An Analysis of the Eastern Mediterranean Earthquake of 20 May 1202

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1. Introduction

A large earthquake was widely felt in the Middle East around daybreak on the morning of 20 May 1202. Contemporary sources indicate that the shock was felt from Lesser Armenia, parts of Anatolia and northwest Iran down to Qus in upper Egypt, and from Sicily in the west to Iraq and Mesopotamia in the east, i.e. within an area of average radius about 1,200 km (Figure 1). Along with this very large felt area, an ensuing seismic sea-wave and aftershock sequence, the earthquake was associated with extensive and serious damage in Syria and to a lesser extent in Cyprus, with great loss of life. Comparison with 20th century earthquakes in the eastern Mediterranean suggests that this was a shallow, large magnitude ($M_S = 7.6$) event.

We have chosen to study this event not only to try to resolve the problems connected with it, and for its large size, but also because it occurred in what appears today to be a seismically quiescent region in a densely populous part of the Middle East. Reflecting some uncertainties contained in contemporary accounts of the earthquake, particularly regarding its date, this event is found in different guises in various catalogues, often appearing more than once under different entries. A thorough review of primary sources is necessary to clarify the effects and scale of the shock. More recent earthquakes in the area also need to be re-examined before they can be used to calibrate this and other early events in the Middle East.

The analysis that follows provides a detailed account of our investigations, rather than a mere summary of the findings. It is important that all the direct and circumstantial evidence that combine to build a picture of an early earthquake should be presented and discussed.

2. Analysis of Historical Earthquake Data

Our procedure for the study of the historical seismicity of Iran, the Middle East and certain regions in Europe and Africa, has been to collect macroseismic data from original sources and review them gradually as they accumulate. Likely sources of information include local histories and documentary material, general chronicles, diaries, private correspondence and travel narratives. A considerable amount of such material is available in libraries throughout Europe, including official archives of diplomatic and political correspondence. European and local newspapers and special studies of past earthquakes also provide useful macroseismic data (see for instance Ambraseys and Melville, 1982, for Iran and 1983, for the Yemen; Melville, 1983, for the UK and 1984, for the Northern Red Sea; Ambraseys, 1985a, for Scandinavia).

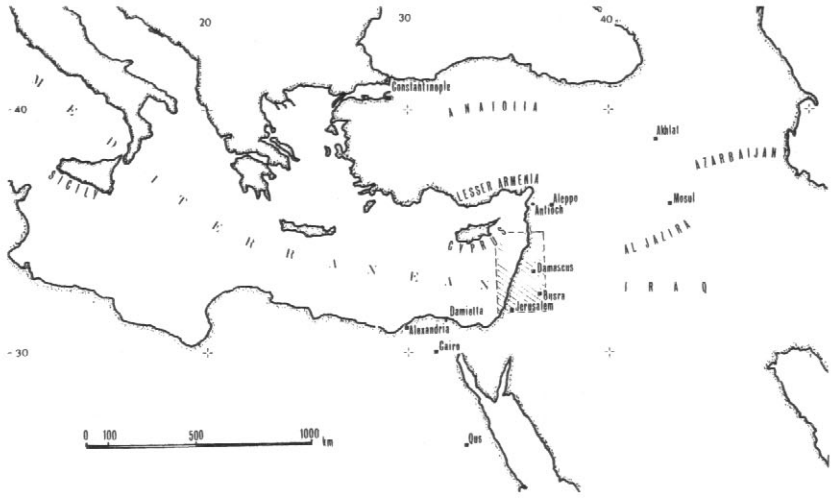

Figure 1. Map showing the area over which the earthquake of 20 May 1202 was felt. Ceuta is situated on the Moroccan coast opposite Gibraltar, 3,800 km from the epicentral region. The shaded inset shows the location of Figure 2.

The next stage is the analysis of all the data retrieved, including both the macroseismic and instrumental data recovered for 20th century events. Following the procedures put forward by Ambraseys, *et al.* (1983), this requires the unification of instrumental data in terms of location and magnitude, which will provide a consistent quantitative yardstick for the assessment of long-term seismicity. Examples of this kind of reduction of macroseismic data into a uniform body of information are found in Melville (1985) and Ambraseys and Jackson (1985) for the UK, Ambraseys (1985b) for Northwest Europe, and Ambraseys and Melville (1982) for Iran, where extensive field work was necessary to resolve ambiguities in the epicentral areas of important historical earthquakes and to delineate local tectonics. Similar procedures have been followed by Muir Wood *et al.* (1987), Vogt (1984a,b) and in particular in Italy (ENEA-ENEL, 1981; Postpichl, 1985). The work of these groups is distinguished by the fact that, regardless of the details of the evaluation procedures adopted, the basic data have been established from primary sources of information. Some general points may be made arising from previous experience of this work.

2.1. Location

In addition to early 20th century events for which only felt information exists, there are a considerable number of early teleseismic locations of offshore events and earthquakes with epicenters in sparsely populated parts of the Middle East, Europe and Africa, which can be examined. Up to 1915, these are recorded mainly on Milne seismographs, with readings reported in the Shide Circulars (no. 1-27) or early issues of the International Seismological Summary (ISS). These instruments

do not record body waves well and the best results are obtained by using the time of the reported maximum phase, presumed to be a surface wave travelling with a velocity of about 2.9 to 3.1 km/sec. Simple graphical location methods have been used. For some later events, readings of P- and S-phases from other instruments are also used to support those of phase maxima. Such relocations are not accurate by modern standards, but an earthquake's epicenter may usually be estimated within a few degrees and felt information may be found to help resolve ambiguities. When the existence of such an event is established in a certain region and teleseismic amplitudes and periods are available, a magnitude can be estimated even if the position is unreliable to within several degrees, since calibration functions do not change rapidly with distance in the teleseismic range (Ambraseys and Adams, 1986).

2.2. Magnitudes

For earthquakes of the period 1898 to 1914, surface-wave magnitudes may be estimated using trace maxima recorded by undamped Milne seismograms. This method has been applied to a number of geographically restricted regions in the Middle East and North Africa with excellent results, along much the same lines as discussed by Abe (1987). For the majority of early earthquakes in Europe and the Middle East, data from the more advanced instruments are available from 1903, so that the need to resort to the undamped Milne trace amplitudes for magnitude determination is minimal.

Magnitudes are often given without indications as to whether they are local (M_L), surface (M_S) or body wave (m) magnitudes and the indiscriminate amalgamation of such values from existing catalogues leads to a body of non-homogeneous data. Similarly, the use of empirical correlations to convert m or M_L into M_S and vice versa is quite unacceptable in areas such as the Middle East and Southeast Europe, where the seismotectonic characteristics of the region vary so rapidly and where the values of m, M_L and M_S reported by local stations are based on procedures that have changed many times during the last few decades.

For events of the pre-instrumental period, surface wave magnitudes may be estimated quite consistently using a set of macroseismic observations such as the radii of the isoseismals of a given intensity grade (see for example Equation (1) below). The use of uniformly processed macroseismic data may also lead to an estimate of focal depth (Ambraseys, 1985b). In practice, however, there are often considerable problems in assessing intensities and felt areas from historical information, particularly in areas of low seismicity or low population density and also the further back in time one goes, since the available documentary sources become both fewer and more laconic.

2.3. Intensities

Whatever the limitations imposed on the type of data available by the particular cultural characteristics of a given age or area, intensities should be assessed uniformly by one or more observers, either on a scale such as the MSK scale or using a simpler one designed for early events in a specific region. Conversion from one intensity scale to another, using empirical formulae, has been found to lead to unacceptably large errors and should be avoided.

Many of these issues are relevant to the identification and analysis of a large earthquake that occurred in the Eastern Mediterranean on 20 May 1202.

3. Previous Catalogues

Early catalogues either ignore the 1202 earthquake (Coronelli, 1693; Seyfart, 1756; Dressdnischer, 1756; Berryat, 1761; Huot, 1837) or mention an earthquake on 30 May 1202 (perhaps converting to the New Style calendar), which caused great damage to the Christian-held territory of Tyre, Tripoli, 'Arqa and Acre (Manetti, 1457; Batman, 1581; Beuther, 1601). None of these authors quote their source of information.

