A MATLAB-BASED DATABASE OF SEISMIC INTENSITY
FOR HISTORICAL EARTHQUAKE IN NORTH CHINA

M. Xia, Z.L. Wu and C.S. Jiang
Institute of Geophysics, China Earthquake Administration, Beijing 100081, China
E-mail: wuzhl@gucas.ac.cn

ABSTRACT:
Pre-instrumental recordings of earthquakes in North China can be traced back to Ming Dynasty about 500 years ago, with most of the destructive earthquakes above magnitude 6½ possessing good coverage of historical documents recording earthquake destruction. To facilitate the using of this set of information in the study of seismic zonation, strong ground motion, and source process, we developed a database of seismic intensity of historical earthquakes in North China. The region spans 30°N~42°N and 104°E~125°E and contains 33 earthquakes with magnitude larger than 6½. To serve various needs of seismological study, the database uses MatLab, with the functions of mapping, intensity indexing, and isoseismal contour plotting.

KEYWORDS: Isoseismal, North China, Historical earthquakes, Intensity

1. INTRODUCTION

Distribution of seismic intensity is not only important in engineering seismology but also contains information of focal mechanism and source process, as revealed by recent studies in strong ground motion seismology (Panza et al., 1991; Sirovich and Pettenati, 2004; Bakun, 2006; Pettenati and Sirovich, 2007). For historical earthquakes, intensity is the only information available to retrieve the focal mechanism and/or source process (Shebalin, 1973; Chen, 1975; Koyama and Zheng, 1991; Song et al., 1995).

North China is one of the important tectonic regions in eastern Asia, characterized by its intense intra-plate seismic activity, and the process of lithosphere destruction and change of stress state in geological times (Xu et al., 2002; Deng et al., 2003; Shen et al., 2004). Pre-instrumental recordings of earthquakes in North China can be traced back to Ming Dynasty about 500 years ago, providing earthquake catalogue complete down to magnitude 5, with most of the destructive earthquakes above magnitude 6½ having good coverage of historical documents recording destruction and/or secondary disasters (Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University, 1986a, b). To facilitate the using of this set of information, we developed a database of seismic intensity for historical earthquakes in North China.

2. REGION FOR STUDY AND DATA PROCESSING

The region for study spans 30°N~42°N and 104°E~125°E, containing 33 earthquakes with magnitude larger than 6½. Figure 1 shows an example of the intensity distribution of historical earthquakes as documented in literature. From the figure it can be seen that there is rich information about earthquake destruction, reflecting the
properties of source process and site-effect. On the other hand, however, the printed information is hard to use in further analysis.

Figure 1 One example of intensity distribution of historical earthquakes in North China, from Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University (1986a). Shown in the figure is the 1556 Huaxian, Shaanxi Province, $M_{8+}$ earthquake.

Transition from destruction recordings in historical documents to intensity has been implemented based on the study of Chinese ethnic architectures and earthquakes in China (Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University, 1986a, b). We use the results of the intensities in the literature and digitized the isoseismals for each earthquake. The data processing uses the tool of MapInfo (MapInfo Corporation, 2003). Calibration was conducted using geographical information such as locations of cities, coastlines, and rivers. The data files contain information exactly the same as that on the map (Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University, 1986a, b), being the isoseismals using Chinese intensity scale which is similar to the European MMI scale (Hao and Xie, 2006), as shown in Table 1.

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<thead>
<tr>
<th></th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
</tr>
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<tr>
<td>China (1999) Acceleration (cm/s²)</td>
<td>90-177</td>
<td>178-353</td>
<td>354-707</td>
<td>708-1414</td>
</tr>
<tr>
<td>MMI (1956) Acceleration (cm/s²)</td>
<td>147-245</td>
<td>245-294</td>
<td>294-588</td>
<td>588-784</td>
</tr>
<tr>
<td>China (1999) Velocity (cm/s)</td>
<td>10-18</td>
<td>19-35</td>
<td>36-71</td>
<td>72-141</td>
</tr>
<tr>
<td>MMI (1956) Velocity (cm/s)</td>
<td>8-20</td>
<td>20-30</td>
<td>30-60</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>
3. THE DATABASE

An example of the database is shown in Figure 2, being the same earthquake as that in Figure 1. Isoseismal distribution is affected not only by source process of the earthquake but also by site geology. Considering the recent results which approx the v30 data by topography gradient (Wald and Allen, 2007), we also plot the topography in the figure.

The database may produce .mif files of intensity distribution. Figure 3 displays the homepage of the database and the instruction of using the .mif files. Shape analysis (Kronrod et al., 2000; Sirovich et al., 2002; Molchan et al., 2002, 2004) can be conducted conveniently using the .mif files. Shown in Figure 4 is an example of the shape analysis using the approach of Molchan et al. (2002; 2004).

Figure 5 shows the distribution of historical earthquakes collected in the database. From the figure it can be seen that among the historical earthquakes in this region there are 28 earthquakes (as shown by the blue dots) containing at least 2 complete isoseismal contours. Other 80 earthquakes contain less than 2 complete isoseismal, which are difficult to use in retrieving the source process but still provide useful information.

Figure 2 One example of intensity distribution of historical earthquakes in North China digitized in the database. Shown in the figure is the 1556 Huaxian, Shaanxi Province, $M_{8+}$ earthquake, being the same as Figure 1. Original isoseismal data is from Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University (1986a). Clicking the buttons to the upper left of the figure gets the .mif file and the guidelines for using the data file.
Figure 3 Homepage of the Intensity database of North China in Ming and Qing Dynasty (left) and instruction of using the .mif file (right) as shown in the database when clicking the button to the upper left of the isoseismal plot in Figure 2.

Figure 4 An example of the shape analysis of isoseismals, using the method of Molchan et al. (2002, 2004) to the database. Shown here is the Juzhou-Tancheng M8+ earthquake in 1668 (Institute of Geophysics, State Seismological Bureau and Institute of Chinese Historical Geography, Fudan University, 1986a), courtesy of Profs. T. L. Kronrod and G. F. Panza.
4. CONCLUDING REMARKS AND DISCUSSION

There have been several works trying to construct the database of destructions and intensities (Jiang et al., 2004; Qu, 2008; Yu and Xie, 2003) using different tools such as GIS. In this work we built the database of seismic intensity for the historical earthquakes occurred in North China since the Ming Dynasty. The MatLab-based database is easy to use for the analysis of source properties and site effects. For using of this database contact xiamin06@mails.gucas.ac.cn.

Ideally when inverting source process using intensities, the isoseismal distribution should be transformed to ground motion parameters. In practice, however, since the distribution of intensity and the shape of isoseismal have a complex relation (Bormann, 2006), and the relation between intensity and ground motion is also complicated (Wald et al., 1999; Hao and Xie, 2006), in this database we just use the original isoseismals.

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REFERENCES


