BIBLIOGRAPHIC RELIABILITY OF CATALOGUES OF HISTORIC EARTHQUAKES IN AND AROUND ISRAEL

I. METHODOLOGY AND BACKGROUND

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ספר

אוצר נחמד

וכלליו

קבוצת מאמרים וענינים שונים אשר אדניהם על יסודות העולם והטבע הטבעי, אצרום וחקרום מליצים וחכמי לב מאמוני עדין כשפת אשכנז ורוסיא, אשר מיטיהם לדורות הבאים אחריהם ישטון והכם כיקרום כי כמוהו שטן הלקי לדלות מהם רעיונות נשגבות עד אין חקר, ומשכלם כויאור לנפש מאכל תאוה.

מאת

נחמיה הרב כ"ר זאב האפפמאנן מבירז,

אוצר נחמד ושמן בנוה חכם.
(משלי כ"א כ')

חלק ראשון.

ווילנא

בדפוס ר' יהודה ליב בן המנוח מו"ה אליעזר ליפמאן מ"ץ נ"י

שנת תרל"ו לפ"ק

האיתנים מרגיזי ארץ.

יְיָ מָלָךְ יִרְגְּזוּ עַמִּים, יֹשֵׁב כְּרוּבִים תָּנוּט הָאָרֶץ:
(תהלות צ"ט, א').

המאמר הנוכחי, קוראים משכילים, והוא מאמר יקר הערך, מועיל ונחוץ מאד, ובטעט לא בא עוד מאמר כזה בליטעראטור העברית, בו הראתי לדעת מכל הרעשים והוועות (ערד בעבען) אשר התחילו בהכל מיני ברא השמים וארץ, אשר אספתי את כל הרעשים בעזיר גורנה מספרי אשכנז ורוסיא הרבה מאד כיד ההקירה והדרישה הטובה עלי, והלבשתים במחלצת מתק המליצה כיד הטבע אשר חנן לי, ואתברך בלבבי כי כל עין הבלתי מוינה בחמת הקנאה ומוציאי דבה, לא תמצא בו שום דופי. ---

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– CATALOGUE OF WORLD EARTHQUAKES, IN MODERN HEBREW, BY N.D.HOFFMAN PUBLISHED IN 1876 IN VILENIUS (WILNO).

ABSTRACT

To be useful in characterization of regional seismic regime and in assessment of earthquakes hazards, catalogues of historic earthquakes must be complete and accurate. This can be achieved only through an extensive search in historic materials for felt-reports of past tremors, and through a systematic verification of earthquake reports extracted from previous catalogues and various secondary sources. The currently available data base for historic macroseismicity in and around Israel includes numerous catalogues pulished since the begining of this century. Unfortunately these catalogues are often repetitive and rely on largely unverified information extracted from preceding catalogues and other secondary sources. Consequently, in many cases, the dates, locations and extent of shock-induced damage are questionable. The extent of the present data base which awaits verification is defined and briefly reviewed.

INTRODUCTION

This is the first of a series of reports on the bibliographic quality of catalogues that record historic earthquakes in and around Israel. The study, sponsored by the Israel Atomic Energy Commission, was undertaken to determine the reliability of the macroseismic data base currently employed in assessments of earthquake hazards in Israel. This report describes the conceptual approach to evaluation of historic

macroseismicity, and summarizes the characteristic features of major catalogues of earthquakes in Israel and the Levant. More detailed evaluations of the documentation specifically cited in the individual catalogues will be presented in reports that follow.

BACKGROUND

The characterization of a regional seismic regime and the hazards related to it relies largely on concepts of statistics and probability and usually requires an extensive data base. Since instrumental monitoring of earthquakes has come into use fairly recently, the record can be extended into the more distant past only through historic materials which may provide information about the occurrence, spread and strength of past earth tremors. The analysis of such information allows a reconstruction of the probable values of magnitude, epicentral distance and Modified Mercalli Scale intensity, to be used in derivation of the empirical equations for regional seismicity and earthquake recurrence interval.For such equations to be reliable, the information in the catalogue must be complete and accurate.

Numerous recent studies of historic macroseismicity in various parts of the world (e.g. Ambraseys, 1968, 1976, 1978; Ambraseys and Melville, 1982, 1985; Lee, 1985) have demonstrated that the completeness and accuracy of a catalogue (or indeed of any source) are largely a function of the extent of successful recovery and analysis of contemporary evidence, i.e. either eye-witness accounts, or summaries of such accounts gathered and written within a few generations after the event. The search for

such documentation should not only aim at the fullest coverage but also at the cross-verification of date, spread and intensity of each seismic event by comparing reports from independent sources. The investment of labor and the extent of scholarship required are so great as to appear prohibitive to the eyes of the modern geoscientist. In practice therefore, halfway methods are used, and most earthquake catalogues consist of often uncritically assembled secondary sources, and information copied from previous earthquake catalogues. Hence, the quality and reliability of any such catalogue depend on the degree of loss and distortion of information, which may enter at any of the following levels: (a) contemporary documentation; (b) secondary sources; (c) extraction from previous earthquake lists and catalogues. The problems encountered at each of these three levels are briefly discussed below.

Contemporary documentation

The amount and the quality of contemporary accounts of past earthquakes that may be obtained in a fully exhaustive bibliographic search depends on numerous factors. First is the cultural level during the period covered by the search, which prescribes the attitude to historiographic practice, and attitude to natural phenomena. Naturally, such attitudes keep changing throughout history in response to the changing political and economic scenes, as well as a result of shifting philosophical and religious trends of thought. Hence, cultural level and

historiographic tradition not always go hand in hand. For example, much of the Jewish sacred and homiletical literature emphasizes the universal theological and moral aspects of contemporary happenings with only slight attention to factual or historiographic details.

Secondly, the availability and geographic distribution of contemporary records of earthquakes is strongly influenced by differences in population density, settlement patterns and the nature of transportation and communication networks. Information is often lacking for sparsely populated areas or wide regions frequented only by nomads, and as a rule even minor tremors in a major city, such as Jerusalem, Antioch or Damascus, have a better chance of being recorded and preserved in the record than a major disaster in a remote village.

Thirdly, the extent of damage and its consequent impact on the written record depend on local geotechnical and geographical conditions, as well as on the type of construction and quality of buildings. Where towns are located along unstable coastal cliffs or along slopes succeptible to landslides, or where foundations are sunk into ground succeptible to liquefaction, seismic damage may be out of proportion to earthquake magnitude and epicentral distance. The importance of such geotechnical factors was stressed by Karcz and Kafri (1978) in evaluation of possible archeoseismic damage in Israel, and by Wachs and Levitte (1978) who showed that much of the reported 1837 and 1927 earthquake damage in Galilee was the result of seismic shock-induced landslides. Quite often, contemporary felt-reports attribute

architectural damage and collapse to sudden display of divine temper expressed in an earth convulsion or a tremor and it is not always clear whether the described event is indeed of a seismic origin. Thus for example, the sudden fall of a chandelier of the Al Aqsa mosque in 1060 CE may have resulted from poor anchoring, and the seismic interpretation must await confirmation from independent felt-reports for the same date. A simialr uncertainty was discussed by Cresswell (1969) with respect to the 1016 CE collapse of Al Aqsa dome, which was generally attributed to an earthquake.

Finally, in regions of heterogeneous population (in religion, culture, nationality or traditions) differences exist not only in style of reporting, but also reports are often prone to bias or international exaggeration of damage, pointing to selective pattern of divine providence and punishment. Common are cases in which the author describes with gusto the destruction and casualties among the Christian, Jewish or Moslim community, as the case may be, and ends by stating that "by mercy of God no harm came upon the memers of our faith". Indeed, occasionally selective damage may result from an adverse geotechnical location of a particular quarter, or from a greater housing density or poorer construction (reflecting lesser political or economic status of that segment of community), but nevertheless in most cases, intentional bias is more probable. In other instances the reverse may be the case: the chronicler providing detailed description and estimates of damage and casualties in his community, but ignoring the fate of others.

