STUDIES ON STABILITY EVALUATION WITH REMOTE SENSING AND GEOPHYSICAL DATA IN HAINAN ISLAND CHINA

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ABSTRACT:

The results on stability evaluation in the Hainan Island, a secondary larger island and one of economic zones in China, are presented in this paper, with the help of the analysis on the informations about linear structures from Landsat TM image as well as the gradient zones derived from geophysical data such as the aerial magnetic and the gravity data, ect. In addition to show the earthquake activity distribution described as a probability contour, the results have also revealved the correspondence between the gradient zones from the geophysical data and the linear structures shown in the Landsat TM image. It is , therefore, clear that the depth fault zones can be, in some degree, reflected as a series of linear features discreted and paralleled each other in the remote sensing data. Finally, a contour of the energy releasedby the historical earthquakes has been compiled to compared with the results on the stability evaluation; the strongher relation on the both contours has been found. So that these results have provided an important basic data for the economic construction and development in the Hainan Island, China.

KEY WORDS: Stability, Remote Sensing, Geophysical Data, China

1. INTRODUCTION

The earthquake, especially the larger earthquake is a kind of serious geological harzadars for mankind, for which are usually controlled by and/or relatedto the depth fault zones in the earth crust.

So far, the remote sensing data of varieties can provide a lot of informations about the regional tectonic features, in particular for the Landsat data. It is pointed as the R. Cassinis (1985) out that the lineaments shown on theremote sensing image is the reflection of the depth fault zones in the crustal structures. In general, the depth fault zones are displayed as a series oflinear features or lineaments discreted and paralleled each other on the remote sensing data. So that geologist can study the earthquake activities and it's distribution in spatial domain with the linear structures revealed by theremote sensing image. However, it is well known that the epicenters of mostearthquakes are located in the depth about 15 to 20 km in the crust, the machenism studies about earthquake distribution and their activities must be done by the informations about the deep crust structures. Therefore, the regional geophysical data such as the gravity and aerial magnetic data have beenused in this study except the Landsat TM data.

2. GEOLOGICAL SETTINGS OF THE AREA

The study area is located in the Hainan Island that is a secondary large island and one of the economic zones in China . In terms of the geotectonics, the Hainan Island is justly situated in the southern boundary of the Qong--Lei Settling. The central island is primarily widespread the Archaean migmatite and graniticintrusives in Mesozoic as well as the Palaeozoic Formations while Neogene sedimentary formation and the Quaternary basalt lava are only well-- development in the north part of the Island.

Since Mesozoic, tectonic of the Island is still activities, and the stress field is also changes. In general, the Hainan Island is charactarized by thedepressing at larger scale of the Neogene and

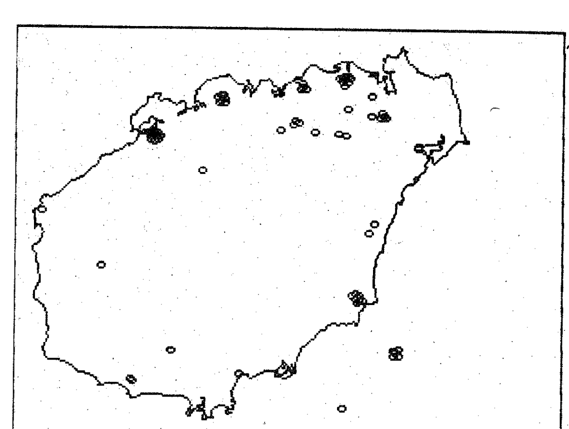

Fig. 1 The distribution map of the epicenters in the Hainan Island.

volcanic eruption in the Quaternary, in particularly in the north part of the Island.

As shown in the Fig.1 and Fig.5, the earthquake activity and its spatial distributionin the Island are closely controlled by the deep fault zones such as the Wang Wu--Wen Jiao deep fault (E--W) in north part and the PuQian--Beao fault zone (N--S) in the eastern part. Results of the historical data studies shown that the larger earthquakes (M > 5.0) were almostly occurred in the intersections of the gradient zones in different direction, for instance the Haiko earthquake (M > 7.5) to be happened at this section in 1605.

