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Preparation and Distribution of Earthquake Information for the Disaster Prevention Program of Tottori prefecture - Preparation of a Database Using GIS -

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Synopsis

Working with Tottori prefecture as a target area, we prepared a basic database of information for earthquake disaster prevention. Using GIS software, we created a database of information for earthquake disaster prevention, which includes hypocenter and seismic wave data, geological data, geophysical exploration data, and hotspring and groundwater data. We analyzed these data and tried to estimate several features of the target area to help reduce earthquake damage.

Keywords: Tottori prefecture, information for earthquake disaster prevention, database, GIS

1. Introduction

Local municipalities often lack detailed information when earthquakes occur and this lack of this information can cause poor management during the critical times following damaging earthquakes. On the other hand, there is much data generated and available from researchers, which can be distributed to the municipality side, but it is possible that this flow of information is one-sided. We have to consider what is the necessary information required by society for meaningful disaster mitigation and prevention. The users in the municipality and the public will hopefully use this information and discuss with researchers about its effectiveness and the distribution methods. Using the input from these discussions, we expect that the data processing system and the distribution methods will be improved.

In this study, we worked with Tottori prefecture and tried to prepare a basic database of information for earthquake disaster prevention. The reason we targeted Tottori prefecture is the municipality staff and the inhabitants have a high interest for earthquake disaster prevention programs because residents experienced the 2000 Western Tottori earthquake and the 1943 Tottori earthquake. We expect that if we distribute earthquake information in this prefecture, users will appreciate the information and request ways to improve it.

2. Preparations of database using GIS

We prepared a database of earthquake information using GIS software. The database can be transformed, shaped and unified into a common format with GIS software. The GIS software we used was ArcGIS (ESRI). Recently, digital map data, for example, coastlines, regional boundaries, roads, building and house shapes have been published and commercialized by the Geographical Survey Institute and various companies. The digital data were composed of grid data or line and point vector data. We were able to include these data into basic maps.

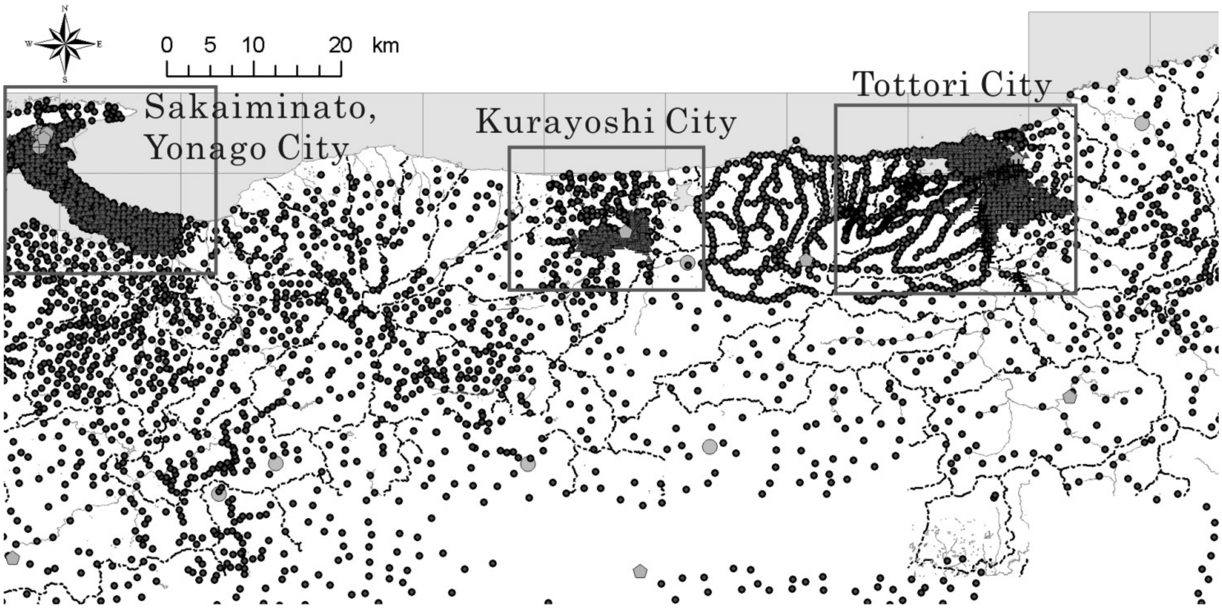

Fig.1 Locations of observation points for earthquake, geophysical explorations and hotsprings.