This is encountered even in fairly modern documents, such as the case of the 1759 disaster in Safed and Tiberias, for which the Jewish materials provide detailed figures of dead Jews and extent of damage to their dwellings and synagogues, but hardly any information about the rest of population.

Secondary sources

The term "secondary" is not quite accurate since it covers all texts based on summaries derived from contemporary documentation, irrespective of how many times the information was transferred. In some cases, secondary sources are based on carefully assembled and cross-verified information, and may well be superior in quality to a single contemporary report; in many other cases the tortuous path that leads down from contemporary documentation is rife with errors, loss of details and distortion of data which occur even whithin a very short time after the event. Thus, for example, Croke (1981) has demonstrated recently how confusion concerning the earthquakes of 5th century in Constantinople crept into the Byzantine sources already within a century, and concludes "...If a normally careful compiler of the 6th century could be so confused about the different 5th century earthquakes, there was a little hope for less careful chroniclers of later date...". It should therefore be kept in mind that often it is not the absolute antiquity of a source that is significant in assessment of relialbility, but the time elapsed between the event described and the actual or inferred year of

compilation. Thus for example the venerable age of Eusebius Chronikon (4th century) does not provide any automatic guarantee of relilability for the descriptions of 1st and 2nd century disasters in Palestine and the Levant. The critical factor in all such cases is the degree of critical appraisal and verification applied by the earliest traced compiler. Fortunately, detailed evaluations of the general quality and reliability of the major chronicles have been published in historic literature.

As a rule, loss of information occurs wherever a comprehensive search for original earthquake documenttion has not been undertaken. Even when detailed chronographies and historic memoirs are available, there is no certainty that they represent the outcome of an exhaustive bibliographic search for earthquake felt- reports, nor is it certain that once found, such reports have always been included in the final text. This applies not only to minor and moderate events, but also to catastrophic shocks with widespread damage and casualties. The record of continuing occupancy in cities and regions hit repeatedly by such strong earthquakes may lead the later-day historian to the conclusion that when viewed in historical perspective these events are of little lasting consequence, and do not merit serious consideration and record. Not only do authors differ in their approach to the listing of earthquakes, but occasionally the same writer or compiler employs a different yardstick in different works or even in the same work. Thus for example, Clinton (1845) Roman chronography includes a well documented

record of major earthquakes, whereas his Hellenic chronography does not. Hence, the absence of references to seismic activity in historic texts does not imply calm, nor does a paucity of such references indicate a long recurrence interval.

Somewhat smaller in scale but equally misleading are the loss and distortion of information resulting from personal judgement, bias or misinterpretation by authors or compilers of secondary texts. Often shocks recorded in contemporary documentation are left out by the later compiler, as being in his view, of little interest to the reader, or of too little historic significance, the shock having hit an area too distant from where the chronicle was being compiled, or having occurred in the midst of more profound political upheavals which determined the course of history. In other cases, the text may be very specific about major locations, though quite vague about the adjoining areas, even if detailed contemporary documentation is available. Hence statements such as "...also widespread destruction across the entire region..." or "...also in many other parts of the world..." require verification by contemporary sources, to determine whether they are justified, or represent a later embellishment.

Each step in transfer, rephrasing or summation of information carries a danger of distortion or misinterpretation by the compiler of the dates and locations indicated in the previous sources. Errors in reporting of chronological details given, the contemporary documentation range from days and months, up to several centuries. In addition to gross blunders, such as

the confusion of Christian, Moslim, Armenian or Seleucid counts, serious discrepancies and errors are found in the calibration of dates originally indicated by the regnal year of an emperor, local ruler or a governor, or by the year of tenure of a bishop. Similar problems arise when the contemporary evidence employs a local or provincial calendar such as those of Arabia, Antioch, Gaza or Ascalon. Consequently the same event is often reported in the different secondary sources as having occured on different dates. Occasionally even two different translations or editions of the same text, such as the case of Eusebius Chronikon, differ in calilbration of dates, so that the timing of a seismic event in secondary sources will depend on the edition used. Unless the contemporary documentation is examined and cross-verified, it often is difficult to decide whether felt-reports dated up to several years apart by different secondary sources indicate consecutive separate events, a series of tectonically-related shocks, or a single earthquake reported under somewhat different dates. The recent studies of 362-365 CE (Russell, 1980), and 1202-1205 CE (Ambraseys and Melville, 1985) dated events provide striking examples of such difficulties and their resolution by resort to contemporary documentation.

Equally detrimental to the assessment of historic maccroseismicity is the misinterpretation of geographic locations indicated in the original documents. The prevailing custom of naming cities and towns after emperors or local rulers, and dedicating churches and monasteries to the same saints, lead to a considerable confusion. Antioch, Alexandria, Caesarea and

Nikopolis are but a few examples of widely dispersed cities of the same name. Errors may arise when qualifying pointers (e.g. Caesarea-Maritima, Alexandria- Troas) are omitted or missing, or when the name is cited out of its original geographic context. Conversely, the same city may have been known under different names during different periods, or to travellers and historians of a different nationality. A good example of such confusion and misunderstanding is the account of the severe 498 CE earthquake, at Imwas, about 30 km west of Jerusalem. This locality was also known as Emmaus, and as Nikopolis (or Nicopolis) and is close to present-day Latrun. Cataloguers of earthquakes (e.g. Arie, 1975; Turcott and Arie, 1986) report extensive damage there, relying on excerpts from the chronicle of Joshua the Stylite (from the very beginning of the 6th century) originally composed in Syriac, translated by P. Martin and quoted in Burstein (1975) to say "...Nicopolis, Emmaus, halfway between Jaffa and Jerusalem had fallen to the ground..." The underlined geographic qualification does not appear in the original text nor in the translation of Wright (1882), and is a later interpretation. The original document proably refers to Nikopolis in Pontus, or to Nikopolis Euphratensis (e.g. Russell, 1985). To increase the confusion, Ben Menahem (1979) reports damage at "Latrun (Nicopolis)" in a list of locations hit by the August, 502 CE earthquake, which according to the same chronicle, spread across the Levant littoral and the Galilee.

In most cases, clarification of such chronological and geographic questions, and the identification of later embellishments or rephrasing is possible only through examination of the contemporary documention.

Lists and catalogues of earthquakes

Paradoxically perhaps, the modern catalogues of earthquakes in an around Israel suggest that it is at this final level of macroseismic analysis that distortion and loss of information are the heaviest. Detrimental effects fall into three main groups: ommission, distortion of information and rejection of evidence.

The modern catalogues of earthquakes discussed here rely mainly on older lists and catalogues and on secondary soources. Relatively little effort has been made to trace the contemporary documents, and many historic sources, particularly the oriental chronicles, as well as the documents and diaries that accumulated in the archives of various ecclesiastic and secular establishments, have not been reviewed.

Misinterpretation and distortion of the reviewed historic materials, discussed in relation to qualitu and reliability of secondary sources, occur more frequently in the catalogues,which usually have been assembled by geoscientists, with inadequate knowledge of Classics, History and Oriental Languages. At one extreme end of such erros are gross blunders such as the confusion of calendars. The error of Willis (1928) in reporting

the dates of Soyouti (Sprenger, 1843) as Christian rather than the original Islamic dates, though corrected later by Willis (1932), nevertheless crept into the catalogue of Sieberg (1932a) and from there was copied into some later catalogues and lists. At the other end are mistakes of personal interpretation by the cataloguer, which often are difficult to identify. Thus for example, Amiran (1951) reports a 808 CE earthquake damage in Jerusalem citing the authority of Abel (1931). Examination of the latter shows however, that the original text (Commemoratorium 808) was cited merely to demonstrate the long-lasting imprint of the major earthquake of 747 CE.

