قاعدة المعلومات الزلزالية

قام مركز الدراسات الزلزالية بجامعة الملك سعود عام 1418هـ بإصدار أول قاعدة معلومات زلزالية لشبه الجزيرة العربية والدول المجاورة واشتملت تلك القاعدة على تقرير مختصر عن الوضع الحركي والتوزيع الزلزالي على امتداد حدود الصفيحة العربية ومواقع شبكات الرصد الزلزالي . وتم إصدار تلك القاعدة على قرص مغناطيسي 3.5 بوصة تحت نظام ألـ **Basic** واحتوت على 7500 حدث زلزالي.

وفي عام 1419هـ تم تحديث القاعدة وتم تشغيلها تحت النوافذ **windows 3.11** واشتملت على أكثر من 8000 حدث زلزالي.

في عام 1420هـ تم إعداد الإصدار الثالث من قاعدة البيانات واحتوت هذه القاعدة على أكثر من 9375 حدث زلزالي تم رصدها محلياً وإقليمياً خلال الفترة من 112 م إلى 1999م تم تشغيلها على جميع انظمه النوافذ تجاوباً مع تطور أجهزة الحاسب الشخصي .

وسوف يصبح استخدام هذه القاعدة أسهل وأسرع مما يُمكّن المستخدم من الاستفادة الكاملة والمُريحة . وفى هذا الإصدار أيضاً يمكن توقيع الزلازل لاى فترة زمنية معينة يريدها المُستخدم وحسب اى قدر زلزالي معين . كما يمكن اختيار أى موقع جغرافي على الخارطة وتحديد الزلازل التي حدثت فيه حسب الاختيارات المطلوبة والموضحة في البرنامج .

ويعتبر هذا الإصدار مرجعاً أساسياً للدراسات والبحوث التي يقوم بإعدادها المختصون في مجال الزلازل والهندسة المدنية للإستفادة منه في تحديد مكامن الخطورة الزلزالية على مستوى المملكة بالدقة المطلوبة ، ووضع مواصفات قياسية للمباني ومدى مقاومتها لأخطار الزلازل ، علاوة على دعم الدراسات الجيولوجية والإنشائية والبيئية للمناطق الآهلة بالسكان والمناطق ذات الأهمية الصناعية والاقتصادية .

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INTRODUCTION

The Arabian Peninsula presents several interesting seismological problems. On the west, rifting in the Red Sea has split a large Precambrian Shield. Active rifting is responsible for the geometry of the plate margins in the west and southwest. To the south, similar rifling running in a more east-west direction through the Gulf of Aden has separated the Arabian Peninsula from Africa. In the northwest, the Gulf of Aqabah forms the southernmost continuation of the Dead Sea transform. The northern and northeastern boundaries of the Arabian Plate are areas of continental collision, with the Arabian Plate colliding with the Persian Plate.

Recently, there are two independent analog seismic telemetry networks in Saudi Arabia. The King Saud University (KSU) network was established in 1985 and consists of 30 stations with denser sub-networks in the Gulf of Aqabah region (12 stations) and the southwestern part of Saudi Arabia (8 stations). A network run by King Abdulaziz City for Science and Technology (KACST) was established in 1993 with 11 short-period stations in the Gulf of Aqabah and the southwestern part of Saudi Arabia adjacent to the Yemen border.

In addition, the Saudi Arabian National Digital Seismographic Network (SANDSN) of King Abdulaziz City for Science and Technology (KACST) is being installed and will be operational by the mid of 1999, representing the third generation of seismic networks and seismic information system. SANDSN utilizes state-of-the-art broadband sensors and 24-bit dataloggers combined with real-time telemetry to monitor local and regional seismicity in the Arabian Peninsula. SANDSN consists of 32 seismic stations equipped with 21 broadband and 11 short-period seismographs. Seven (6 SP and 1 BB) of the 32 stations will be operated by King Abdulaziz University (KAU) and linked to KACST via 64 kbps leased line.