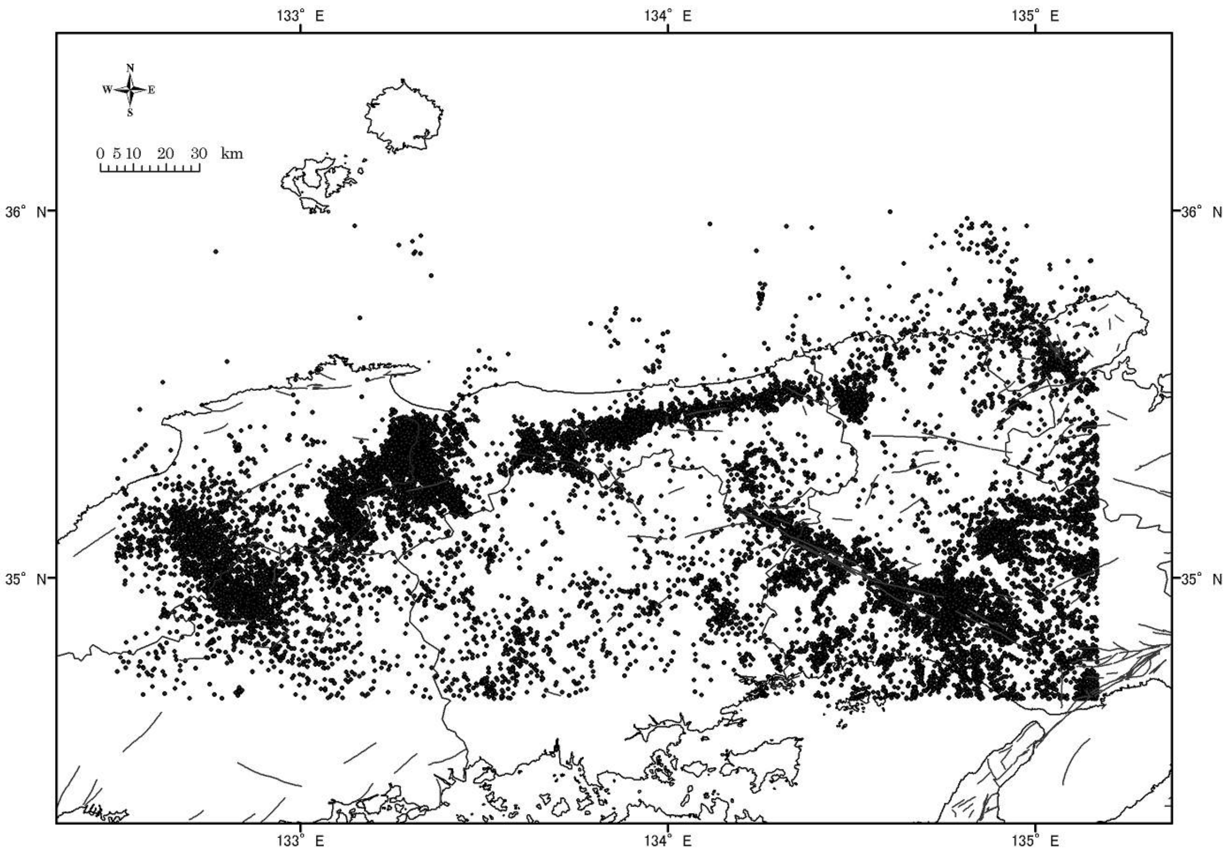

Fig.2 Distribution map of earthquakes in Tottori prefecture and its surrounding area. Hypocentral data are from Kyoto University and JMA.

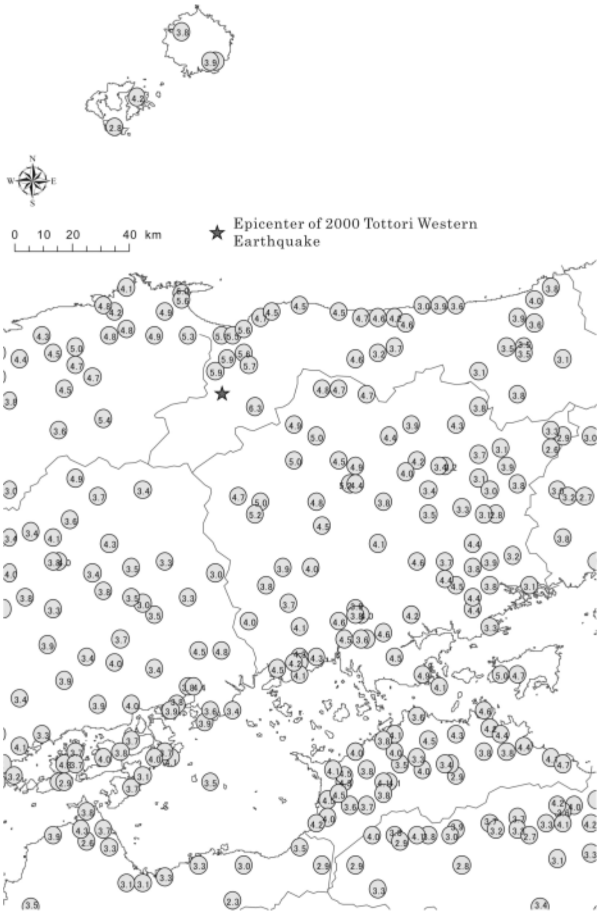

Fig.3 The seismic intensity distribution map of the 2000 Western Tottori earthquake.

In this paper, we describe how related information about earthquakes, for example hypocenter and seismic wave data, seismic intensity data, geological data, geophysical exploration data, and hotspring and groundwater data, were processed. The preparations of the database, on which we continue to work, are divided into the following areas.

[1] Information on micro-earthquake hypocenters and seismic wave data.

[2] Information on seismic intensity in cities, towns and villages.

[3] Information on the local geology and topography.

[4] Information on subsurface structures. Especially, high density data in the plains of Tottori, Kurayoshi and Yonago city.

[5] Information on the hotspring and the subsurface water observational points in the Sanin region.

The locations of observation points of earthquakes, geophysical explorations and hotsprings are shown in Fig.1. Details of these data are explained in following section.

2.1 Seismic Data; [1], [2]

The hypocentral information is from the catalogue of the Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University for the time period from 1970 to 1996) and the Japan Meteorological Agency (JMA) catalog from 1997 to 2003. The current seismic activity and hypocentral distribution can be monitored using GIS software. Fig.2 is a hypocenteral distribution for the Sanin region. Also, continuous records of microearthquake can be checked at stations of Hi-net, operated by the National Research Institute for Earth Science and Disaster Prevention, JMA, and Kyoto University. Along with the continuous seismic recording, time series of seismic activity and occurrence frequency of earthquakes can be checked if a semi-real-time monitoring system (Ohmi et. al., 2004) is used. We can use such as system to constantly monitor the seismic activity and the continuous records. More over, we can effectively and quickly distribute the information to the municipality and inhabitants using both the monitoring system and GIS. Municipality staff can use this information to help make decisions regarding earthquake disaster mitigation if a damaging earthquake happens.