In some cases, the cataloguers conflate two successive events, even when the cited contemporary documentation clearly indicates two separate events, and provides distinct felt-reports for each. An example is found in Turcott and Arie (1986), who conflate reports of the 33 CE and 48 CE shocks listed in many catalogues on the strength of citations from the New Testament and ecclesistic literature. Yet, some of these citations refer explicitly to a tremor in Jerusalem at about the time of the death of Jesus, whereas the other citations refer to an event which is clearly later in the chronological sequence (the earthquake at Philippi and release of Paul and Silas from prison, or somewhat less probably the revelation to Paul on the way to Damascus). Conversely, many catalogues list separate events extrcted from different secondary sources without realizing that they refer to the same event described in the same contemporary documentation, but with a somewhat different date calibration.

Finally, the successive copying of unverified details from secondary texts and catalogues increase the danger of a propagation of a chance lapsus or a typographic error.

Essentially, similar problems arise in evaluation of geographical details, particularly when the catalouer arbitrarily extends the shock effects to a much wider region. Interesting in this repect in the case of 1355 and 1374 CE events included in most catalogues (e.g. Willis, 1928; Sieberg, 1932a; Amiran, 1951; Turcott and Arie, 1986) on the strength of listings in Arvanitakis (1904), who indicates damage in Palestine. The latter does not cite any specific documentation for these events except that the reports come from "various Armenian and Crusaders sources". Examination of Armenian chronicles and earthquake catalogues indicates however that though destructive in Armenia, effects of these earthquakes were not documented from Levant nor Palestine, and the decision of Arvanitakis (1904) to extend the affected region further to the south may have been arbitrary. Such a decision may have been influenced by reports of respectively 1353 CE, and 1373 and 1375 CE earthquakes in Egypt. The last, but certainly not the least, is the impact of distortion of the data base, through the selective transfer of data in successive catalogues. As a rule, the catalogues of historic earthquakes in and around Israel (with the possible exception of Arvanitakis, 1904) tend to rely on a core of earthquake listings extracted from one or more previous catalogues. The extraction process is, however, highly selective and often events considered by one cataloguer to be significant,

are rejected by another. This is perhaps natural, but none of the catalogues considered here explain their criteria for rejection. Since the original documentation was not verified by any of the cataloguers, and in most cases was not even consulted, the basis for this admission-rejection process is not clear. Numerous events are listed in some catalogues on what appears to the the flimsiest of evidence or with no supporting documentation whatsoever, and then are repeatedly copied on the authority of the catalogues the list of which increases with each successive transfer. In other cases, well documented events are excluded from some catalogues, without any explanation. For such reasons, it is very difficult at this stage to compare the statistical characteristics of the individual catalogues, and their implications in seismic characterization.

Archeoseismic evidence

This background discussion would be incomplete without a reference to the use of archeological data in the study of historic seismicity. In the archeological literature, structural damage, disaster horizons and signs of abandonement, which are encountered at numerous sites in the Middle East, are often attributed to seismic calamities. Attempts have been made to incorporate such evidence in earthquake catalogues (e.g. Ben Menahem, 197) as proof of ancient seismic events, or as a supporting evidence for textual documentation. However, the collation of such data within the catalogue framework is highly

succeptible to circular reasoning. First, as shown by Karcz and Kafri (1978,1981), the identification of damage as seismic damage per se usually is inconclusive and leaves room for alternate explanations such as poor construction, adverse geotechnical conditions and intentional destruction. In most cases, where the damage is attributable to an earthquake, the archeologist determines the general age interval for the suspected event and proceeds to examine one of the available earthquake catalogues in search of the most probable date of such a destructive event. The possible time interval may encompass several centuries, and the more accurate dating of the observed damage is based on historic documentation and on catalogues. Hence, archeological evidence is admissible as independent verification of a listed earthquake, only when it can be dated by other (epigraphic, nummismatic etc) means, based on data from the site.

PRESENT DATA BASE FOR HISTORIC SEISMICITY IN AND AROUND ISRAEL

The relatively calm seismic background of Israel and the Levant is punctuated by sporadic earthquakes strong enough to inflict widespread destruction and casualties. Since instrumental monitoring of seismicity in Israel has started only about thirty years ago, a detailed characterization of the regional earthquake regime can be obtained only throughj the study of historic accounts of ancient seismic events. Fortunately, the region is one of the major craddles of

civilization, with historiographic traditions going back several thouand years. Indeed the devout interest in a land holy to Jews, Christians and Moslims alike, and the long prevailing endency to draw theological conclusions from the incidence and spread of natural disasters hae resulted in a wealth of references to ancient earth tremors. These abound in written sources of all kinds, scriptures, chronicles, memoirs, texts as well as in itineraries and letters of pilgrims, explorers and other travellers. Many such references are incorporated in old and modern chronographies (e.g. Clinton, 1845; Muralt, 2963,1965) and in various History and Geography books and articles. A more systematic collation of references to earthquakes in the Levant may be found in the high-quality catalogues of worldwide historic seismicity (e.g. Von Hoff, 1840; Perrey, 1850; Mallet, 1852-1853; Milne, 1912) and in the modern catalogues of earthquakes in and around Israel. Of the latter, at least eight were published since the beginning of the 20th century: Arvanitakis (1899); Willis (1928,1932); Sieberg (1932a,b); Shalem (1949 and unpubl.); Amiran (1951); Plassard and Kogoj (1962); Arie (1967,1975); Ben Menahem (1979). The catalogue of Turcott and Arie (1986) in a provisional report of the Israel Electricity Corporation is the most recent.

So far, studies of regional seismicity and its theoretical and applied implications have relied only on the modern regional catalogues listed above. it would appear that assumption is made that such repetitive studies of historic earthquaes ensure the required completeness and accuracy. Unfortunately, this is very

far from being the case, since all catalogues suffer heavily from loss and distortion of information, as reviewed above. Following is a brief critical review of the main bibliographic characteristics of the nine modern catalogues which jointly form the present data base for tudy of historic macroseismicity of Israel.

Arvanitakis (1899, 1904)

This catalogue of historic earthquakes in Palestine and Syria is presented in form of a table appended to a summary of meteorological observations conducted by the author in Jerusalem during the year 1896. Events are presented chronologically, and noted for each event are geographic location and extent of damage as well as bibliographic source. This study is unique amongst the catalogues discussed here in that the author appears to have been unaware of the older studies of earthquakes in the Levant. Arvanitakis (1899) in an introduction to the Greek version of his article, indicates that he has consulted several memoirs on the Historical Geography of the region (e.g. Kitto, 1844; Robinson, 1865) but these texts are not specifically cited in the table. Remarkably, not all events listed in these texts were listed in the catalogue. The catalogue lists eleven events that took place before 1 CE and seventy one events during the time span 1-1837 CE. Of the latter events, fifteen are presented without any supporting documentation, and for another sixteen , documentation is referred to in very vague terms. Where cited, bibliographic

references are often incomplete or incorrect in important details, at times making retrieval impossible. Irrespective of such lack of supporting documentation or bibliographic errors many events were copied from Arvanitakis (1904) by the later cataloguers, without any further verification. The time-distribution of the 71 events (1-1837 CE) is shown in Fig. 1.

