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# RECENT EARTHQUAKE ACTIVITY AND NEOTECTONICS IN THE DEAD-SEA RIFT AREA, JORDAN.[1]

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## ABSTRACT

*A total of 1488 events reported in the Dead Sea region by the Jordanian Seismological Net Work are used to study the recurance-rate relation of the area. The events cover the period from September 1983 to September 1986 and lie in a magnitude range between 1.4 and 5.1. The frequency-magnitude relation for the considered period has been derived in the form :*

$$Log\,(N) = 5.271 - 1.025\,M_L$$

*where N is the cumulative number of events per year for events with magnitude $M_L$. The b-value in this relation is considered to be well representative of the region since in its evaluation it was found that incorporating events at the high magnitude limits, tends to produce a more stable and constant factor. The relation seems to fit well with the pattern of the historical earthquakes in the area. The geographic distribution of epicenters show, in many cases, a direct relation to geologically known surface faults. Earthquakes follow NW-SE faults in the southern parts, while in the central and northern parts they are associated with the main Dead Sea rift direction and the E-W and NE-SW fault systems. The relatively low number of events reported for the western side of the rift is believed related to major differences in the crustal structure of both sides.*

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## STRUCTURE and SEISMICITY

The Dead Sea lies between two tectonically different regions, the Red Sea to the south with its active spreading center pushing the African and Arabian plates apart, and the Tourus-Zagros thrust zone to the north resulting from the continued convergence of the Afro-Arabian plate relative to the Iranian blocks.

Structurally the Jordan rift valley is crossed by two major diagonal faults (Figure 1), the Er Risha fault in Wadi Araba and the Jordan Valley fault in the Jordan Valley. These two faults overlap in the Dead Sea region. The Er Risha fault starts on the west of the Gulf of Aqaba crosses Wadi Araba diagonally continuing to the Wadi Hasa at the shores of the Dead Sea where it dies away. The maximum throw of the Er Risha fault is reported to be around 2200 meters or more [Burdon, 1959]. The Jordan Valley fault begins from the eastern shores of Lake Tiberias and extends southward forming the western shores of the Dead Sea. These two major faults are characterized by a tremendous horizontal sinistral displacement of about 107 - 111 km [Burdon, 1959; Quennell, 1956; Fruend et al. 1970]. This left-lateral displacement is also deduced from the seismicity of the region [Ben Menahem et al., 1976; Reches and Hoexter, 1981].

Less prominant faults fall in two directional groups. Those striking NW-SE, most of which appearing as tensional faults, and where double faults exist, they lead to the formation of grabens. The normal faults of this group are located south of the Dead Sea as is the case of the Petra group of faults, Ras El Naqb group and the Wadi Khuneizra group located west of Tafilia, while the grabens of this group are located east of the Dead Sea as is the case for the Karak and Wadi Sirhan grabens (Figure 1). The second