Among later authors, Hoff (1840) quotes early editions of Muslim writers (Abu 'l-Faraj, Abu 'l-Fida and Hajji Khalifa), all secondary sources, but separates the events into two distinct earthquakes in 1201 and 1204. Hoff is followed by Mallet (1852, p. 30), who notes however that non-Arab authors have 13th, 20th or 30th May 1202, probably referring to the sources cited by Perrey (1850, p. 18). Perrey quotes Baronius's *Annalium Ecclesiasticorum*, where an account similar to that of Robert of Auxerre's, but dated 30 May 1202, is found (ed. O. Raynaldo, Rome 1646, xiii, 89); also Ralph of Coggeshall and Robert of Auxerre's accounts (ed. Dom Bouquet, *Rec. des Hist. de Gaule et de la France*, xviii, 97, 265-6), cf. below. The chronicle published in L. Muratori, *Rerum Italicarum Scriptores*, XXVI, 85 is probably Sozomenus's 15th century universal history. The chronicle published in Luc d'Achery, *Spicilegium*, xi, 478 has not yet been examined. One or other of these latter two must give the date 13 May 1202. This results in three earthquakes, occurring in 1201 or 1202, 20 May 1202 (Old Style) and 1204, which affected parts of Syria, Mesopotamia and Egypt, though Perrey notes that the first two are probably the same.

Authors since Mallet add nothing but further chronological confusion, which in turn obscures the size and effects of the earthquake. Willis (1928), on the authority of secondary works (Tholozan, 1879; Arvanitakis, 1903; Blankenhorn, 1905; Vigouroux, 1912) increases the number of earthquakes in the period to four, i.e. in 1201, 1202, 1203, and 1204, and adds another two shocks in 597 and 600 A.D., which are in fact the Muslim years covering the period 1201-1204 that he misinterprets from Sprenger (1843), cf. Ambraseys (1962). Ambraseys' own early work (1961), which is an uncritical translation of one of the many manuscripts of al-Suyuti's treatise, passes on the errors in the text. Ambraseys' studies on the seismicity of Iran and adjacent regions (1968, 1974) are very incomplete and occasionally misleading, but likewise continue to be used uncritically. Willis is followed by later authors, such as Sieberg (1932a,b), Kallner-Amiran (1951), Plassard and Kagoj (1968) and others. Some produce two major earthquakes out of the 20 May 1202 event (Ben-Menahem, 1979), others five (Alsinawi and Ghalib, 1975), with an average of three destructive shocks given by Poirier and Taher (1980), the only 20th century authors who have the credit of using an extensive number of Arabic sources.

4. Sources of Information.

Owing to the Crusader presence in the Levant, information on the effects of the earthquake is available from both Christian and Muslim authors. Both sets of data naturally refer most particularly to the territory belonging to the respective

sides, but to a large degree they complement each other. It is clear that most of the chronological confusion surrounding the event is caused by the uncritical use of Muslim chronicles. It is also remarkable that almost no use has been made of western sources, which are far more accessible to most European authors and unambiguously resolve the dating of the earthquake. These works, though largely ignored by earthquake cataloguers are of course well known to the historians of the Crusades (e.g. Röhricht, 1898).

The political context of the earthquake is briefly outlined in Mayer (1972, 1984) and more fully in Cahen (1940), Runciman (1971) and Setton (1969), where detailed reference is made to the narrative sources available. The Crusader states had been greatly reduced by Saladin's campaign of 1187 and only partially reconstituted by the Third Crusade. Regarding the non-Muslim accounts, it is unfortunate that the main political and military developments at this time were not taking place in the Levant at all, but lay in the preparations for the ill-fated Fourth Crusade. The focus is not therefore so clearly on events in the east, where the Crusader states were on the defensive and greatly reduced in their sphere of operations. Most of the relatively few places retained by the Christians are mentioned in European accounts, all in the truncated kingdom of Jerusalem and the county of Tripoli, on or near the coastal strip. No details are given in Christian sources of wider effects in the Syrian hinterland. Similarly, no details are given of the shock further north, in the principality of Antioch, beyond the indications that it was not so severe there.

The two letters from the Hospitaller and Templar Grand Masters published in Mayer (1972) contain the fullest occidental accounts and refer particularly to the possessions of their respective Orders. Very few additional details are found in other sources (among them the references to Jubail in various texts of the *Annales de Terre Sainte*). As demonstrated by Mayer, the near contemporary account of Robert of Auxerre (d. 1212) has many points of similarity with Philip du Plessis' description. Variations of date occur in the Christian sources, but not concerning the year: William of Nangis (d.ca 1300) has 30 May, three days before Ascension (which was in fact on 23 May in 1202); Felix Fabri (fl. 1480) has 30 March. The Barletta manuscript (Kohler, 1901, p. 401) appears to read 3 March. Most of these sources are telegraphic, containing only general summary information.

Arabic sources from the Muslim areas surrounding the Christian states naturally present a wider view and provide the most information. Just as both the contemporary European letters date the earthquake Monday, 20 May 1202, so too do a comparable pair of Arabic letters from Hamah and Damascus. These were received by 'Abd al-Latif b. al-Labbad al-Baghdadi, who was in Cairo at the time of the earthquake and wrote his account in Ramadan 600/May 1204, two years after the event. Both he and the letters he transcribes give the date as early on the morning of Monday 26 Sha'ban 598 hijri [Muslim calendar] (= 21 May 1202, which was a Tuesday) or 25 Pashon [Coptic calendar] (= Monday 20 May). A discrepancy of one day is common in converting the Muslim calendar. As noted above, the latter date is confirmed by the contemporary European accounts. Abu Shama, quoting the testimony of al-'Izz Muhammad b. Taj al-umana' (d. 643/1245), also has Monday, 26 Sha'ban 598 or 20 Ab [Syriac calendar] (= August (sic.) 1202).

There can thus be no doubt that the correct Muslim year is 598 H., which runs from 1 October 1201 to 19 September 1202. Unfortunately other later Arabic texts contain variations in the date of the earthquake and in cases split its effects into accounts of separate events in different years. The most influential of these alternative texts is that of Ibn al-Athir of Mosul (d. 1233), who has a general account of the earthquake felt throughout Mesopotamia and in Egypt, Syria and elsewhere, dated Sha'ban 597 H., which is a year early. He is clearly referring to the same event. His account is followed almost verbatim in the Syriac Chronicle of Bar Hebraeus [Abu 'l-Faraj] (d. 1286), and in greatly abbreviated form by Abu 'l-Fida (d. 1331), under 597 H. Another early source, Abu 'l-Fada'il of Hamah (ca. 1233) has a brief notice of the shock under 597 H. It is of interest that he does not refer to the shock in Hamah, but mentions that it destroyed most of the towns belonging to the "Franks". Reconciling these accounts is no problem, simply an error of one year has occurred.

A greater problem is introduced when Ibn al-Athir has another, shorter but similar, account of the (same) earthquake under the year 600 H. (10 September 1203 - 28 August 1204), without specifying the month. He says the shock destroyed the walls of Tyre and also affected Sicily and Cyprus. This "second" earthquake is once more reported by Bar Hebraeus and Abu 'l-Fida. A similar account, but adding new information that the shock was felt in Sabta (Ceuta), is given by Ibn Wasil (d. 1298). Since Ibn Wasil was a native of Hamah, it is surprising that he does not have independent local information, also that he does not have any reference to the shock under 597 or 598 H.

It is not clear why Ibn al-Athir should duplicate his account under the dates 597 and 600 H., but it is perhaps sufficient to note that this sort of duplication is not uncommon in both European and Islamic medieval chronicles. Within this repetition, there may be some echo of a strong aftershock or a prolonged period of seismic activity. News from Sicily and Cyprus clearly took longer to arrive than information from Syria.

Two separate notices are also found in the chronicle of Sibt b. al-Jauzi (d. 1256), this time under 597 and 598 H. The first account, under Sha'ban 597 H., echoes that of 'Abd al-Latif, while mentioning a few additional places. The date, however, is the one given by Ibn al-Athir. Sibt b. al-Jauzi supports this date by saying (p. 480) that after these earthquakes in 597/1201, died both 'Imad al-Din [the historian whose work he had earlier quoted for an account of the famine in Egypt that year] and the author's own grandfather [the historian Ibn al-Jauzi]. It is generally accepted that both men did indeed die in 597/1201 and thus before the earthquake. This is awkward to explain, but the author is probably trying to rationalize two conflicting pieces of chronological data. He is not so much dating the deaths by reference to the earthquake, as accommodating the false date that he has accepted for the earthquake within the sequence of other events that year. Under the correct year, 598 H., he has a much briefer account, describing damage to the castles at Hims and Hisn al-akrad. He says the shock extended to Cyprus and destroyed what was left of Nablus (i.e. after the first earthquake). This implies two shocks. On the other hand, Sibt b. al-Jauzi's second account is not unlike Ibn al-Athir's second account (under 600 H.), and may again simply be an attempt to accommodate the conflicting dates. It is significant that Sibt b. al-Jauzi has no report of an earthquake under 600 H.