3. DATA ANALYSIS

3.1 The Interpretation of the Landsat TM

In this study, the digital false colour mosaic (Fig. 2) provided by the Remote Sensing Satellite Ground Station in Beijing China has been used to interprete the linear structures in the study area at scale 1 : 500000. Finally, a distribution map of the linear structures in the study area has been obtained as shown in the Fig.3.

In order to study the relationship between the linear structures in different directions and the earthquake distribution, a rose diagram (Fig.4) for the linear structures has also been compiled in this study.

3.2 The Interpretation of Geophysical Data

As mentioned above, the earthquake active are usually controlled by the depth fault zones, therefore, the geophysical data such as the aerial magneitc and the regional gravity data has also used in this study, in addition to extract the linear structure informations from the Landsat TM image.

As contrast with the conventional method that is the interpretation for thelineaments from the geophysical data, the aerial magnetic data storaged in the data bank as well as the gravity data corrected have been firstly processed as the direction derivation algorithm in the four different directions (i.eSN, EW, NE, and NW). Then the gradient zones delineated as some interval in the contours have been extracted, for which is a kind of important information for the earthquake studies (Fig.5). Finally, the stronger relation between the earthquake distribution and the gradient zones mentioned above has been discovered in the study.

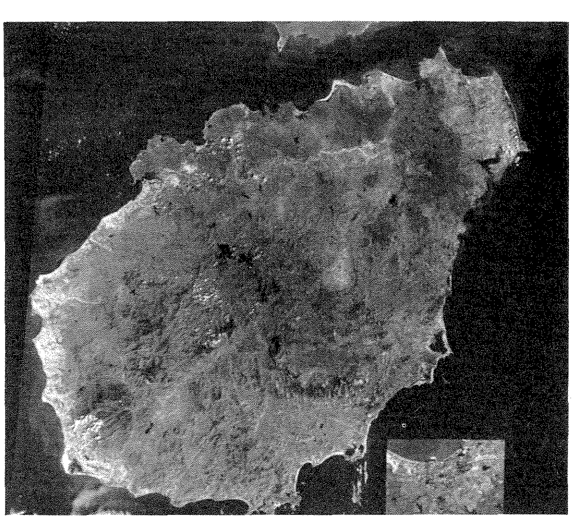

Fig. 2 The mosaic of the false colour image with Landsat TM bands 4,5,7, (R G B) in Hainan Island.

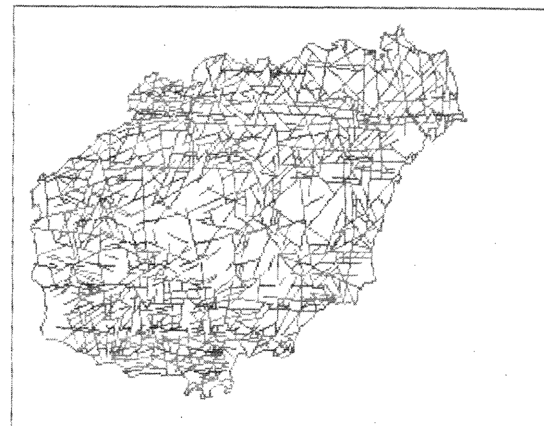

Fig. 3 Linear structures interpreted from the Landsat TM image.

3.3 Comprehensive Analysis

After the informations mentioned above have been extracted, all of them havebeen digitized and inputed into a GIS system established in the IBM 386 computer.

In this study, a probabilitic model developed by

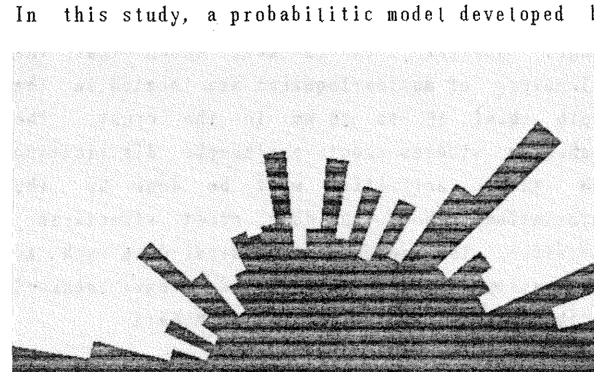

Fig.4 The rose diagram of the linear structures.