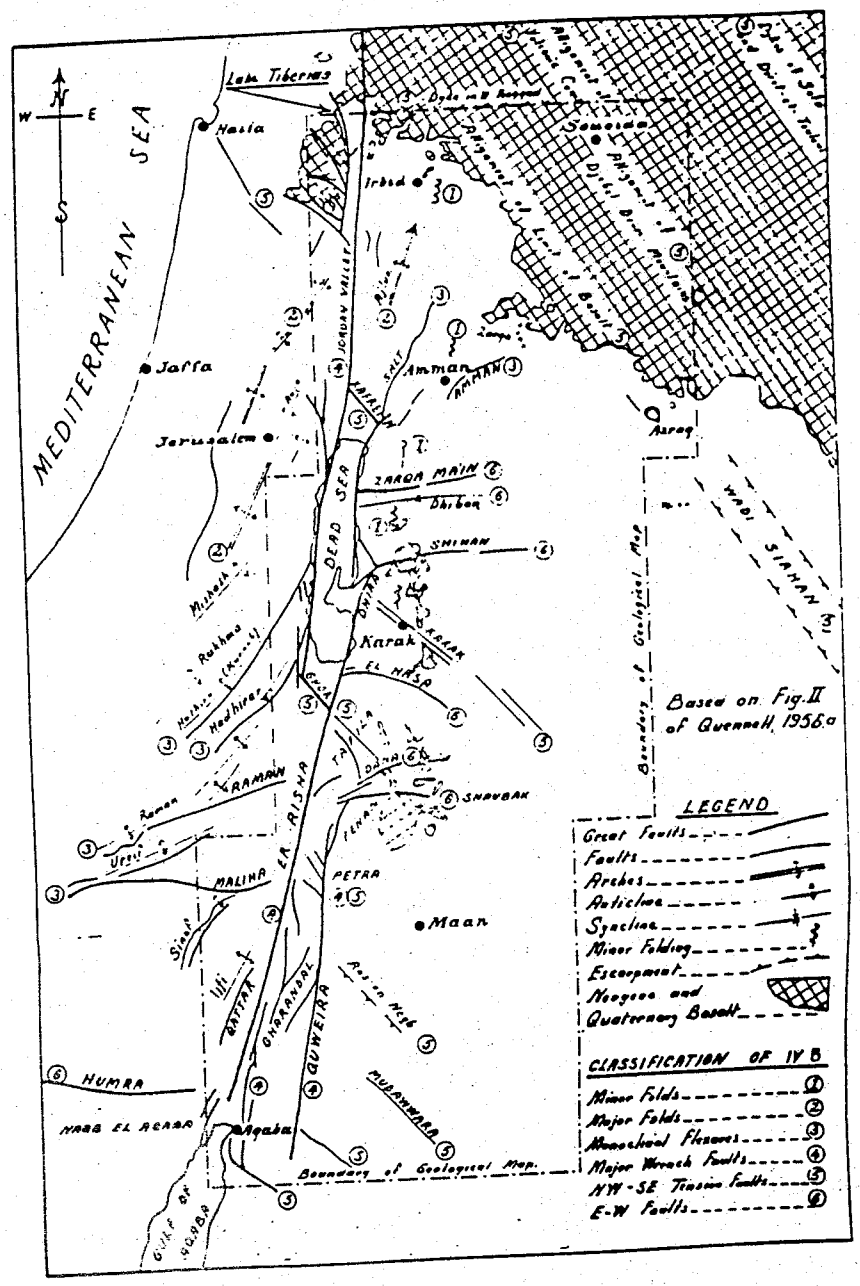


Figure (1) Structural features of the Jordan Valley (after Burdon 1959).

group of these less prominent faults strike E-W and are found to extend eastward from the Rift and are concentrated in the south. They show maximum diMwlacements near the Rift and die out to the east. Of these are the Wadi Zarqa Ma'in, the Sirhan, the Wadi Hasa, the Dana and the Shaubak faults (Figure 1).

This structural setting has been accompanied with seismic activity dating as early as the year 2150 B.C. Alsinawi (1986) collected 400 historical earthquakes for the whole Arab region between 1606 B.C. and 1900 A.D. His historical isointensity map of the Dead Sea rift region (Figure 2) indicates the historical high sciesmicity of the Dead Sea region. El Isa and Hasweh (1986) reported 26 historical earthquakes of local magnitudes between 6.1 and 7.3 occuring in the Dead Sea region between 2150 B.C. and 1837 A.D. and 1006 instrumental earthquakes of magnitude less than 5.5 in the period 1903-1984. Both historical and instrumental earthquakes are located along the Dead Sea trasform faults as well as along the two less prominant fault groups mentioned previously (Figure 3).

## MAGNITUDE-FREQUENCY RELATION

The b-value, one of the two factors of the relationship $\log N = a - bM_L$, is considered to have a direct physical meaning with respect to the area being investigated. It reflects the extent of the tectonic stress under which an area is subjected to and when monitored in time could lead to foretelling the degree to which the region is approaching its ultimate strength and so nearing the release of accumulated energy through an earthquake of high magnitude [ Li et al., 1978; Riad et al., 1991]. Different b-values have been reported for one and the same region. For the Dead Sea region b-values of 0.86 and 0.65 are reported [Ben-Menahem, 1981; Ben-Menahem and Aboodi, 1981; Ben-Menahem et al., 1982; El-Isa and Hasweh, 1986].