Abu Shama, who quotes Sibt b. al-Jauzi's accounts under 597 and 598 H. in turn (pp. 20, 29), in both cases cites the additional testimony of al-'Izz b. Taj al-umana', a descendant of Ibn 'Asakir and continuator of the latter's Biographical history of Damascus (Cahen, 1940). It is clear that the first part of Sibt b. al-Jauzi's 597 H. account also follows al-'Izz. Under 598 H., al-'Izz records the effect of the shock in north Syria and in Damascus, with some minor details additional to those provided by 'Abd al-Latif.

Al-Suyuti summarizes the dating confusion found in his sources, by entering the earthquake under 597 H. (quoting al-Dhahabi, *'Ibar* and Sibt b. al-Jauzi); 598 H. (quoting Sibt b. al-Jauzi) and 600 H. (citing Ibn al-Athir). Later sources add no details. It is worth noting that the Aleppo author, Ibn al-'Adim (d. 1262), makes no reference to the earthquake under any of the years found elsewhere.

Despite the conspicuous duality of accounts in almost all Muslim sources, probably reflecting protracted aftershock activity, there remains no evidence of more than one principal earthquake. Apart from the silence of contemporary occidental and oriental authors, 'Abd al-Latif was in a position to record separate earthquakes in both 597 and 600 H. had they occurred. The amalgamation of these several accounts therefore removes much of the mystery surrounding the 598/1202 earthquake, and allows a coherent identification of its effects and felt area.

5. The Earthquake of 20 May 1202

Many sources speak of strong effects and significant damage along the Mediterranean littoral of Syria, affecting both the "Franks" and "Saracens" (Abu 'l-Fada'il, fol. 113a-b; Hethum Gor'igos, p. 480, Ibn al-Furat, p. 240). Specifically, both Acre and Tyre, the two main Christian centres, were severely damaged, with heavy loss of life (Figure 2). Contemporary letters (Mayer, 1972) speak of damage to walls and towers in both cities, including the palace at Acre. The house of the Templars in Acre (in the Southwest of the city, see Enlart, 1928, p. 23) was however fortunately spared. All but three towers and some outlying fortifications were destroyed in Tyre, along with churches and many houses. The English chronicler, Ralph of Coggeshall (d. 1228) says most of Tyre and one third of Acre were overthrown (p. 141-2). Muslim sources largely confirm this, 'Abd al-Latif stating that the greatest part of Acre and one third of Tyre were destroyed. Intensities in Tyre may be assessed higher than those in Acre, respectively around IX and VIII (see Table 1). Funds were made available for both cities to be reconstructed (*L'Estoire d'Eracle*, p. 245; Sanuto, p. 203), though no specific indication is available of the extent of these repairs (Enlart, p. 4, Deschamps, 1939, p. 137).

Inland from the Christian territories, in Shamrin (Samaria) and Hauran, damage was equally severe. It was reported that Safad was partially destroyed, with the loss of all but the son of the garrison commander; also Hunin (Chastel Neuf), Baniyas (Paneas) and Tibnin (Toron). At Bait Jann (Bedegene), not even the foundations of walls remained standing, everything having been "swallowed up". Two possibilities present themselves for the identification of Bait Jann out of the three noted by de Sacy in 'Abd al-Latif, p. 446, both being known to the Crusaders (see Dussaud, 1927, pp. 7, 391). The first is 10 km west of Safad and the second on the road between Damascus and Baniyas, see Ibn Jubair, p. 300, who described it as situated in between the mountains. The context in which Bait Jann is mentioned by 'Abd al-Latif allows either alternative to be acceptable, but the second is preferred here

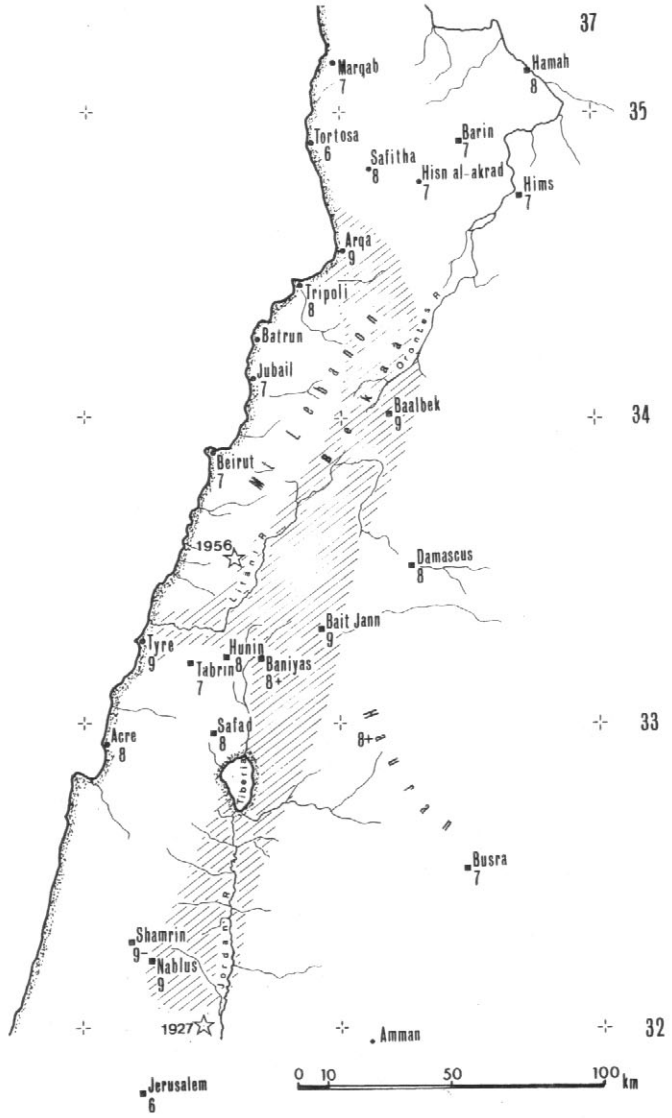

Figure 2. The epicentral region of the earthquake of 20 May 1202. Sites shown are localities affected by the earthquake and numbers indicate the intensity experienced on the MSK scale, see Table 1. Dots mark Christian-held localities, squares indicate Muslim possessions. The shading shows the approximate extent of the meizoseismal region, associated with the main shock and its aftershocks. Open stars show epicenters of the more important 20th century events discussed in the text. The location of sites is based mainly on Dussaud (1927).

Table 1. Places Where the Earthquake of 20 May 1202 Was Reported

Places mentioned	Intensity (MSK)	Territory
Acre ('Akka)	VIII *	Christian
Akhlat (Khilat)	(IV)	Muslim
Aleppo (Halab)	(V)	M
Alexandria (al-Iskandariyya)	(V)	M
Anatolia (Bilad al-rum)	(IV)	M
Antioch (Antakiya)	(V)	C
'Arqa ('Irqa, Irqata)	IX	C
Arsum ('Arima ?)	IX	C (Temp.)
Azarbaijan	(IV)	M
Baalbek (Ba'labakk)	IX	M
Bait Jann (Betegen)	IX	M
Baniyas (Paneas)	VIII+	M
Barin = Ba'rin (Montferrand)	VII	M
Batrun (Botron)	VII ?	C
Beirut (Bairut)	VII *	C
Busra (Bosra)	VII-VIII	M
Cairo (al-Qahira)	V	M
Ceuta (Sabta)	(III) ?	M
Constantinople	IV	C
Cyprus (Qubrus)	VII ?	C
Damascus (Dimashq)	VIII *	M
Damietta (Dumyat)	(V)	M
Hamah (Epiphania, Hamath)	VIII	M
Hauran	VIII	M
Hims (Homs, Emessa)	VII	M
Hisn al-akrad (Krak des Chevaliers)	VII *	C (Hosp.)
Hunin (Chastel Neuf)	VIII	M
Iraq	(IV)	M
Jerusalem (al-Quds)	VI	M
Jubail (Gibelet, Byblos)	VII	C
Lesser Armenia	IV	M
Marqab (Margat)	VII	C (Hosp.)
Mesopotamia (al-Jazira)	(IV)	M
Mosul (al-Mausil)	IV-V	M
Mount Lebanon (Jabal Lubnan)		
Nablus (Nabulus)	IX	M
Qus	(IV)	M
Safad (Saphet)	VIII	M
Safitha (Chastel Blanc)	VIII *	C (Temp.)
Shamrin (Samaria)	VIII+	M
Sicily (Siqilliya)	(IV)	C
Tabrin = Tibnin (Toron)	VII	M
Tortosa (Tartus)	VI	C (Temp.)
Tyre (Sur)	IX *	C
Tripoli (Tarablus)	VIII	C

