A careful and intensive study of historical sources and a review of the instrumental data of this century have led to this detailed catalogue of earthquakes. Egypt, Arabia, the Red Sea region and the surrounding areas of Libya, Sudan and Ethiopia are studied from the earliest times to the present day. Each earthquake is described as fully as possible from the available data, and is analysed in a geographical and historical context. The completeness of the earthquake catalogue over time is analysed and the range of sources and problems associated with the scrutiny of historical sources are discussed. The information is then placed in a geophysical framework.

The seismicity of Egypt, Arabia and the Red Sea:
a historical review

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To Xeni, Alison and Thelma,
for putting up with all this

Contents

Preface

Collecting earthquake records can be like collecting stamps, or butterflies, or rare books – a harmless pastime, or an obsession. Different interests have contributed to producing this book. First, the scientific urge to accumulate, to map and to quantify the reported effects of past earthquakes. In addition, the fascination of the texts themselves, not only for what they record, but why and how they did so. Then there is the true collector's obsession for the most accurate, up to date and comprehensive catalogue of the trophies jealously acquired from years of bibliographical detective work and weeks of numerical calculation.

One problem with the collector's mentality is that the work of acquisition never stops. The greatest earthquake hoarder of the last century, Alexis Perrey (d. 1882), got round this by publishing regional and global catalogues, constantly updated by supplementary lists. This resulted in an unwieldy output spanning four decades. Modern publishing conditions, as well as the objectives of a modern earthquake catalogue, make this solution impracticable, and the present work represents both the culmination and the temporary interruption of a long-term process.

The immediate origins of the book lie in a research project carried out by the Civil Engineering Department at Imperial College, London, for the Saudi Arabian National Centre for Science and Technology (SANCST), at the King Abdulaziz City for Science and Technology in Riyadh (KACST), between 1985 and 1988. The report arising from this research project on 'The Seismicity of Saudi Arabia and Adjacent Areas' was not widely circulated. We are grateful to KACST for permission to publish this revised version, and to Cambridge University Press for agreeing to do so – doubtless encouraged and surprised by the fact that an earlier work, on earthquakes in Persia (Iran), published in 1982, is now out of print.

Since one conclusion of the report was that Saudi Arabia itself (with the exception of the Hejaz) is almost totally aseismic, the concentration of the book tends to focus on the wider context of the 'adjacent areas' and particularly, in view of work already done on Iran, those areas to the west of the Arabian Peninsula.

Although Egypt, too, is an area of relatively low seismicity, it has experienced damaging local shocks, as well as the effects of larger earthquakes in the Hellenic Arc and eastern Mediterranean. It has also been affected by earthquakes in southern Palestine and the northern Red Sea. The Red Sea itself is an active plate boundary and at its southern end, long-term moderate seismicity associated with volcanism has been observed in the Yemen, as well as in Ethiopia. The complexities of the geology of the Red Sea make a good knowledge of regional seismicity useful for an understanding of the tectonic processes at work there. Furthermore, both Egypt and the Yemen have long and well-documented histories, a prerequisite for undertaking macroseismic studies. Finally, the human geography and distribution of population in the area – particularly its concentration in a narrow band along the river Nile – create challenging problems in identifying and assessing the origin and effects of Egyptian earthquakes.

The cut-off dates for the catalogue in the original report were 1983 for macroseimic data and 1987 for instrumental data. These cut-off dates have been essentially retained in the present work, although the instrumental catalogue in particular has been selectively updated to the end of 1992. In contrast with Iran, where several important earthquakes have occurred since our work was published, few major events have affected our area of interest since the Yemen earthquake of December 1982. Of these, the earthquake of 20 May 1990 in southern Sudan was one of the largest known in Africa, but its location in an area of conflict seriously inhibited the gathering of macroseismic information. For the sake of completeness, this earthquake and its largest associated events have been included in the instrumental catalogue. The Egyptian earthquake of

October 1992 occurred when this book was in the final stages of preparation, and has also been included in the catalogue. Occurring within 10 km of Old Cairo, it caused substantial damage to ageing buildings and vulnerable historical monuments, and provides a useful yardstick for the analysis and interpretation of earlier, less well-known events.

Although our actual cut-off date is thus largely determined by the publishing schedule, we consider this to be an appropriate moment to present the results of our work so far. The likely return from pursuing our researches further does not at the moment justify a longer delay in publishing the catalogue. A similar expectation in the case of Iran turned out not to be accurate, for quite a few additional data have since been retrieved from sources not used by us at that time; but this is largely a function of the higher level of seismicity of Iran. Although there are substantial gaps in the macroseismic information presented here, there is little likelihood of filling them in the foreseeable future, without disproportionately laborious and systematic researches that we are not now in a position to carry out.

A second problem with the collector's instinct is that there is a tendency to hoard but not to discard. Most previous earthquake catalogues are accumulative, in the sense that data from one are absorbed by the next, errors and all, and 'new' events are added. However, the new events often turn out to be the old events appearing under a new date. The single most common failing in several generations of earthquake catalogues, for the Middle East as elsewhere, is the problem of multiple entries for the same event. The only catalogues to avoid these problems are those that refer back to the original sources of information, rather than relying on secondary evidence and a slavish repetition of previous lists.