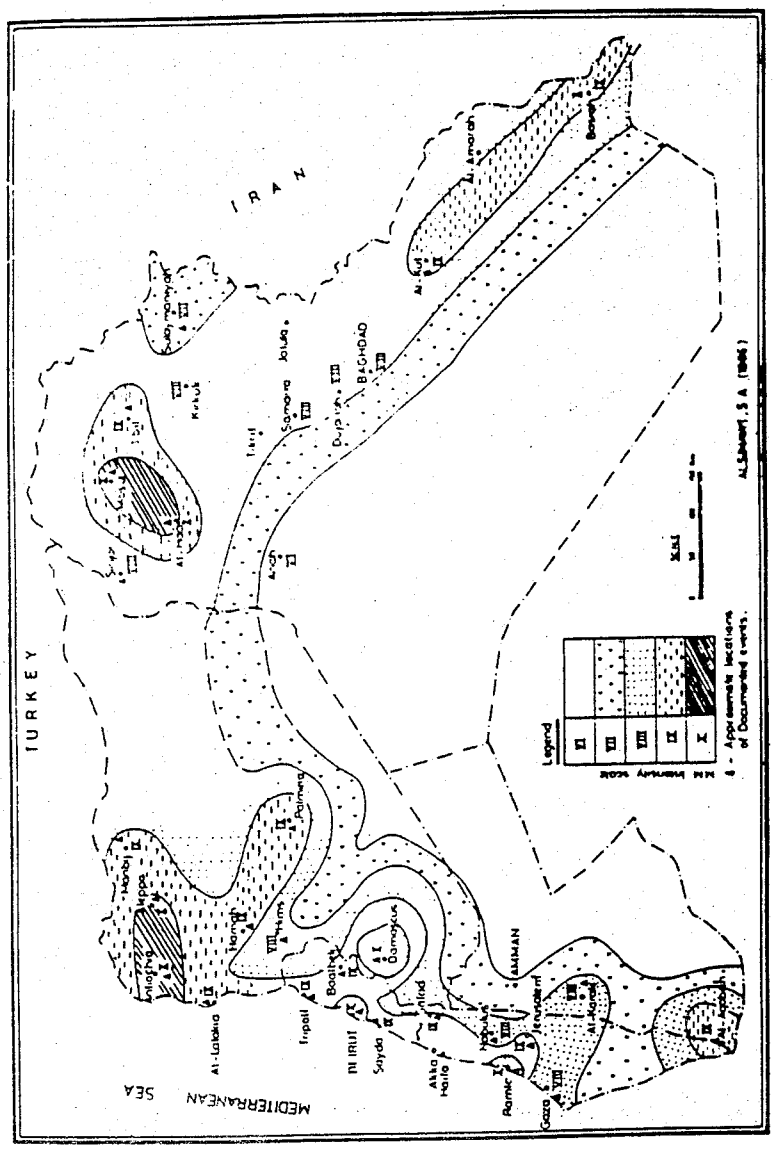


Figure (2) Historical isointensity map of the Dead Sea region (after Alsinawi, 1986).

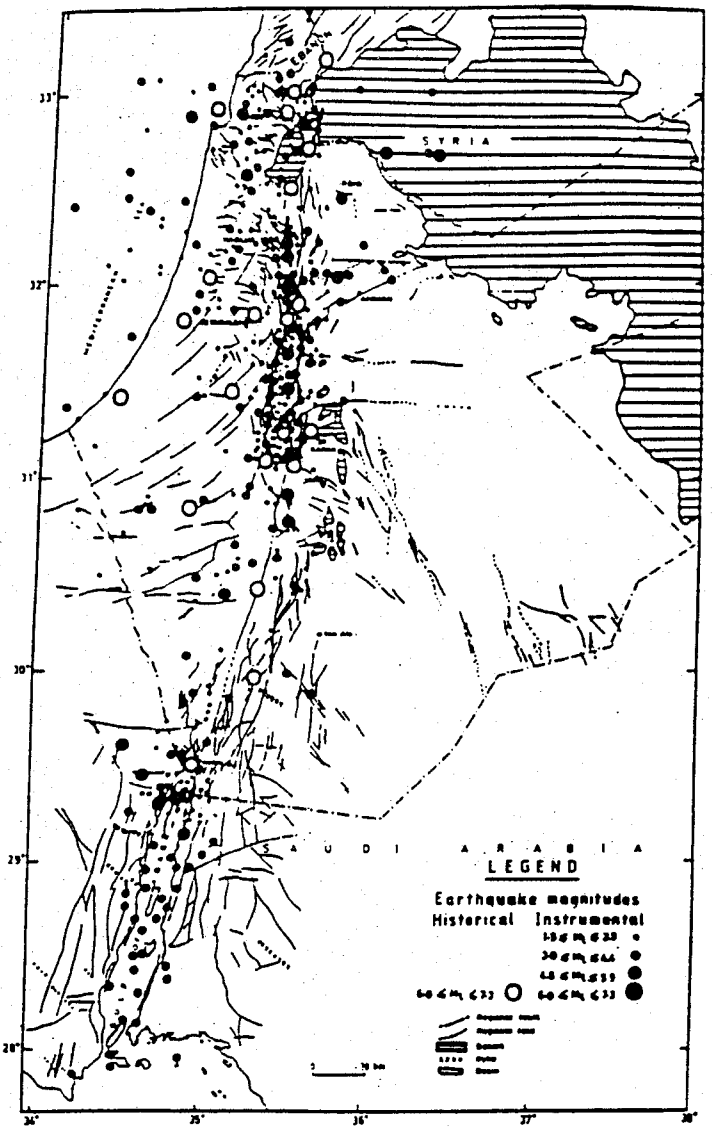


Figure (3) Earthquakes between 2150 B.C. and 1984 A.D. (after El Isa and Hasweh, 1986).

## MANIPULATION

A total of 1488 events recorded by the Jordanian Seismological Observatory (J.S.O.) from September 1983 to September 1986 were utilized [Jordanian Seismological Observatory, Bull. 1-12, 1984-1986]. The events lie in the magnitude range between 1.4 and 5.1 with a predominating magnitude between 3.2-3.3 (Figure 4). These events are seen to be mainly localized on the eastern side of the Dead Sea rift and being grouped about the tectonic features of the region (Figure 5 & 6).

The two elements affecting the evaluation of a and b in the LogN versus Magnitude relationship are the period and the magnitude range utilized. The period, whether monthly, bimonthly, quarterly or anualy does not affect the b-value. Figure (7) shows the two best-fitting straight lines for the cummulative grouping of events per year and for the cummulative grouping reported for the whole period. The two lines are parallel, indicating the same value of b. The intercepts of these two lines change bringing a difference in the value of the constant a. On the otherhand the choice of magnitude range has a more considerable effect on both a and b. Figure (8) shows that as the magnitude range is increased, incorporating more events in the calculation, the straight line's slope gets steeper, thus significantly increasing the value of b as well as a in the process. By stabelizing the lower limit of the magnitude range at two values, 1.5 and 2, while varying the upper limit, the corresponding changes in both b and a were monitored (Figure 9 & 10). The two plots show an increase in the value of both factors accompanying the increase in the upper limit of the range. A tendency for the curves to stabelize towards the high upper-value limits is felt, being more evident in the plot for the b-value. This would imply that with the incorporation of high magnitude events more stable a and b-values would be calculated. The following table gives values of a and b for the different ranges used.