The information on seismic intensity is from JMA data for the time period of 1926 to 2003. The data were recorded at observational points in cities, towns and villages in Tottori prefecture. Seismic intensity distributions of various earthquakes can be displayed quickly by making a database for each earthquake. The distributions can be utilized to check the local site effect on earthquake ground motions. An example of an intensity distribution map for the 2000 Western Tottori earthquake is shown in Fig.3. The relationships between the seismic intensity data and the geophysical data can found by overlaying the two data sets using the GIS software.

2.2 Site and Subsurface Structural Data; [3], [4]

To predict a strong ground motions in a target area, site data and subsurface structural data are necessary, so we deal with the following types of data.

[a] Digital geological data on a scale of one to a million.

[b] Topographical digital data on 50m and 250m meshes.

[c] Subsurface borehole data.

[d] Subsurface structure data from geophysical explorations (Noguchi et. al., 2003; Yoshikawa et. al., 2002).

The data of [c] include information such as, N-values, strata to engineering bedrock or bearing layer. The data of [d] include microtremor, gravity and seismic exploration data. The microtremor exploration data include the information of amplification factors and predominant period of the subsurface, S-wave velocity structures and bedrock seismic velocity structures. A contour map of microtremor predominant period for the Tottori plain is shown in Fig.4 and subsurface structure models for the same location from microtremor array surveys is

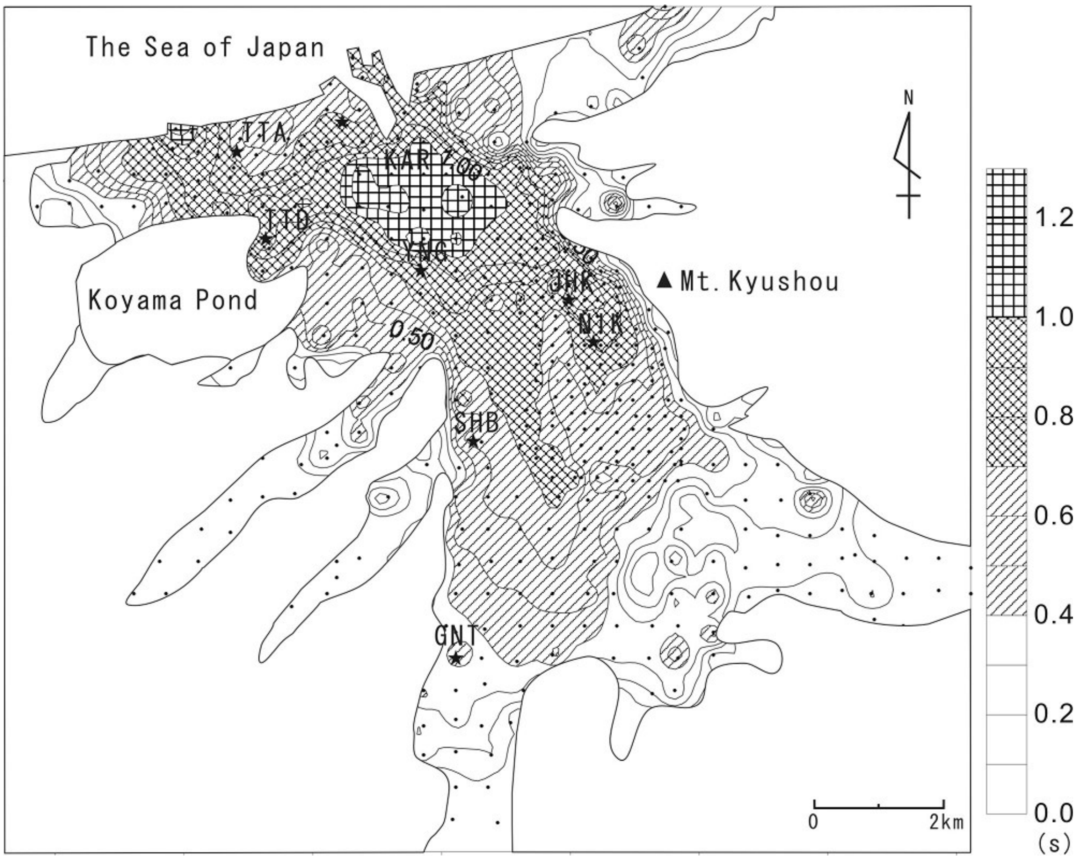

Fig.4 The contour map of microtremor predominant period of the Tottori plain obtained from single-site 3-component microtremor surveys.

Table 1 Subsurface structure models for the Tottori plain from microtremor array surveys.