Willis (1928)

This catalogue was prepared by the author following a visit to Palestine after the destructive 1927 earthquake. It presents an indiscriminate listing of virtually all geographically relevant events in the catalogues of Perrey (1850), Mallet (1852-1853), Milne (1912) and Arvanitakis (1904), the Arabic catalogue of Soyouti (Spregner, 1843) and in several articles by Legendre (1912), Tholozan (1879) and Blankenhorn (1905). No attempt has been made to verify the documentation included in these works, nor even to compare the consulted sources. Very often the same event reported under slightly different dates, appears as a serie of close events thus inflating the number of earthquakes. Moreover, through an unfortunate oversight the Islamic dates in Soyouti were listed as if they were CE common era dates. Though the error was rectified several years later by Willis (19332) himself, the ammendement which was published in a different journal remained unnoticed by some later authors. Thus, erroneous dates crept into the catalogue of Sieberg (1932)

for example and from there into the later studies. In some cases, the later cataloguers having already corrected the dates of Willis (1`928) proceeded to copy some of the erroneous dates from Sieberg (1932), not realizing that they refer to the same events. Further confusion arises when the erroneous dates of Willis (1928) coincide with years on which according the occidental sources genuine earthquakes took place. The time distribution of the 140 events (1-1837 CE) is shown in Fig. 1.

Sieberg (1932a,b)

Within the framework of a worldwide study of Earthquake Geography, Sieberg (1932a,b) prepared detailed lists of ancient shocks in various East Mediterranean countries, including also Palestine, Egypt and Syria. Unfortunately, none of these lists cites specific documentation for the individual events, although references at the end of publication contains numerous previous catalogues and lists. Two major catalogues that apparently were not consulted by Willis (1928) are those of Von Hoff (1840) and of Lersch (unpublished), neither of which deals specifically with the Levant. Though the description of several events in this study includes details which suggest that some contemporary or secondary documentation may have been consulted, this catalogue, like this of Willis (1928), essentially is a catalogue of previous catalogues. No explanations are offered as to why certain events listed in the consulted works, were excluded. The time distribution of events (1-1837 CE) in Egypt (23 events)

Syria (99 events) and Palestine (33 events) is shown in Fig. 1.

Shalem (1949)

The author, -the first Israeli seismologist- published a study of historic earthquakes in Jerusalem and the way that they have been reflected in Jewish chronicles and literature. Much of the subject matter leans on the catalogues of Arvanitakis (1904), Willis (1928, 1932) and Sieberg (1932a), but presents also some previously untapped Jewish sources. Admittedly some of these sources are somewhat arcane and collation with other documentation often conjectural, but there is no doubt that this study presents the first effort to tap the talmudic, gaonic and rabbinical literature for references to ancient seismic disasters. In addition, Shalem gathered in his personal archives a considerable amount of citations and references to historic earthquakes in Israel and the Levant, which he extracted mostly from various catalogues and secondary sources. Unfortunately, the part of archives dealing with the pre-1150 CE period is still missing.

Unlike the other catalogues, Shalem (1949) is seldom mentioned in later studies of historic macroseismicity of Israel. The time distribution of 54 events (1-1837 CE) in Jerusalem is shown in Fig.2.

Amiran (1951)

Though like other catalogues discussed above, this study relies on the previous catalogues and lists of earthquakes, it employs also a considerable number of secondary sources and some

contemporary documentation. The author has made an attempt to assess the intensity of some individual events and to filter out earthquakes too distant to have been significantly felt in Israel. In the latter effort, he is not always consistent and the catalogue includes numerous events for which no contemporary documentation suggests felt-effects closer than Asia Minor. Such and other discrepancies in description and dating of individual events suggest that little effort has been made to examine and verify the original documentation on which the previous catalogues and secondary sources are based. Moreover, this catalogue lists numerous events for which the previous cataloguers did not provide any specific documentation, while some events listed by Perrey (1850) and Von Hoff (1840) on strength of historic documents and texts have not been included. The time distribution of 91 events (1-1837 CE) felt in Palestine is shown in Fig.2.

Plassard and Kogoj (1962) This catalogue lists the historic earthquakes felt in Lebanon, and includes comments on location and extent of damage with estimates of shock intensity in Lebanon. Documentation for the individual events is not presented, but from the introductory statements made by the authors, as well as from the contents, it appears that this catalogue follows largely the listings in Perrey (1850), Willis (1928,1932), Sieberg (1932a,b) and Soyouti (the version of Ambraseys, 1962). The introduction mentions also that some historic Byzantine sources were used to define the 6th century

earthquakes. These shocks and their respective documentation are discussed in a separate article by Plassard (1968).

This catalogue lists 103 events of which had an intensity of 8 and greater in Lebanon. The time distribution of these events is shown in Fig. 2.

Ben Menahem (1979)

This catalogue, the larger part of which was published in an abbreviated version by Ben Menahem et al. (1976) reviews the historic seismicity in and around Israel during the past 4000 years. The shocks are classified according to the parent tectonic element and assessments of magnitude and location of epicenters are provided wherever possible. With but few exceptions the listing is based on the various preceding catalogues for the Levant, as well as catalogues for Turkey, Greece, Iraq and Cyprus. This study cites also numerous secondary sources and mentions related archeological findings, although these are sometimes of questionable relevance and contribute little to the documentation. Much of the historic data (whether from catalogues or from secondary sources) and the archeological evidence appear to have been carried over uncritically from the previous literature. On the other hand, the inclusion-rejection criteria are not explained and the reason for exclusion and conflation of certain events remain unclear.

The time distribution of 74 events is shown in Fig. 2.

Turcott and Arie (1986)

This latest addition to the available catalogues of earthquakes was presented in an unpublished report of the Israel Electricity Corporation dealing with the proposed nuclear power station in the northern Negev. It includes a list of earthquakes having the potential to be felt or cause damage at the Shivta site, and covers the past 2000 years. Wherever possible assessments are given of location of the epicenter, magnitude and the site intensity. The list is based almost entirely on the previous catalogues, but no detailed explanation of the inclusion-rejection process has been provided. Numerous discrepancies and errors carried over from the previous catalogues indicate that no attempt has been made to examine the original documentation.

The catalogue mentions year dates of aboout 90 felt reports which in the opinion of the authors refer to 64 major events. Time distribution of the mentioned felt reports is shown in Fig.2.

The dates of all events listed in the catalogues described above are presented in TABLE 1. Information is quoted verbatim, except for the erroneous dates of Willis (1928) which were corrected according to Willis (1932) anad Ambraseys (1962). It should be kept in mind however, that the corrected dates indicate the Common Era year on which the corresponding Islamic year began, so that a difference of up to a year may occur between some of the corrected dates and those reported in the occidental sources for the same events.

The time-distribution of the listed events in individual catalogues, expressed in number of events per century, is shown in histograms of Figures 1 and 2.

Since all these catalogues rely heavily on the various previously published catalogues and lists, but fail to provide a detailed explanation of the selective extraction of seismic events from these sources, two further summary tables are presented here. TABLE 2 presents historic earthquakes which occured in and around Israel and have been listed in the worldwide catalogues of Von Hoff (1840), Mallet (1852-1853) and Milne (1912), and in the regional catalogues of Perrey (1850) and Poirier and Taher (1980). The table includes also seismic events mentioned in the Historical Geography texts of Kitto (1844), Diener (1886) and Smith (1907), and in articles of Tholozan (1879) and Blanckenhorn (1905) TABLE 3 presents the dates of events that took place in Greece, Turkey and Cyprus, as listed in the catalogues of Schmidt (1874), Galanopoulos (1961), Galanopoulos and Delibassis (1965) and Ergin, Guclu and Uz (1967), as well as those included in Byzantine Chronography of Muralt (1963.1965). Figures 3, 4 and 5 show the respective histograms of the time distribution of the listed earthquakes.

It should be kept in mind that histograms of Figs. 1-5 may not be compared, since the data have not been verified nor were they reduced to a common base.