Upon completion the digital network, regional monitoring capability in the Middle East in

general and in the Arabian Peninsula in particular will be improved by observing and characterizing the propagation of regional phases across the Arabian Shield over a broadband of frequencies.

This report describes briefly historical and recent seismicity of the Arabian Peninsula, particularly along the Arabian plate boundaries. Due to the huge amount of earthquake data in the Saudi Arabian Earthquake Database (SAED), some of earthquake swarms in 1980's and 1990's were not included in the catalogues. However, these data are available upon request for educational and research purposes. The database is distributed on one 3.5" diskettes and is operating under Windows 95 and 98 environments.

SEISMOTECTONICS OF THE ARABIAN PENINSULA

Tectonically, Saudi Arabia is part of the Arabian Plate which consists of crystalline Precambrian basement overlain by low-dipping Phanerozoic sedimentary and volcanic rocks. The Arabian Plate came into existence 25-30 million years ago, when the rocks that comprise the Arabian Peninsula, Syria, Jordan, Iraq, and westernmost Iran began to separate from the African continent because of rifting along the margin of northeast Africa and the opening up of the Red Sea and Gulf of Aden (Johnson, 1998).

The majority of earthquakes in the Arabian Peninsula are concentrated along three major belts. The first is the Zagros fold belt that extends about 1500 km in a northwesterly direction from Oman through west Iran and northeast Iraq to Turkey. The second belt expands from the central Red Sea region south to Afar and then east through the Gulf of Aden. The third belt extends from the northern tip of the Red Sea in a northeasterly direction through the Gulf of Aqabah, Dead Sea, Lebanon, Syria, and terminates in southern Turkey. Analysis of the seismicity map of the Arabian Peninsula and adjacent regions during the period from 112 to 1998 A.D. includes nearly 3540 earthquakes ($3.5<mb<7.0$), excluding some swarm activities of 1993 and 1995, which occurred in the Gulf of Aqabah region.

The Dead Sea transform system connects active spreading centers of the Red Sea to the area where the Arabian Plate is converging with Eurasia in southern Turkey. The Gulf of Aqabah in the southern portion of the rift system has experienced left-lateral strike-slip faulting with a 110 km offset since early Tertiary to the present. The seismicity of the Dead Sea transform is characterized by both swarm and mainshock-aftershock types of earthquake activities. The instrumental and historical seismic records indicate a seismic slip rate of 0.15-0.35 cm/year during the last 1000-1500 years, while estimates of the average Pliocene-Pleistocene rate are

0.7-1.0 cm/year. Geological and tectonic information attribute the swarms to subsurface magmatic

activity and consequent isostatic adjustments in the Gulf of Aqabah region. Historically, the most significant earthquakes to hit the Gulf of Aqabah area were the events of 1759, 1822, 1837 and 1068 that caused deaths of more than 30,000 people. Historical seismicity indicates that about 26 major earthquakes ($6.1<M_L<7.3$) occurred in southern Dead Sea region between 2100 B.C. and 1900 A.D.

In 1980's and 1990's, the occurrence of earthquake swarms in 1983, 1985, 1991, 1993 and 1995 in the Gulf of Aqabah clearly indicates that this segment is one of the most seismically active zones in the Dead Sea transform system. Probabilistic seismic hazard estimates of the Gulf of Aqabah have been reported by Al-Haddad *et al*. (1994). Peak ground acceleration (PGA) predicted for 10% probability of being exceeded in 50 and 100 years are about 0.20 g and 0.30 g, respectively. Earthquake locations provide evidence for continuation of faulting regime from the Gulf northeastward inland beneath thick sediments, suggesting that the northern portion of the Gulf is subjected to more severe seismic hazard compared to the southern portion (Al-Amri *et al*.,1991).