ρ (t/m^3)	Vp (m/s)	Vs (m/s)	Thickness (m)								
			JHK	NIK	MTA	YNR	KON	KSA	HGA	GKA	KRC
1.6～1.8	1400～1620	100～300	30	26	16	27	12	19	22	28	47
1.9	1850	500	50	40	40	50	55	30	80	40	15
2.1	2070	700	100	90	90	100	100	100	120	100	80
2.2	2960	1500	150	150	150	150	150	150	150	150	100
2.4	4070	2500	∞	∞	∞	∞	∞	∞	∞	∞	∞

Thickness (m)									
TTA	TTD	KAR	YNG	SHB	GNT	BAB	SMD	MYD	NEJ
29	58	60	33	37	20	10	37	20	-
20	20	50	20	20	10	30	20	10	50
50	40	80	100	80	80	80	80	70	-
100	100	150	150	100	100	100	100	100	25
∞	∞	∞	∞	∞	∞	∞	∞	∞	∞

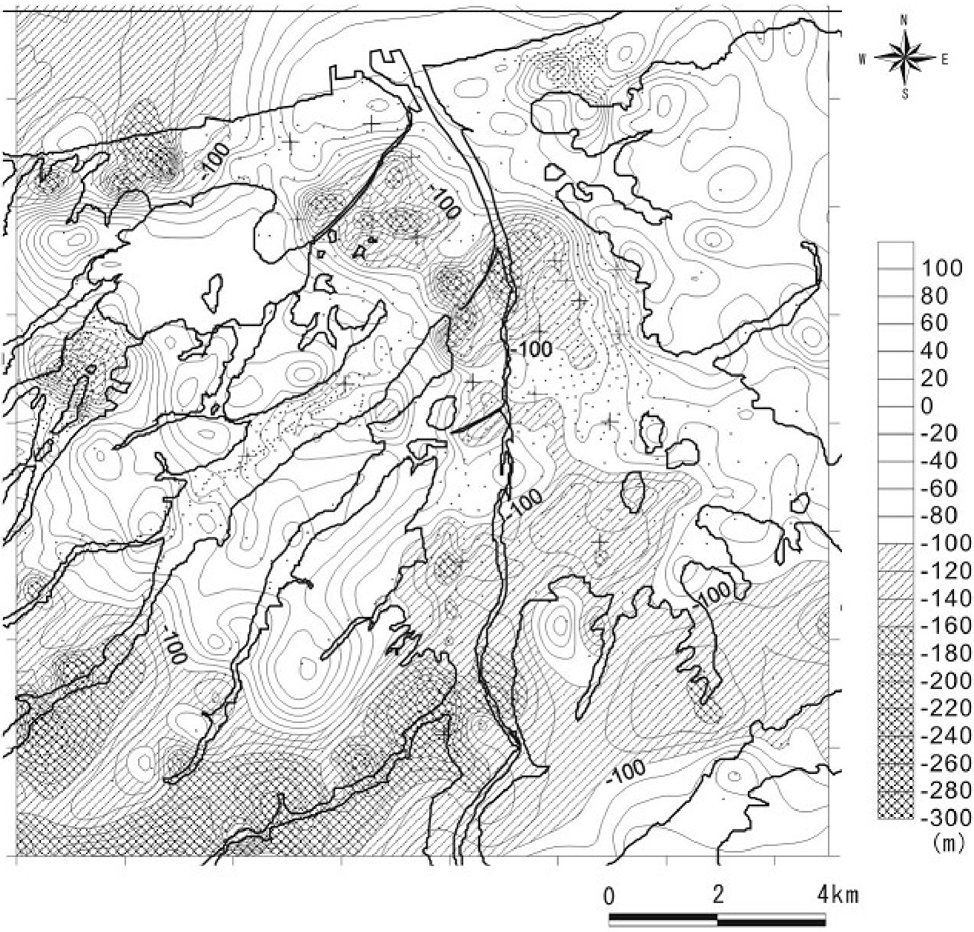

Fig.5 The gravity basement of the Tottori plain. Assumed density of gravity anomalies is 2.4g/cm^3 and a band-pass filter from 50m to 1000m was used for calculating residual gravity anomalies. The structure was a 2-layer model with 0.4g/m^3 density difference.

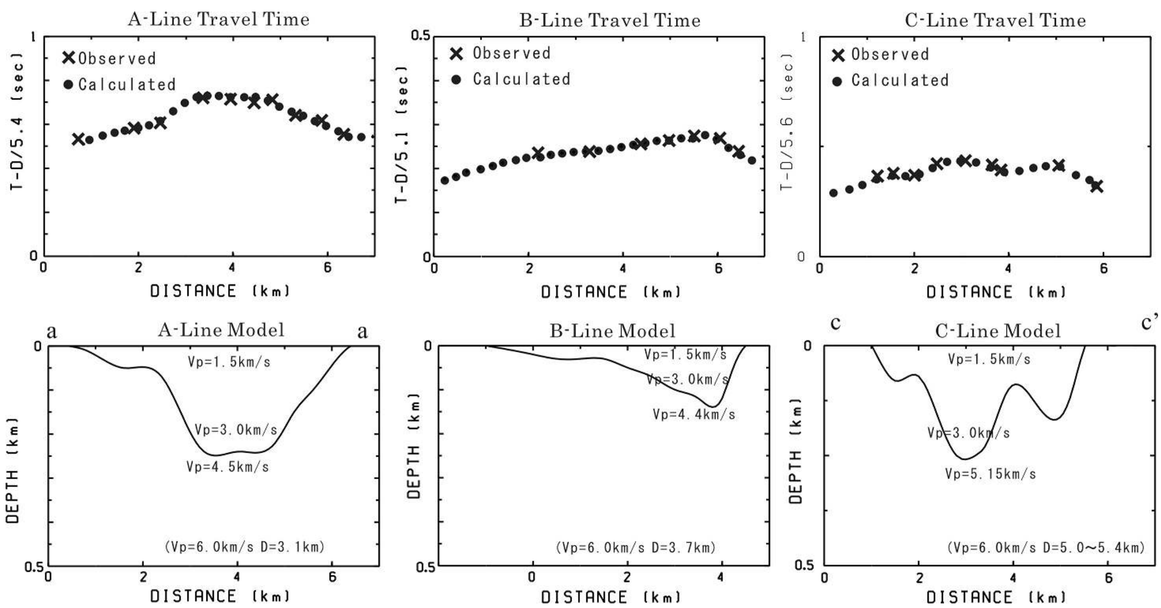

Fig.6 A section of the bedrock P-wave velocity structure for the Tottori plain by ray-tracing analyses from explosion observations.

