EXECUTIVE SUMMARY

This work encompasses several key aspects required for a seismic hazard assessment (SHA) for a country. Typically, there are four basic steps in a SHA:

1. The definition of *seismotectonic units*. These units may range from small faults to large seismotectonic provinces.
2. The determination of *earthquake hazard parameters* for each unit, which defines the temporal and spatial distribution of earthquake occurrence. The recurrence time of an earthquake is usually defined as the average number of years between occurrences of an earthquake of a given magnitude. An upper bound for the earthquake for each unit is estimated, which represents the maximum earthquake magnitude.
3. The *estimation of the earthquake effects*, using several ground motion attenuation relationships, each relating to a ground motion parameter, such as peak ground acceleration (PGA) with distance and earthquake magnitude.
4. The determination of the *hazard at the site*. The effects of earthquakes of different sizes occurring at different locations in different earthquake sources at different probabilities of exceedance are integrated into one hazard curve that shows the probability of exceeding different levels of ground motion (such as PGA) at the site during a specified period of time.

The scope of this work is limited to Steps 1 and 2. Due to the very detailed and complex nature of each step and the very large geographic region covered, this report is presented in six self-contained parts:

1. <u>Seismotectonic Models for South Africa: Synthesis of Geoscientific Information, Problems, and the Way Forward (for STEP 1)</u>

   Attempts were made to: (i) summarize known earthquake activity in South Africa, (ii) synthesize well-established trends observed from the geosciences e.g. geological provinces, geophysical anomalies and neotectonic activity, (iii) determine the correlations (if any) with seismicity, and (iv) identify possible areas of further research required to better model or constrain the seismotectonic provinces.

The earthquake record has indicated that South Africa has moderate levels of seismicity. The seismicity is composed of tectonic, mining and mining tectonic seismicity. Historical earthquakes, like M_L 6.3 Ceres 1969, M_L 6.3 St Lucia 1932, and the most recent Mw 7.0 Mozambique 2006 have shown that the effects of these earthquakes can be felt as far as 1000 km from the epicentre. Consequently, our infrastructure should be designed to withstand these earthquakes.

The integration of geoscientific knowledge helps to quantify the uncertainties in the models used to assess the seismic hazard. Several fundamental gaps in the available data were identified, which make the derivation of regional seismotectonic models highly presumptuous. Regional geological and geophysical data show little, if any, clear correlation with present-day earthquake activity. The following activities are recommended to remedy the situation: mapping of Quaternary cover strata, discrimination between mining-related and natural earthquakes, countrywide mapping of neotectonic and palaeoseismic features, determination of focal mechanisms of tectonic earthquakes, microseismic monitoring of key areas like Koffiefontein and Ceres and neotectonic regions like Baviaanskloof, Bronkhortspruit. This information will enable a seismotectonic zonation program.

This work has been published in 2009 in: Seismological Research Letters, Volume 80, Pages 65-73. I contributed to the concepts, ideas and text therein. My co-authors provided guidance, supervision, technical criticism and editorial comments.

2. Collection of isoseismal maps for South Africa (for STEP 1)

   A collection of isoseismal maps is presented. These maps date as far back as 1932 and capture the damage footprint of the largest earthquakes. It is an essential dataset that will be used to characterize the earthquake hazard in subsequent parts of this work. This work was published as a Short Communication in 2009 in: Natural Hazards, Volume 50. Pages 403-408. The initial work was performed by Ms Hattingh who collected some literature and digitized maps from hardcopies and produced some maps from questionnaires. I then took this information, methodologically found the rest of the literature, re-digitized all the maps, drew the rest of the isoseismal maps from questionnaires and wrote the article.

3. First-order Regional Seismotectonic Model for South Africa (for STEP 1) A first order seismotectonic model was created for South Africa. This was done using four logical steps: (i) geoscientific data collection, (ii) characterization, (iii) assimilation, and (iv) zonation. Through the definition of subunits of concentrations of earthquake foci and large neotectonic and structural domains, seismotectonic structures, systems and domains were created.

   Relatively larger controls of seismicity exist between the Great Escarpment and the coast. In the south, this region is characterized by large aeromagnetic anomalies and large E-W trending faults. In the west, the region is characterized by the NW-SE trending Wegener Stress Anomaly, radial-trending dykes and earthquake clusters. In the east, it is characterized by a large neotectonic domain where several large historical earthquakes occurred.

In the centre of South Africa, several clusters of earthquake activity are found, often related to some kind of mining activity. Further north, seismicity is related to both mining activity and neotectonic deformation.

This work contributes to the development of a seismotectonic model for South Africa by (i) bringing together, digitally, several datasets in a common GIS platform (geology, geophysics, stress, seismicity, neotectonics, topography, structure and anisotropy of the crust and mantle), (ii) understanding the significance of datasets for seismotectonic zonation and limitations thereof, and (iii) obtaining a reasonable regional model for use in seismic hazard assessments.

4. Earthquake recurrence parameters and maximum possible earthquake magnitudes (for STEP 2)

Earthquake recurrence parameters and maximum possible earthquakes are estimated across South Africa. Computations are made for twenty zones using various statistical methods. It was found that the mining regions have higher levels of seismicity but relatively few large earthquakes. With regard to tectonic zones, the Ceres region, KZN zone and Koffiefontein (in that order) have the highest levels of seismicity.

The earthquake database is highly incomplete and variable for each zone. Consequently no one method is suitable to assess parameters related to the earthquake distribution. Each zone needs to be considered on a case-by-case basis. Typically, the maximum possible earthquake magnitude m_{max} is 5.8 for the mining zones and 7.3 for tectonic zones.

5. Conclusion

   This part summarizes the knowledge gaps identified in the previous parts and areas where future work should be concentrated in order to improve the earthquake hazard characterization for the country.

6. Appendix

   Preprints of publications.