Alternative European and Arabic spellings are given. Locations in the epicentral region are shown in Figure 2. Intensity estimates in brackets are based on felt reports only. An asterisk (*) indicates that subsequent reconstruction or repairs are mentioned (see text).

because the location was better known as marking the boundary between Muslims and Franks before the conquests of Saladin (cf. Deschamps, 1939, p. 146). In Nablus there was total destruction except for some walls in the "Street of the Samaritans", while in Hauran province most of the towns were so badly damaged that they could not be readily identified ('Abd al-Latif, p. 417, Sibt b. al-Jauzi, p. 478). One of the villages around Busra is said to have been completely destroyed, perhaps by landslides (Ibn al-Athir, xii, 112). This region must be near the epicentral area of the earthquake, and there is some hint in the account of Sibt b. al-Jauzi (p. 510) of additional damage in an aftershock at Nablus (see above), where intensity IX (MSK) may be assigned.

To the south of this area, Jerusalem suffered relatively lightly, according to the information available to 'Abd al-Latif (pp. 415, 417), at intensities not exceeding VI. His account indicates that further north, however, Damascus was strongly shaken. A large number of houses are reported to have collapsed and beside the destruction in town, major buildings near the citadel were damaged. The Umayyad mosque lost its eastern minaret and 16 ornamental battlements along its north wall. One man was killed in the collapse of the Jirun (eastern) gate of the mosque. The lead dome of the mosque was split in two and one other minaret fissured (cf. Le Strange, 1890, p. 241). The adjacent Kallasa mosque was ruined, killing a North African and a Mamluk slave (Abu Shama, p. 29, quoting al-'Izz). This building had been founded in 1160 by Nur al-Din and restored by Saladin in 1189 after its destruction by fire (Elisséeff, 1967, p. 294). West of the mosque, Nur al-Din's hospital was completely destroyed. People fled for the open spaces. The shock in Damascus was of long duration and old men could not recall such a severe one having occurred before ('Abd al-Latif, p. 416-417). Previous destructive earthquakes had occurred in 1157 and 1170. Another slight shock was felt early the following morning (Abu Shama, p. 29), and aftershocks continued for at least four days ('Abd al-Latif, p. 417).

Further north, houses are said to have collapsed at Jubail (Gibelet), recently recovered by the German Crusade (1197) which restored the landlink between the Kingdom of Acre and the County of Tripoli (*Annales de Terre Sainte*, p. 435, *Chronique de Terre Sainte*, p. 16). The walls of Beirut, also regained in 1197, are said to have been repaired around this time following earthquake damage (variant readings in *L'Estoire d'Eracle* (p. 244-5) incorrectly under A.D. 1200; likewise Ernoul, p. 338). The fact that the Prince of Batrun, a Pisan, granted his compatriots remission of taxation early in 1202 indicates that this town too suffered damage (Muralt, 1871, p. 264). The extent of the destruction is not easy to assess in these places. The walls of Jubail were dismantled by Saladin in 1190 and were probably not rebuilt after the Christian takeover. Wilbrand of Oldenborg who visited Jubail in 1211 found only a strong citadel, and a similar situation in Beirut and Batrun (p. 166-7; cf. Rey, 1871, p. 121). There is therefore the danger that damage from the extensive military operations in the period before and during the Third Crusade is misreported as earthquake damage, and even if not, some of these castles may have been rendered more vulnerable by acts of warfare. Inland, however, rockfalls in Mount Lebanon overwhelmed about 200 people from Baalbek who were gathering rhubarb; Baalbek itself was destroyed despite its strength and solidity ('Abd al-Latif, p. 416).

In the County of Tripoli, the Christian sources disagree slightly on the degree of damage to Tripoli itself, though both main accounts refer to heavy loss of life (Mayer, 1972). Ibn al-Athir (xii, 112) also refers to the heavy damage there, suggesting intensities not less than VIII. Other strongholds were severely shaken: the castle of 'Arqa (Arches) was completely ruined and deserted villages in the area were taken to indicate heavy loss of life (Philip du Plessis: but perhaps simply the flight of the inhabitants, since famine and sickness were also rife). It may be noted that Rey (1871, p. 92) cites 'Abd al-Latif and Robert of Auxerre concerning an earthquake in Sha'ban 597 (sic.)/20 May 1202 which destroyed Jebel 'Akkar and Chastel Blanc, falsely equating "Archas" with 'Akkar, which the occidentals called Gibelcar. The destruction of 'Arqa is also mentioned by Arab writers ('Abd al-Latif, p. 417, Abu Shama, p. 29). Philip du Plessis records the complete destruction of the castle at "Arsum", which is not satisfactorily identified but perhaps refers to 'Arima. Mayer (1972, p. 304) is reluctant to identify Arsum but points to the possibility of Arsuf, near Caesarea. Support for this is found in the account of the pilgrimage of Wilbrand of Oldenborg, who in 1212 found the small ruined town of "Arsim" (Arsuf) on his way to Ramla (p. 184). As Mayer mentions, however, the letter seems to refer rather to a place in Tripoli, and 'Arima is suggested on the grounds: 1) that it probably belonged to the Templars; and 2) it was one of the few strongholds retained by the Christians in the truce that ended the Third Crusade (Setton, 1969, i, 664). It is situated a few miles SSW of Chastel Blanc. Philip further reported that the greater part of the walls of the Templar stronghold Chastel Blanc (Safitha) had fallen and the keep weakened to such an extent that it would have been better had it collapsed completely. 'Abd al-Latif (p. 417) also mentions the destruction of the castle. The castle keep was probably rebuilt using existing materials (Deschamps, 1977, pp. 257-258). Tortosa (Tartus) however and the Templar citadel there seem largely to have been spared, notably the Cathedral of Notre Dame (Berchem and Fatio, 1914, p. 323, Enlart, 1928, p. 397).

The Grand Master of the Hospitallers (Geoffrey of Donjon) wrote that their strongholds at Margat (Marqab) and Krak were badly damaged but could probably still hold their own in the event of attack. Damage to Krak (Hisn al-akrad) is also mentioned in the account of Sibt b. al-Jauzi (p. 510). In the same vicinity, but in Muslim hands, the castle of Barin (Montferrand), despite its compactness and fineness, was also damaged ('Abd al-Latif, p. 416).

There is little additional evidence to help assess the intensities indicated by these reports. Studies of military architecture (e.g. Rey, 1871, Deschamps, 1934, 1977) on the whole use documentary evidence of earthquakes to support the chronology and identification of building phases at the castles, rather than documentary or archaeological evidence of rebuilding to indicate the extent of earthquake damage. Indeed, it is interesting that Deschamps, unaware of the reports of earthquake damage at Marqab in 1202, makes no reference to this specific period as being one of substantial building at the castle (Deschamps, 1977, p. 282-284), whereas in the case of Krak damage done by the earthquake is thought to have been responsible for some of the reconstruction work analysed (Deschamps, 1934, p. 281). Even so, the fact that the knights of Krak were frequently on the offensive in the next few years after 1203, and were joined by the knights from Marqab, is thought to indicate that both castles were "already in a perfect state of defense". These raids may rather suggest that attack was the best form of defense. Nevertheless, the circumstantial testimony by Geoffrey can be taken at face value and is supported by the fact that Marqab successfully resisted a counter-attack by al-Malik al-Zahir, amir of Aleppo, in 601/1204-1205 (Ibn Wasil, iii, 165). Both Marqab and Krak were visited in 1211 by Wilbrand of Oldenborg and seemed to his probably unprofessional gaze to

be very strong, the latter housing 2000 defendants (p. 169-170). Few details are available about Barin, which was finally dismantled in 1238-1239 (Deschamps, 1977, p. 322). It seems unlikely that intensities exceeding VII were experienced at any of these strongholds.

