeled by their international code.

Considering data on recent earthquakes in Eritrea, there are catalogs provided with readings on seismic activity by wide networks of monitoring stations and agencies. Thus to an extent, many consider listings of seismic events in a global scale.

The *International Seismological Centre* (ISC) keep a catalog on seismic events, provided with data by several agencies across the globe (*web: ISC 1, 2011*). Figure 9 shows the spatial distribution of seismic events in the study area based on the ISC catalog considering a fifty year period between 1961/06/20 and 2011/06/20, appendix 2 give the data.

The *Preliminary Determination of Epicenters* (PDE) catalog, assembled by U.S. Geological Survey(USGS), National Earthquake Information Center(NEIC) and their predecessors, is considered a preliminary catalog since information and data on events in this is further contributed to the ISC and their bulletin, which is considered the most final catalog. (*web: USGS 4, 2011*)

Figure 10 shows the spatial distribution of seismic events in the study area based on the PDE catalog considering a period between 1961/06/20 up to 2011/06/20, and appendix 3. give a list of data used.

Considering local source, provided with seismic-data in *Nordic*-format (*web: ISC 3, 2011*) on readings from Eritrean seismic monitoring stations in *Abesalama* (ABSE) and *Asmara* (ASME) which covered, though not a continuous, period between 1999/01/05 and 2003/12/23. Annual datasets have been created after selections of events, the outcome concern periods during 1999 and 2001. Epicenter and magnitude have been re-determined through computation of data provided, using the *SEISAN*-software version 8.2.1. (*web; Universitetet I Bergen, 2011*) The outcome and spatial distribution of the events are given in figure 11 and 12 , data used is present in appendix 4 and 5.

In order to determine location of seismic events, preferably one would use data from stations spatially distributed well in and around the area given, this to increase both locational accuracy and the coverage of events, and traditionally when locating seismic events based on the different travel-times of seismic waves, a general minimum of readings from at least three stations is used. (*web; IRIS, 2011*)

Single-station location of seismic events can be accomplished when a station is capable of so called three-component reading. Combining both vertical- and horizontal data on arriving phases of seismic waves, a direction of the same can be determined. (*web; Department of Energy - Office of Scientific and Technical Information, 2011*) Readings from ABSE and ASME in data used consider single-component, locating events using data from two single component seismographs has in this case been made possible via an estimated and “artificially” added case specific approximate azimuth to seismic-phases recorded.

The GCMT; Global Centroid Moment Tensor Database –catalog contains re-computations of global events, for example often found listed in the PDE catalog, after their specific model. The catalog mainly cover those above magnitude (M_w) 5.0 and doesn’t concern events prior to 1976. (*web; GCMT and USGS 3, 2011*)

Figure 13 gives the spatial distribution and moment magnitude, Mw,of events considering a period between 1976 and 2011/06/20 in the area of study based on GCMT-data, appendix 6 gives data used.

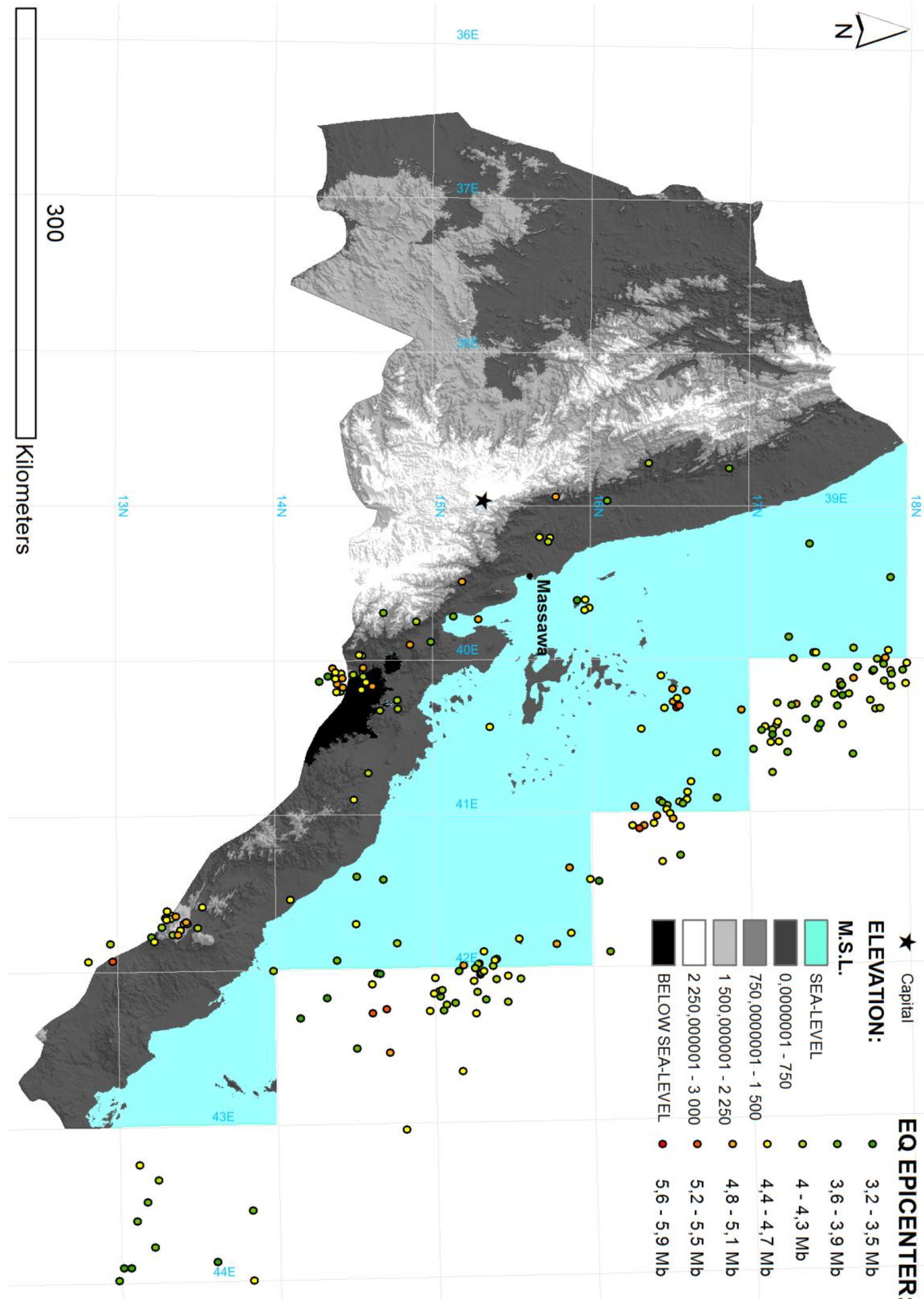

Figure 9. Map giving the spatial distribution of seismic-events in the area of study based on entries from ISC.

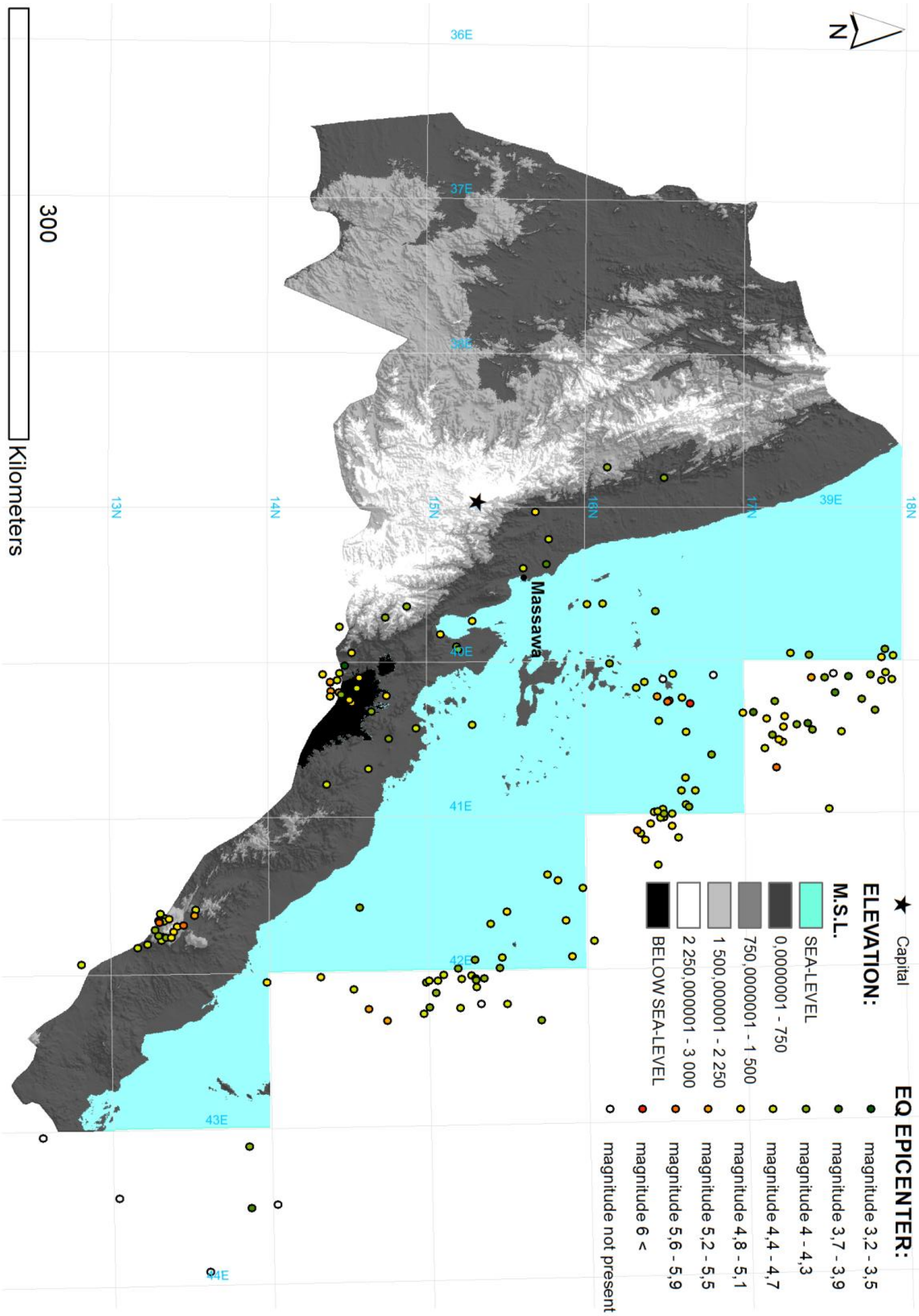

Figure 10. Map giving a spatial distribution of seismic-events in the area of study, based on PDE-data.

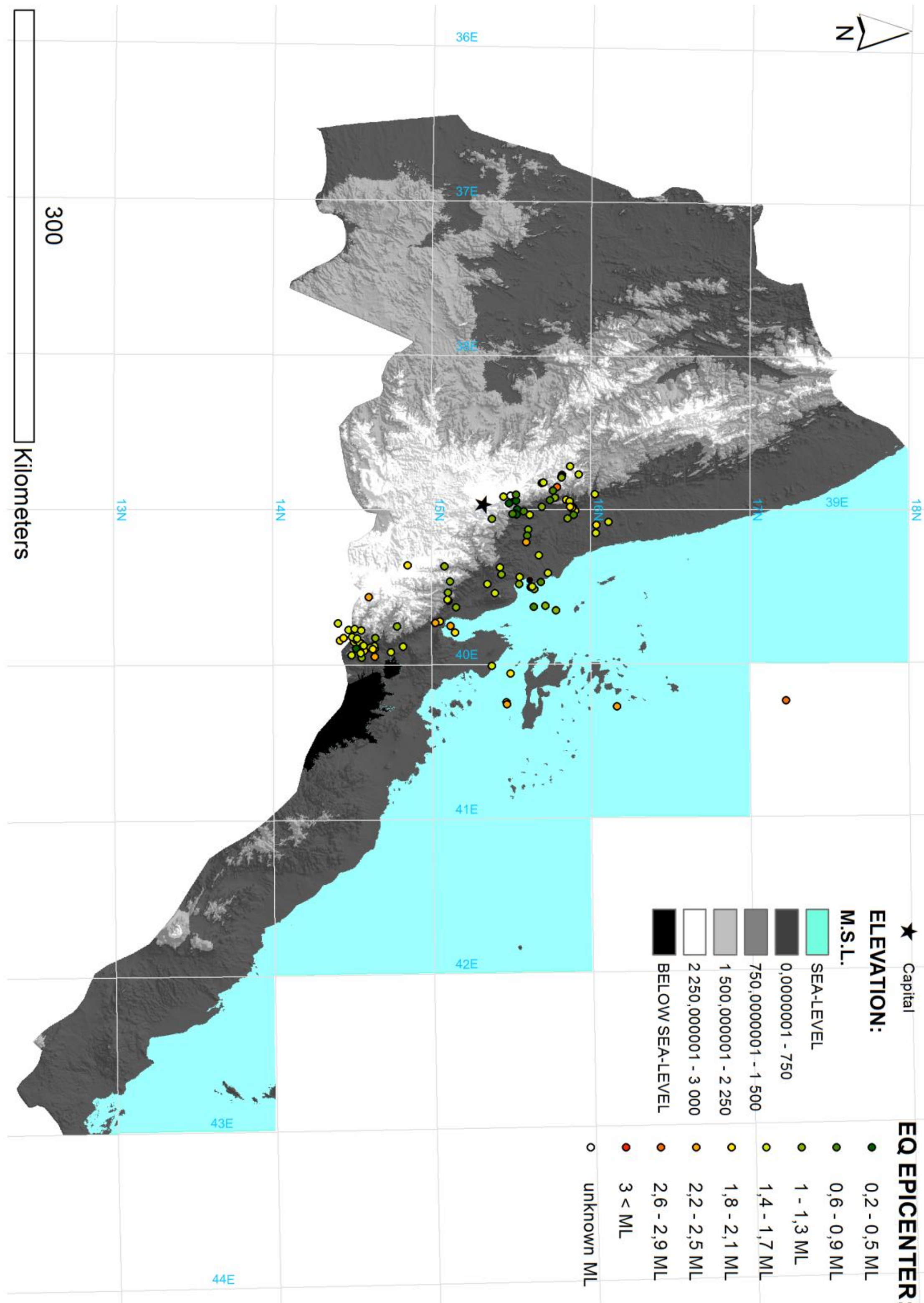

Figure 11. Spatial distribution of events after calculations on epicenters based on data from ABSE and ASME during 1999