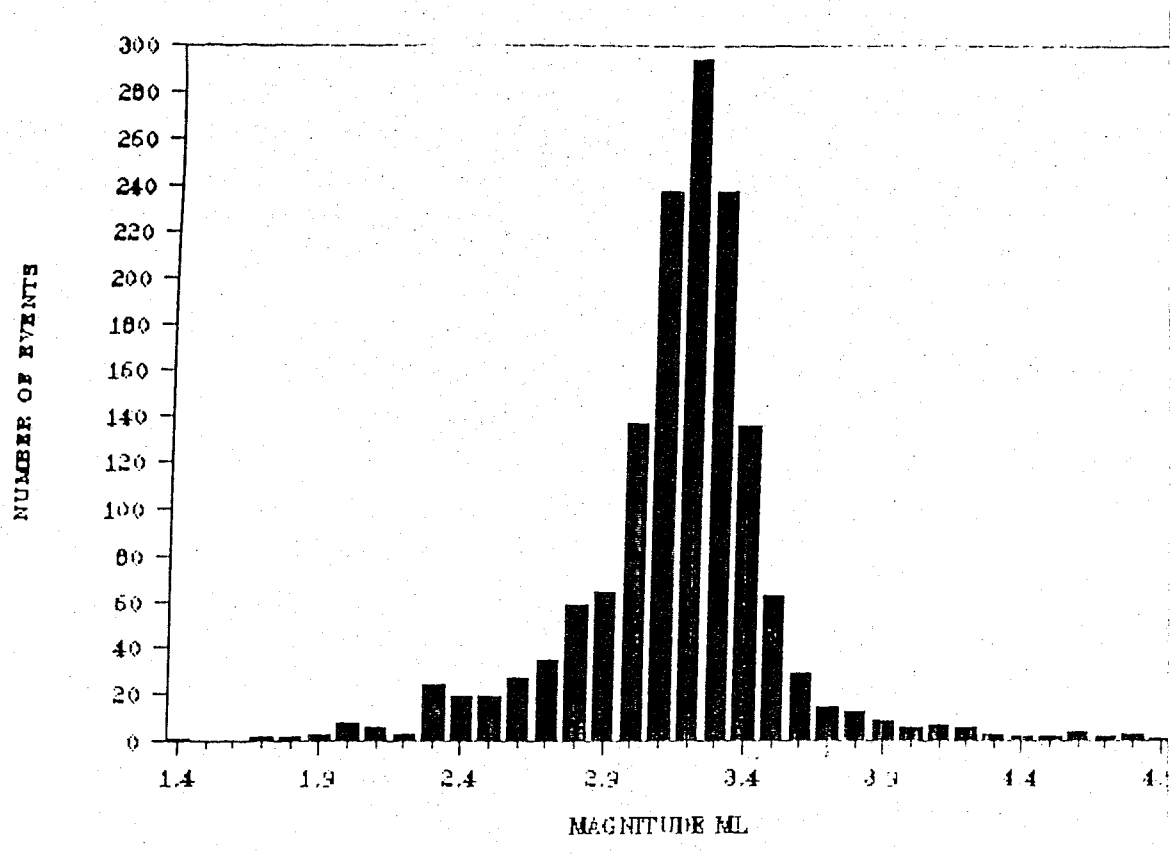


Figure (4) Predominant magnitudes for the period September 1983 - September 1986.