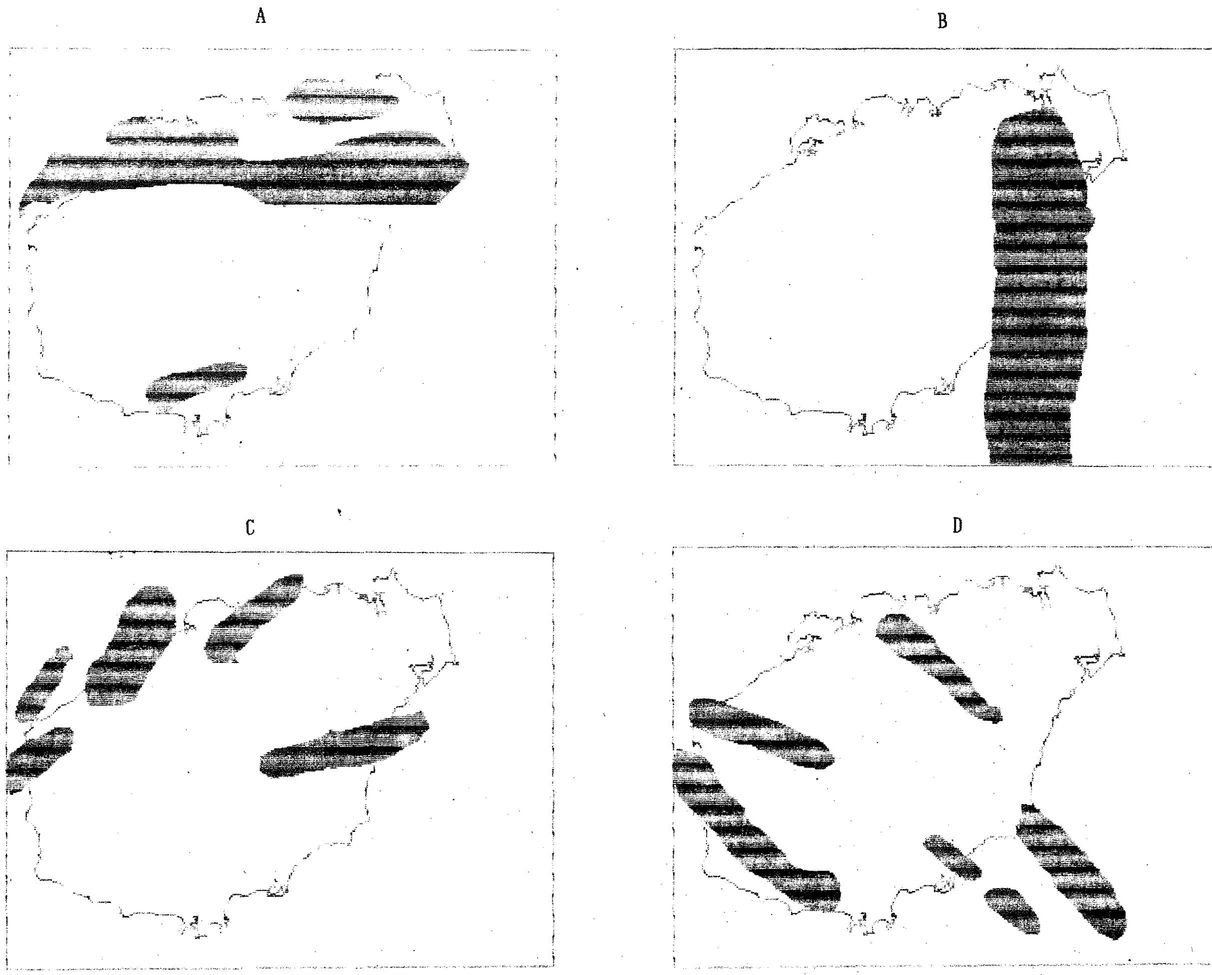

Fig.5 The gradient zones from the geophysical data.
A. E -- W ,B.S -- N, C. N -- E, D. N -- W.