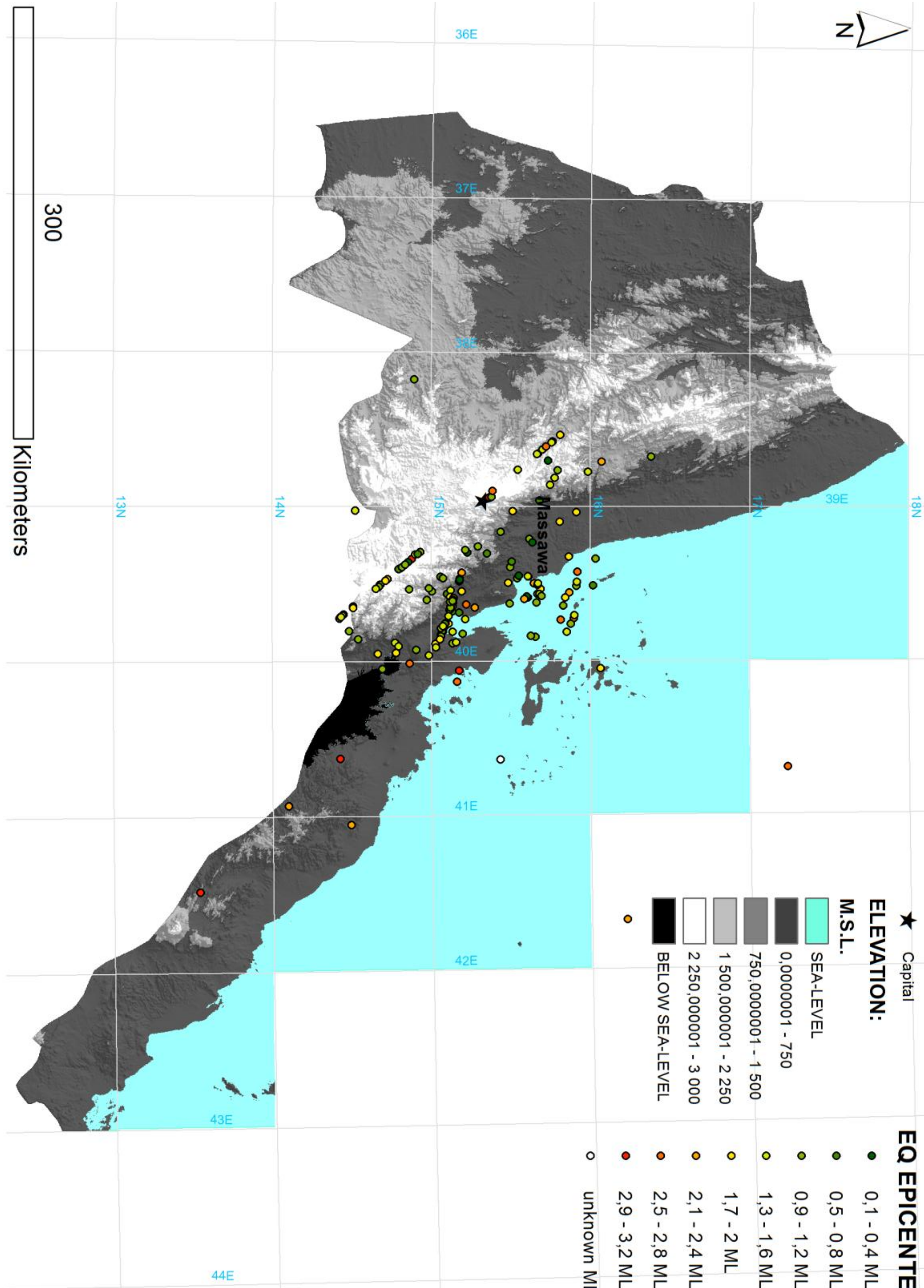

Figure 12. Spatial distribution of events after calculations on epicenters based on data from ABSE and ASME during 2001

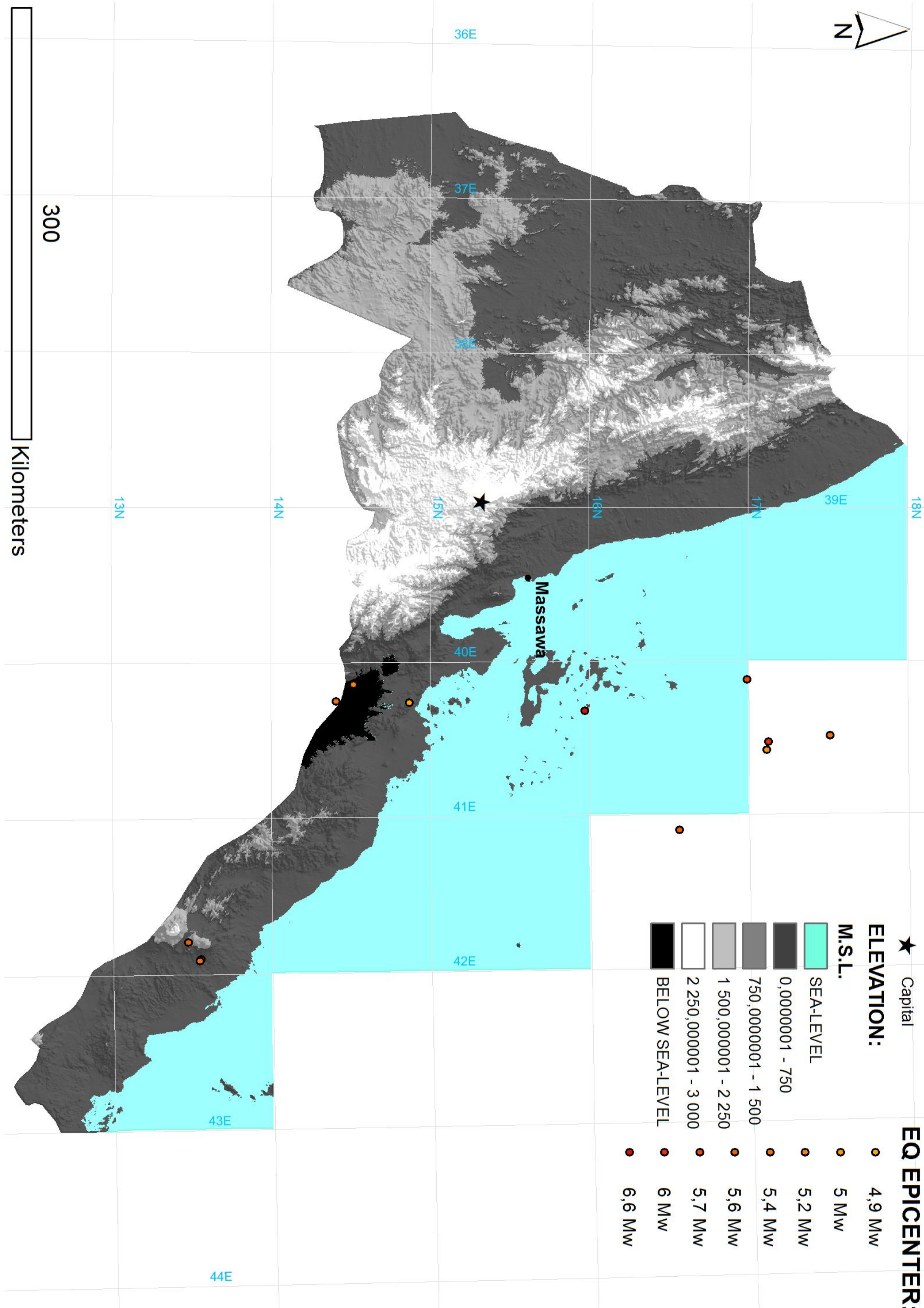

Figure 13. Distribution of seismic events based on data from GCMT

3.3 Magnitude and frequency

The amount of energy released at seismic event is commonly measured in magnitude, and the size of an earthquake is often defined by either its body-wave magnitude (m_b) or surface-wave magnitude (M_s). The size can also be defined in local-magnitude (M_L) or moment magnitude (M_W). The different magnitude-scales doesn't run parallel and a single quake would be given a different value depending on scale used. (*Båth 1970, p.96-99 and web; USGS 2, 2011*)

Data retrieved from eritrean monitoring stations ABSE and ASME for periods of 1999 and 2001 (appendix 4 and 5) concludes that the amount of seismic events recorded annually, with an estimated epicenter located within an area covering southern parts of Semienawi Keih Bahri as well as adjacent coastal waters and central highlands, would exceed more than a hundred. A majority of these events consider micro-seismic events. Comparing this with the PDE and ISC data, there are only four events listed in the whole area of study during the years of 1999 and 2001 respectively in the data retrieved from the ISC-bulletin and considering data retrieved from the PDE-catalog, only two events for 1999 are displayed, none for 2001.

Note that neither PDE or the ISC bulletin claim some sort of uniform coverage of all earthquake events, and there are magnitude thresholds present in both catalogs. Considering data used and events displayed in the figures, m_b 3.2 for the ISC and magnitude 3.5 for the PDE are the smallest events present. (*web; ISC 2 & USGS 1, 2011*)

According to USGS, It's the "preferred" magnitude given on entries in the PDE-catalog, thus magnitudes present in the data could vary and magnitude values among entries could consider M_L,M_W, m_b or M_s. One can assume its m_b given in many cases since overlapping PDE (CGS) entries in Gouin (*1979*) and data from USGS/NEIC used in most cases state this.

Studying the frequency of earthquakes in a specific area, a relationship between the amount of energy released among seismic events and amount of events in a given time-period can be identified. The specific relationship for a region can be calculated and determined via a mathematic formula. Widely recognized as the *Gutenberg-Richter law*, in short it states that in a given area of study and time frame the amount of seismic events would increase, following a linear pattern, as magnitudes on events dropped. (*Båth 1970, p. 119-122 & web; Edinburgh Earth Observatory 2011*)

That the amount of small earthquakes is greater than large is concluded by *BCIT (web; 2011)*, stating that the occurrence of a magnitude 8 or greater earthquakes is approximately one every 5- to 10 years globally, while the occurrence of quakes in the 5.5-6.0 magnitudes would count for up to 500 annually.

Looking at data used in above maps for seismic events in the area of study, Figure 14 and 15 give the magnitude distribution among entries in data used retrieved from ISC respectively the PDE, consider this regards *magnitude body-wave* in the case of ISC data, and PDE-data magnitudes given varies in between entries. Entries from the where magnitude isn't present are not considered in the charts.

Figure 16 and 17 give the energy distribution among events considering data received from ABSE and ASME-stations in the Eritrean network, regarding magnitude local and the given periods in 1999 and 2001 respectively. The charts consider all events located in SEISAN.

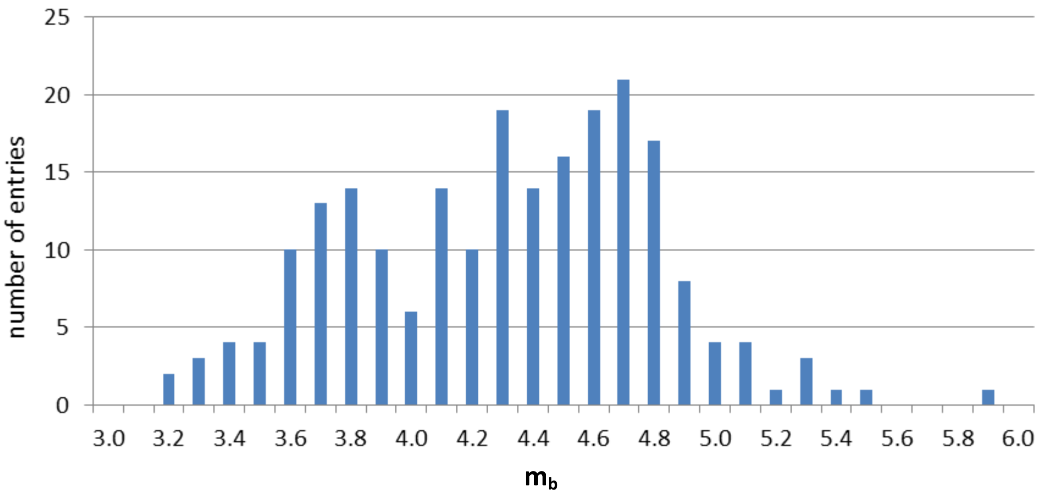

Figure 14. Energy(magnitude body-wave) distribution among entries in data retrieved from the ISC.

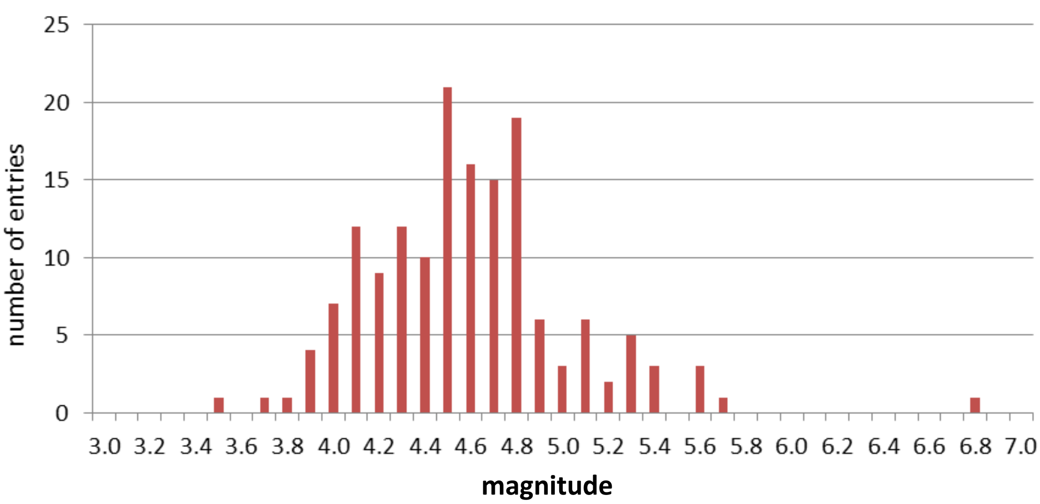

Figure 15. Energy (case preffered magnitude) distribution among entries in the PDE-data used.

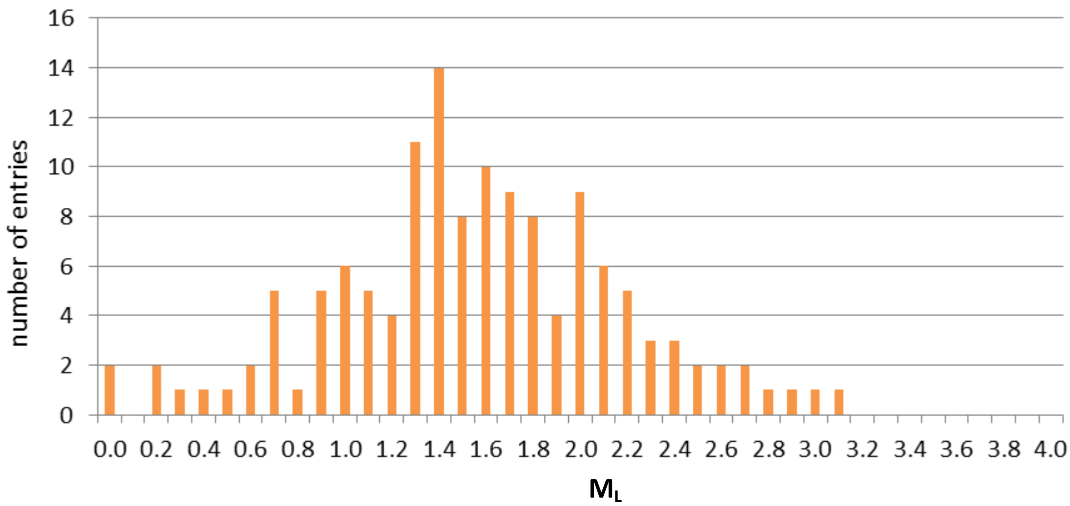

Figure 16. SEISAN determined energy (local-magnitude) distribution among events in data retrieved from ABSE/ASME concerning the year of 1999.

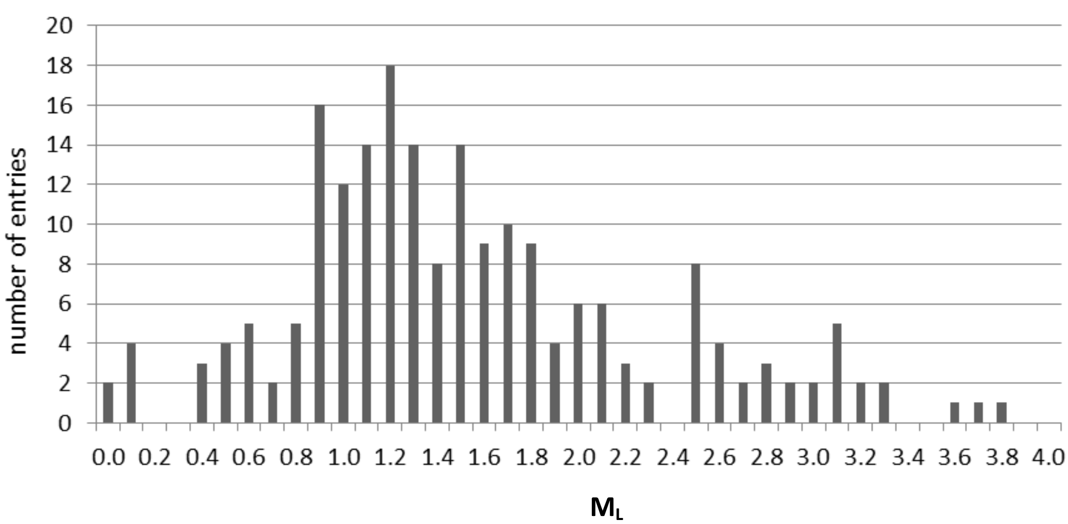

Figure 17. SEISAN determined energy (local magnitude) distribution among events in data retrieved from ABSE/ASME concerning 2001.

