11 WCEE

Published by Elsevier Science Ltd 1996
Paper No. 136. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

ASSESSMENT OF SEISMIC HAZARD IN ASWAN AREA, EGYPT

BY

RAAFAT E. FAT-HELBARY AND Y. OHTA

[1] Aswan Seismological data center. P. O. Box 152, Aswan, Egypt.
[2] Earthquake Resesearch Institute, University of Tokyo.

ABSTRACT

In this paper, the probabilistic seismic hazard analyses were conducted in detail in the Aswan High Dam area. The objective was to evaluate the probability of exceedance for different levels of ground shaking not only due to earthquakes that may occur naturally but also due to earthquakes that may be triggered by the High Dam reservoir. The probability approach is used to assess the seismic hazard of the study area, in use of two models of the Area source model (ASM) and the line-source model (LSM). ASM was applied to the earthquakes that may be triggered by the reservoir. LSM was applied to earthquakes that may occur naturally, where 5 active faults are modeled as seismic line sources. The probabilistic evaluation includes the use of logic trees for the selection of applicable source models, recurrence rates, maximum magnitudes and attenuation relationships. For this study the 90% probability of not being exceeded (or 10 % being exceeded) in a time span of 100 years are used. The study results that the highest relative predicted ground-motion occurs in Kalabsha area (about 60 Km south of Aswan High Dam). Comparison of hazard maps from each model made clear that the ground motion calculated from triggered earthquakes is larger than that calculated from natural earthquakes. Also a microzoning map for Aswan Town was constructed.

KEYWORDS

Hazard; source model; attenuation; microzoning; amplification factor.

SEISMIC HAZARD ANALYSIS

In accordance with the requirements of the Cornell-McGuire method, the hazard analysis procedure is repeated systematically in successive sites over a grid with 0.25 degree spacing on the Aswan regional map to get the distribution of (PGA). Then contour lines are drown and smoothen to give the regional hazard map. The computer programs are used for this purpose. (1) ESA program (Ahmed, 1991): is used to evaluate the cumulative normalized frequency-magnitude fitting coefficients needed to define the magnitude density function and to evaluate many other results which is used in hazard calculation. (2) EHA program (Ahmed, 1991): This program was originally coded by McGuire (1976) under the name "EQRISK" and some modifications and additions was made usable for IBM personal computer. This program was used to evaluate the site-by-site hazard associated with different acceleration levels in an adoption of the area source model. (3) FRISK program (McGuire): used to evaluate the hazard associated with different acceleration levels in an adoption of the line source model.

SEISMICITY OF THE ASWAN REGION.

In this study, recent earthquake activity recorded by Aswan and Abu Simble Seismographs and Aswan telemeterd network was used. Within the region, instrumentally located earthquake have occurred in two localities: near the north end of the High Dam Lake (Kalabsh area), about 60 Km south west of the High Dam, where the 14 November 1981 earthquake took place; and northeast of Aswan at Abu Dabbab near the Red Sea coast. The earthquake recorded from Kalabsha area is near and more effective to the study area and so used in this study. Due to the possibility of the relation between the seismic activity from the Kalabsha area and Aswan High dam Lake, this activity is known as reservoir - induced seismicity (RIS) (Idriss *et al.*, 1985).

TECTONIC AND STRUCTURAL SETTING.

The tectonic history of the area is complex and mainly determined by faulting system, which includes two major fault trends, viz., N-S and E-W, (Issawi, 1969; 1978) as shown in Fig 2. Many small faults were mapped from the area, as those having trends oblique to the two fault systems in the area.

SEISMIC SOURCE MODELING.

Two seismic source models were used, area source model (ASM) for reservoir-induced seismicity (RIS) and line source model (LSM) were used for significant earthquake sources (Non-RIS) that have a potential of generating future earthquakes that may attack the study area.

SEISMIC HAZARD MAPS FROM THE AREA SOURCE MODEL

Source location and geometry.

A view of the of Aswan area with respect to magnitude classes for the period of November, 1975 to August, 1993, is shown in Fig. 1. This indicates that there are six active zones (clusters), Gable Marawa (along Kalabsha Fault), Khor el Ramla Fault, East of Marawa (along Kalabsha Fault), Abu-Dirwa fault, Old stream channel north of Kalabsha area and a random distribution around Gable El-Barka Fault. Based on the distribution data of these active zones, a total of 350 events with magnitude 3.2 and larger was selected and the subjected source area was defined by six main seismic area sources as shown in Fig. 3.