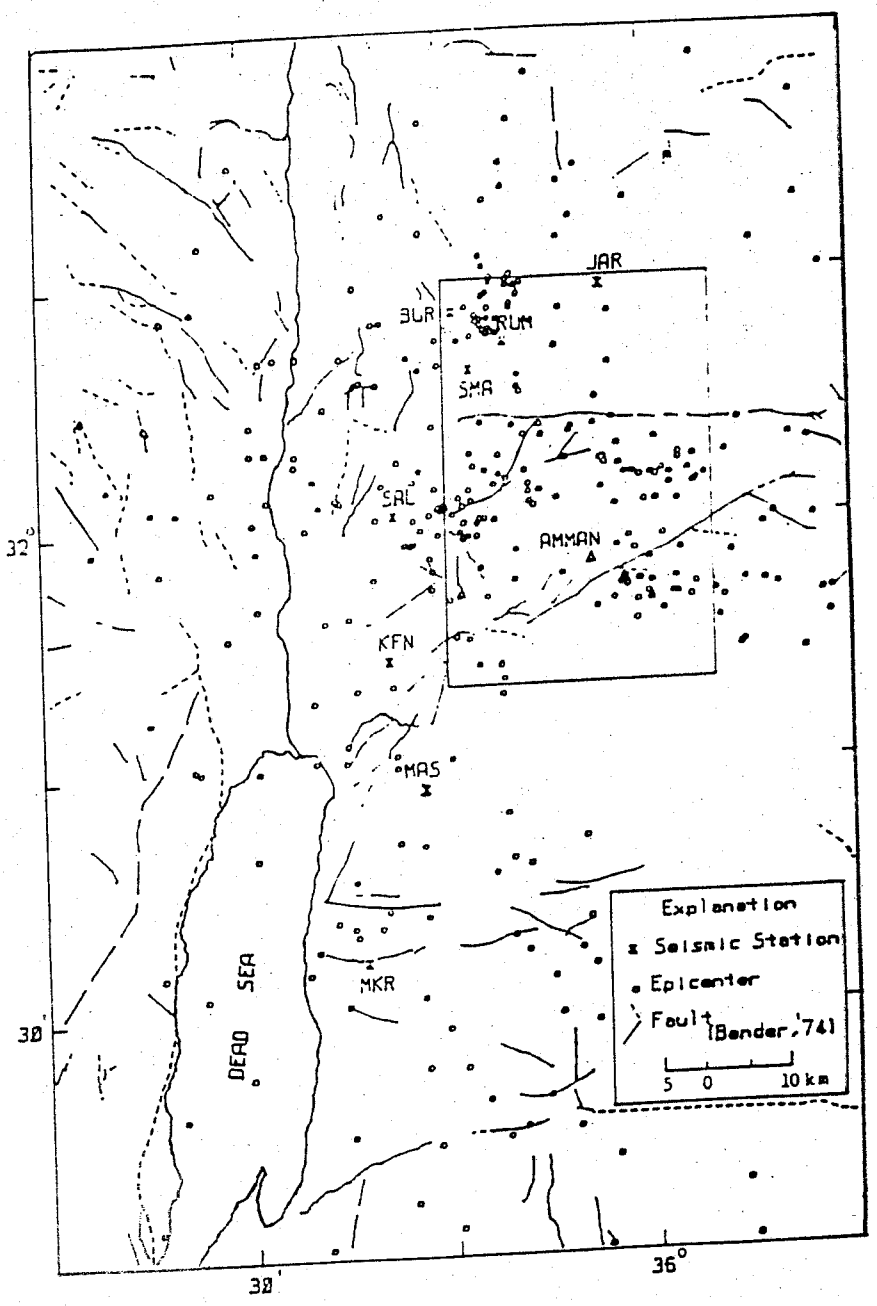


Figure (5) Location of events between September 1983 and December 1984 in the Dead Sea Region (J.S.O. Bull.5).