3.4 Massawa; vulnerable elements and the structural environment

Concerning the vulnerability of Massawas inhabitants regarding earthquakes, a common saying is that in the scenario of an earthquake; the shaking of the ground probably won't cause any casualties but buildings collapsing as a result of the ground motion could. Further to this of course one could add the potential presence of secondary effects such as landslides, tsunamis or fires, all known to be generated by earthquakes and could pose a threat to humans.

According to *ADPC Earthquake Vulnerability Reduction for Cities* (*web; 2011*) the structural designs that are most prone to collapse, and thus claim most lives when it comes to earthquakes, are those of masonry type. In present day Massawa´s case such material used in the structural environment would mainly concern brick or coral-stone.

Coral-stone mainly a building material used in structural development of Massawa during periods Turkish- and Egyptian reign and thus preceed 1885. These sturctures are mainly concentrated on the Massawa-island which, at the time, constituted most of the city. (*CARP 2005, p. 54-56*)

Figure 18. Egyptian style polished coral block-building, Massawa 2011

According to the Northern Red Sea regional museum, all present day buildings found on the Massawa-island and built in coral (figure 18), are post 1921 reconstructions since all buildings were either partly or completely destroyed by the earthquake. Due to safety reasons, those still standing was ordered to be demolished and rebuilt.

The use of brick in construction were later introduced during the Italian-period of reign, though the Italian administration favored to preserve the designs of previous colonizers, thus many brick-buildings in Massawa are also partly constituted by coral-stone.(*CARP 2005, p.57*)

Tualud-island is a section of the city which was largely developed by the Italian administration and thus have presented many structures in the material.(*CARP 2005, p.63*)

As result of the 1921 earthquake, the use of reinforced concrete in constructional methods were widely introduced, though the climatic environment Massawa presents have proven not to be very suitable, with a high rate of corrosion as result. (*CARP 2005, p.57, 64-65*)

More recent and many post-independence major development projects visible in Massawa´s built environment, residential, commercial and administrative, mainly consider reinforced-concrete structures (figure 19).


Figure 19. Construction in residential buildings, mainland-Massawa, 2011

vulnerable elements in present day Massawas structural environment, besides residential or commercial, could be services and infrastructure regarded essential in terms of the general function of the community.

Such services, commonly known as lifeline utilities, is considered vital since the community relies on them in order to operate. In hazard management these are a primary objective to identify and focus on protecting


Figure 20. Hirgigo power plant from Tualud island, Massawa 2011

During the 1998-2000 conflict, Ethiopian military-aircraft targeted Eritrean lifeline utilities located off assumed disputed border areas, thus the *Hirgigo power plant* (figure 20) located southeast of Massawa was, in May 2000, partly destroyed before full operation had begun. In production since 2001, the plant is currently Eritrea's main source of energy and, according to *ISC Consulting Engineers (web; 2011)*, the capacity of production could make up for more than twice of the previous existing capacity in the country.

Other such lifeline services found in Massawa would consider the port area which as one of two deep-water ports in the country, states the national reliance on its operational ability. As well as the *Massawa International Airport*, which, though current operational status is unknown, count for one of two non-domestic airports in the country.

Further there are precence of potentially large scale industrial facilities in the area, such as the *Gedem cement factory* and *Salina salt works*.

4. Discussion

4.1 Source criticism; seismic data, magnitudes and location of events

Regarding seismic data, a determination in location and magnitude of an earthquake is seldom considered final close in time to the event, and in some cases even for long periods after. This because re-computations often are made after different models, as well as new and supposedly improved methods and models are frequently introduced.

Considering above, the ISC-bulletin on earthquake-events since it's a latter publication probably should be generally regarded more accurate than the USGS(PDE). Even though ISC-data for up to two-thirds is constituted of that contributed by USGS(PDE).

Though events listed in data retrieved from the USGS(PDE) and ISC-databases most likely the result of cooperative work between global networks of seismic monitoring stations, the accuracy for entries regarding the area of study still should be questioned. The notable magnitude-minimum around 3, regarding events from both could be an indicator on the inability for monitoring stations used by USGS and ISC in covering events of smaller magnitudes in the area. An explanation for this would be that stations used are located at distances that limits them from picking up or retrieving sufficient data on smaller seismic events in the area, thus the preciseness in location of larger events might as well be affected.

Threshold on events listed aside; focal depth given on entries also indicates limitations in the instrumental sensitivity. One could for example question the accuracy of the very common depth of 10 km given entries, see appendix 2 and 3, in data retrieved from both USGS and ISC. Even if earthquakes in the region usually consider shallow events and this in no way is an extraordinary figure, the amount of entries that bears the very same indicates a lack in preciseness of the data.

The GCMT-data consider determinations on magnitude and location made after their specific model, thus the accuracy of this model is mainly what should be taken into consideration when reading figure 13. According to this seismicity related to the Nabro 2011 eruption, is for instance found displayed as more closely located around the volcano of Dubbi than Nabro.

Regarding data from the Eritrean network, the spatial distribution of seismic events in figure 11 and 12 cover shorter time-periods than the catalogs of ISC and PDE, and is based on readings from only two stations. Though locally based, this doesn't give a very uniform coverage considering Eritrea as whole, thus the area of study.

Data has further been given location and magnitude using the SEISAN-software, thus there are some aspects to take into consideration before reading figure 11 and 12. Magnitude and location has been given based on a pre-programmed model in the software. This model is general and not case specific, thus it doesn't consider parameters that could possibly affect the location of events such as local crustal characteristics of the region.

Further, data on events retrieved from the Eritrean network have been added an azimuth artificially in order to be able to locate events using only two monitoring stations. The azimuth added automatically give a location in the earthquake epicenter north east of a hypothetical line connecting ASME and ABSE. This assumption seems correct overlooking the location of events given in data from ISC and PDE, since no seismic events in this south west of such a hypothetical line. Thus the probability of seismic events originating in the central highlands or western lowlands of Eritrea should be considered quite small in comparison, though an general unprecence of larger seismic events shouldn't exclude a hypothetical precense of smaller.

The artificial azimuth given has further been refined until the location is as most precise possible. According to Dr. Ghebrebrhan Ogubazghi of Eritrean Technical Institute, locating events using this technique has been verified via felt quakes and its accuracy is considered good in a region concerning the greater Massawa-area located east in the middle of the presumed line connecting ASME and ABSE.

Thus the accuracy of events located north-west or south-east from this area in direction towards respective station are less precise and the trend-line of events connecting ASME and ABSE in figure 12 is inaccurate.

A majority of located events from the above sources, besides the obvious erroneous trend-line displayed in figure 12 either appear to follow some geological structure and occur in areas known of seismic activity. However all events displayed in the figures are probably not to be read as equal in terms of accuracy

Regarding coverage of events, as apparent in figure 16 and 17 there's a decline present among entries in data retrieved from the Eritrean network from around magnitude 1 and magnitude 1,4 respectively, upward. This could indicate a relationship between seismic events and energy released, thus the coverage of events during given years and the area is likely reasonable. Regarding figure 14 and 15, there appear to be no such obvious decline and linear trend among entries, though reading these one should bear in mind that this data concern a fifty year period, and as one can assume monitoring techniques most probably have been refined, as well as station networks widened since. Its thus not likely that an equally uniform coverage of seismic events for such a long continious period concerning the area present in the PDE- or the ISC-catalogs.

Figure 9 and 10 gives a overview in the distribution of minor- up to majpr-earthquakes(~magnitude 3 to 7) in Eritrea and the southern Red Sea during a fifty year-period, figure 11 and 12 give a picture in the distribution of seismic events given years covering micro- up to minor-seismic events (local magnitude 0.1 – 3.9), though in an area more narrow than above concerning most of southern Semienawi Keih Bahri and adjacent coastal waters. This data also appear to cover some larger events off this area, displayed in figure 12 with locations in SE Eritrea in the region of Debubawi Keih Bahri. Figure 13 only concerns moderate-, around M_w 5<, events and upward from 1976 and onward considering the same area as figure 9 and 10. One need to consider the different magnitude-scales used between the data from the different sources when comparing the figures.

4.2 Vulnerability of Massawa

Regarding Massawa in the context of being located in one of the most earthquake prone regions of Eritrea as well as Africa, as well as having a history of destructive earthquakes, building regulations regarding the structural ability to withstand a ground motion probably should be implemented.

Though there seem to have been no obvious signs of affection considering more recent seismic activity in present day structural outline. Newer buildings does most often present modern building-techniques and older buildings present appear to have resisted ground motion present.

It has to be stated though that harsh corrosive climatic conditions, as well as war where Massawa was the point of some of the most severe battles in 1977 and 1990 during the war of liberation, there are most likely some buildings in the city found in a condition maybe not the most suitable considering the earthquake hazard.

According to staff at the Ministry of Public Works in Asmara, the presence of earthquakes and the seismic hazard is kept in mind while planning, and this was said to be the reason for a current absence in constructioning high-rise building as well as a decision in less infrastructural development regarding certain specific coastal areas.

The question of a national building-code and specific earthquake resistant engineering was also said to have been raised at the national symposiums running prior to the twenty-years national anniversary 2011. Thus the subject of seismic-resistant engineering seem to be regarded a serious matter and expected to be at least further investigated by the local authorities.

Regarding the location of and lifeline utilities given in Massawa; the historical location of Massawa and the port appear to have origins in the natural conditions given at the site, where the Massawa-island provide a natural deep-water entrance. In a present day context, its location and its proximity to the populated parts of Eritrea it is strategically the only option in use as main port of the country. This considering that the only other deep-water option present is Asseb, is inaccessibly located approximately 450 kilometers off-road from Massawa in the sparsely populated south eastern parts of the country.

The reasons for the location in the Hirgigo power plant seem to be on logistical grounds concerning the access to the nearby port, as well as practical where seawater is used as coolant for the plant. As well as the efficiency and output of the plant considering that air in the area presents more oxygen and higher pressure in comparison to for example the highland areas. (web; *seriforum 2011*)

The project and construction of Massawa International Airport could partly be due to Asmara International Airport, as only international in Eritrea at the time, being targeted in the conflict of 1998-2000. A second option was needed since the airstrikes left the country standing without an international flight connection. Though one might get an impression that the specific area still wouldn't be the most suitable in Eritrea concerning the more recent construction in lifeline facilities such as the Hirgigo power plant and Massawa International Airport, the strategic value probably overweighs the potential effects from the present seismic activity. Relating these results to the grading of quake effects BCIT present (*web; 2011*), keeping in mind that proximities vary and intensity of course declines with distance from earthquake epicenters, general effects from seismic events in the magnitude-span considered in the Massawa area would range from; "*not felt"*- up to "*causes minor damage"*.

The destructiveness of the quakes in 1884 and 1921, both by Gouin (1979, p.102-103, 108-109) inferred to have originated in the *Massawa- channel*, could probably be explained more as result of poor construction methods used at the time. This rather than reading reading too much in to the, in the Eritrean context and in specific regarding the the Massawa-area, large estimated magnitudes of 6.2 and 5.8.

5. Conclusions

Data used concludes that the magnitude of events in the area, considering a period at most covering up to 50 years before present, seldom have exceeded a magnitude of 5 and none have exceeded the magnitude of 7.

The distribution concludes that most of the larger events of seismic activity during the last 50 years in Eritrea mainly are associated with the major rifting structures; trends of events are present, in both ISC and PDE data along what appears to be the Red Sea median axis. Further, a cluster of events is found in the north western section of the Danakil-depression in southeastern Semienawi Keih bahri, both features considerd part of the same Red Sea-rift. Though less pronounced, data from the Eritrean network as well as GCMT presents events in areas above.

There is a number of events in moderate-magnitude range found around the volcanic peak of Nabro located along the transverse –structure crossing Debubawi Keih Bahri, which most likely concerns events in relation to the volcanic eruption of June 2011.

Concerning Massawa; if a hypothetic circle was drawn with the diameter of ~15 kilometers around the city, ISC and PDE data each locates under 10 events during the fifty-year period data covers within this. Events present would concern a magnitude–span of 3.2 up to 5.1. Data from the Eritrean network concludes seismic activity in direct relation to- and around Massawa anually is much more frequent, though events displayed regarding the years of 1999 and 2000 concludes that activity is mainly constituded by micro seismic events in an approximate M_L-span of ~0.1 up to ~2.5.

Present day Massawa is thus clearly located in a seismically-active region, though events located and determined in data studied, solely baed on instrumental readings, doesn't present events in direct relation to the city in estimated magnitude ranges of the destructive quakes in 1884 and 1921.

Geological structures present originating larger seismic events in the area in recent times appear to be constituted by the Red Sea-through, as well as the northern section of the Danakil depression. Located aprroximately 170 km, respectively 70 km from Massawa.

Regionally large seismic events appear to be feature expected in relation to volcanic eruptions as well, though such activity seem restricted to above mentioned transverse-structure in the administrative region of Debubawi Keih Bahri.

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6.3 GIS-Data

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1° latitude by 1° longitude-grid present in figure 6 and 9- 13, as well as the 5° latitude by 5° longitude-grid present in figure 4 is from ESRI
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The MMI-scale zoning of Africa in figure 1 was retrieved from UNEP http://geodata.grid.unep.ch/ (accessed 2011-10-03)

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I also want to thank the Eritrean embassy in Stockholm, providing me necessary documents in order to conduct my field-research.

8. Appendices

Appendix 1. Seismic- and volcanic history of Eritrea, interpretation of P. Gouin (1979)

the interpretation in the chronological listing of seismic and volcanic events present in Gouin (1979) p. 189-238, has been done through the following processes of exclusion: Initially, regarding all entries listed with coordinates, those below longitude N 12.3, and west of latitude E 36.0, have been excluded. Entries without coordinates given, including those north of longitude N 12.30 and east of latitude E 36.0 have been sorted by case, this after available information provided under LOCATION & COMMENTS and/or their geographical position when present in GIS.

Note; there are still entries which gives geographical coordinates outside Eritrea and adjacent coastal waters, though regarding these cases, at least one agency has located the epicenter within these areas.

The entry on a tremor report originating from in Asseb 1883/03/ originally gave coordinates N 13.0, E 34.5. I assumed this was a typo and gave coordinates for this entry N 13.0, E 42.74. In the catalog under comments; following corrections and updates of place names have been made, *Ela Bered* have been replaced with *Elabered*, *Decamere* have been replaced with *Dekamhare,* and *Adi Ugri* have been replaced with *Mendefera*.

H1 – The time of day.

LONG - longitudes East. Greenwich system.

LAT – latitudes North, Greenwich system.

H2 – Focal depth given in kilometres.

MB – Magnitude body-wave (from teleseismic record or converted from local magnitude).

MS - Magnitude surface-wave (from teleseismic records).

ML – Magnitude locally determined.

ME - Magnitude estimated (from non-instrumental description)

I – Intensity after the 1931 Modified-Mercalli scale, in Arabic-numerals.