In neighboring Muslim territory, the shock was experienced at similar intensities in Hims (Homs, Emessa), where a watchtower of the castle was thrown down (Sibt b. al-Jauzi, p. 510) and Hamah, where the earthquake was experienced as two shocks, the first lasting "an hour" and the second shorter but stronger. Despite its strength, the castle was destroyed, along with many houses and other buildings. Two further shocks were felt the following afternoon ('Abd al-Latif, p. 416). Considerable damage to houses in both towns is implied by Ibn al-Athir (xii, 112).

Further north, the earthquake is said to have been felt in Aleppo and other regional capitals (Sibt b. al-Jauzi, p. 478), and also in Antioch, though less strongly (Geoffrey of Donjon). It was also reported in Mosul and throughout the districts of Mesopotamia, as far as Iraq, though without destruction of houses. Azarbaijan, Armenia, parts of Anatolia and the town of Akhlat are said to have experienced the earthquake (Ibn al-Athir and Sibt b. al-Jauzi, *loc. cit.*).

In the south, the shock was felt throughout Egypt from Qus to Alexandria. Sibt b. al-Jauzi (p. 478, probably quoting al-'Izz) says that the shock came from al-Sa'id and extended into Syria; al-Sa'id being the region south of Fustat (Old Cairo) down to Aswan (Yaqut, iii, 392). In Cairo, the shock was of long duration and aroused sleepers, who jumped from their beds in fear. Three violent shocks were reported, shaking buildings, doors and roofs. Only tall or vulnerable buildings were particularly affected, and those on high ground, which threatened collapse ('Abd al-Latif, p. 414-5). Such a strong shock was considered unusual for Egypt and must have been at least intensity V. The details provided indicate that Egypt experienced long-period shaking at a large epicentral distance. A lesser shock was felt at about midday the same morning, probably the one reported from Hamah at midday on Tuesday 27 Sha'ban (21 May).

In Cyprus, under Frankish rule since 1191, the earthquake damaged churches and other buildings and was strongly felt (*Annales* 5689, fol. 108b; 'Abd al-Latif, p. 415; Ibn al-Athir, xii, 130). Damage to buildings is not however very well attested and it is noteworthy that most of the "Cypriot Chronicles" refer only to damage on the mainland. In the words of the Arabic authors, the sea between Cyprus and the coast parted and mountainous waves were piled up, throwing ships up onto the land. Eastern parts of the island were flooded and numbers of fish were left stranded ('Abd al-Latif, p. 415; Ibn Mankali in Taher, 1979). The significance of this seismic sea-wave is discussed below.

The earthquake is said to have been felt as far as Sicily (Ibn al-Athir, xii, 130) and Ceuta (Ibn Wasil, iii, 161), but this still lacks confirmation in the annals of the Muslim west, dominated at this period by the Almohads. No details have been recovered of the shock in the western Mediterranean area. It is very likely that the shaking reported on or after 1 March 1202 felt in and around Constantinople was from the earthquake of 20 May (Nicetas, p. 701).

The loss of life caused by this earthquake and its aftershocks is difficult to estimate. A figure frequently quoted in Arab sources is 1,100,000 dead (e.g., al-Dhahabi, iv, 296; al-Suyuti, p. 47) for the year 597-598 H. (A.D. 1201-1202). This specifically includes those dying of famine and the epidemic consequent on the failure of the

Nile floods, graphically described by 'Abd al-Latif, who notes 111,000 [sic.] deaths in Cairo alone between 596 and 598 H. (p. 412). More realistically, the figure of 30,000 casualties is given, primarily, it would seem, in the Nablus area (Sibt b. al-Jauzi, p. 478). No reliance can be placed on such figures, but the fact that the main shock occurred at dawn, when most people were in bed, without noticeable foreshocks, probably contributed to a high death toll.

Aftershocks were reported from Hamah, Damascus, and Cairo, for at least four days ('Abd al-Latif, p. 417, Abu Shama, p. 29), one of which, apparently felt in Cairo and Hamah, must have been a large event. There remains the possibility that the aftershock sequence was terminated with a destructive shock that totally destroyed what was left of Nablus, but it seems preferable to consider both reports by Sibt b. al-Jauzi as referring to the same one shock. Whatever the exact sequence of events, the cumulative effects of the earthquake were clearly catastrophic. Most of the sites affected in the epicentral region (see Figure 2) must have needed total reconstruction or major repairs (cf. Table 1), although in most cases the evidence is circumstantial, not specific.

6. Discussion

From the foregoing it appears that the 1202 earthquake was a shallow, large magnitude multiple event. This is attested by: (1) the large area over which the shock was felt; (2) the long-period effects observed at large epicentral distances; (3) the fact that the main shock was followed by aftershocks at least one of which was very widely felt; (4) by a seismic sea-wave generated between Cyprus and the Syrian coast; and finally (5) by the observation that in the epicentral region the earthquake was experienced as more than one shock.

From Figure 1 we notice that the radius of the felt area, which includes Sicily but not Ceuta, was about 1,200 km. From Figure 2 we see that the epicentral region, within which intensities exceeded VIII (MSK), forms a narrow inland strip about 250 km long and 40 km wide that extends from Nablus in the south to 'Arqa in the north. The number of sites at which intensities can be assessed (shown in Figure 2) is obviously insufficient to allow the construction of a proper isoseismal map (but cf. Sieberg, 1932b). However, it would appear that the maximum effects of the earthquake were experienced away from the coast, in the upper Jordan and Litani valleys as well as the upper reaches of the Orontes river, in the vicinity of Baalbek. Several thousand people perhaps perished in this area. Without further details, it is difficult to indicate more precisely the exact location and extent of the epicentral region. The vague details of severe damage in the Hauran district may suggest that the rupture zone was wider than shown on Figure 2. Since most of the aftershocks were reported from the north (Hamah), we may conjecture that the event nucleated in the south, near Nablus, and that it was completed by a second rupture that originated in the Tyre-Baalbek segment of the meizoseismal area. Apart from the statement that large-scale landslides occurred in Mount Lebanon, there is no indication that this event was associated with faulting.

The 1202 earthquake may however be compared with the earthquake sequence between June 1759 and January 1760, which affected almost exactly the same epicentral region. Preceded by strong foreshocks on 10 June, the main shock on 30 October 1759 completely destroyed the region of the Litani and upper Orontes valleys. A violent aftershock on 25 November extended the damage to Safad in the

south, with a cumulative epicentral region somewhat smaller than that of the 1202 event. Aftershocks continued well into January 1760 and damage in Tyre, Tripoli and Damascus was as serious as in 1202. One important aspect of the 1759 earthquake, which is much better documented, is that we know it was associated with a 95 km long fault-break in the Bekaa, on the west side of the valley, in places many metres wide (Archives Nationales, 1759). It is not possible to assess the tectonic effects of the 1202 earthquake, which was much larger than the multiple shock of 1759, but it may have been comparable in location and in its extent of faulting.

7. Calibration with 20th Century Earthquakes

No earthquake of comparable felt area has occurred in the Middle East during the present century that can be used to calibrate the magnitude of the 1202 event. The nearest is the eastern Mediterranean earthquake of 26 June 1926, which had an offshore epicenter near Rhodes and a radius of perceptibility of about 900 km as shown in Figure 3 (Shebalin and Kárník, 1974). This earthquake was originally located by the International Seismological Summary (ISS) at 36.0° N, 28.0° E, with a shallow depth, but because of its relatively large felt area it was relocated at intermediate depth between 100 and 150 km and assigned a body wave magnitude between 7.7 and 8.0 (Gutenberg and Richter, 1965; Shebalin and Kárník, 1974; Alsan, *et al.* 1975; Makropoulos, 1978). It has also been suggested that its radius of perceptibility was as large as 1,600 km (references in Kárník, 1968), a value inferred from the fact that Gassmann (1926) reports the event felt in Switzerland. However, Galanopoulos (1953) and Wyss and Baer (1981) show that these relocations cannot be trusted and that the 1926 earthquake was a relatively shallow event. The felt foreshocks of 1 and 27 April, 26 and 27 June and 5 July, of magnitude $M_S \geq 5$, all located as shallow events, imply a shallow source. This is supported by a revised radius of perceptibility of the main shock of just under 900 km (Figure 3), which is based on a re-examination of Sieberg's data (1932a,b), with the use of additional information (Mihailovič, 1928; Critikos, 1928; Press Reports). The recent evaluation of Italian data (Margottini, 1982) in particular shows that the shock reported in Switzerland should be attributed to a local earthquake. Moreover, using the method put forward by Ambraseys (1985b) and the seven isoseismal radii listed by Shebalin and Kárník (1974), our estimate of the macroseismic focal depth of the 1926 earthquake is only 35 km with a corresponding absorption coefficient of $3 \times 10^{-3}\,\mathrm{km}^{-1}$ and an n-value close to the Airy phase, i.e. $n = 1.3$. For this focal depth the recalculated surface wave magnitude from 25 station estimates was found to be 7.0 (± 0.2), while the body wave magnitude from 7 station estimates was 7.5 ($\pm$ 0.3).