Frequency-Magnitude Relationship.

According to the proposed source area pattern, a linear regression analysis was carried out to estimate the coefficients of Gutenberg-Richter's relationship between magnitudes and their cumulative normalized frequency. The slop of the line (b) and vertical axis intersection (a) are calculated and given in the output, the rate of occurrence at the minimum magnitude as well as the value [β=b Ln(10)] are then calculated and given as in Table 1 as well.

Ground Motion Attenuation.

The peak ground acceleration (PGA) will be used to represent the ground motion intensity in the both area-source model and the line source model. Therefore, the attenuation models developed from peak ground acceleration (Raafat and Ohta, 1994) are used.

$$\text{Ln } A=1.895\ m_b\ -938\ \text{Ln}\ (\Delta) - 3.715 \qquad (1)$$

where A represent the peak ground acceleration in cm/s^2 on base rock, m_b is body wave magnitude and hypocentral distance Δ is in Km.

Table 1
Parameters of seismic recurrence curve for each source

Source No.	Max. Mag.. (m_b)	No. of events	β	Occu-rance rate	Average depth
A1	5.3	7	3.86	0.448	7.9
A2	5.3	4	2.328	0.213	17.25
A3	5.77	27	2.58	1.67	5.48
A4	6.37	15	2.58	1.161	7.33
A5	5.3	42	2.034	2.375	9.4
A6	6.37	238	2.58	7.554	19.53

Contour mapping.

The computations are carried out using the computer algorithm (EHA) for attenuation relations given by Eq.(1). the peak ground acceleration with 90 percent probability of being not-exceeded in 100 years of exposure period are calculated at 63 points in and around the area. Contours of peak ground acceleration were generated and plotted on the digitized geographical map of Aswan area, using a contour plotting program on PC computer The corresponding seismic hazard maps are shown in Fig. 4. From these figure, it can be seen that the regions of highest seismic threat are in Kalabsha area.

SEISMIC HAZARD MAP FROM THE LINE SOURCE MODEL

Source location and geometry.

A detailed field study performed by the working group from WCC, HADA and EGMA (1986) disclosed the nature and characteristics of significant earthquakes sources that have a potential for future earthquakes attacking the study area. For each of these sources, maximum earthquake magnitude and the frequency of occurrence of potentially damaging earthquakes have been estimated. Five faults were identified as active faults that have the potential for producing significant earthquakes. These Faults are: Kalabsha, Seiyal, Gebel el-Barqa Kurkur and Khor el-Ramla and shown in Fig. 5.

The maximum earthquake magnitude.

Five approaches were used by the above working group to assess the maximum earthquake magnitude. One of these approaches' aims at, the evaluation of fault displacement, provides strong evidences to defined maximum magnitude values for the five active faults and for the random area source.

Annual mean number of evens and recurrence rates.

The recurrence model for the five significant faults and the random area source designed by Wooodward-Clyde Consultants (1985) are used . The occurrence of earthquakes on these sources is assumed to be a Poisson process. Due to the lack of historical seismicity data for the region, the b-value determined from Gutenberg-Richter relationship for the induced activity was used.

Magnitude/ Rupture length relationship:

The magnitude / rupture length relationship in hazard analysis was developed from a relationship between rupture area and magnitude (Idriss *et al.*, 1985), as rupture area has a higher correlation with magnitude than does surface rupture length. The resulting relation was modified in normal logarithm as follows:

$$\text{Log } L = 0.547\, M_s - 2.137 \qquad (2)$$

where L is the rupture length. The definition of distance used in the attenuation relationship is closest distance to the surface projection of the center of energy release.

Ground motion attenuation relationship:

The attenuation equation developed for Aswan area (Raafat and Ohta, 1994) from earthquake recorded by Aswan Seismic Network as in Eq. (1) are used.

The output hazard map.

Based on the above input data . the computations are carried out using the computer (FRISK). The peak ground acceleration 100 years of exposure period and 90% of non-exceedance probability is presented in the Fig. 6.