the author (Wang Pin Qing, 1985) has been used to analyis of the data that is :

$$Pt(e \geq 1) = 1 - P(e = 0)$$
$$= 1 - \prod_{i=1}^{N} \exp(-ni \times Pi) \quad \cdots\cdots(1)$$

$$0 \leq Pt(e \geq 1) \leq 1$$

In the equation (1), Pt is the probability of theone earthquake to be, at least, occurred, the ni is the cell number of i th factor to be occurred inthe each grid, (10 km x 10 km grid size used);thePi listed in Table 1 is the probabilitic constantsfor each factor to be automatically obtained by using the Meximum Likelihood estimation, respectivily, and N is total number of the factors that are closely related to the earthquakes. However, it should be here emphasized that the final output Pt (e>1) of the model is not only take into account thecontributions of each factors to the earthquake but also their spatial distribution as well as the combination each other in spatial domain. So that,it can provide an important basic data for the regional stability evaluation.

It should be have pointed out that the probabilityPt (e> 1) is not to indicate the possibility of theearthquakes to be occurred, only description of the order for them.

In addition, the energe released by the earthquakes in each grid has also calculated by the empirical formulation (C. Lomnitz, 1974) as follow:

$$\text{Log } E = 1.7\,M + 10 \quad \ldots\ldots(2)$$

Thus, the energe is able to provide the quantitative description for the earthquake activity and their spatial distribution

4. DISCUSSION AND CONCLUSION

Table 1. Probability Constants obtained automatically by Maximum Likelihood Estimation.

Geo-Factor	Direction	N	M	Pi = M/N
LF1	270--275	133	10	0.075188
LF2	275--300	139	5	0.035971
LF3	300--330	121	12	0.099174
LF4	330--355	129	8	0.062016
LF5	355--5	45	6	0.133333
LF6	5--30	140	10	0.071429
LF7	30--60	199	11	0.055276
LF8	60--85	209	9	0.043062
LF9	85--90	30	3	0.100000
GG1	E -- W	2482	32	0.012893
GG2	S -- N	2491	32	0.012846
GG3	N -- W	2000	9	0.004500
GG4	N -- E	1575	13	0.008254

Fig. 6 and Fig. 7 show the contours of both probability and the energy to be obtained by the above models, respectively. The results compared with theboth contours shown that the spatial distributionof probability Pt is consistent with the energy tobe released by the historical earthquakes but theformer is little shieft move towards southern, perhaps because the positions ofthe historical earthquakes are not located exactly from the acient recording, since the geophysical fields such as the gradients zones from the regional gravity and aerialmagnetic data could not be changed. Another evidence aboutthis phenominan is that the earthquakes tobe recently occurred by recordingof seismic instruments only distribute in the south-east part of the area and all of them are compeletly correspondence with the probability Pt (e≥1).

The active areas delineated by the probability contour are clearly controlled by the two deep faultzones, i.e Wang Wu--Wen Jiao fault in E -- W direction and Pu Qian -- Beao fault in S -- N direction, e specially in the intersection part of the both fault zones. For example, the most earthquakes of magnitude larger than 5. 0 are distributed in this area.

Thus, the major earthquake activities in the Hainan Island are basicaly controlled by the Wang Wu--Wen Jiao fault zone and the PuQian--Beao fault zone, however the later are not pay more attention in the previous work. The contour of the energy released by the earthquakes shows that the energy (i. e stress in the earth crust) is almostly balanced inthe eastern and west parts in the Wang Wu--Wen Jiao fault, but it not truth for the PuQian--Beao fault zone, in particular in the southern part (in the ocean area). This conclusion is also verifiedby the earthquake recordings in recent, the six earthquakes of magnitude at 3,0 degree have been occurred in this part since 1960.

Fig. 8 and Fig.9 are the 3 -- D display of both theprobability Pt (e≥1) andthe energy E, for which provide the intuitive methods for the comparision analysis.

In summarize, the regional stability evaluation inthe Hainan Island has been studied by combining the informations from the remote sensing image

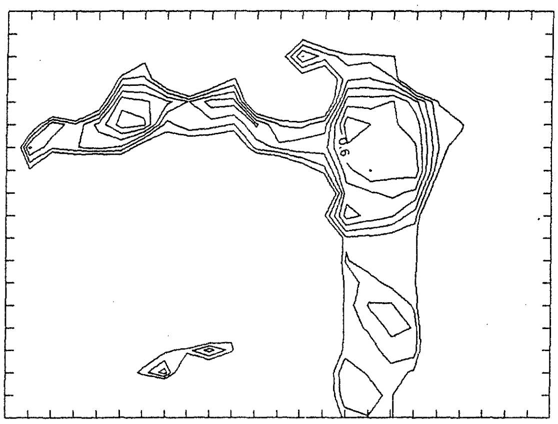

Fig.6 The probability contour of the one earthquake to be at least occurred.