AGENCY – Reporting agency or source for entry, see Gouin(1979 p.190)

YEAR	MONTH	DAY	H1	LONG	LAT	H2	MB	MS	ML	ME	I	COMMENTS	AGENCY
1400				13.50	41.87					6.0		DUBBI VOLCANO	ZZZ
1733	11	30		15.7	39.0					6.0		ERITREAN SCARP (N)	ZZZ
1733	11	29		15.7	39.0							ERITREA. LANDSLIDES AND CASUALTIES	
1733	11	30										ERITREA. LANDSLIDES AND CASUALTIES	
1832	5	4		15.0	39.5						4.5	FELT IN HALAI	
1838	2	23	23 18 00	15.6	39.5						4.0	FELT IN MASSAWA	PAL
1838	2	25	23 20 00	15.6	39.5						3.0	FELT IN MASSAWA	PAL
1838	2	27	22 25 00	15.6	39.5						5.0	FELT IN MASSAWA	PAL
1838	2	27	22 48 00	15.6	39.5						4.0	FELT IN MASSAWA	PAL
1838	2	27	23 02 00	15.6	39.5						3.0	FELT IN MASSAWA	PAL
1838	3	1	03 00 00	15.6	39.5						6.0	FELT IN MASSAWA	PAL
1838	3	4	03 46 00	15.6	39.5						6.0	FELT IN MASSAWA, MUNCULLO	PAL
1838	3	5	07 24 00	15.6	39.5						3.0	FELT IN MASSAWA	
1838	3	22	13 38 00	15.6	39.5						3.0	FELT IN MASSAWA	PAL
1844	10	23		15.6	39.4						5.0	FELT IN MASSAWA,MUNCULLO CHANNEL	PAL
1844	10	23		15.5	39.5							FELT IN MASSAWA,MUNCULLO CHANNEL	ZZZ
1848	8			15.5	39.6					4.0		MASSAWA CHANNEL	
1848	7											RED SEA COAST, 2 MONTHS OF ACTIVITY IN	
1848	7											MASSAWA CHANNEL	
1848	7												
1848	7	13	MD	15.5	39.4							FELT ON W-COAST GULF OF ZULA	
1848	8	1	NT	15.6	39.4						5.0	FELT IN MUNCULLO	

1848	8	2	02 00 00	15.6	39.4			4.0	FELT IN MUNCULLO	
1848	8	3	NT	15.6	39.4			3.0	FELT IN MUNCULLO	
1848	8	6	15 00 00	15.6	39.4			3.0	FELT IN MUNCULLO, MASSAWA	
1848	8	10	PM	15.6	39.4			4.0	FELT IN MUNCULLO	
1857	4								FREQUENT TREMORS IN NORTHERN ETHIOPIA	PAL
1857	4									PAL
1857	4							4.0	FELT IN MASSAWA	PAL
1857	4								TOWN REPORTED DESTROYED IN TIGRAY	PAL
1857	4									
1861	5	8		13.74	41.55	5.5			VOLCANO DUBBI	GUT
1861	5	8		13.5	41.8				ERUPTION OF DUBBI VOLCANO - OVER 100 CASUALTIES,	
1861	5	5							ACTIVITY LASTED MONTHS	
1861	5	8								
1861	5	8		13.9	41.6			5.0	EDD: + 50 CM ASH AND LAPILLI	
1861	5	8		14.8	42.9			3.0	HODDEIDA: TREMORS + ASH	
1861	5	8		15.6	39.5			3.0	MASSAWA: TREMORS + NOISE	
1861	5	8		13.3	43.3			3.0	MUKKA: TREMORS, ASH, NOISE	
1861	5	8		12.6	43.4				PERIM IS: NOISES	
1864	3	5	20 00 00	15.6	39.5			3.0	FELT IN MASSAWA	
1864	9	14	11 15 00	15.6	39.5				MASSAWA: FELT ON LAND AND IN HARBOUR ON SHIP	
1864	9	14							MASSAWA: FELT ON LAND AND IN HARBOUR ON SHIP	PAL
1864	9	15	13 45 00	15.6	39.5				MASSAWA: FELT ON LAND AND IN HARBOUR ON SHIP	
1864	9	15							MASSAWA: FELT ON LAND AND IN HARBOUR ON SHIP	
1864	10	21	08 45 00	15.6	39.5			5.0	FELT IN MASSAWA	
1875	11	2		16.0	38.5		6.0		ANSEBA FAULTS. AFTERSHOCKS TILL MARCH 1876,	
1875	11	2							LANDSLIDES CASUALTIES	
1875	11	2								
1875	11	2	11 00 00	14.2	38.9			6.0	ADUA (ROCKSLIDE)	

1875	11	2		15.8	38.5					8.0	KEREN (DAMAGE)	
1883	3			12.0	42.0				5.5		AUSSA	ZZZ
1883	3			13.0	42.74						REPORTED FELT IN ASSEB	
1883	3			10.5	41.1						FELT AT MT JANGHUDI	PAL
1884	7			15.6	39.5						MASSAWA: 3 MONTHS OF TREMORS - DAMAGE	
1884	7										MASSAWA: 3 MONTHS OF TREMORS - DAMAGE	
1884	7	12	AM	15.6	39.5					3.0	MASSAWA	PAL
1884	7	12	NT	15.6	39.5					3.0	MASSAWA	PAL
1884	7	20	08 30 00	15.6	39.5					3.0	MASSAWA	PAL
1884	7	20	06 45 00	16.0	41.0			5.9				GUT
1884	7	20	06 45 00	15.7	39.6	15	5.9				MASSAWA CHANNEL	ZZZ
1884	7	20	09 30 00	15.6	39.5					8.0	MASSAWA: HEAVY DAMAGE	
1884	8	18	09 00 00	15.6	39.5					5.0	FELT IN MASSAWA	PAL
1884	10	3		15.6	39.5					4.0	FELT IN MASSAWA	PAL
1886	5	8	PM	15.6	39.5					4.0	MASSAWA: 4 TREMORS	PAL
1886	6	15	09 45 00	15.6	39.5						FELT IN MASSAWA	PAL
1886	8	8	SS	15.6	39.5					4.0	MASSAWA E MUNCULLO (2)	PAL
1886	12	7	06 25 00	15.6	39.5					4.0	FELT IN MASSAWA	PAL
1886	12	23	18 10 00	15.6	39.5					3.0	FELT IN MASSAWA	PAL
1887	1	30	23 44 00	15.6	39.5					4.0	FELT IN MASSAWA	PAL
1887	2	1	02 00 00	15.6	39.5					3.0	FELT IN MASSAWA (2)	PAL
1887	3	14	10 00 00	15.6	39.5						FELT IN MASSAWA	PAL
1887	12	28	02 45 00	15.6	39.5					4.0	FELT IN MASSAWA	PAL

1889	10	4	NT	15.6	38.5	3.0	FELT IN KEREN	
1891	2	12	MD	15.6	39.5	4.0	2 FELT IN MASSAWA	PAL
1891	4	27	04 40 00	15.6	39.5	3.0	FELT IN MASSAWA	PAL
1892	11	23		15.6	39.5	3.0	N FELT IN MASSAWA	PAL
1894	5	13	06 45 00	15.6	38.5		KEREN: TREMORS + NOISE	PAL
1894	7	4	NT	15.6	38.5		KEREN (NOISE)	PAL
1894	9	12	12 50 00	15.6	39.5	4.0	FELT IN MASSAWA	PAL
1894	11	3	23 00 00	15.0	39.4	5.0	FELT IN HALAI	PAL
1894	11	8	SR	15.6	38.5	3.0	FELT IN KEREN	PAL
1896	12	11	02 20 00	15.6	39.5	4.0	FELT IN MASSAWA	MED
1897	9	30	21 14 00	15.6	39.5	4.0	FELT IN MASSAWA	PAL
1900	4	2	22 00 00	15.6	39.5	5.0	FELT IN MASSAWA	PAL
1900	4	2	22 00 00	14.9	38.8	3.0	FELT IN MENDEFERA	
1901	5		SR	15.8	38.8	6.0	FELT IN AMAZI	PAL
1901	11	11	05 10 00	14.8	40.2	5.0	3 FELT AT BUIA WELL	
1902	1	24	01 15 00	15.6	39.5	4.0	N FELT IN MASSAWA	PAL
1902	2	24	19 00 00	14.8	39.9	3.0	N FELT IN BABALA MADETO	PAL
1902	3	4	20 30 00	14.8	39.9	4.0	2 FELT IN UETEN	PAL
1902	3	5	02 20 00	14.8	39.9	3.0	FELT IN UETEN	PAL
1902	5	3	02 00 00	15.6	39.5	4.0	FELT IN MASSAWA	PAL
1902	5	26	09 25 00	15.6	39.5	4.0	FELT IN MASSAWA	PAL

1902	9	29	22 30 00	15.6	39.5				4.0	FELT IN MASSAWA	PAL
1902	1			15.1	39.7			5.0		GULF OF ZULA	ZZZ
1903	9	26	05 42 00	15.5	39.0					FELT IN ASMARA	
1905	3	9	PM	14.9	38.8				3.0	FELT IN MENDEFERA	
1905	3	9	PM	15.5	39.0					FELT IN ASMARA	
1905	12	23	MD	14.0	39.0						
1905	12	23	MD	15.5	39.0					FELT IN ASMARA (N)	
1908	12	28	19 30 00	15.7	38.5				4.0	FELT IN ELABERED	PAL
1912	4	15	06 30 00	14.85	39.4					3 FEL IN ADI CAIEH	PAL
1912	4	20	12 00 00	15.7	38.6				4.0	FELT IN ELABERED	PAL
1912	12	28	23 00 00	15.5	39.0				5.0	FELT IN ASMARA	PAL
1913	1			15.5	39.0					MANY TREMORS IN ASMARA	
1913	2									FROM FEB. TO MAY 457 TREMORS FELT IN ASMARA, KEREN,	PAL
1913	2									ADI CAIEH, MASSAWA. MAX INTENSITY IN ASMARA = 8	
1913	2	4		15.5	39.0				6.0	FELT IN ASMARA	FAN
1913	2	10		15.5	39.0				7.0	FELT IN ASMARA	FAN
1913	2	18		15.5	39.0				7.0	FELT IN ASMARA	FAN
1913	2	27	16 22 54	17.5	39.0		5.8				GUT
1913	2	27	16 22 34	14.0	39.0						ISS
1913	2	27	16 22 34	16.0	39.0						PUL
1913	2	27	16 22 54	17.2	38.8	33	5.8	5.8		ERITREAN ESCARPMENT	ZZZ
1913	2	27	16 23 00	15.5	39.0				8.0	FELT IN ASMARA	FAN
1913	3	4		15.5	39.0				6.0	FELT IN ASMARA	FAN

1913	3	5		15.5	39.0		6.0	FELT IN ASMARA	FAN
1913	3	23		15.5	39.0		7.0	ASMARA (PANIC)	FAN
1913	3	27	03 13 00	16.5	39.0	5.8			GUT
1913	3	27	03 12 45	15.9	39.0				ISS
1913	3	27	03 11 45	15.9	39.5				TIF
1913	3	27	03 13 00	16.0	39.0	5.5		ERITREAN ESCARPMENT	ZZZ
1913	3	27	03 15 00	15.5	39.0		8.0	FELT IN ASMARA	FAN
1913	5	13		15.5	39.0		7.0	6 TREMORS FELT IN ASMARA	FAN
1913	5	22	NT	15.5	39.0		4.0	3 TREMORS FELT IN ASMARA	FAN
1913	5	23	SR	15.5	39.0		3.0	2 TREMORS FELT IN ASMARA	FAN
1913	6							NEW SEISMIC STATION IN ASMARA RECORDED	PAL
1913	6							141 EVENTS FROM JUNE 6 TO JULY 16	
1915	9	23	08 14 48	16.0	39.0	6.8			GUT
1915	9	23	08 14 48	16.0	38.5				ISS
1915	9	23	08 15 00	15.7	34.8				PUL
1915	9	23	08 14 48	16.0	39.0	6.8		NAKFA GRABEN	ZZZ
1915	9	23		15.5	39.0		6.0	DAMAGE IN ASMARA	AAE
1921	1	28	15 30 00	15.0	39.0		5.0	FELT AT MENDEFERA	CAV
1921	1	28	15 45 00	15.0	39.0		3.0	FELT AT MENDEFERA	CAV
1921	1	28	18 34 00	15.0	39.0		4.0	FELT AT MENDEFERA	CAV
1921	1	28	18 36 00	15.0	39.0		3.0	FELT AT MENDEFERA	CAV
1921	1	31	21 23 00	15.0	39.0		4.0	FELT AT MENDEFERA	CAV
1921	2	1	14 58 00	15.0	39.0		4.0	FELT AT MENDEFERA	CAV
1921	2	1	19 09 00	15.0	39.0		2.0	FELT AT MENDEFERA	CAV
1921	2	24	01 20 00	15.0	39.0		5.0	FELT AT MENDEFERA	CAV
1921	2	24	01 25 00	15.0	39.0		5.0	FELT AT MENDEFERA	CAV
1921	4	12	21 00 00	15.0	39.0		3.0	FELT AT MENDEFERA	CAV

1921	8	14	13 15 28	15.5	40.5	5.8			GUT
1921	8	14	13 15 00	15.5	39.0				ISS
1921	8	14	13 15 28	15.6	39.6	5.8		MASSAWA CHANNEL. VOLCANIC ACTIVITY ON SEAFLOOR	ZZZ
1921	8	14						MASSAWA CHANNEL. VOLCANIC ACTIVITY ON SEAFLOOR	ZZZ
1921	8	14	13 15 20	15.6	39.5		9.0	FELT IN MASSAWA	CAV
1921	8	14	18 00 00	15.6	39.5		5.0	FELT IN MASSAWA	CAV
1921	8	14	18 00 00	15.6	39.5		5.0	FELT IN MASSAWA	CAV
1921	8	14	20 00 00	15.6	39.5		3.0	FELT IN MASSAWA	CAV
1921	8	14	18 05 00	15.6	39.5		3.0	FELT IN MASSAWA	CAV
1921	8	15	00 25 00	15.6	39.5		3.0	FELT IN MASSAWA	CAV
1921	8	15	09 00 00	15.6	39.5		2.0	FELT IN MASSAWA	CAV
1921	8	17	23 00 00	15.6	39.5		4.5	FELT IN MASSAWA	CAV
1921	8	18	23 25 00	15.6	39.5		3.0	FELT IN MASSAWA	CAV
1921	9	3	PM	15.0	39.0		4.0	3 FELT IN MENDEFERA	CAV
1921	9	3	23 21 00	15.0	39.0		3.0	FELT IN MENDEFERA	CAV
1921	9	4	01 00 00	15.0	39.0		5.0	FELT IN MENDEFERA	CAV
1921	9	4	14 00 00	15.0	39.0		3.0	FELT IN MENDEFERA	CAV
1921	9	8	13 32 00	15.0	39.0		4.0	FELT IN MENDEFERA	CAV
1921	9	8	14 47 00	15.0	39.0		3.0	FELT IN MENDEFERA	CAV
1921	9	21	11 01 31	14.0	39.0	5.7			GUT
1921	9	21	11 01 31	15.5	39.0				ISS
1921	9	21	11 01 31	15.6	39.7			MASSAWA CHANNEL	ZZZ
1921	9	21	11 01 30	15.6	39.5		9.0	FELT IN MASSAWA	CAV
1921	9	21	14 07 00	15.5	39.0		5.0	FELT IN ASMARA	CAV
1921	9	21	16 07 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	21	16 35 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	21	20 15 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	22	00 06 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	22	03 45 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	22	08 47 00	15.5	39.0		4.0	FELT IN ASMARA	CAV

1921	9	22	14 51 00	15.5	39.0		5.0	FELT IN ASMARA	CAV
1921	9	22	15 34 00	15.5	39.0		5.0	FELT IN ASMARA	CAV
1921	9	22	21 00 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	23	00 33 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	23	03 17 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	9	24	02 30 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	10	2	02 20 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	2	14 14 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	3	23 07 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	4	01 16 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	6	NT	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	10	6	03 00 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	6	06 23 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	6	07 30 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	7	02 20 00	15.5	39.0		2.0	FELT IN ASMARA	CAV
1921	10	7	09 40 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	10	7	11 32 00	15.5	39.0		2.0	FELT IN ASMARA	CAV
1921	10	11	07 22 00	15.5	39.0		2.0	FELT IN ASMARA	CAV
1921	10	15	19 20 00	15.5	39.0		2.0	FELT IN ASMARA	CAV
1921	10	17	23 15 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	10	18	02 20 00	15.5	39.0		5.0	FELT IN ASMARA	CAV
1921	10	22	13 13 00	15.5	39.0		3.0	FELT IN ASMARA	CAV
1921	11	1	21 51 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1921	11	2	04 45 00	15.5	39.0		4.0	FELT IN ASMARA	CAV
1924	3	13	12 47 40	16.0	38.5				ISS
1924	3	13		16.0	38.8			ERITREAN ESCARPMENT	ZZZ
1934	2	1	23 58 00	15.5	39.0		4.0	FELT IN ASMARA	FAN
1934	7	2	14 35 00	15.6	39.5		4.0	FELT IN MASSAWA	FAN
1938	5	12	21 31 30	17.0	38.0				CGS
1938	5	12	21 31 35	18.5	37.5	5.7			GUT
1938	5	12	21 31 35	18.0	37.5				ISS