MICROZONING MAPPING OF URBAN AREA

Microzoning is a developing technique that promises, in the future, to bring very important benefits for earthquake protection (Coburn and Spence 1992). It aims to identify the variation in earthquake hazard within a limited area -typically a city or municipality-as a result of local change in ground condition.

Acceleration at the base rock:

Generally, the process to estimate the ground motion starts with the investigation of seismic motion characteristics at the base rock from the seismological source, and then to the surface as function of site effect. Various methods concerning with the estimation of the seismic motions at given locations have been proposed (Shima and Imai, 1982). One of these methods consists of the determination of relevant ground motion parameters with specified probability of exceedance for a given return period for all points in a given area. This method was applied , following the same procedures used in seismic hazard analysis in this study from the area source model. The hazard analysis procedures are repeated systematically in sites located on appropriate grid pattern (26X24 segments) with about 1 Km spacing. The output represents the expected acceleration amplitude at the base rock with 90 percent probability of being not-exceeded in exposure time 100 years.

Geologic Setting:

The general distribution of rock units of the study area are devided into three rock units as shown in Fig. 7.

Estimation of the acceleration at the surface:

Local site conditions play an important role in changing the characteristics of seismic waves. It is often associated with the extent of damage and destructiveness of a site incurs due to a strong earthquake. Therefore, it is important to incorporate some type of site factor into the analysis of risk.. This factor is Known as amplification factor, defined as the ratios of the peak accelerations of the ground surface motions to those of incident waves from seismic bedrock. Midorikawa and Kobayashi (Midorikawa and kobayashi, 1980) deduced the relation between the amplification factor of ground for peak acceleration and the shear wave velocity of surface layer, and from this relation and the shear-wave velocity corresponding to the geological condition, they also derived the relation between geological conditions and amplification factors. Therefore, the amplification factors in this study were specified as 5.2 for Quaternary Alluvium, 3.0 for Nubia Formation and 2.5 for Pre-Cambrian rocks. The amplification factor relative to the hard rocks for each segment was derived. Finally the surface peak acceleration was estimated by the multiplication of peak acceleration at the base rock with relative amplification factor for the surface layers. Peak accelerations and their distributions at the ground surface in exposure time 100 years are plotted on the digitized geographical map of study area as shown in Fig. 8. It appears that the highest ground acceleration is seen in the northern part of the town, where the surface rocks dominant in this area are Quaternary Alluvial sediments.

CONCLUSIONS

Probabilistic seismic hazard procedures are used to assess the seismic hazard in Aswan region in adoption of area and line source models for earthquake sources. The results from two models appear slightly different. This difference may be related to the possibility of earthquake occurrence triggered by the present of the High Dam lake. The region of highest seismic threat is on Kalabsha area, where the most active zone is located, and the threat decreases to the north. The microzoning map presents the highest expected maximum ground acceleration at the north part of Aswan Town, where the dominant rock units are Quaternary alluvial sediments. As a general the exposure output is slight high, this may be due to the amplification of topographical effect on the used attenuation equation.

ACKNOWLEDGMENTS

This work was accomplished as a part of the first author's doctoral study. It is financially supported by the Japanese Ministry of Education to which authors acknowledge.

REFERENCES

Ahmed, K. A. (1991). Computer program for earthquake statistical analysis (ESA), *Cairo University, Faculty of Engineering.*

Ahmed, K. A. (1991). Computer program for hazard analysis (ESA), *Cairo University, Faculty of Engineering.*

Coburn, A. W. and R. J. S. Spence (1992). *Earthquake Protection*, Library of Congress Cataloging-in-Publication data.

Idriss, I. M., I. Arango, W. Savage, R. Youngs and K. W. Lee (1985). Probabilistic analysis of potential ground motion levels, *Internal Report*, High and Aswan Dams Authority, Egypt.

Issawi, B. (1969). *The geology of Kurkur-Dungul area*, General Egyptian Organization for Geological Research and Mining Geol. Surv., Paper *No. 46*, P. 102, Cairo.

Issawi, B. (1978). *Geology of Nubia west area*, Western Desert, Egypt. Annals of the Geol. Surv. of Egypt, *Vol. 8*, 237-253.

McGuire, R. K.(1976) FORTRAN computer program for seismic risk analysis, U. S. Dept. of Interior, *Geological Survey, Open-File report* 76-67, 90 pp., Denver, Colorado.