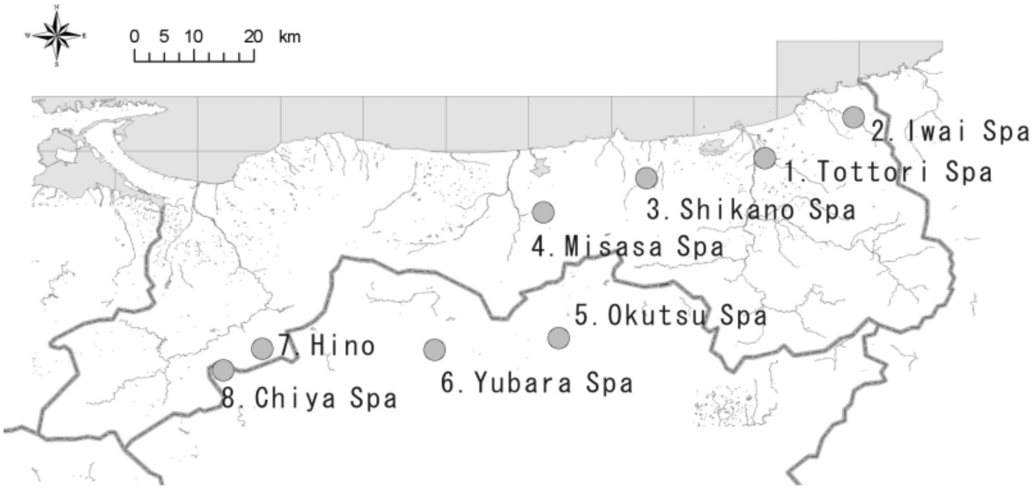

Fig.7 Locations of the stations for subsurface water temperatures and levels of the hotsprings observational network.

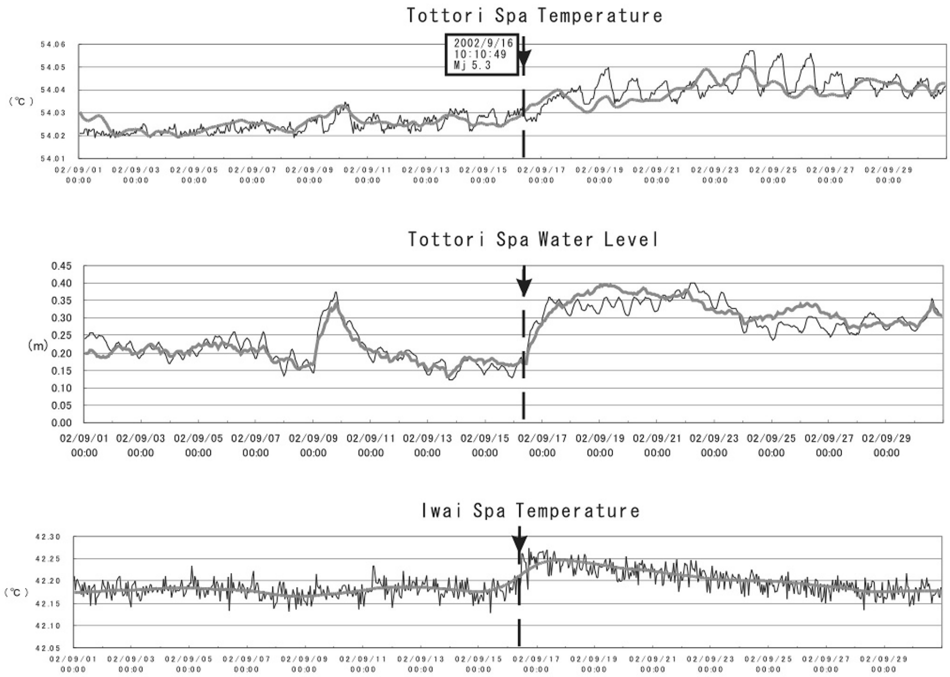

Fig.8 An example record section of subsurface water temperatures.

shown in Table 1. The gravity exploration data include information on gravity anomalies (Komazawa, 2000; Shichi and Yamamoto, 2001) and bedrock density structures. The gravity basement of the Tottori plain is shown in Fig.5. The seismic explorations data include information on bedrock seismic velocity structures. The locations of [c] and [d] data were mainly in three areas, Tottori plain, Kurayoshi basin and Yumigahama peninsula. A section of the bedrock P-wave velocity structure of the Tottori plain is shown in Fig.6.

2.3 Hotspring and the Subsurface Water Data; [5]

We know that characteristics of subsurface water are often changed when an earthquake occurs. It is thought that this phenomenon is related to crustal movement from a changing stress field or after effects following the earthquake. Therefore, crustal movements can be checked if the characteristics of underground water are monitored.

The subsurface water temperatures and levels at hotsprings have been observed in Sanin area since March, 2001 (Nishida et al, 2002). This observation is carried out as a part of the Western Tottori earthquake projects funded by Rotary International district 2690. 8 observation stations, Tottori, Iwai, Misasa, Shikano, Okutus, Yubara, Chiya hotspring and Hino are now in operation (Fig.7). Ground water temperatures are observed at all stations and water levels are observed at Tottori and Iwai stations. The water temperatures and levels significantly increased after 3 earthquakes at several stations. Example o record sections are shown in Fig.8.