1938	5	12	21 31 44.1	18.580	37.438	33					PG3
1938	5	12	21 31 44	18.5	37.5	33		5.8		SUDAN RED SEA COAST	ZZZ
1945	3	31	22 07 48	14.5	39.5						ISS
1945	3	31	22 07 56.9	14.870	39.541	33					PG3
1945	3	31	22 07 57	14.87	39.54	33			4.5	W. PLATEU MARGIN	ZZZ
1950	8	2	13 49 55	15.0	39.5						CGS
1950	8	2	13 49 55	14.5	39.5						ISS
1950	8	2	13 50 01.8	14.522	39.715	33					PG3
1950	8	2	13 49 45	15.0	38.0	150					P00
1950	8	2	13 49 43	12.0	43.0						PRA
1950	8	2	13 49 55	14.5	39.5		6.2				ROT
1950	8	2	13 49 58	14.5	40.0	500					STR
1950	8	2	13 50 02	14.52	39.72	33		6.2		TIGRAY (ESCARPMENT)	ZZZ
1950	9	18	00 39 30	13.7	42.2						STR
1950	9	18	00 39 30	13.8	42.5				4.5	S. RED SEA	ZZZ
1952	9	10	09 06 13	14.5	39.5						ISS
1952	9	10	09 06 17.5	14.524	40.204	33					PG3
1952	9	10	09 05 58	14.5	39.5			5.2			ROT
1952	9	10	09 05 58	12.8	39.6						STR
1952	9	10	09 06 17	14.5	40.2		5.2			DEPRESSION E MARGIN	ZZZ
1955	3	3	00 43 44.8	16.54	41.25						JED
1955	3	3	00 43 40.2	16.46	41.29						S-L
1955	3	3	00 43 40	16.0	41.5			5.0			STR
1955	3	3	00 43 45	16.54	41.23	33		5.0		RED SEA TROUGH	ZZZ
1957	3	14	00 11 38.5	14.97	40.19						JED
1957	3	14	00 11 38	14.8	40.2						ROT
1957	3	14	00 11 36	15.0	40.0			5.2			STR
1957	3	14	00 11 33	14.8	40.22						S-L
1957	3	14	00 11 39	14.89	40.20	16		5.2		BURI PENINSULA	ZZZ

1957	3	14	00 43 40.2	16.46	41.29							S-L
1957	3	14	00 43 40	16.46	41.29						RED SEA	ZZZ
1958	1	9	07 56 27.2	17.71	40.12							S-L
1958	1	9	07 56 27	17.71	40.12				4.5		RED SEA TROUGH	ZZZ
1958	2	13	10 23 34	14.35	42.01							ISS
1958	2	13	10 23 36.5	14.26	41.92							JED
1958	2	13	10 23 38.9	14.112	42.005	33						PG3
1958	2	13	12 23 34	13.75	41.25			5.2				STR
1958	2	13	10 23 33.7	14.34	42.00							S-L
1958	2	13	10 23 36	14.24	41.98			5.2			RED SEA	ZZZ
1960	8	13	20 04 25	15.2	40.1			4.9			HAWACHIL BAY	ZZZ
1960	8	13	22 28 19	15.27	40.00							AAE
1960	8	13	22 28 24.6	15.8	40.2	42						CGS
1960	8	13	22 28 19.4	15.11	40.15							JED
1960	8	13	22 28 13.6	14.70	40.16							S-L
1960	8	13	22 28 19	15.2	40.2	42			4.5		HAWACHIL BAY	ZZZ
1960	10	23	19 21 15.7	17.90	40.30	25						CGS
1960	10	23	19 21 07.7	17.50	40.07							S-L
1960	10	23	19 21 00	17.50	40.07	42			4.5		RED SEA TROUGH	ZZZ
1962	8	25	00 54 08	16.49	40.12	33		4.8				CGS
1962	8	25	00 54 17.5	17.12	40.14		4.8					JED
1962	8	25	00 54 30	19.0	40.0			4.8				MOS
1962	8	25	00 54 08.0	16.50	40.10							ROT
1962	8	25	00 54 25	18.00	40.00							STR
1962	8	25	00 54 08.0	16.49	40.12			4.8				S-L
1962	8	25	00 54 17	17.12	40.14	33		4.8			RED SEA TROUGH	ZZZ
1969	9	9		15.33	37.53					3.0	FELT IN AGORDAT	AAE

1962	11	11	15 15 33.6	17.20	40.70	34	5.6						CGS
1962	11	11	15 15 34.0	17.12	40.52	43							ISS
1962	11	11	15 15 33.9	17.22	40.58								JED
1962	11	11	15 15 27.0	16.50	40.00			5.5					MOS
1962	11	11	15 15 20.0	16.50	39.50	15		5.2					PEK
1962	11	11	15 15 28.0	17.10	40.60	34		5.8					ROT
1962	11	11	15 15 30.0	17.25	40.75			5.8					STR
1962	11	11	15 15 28.0	17.05	40.58			5.6					S-L
1962	11	11	15 15 20.0	17.22	40.58	15		5.7				RED SEA	ZZZ
1963	7	14	17 18 06	15.1	38.7				4.5				MOS
1963	7	14	17 18 10	15.6	39.0								STR
1963	7	14	17 18 10	15.6	39.1				4.5			ERITREAN ESCARPMENT	ZZZ
1963	7	14	17 20 00	15.5	39.0						4.5	2 FELT IN ASMARA	AAE
1964	8	3	10 45 09	17.5	39.1								STR
1964	8	3	10 45 14	15.2	39.0								MOS
1964	8	3	10 45 09	17.1	39.0	33				4.5		FOOT OF ESCARPMENT	ZZZ
1965	6	29	22 04 33.3	16.3	38.9		3.8		4.2			D(AAE)=850 KM	AAE
1965	6	29	22 02 30	16.1	38.9		3.8					ERITREAN ESCARPMENT	ZZZ
1965	6	29	22 04 33	15.3	38.9						3.0	FELT IN ASMARA	AAE
1965	12	30	08 54 13.5	18.75	39.49	33		4.1					CGS
1965	12	30	08 54 14.5	18.87	39.71		4.1						JED
1965	12	30	08 54 14.5	18.87	39.71			4.1				RED SEA TROUGH	ZZZ
1966	2	5	04 20 10				3.8		4.2			D (AAE)= 785 KM	AAE
1966	2	5	04 20 00	15.5	39.0						5.0	FELT IN ASMARA	AAE
1966	2	5	10 25 00	15.5	39.0						3.0	FELT IN ASMARA	AAE
1966	4	9	19 11 10.5	14.37	40.79	33	4.7						CGS
1966	4	9	19 11 11.0	14.50	40.90	27	4.8						ISC
1966	4	9	19 11 12.0	14.46	40.74		4.7						JED

1966	4	9	19 11 00	14.45	40.75	27	4.7					DANAKIL ALPS	ZZZ
1967	1	30	19 25 00	15.5	39.0					4.2	3.0	FELT IN ASMARA	AAE
1967	5											4 FORESHOCKS	
1967	5	19	15 52 34.2	14.53	40.26	13	5.1						CGS
1967	5	19	15 52 39.0	14.62	40.17								ISC
1967	5	19	15 52 40.5	14.87	40.14		4.8						JED
1967	5	19	15 52 39	14.70	40.10								STR
1967	5	19	15 52 39	14.68	40.17	13	5.1					N END DANAKIL DEPRESSION	ZZZ
1967	5											74 AFTERSHOCKS	
1967	5	19	17 11 12.8	14.82	40.03			4.7				DEPRESSION E MARGIN	ZZZ
1967	5	19	21 21 34.2	14.67	40.12	13		4.2				DEPRESSION E MARGIN	ZZZ
1967	5	20	00 20 33.8	14.55	40.19	13		4.2				DEPRESSION E MARGIN	ZZZ
1967	5	20	03 38 36	14.74	40.08	13		4.3				DEPRESSION E MARGIN	ZZZ
1967	9	18	02 04 37.5	15.79	38.97		4.9						AAE
1967	9	18	02 02 59.8	15.69	39.03	33	4.8						CGS
1967	9	18	02 03 04.0	15.78	38.94	58	4.9						ISC
1967	9	18	02 03 01.8	15.80	38.93		4.8						JED
1967	9	18	02 03 02	15.79	38.93	33	4.8					SABARGUMA GRABEN	ZZZ
1967	9	18	NT	15.5	39.0						3.0	FELT IN ASMARA	AAE
1967	9	21	18 36 35	18.1	40.1				4.6				AAE
1967	9	21	18 36 26.1	17.94	39.97	16	4.4						CGS
1967	9	21	18 36 32.0	17.84	40.30	80							ISC
1967	9	21	18 36 27.0	18.05	40.13		4.4						JED
1967	9	21	18 36 27	17.94	40.13		4.4					RED SEA	ZZZ
1967	11	16	02 22 03.1	15.09	39.82	33	5.1						CGS
1967	11	16	02 22 05.2	15.19	39.49	33	5.1						ISC
1967	11	16	02 22 06.2	15.17	39.53		5.1						JED
1967	11	16	02 22 03.1	15.10	39.80	33	5.1						SYK
1967	11	16	02 22 03	15.09	39.81	33	5.1		5.9			GULF OF ZULA	ZZZ
1967	11	16	NT	15.5	39.0						4.0	FELT IN ASMARA	AAE

1967	11	16	NT	15.1	39.1					4.0	FELT IN DEKAMHARE	AAE
1968	5	11	18 16 00	14.4	39.8		4.1		4.6		ESCARPMENT	ZZZ
1968	5	11	21 53 00	15.0	39.8		3.4		3.9		ESCARPMENT	ZZZ
1968	5	11	NT	15.1	39.1					4.0	FELT IN DEKAMHARE	AAE
1968	5										18 FORESHOCKS	AAE
1968	5	23	23 37 33.7	14.8	40.1				5.0		D(AAE)=650 KM	AAE
1968	5	23	23 36 06.43	14.747	40.217	33	4.8					CGS
1968	5	23	23 36 08.4	18.86	39.90	33						ISC
1968	5	23	23 36 07	14.80	40.10	33	4.8		5.0		DEPRESSION E MARGIN	ZZZ
1968	5	23	NT	15.05	39.05						FELT IN DEKAMHARE	
1968	5										61 AFTERSHOCKS	AAE
1969	9	26	04 54 35.66	16.428	40.983	25	5.1	5.3				CGS
1969	9	26	04 54 38	16.41	41.02	45	5.0					ISC
1969	9	26	04 54 38	16.6	41.2			5.5				MOS
1969	9	26	04 54 37	16.4	41.0							STR
1969	9	26	04 54 36	16.46	41.05	25	5.1	5.3			RED SEA THROUGH	ZZZ
1974	3	26	10 20 20.1	13.49	41.55						AFAR	TLN
1974	3	26	10 20 20.1	12.74	42.54						AFAR	TLN
1974	3	26	11 28 20.1	13.47	41.62						AFAR	TLN
1974	3	26	11 28 20.1	12.80	42.50						AFAR	TLN
1974	3	26	11 57 10.4	13.44	41.68						AFAR	TLN
1974	3	26	11 57 10.4	12.85	42.45						AFAR	TLN
1974	4	26	18 08 16.86	17.141	40.380	33	4.8					CGS
1974	4	26	18 08 18	17.10	40.44	48	4.4					ISC
1974	4	26	18 08 07	15.7	40.2		4.9					MOS
1974	4	26	18 08 12	17.0	40.6							STR
1974	4	26	18 08 00	17.12	40.41		4.8				RED SEA TROUGH	ZZZ
1974	6	30	13 26 24.72	16.013	39.631	33	4.4					CGS

1974	6	30	13 26 25.7	15.970	39.610	33	4.5			ISC
1974	6	30		15.99	39.62		4.4		WEST COAST OF RED SEA	ZZZ
1974	8	1	10 33 30.5	15.60	39.48				MASSAWA CHANNEL	TLN
1974	8	30	02 03 15.8	14.14	40.41				N DANAKIL DEPRESSION	TLN
1974	8	30	08 16 18.6	14.05	42.03				RED SEA	TLN
1975	8	7	22 43 13.3	15.288	40.407	37	4.6			CGS
1975	8	7	22 43 17	15.36	40.44	37	4.7			ISC
			00 00 09	0.8	0.3		4.9			MOS
1975	8	7	22 43 12	15.5	40.5					STR
1975	8	7	22 43 13.5	15.32	40.42	37	4.6		HAWACHIL BAY	ZZZ
1976	11	7	05 53 07.6	15.820	41.423	34	4.8			CGS
1976	11	7	05 53 08	15.82	41.42	34	4.8		RED SEA	ZZZ
1976	11	7	05 53 07.6	15.820	41.423	34	4.8			CGS
1976	11	7	05 53 07.6	15.820	41.423	34	4.8		RED SEA NEAR DAHLAC IS.	ZZZ
1976	11	16	12 53 33.70	15.905	41.915	33	4.9	3.9		CGS
1976	11	16	12 53 33.7	15.91	41.92	33	4.9		RED SEA	ZZZ
1976	11	27	14 13 20.2	16.154	40.013	33	4.3			CGS
1976	11	27	14 13 20.2	16.154	40.013	33	4.3		RED SEA	ZZZ
1977	12	28	02 45 36.7	16.659	40.278	33	5.9	6.6		CGS
1977	12	28	02 45 36.7	16.659	40.278	33	5.9	6.6	RED SEA TROUGH	ZZZ

Appendix 2. Data on seismic events retrieved from ISC

DATE	TIME	LAT	LONG	DEPTH	MB	OTHER
1966-04-09	19:11:11.0	14.5	40.9	27	4.5	0
1967-05-19	15:52:39.0	14.62	40.17	43	4.9	0
1967-09-18	02:03:04.0	15.78	38.94	58	4.8	0
1967-11-16	02:22:05.2	15.19	39.49	33	5	0
1968-05-23	23:36:08.4	14.86	39.9	33	4.9	0
1969-09-26	04:54:38.0	16.41	41.02	45	5	0
1974-04-17	18:27:33.6	17.2952	40.2983	27.1	5.1	0
1974-04-26	18:08:18.2	17.095	40.4438	48.4	4.4	0
1974-06-30	13:26:25.7	15.9652	39.6109	33	4.5	0
1975-04-16	02:55:09.2	14.5927	40.7291	33	4.3	0
1975-06-30	04:20:52.0	17.9837	40.1641	33	4.6	0
1975-08-07	22:43:13.7	15.3617	40.4352	37	4.7	0
1975-12-14	23:16:49.2	14.6035	42.2852	41.3	5.3	0
1975-12-14	23:27:27.2	14.6921	42.2589	40.7	5.2	0
1976-11-07	05:53:06.7	15.8566	41.3564	24.9	4.8	0
1976-11-07	20:21:47.4	15.987	41.4327	33	4.7	0
1976-11-16	12:53:34.2	15.8612	41.7816	33	4.6	0
1976-12-01	05:03:41.3	15.7692	41.8501	56.9	4.8	0
1977-12-28	02:45:33.1	16.5399	40.3169	9.7	5.9	0
1978-01-04	05:04:43.0	16.5541	40.9322	33	4.4	0
1978-01-17	15:00:30.7	16.5181	40.2761	29.8	5.1	0
1978-02-21	22:04:42.2	16.3161	40.4527	33	4.7	0
1978-03-25	02:55:04.2	16.513	40.1938	7.2	4.9	0