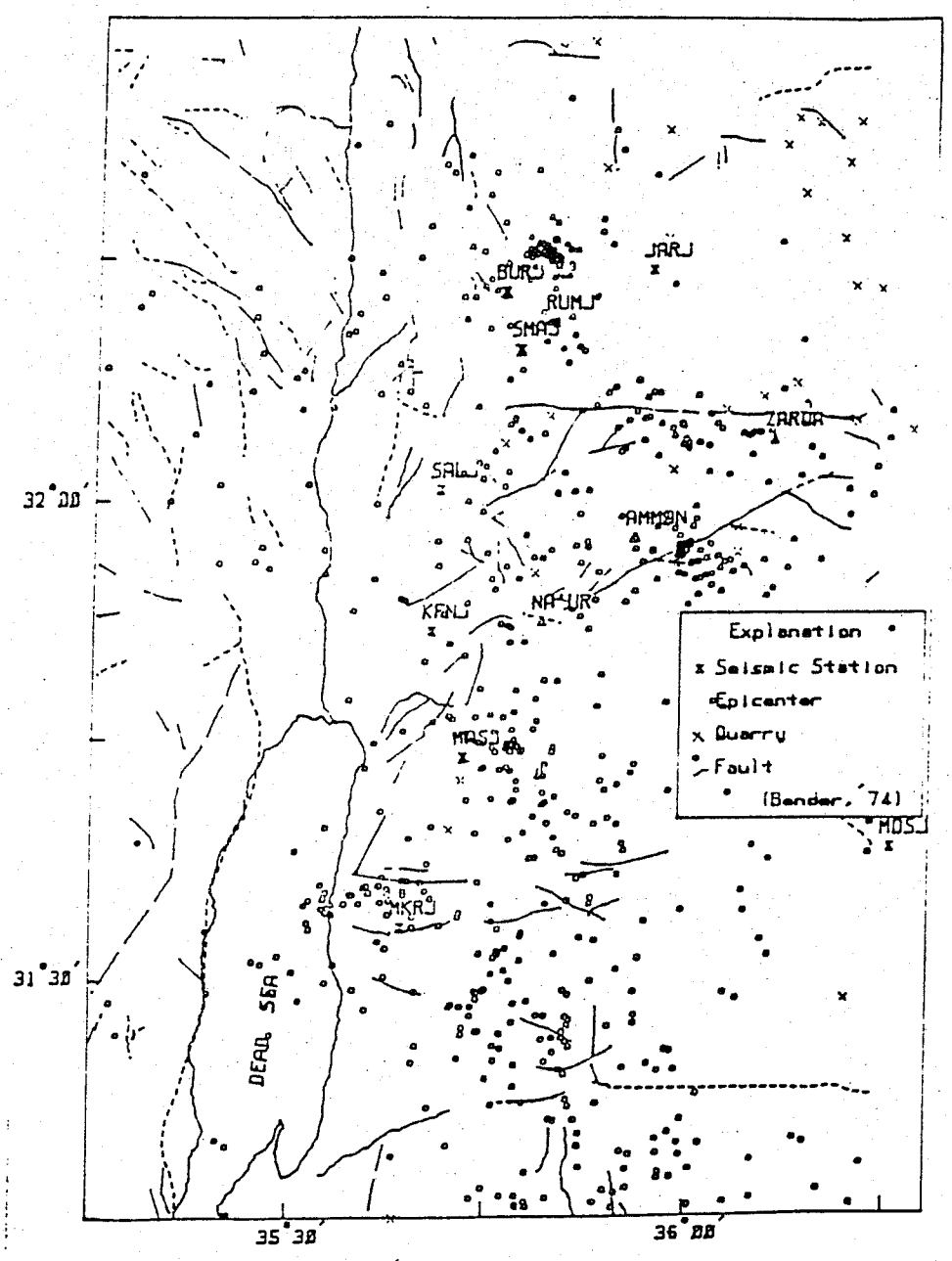


Figure (6) Location of events for 1985 in the Dead Sea Region (J.S.O. Bull.9).

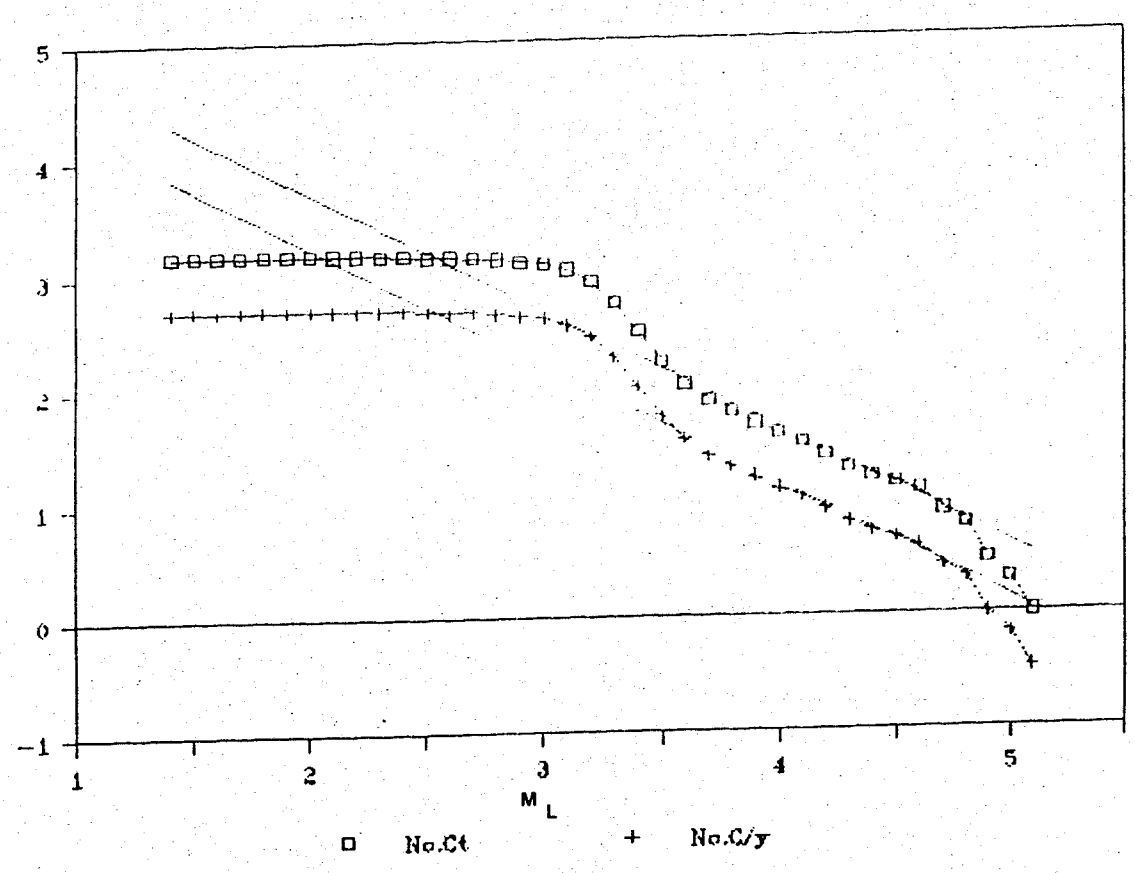


Figure (7) Effect of period variations on the b-value.