TABLE 1

Year dates of felt reports in earthquake catalogues

ARV	Arvanitakis, 1904
WIL	Willis, 1928, 1932
SIEE	Sieberg, 1932 (Egypt)
SIES	Sieberg, 1932 (Syria)
SIEP	Sieberg, 1932 (Palestine)
SHAL	Shalem, 1949
AMIR	Amiran, 1951
PLKO	Plassard and Kogoj, 1962
BMEN	Ben Menahem, 1979
TA	Turcott and Arie, 1986

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	EMEN	TA
	19	19		19			19	19	19	19
					30	30	30			
									31	
	33	33				33	33			33
	37	37		37		37	37	37		
	48	48			48	48	48			48
				53				53		
	65	65								
	76	76							76	
								82		
				83						
	115	115		115		115		115	115	115
	128	128						128		
										130
		131				131				
									142	
			262							
				272		272		272		
		306		306		306	306	306	306	
					308					
			320							
		322							320	
									330	
		333								
				334		334		334	334	
		340		340				340		
	341	341		341						
	342	342							342	
		343								
		344					344	344	344	
		348		348		348				
		349				349		349	349	
	362	362			362		362		362	362
						363				363
	365	365					365	365		365
							367		367	
		387						387		

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	BMEN	TA
	394	394			394		394	394		394
	396	396		396			396			396
							415			415
		419			419	419	419	419		419
			445							
	447	447				447	447	447	447	447
	457	457		457				457		
	458	458		458						
				477						
								492		
		494		494				494		
						497				
							498			498
	500	500		500		500	500	500	500	500
								501		501
						502	502		502	502
	525	525		525		526		525	525	
	526	526		526				526		
	528	528		528					528	
	529	529		529				529		
		533								
										551
		553	553	553						553
	554	554				554	554		554	554
									555	
		557		557						
		560								
		579		579				579		
		580			580		580			580
	583	583					583			583
		587		587				587		

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	BMEN	TA
		589								
		631				631	632			631
					633					632
										633
		637					637			637
		639		639						
		641					641			641
						643				
		658			658		658	658	658	658
							660			660
					672		672			672
				678		678		678		
					710	710	710	710		710
		712								
		713		713				713	713	
		716						717		
				718						
							738			738
	742	742	742							
		746			746	746	746	746	746	746
		747					747	748	747	747
	748	748					749	749		748
						749				749
		756					756			756
	759	759								759
					765		765			765
	776	776		775	776	776		775		776
									796	
							808			808
					828					
								830		
		835						835		
								844		
								845		
	846	846		846				846		
		847							847	
							853	854		853
										854
		856					856	856	856	

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	EMEN	TA
		859	859	859		859	860	859	859	859
	860	860		860			860			860
		880								
		882			881		882		881	881
										882
			887							
	894	894		894			894	894	894	
			934							
			954							
								958		
				963		963		963		
			967							
	973	973			973		973		973	972
		991		991		991		991	991	991
		992								
							1002			
					1016	1016	1016			1016
							1022			
				1029				1029		
		1030								
		1032					1032		1032	1032
	1033				1033	1033	1033	1033	1033	1033
	1034	1034			1034				1034	1034
		1035					1035	1035		1035
			1040							
				1042					1042	
	1045									
										1047
	1060	1060			1060	1060	1060			1060
				1063			1063	1063	1063	
					1067				1067	1067
		1068				1068	1068	1068	1068	1068
							1070	1070	1070	1070
								1086		
		1087								

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	BMEN	TA
		1092		1092				1092		
		1095								
							1096			
	1098	1098		1098						
		1105			1105	1105	1105		1105	1105
		1109		1109						
			1111							
	1113	1113					1113			
	1114	1114		1114		1114	1114	1114		
		1115				1115	1115		1115	
							1117			1117
							1119			
		1127						1127		
				1128						
				1135						
				1137					1137	
		1138		1138				1138		
		1139		1139						
								1144		
		1151			1151		1151	1151	1151	
		1152		1152						
		1155						1155		
							1156	1156	1156	
	1157			1157			1157	1157	1157	
		1159								
	1160	1160			1160	1160	1160			1160
				1163		1163				
	1166									
	1168									
	1170	1170		1170		1170	1170	1170	1170	1170
		1172								
							1175			
								1179		
				1182		1182	1182	1182	1182	1182
		1183						1183	1183	
						1184				
		1201					1201	1201	1201	1201
	1202	1202		1202	1202	1202	1202	1202	1202	1202
										1203
	1204	1204						1204		1204

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	EMEN	TA
		1212		1212						1212
				1222					1222	
	1236			1236						
				1248						
	1254			1254						
			1260							
									1261	
			1263							
	1268	1268						1268		
		1274		1274				1274		
	1281			1281						
	1287	1287		1287			1287	1287	1287	
	1290	1290		1290						
		1292		1292						1292
							1293	1293		1293
								1302		1302
		1303	1303	1303		1303	1303	1303	1303	1303
		1304								1304
										1312
			1326							
				1338						
		1339					1339	1339		
		1343		1343				1343		
		1344		1344						
	1355	1355		1355			1355	1355		1355
	1374	1374		1374			1374	1374		1374
				1388						
		1402		1402			1402	1402	1402	
		1404		1404						

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	EMEN	TA
							1456			
	1457	1457		1457			1457	1457	1457	
										1458
										1459
	1481	1481		1481			1481	1481	1481	
		1484		1484						
									1491	
						1497				
						1519				
	1534	1534			1534	1534	1534			1534
					1541		1541			
							1545			
		1546			1546	1546	1546	1546	1546	1546
				1566				1566		
		1569								
	1577	1577		1577			1577	1577	1577	
	1582									
										1588
	1598									
						1601				
									1605	1605
									1608	1608
				1616				1616		
		1640		1640				1640		
	1641									
	1648									
		1656		1656		1656	1656	1656	1656	
		1666		1666				1666		
									1672	1672
			1687							
			1698							
							1710			

1	ARV	WIL	SIEE	SIES	SIEP	SHAL	AMIR	PLKO	BMEN	TA
				1719					1718	
		1726		1726				1719		
				1737					1735	
	1752	1752		1752			1752	1752	1752	
			1754						1754	
	1759	1759		1759	1759	1759	1759	1759	1759	1759
		1760		1760				1760		
		1764		1764				1764		
	1769									
		1778	1778	1778					1778	
	1783	1783		1783				1783		
		1795		1795						
		1796		1796				1796		
	1802	1802		1802		1802	1802	1802		1801
			1805							
			1811							
					1814					1814
				1819				1819		
	1822	1822		1822		1822	1822	1822	1822	
		1823								
			1825							
	1830	1830		1830						
				1831				1831		
	1834	1834			1834	1834	1834			1834
	1837	1837			1837	1837	1837	1837	1837	1837

TABLE 2

Year dates of relevant felt reports in earthquake catalogue and secondary sources

SMIT	Smith, 1907
KITT	Kitto, 1849
DIEN	Diener, 1886
MILN	Milne, 1912
PERR	Perrey, 1850
BLAN	Blanckenhorn, 1905
MALL	Mallet (1852-1853)
SOYU	Soyouti (Sprenger, 1843)
THOE	Tholozan (Egypt)
THOS	Tholozan (Syria)
VANH	Van Hoff, 1840
POTA	Poirier and Taher, 1980

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
	17											
						31						
	33			33			33				33	
				78								
											105	
				109								
	115										115	
			131			131						
				262								
							287				287	
			306		306	306						
					315		315					
	320											
					322							
			333			333						
			340		340	340						
					341		341					
					342							
					343							
					344							
					345							
					348		348					
						349					349	
					358							
	362				362		362					
		365			365		365				363	
					366						365	
				373								
			387			387						
	389											