1979-07-17	17:07:04.5	17.6577	40.1278	51.3	5.1	0
1979-07-22	18:51:57.9	17.4041	39.959	33	4.1	0
1979-08-13	16:17:51.1	15.2778	41.9699	10	4.4	0
1979-08-15	02:20:42.3	15.3084	41.8922	10	4.7	0
1979-11-10	17:42:45.2	14.8987	39.7514	10	4.3	0
1980-01-14	04:10:53.5	16.5492	40.3015	3	5.4	0
1980-01-14	04:21:47.5	16.4432	40.1067	0	4.7	0
1980-01-14	12:28:21.9	16.5586	40.3032	0	5.3	0
1980-01-14	12:57:16.9	16.5445	40.2541	10	4.7	0
1980-01-26	06:15:31.1	16.4624	40.3184	10	4.5	0
1980-03-05	03:12:05.2	16.6008	40.2079	7.5	4.9	0
1980-04-07	16:45:37.9	17.5771	40.1832	33	4.8	0
1980-07-12	12:59:04.2	17.1734	40.2901	10	4.3	0
1980-07-16	23:14:54.7	17.1684	40.4354	0	4.7	0
1980-07-17	00:08:21.6	17.1761	40.4135	0	4.6	0
1980-07-17	00:12:46.0	17.1427	40.7436	10	4.3	0
1983-08-07	10:42:18.5	16.4441	41.3197	10	4.7	0
1984-10-12	06:38:29.8	14.6675	40.325	33	4.1	0
1985-06-13	08:14:45.6	15.9905	39.6632	10	4.6	0
1986-08-02	16:45:32.1	15.9633	39.6772	10	4.7	0
1987-09-11	00:48:16.2	16.9463	40.3337	10	4.9	0
1988-03-30	06:33:51.5	16.3899	41.0703	10	4.7	0
1988-04-06	03:11:22.8	16.33	41.0854	10	4.8	0
1988-04-08	22:32:37.4	16.2569	41.0828	10	4.5	0
1988-11-01	19:06:48.4	16.6037	40.8667	10	4.6	0

1988-11-01	19:19:45.5	16.2717	40.958	10	4.8	0
1988-11-01	23:51:05.0	16.7905	40.6122	10	4.1	0
1988-11-02	00:57:13.7	16.6284	40.8003	10	4.7	0
1988-11-02	14:06:36.3	16.4765	40.9542	10	4.3	0
1988-11-03	01:19:37.8	16.4301	40.9222	10	4.4	0
1988-11-03	07:55:09.6	16.4715	40.9799	10	4.6	0
1988-11-03	19:27:22.7	16.4925	41.0086	10	4.6	0
1988-11-03	19:50:58.5	16.5112	41.0395	10	4.8	0
1988-11-04	01:02:56.8	16.5991	40.9186	10	4.6	0
1988-11-06	15:00:08.3	16.5569	41.0903	10	4.5	0
1988-12-10	17:33:19.0	16.3011	41.1018	3.6	5.3	0
1989-06-20	21:11:48.4	12.9553	41.8208	10	4.2	0
1990-06-07	21:46:00.4	17.6571	39.9314	10	4.2	0
1990-06-07	22:18:24.5	17.5845	40.434	10	4.3	0
1990-06-08	03:17:06.2	17.5739	40.1554	10	4.8	0
1991-08-07	16:58:35.8	17.8079	40.0046	10	4.2	0
1992-05-19	01:26:47.0	13.8273	43.9964	26.6	4.5	0
1993-05-01	07:57:14.5	14.7771	40.26	10	4.1	0
1993-05-02	10:08:09.4	14.4232	40.0851	10.3	4.7	0
1993-05-02	17:58:26.1	14.5649	40.0469	30	4.8	0
1993-05-02	21:34:18.2	14.5545	39.9713	33	4.1	0
1993-05-03	12:37:39.5	14.3684	40.0522	11.5	4.8	0
1993-05-04	02:23:02.0	14.4202	40.1995	10	4.3	0
1993-05-04	16:46:09.3	14.5805	40.1416	10	4.4	0
1993-05-05	18:06:53.3	14.389	40.0787	21.6	4.6	0

1993-05-06	20:35:57.2	14.4333	40.115	17.3	5	0
1993-05-07	03:58:22.3	14.7793	40.3167	10	4.3	0
1993-05-08	22:40:47.8	14.5008	40.0937	10	4.1	0
1993-05-10	10:55:00.9	14.4346	40.1748	17.9	5	0
1993-05-11	03:44:10.0	14.5512	40.191	17.6	4.4	0
1993-05-13	18:20:48.5	14.3997	40.1525	10.1	4.9	0
1993-05-14	05:01:42.0	14.5631	40.1033	10	4.1	0
1993-05-18	09:33:13.5	14.393	40.2064	10	4.6	0
1993-06-16	11:10:15.5	17.4189	39.9589	10	4.7	0
1993-07-03	01:37:17.8	17.8756	39.9487	10	4.7	0
1993-11-01	00:27:55.6	13.8309	43.5429	26.7	3.9	0
1994-01-13	05:09:53.8	15.1688	42.6666	10	4.4	0
1994-05-11	10:08:03.9	15.3064	42.021	10	4.4	0
1994-05-11	20:22:14.3	15.3185	42.2052	10	3.6	0
1994-05-12	00:55:35.7	15.2644	42.1537	10	4.3	0
1994-05-13	10:56:09.4	15.4602	42.0522	10	4.7	0
1994-05-14	22:34:34.9	15.179	41.9802	10	4.9	0
1994-05-16	12:10:22.8	15.2456	42.0856	10	4.6	0
1994-06-21	02:12:19.1	15.388	41.9449	10	4.8	0
1995-06-24	08:41:33.3	17.1455	40.4652	10.1	4.3	0
1995-09-10	12:31:03.6	15.6787	39.2029	29.7	4.5	0
1996-02-20	08:36:48.2	15.7428	39.2074	46.3	4.4	0
1996-04-07	05:57:55.3	15.4568	42.2212	46.3	4.1	0
1996-04-16	12:32:51.0	15.734	39.233	24.6	4.1	0
1996-04-30	03:41:41.2	15.2873	42.0443	10	4.3	0

1996-04-30	15:20:42.4	16.1067	41.9041	36.7	3.9	0
1996-04-30	17:36:09.5	15.3648	41.9863	10	4.3	0
1996-05-01	11:45:21.9	15.5336	41.812	10	4.5	0
1996-05-02	23:12:20.2	15.2847	42.0315	25.5	4.4	0
1996-05-03	17:04:03.1	15.3872	42.0765	10	4	0
1996-05-05	19:39:44.6	14.6373	42.0277	33	3.5	0
1996-05-05	20:03:00.9	15.2726	41.9757	33	4	0
1996-05-05	20:42:16.7	15.3789	41.9491	10	4.5	0
1997-07-11	20:38:25.3	15.2938	42.0308	25.8	3.8	0
1997-07-13	16:13:08.2	15.2526	42	10	4	0
1997-07-13	18:50:42.6	15.1523	42.0193	47.2	3.9	0
1997-07-14	13:29:19.1	15.5399	42.0722	10	4.2	0
1998-05-13	00:27:52.5	14.0935	41.5463	10	4.4	0
1998-05-13	09:59:00.4	13.9802	42.0041	10	4.3	0
1999-03-20	23:26:38.4	14.657	42.031	5.7	3.3	0
1999-04-29	14:57:23.3	17.85	40.151	10	4.2	0
1999-04-29	17:54:36.5	17.993	40.031	34.2	4.4	0
1999-12-27	02:54:19.3	17.894	40.186	33	4.2	0
2000-04-23	18:48:12.2	12.98	43.98	44.9	3.7	0
2000-07-13	11:21:58.2	14.71	42.54	11.6	4.9	0
2000-07-22	05:59:15.8	13.24	43.34	52.1	4.1	0
2000-07-22	06:32:58.2	13.21	43.77	9.8	3.7	0
2000-07-22	08:54:41.6	13.12	43.24	40.7	4.6	0
2000-07-22	15:28:37.0	13.1	43.6	55.1	3.7	0
2000-07-22	17:34:56.5	13.17	43.48	3	3.8	0

2000-08-25	06:04:19.6	17.414	40.299	10	3.9	0
2000-08-27	08:07:30.5	13.06	43.9	64.7	3.2	0
2000-09-08	21:41:50.4	14.15	42.31	3.5	3.2	0
2000-09-09	10:10:37.7	13.01	43.9	54.1	3.3	0
2000-12-05	01:27:09.5	13.6	43.87	10.4	3.4	0
2001-01-15	21:28:07.5	16.7899	40.9097	0	3.7	0
2001-05-25	22:18:24.5	17.857	39.997	33	4.8	0
2001-07-17	20:51:24.9	14.507	41.708	5.2	4.7	0
2001-09-09	10:55:35.1	14.992	39.881	10	3.9	0
2002-06-18	10:44:16.1	14.605	42.099	10	4.5	0
2002-06-24	07:15:47.2	14.809	43.04	54.6	4.7	0
2003-01-10	18:25:08.9	17.2765	39.9965	10	4.2	0
2003-06-10	07:10:38.5	14.3861	40.1184	10	4.5	0
2003-11-26	01:26:10.2	14.317	42.182	94	3.3	0
2004-01-29	23:19:34.4	17.7927	40.3321	10	4.3	0
2004-01-30	00:19:50.9	17.4341	40.2672	10	4	0
2004-03-10	10:44:40.1	14.7628	41.8341	7.1	4.1	0
2004-04-11	20:19:49.7	14.6794	41.4214	4.2	3.9	0
2004-08-16	22:33:30.0	14.5035	42.5102	10	3.8	0
2004-08-31	23:16:07.4	15.1354	39.7175	10	3.8	0
2004-10-11	18:30:32.0	16.8737	38.7542	10	3.9	0
2006-01-31	13:36:56.9	14.5127	41.3988	10	3.8	0
2006-04-10	13:36:47.2	14.5373	39.9663	10	4.6	0
2006-04-26	07:50:37.5	17.683	40.0583	0	3.7	0
2006-04-26	10:36:24.0	17.7776	40.0831	10	4.4	0

2006-10-01	01:53:51.5	17.5855	40.2425	10	3.4	0
2006-10-01	02:35:49.8	17.2387	40.614	0	3.6	0
2006-10-01	02:38:02.2	17.2643	40.3042	0	3.7	0
2006-10-01	06:23:48.9	17.0744	40.4685	10	3.8	0
2006-10-01	06:26:40.8	17.4856	40.0551	0	3.6	0
2006-10-01	06:51:19.8	17.1451	40.4985	10	3.5	0
2007-01-07	14:55:31.9	15.032	42.1805	10	3.6	0
2007-01-07	22:24:55.4	15.0539	42.2721	10	3.6	0
2007-01-08	07:52:20.0	15.1252	42.2248	10	3.7	0
2007-01-08	14:44:06.8	15.0722	42.2349	10	4.3	0
2007-01-08	15:03:18.6	16.3674	38.7194	10	4.1	0
2007-01-09	07:29:12.4	15.0263	42.147	10	4.1	0
2007-11-23	00:18:37.2	16.5572	41.2782	10	3.9	0
2007-12-20	15:13:43.2	17.5363	40.231	10	4	0
2008-04-15	20:40:44.5	17.3836	39.2453	0	3.6	0
2008-04-25	02:13:39.0	16.1047	38.9662	10	3.9	0
2008-07-22	12:00:41.8	16.4423	40.9364	0	3.8	0
2008-09-05	20:57:41.5	14.6922	39.6944	10	3.8	0
2008-09-18	17:14:12.6	17.6486	40.6272	10	3.8	0
2008-09-18	21:42:16.8	17.5546	40.3118	10	3.8	0
2008-09-20	04:50:49.2	17.6272	40.2307	10	4.2	0
2008-11-05	05:05:22.2	17.5822	40.176	10	3.8	0
2008-12-31	21:54:49.9	17.3544	40.3959	20.2	3.9	0
2008-12-31	21:56:18.3	17.4306	40.4583	10	3.7	0
2008-12-31	22:14:37.6	17.4484	40.4288	10	3.7	0

2009-01-01	01:39:21.8	17.1844	40.545	10.7	4.6	0
2009-01-01	01:51:27.3	17.2332	40.4887	10	4.1	0
2009-03-11	08:25:30.6	17.8925	39.4683	0	3.8	0
2009-07-27	19:11:48.3	16.0392	41.4454	0	3.5	0
2009-11-29	16:46:30.4	14.3842	41.9402	0	3.7	0
2009-12-10	20:26:34.2	14.2863	40.1379	0	3.5	0
2010-01-08	03:31:56.4	17.416	40.2973	0	3.6	0
2010-01-09	20:34:39.6	14.3405	40.1036	0	3.4	0
2010-01-20	01:00:43.6	15.9149	39.6152	0	3.4	0
2010-03-12	16:46:32.5	17.7837	40.0749	0	3.6	0
2010-03-12	16:54:20.6	17.9655	40.0793	0	3.6	0
2010-08-17	05:46:03.4	16.5731	40.9433	0	3.8	0
2010-09-12	13:11:00.7	17.0216	40.5936	0	3.8	0
2010-09-13	01:35:22.3	17.134	40.547	15	4.6	0
2010-10-30	01:29:39.4	17.2506	39.8575	0	3.6	0
2010-12-16	18:23:09.4	17.889	40.08	10	4.6	0
2010-12-17	06:27:02.8	17.8473	40.0401	0	3.7	0
2010-12-18	10:40:51.3	17.8989	40.1039	0	3.7	0
2011-03-25	05:21:33.4	15.289	39.736	10	4.8	0
2011-03-31	18:33:37.3	13.216	41.7758	0	3.7	0
2011-04-29	16:41:33.9	15.309	42.02	9.9	4.6	0
2011-04-30	06:39:55.0	15.001	42.063	10	4.6	0
2011-04-30	13:48:48.1	15.044	42.14	10	4.3	0
2011-04-30	22:36:01.4	15.257	42.293	10	4.5	0
2011-05-03	15:12:10.9	14.964	42.274	10	4.5	0

2011-05-03	18:50:32.2	14.994	42.164	14.7	4.4	0
2011-06-08	02:02:00.6	17.823	40.329	10	4.3	0
2011-06-08	02:29:43.1	17.763	40.276	10	4.2	0
2011-06-12	15:37:04.1	13.42	41.694	1.9	5.1	0
2011-06-12	15:38:52.0	13.339	41.637	10	4	0
2011-06-12	16:09:30.3	13.443	41.696	2.9	4.5	0
2011-06-12	16:12:02.9	13.397	41.734	10	4.7	0
2011-06-12	16:22:11.2	13.282	41.716	10	4.2	0
2011-06-12	16:24:44.0	13.436	41.682	10	4.8	0
2011-06-12	16:27:49.9	13.305	41.654	10	4.8	0
2011-06-12	16:33:11.9	13.507	41.722	10	4.3	0
2011-06-12	16:44:40.9	13.337	41.659	10	4.7	0
2011-06-12	16:51:00.4	13.349	41.763	10	4.3	0
2011-06-12	17:18:09.9	13.381	41.764	9.9	4.8	0
2011-06-12	17:47:21.0	13.538	41.588	10	4.7	0
2011-06-12	18:01:19.2	12.817	41.933	10.1	4.5	0
2011-06-12	19:37:42.9	13.316	41.611	10.1	4.7	0
2011-06-12	19:44:16.1	13.369	41.644	9.9	4.8	0
2011-06-12	21:37:14.1	13.234	41.806	15	4.5	0
2011-06-12	21:41:57.2	13.309	41.668	15.3	4.6	0
2011-06-17	09:16:10.3	12.97	41.93	142	5.5	0

Appendix 3. PDE Data on seismic events.