3. Analyses of Information

3.1 Characteristics of seismic activity

We tried to investigate earthquake activity using hypocentral data of micro earthquake. The fundamental data for an objective estimation of earthquake activity and mechanism of earthquake occurrence can be obtained from this investigation. For example, Itaba et. al.(2003) quantitatively investigated the earthquake activity of and around active inland faults in Japan .

Numbers of earthquake occurrences were counted in tile polygons with a size of 3 minutes. The polygons were spatially adjusted to hypocentral point data. Gridded distributions of active areas can be found by coloring the results on the display (Fig.9). Moreover, a density distribution of earthquakes was made from this grid data (Fig.10). There are three active areas in this analysis area, the area parallel to the coast line in Tottori, the area around the boundary between Tottori and Shimane and the area of the Yamasaki fault in Hyogo and Okayama.

3.2 Relationship between Seismicity and Gravity Anomalies

To investigate a relationship between seismicity and gravity anomalies, a contour map of gravity anomalies was overlaid with the hypocenteral distribution map (Fig.11). Gravity anomalies are affected by subsurface structures. If the seismicity is affected by these structure differences, it is thought that the area of gravity anomalies changes may correlate with the active earthquake areas.

It appears that there are the hypocentral concentrations in the areas of gravity anomalies. To confirm this relationship, it is necessary to analyze these data more thoroughly. For example, the grid of hypocentral distribution is overlaid with the gravity anomalies, which are filtered with an objective depth to remove deep or thin structures. Then, the two data sets are linked together spatially and an overlaid map is created with new relational values indicated by the strength of the correlation. In this way, a distribution map of the correlation between seismicity and gravity can be obtained.

4. Image of the System Processing

Fig.12 is an illustration of the operational system in this study. We explain our image of the operational system in this section.

On the distributor side, earthquake data are updated and analyzed by research institutes, such as JMA, NIED, and Universities. The hotspring and subsurface water data along with the subsurface structure data are treated in the same manner as the earthquake data. Determinations of earthquake occurrence areas and quantitative analysis of seismic activities can be immediately carried out from the latest seismic data. Crustal movements can be monitored from the latest hotspring or subsurface water data. A seismic hazard map, especially detailed version for an urban area, can be obtained from the dense and varied subsurface structural data. These operations will add and update data and analyzed results, using GIS or the WEB. Then, this information is distributed to the user side.

On the user side, municipality staff and prefecture inhabitants can apply the information and discuss with researchers to improve the information and the distribution methods. It is expected that the earthquake knowledge available to the local government and public will be greatly improved through this process.

5. Future plans

[1] Check temporal earthquake activity changes on maps that include various types of information. A tile polygon will be made for every several years.
[2] Create a detailed seismic hazard map from information of the subsurface structure.
[3] Create a new system link with a semi-real-time earthquake information system (Ohmi et.al., 2004) .

Acknowledgments

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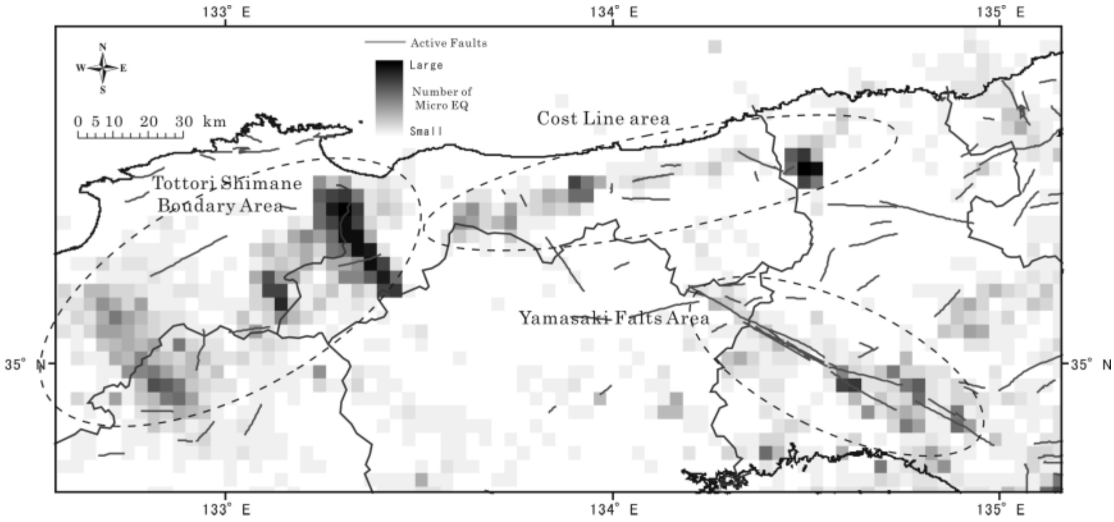

Fig.9 The gridded distribution map of earthquake occurrence numbers. The grid size is 3'.