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
		394			394							
					395							
		396			396							
	419			419	419		419				419	
					427							
		447			447						447	
					450							
				457	457	457						
		458	458		458		458				458	
											458	
				471	471							
			494	494	494	494	494				494	
					499							
					525							
	526					526					526	
			528	528	528	528						528
							550					
	551				551						551	
			553		553	553						
					555						555	
					557							
					558							
			560		560	560	560					
												565
					579		579				579	
			580			580						
					587		587					

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
			589		589							
	631				632		632				631	
								633				
												634
	637									637		
					639							
640			640									
	641									641		
								650				
	658			658	658		658					
								659				
								660				
								667				
										712		
	713		713	713	713	713	713	713		713	713	713
				715				716		716		
					718		718	718				
	718											
				738								
				742	742						743	
	746		746	746	746	746	746					
											747	747
		748									750	
												749
					757		757				757	
			775		775	775					775	
											794	
				794					796			
												796
								802				
								824				
								835				835
								846				
								847				845
								853				
												847
												854

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
	856	856	856	856		856	856	856	856		856	
												857
			859	859	859	859		859		859	859	859
					860		860		860	860		
										880		
										882		
									885			
							887				887	885
				893								
										911		
									912			933
												935
												950
												951
									952			
								955				
								956			956	
										957		
												963
							966	968			966	
								972				969
	973				973							
												974
				991						991		991
			992			992						

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
								996	996			995
							997					1002
	1016											
				1029	1029		1029				1029	
									1030	1030		
			1032		1032	1032	1032					
								1033		1033	1033	
	1034	1034			1034		1034		1034			1034
				1035	1035		1035					
								1042		1042		
												1042
				1045								
											1058	1047
			1063	1063	1063	1063	1063	1063		1063	1063	1063
								1068	1068	1068		1068
			1069	1069	1069	1069	1069		1069		1069	
								1070				
												1086
								1086				
				1091				1091				1091
				1092	1092		1092				1092	
												1094
	1105				1105		1105				1105	
			1109		1109		1109					
	1113				1113							
				1114	1114	1114	1114	114				1114
	1115		1115		1115	1115	1115				1115	
												1119
				1122	1122							
			1127	1127	1127	1127	1127					
					1128						1128	
								1137				1137
	1138		1138		1138	1138	1138			1138	1138	
				1139	1139						1139	1139

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
			1155	1155	1155	1155	1155					1152
				1156				1156				
	1157	1157			1157	1157		1157			1157	1156
				1158	1158		1158				1158	
			1159		1159						1159	
					1160							
				1168								
								1169				
		1170	1170	1170	1170	1170	1170				1170	1170
					1171							
					1172		1172					
					1179							
	1182			1182	1182						1182	
				1183	1183		1183					
								1191				
								1195				
			1201	1201	1201	1201	1201	1201	1201	1201	1201	1201
		1202			1202							1202
										1203		1203
			1204	1204	1204	1204	1204		1204			
								1211				1208
			1212		1212	1212	1212		1212			1212
								1226		1226		
							1248					
					1255							
								1258	1259			1259
								1263				
												1262
				1268								1263
					1285							1284
				1287					1287			1287
								1293	1294			
							1303	1303	1303	1303	1303	1292
					1304							1303
										1314		
				1319								
								1322				

1 SMIT KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
									1323	
	1339			1339	1339				1339	1339
										1341
						1343				1343
			1344		1344		1344		1344	
		1346								1347
										1353
										1366
							1373			1373
						1373				
		1374								1375
		1383					1385			1385
						1385				
										1399
	1402		1402	1402						
		1402			1402					1403
						1403		1403		1404
						1407				1408
										1437
							1422			1438
						1421	1425			
						1425				
						1434				
						1438				1459
						1455				1476
			1481			1456	1481			1481
						2481	1482			
		1482								1484
										1490
						1491				
						1497				
						1500				1500
		1509								1512
										1523
										1525
										1526
										1529
										1532
	1546		1546	1546	1546				1546	
			1569							
										1573
										1576

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
							1577					
											1584	
											1588	
							1616					
												1613
					1630		1633					
				1630	1640		1640				1640	
				1640	1641							
			1656	1653	1656	1656	1656				1656	
			1666	1656	1666	1666	1666					
							1667					
					1668							
				1668								
							1687					1705
	1710											
					1712							
				1717								
							1719					
				1719								
												1735
												1746
					1752							
							1754					1753
				1754							1756	1754
		1759	1759	1759	1759	1759	1759				1759	1759
					1760						1760	1760
					1764	1764						
				1769	1769							
				1778	1778						1778	
					1783		1783				1783	
				1784								
					1795						1795	
			1796	1796	1796	1796					1796	
					1802							

1	SMIT	KITT	DIEN	MILN	PERR	BLAN	MALL	SOYU	THOE	THOS	VANH	POTA
		1822	1822	1822	1822	1822					1822	
					1823	1823						
						1830						
					1831							
					1834	1834						

TABLE 3

Year dates of felt reports in some earthquake catalogues for Cyprus, Turkey and Greece

GDEL	Galanopoulos and Delibassis, 1965
GAL	Galanopoulos, 1961
EGU	Ergin, Guclu and Uz, 1967
MUR	Muralt, 1963, 1965
SCH	Schmidt, 1879

1	GDEL	GAL	EGU	MUR	SCH
	23	-26	11	396	15
	46	-15	17	408	60
	55	76	29	416	82
	66	332	33	418	115
	77	342	44	422	312
	110	367	53	423	333
	138	1183	60	423	334
	155	1222	68	438	335
	251	1491	69	439	336
	344	1567	93	444	340
	365	1577	105	447	350
	438	1718	110	450	358
	448	1735	115	451	359
	506	1896	121	459	363
	522	1900	127	460	365
	551	1918	138	462	378
	554	1919	160	472	387
	667	1921	170	477	394
	796	1924	176	480	395
	896	1930	190	488	396
	913	1936	253	492	412
	968	1937	290	494	438
	1147	1940	334	515	451
	1246	1941	335	516	503
	1304	1952	341	518	515
	1306	1953	343	522	516
	1366	1959	345	526	518
	1383	1961	350	528	525
	1389	1963	358	529	526
	1430		359	530	527
	1459		362	531	528
	1469		363	540	530
	1481		366	545	532
	1490		382	548	543
	1493		396	549	548
	1501		398	551	551
	1508		402	553	567
	1511		403	555	571
	1515		412	557	580
	1546		412	557	589
	1547		427	557	640
	1554		430	561	658
	1572		434	567	803
	1580		438	580	986
	1585		440	583	990
	1592		446	589	1159
	1595		447	611	1169
	1604		450	633	1226
	1612		457	659	1323
	1613		460	713	1343
	1622		467	718	1454
	1625		477	740	1481

1 GDEL	GAL	EGU	MUR	SCH
1629		478	743	1509
1630		487	747	1542
1633		488	750	1546
1636		499	756	1764
1641		500	765	1825
1650		500	790	
1655		503	796	
1658		506	814	
1660		518	823	
1662		524	843	
1664		525	844	
1665		526	854	
1672		527	857	
1673		528	860	
1674		528	860	
1676		528	864	
1681		528	865	
1696		533	869	
1704		542	872	
1707		543	885	
1710		546	945	
1714		547	956	
1717		548	968	
1718		551	986	
1722		552	1007	
1723		553	1032	
1729		553	1033	
1733		554	1034	
1736		554	1036	
1738		555	1037	
1741		557	1041	
1742		557	1042	
1745		560	1063	
1748		561	1105	
1750		580	1113	
1751		580	1114	
1752		583	1130	
1758		601	1158	
1759		611	1169	
1765		677	1202	
1766		678	1222	
1767		688	1269	
1769		713	1296	
1772		715	1298	
1780		718	1303	
1783		732	1304	
1785		740	1331	
1786		789	1343	
1791		795	1344	
1798		797	1353	