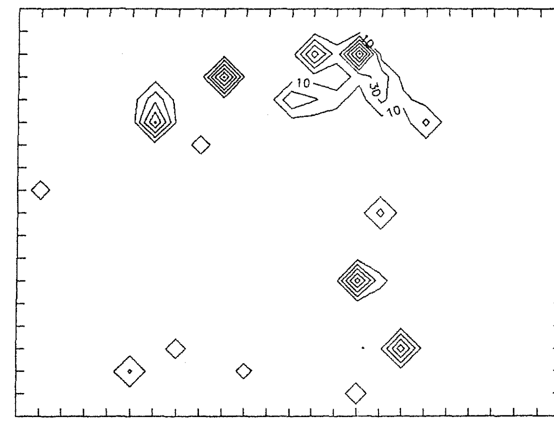

Fig.7 The contour of energy released by the historical earhthquakes.

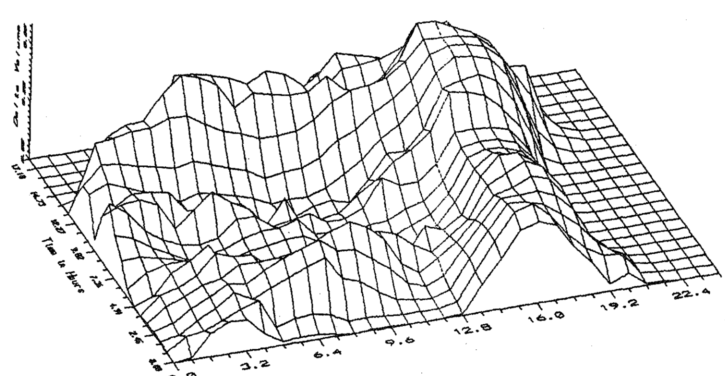

Fig.8 The 3 -- D display of the probability.

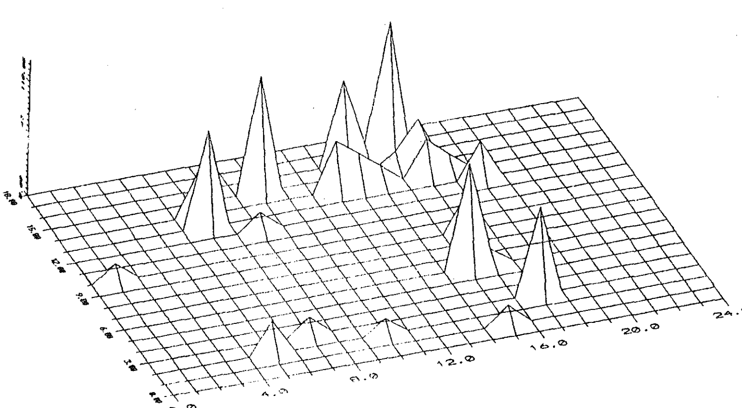

Fig.9 The 3 -- D display of the energy.

withthe geophysical data. With the help of the probability model and regression equation for the energyreleased by the earthquakes, quantitative data forthe stability analysis in the area has been obtained. In addition to delineatethe ditribution for the historical earthquakes, the potential areas for the earthquake activities have been predicted on the base of the results mentioned above.

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REFERENCES

1. R. Cassinis, 1985. Seismicity and Crustal Structure in the Italian Region; A Preliminary Zoning.

2. C. Lomnitz, 1974. Globale Tectonic and Earthquake Risk.

3. Wang Pin Qing, 1986. Application of ProbabilityAnalysis of Linear Structure for Earthquake Studies in the Southern Alps. Proceedings of the 20 st International Symposium on Remote Sensing of Environment, pp.897-888.

4. R. Cassinis, C. M. Marino and F. Pinali, 1985. Long Linear Features Observed on the Alpine Orogen and Their Comparision with Some Geophysical Data, Proc. EAR Sel/ESA Symposium, pp.217