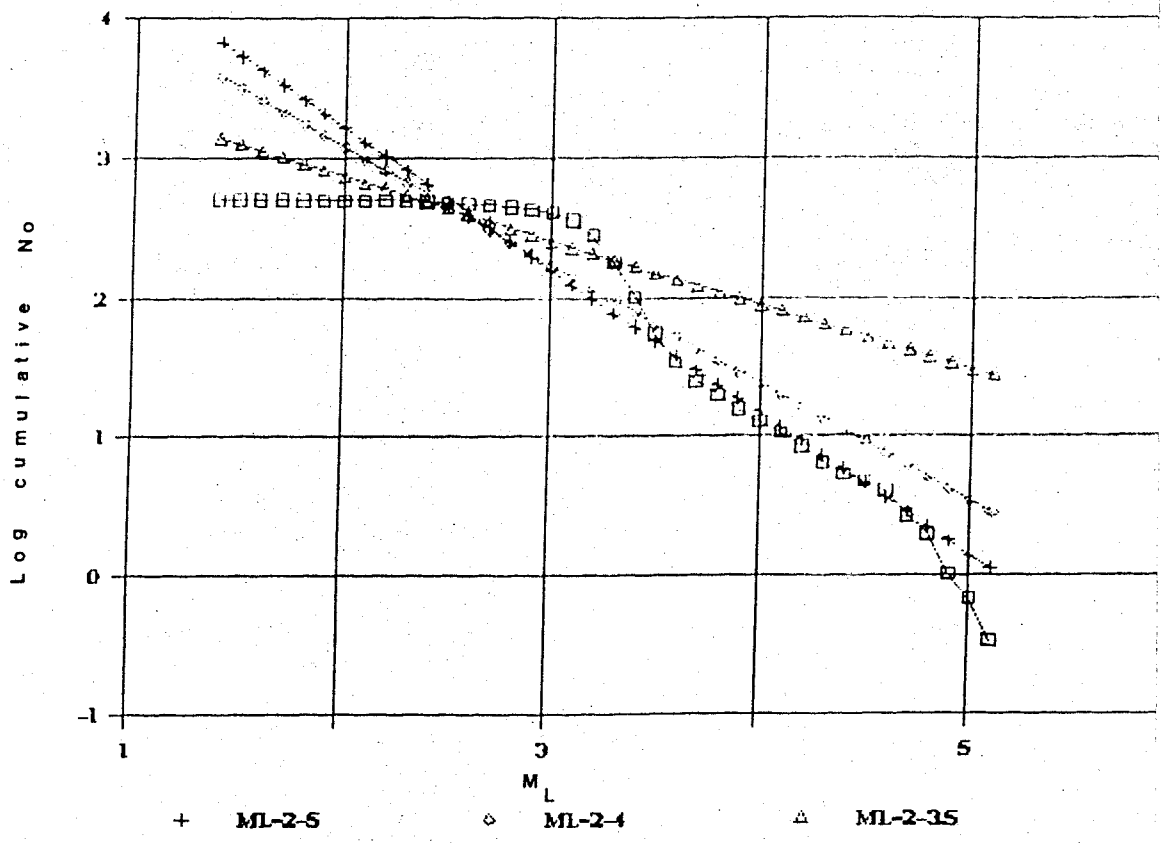


Figure (8) Effect of magnitude-range variation on b values.