1	GDEL	GAL	EGU	MUR	SCH
			816	1401	
			840		
			859		
			861		
			881		
			867		
			870		
			926		
			945		
			975		
			985		
			986		
			990		
			990		
			995		
			995		
			1002		
			1003		
			1010		
			1011		
			1031		
			1032		
			1033		
			1034		
			1037		
			1038		
			1040		
			1041		
			1045		
			1064		
			1082		
			1091		
			101		
			1104		
			1111		
			1114		
			1131		
			1151		
			1156		
			1161		
			1165		
			1166		
			1168		
			1170		
			1205		
			1211		
			1222		
			1236		
			1245		
			1251		
			1254		
			1268		

1	GDEL	GAL	EGU	MUR	SCH
			1276		
			1287		
			1296		
			1305		
			1308		
			1319		
			1322		
			1343		
			1344		
			1346		
			1354		
			1363		
			1366		
			2374		
			2384		
			2388		
			1415		
			1417		
			1422		
			1433		
			1439		
			1441		
			1458		
			1481		
			1482		
			1493		
			1505		
			1508		
			1508		
			1509		
			1509		
			1510		
			1513		
			1514		
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			1542		
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			1556		
			1569		
			1571		
			1578		
			1582		
			1584		
			1592		
			1598		
			1605		
			1626		
			1633		
			1635		
			1639		
			1641		

1	GDEL	GAL	EGU	MUR	SCH
			1644		
			1646		
			1646		
			1647		
			1653		
			1654		
			1659		
			1660		
			1664		
			1666		
			1667		
			1668		
			1668		
			1672		
			1674		
			1679		
			1685		
			1687		
			1688		
			1688		
			1688		
			1690		
			1690		
			1700		

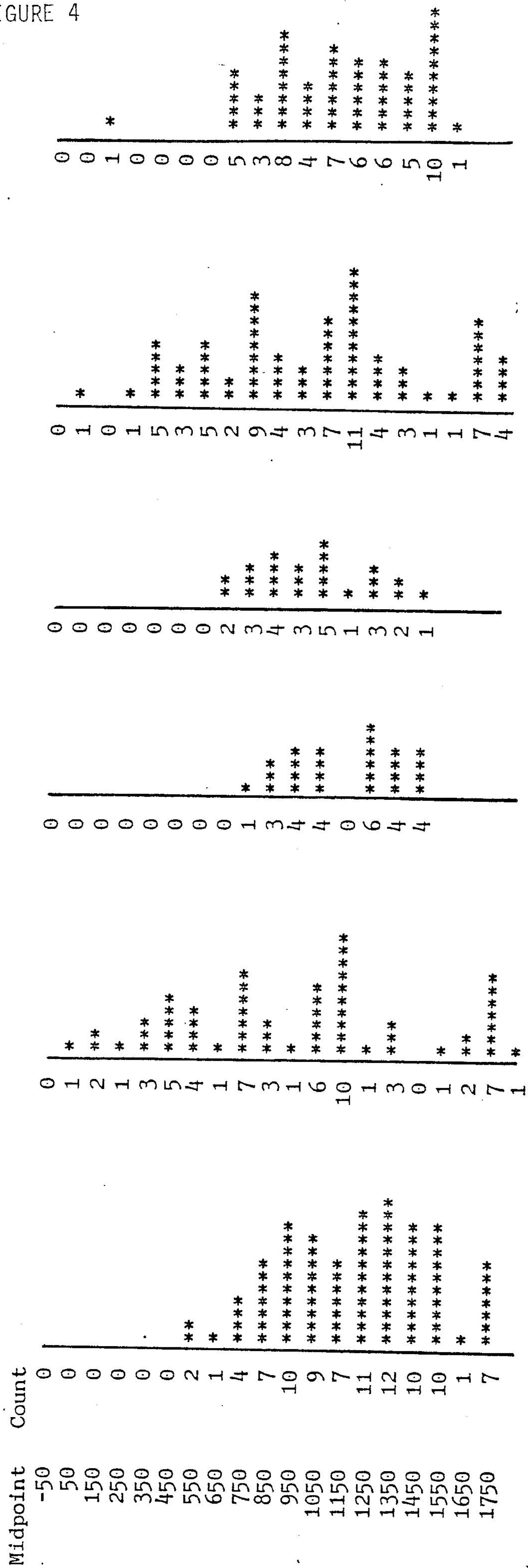
FIGURE 1

point	SIEBERG (Pal) Count	SIEBERG (Syr) Count	SIEBERG (Egy) Count	WILLIS Count	ARVANITAKIS Count
-50	0	0	0	0	0
50	2	4	0	6	6
150	0	1	0	3	2
250	0	1	1	0	0
350	3	6	1	15	6
450	1	4	1	5	3
550	1	9	1	15	7
650	3	2	0	5	0
750	4	3	1	10	4
850	2	4	2	9	3
950	1	2	3	3	1
1050	5	6	1	10	5
1150	3	12	1	16	7
1250	1	11	2	9	8
1350	0	7	2	7	2
1450	0	5	0	5	2
1550	3	2	0	4	4
1650	0	4	2	3	2
1750	1	11	2	9	4
1850	3	5	3	6	5
Total	33	99	23	140	71

Midpoint	TURCOTT and ARIE (90)	BEN MENAHEM (74)	PLASSARD and KOOOJ (103)	SHALEM (54)	AMIRAN (91)
-50	0	0	0	0	0
50	3	3	4	4	5
150	2	2	2	2	0
250	0	0	1	1	0
350	5	9	8	5	7
450	4	1	5	3	4
550	8	6	7	4	5
650	8	1	2	3	6
750	10	4	7	4	7
850	7	5	9	1	7
950	2	2	3	2	1
1050	10	8	8	4	11
1150	5	9	12	8	13
1250	7	5	7	1	4
1350	6	1	6	1	4
1450	2	4	3	1	4
1550	3	2	3	3	5
1650	3	4	4	2	1
1750	1	6	7	1	3
1850	4	2	5	4	4

Midpoint	KITTO Count	SMITH Count	DINNER Count	BLANKENHORN Count	MILNE Count	PERREY Count
-50	0	0	0	0	0	0
50	0	2	0	1	2	0
150	0	1	1	1	1	0
250	0	0	0	0	1	0
350	3	3	4	5	1	17
450	2	1	2	2	4	9
550	0	2	5	5	1	11
650	1	4	0	0	1	4
750	1	3	3	3	6	6
850	1	1	2	2	3	2
950	0	1	1	1	1	1
1050	1	2	3	3	7	7
1150	2	6	7	7	11	21
1250	1	0	3	3	4	6
1350	0	0	1	1	4	2
1450	0	0	1	1	2	2
1550	0	0	1	1	2	3
1650	0	0	2	2	5	6
1750	1	1	2	3	9	10
1850	2		2	5	2	5
	15	27	40	46	67	112