McGuire, R. K. (1978). Computer program for seismic risk analysis using faults as earthquake sources (FRISK), U. S. Dept. of *Interior Geological Survey, Open-File report* 78-1007, 71 pp., Denever, Colorado.

Midorikawa, S. and H. Kobayashi (1980). Isoseismal map in Near- Field with regard to rupture and site geological conditions, *Proc. of the 7th WCEE, II*, 259-262.

Raafat E. Fat-Hel bary and Y. Ohta (1994). Attenuation models of seismic intensity and peak
ground acceleration in Egypt. *First Cairo Earthquake Engineering Symposium on Seismic Risk Assessment*, Cairo, Egypt.

Shima, E. and T. Imai (1982). The Estimation of strong motion due to the future earthquake- A case study for Saitama Prefecture, Japan. *3rd Int. Earth. Micro. Conf. Proc., Vol. 1*,519- 530.

Woodward-Clyde Consultants (1985). Identification of earthquake sources and estimation of magnitudes and recurrence intervals, *Internal Report*, High and Aswan Dam Authority, Egypt.

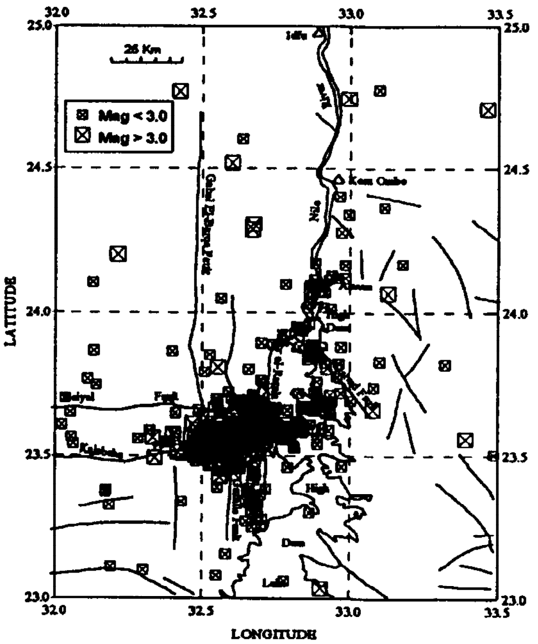


Fig. 1. Epicentral distance in study area from November, 1975 to August, 1993.