Retrieved from the online USGS-catalog & P. Gouin (*1979*)

YYYY	MM	DD	TIME	LAT	LONG	MB	DEPTH	CATALOG
1962	8	25	00 54 08	16.49	40.12		33	USCGS
1962	11	11	15 15 33.6	17.2	40.7	5.6	34	USCGS
1966	4	9	19 11 10.5	14.37	40.79	4.7	33	USCGS
1967	5	19	15 52 34.2	14.53	40.26	5.1	13	USCGS
1967	9	18	02 02 59.8	15.69	39.03	4.8	33	USCGS
1967	9	21	18 36 26.1	17.94	39.97	4.4	16	USCGS
1967	11	16	02 22 03.1	15.09	39.82	5.1	33	USCGS
1968	5	23	23 36 06.43	14.747	40.217	4.8	33	USCGS
1969	9	26	04 54 35.66	16.428	40.983	5.1	25	USCGS
1974	4	17	182733.7	17.255	40.365	5.1	33	PDE
1974	4	26	180816.9	17.141	40.38	4.8	33	PDE
1974	6	30	132624.7	16.013	39.631	4.4	33	PDE
1975	4	16	25508.8	14.632	40.69	4.5	33	PDE
1975	8	7	224313.3	15.288	40.407	4.6	37	PDE
1975	12	14	231647.6	14.62	42.24	5.3	33	PDE
1975	12	14	232725.9	14.735	42.318	5.3	33	PDE
1976	11	7	55307.6	15.82	41.423	4.8	34	PDE
1976	11	7	202147.4	15.973	41.474	4.7	33	PDE
1976	11	16	125333.7	15.905	41.915	4.9	33	PDE
1976	12	1	50338.7	15.866	41.681	4.8	33	PDE
1977	6	27	141320.2	16.153	40.013	4.3	33	PDE
1977	12	28	24536.7	16.659	40.278	6.8	33	PDE

1978	1	4	50443.1	16.689	40.848	4.5	33	PDE
1978	1	17	150027.4	16.521	40.263	5.2	10	PDE
1978	2	21	220442.3	16.462	40.392	4.7	33	PDE
1978	3	25	25504.2	16.53	40.259	5,00	10	PDE
1979	7	17	170657.7	17.425	40.112	5.2	10	PDE
1979	8	13	161750	15.267	42.032	4.4	10	PDE
1979	8	15	22043.2	15.393	41.699	4.7	10	PDE
1979	11	10	174244.8	14.88	39.64	4.3	10	PDE
1980	1	14	41054	16.518	40.268	5.7	10	PDE
1980	1	14	42149.2	16.551	40.083	4.5	10	PDE
1980	1	14	122822.6	16.453	40.232	5.3	10	PDE
1980	1	14	125715.4	16.323	40.173	4.7	10	PDE
1980	1	26	61530.4	16.372	40.137	4.6	10	PDE
1980	3	5	31205.2	16.61	40.239	4.9	10	PDE
1980	7	12	125904.5	17.193	40.266	4.3	10	PDE
1980	7	16	231456.7	17.245	40.435	4.8	10	PDE
1980	7	17	819.1	16.633	40.465	4.6	10	PDE
1980	7	17	1250.9	17.411	39.965	4.3	10	PDE
1980	11	28	21131.3	12.562	43.039	0,00	10	PDE
1983	8	7	104218.35	16.449	41.326	4.5	10	PDE
1984	9	24	212507.52	13.034	43.433	0,00	10	PDE
1984	10	12	63829.8	14.653	40.318	4.1	33	PDE
1985	6	13	81445.35	16.112	39.627	4.7	10	PDE
1987	9	11	4816.45	16.992	40.341	4.8	10	PDE
1988	3	30	63351.62	16.404	41.059	4.8	10	PDE

1988	4	6	31122.64	16.371	41.166	4.8	10	PDE
1988	4	8	223237.8	16.344	41.121	4.6	10	PDE
1988	11	1	190648.27	16.602	40.846	4.5	10	PDE
1988	11	1	191947.13	16.541	40.997	4.7	10	PDE
1988	11	1	235104.95	16.791	40.614	4.2	10	PDE
1988	11	2	5713.69	16.627	40.763	4.6	10	PDE
1988	11	2	140636.14	16.482	40.967	4.4	10	PDE
1988	11	3	11937.58	16.451	40.982	4.5	10	PDE
1988	11	3	75509.48	16.49	41.019	4.7	10	PDE
1988	11	3	192722.43	16.467	41.02	4.6	10	PDE
1988	11	3	195058.59	16.539	41.076	4.8	10	PDE
1988	11	4	10256.43	16.63	40.938	4.4	10	PDE
1988	11	6	150008.16	16.58	41.15	4.6	10	PDE
1988	12	10	173319.97	16.32	41.102	5.4	10	PDE
1989	4	16	62054.98	13.855	43.113	4.1	10	PDE
1990	6	7	221824.33	17.609	40.466	4.5	10	PDE
1990	6	8	31702.07	17.529	40.972	4.5	10	PDE
1991	1	25	232251.86	13.599	43.91	0,00	10	PDE
1993	5	1	75713.48	14.761	40.497	4.2	10	PDE
1993	5	2	100809.24	14.439	40.116	4.7	10	PDE
1993	5	2	175823.03	14.577	40.099	4.8	10	PDE
1993	5	2	213417.9	14.453	39.77	4.6	33	PDE
1993	5	3	123738.99	14.394	40.131	4.6	10	PDE
1993	5	4	22318.19	16.443	39.675	4.3	10	PDE
1993	5	4	64754.13	15.191	39.9	4.1	10	PDE

1993	5	4	164608.92	14.562	40.167	4.5	10	PDE
1993	5	5	180651.21	14.349	40.079	4.9	10	PDE
1993	5	6	12132.63	14.935	40.428	4.4	10	PDE
1993	5	6	203555.62	14.395	40.126	5.3	10	PDE
1993	5	8	224053.1	15.201	39.92	4.1	10	PDE
1993	5	10	105459.55	14.449	40.194	5.4	10	PDE
1993	5	11	34410.56	14.516	40.242	4.8	25	PDE
1993	5	13	182049.72	14.4	40.186	5.3	19	PDE
1993	5	14	50144.75	14.487	40.021	3.5	33	PDE
1993	5	18	93313.31	14.393	40.221	5,00	10	PDE
1993	6	16	111014.68	17.294	39.951	4.7	10	PDE
1993	7	3	13717.53	17.865	39.982	4.9	10	PDE
1993	11	1	2755.16	13.863	43.509	3.9	24	PDE
1994	5	11	100804.18	15.752	41.383	4.5	10	PDE
1994	5	11	202214.1	15.327	42.216	0,00	10	PDE
1994	5	13	105614.63	16.042	41.815	4.5	10	PDE
1994	5	14	223434.68	15.207	42.055	4.6	10	PDE
1994	5	16	121023.05	15.301	42.108	4.7	10	PDE
1994	6	21	21221.06	15.495	41.622	4.8	10	PDE
1995	6	24	84133.64	17.243	40.532	4.8	10	PDE
1995	9	10	123059.5	15.612	39.396	4.5	10	PDE
1995	11	8	20842.03	14.029	43.49	0,00	10	PDE
1996	2	20	83646.71	15.775	39.205	4.5	33	PDE
1996	4	7	55752.75	15.703	42.328	4.1	10	PDE
1996	4	16	123248.56	15.76	39.369	3.9	10	PDE

1996	4	30	34141.24	15.294	42.052	4,00	10	PDE
1996	4	30	173609.03	15.296	42.063	4.1	10	PDE
1996	5	1	114520.6	15.448	41.987	4.3	10	PDE
1996	5	2	231217.41	15.346	42.053	4.3	10	PDE
1996	5	5	204217.48	15.464	41.918	4.4	10	PDE
1997	7	13	161308.57	15.292	41.93	4.2	10	PDE
1997	7	13	185038.08	15.186	41.986	4.2	10	PDE
1997	7	14	132918.38	15.491	42.219	4.4	10	PDE
1998	5	13	2751.38	14.32	42.028	4.9	10	PDE
1998	5	13	95900.39	13.98	42.059	5.1	10	PDE
1999	4	29	145723.41	17.93	40.127	4.5	10	PDE
1999	12	27	25418.1	17.888	39.93	4.1	33	PDE
2002	6	18	104415.89	14.525	42.111	4.4	10	PDE
2003	1	10	182510.75	17.562	40.088	0,00	10	PDE
2003	6	10	71038.87	14.455	40.071	4.6	10	PDE
2003	6	10	182322.64	14.464	40.21	4.3	10	PDE
2004	1	29	231936.68	17.865	40.135	4.5	10	PDE
2004	1	30	1948.32	16.808	40.093	0,00	10	PDE
2004	8	31	231605.72	14.744	39.711	4.2	10	PDE
2006	1	31	133657.51	14.568	41.584	4,00	10	PDE
2006	4	10	133646.68	14.529	39.939	4.9	10	PDE
2006	10	1	15351.17	17.573	40.213	3.7	10	PDE
2006	10	1	62348.93	17.056	40.337	3.9	10	PDE
2007	1	8	144406.18	15.004	42.233	4,00	10	PDE
2007	1	8	150319.66	16.5	38.806	4.1	10	PDE

2007	1	9	72912.12	14.984	42.071	4.1	10	PDE
2007	11	23	1836.75	16.489	40.994	4,00	10	PDE
2007	12	20	151343.21	17.506	40.114	4.1	10	PDE
2008	4	25	21340.11	16.143	38.739	4,00	10	PDE
2008	9	20	45050.74	17.794	40.096	4.2	10	PDE
2008	11	5	50522.69	17.658	40.106	3.9	10	PDE
2008	12	31	215448.05	17.33	40.421	4.2	10	PDE
2008	12	31	215618.18	17.427	40.454	4,00	10	PDE
2008	12	31	221437.6	17.399	40.414	3.8	10	PDE
2009	1	1	13921.9	17.217	40.519	5,00	10	PDE
2010	8	17	54605.08	16.649	40.952	4.1	10	PDE-W
2010	9	12	131103.48	17.175	40.487	4.1	10	PDE-W
2010	9	13	13523.49	17.129	40.572	4.6	10	PDE-W
2010	12	16	182309.36	17.889	40.08	4.6	10	PDE-W
2011	3	25	52133.44	15.289	39.736	4.8	10	PDE-Q
2011	3	31	183338.04	13.17	41.829	4.5	6	PDE-Q
2011	4	29	164132.14	15.094	42.027	4.6	9	PDE-Q
2011	4	30	63955.02	15.001	42.063	4.6	10	PDE-Q
2011	4	30	134848.06	15.044	42.14	4.3	10	PDE-Q
2011	4	30	223601.09	15.196	42.242	4.5	10	PDE-Q
2011	5	3	151210.89	14.964	42.274	4.5	10	PDE-Q
2011	5	3	185031.96	15.054	42.063	4.4	10	PDE-Q
2011	6	8	20200.57	17.823	40.329	4.3	10	PDE-Q
2011	6	8	22943.18	17.738	40.254	4.2	10	PDE-Q
2011	6	12	153704.11	13.42	41.694	5.1	1	PDE-Q

2011	6	12	153852	13.339	41.637	4,00	10	PDE-Q
2011	6	12	160930.95	13.331	41.76	4.5	10	PDE-Q
2011	6	12	161203.18	13.322	41.781	4.7	12	PDE-Q
2011	6	12	162211.16	13.282	41.716	4.2	10	PDE-Q
2011	6	12	162444.07	13.398	41.726	4.8	10	PDE-Q
2011	6	12	162749.9	13.305	41.654	4.8	10	PDE-Q
2011	6	12	163309.52	13.304	41.751	4.3	1	PDE-Q
2011	6	12	164440.87	13.337	41.659	4.7	10	PDE-Q
2011	6	12	165100.39	13.349	41.763	4.3	10	PDE-Q
2011	6	12	171809.94	13.381	41.764	4.8	9	PDE-Q
2011	6	12	174720.98	13.538	41.588	4.7	10	PDE-Q
2011	6	12	180119.23	12.817	41.933	4.5	10	PDE-Q
2011	6	12	193742.92	13.316	41.611	4.7	10	PDE-Q
2011	6	12	194416.05	13.369	41.644	4.8	9	PDE-Q
2011	6	12	203240.66	13.46	41.688	5.6	10	PDE-Q
2011	6	12	210323.22	13.53	41.625	5.4	9	PDE-Q
2011	6	12	213714.06	13.234	41.806	4.5	15	PDE-Q
2011	6	12	214157.24	13.309	41.668	4.6	15	PDE-Q
2011	6	17	91612.69	13.307	41.668	5.6	10	PDE-Q

Appendix 4. SEISAN-Processed data from ASME and ABSE considering 1999.

Not listed chronologically

YYYYMMDD	HHMM	LAT	LONG	DEPTH	MAG
19990125	1947	15.053	39.721	15.2	1.2
19990125	2020	15.053	39.722	14.2	1.8
19990125	2232	15.024	39.729	15.0	2.2
19990126	121	15.118	39.749	0.0	2.3
19990203	2344	15.552	39.479	19.0	1.3
19990208	1850	14.284	40.259	11.5	1.6
19990201	1822	15.117	39.462	28.4	1.1
19990215	2354	15.622	39.501	22.1	0.7
19990216	2053	12.175	40.146	12.1	2.7
19990216	2055	12.162	40.192	12.1	2.6
19990218	1752	14.163	40.100	0.0	2.0
19990218	1838	13.980	40.092	12.1	1.9
19990218	1842	14.018	40.064	0.1	1.3
19990218	1845	14.118	39.978	0.0	1.7
19990220	2100	17.431	37.130	0.0	1.3
19990221	649	15.822	38.771	12.1	1.8
19990220	2108	15.818	38.783	10.3	0.9
19990223	1919	14.641	39.947	14.1	2.5
19990227	127	14.511	39.851	12.2	1.9
19990227	1324	15.608	39.127	14.5	1.0
19990228	2206	14.820	39.882	12.0	1.6
19990228	2235	14.644	39.825	15.0	1.3

19990228	2323	12.068	39.873	12.1	3.0
19990302	2153	13.113	40.822	0.0	2.8
19990308	1103	15.106	39.586	0.6	1.8
19990311	1432	13.786	40.255	16.7	2.5
19990312	2255	15.377	40.008	15.7	1.4
19990319	304	12.582	41.259	17.5	3.1
19990319	922	15.673	39.292	0.0	1.5
19990321	721	14.373	39.761	0.0	2.0
19990326	1554	15.776	38.921	19.2	1.0
19990328	1014	15.743	38.935	15.0	0.6
19990406	2328	15.644	39.512	15.0	1.1
19990407	1642	13.931	40.132	22.7	1.6
19990407	1645	13.843	40.201	22.6	0.9
19990903	1253	15.892	38.981	15.0	1.6
19991023	2043	15.581	39.009	12.1	0.7
19990903	2051	15.845	38.932	18.9	2.0
19991023	2106	15.539	38.994	13.7	0.5
19990904	1555	15.693	38.825	15.7	1.1
19991023	2243	15.487	38.957	13.6	0.2
19990904	1559	16.163	40.275	15.0	2.4
19991023	2313	15.497	38.906	15.7	0.0
19990905	13	15.902	39.004	16.8	1.5
19991023	2337	15.453	38.913	11.4	1.5
19990905	1113	15.895	39.032	15.0	0.9
19991024	101	15.533	38.941	18.4	0.2

19991103	256	14.553	39.859	13.6	1.3
19991103	1806	14.640	39.895	5.4	1.4
19991103	2337	14.638	39.880	7.7	1.4
19991123	149	13.934	40.134	0.0	2.3
19991123	29	14.613	39.890	13.5	1.0
19991121	1710	14.105	40.272	0.1	2.0
19991119	2246	15.468	40.245	15.0	1.4
19991115	1542	15.440	39.416	0.7	1.2
19991115	233	15.882	38.989	12.8	1.2
19991114	331	14.524	39.893	13.2	0.3
19991103	2349	14.521	39.835	12.6	1.4
19991104	47	14.546	39.854	12.5	1.7
19991104	919	14.411	39.730	12.1	1.7
19991105	2032	14.499	39.820	12.1	1.5
19991105	2159	14.564	39.879	12.1	1.4
19991106	1315	14.207	40.186	12.1	1.7
19991107	952	15.431	39.371	14.5	1.4
19991109	607	14.630	39.898	13.6	1.8
19991110	320	14.558	39.952	12.4	1.3
19991109	1916	14.532	39.829	12.6	1.7
19991109	1053	14.478	39.775	12.1	1.5
19991109	1048	14.574	39.908	12.6	2.0
19991023	1859	15.531	38.900	15.0	0.6
19990903	1058	15.788	38.852	12.1	2.7
19991022	1526	14.141	40.309	0.0	2.1