To the south, the majority of earthquakes and tectonic activity in the Red Sea region are concentrated along a belt that extends from the central Red Sea region south to Afar and then east through the Gulf of Aden. There is little seismic activity in the northern part of the Red Sea, and only three earthquakes have been recorded north of latitude 25^0 N. Instrumental seismicity of the northern Red Sea shows that 68 earthquakes ($3.8<mb<6.0$) are reported to have occurred in the period from 1964 to 1993 (Al-Amri, 1995a).

Historically, about 10 earthquakes have occurred during the period 1913 - 1994 with surface-wave (*Ms*) magnitudes between 5.2 and 6.1. Some of these events were associated with earthquake swarms, long sequences of shocks and aftershocks (the earthquakes of 1941, 1955,

1967 and 1993). The occurrence of the January 11, 1941 earthquake (*Ms* 5.9) with an aftershock on February 4, 1941 (*Ms* 5.2), the earthquake of October 17 , 1955 (*Ms* 4.8), and the 1982

Yemen earthquake of magnitude 6.0 highlight the hazards that may result from nearby seismic sources and demonstrate the vulnerability of northern Yemen to moderate-magnitude and larger earthquakes. Instrumental seismicity of the southern Red Sea shows that 170 earthquakes ($3.0<mb<6.6$) are reported to have occurred in the period 1965-1994. The historical and instrumental records of strong shaking in the Arabian Shield (1832, 1845, 1941, 1982, and 1991) indicate that the return period of severe earthquakes which affect the area is about 60 years (Al-Amri, 1995b).

The Arabian Plate boundary extends east-northeast from the Afar region through the Gulf of Aden and into the Arabian Sea and Zagros fold belt. The boundary is clearly delineated by teleseismic epicenters (Figure 2), although there are fewer epicenters bounding the eastern third of the Arabian Plate south of Oman. Most seismicity occurs in the crustal part of the Arabian Plate beneath the Zagros folded belt (Jackson and Fitch, 1981). The Zagros is a prolific source of large magnitude earthquakes with numerous magnitude 7+ events occurring in the last few decades.

Generally, most of sites in the Arabian shield are extremely quiet with ground noise near or equal to the low noise model in the frequency band from 1-10 HZ. The low noise contributes to the very low detection threshold of events with mb >=3.5 at distances from 10 to 100 degrees. The Arabian Shield appears to be among the best sites in the world for the properties of detection thresholds and ground noise levels (Vernon and Berger, 1997; Mellors, 1998).

The overall lack of seismicity in the interior of the Arabian Peninsula suggests that little internal deformation of the Arabian Plate is presently occurring. There is widespread Quaternary volcanism along the Red Sea coast, with at least one documented historical eruption in 1256 A.D. (Barazangi, 1981). Some seismicity was associated with that eruption. Seismicity may also

be related to transform faults in the Red Sea continuing onto land as well as to other causes. To date, few on-land epicenters are accurately located and there are few focal mechanisms available.

EARTHQUAKE DATABASE OF THE ARABIAN PENINSULA

Nearly all earthquake catalogues documents temporal changes in the rate of activity with particular magnitude ranges. These changes could be due to the variations in global network coverage and to seismographic station practice which can systematically affect magnitudes. In order to construct a consistent and reliable earthquake database, the catalogue of the Saudi Arabian Earthquake Database (SAED) has been compiled from different sources and served as the primary source for the historical and instrumental seismicity (112 - 1999) in the Arabian plate boundaries and Arabian Peninsula. Entries in SAED were cross-checked and additions made from various sources of earthquake records to ensure that repetitions are not included in this analysis. Searches were made in a number of seismological catalogues and bulletins including those of the International Seismological Center (ISC), Preliminary Determination of Epicenters (PDE) and related publications, with special interest in the work of Ambraseys (1988), and Poirier and Taher (1980). For the period 1900 - 1964, the SAED catalogue relies heavily on Ambraseys (1988); Poirier and Taher (1980) and from 1965 onwards on the PDE, ISC and Ambraseys (1988). Local Earthquake data for the period 1985-1998 was acquired from the Seismic Studies Center, King Saud University, Riyadh.