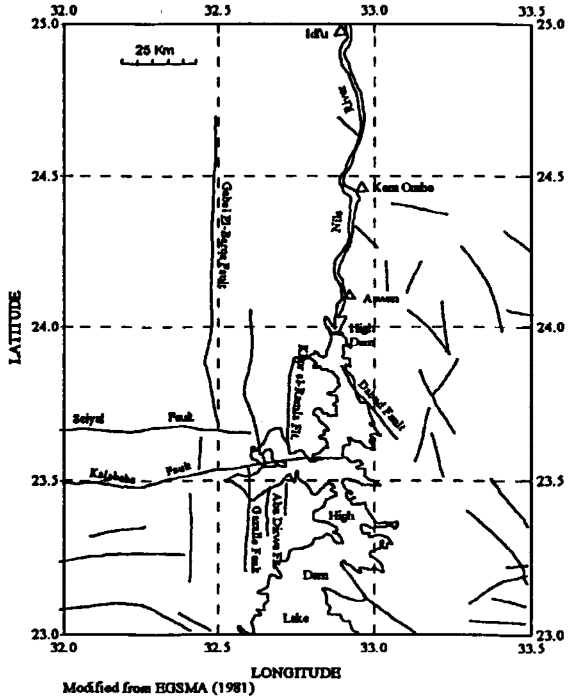


Fig. 2. Location of fault system in study area

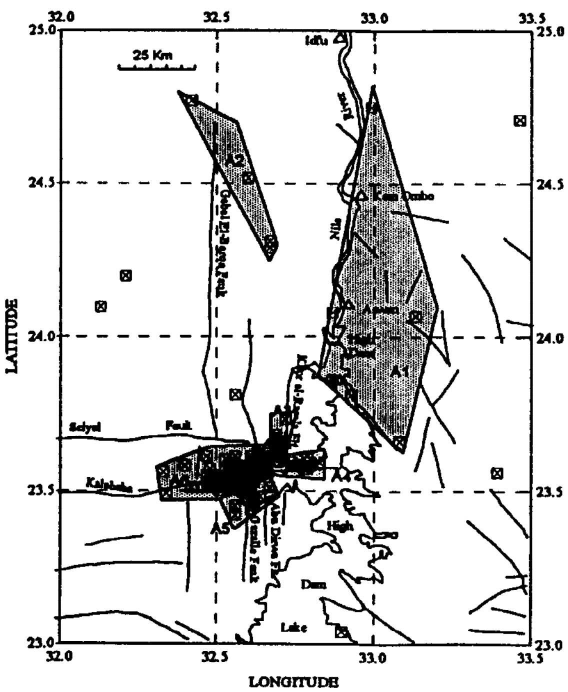


Fig. 3 Proposed of RIS seismic sources model

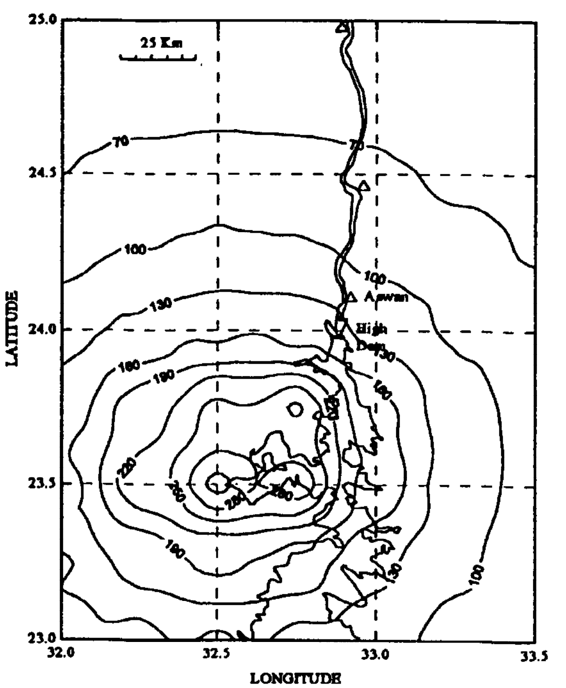


Fig. 4 Maximum peak ground acceleration (gals) with 90% probability of not exceeded in 100 years for Aswan area and its vicinty, resulting from RIS