With an epicentral area entirely offshore, the effects of the 1926 earthquake were obviously not representative of its magnitude. The shock killed 13 people and destroyed or damaged beyond repair about 4,000 houses, mainly in Rhodes, the nearby coast of Turkey and in Crete. A few old and delapidated houses in Cairo, Alexandria and the Jordan Valley suffered damage; minarets and belfries in Turkey and Greece swayed dangerously. The 1926 earthquake thus had a radius of perceptibility at I = II$^+$ (MSK) of about 900 km, a shallow depth and a surface wave magnitude of 7.0.

The largest 20th century earthquake in the Jordan Valley, on 11 July 1927, was again of shallow depth but a much smaller event, with a surface wave magnitude

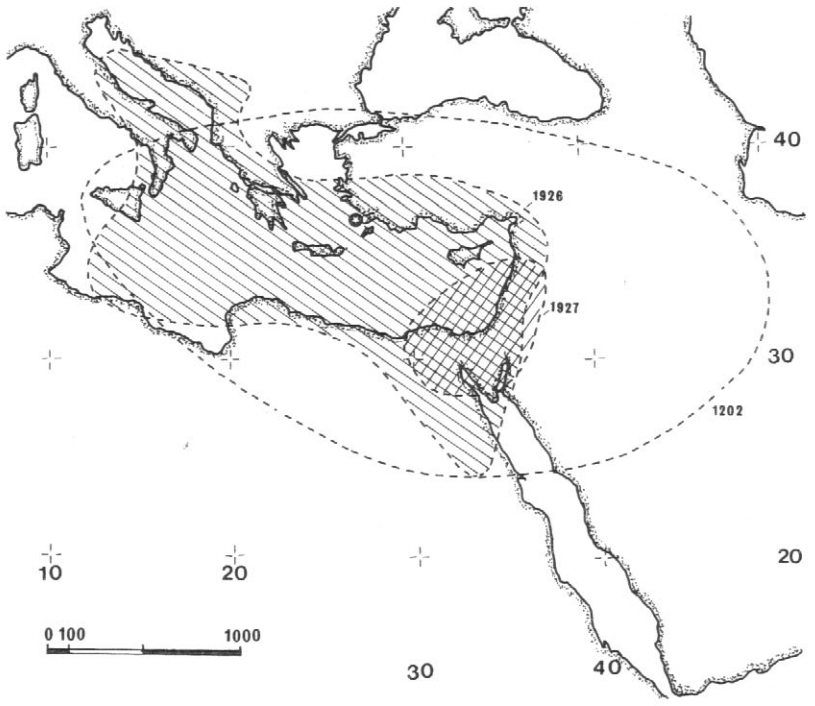

Figure 3. Comparison of the felt areas of the earthquakes of 20 May 1202, 26 June 1926 (M_S = 7.0, m = 7.5) and 11 July 1927 (M_S = 6.0, m = 6.4).

of only 6.0 (± 0.1) from 20 station estimates ($m = 6.4$). The shock was centered at 32.0° N and 35.4° E. It destroyed hundreds of houses on both sides of the Jordan River, killing 361 people and injuring about 1,000. Detailed studies of this event have been published by Sieberg (1932a, b), Berloty (1927) and more recently by Vered and Striem (1976). This earthquake must be described as one which excited widespread interest and sympathy rather on account of where it happened than because of its special violence, and its effects have been overestimated. Our re-evaluation of its effects, based on official reports compiled by the British and French authorities, shows that Sieberg's intensity assessments are greatly exaggerated and that the radius of perceptibility he deduces, of 600 km, contains large areas from which negative reports predominate (see Berloty, 1927, p. 80-81). On Figure 3 we show an area of radius only 300 km where the shock was felt at intensity III (MSK), and on Figure 2 the epicenter of this event is shown with respect to the epicentral region of the 1202 earthquake. The 1927 earthquake was followed by a long series of aftershocks which terminated on 22 February 1928 with a damaging shock of $M_S = 5.2\,(\pm 0.2)$ that was centered in the Judean Hills.

The earthquake of 16 March 1956 was a smaller, double shock consisting of two events of $M_S = 5.0\,(\pm 0.1)$ and $5.1\,(\pm 0.1)$, both shocks having $m = 5.6$, occurring within ten minutes of each other. The epicentral region was situated in the Shouf

area on the west slopes of Mt. Lebanon, Figure 2. These shocks killed 136 people and rendered 5500 houses uninhabitable in 55 communities. The earthquake was felt with an intensity greater than II (MSK) within a radius of about 160 km (Shalem, 1956; Plassard, 1956; Anon., 1958).

Thus, on a comparative basis, the 1202 earthquake had a magnitude greater than 7.3. If we use the relationship derived to predict surface wave magnitudes from macroseismic data of Balkan earthquakes, i.e.

$$M_{SC} = 0.40 + 0.46\,(I_i) + 2.8 \times 10^{-4}\,(R_i) + 1.8 \log (R_i), \quad (1)$$

where R_i is the average radius of isoseismals of intensity I_i, For $R_3 = 1200$ km we find that the magnitude of the 1202 earthquake should be $M_S = 7.6$. This attenuation law is based on macroseismic data of the Balkan region compiled by Shebalin and Kárník (1974) and it has been derived using the procedure employed by Ambraseys (1985b) for Northwest Europe. Assuming that the rupture length associated with this event is defined approximately by the length of the zone of maximum intensity shown in Figure 2, i.e. about 200 km, the relative co-seismic displacement for an earthquake of magnitude 7.6 may be estimated from

$$M_S = 1.1 + 0.4 \log (L^{1.58} D^2), \quad (2)$$

which yields a relative displacement of D = 2.5 m, most probably wholly strike-slip in nature. Equation (2) is derived from rupture dimensions and dislocation of Eastern Mediterranean and Middle Eastern events (Ambraseys and Melville, 1982). L and D are the length of the fault break and relative displacement, in centimeters; M_S is the corresponding surface wave magnitude. This is all the more interesting in that there is no record of faulting in this earthquake, which occurred on land, far enough from the Syrian coast not to be directly associated with the reported seismic sea-wave east of Cyprus. At any rate, it is unlikely that such a wave would be generated by a mechanism lacking in a substantial dip-slip component. Although the details of damage in Cyprus are not very satisfactorily recorded, the earthquake must have been as damaging in the island as along northern parts of the Syrian coast but not as destructive as further inland. This would enlarge the area of intensive high shaking and reduce the emphasis on an offshore epicentral region that reports of the sea-wave might imply.

The occurrence of a seismic sea-wave between Cyprus and the Syrian coast may be explained through the generation of a large-scale subaqueous slide from the continental margin of Syria, triggered by the earthquake. North of Acre the continental shelf narrows to a few kilometers and off the coast of Lebanon the continental slope steepens from near Acre northwards to an average slope of 10° (Boulos, 1962). Under these circumstances, the principal cause of a seismic sea-wave is submarine slumping. The whole of that coast is certainly prone to slumping because of evaporites in the sedimentary section (Garfunkel, *et al.* 1979).

In conclusion, although it is clear that the damage reported in contemporary sources was due to the main shock on 20 May 1202, there remains the possibility of cumulative damage, particularly from a belated, large magnitude aftershock, perhaps four or five months later, centered in the southern portion of the epicentral region. The main shock was catastrophic, with an on-land meizoseismal area and

source dimension of about 200 km. The magnitude of the 1202 earthquake was in excess of 7.5 and it was associated with a protracted sequence of aftershocks and a damaging sea-wave that affected the coasts of Syria and Cyprus.