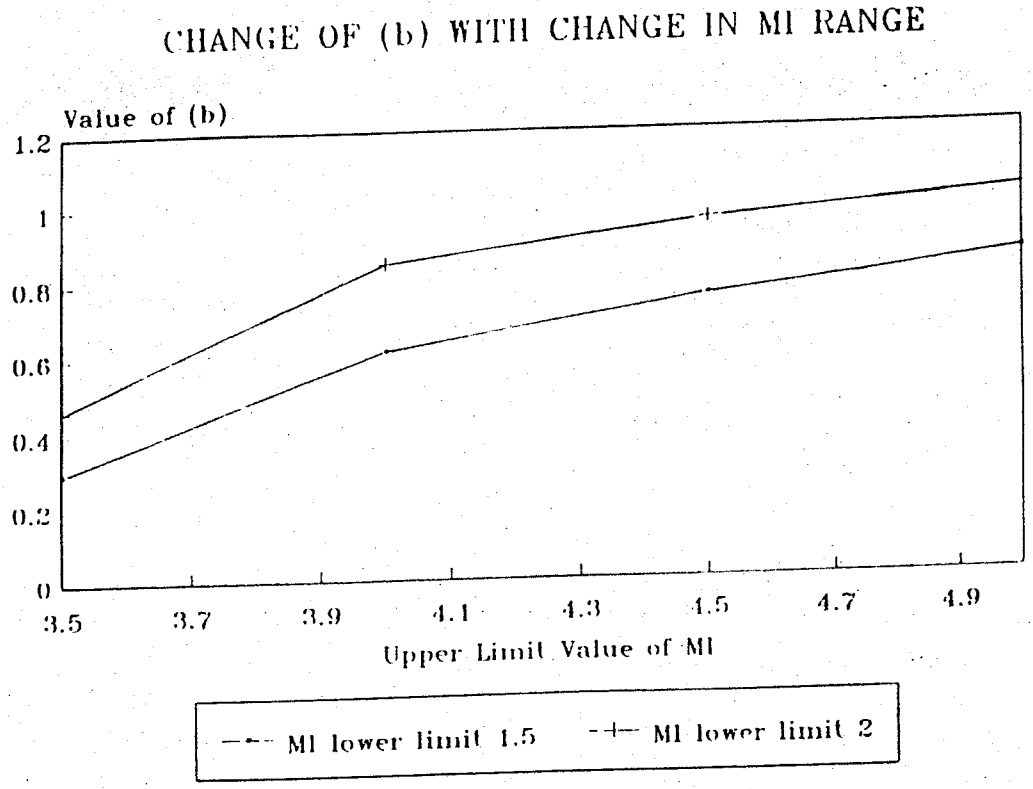


Figure (9) Effect of varying the upper limit of the magnitude range while stabilizing the lower limit on the b-value.

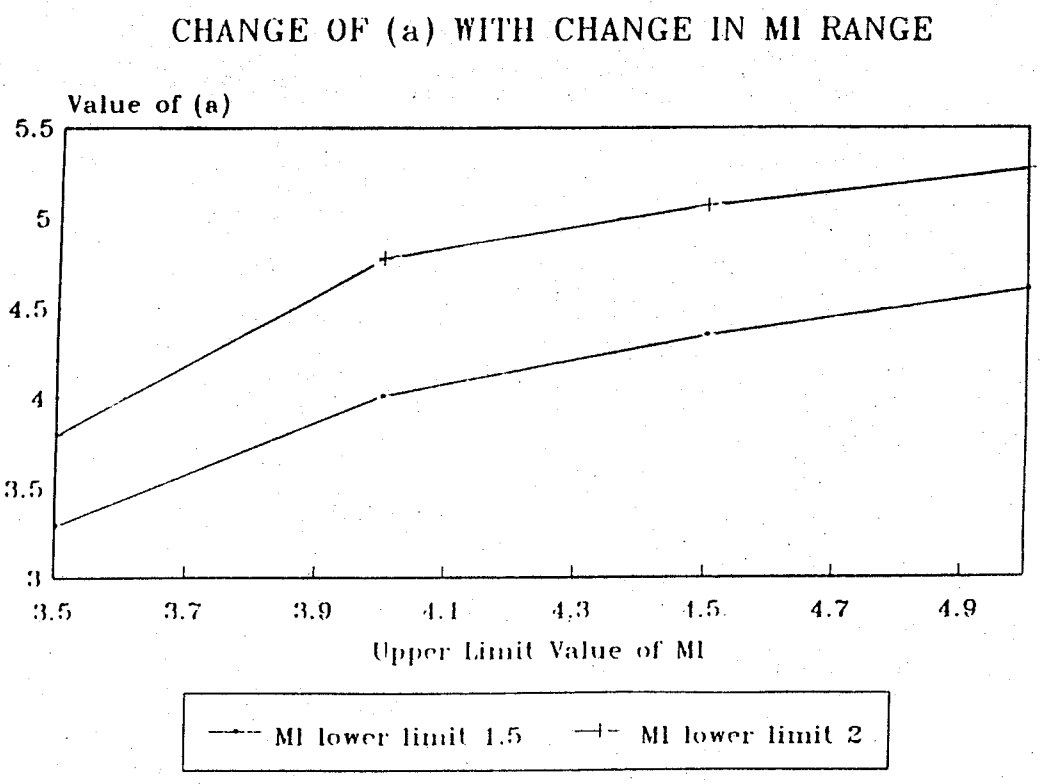


**Figure (10) Effect of varying the upper limit of the magnitude range while stabilizing the lower limit on (a).**

## CONCLUSION

1. The Dead Sea has been a siesmically active region for the past 40 centuries. Its siesmicity coincides with the regions stuctural and tectonic setting. Earthquakes follow NW-SE faults in the southern parts, while in the central and northern parts they are associated with the main Dead Sea rift direction and both NE-SW and E-W fault systems.

2. The relatively low number of recent earthquakes reported for the western side of the rift may be related to major differences in the crustal structures of both sides.

3. In calculating the b-value, incorporating events of the high magnitude limits tend to produce a more stable and constant b-values than when events of the low-end magnitudes are encorporated.

4. The Dead Sea region is thus characterized by a magnitude-frequency relation as follows

$$\text{Log ( N/year)} = 5.271 - 1.025\ M_L$$

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# الحركات الزلزالية والتكتونية المتزامنة بمنطقة البحر الميت بالأردن

سمير رياض، حسن حسنى، محمود غالب

استخدمت المعلومات السيزمية المنشورة عن ١٤٨٨ هزة ارضية وقعت بمنطقة البحر الميت فى الفترة ما بين سبتمبر ١٩٨٣ وسبتمبر ١٩٨٦ للتوصل الى العلاقات التى تربط بين القوة الزلزالية والتكرار العددى للهزات بالمنطقة المذكورة. كما وجد أنه بإستخدام القيم العليا للقوة للهزات المستخدمة فى حساب الثابت (b) بالمعادلة يعطى قيمة أثبت لهذا الثابت.