19990902	228	15.817	38.789	6.4	1.0
19991022	1524	13.934	40.1333	12.4	2.3
19990901	2345	15.641	39.629	17.1	0.9
19991021	1251	15.472	40.258	17.8	2.4
19990831	1553	15.703	38.822	18.9	1.6
19991021	216	15.632	39.495	22.5	1.7
19990831	27	13.763	40.278	17.0	2.1
19991019	2256	13.658	40.360	10.2	2.1
19990830	218	15.885	38.987	13.7	2.4
19991019	2139	15.603	39.166	12.1	0.8
19990830	115	15.869	38.942	18.7	1.4
19991015	2008	15.686	39.467	15.0	0.9
19990826	1904	14.605	39.564	0.0	2.2
19990821	2043	15.695	38.980	12.1	1.3
19991008	2147	14.225	40.184	12.1	2.0
19990819	2054	15.521	39.023	12.5	0.7
19991006	1811	14.070	40.288	13.3	2.1
19990819	1859	15.534	39.028	12.2	0.4
19990819	1844	15.511	39.024	12.3	0.7
19990928	2300	16.112	39.076	20.0	1.5
19990922	127	16.027	38.898	19.6	1.7
19990816	2345	13.402	41.200	11.1	2.6
19990921	2222	16.038	39.097	4.3	2.0
19990921	443	16.032	39.151	2.2	1.5
19990813	1651	15.103	39.534	0.0	1.1

19990813	1645	15.098	39.579	15.0	1.6
19990918	1111	15.765	38.875	4.3	0.7
19990810	1901	15.716	39.621	23.0	1.3
19990912	1157	14.496	39.936	13.3	1.4
19990729	1328	13.870	40.184	15.0	2.0
19990910	1116	15.873	38.978	8.1	1.8
19990910	1042	15.856	39.054	11.4	1.2
19990724	2155	14.783	39.753	19.4	1.0
19990722	30	15.399	39.538	7.2	1.5
19990721	333	14.514	39.766	9.5	1.6
19990720	1726	15.555	39.434	60.3	1.6
19990720	1642	14.554	39.923	12.5	1.7
19990715	116	15.782	39.652	22.9	1.1
19990708	2116	13.872	40.180	0.0	1.8
19990630	1740	14.573	39.876	8.1	1.4
19990628	1313	14.742	39.919	1.5	1.6
19990627	1527	12.855	41.035	0.1	0.0
19990625	705	14.422	39.841	6.8	2.1
19990624	900	15.496	40.058	15.0	1.9
19990618	849	15.617	39.030	18.1	1.6
19990617	1709	15.147	39.792	15.0	1.8
19990611	32	15.080	39.363	0.0	1.3
19990609	1030	15.595	39.208	6.8	2.2
19990603	2114	14.849	39.357	0.1	1.8
19990528	2013	15.924	38.770	12.1	1.4

19990521	912	15.379	39.056	0.0	1.0
19990512	115	15.730	39.409	15.0	1.4
19990512	40	12.808	41.073	0.0	1.3
19990509	23	14.557	39.777	0.2	1.4
19990506	846	15.870	38.717	9.3	1.4
19990429	1457	17.226	40.244	15.0	2.9
19990429	29	15.349	39.480	6.0	1.7
19990426	2239	13.700	40.340	13.2	2.2
19990426	2238	13.8333	40.689	15.0	2.2
19990425	1553	14.344	39.786	0.1	2.0
19990417	441	14.444	39.826	14.9	2.1
19990417	417	14.364	39.770	12.2	1.9
19990413	2256	15.154	39.628	4.1	1.3

Appendix 5. SEISAN-Processed data from ASME and ABSE considering 2001.

YYYYMMDD	HHMM	LAT	LONG	DEPTH	MAG
20010111	626	14.422	39.720	0.0	1.7
20010111	626	14.303	39.819	0.1	1.6
20010111	1159	15.162	40.133	40.9	2.7
20010111	1216	14.448	39.697	0.0	1.8
20010111	1435	14.407	39.733	0.0	1.8
20010111	1438	14.394	39.743	0.0	1.7
20010111	1718	14.407	39.733	0.0	1.3
20010111	2333	14.381	39.754	0.1	1.5
20010112	26	14.442	39.703	0.0	1.5
20010121	318	14.430	39.713	0.0	1.6
20010121	2052	13.290	40.668	0.0	2.8
20010125	1917	13.966	40.104	14.6	2.2
20010127	717	13.957	40.111	13.7	2.6
20010129	1200	14.431	39.711	0.0	1.5
20010130	2135	14.510	39.645	0.0	1.1
20010131	117	14.162	39.941	0.0	1.5
20010202	1932	16.034	39.335	6.5	1.2
20010202	2222	17.234	40.696	15.0	2.5
20010205	2348	15.671	38.653	0.0	1.5
20010211	1529	19.364	40.324	13.8	3.1
20010216	1215	15.812	38.532	0.0	1.8
20010301	16	15.430	40.638	3.8	0.0
20010306	143	15.497	39.390	19.5	1.2

20010307	18	15.003	39.546	23.5	0.9
20010311	1630	12.840	41.046	15.0	0.0
20010312	2242	13.540	41.480	12.1	3.2
20010314	2044	13.917	40.148	23.0	2.5
20010314	2058	13.892	40.173	15.0	1.4
20010314	2103	13.880	40.174	23.0	1.7
20010315	1047	18.105	38.970	15.0	3.1
20010318	712	14.692	40.050	15.6	1.0
20010318	1719	13.433	40.571	31.1	2.9
20010327	123	15.795	38.763	15.0	1.2
20010402	1946	15.867	39.557	15.0	2.1
20010403	1244	14.491	41.055	0.0	2.1
20010404	100	15.173	40.061	31.0	3.0
20010405	1131	15.607	39.589	67.8	1.5
20010406	2040	15.176	39.686	0.0	0.6
20010418	1808	15.762	38.575	0.0	1.0
20010503	1339	13.212	40.703	15.0	3.8
20010504	1726	13.304	40.662	15.0	3.3
20010504	1833	13.087	40.845	15.0	2.7
20010510	1125	15.700	38.629	0.0	1.3
20010518	21	16.016	39.509	15.0	0.8
20010518	58	15.913	39.513	15.0	0.9
20010518	100	15.913	39.033	35.7	1.8
20010518	319	14.893	38.176	22.3	0.9
20010609	152	14.099	40.930	15.0	2.2

20010614	100	15.364	38.938	15.0	3.1
20010617	1820	14.878	39.337	35.6	3.0
20010617	1921	14.855	39.357	36.7	0.1
20010617	2038	14.932	39.291	27.2	1.2
20010617	2204	15.111	39.569	6.4	0.7
20010617	2222	15.109	39.571	0.0	0.6
20010618	33	15.098	39.565	0.0	0.5
20010620	2051	14.541	39.854	22.8	0.9
20010621	1031	15.121	39.542	4.1	1.3
20010622	622	14.807	39.398	45.3	0.9
20010622	806	14.796	39.402	64.4	0.5
20010627	2213	14.860	39.535	36.0	1.0
20010718	2152	14.016	40.061	9.8	1.6
20010731	41	13.896	40.167	0.0	2.0
20010731	731	13.788	40.257	15.0	1.8
20010802	727	15.275	39.652	2.4	2.2
20010802	2349	15.541	39.463	30.8	0.9
20010817	832	14.677	39.505	0.0	1.5
20010819	819	15.057	39.451	7.9	0.5
20010821	43	16.219	41.683	52.2	2.1
20010826	847	16.064	40.049	15.0	2.0
20010831	733	15.546	38.761	0.1	1.5
20010901	52	15.212	39.729	89.4	1.3
20010901	2044	15.226	39.295	0.0	0.1
20010901	2134	15.916	39.487	36.5	1.4

20010902	1337	14.323	39.810	15.0	1.5
20010903	4	13.319	40.684	12.1	2.3
20010905	1855	15.294	39.256	109.7	0.9
20010906	327	15.617	39.207	11.7	1.1
20010909	1055	15.219	39.634	10.0	2.6
20010912	439	14.983	39.961	12.2	1.5
20010913	29	13.456	40.531	0.0	2.9
20010913	1750	12.786	41.105	12.1	2.6
20010914	214	14.905	39.924	11.9	1.2
20010915	808	14.249	39.254	18.7	1.2
20010916	16	12.970	40.938	0.1	2.5
20010924	515	14.863	40.015	21.2	2.5
20010927	2125	15.024	39.888	30.9	1.7
20010927	2153	14.817	39.389	90.3	1.2
20010928	1852	15.635	39.230	0.0	0.1
20010928	1951	14.901	39.31	58.9	1.3
20010930	1735	15.118	39.584	29.0	1.9
20011001	106	15.139	39.619	22.9	1.1
20011001	141	15.120	39.653	23.1	0.9
20011001	228	15.124	39.643	23.0	0.6
20011001	1112	15.123	39.644	29.2	1.6
20011001	1448	15.192	39.428	6.1	2.1
20011001	2258	15.115	39.669	25.0	0.6
20011001	2259	15.127	39.636	23.0	2.0
20011001	2304	15.073	39.464	14.6	1.0

20011003	1012	15.180	39.466	17.9	1.9
20011003	2148	15.134	39.641	22.8	1.4
20011004	957	15.665	38.657	20.9	1.3
20011005	1321	13.707	40.324	10.7	2.8
20011005	2305	13.669	40.353	0.1	2.0
20011006	150	14.972	39.602	45.0	1.0
20011006	201	15.134	39.612	20.5	0.9
20011006	430	15.132	39.678	15.0	0.8
20011006	431	15.028	39.910	0.0	1.4
20011006	443	15.121	39.653	20.5	1.1
20011006	444	15.133	39.624	12.1	1.2
20011006	504	15.123	39.645	21.6	1.3
20011008	15	16.070	38.706	12.1	2.3
20011008	318	15.117	39.665	15.2	1.2
20011008	2256	15.645	39.495	27.4	2.1
20011005	2258	15.552	39.448	64.3	0.4
20011008	2259	15.601	39.581	19.3	0.4
20011008	2347	15.662	39.621	15.0	0.9
20011008	2356	15.688	39.532	15.0	1.7
20011008	2359	15.667	39.566	15.0	1.1
20011009	13	15.679	39.564	15.0	1.4
20011009	24	15.692	39.579	15.0	1.1
20011009	739	15.777	38.812	20.0	1.3
20011010	34	15.985	38.771	23.0	1.4
20011014	120	14.483	39.802	23.3	1.2

20011022	1247	43.328	40.636	0.1	3.1
20011025	1728	14.663	39.951	23.0	1.7
20011025	1836	14.771	39.879	16.1	1.6
20011025	2121	14.509	39.653	25.4	1.7
20011027	808	15.756	38.582	0.0	1.3
20011028	1710	14.986	39.527	40.6	1.2
20011029	1707	14.318	39.816	97.3	1.5
20011031	1843	15.141	39.590	24.9	1.2
20011031	2125	15.128	39.629	20.1	1.0
20011101	52	15.121	39.653	21.3	0.9
20011101	142	15.136	39.604	11.6	0.9
20011101	234	15.118	39.615	12.1	1.2
20011101	239	15.135	39.608	14.8	1.2
20011101	1619	15.918	39.423	58.3	2.5
20011101	2028	15.585	39.599	75.5	2.1
20011102	1818	15.812	39.732	19.1	2.5
20011104	331	14.522	39.023	22.9	1.4
20011104	451	14.725	39.468	52.6	1.7
20011104	902	14.682	39.505	50.1	0.9
20011104	2155	14.836	39.373	32.4	1.0
20011105	235	14.712	39.479	45.2	0.8
20011105	239	14.670	39.516	60.1	1.0
20011107	10	15.108	39.758	23.0	1.8
20011107	14	15.071	39.808	26.5	1.5
20011107	55	15.072	39.807	23.0	1.1

20011107	117	15.062	39.828	23.3	1.0
20011107	231	15.134	39.884	15.0	1.2
20011107	300	15.084	39.776	15.0	1.1
20011107	614	15.155	39.878	15.0	1.3
20011107	626	14.714	39.478	80.4	2.0
20011107	1514	15.175	39.482	135.1	1.6
20011107	2015	15.133	39.809	15.0	1.3
20011107	2022	15.067	39.806	13.4	1.1
20011107	2023	15.089	39.753	14.1	1.1
20011107	2043	15.062	39.837	25.1	0.9
20011108	120	16.382	38.674	0.0	1.1
20011108	244	15.485	39.493	1.4	1.9
20011108	302	15.736	38.700	0.0	0.1
20011108	923	15.722	38.610	29.0	2.5
20011109	1308	15.350	39.302	2.3	0.7
20011109	1945	13.461	40.527	0.1	2.8
20011111	2237	14.287	45.387	15.0	3.7
20011116	515	15.830	39.641	15.0	1.1
20011116	2040	14.916	39.304	13.5	0.6
20011119	58	15.808	39.098	63.3	1.8
20011119	58	15.864	39.322	30.9	1.7
20011119	1737	15.378	38.937	83.0	1.0
20011119	1737	15.667	39.505	14.0	0.9
20011121	1041	15.507	39.354	50.6	0.8
20011121	1829	11.813	41.899	0.0	3.3

20011124	1926	15.494	39.628	92.2	1.2
20011124	1933	15.654	39.845	12.1	1.2
20011125	523	11.731	41.965	15.0	3.2
20011125	530	11.941	41.786	15.0	3.6
20011126	829	15.607	39.451	6.1	1.6
20011127	2044	15.672	39.496	0.0	1.4
20011127	2235	15.110	39.709	31.0	1.3
20011214	1712	15.087	39.757	48.8	0.5
20011214	2348	15.749	38.857	9.4	1.3
20011216	1409	14.651	39.531	57.6	1.3
20011218	1649	15.512	39.027	53.9	1.9
20011220	2247	15.178	39.472	31.2	0.4
20011221	711	15.843	39.590	15.0	1.8
20011222	140	15.627	39.837	17.5	1.1
20011223	1209	15.895	39.724	13.8	2.5
20011223	2039	15.877	39.760	15.0	1.2
20011223	2142	15.898	39.702	30.1	1.6
20011224	1515	15.438	39.161	12.2	1.0
20011226	1550	15.850	39.812	23.0	1.5
20011227	349	15.196	39.821	55.3	0.9
20011229	1430	15.191	39.549	25.4	1.8
20011229	1637	15.213	39.278	0.9	1.1
20011229	2322	15.062	39.787	17.0	1.0
20011229	2324	15.074	39.773	23.0	1.5
20011230	943	15.055	39.859	7.6	1.7

20011230	1004	14.795	39.902	15.0	1.6
20011230	1227	14.779	39.944	22.9	2.0
20011230	1253	14.424	40.628	31.0	3.1
20011231	1633	15.387	38.898	0.0	2.6
20011231	1906	15.681	38.960	10.0	0.8

Appendix 6. Seismic data from GCMT.

lon	lat	str1	dip1	rake1	str2	dip2	rake2	sc	iexp	name	mw
40.32	15.97	106	66	-171	13	81	-24	9.930	25	122877A	6.6
40.49	17.51	282	90	180	12	90	0	1.410	24	011778B	5.4
40.53	17.12	24	76	-9	116	81	-166	1.400	25	011480B	6.0
40.12	16.99	301	90	180	31	90	0	4.820	24	011480D	5.7
41.10	16.56	339	74	-17	74	74	-163	2.840	24	121088C	5.6
40.14	14.52	337	45	-90	157	45	-90	8.830	23	050693E	5.2
40.25	14.41	170	40	-71	326	53	-105	1.752	24	102204D	5.4
40.26	14.87	172	29	-75	335	62	-98	2.938	23	200604101336A	4.9
40.58	17.11	328	26	-61	116	67	-104	3.492	23	200901010139A	5.0
41.90	13.55	122	45	-97	311	46	-83	2.867	24	201106122032A	5.6
41.91	13.54	123	44	-75	282	48	-104	1.412	24	201106122103A	5.4
41.79	13.47	11	84	1	281	89	174	3.265	24	201106170916A	5.6