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REFERENCES

1. Arabic Sources:

'Abd al-Latif, Kitab al-ifada, trans. Silvestre de Sacy, Relation de l'Egypte, Paris, 1810.
Abu 'l-Fada'il, Tarikh Mansuri, facs. ed. P. A. Gryaznevitch, Moscow, 1960.
Abu 'l-Fida, Tarikh al-mukhtasar fi akhbar al-bashar, vol. iii, ed. Cairo, 1907.
Abu Shama, Dhail 'ala al-raudatain, ed. al-Zujari and al-Hasani, Cairo, 1947.
al-Dhahabi, Kitab al-'ibar fi khabar man ghabara, vol. iv, ed. S. Munajjid, Kuwait, 1963.
Ibn al-Athir, al-Kamil fi 'l-tarikh, vol. xii, ed. Tornberg, Leiden, 1853.
Ibn al-Furat, Tarikh al-duwal wa 'l-muluk, vol. iv/2, ed. Hassan al-Shamma, Basra, 1969.
Ibn Jubair, The travels of Ibn Jubayr, ed. W. Wright, 2nd ed. J. M. de Goeje, Gibb Memorial Series vol. 5, London, 1907.
Ibn Mankali, al-ahkam al-mulukiyya, fol. 37, quoted in Taher (1979, p. 125).
Ibn Wasil, Mufarrij al-kurub fi akhbar bani ayyub, vol. iii, ed. M. Shayyal, Cairo, 1962.
Sibt b. al-Jauzi, Mir'at al-zaman, vol. viii, printed ed. Hyderabad, 1951.
al-Suyuti, Kashf al-salsala 'an wasf al-zalzala, ed. and trans. S. Nejjar, Fez, 1971 and Rabat, 1974.
Yaqut al-Hamawi, Mu'jam al-buldan, ed. Wustenfeld, 4 vols., Leipzig, 1866-1871.

2. Other Primary Sources:

Salimbene de Adam, Cronica, Mon. German. Hist. Ss. vol. 32.
Francesco Amadi, Chroniques d'Amadi et de Strambaldi, vol. 1, Chronique d'Amadi, ed. Mas Latrie, Coll. de doc. inedit. sur l'hist. de France, Paris, 1891.
Annales de Terre Sainte, ed. G. Raynaud and R. Röhricht, Archives de l'Orient latin, vol. 2b, 1884.
Annales 5689, Annales Terrae Sanctae, Bibl. Nationale de Paris, Fonds Latin no. 5689.
Robert of Auxerre, Chronicon, Mon. German. Hist. Ss. vol. 26; also ed. Bouquet, Rec. Hist. Gaule et de la France, vol. 18.
Bar Hebraeus [Abu 'l-Faraj], Chronography, trans. E. A. W. Budge, London, 1932.
Barletta Ms. in Kohler (1900-1901).
Ralph of Coggeshall, Chronicon Anglicanum, ed. J. Stevenson, Rolls Ser. Vol. 66.
Les Gestes des Chyprois, Rec. Hist. Croisades. Arm., vol. 2.
Chronique de Terre Sainte, 1131-1224, in Gestes des Chiprois, ed. G. Raynaud, Publ. Soc. de l'Orient Lat., vol. 5, Paris, 1887, (repr. Osnabruck, 1968).
Geoffrey of Donjon, Letter in Mayer (1972).
Ernoul, Chronique d'Ernoul et de Bernard le Trésorier, ed. Mas Latrie, Paris, 1871.
L'Estoire d'Eracle, Rec. Hist. Croisades. Occ., vol. 2.
The book of the wanderings of Felix Fabri [1480-83], vol. 2, tr. A. Stewart, Palestine Pilgrims' Text Soc., vol. 9, London, 1893, (repro. AMS, New York, 1971).
Hethum of Gor'igos, Table chronologique, Rec. Hist. Croisades. Arm., vol. 1.
Hethum Patmic, Chronicle, in Hakobyan (1956, p. 61).
Albert Milioli, Cronica Imperatorum, Mon. German. Hist. Ss., vol. 31.
William of Nangis, Chronicon, Rec. Hist. Gaule et de la France, vol. 20.

Nicetas Choniates Acominatos, Historia chronicon, ed. I. Bekker, Corp. Script. Hist. Byz., Bonn, 1835.
Wilbrandus of Oldenborg, Travels, ed. J. C. M. Laurent, Peregrinatores medii aevi quatuor, p. 161-191, 2nd ed., Leipzig, 1873.
Philip of Plessis, Letter in Mayer (1972).
Marino Sanuto, the elder, Liber secretorum (Secrets for the Crusaders) or Gesta Dei per Francos, book III/xi, chapter 1, ed. Hannover, 1611.

3. Other Works:

Abe, K. (1987). Magnitude determination from Milne undamped seismographs (this volume).
Alsan, E., L. Tezucan, and M. Bäth (1975). An earthquake catalogue for Turkey, 1913-1970, *Publ. Seism. Inst. no. 7-75*, Uppsala.
Alsinawi, S. and H. Ghalib (1975). Historical seismicity of Iraq, *Bull. Seism. Soc. Am.*, **65**, 541-547.
Ambraseys, N. (1961). On the seismicity of South-West Asia: data from a XV-century Arabic manuscript, *Rev. Etude Calamités*, **37**, p. 18-30.
Ambraseys, N. (1962). A note on the chronology of Willis' list of earthquakes, *Bull. Seism. Soc. Am.*, **52**, 77-80.
Ambraseys, N. (1968). Early earthquakes in North-Central Iran, *Bull. Seism. Soc. Am.*, **58**, 485-96.
Ambraseys, N. (1974). The historical seismicity of North-Central Iran, *Geol. Survey Iran*, publ. 29, 47-96.
Ambraseys, N. (1985a). The seismicity of western Scandinavia, *J. Earthq. Eng. Struct. Dyn.*, **13**, 361-400.
Ambraseys, N. (1985b). Intensity-attenuation and magnitude-intensity relationships for northwest European earthquakes, *J. Earthq. Eng. Struct. Dyn.*, **13**, 733-778.
Ambraseys, N. and R. Adams (1986). Seismicity of the Sudan, *Bull. Seism. Soc. Am.*, **56** (in press).
Ambraseys, N. and J. Jackson (1985). Long-term seismicity of Britain, *Earthquake Engineering in Britain*, 49-65, London.
Ambraseys, N. and C. Melville (1982). *A history of Persian Earthquakes*, Cambridge.
Ambraseys, N. and C. Melville (1983). Seismicity of Yemen, *Nature*, **303**, 321-323.
Ambraseys, N., *et al.* (1983). Notes on historical seismicity, *Bull. Seism. Soc. Am.*, **73**, 1917-1920.
Anonymous (1958). Le recent tremblement de terre de Litani, *Service des Renseignments, Publ. d'Urbanisme*, Beirut.
Archives Nationales (1759). Serie Bl-Correspondence Consulaire/AE.B1.1120 Tripoli 4 fev. 1760 and B1.88 Aleppo 11 Dec 1759.
Arvanitakis, G. (1903). Essai sur le climat de Jerusalem, *Bull. Inst. Egypt.* **4**, 178-183, Alexandria.
Batman, K. (1581). The Doome warning all men to the Judgement, Newbery: London.
Ben-Menahem, A. (1979). Earthquake catalogue for the Middle East (92 B.C. to 1980 A.D.), *Bol. Geof. Teor. ed Applic.*, **21**.
Berchem, M. van and E. Fatio (1914). Voyage en Syrie, *MIFAO*, **37**, Cairo.
Berloty, R. (1927). Sur le tremblement de terre de Palestine 11 juillet 1927, *Annales Obs. Ksara, Section Seism.*, 62-93, Zahle.
Berryat, J. (1761). Liste chronologique des eruptions de volcans, etc., *Coll. Acad.*, **6**, 488-676, Paris.
Beuther, T. (1601). Compendium terrae motuum, Strassburg.
Blankenhorn, M. (1914). Morphologische uebersicht; Erdbeben Syrien etc., Handbuch der Region. Geol. vol. 5 and Zeitschr. deutsch. Palaest.-Vereins, vol. 28/i (1905), 206-219.
Boulos, I. (1962). Cartes de reconnaissance des côtes du Liban, 1:150,000, Service Topographique, Beirut.
Cahen, C. (1940). La Syrie du Nord à l'époque des Croisades et la principauté franque d'Antioche, Paris.