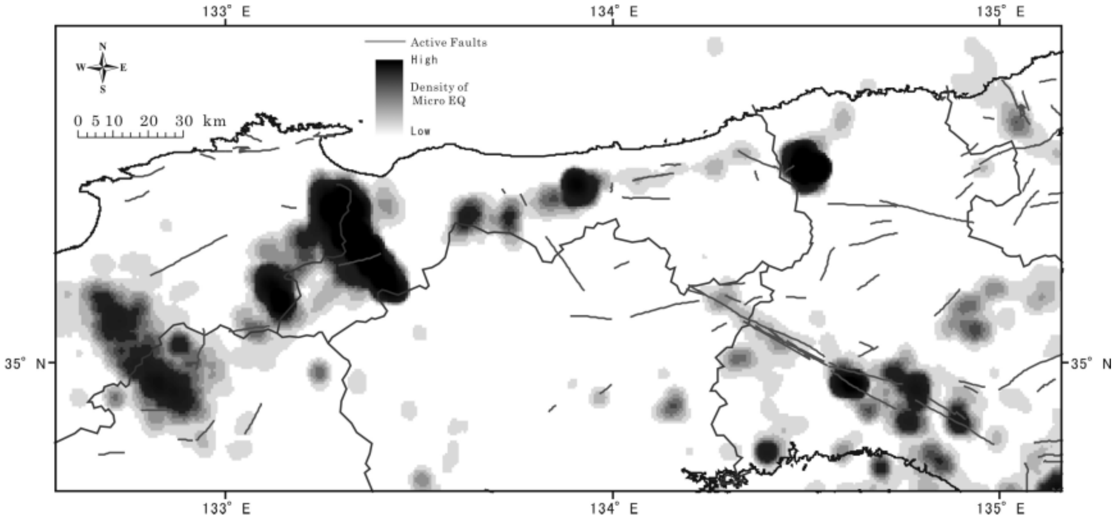

Fig.10 The density distribution of earthquakes using the grid data of Fig.9.

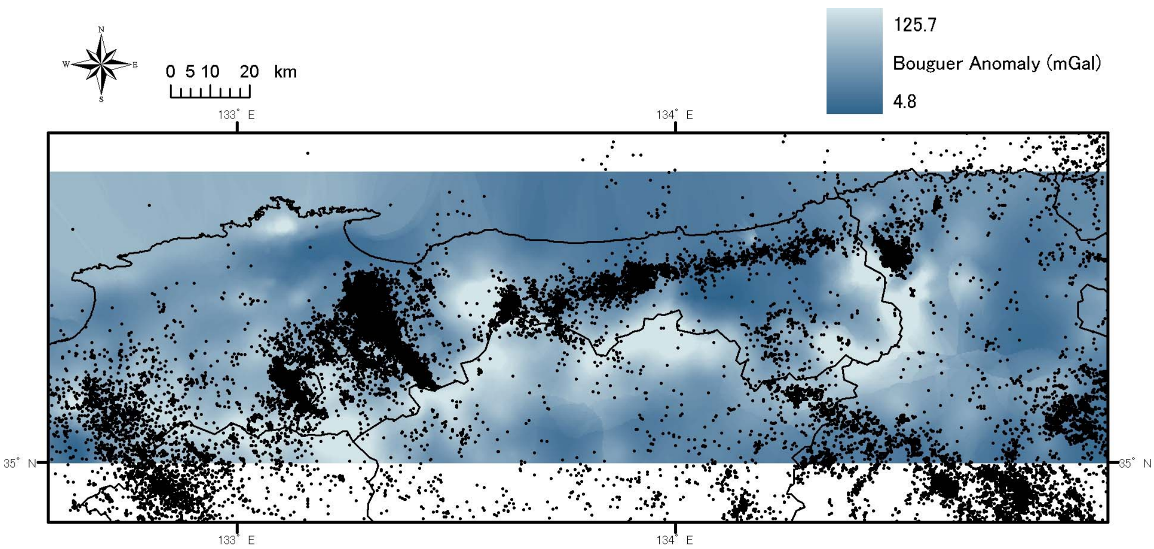

Fig.11 Overlaid map of the hypocentral distribution and the gravity anomalies. The gravity anomalies are calculated with an assumed density of $0.4 g/m^3$.