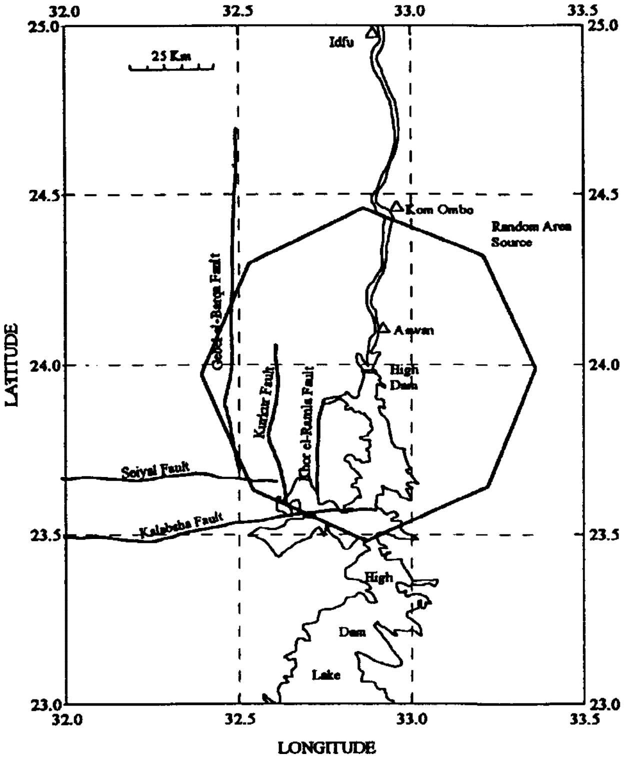


Fig. 5. Proposed of naturally seismic source model

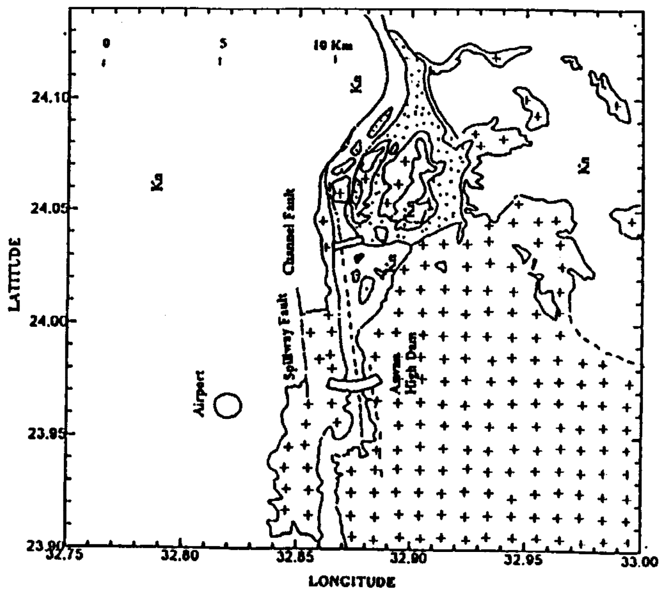
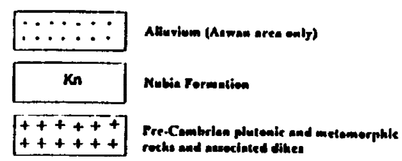


Fig. 7 Geological map Of Aswan Town



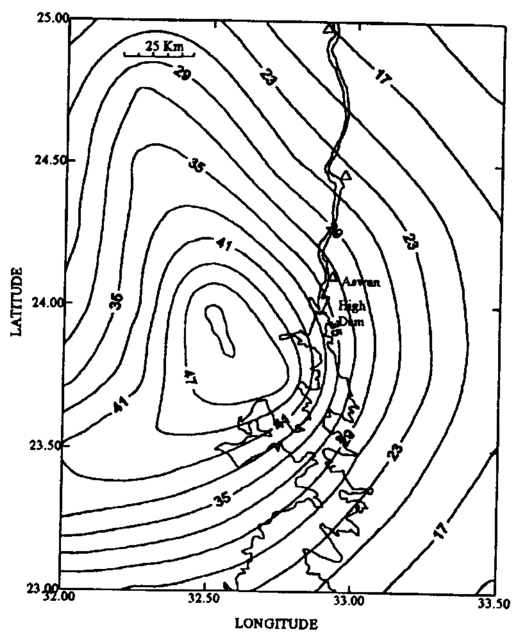


Fig. 6. Maximum peak ground acceleration (gals) with 90% probability of not exceeded in100 years for Aswan area and its vicinity, resulting from Non-RIS

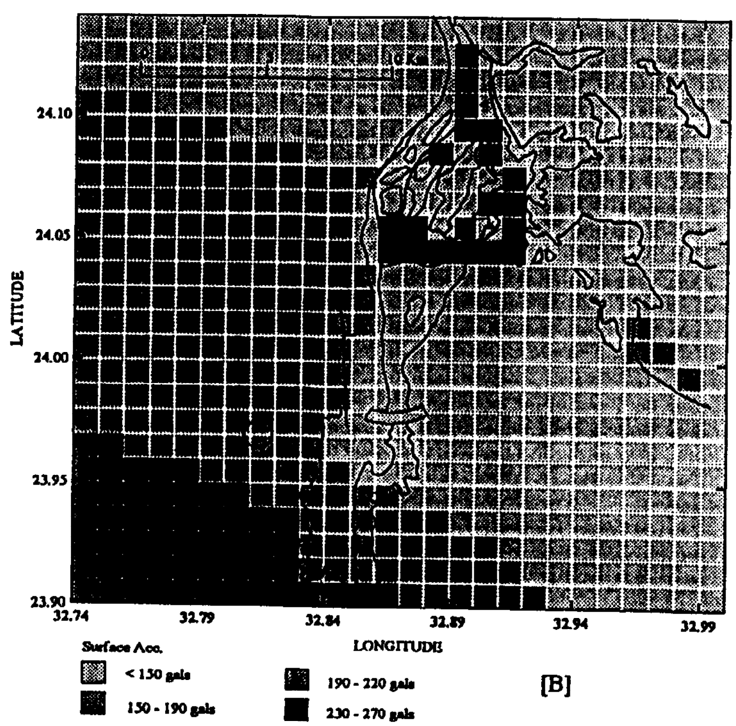


Fig. 8..Surface acceleration for expected value in 100 years