Coronelli, P. (1693). De'tremuoti accaduti dal diluvio, etc., in *Epitome Cosmografica*, 286-324. Venice.
Critikos, N. (1928). Le tremblement de terre de la mer de Crete du 26 juin 1926, *Annales Obs. Natl. Athens*, **10**, 39-53.
Deschamps, P. (1934-1977), Les châteaux des Croisés en Terre Sainte, 3 vols. in 5, Bibl. Arch. et Hist. vols. 19 (1934), 34 (1939) and 90 (1977), Paris.
Dressdnische Gelehrte Anzeigen (1756). Nachrichten von Erdbeben, No. 2-40, Dresden.
Dussaud, R. (1927). Topographie historique de la Syrie antique et mediévale, *Bibl. Archeol. Hist.*, **4**, Paris.
Elisséeff, N. (1967). Nur al-Din, Inst. Fr. Damas, 3 vols., p. 924.
ENEA-ENEL (1981). Contributo alla caratterizzazione della Sismicita del territorio Italiano, Udine.
Enlart, C. (1928). *Les monuments des Croisés dans le Royaume de Jerusalem*, vol. 2, Paris.
Galanopoulos, A. (1953). On the intermediate earthquakes in Greece, *Bull. Seism. Soc. Am.*, **43**, 159-175.
Garfunkel Z., A. Arad, and G. Almagor (1979). The Palmahim disturbance and its regional setting, *Bull. Geol. Survey Israel*, **72**, 39-40, Jerusalem.
Gassmann, F. (1926). Jahresbericht 1926 des Erdbebendies der Schweizerischen Meteorologischen Zentralanstalt, *Annal. Schweiz. Met. Zentral.*, p. 4, Fig. 6.
Gutenberg, B. and C. Richter (1965). *Seismicity of the earth.* Hafner.
Hakobyan, V. A. (1956). Manr Zhamanakagrut'yunner XIII-XVIII (Armenian short chronicles, 13th - 18th centuries), vol. 2, Erivan.
Hoff, K. von (1840). Chronik der Erdbeben, etc. Gesch. Ueberlief. nachgew. naturl. Veraender. Erdoberfl. vol. 4, Gotha.
Huot, J. (1837). Nouveau cours élémentaire de géologie, vol. 1, p. 108-118, E. Roret: Paris.
Kallner-Amiran, D. (1951-1952). A revised earthquake catalogue of Palestine, *Israel Explor. Jnl.*, **1**, 223-246; **2**, 48-65.
Kárník, V. (1968). *Seismicity of the European area*, Academia, Prague.
Kohler, Ch. (1900-1901). Un rituel et un breviaire du Saint-Sepulchre de Jerusalem, *Rev. de l'Orient lat.*, **8**, 383-469.
Le Strange, G. (1890). *Palestine under the Moslems*, London.
Makropoulos, K. (1978). The statistics of large earthquake magnitudes and an evaluation of Greek seismicity, *Ph.D. thesis*, University of Edinburgh.
Mallet, R. (1852). Third report on the facts of earthquake phenomena, *British Ass. Adv. Sci.*, 1-176, London.
Manetti, G. (1457). De terraemotu, trans. C. Scopelliti, p. 102, ENEA, Rome.
Margottini, C. (1982). Osservazioni su alcuni grandi terremoti con epicentro in oriente; campo macrosismico in *Italia. Publ. Comm. Nazion. energ. Nucleare*, Rome.
Mayer, H. E. (1972). Two unpublished letters on the Syrian earthquake of 1202, Medieval and Middle Eastern Studies in honor of Aziz Suryal Atiya, ed. S. A. Hanna, 295-310, Leiden.
Mayer, H. E. (1984). *The Crusades*, Oxford University Press.
Melville, C. (1983). Seismicity of the British Isles and the North Sea, Rept. SRC, London Centre for Marine Technology, vol. 1, Imperial College, London.
Melville, C. (1984). Sismicité historique de la mer rouge septentrionale, in Tremblements de terre: histoire et archéologie, p. 95-107, APDCA, Valbonne.
Melville, C. (1985). The geography and intensity of earthquakes in Britain; the 18th century, *Earthquake Engineering in Britain*, 7-22 London.
Mihailovič, J. (1928). Annuaire seismique phenomènes macroseismiques, *Ann. Obs. Belgrade*, Ser. A fasc. 4.
Muir Wood, R. G. Woo, and H. Bungum (1987). The history of earthquakes in the northern North Sea (this volume).
Muralt, E. von (1871). Essai de chronographie byzantine, 1057-1452, vol. 1, Basle.
Perrey, A. (1850). Sur les tremblements de terre ressentis dans la Peninsule Turco-Hellenique et en Syrie *Memoires Couronn. Acad. R. Sci. de Belgique*, **23**, Brussels.
Plassard, J. (1956). Note sur le tremblement de terre du 16 mars 1956, *Publ. Obs. Seism. Ksara*, Zahle.

Plassard, J. and B. Kagoj (1968). Catalogue des seismes ressentis au Liban, *Annales-Mem. Obs. Ksara*, **4**, no. 1.
Poirier, J. and M. Taher (1980). Historical seismicity of the Near and Middle East, etc., *Bull. Seism. Soc. Am.*, **70**, 2185-2201.
Postpichl, D. (1985). ed., Atlas of isoseismal maps of Italian earthquakes, Progetto Finalizzato Geodinamica, Bologna.
Rey, G. (1871). Etude sur les monuments de l'architecture militaire des Croisés en Syrie et dans l'Ile de Chypre, Doc. inédits sur l'hist. de France, Paris.
Röhricht, R. (1898). Geschichte des Königreichs Jerusalem, Innsbruck.
Runciman, Sir S. (1971). *A history of the Crusades*, 3 vols., Harmondsworth.
Setton, K. M. (1969). ed., *A history of the Crusades*, vols. 1 and 2, 2nd ed., Univ. of Wisconsin Press, Madison and London.
Seyfart, J. (1756). *Algemeine Geschichte der Erdbeben*, Frankfurt.
Shalem, N. (1956). Isoseismal map of the 16 March earthquake, *Geomorph. Dept. Rept. Geol. Surv. Israel*, Jerusalem.
Shebalin, N. and Kárník, V. (1974). Catalogue of earthquakes in the Balkan region, UNESCO Survey of Seismicity of the Balkan Region, 2 vols. and Atlas, Skopje.
Sieberg, A. (1932a). Erdbebengeographie, in B. Gutenberg, *Handbuch der Geophysik*, vol. 4, Berlin
Sieberg, A. (1932b). Erdbeben und Bruchschollenbau im Ostlichen Mittelmeergebeit, Denk. d. Medizin.-Naturwiss. Ges. zu Jena, vol. xviii, no. 2, Jena.
Sprenger, A. (1843). As-Soyuti's work on earthquakes, *J. R. Asiatic Soc. Bengal*, **12**, 741-749.
Taher, M. A. (1979). Corpus des textes arabes rélatifs aux tremblements de terre de la conquête arabe au xii H./xviii J.C., *Doctoral thesis*, Sorbonne, 2 vols., Paris.
Tholozan, J. (1879). Sur les tremblements de terre qui ont eu lieu en Orient, etc., *Comp. Rend. Acad. Sci.*, **88**, 1063-1066.
Vered, M. and H. Striem (1976). A macroseismic study of the July 11, 1927 earthquake, Publ. IA-LD-1-107, Israel Atomic Energy Commission.
Vigouroux, F. (1928). Dictionnaire de la Bible, vol. 4/ii, 2031, Letouzey-Ane.
Vogt, J. (1984a). Revision de deux seismes majeurs de la région d'Aix-la-Chapelle/Verviers/Liège ressentis en France - 1504, 1692, in *Tremblements de terre: histoire et archéologie*, 9-21, APDCA, Valbonne.
Vogt, J. (1984b). Problèmes de sismicité historique, etc. in *Seismic activity in western Europe: with particular consideration to the Liège earthquake of November 8, 1983*, P. J. Melchior, ed., 205-214, NATO ASI ser. C144, Reidel, Dordrecht.
Willis, B. (1929). Earthquakes in the Holy Land, *Bull. Seism. Soc. Am.*, **18**, 73-103.
Wyss, M. and M. Baer (1981). Earthquake hazard in the Hellenic Arc, *Earthquake Prediction - Maurice Ewing Series*, no. 4, 153-172, Publ. Amer. Geophys. Union.