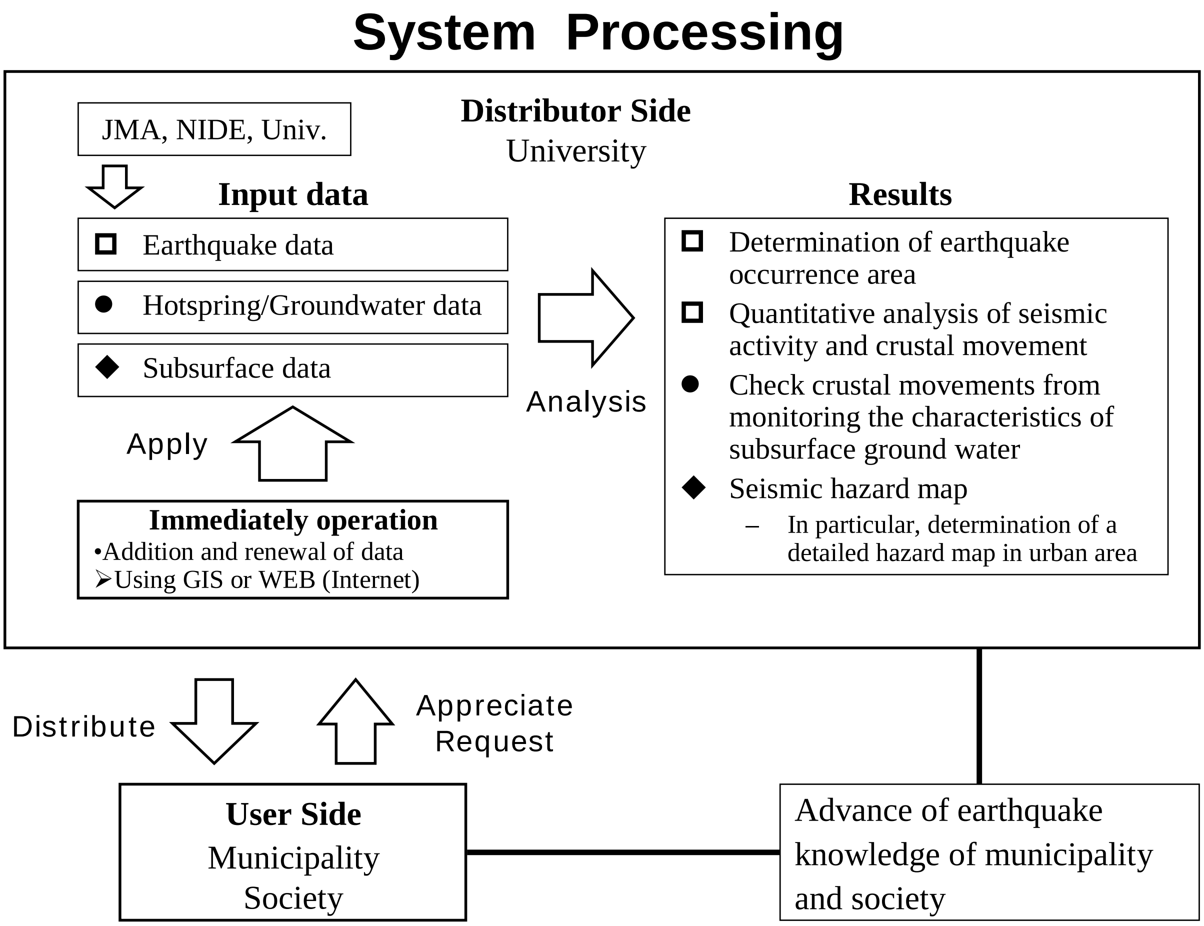

Fig.12 An illustration of the processing of the operational system in this study.

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要　旨

自治体や住民に貢献する地震情報の構築とその伝達手法の開発を目的とする．そのためには，まず基礎となるデータベースの構築が必要となる．本報告は，鳥取県を対象とした地震防災に関する情報のデータベース化についての報告である．データベース化にはGISを利用した．基本的な地図情報，地震防災に関連する震源，地盤構造，地下水観測情報についての説明，地震発生の特徴について震源，地盤情報を用いた解析例を示す．

キーワード：鳥取県，地震防災情報，データベース，GIS

自治体の防災に貢献する地震情報の構築と提供－GISによるデータベースの構築－

野口竜也·渡辺邦彦·板場智史·西田良平·梅田康弘

１．はじめに

本研究では，鳥取県を対象として地震防災に関する情報を構築し，その提供手法の開発を行うことを目的とする．これまで，衛星を用いた地震情報表示システムの開発進められ，運用が開始されている[1)]．これらの情報を始めとした地震防災に関する各種情報のデータベース化について報告をする．

２．GISによるデータベース化

データベース化を完了，もしくは継続のものは次の通りである．

①鳥取県とその周辺における微小地震震源情報．
②鳥取県内の地質，平野部（鳥取市，倉吉市，米子市，境港市）における地盤構造．
③ 温泉·地下水観測情報．
④ 各市町村の震度情報．

①の震源情報は，1970～2002年までの京都大学防災研究所地震予知研究センターの震源データ，および気象庁の一元化震源データである．②の地盤構造は，物理探査（人工地震·微動·重力探査）による弾性波速度構造·密度構造，地盤ボーリングによる地質区分·N値データ等である．③は温泉観測ネットワークによる温泉·地下水の水温·水位データである．④は1926年～2003年の気象庁が管理する震度データである．

３．物理探査による地盤構造の情報

物理探査は，主に鳥取平野[2)]，弓ヶ浜半島[3)]，倉吉平野部[4)]で実施されている．それらのデータの概要は，次の通りである．

(1) 鳥取平野

微動探査による19地点のS波速度構造ならびに地盤卓越周期，人工地震探査によるP波速度構造，重力探査による2次元·3次元の基盤構造の推定結果．

(2) 弓ヶ浜半島

微動探査による5地点のS波速度構造ならびに地盤卓越周期，重力探査による2次元·3次元の基盤構造の推定結果．

(3) 倉吉市平野部

微動探査による4地点のS波速度構造ならびに地盤卓越周期，重力探査による2次元·3次元の基盤構造の推定結果．

４．震源情報による地震活動度の特定

微小地震の震源データベースを用いて，地震発生地域の特定を試みた．このことにより，地震活動の客観的評価，地震発生メカニズムの解明等の基礎資料になり得る．このような試みは日本全国の内陸の地震活動について行われている[5)]．今回の解析では，対象エリアについて3′のタイル内に含まれる地震発生数をカウントし，それらの分布を調べた．地震発生数の多い領域は，鳥取県の海岸付近，島根県との県境付近，山崎断層付近の，大きく分けて3地域で顕著である．

５．震源分布と重力異常の関係

震源分布と重力異常を重ね合わせることにより，それらの関係を調べた．重力異常は地下構造の変化を反映していると考えられるため，その変化と地震活動に相関がある可能性がある．この地域でも，そのような傾向が数箇所でみられた．今後は，重力異常にフィルタリング処理を施す，震源グリッドデータとの重ね合わせをして，関連性を調べることを検討している．

６．今後の予定

1. 震源情報から，地震活動度を年数ごとに分け，地震発生パターンの移り変わり，領域ごとの相互関係などについて調べる．
2. 震源情報と地質·地下構造に関する情報との重ね合わせを行い，それらの関係を調べる．
3. 地盤構造情報を基に，詳細な地震動予測地図を作成．
4. 衛星地震情報システムと連携させて，即時地震動予測地図作成システムを開発．

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