FIGURE 4



SOUYUTI 55

MALLET 71

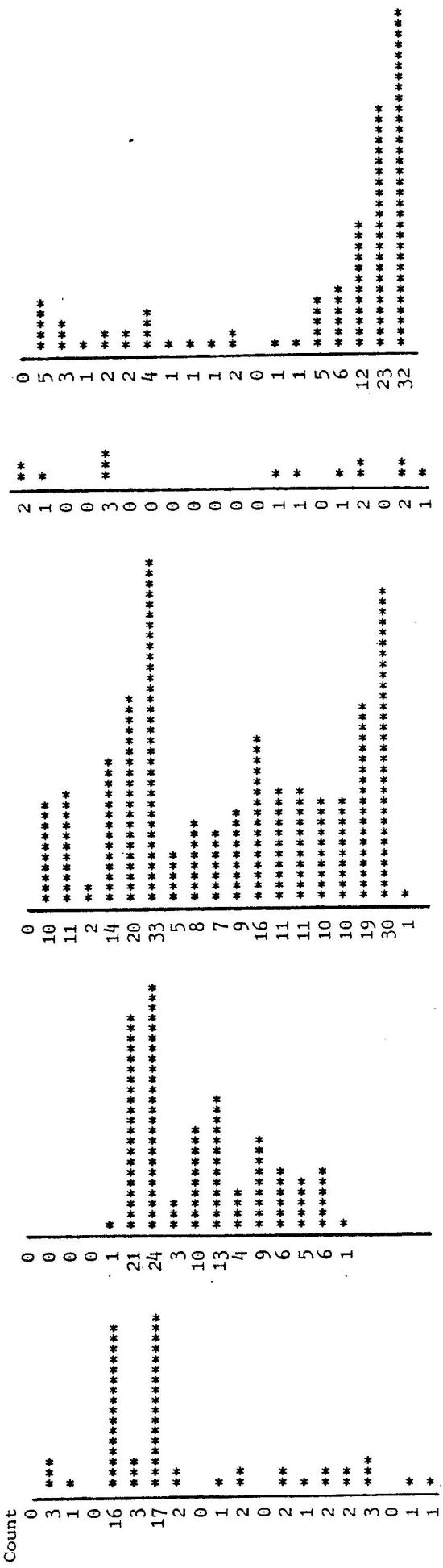
THOLOZAN (Syr) 24

THOLOZAN (Egypt) 26

VON HOFF 59

POIRIER AND TAHER 91

FIGURE 5


Count
SCHMIDT
57
MURALT
103
ERGIN, GUCLU AND UZ
230
GALANAPOULOS AND DELIBASSIS
14
GALANAPOULOS
103

EVALUATION OF BIBLIOGRAPHIC RELIABILITY

Since the catalogues of earthquakes which form the present data base for study of historic macroseismicity in Israel are not independent of each other, and rely only on a motley of documents, secondary sources and inter-related catalogues of widely differing quality, it is essential to determine the precise nature and reliability of the documentation on the strength of which each individual event was listed.

At the outset of the study, all bibliographic authorities specifically indicated in the various catalogues (Arvanitakis, 1904; Willis, 1928; Sieberg, 1932a; Shalem, 1949; Amiran, 1951; Ben Menahem, 1979 and Turcott and Arie, 1986) were identified and included in a comprehensive bibliography appended to this report. Where necessary, the careless and often enigmatic bilbiographic citations were traced and rectified (TABLE 4).

TABLE 4

Cummulative bibliography of major catalogues of historic earthquakes in Israel

AMN	Amiran, 1951
ARV	Arvanitakis, 1904
BMN	Ben Menahem, 1979
SLM	Shalem, 1949
WIL	Willis, 1928
SIE	Sieberg, 1932
TA	Turcott and Arie, 1986

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Next, in each catalogue the documentation cited specifically for each individual event was examined. Where the citation is from another catalogue or a secondary source, the authorities cited therein were examined in turn. This process continued until the the earliest references were terminated in a "cul de sac", i.e. where the text does not disclose the source from which the information was copied or extracted.

The systematic tracing of successive references reveals the possible duplications, discrepancies, circular citations and confusion or errors in copying of information, as well as identifies the nature of the earliest documentation used in definition of an ancient earthquake. Two typical examples of such a bibliographic evaluation are described below.

Earthquake of 128-130 CE (Event 6 in the catalogue of Turcott and Arie, 1986)

Documentation cited by Turcott and Arie (1986) for this event includes the listings of Willis (1928) and Plassard and Kogoj (1962) who date the shock to 128 CE; and the listings of Amiran (1951), Arie (1975) and Ben Menahem (1979) who date the earthquake to 130 CE. Since all of these are catalogues, evaluation moves to the authorities cited therein.

Plassard and Kogoj (1962) provide no documentation (but quite probably copy the event from Willis, 1928); while Willis (1928) includes the 128 CE event on the strength of a listing in

the catalogue of Arvanitakis (1904), who in turn relies on the 4th century chronicle of Eusebius.

Amiran (1951) dates the event to 130 CE, on the authority of Willis (1928), Arvanitakis (1904) and Abel (1927). It is true that Willis (1928) cites two events, one in 128 CE and the other in 130 CE, the latter however, is one of the erroneous dates resulting from a confusion of Christian and Islamic counts, and should in fact read 747 CE. Arvanitakis (1904) as indicated already dates the event to 128 CE on the authority of Eusebius. Abel (1927) gives the date as 130 CE, on the authority of St. Jerome (Hieronymus), who however, follows the chronicle of Eusebius. Indeed, examination of different editions of the works of Eusebius and Hieronymus reveals discrepancies of two years in calibration of the original chronological details.

Ben Menahem (1979) dates the event to 130 CE, citing the erroneous date of Willis (1928), citing Plassard and Kogoj (1962) who provide no documentation but date the event to 128 CE, and Sieber (1932a) who provides no documentation, and dates the event to 130 CE.

From this bibliographic maze, it appears that all references and citations in fact hail from a single sentence in the chronicle of Eusebius, which was written about two hundred years after the earthquake is supposed to have occurred. It is not suprising therefore that some questions were raised in the literature with respect to this event. First, the chronicle indicates a shock in Caesarea, Nikopolis, Hierapolis, Laodicea

and Nicomedia. Geographic region is not specified, and Von Hoff (1840) and Ambraseys (in Russell, 1985) suggest that the description refers to Nikopolis and Neocaesarea in Pontus and not in Palestine. Second, it was suggested by Russells (1985) and in a more roundabout way also by Krauss (1914) that Eusebius may have confused the reports of this more distant earthquake with reports of the well documentated 115 CE earthquake that hit the Palestine and Levant coasts.

1060 CE earthquake (Event 33 in the catalogue of Turcott and Arie, 1986)

This event was listed by Turcott and Arie (1986) on the authority of the catalogues of Sieberg (1932a), Arie (1975), Ben Menahem (1976), Willis (1928), Amiran (1951) and Ben Menahem (1979).

The first three studies do not cite any documentation for this event. Ben Menahem (1979) lists the event on the strength of listings of Willis (1928), Sieberg (1932a) and Amiran (1951). Amiran (1951) in turn cites for the 1060 CE event the authority of Sieberg (1932a), Willis (1928) and Arvanitakis (1904), whereas Willis (1928) cites ARvanitakis (1904).

It appears that once again all cited reference converge upon a single listing, i.e. the report in Arvanitakis (1904). The latter, however, indicates in a rather vague way that the information was extracted from "Hist. Croisades". It is

possible that this abbreviation refers to the memoir of Michaud (1857), that was used to document other events in the catalogue of Arvanitakis (1904). Unfortunately, this work does not provide any documentation for the 1060 CE event.

Several comments should be added at this point. While Arvanitakis (1904) indicates that this shock was slight, Sieberg (1932a) and Turcott and Arie (1986) postulate high intensities for Judea and northern Negev. Second, Shalem (1949) mentions without any specific documentation, that in 1060 CE a chandelier in the Al Aqsa mosque fell down causing considerable fright, but apparently no further damage. Thidly, only three years later, in 1063 CE, a severe earthquake hit the Levant coast causing damage between Akko and Antioch, and it is possible that the felt reports of the two events were confused.

The same general guidelines and approach are employed in evaluation of documentation cited in the individual catalogues. The results will be presented in reports that follow.

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