Since the available earthquake sources contained events that were repeated more than once, it was necessary to eliminate the repetitions. The events were considered duplicate if they had time-origin difference of 10 seconds or less, and space-origin difference of 50 km or less. In a given set of duplicate events, an event which had a magnitude and PDE source was retained as the record of the event. However, in the case of a set of repetitive records, which neither had no magnitude reported,

the one which was derived from a PDE source was retained. Measures of earthquake size appear in the SAED catalogue as body-wave magnitude (mb) and duration magnitude (MD).

For statistical analysis of earthquake recurrence frequencies, the various measures of earthquake size were converted to surface-wave magnitude. A least-squares regression fit to the catalogue data for the southern Red Sea (as an example) gives the equation :

Ms = 1.07 mb - 0.476

A major problem in the evaluation of the frequency-magnitude relationship is the incompleteness of the catalogues. The common approach for treatment of this incompleteness is to employ earthquake detection and reporting probabilities. These probabilities are allowed to vary in time-span and with the size of the earthquake. The number of events for a specific magnitude range are adjusted to reflect the probability of detection and reporting. The rate of occurrence of the magnitude is then evaluated based on the time-span over which it is observed to occur. The SAED catalogue for the period 1900-1999 has in this way been made as homogeneous and complete as possible. Consequently, epicentral locations and seismicity parameters were determined based on the date reported in the aforementioned refined catalogue.

The bulletin contains some basic data on earthquakes occurred in Saudi Arabia and the adjacent areas for the period from 112 to 1999. It covers the geographical area from latitude 10 to 35^0 North and longitude from 30 to 60^0 East. This bulletin contains the earthquakes reported by the previous compiled catalogues as well as the Seismic Studies Center of King Saud University.

The basic information contained for each earthquake are date, time of occurrence (GMT), location (Latitude, Longitude), the body wave magnitude (mb) according to Richter Scale. Other data are kept out of the program to keep it running faster and to make the basic requirement to run it little easier.

DESCRIPTION OF THE PROGRAM

This database is distributed on one 3.5" diskettes. It is working under Windows 95 and windows 98 environments.

Program Installation :

To install the software, just follow the steps:-

1- Insert the associated disk into drive **A:**

2- From **Start** 

, choose 

Run.

3- From **Browse** , choose **Setup**.

Then follow the procedure, it will create an Icon for you.

Getting Started :

To use the database, double click the Icon of the Database **(s_map_99)** or from the **"START"** button move to **"PROGRAM"** then to **"s_map_99".** You will get the opening screen.

The screen shows the map of the Arabian Peninsula on your right hand side and three sets of scroll bars on your left hand side.

- The upper scroll bar set is used for date definition for the period from 112 to 1999 A.D. Use the mouse to scroll, you can press on the two end arrows to change the range by one year, or on the scroll bar itself to make large changes by 10 years. Another way is by dragging the scroll bar by mouse. Note if you make the starting and ending years are equal, it means that you will get the events occurred in this year only.

- The middle scroll bar is used for magnitude selection. The full range is from 0.0 to 8.0 magnitude. Again to scroll by 0.1 M_D (Duration magnitude) use the two end arrows. By pressing the scroll bar, will change the range by one magnitude scale. The new values will be written on the square right to the scroll bar.
- The lower scroll bar is used for border definition (Latitudes and Longitudes). The full range for longitude is from 30 to 60 E. and the full range of latitude from 10 to 35 N. By pressing the two end arrows, it will change the range by 0.1 degree. Pressing the scroll bar itself will give a change of one degree.

After choosing your selection of date, magnitude and borders, you can just press the **"REFRESH"** key to have the program replot the new seismicity map for your selection. The selected events are kept on a temporary file called **"map.dat** " .

If you want to get the printout of the map of your selection, You can press the button " **PRINT".** This will print the seismicity map and your selections on the default printer. When you finish working, just press the **" EXIT "** button to go back to your window.

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