An Attempt to Construction of Seismotectonic Province Map

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1. Introduction

A seismotectonic province is a kind of seismic source where, in general, seismic characteristics are assumed to be uniform. It is different from earthquake-generating geological structures such as faults or folds. It is an area or a zone where earthquakes diffusely occur but no specific geological structure is identified to be responsible for those earthquakes. The terminology, a seismotectonic province is originated from a tectonic province of U.S. federal code [1], with emphasis on earthquakes. The seismotectonic province is called the seismogenic source in the regulatory guides [2, 3] of U.S. Nuclear Regulatory Commission (NRC), and the zone of diffuse seismicity in a guide [4] of International Atomic Energy Agency (IAEA).

In Korea, existing seismotectonic province maps were constructed based on the geological information due to insufficient earthquake data. As understood in its name, however, a seismotectonic province map should be based on the seismic information. Moreover, it should be noted that the Korean (geologic) tectonic structures cannot correctly represent the current tectonic regime because they were formed before the Cenozoic. In this context, we attempted to construct a seismotectonic province map by using seismic and geophysical information as well as geologic information.

2. Methods and Results

2.1 Data

Various types of data available are gathered. They are geologic boundary, sea-bottom topography, earthquakes, crustal thickness, heat flux, current stress, and Lg-Q. While earthquakes, sea-bottom topography, and geologic boundary cover the whole Korean Peninsula and its vicinity, the rest covers only the southern part of the peninsula due to the limitation of available data. Earthquake origin parameters reported by Korea Meteorological Administration were adopted. Only the earthquakes greater than M=3.0 were used to maintain the data completeness. Data of the crustal thickness, heat flux, current stress, and Lg-Q were provided by Korean experts.

2.2 Processing

To prospect the spatial distribution characteristics, all types of data except geologic boundary and sea-bottom topography need to be sampled on the grid points. A grid of 0.1° by 0.1° was chosen in this study. Data of crustal thickness, heat flux, current stress, and Lg-Q were provided by the experts in the grid format. To calculated frequencies of earthquakes, $\tilde{n}_{ij}$ on a grid point (i, j), the spatial smoothing method was applied [5].

$$\tilde{n}_{ij} = \frac{\sum_{k,l} n_{kl} e^{-d_{kl}^2 / c^2}}{\sum_{k,l} n_{kl} e^{-d_{kl}^2 / c^2}} \quad (1)$$

where d_{kl} is the distance between the grid points (i, j) and (k, l), and c is the correlation distance. We used the correlation distance of five grid spacing. The summation was made for those earthquakes within 3 c.

If the spatial variation of the data used is related to the boundaries of seismotectonic provinces, it would be reflected on the contour maps. And the variation will be more clearly seen in their first derivatives. For this reason, we calculated 2D spatial derivatives as following.

$$\left|\nabla \phi(x, y)\right| = \sqrt{(\partial \phi / \partial x)^2 + (\partial \phi / \partial y)^2} \quad (2)$$

Derivatives of each data were normalized to have the absolute maximum of 10. Then, all derivative data were summed with the evaluated weights.

Table I: Evaluated credibility of data. C : contribution, Q : quality, W : weight.

Data types		C [0~4]	Q [0~1]	W [$W \times Q$]
Geol.	Geol. boundary	1	1	1.0
	Sea topography	1	1	1.0
Seism.	Focal depth	4	-	-
	Richter-a*	2	0.5	1.0
	Richter-b	2	-	-
	Q-value	1	0.5	0.5
	Crustal velocity	1	-	-
	Crustal thickness	1	0.5	0.5
Geophy.	Gravity	0.5	-	-
	Geomagnetism	0.5	-	-
	Heat flux	1	0.5	0.5
	Stress	1	0.5	0.5
Sum		16	-	31.25%

*: Richter-a was replaced by earthquake frequencies.

Table I shows data types that are considered to be useful for the construction of seismotectonic province maps. The table contains not only the data used in this study but also the data not used. The value C represents the degree of contribution determined by considering the relative usefulness in the determination of the province boundary. The value Q represents the data quality. One half was assigned to the data that cover the southern part of the peninsula only. Due to the limitation of earthquake data, the earthquake frequency was used instead of the Richter-a. For this reason, one half was assigned. The value Q was assigned to only those data used in this study. In the summation of derivative data, W was used as the weight.

2.3 Result

Fig. 1 is the contour map of the summed 2D derivatives. Superimposed are trial boundaries of seismotectonic provinces. It seems that the contours do not clearly define boundaries of seismotectonic provinces yet. This can be improved as increasing data. As a result, the seismotectonic province map of this study is much simpler than existing ones.

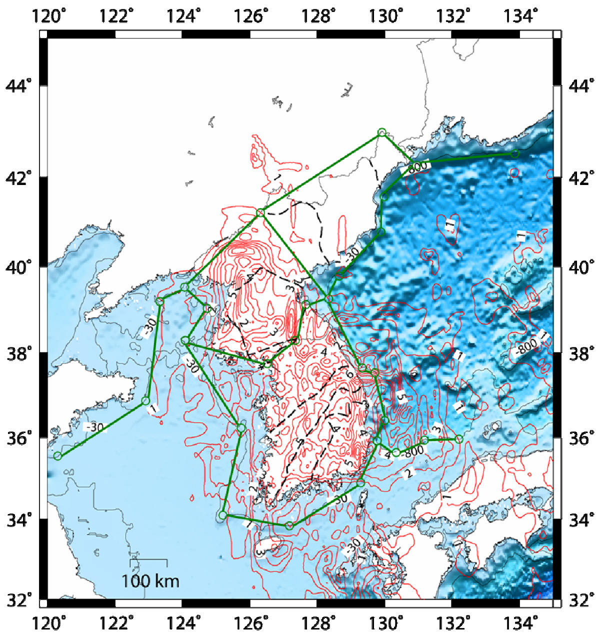

Fig. 1. Contours (red) of the summed 2D derivatives. Superimposed are trial boundaries (green) of seismotectonic provinces.

3. Conclusions

A trial seismotectonic province map was constructed by combing geologic, seismic, and geophysical information. The current information appears insufficient to clearly define the boundaries of the seismotectonic provinces. In fact, the credibility (sum of weight in Table I) is just about 31 %. The map need to be more elaborated to be adequate for practical use. The map-construction method, however, is reasonable in that it incorporates various data related to the seismotectonic provinces. As the data are accumulated, it will be possible to construct the seismotectonic province map that is adequate for practical use.

REFERENCES

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