A considerable amount could be said on this subject, and has been said elsewhere; but despite recent advances in the field of historical seismicity, to the extent that a European working group now meets regularly, it is worth reiterating the basic concept that underlies our work and the way it has been presented. Above all, we emphasise the need for critical analysis of historical sources. This involves identifying primary historical and instrumental evidence, distinguishing false reports and resolving conflicting information, particularly over dates and locations. This in turn has determined the layout and presentation of the main catalogue. Unlike our book on Iran, in which the notes were kept at the end, we have thought it preferable to present all the textual evidence and critical analyses together, to demonstrate the intimate connection between source criticism and the interpretations reached about individual earthquakes.

In the course of this, we aim to demonstrate why certain events should be removed from existing catalogues. It is not enough merely to remove (or ignore) them without comment, since later compilers simply reinstate them. It has to be shown conclusively why false earthquakes are false. The problem is usually chronological, but may be locational (Tripoli in Syria mistaken for Tripoli in Libya, or degrees West taken as degrees East, for example); or the 'earthquake' might actually have been a meteorite impact, a destructive flood, or a landslide. As a general principle, no earthquake that has not been confirmed or verified in a primary source of information has been included in our list.

This does not mean that we believe our catalogue to be perfect, with all sources of error or uncertainty removed. Nor would we wish it to be copied straight into computer databanks, any more than those of our predecessors. On the contrary, we emphasise that different interpretations of the evidence are possible, and that ours are not definitive. Rather, we aim to present the data available to us and the reasons for our own conclusions as transparently as possible, so that the reader or user can form his own opinion. Conclusions are often reached on very flimsy or uncertain evidence; indeed, sometimes it might be better if no conclusion were made, as this gives a misleading impression of exactitude.

These points are examined more fully in Chapter 1, which discusses the historical geography of the region, the sources of information available, and the methods of analysis of macroseismic data. In Chapter 2, a descriptive catalogue of all the earthquakes retrieved is followed by a table summarising our conclusions. We also present a section on earthquakes that have been reported but which it has not been possible to identify, and a summary list of false events.

A similarly critical approach has been adopted with regards to instrumental data, which are covered in Chapter 3. We have collected and reassessed all available reports, and where possible redetermined magnitudes from intensity reports and instrumental readings. One important aspect of this reevaluation of twentieth-century seismicity is the reconciliation between instrumental data and the macroseismic information presented in Chapter 2. Not only do reliable descriptions of the effects of an earthquake help determine its general location and size, thus minimising the chances for gross error, but they also permit correlations to be defined between various parameters of twentieth-century earthquakes, such as felt area, magnitude and

depth. These in turn can be used to quantify our assessments of events that occurred in the pre-instrumental period.

The work ends with a discussion of the completeness of the earthquake catalogue and the long-term seismicity of the region.

Comparisons with our book on Iran are perhaps inevitable, but our objectives here are less ambitious and this is not conceived as a comparable work. In the first place, the level of seismicity in the region studied is much lower, which imposes itself on the character of the data at our disposal. In particular, in the absence of major earthquakes and because of other constraints, we undertook almost no field trips to the scene of recent and early twentieth-century events.[1] Such visits could doubtless have thrown light on historical events, such as the Yemen earthquake of 11 September 1154. The research out of which this book grew was undertaken with the aim solely to provide a *catalogue raisonné* of earthquakes in the region, and this work was done in a relatively short time. The speed of the work was, however, facilitated in practice by experience gained in Iran and the random accumulation of information over a much longer period. Many points already addressed in our earlier book continue to be applicable and are not repeated. In addition, no attempt has been made to investigate regional tectonic processes or to evaluate seismic risk. We aim rather to produce a detailed source book of earthquakes affecting the area, for others to use for their own purposes, in the hope that they will be fully aware of the completeness and reliability of the information presented.

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[1]In January 1982, one of us (R.D.A.) undertook a UNESCO-sponsored mission to investigate the effects of the Aswan earthquake of 14 November 1981. Instrumental analysis of the main shock and aftershocks was evaluated, and damaged buildings were inspected in the Aswan region, where the intensity reached VI (MSK). A second visit to the area was made in March 1985; ground cracking near the Kalabsha fault was still evident.

A note on transliteration

Much of the research undertaken for this book is based on material written in Arabic or in Arabic script. The spelling of proper names, book titles, place names and other terms has been based on a consistent transliteration from Arabic, according to the system used in the *Cambridge History of Islam* (Cambridge, 1970), though for ease of reading, rigorous transliteration is only found in the bibliography.

Only the Arabic vowels a, i, and u are utilised; long and short vowels are not distinguished: thus u for al-Mukha (or Mokha, Mocha) and Qus. The diphthongs are written *au* and *ai*, though some may be more familiar with *aw* and *ay*: thus Hadramaut (Hadramawt). The signs ‘ and ’ represent the *‘ain* and the *hamza* respectively; the latter is used only in its medial position and ignored in the final position: thus Taima for Taima’ (Tayma’), San‘a for San‘a’. The *ta marbuta* is spelled *-a* (not *-ah*), or *-at* in the construct state: thus Jidda (Jeddah). The Arabic definite article is retained in personal names, thus al-Maqrizi, and generally in geographical names, as in al-Hudaida (Hudaydah, Hodeidah, etc.), though the *al-* is normally omitted from the maps. In all cases, well-known places are spelled in the current usage: Alexandria, Cairo, Medina, Mecca, the Yemen (Arabic: al-Yaman), the Hejaz (al-Hijaz).

This is fine for the earliest periods, but in the accounts of more recent events, this strict system can seem unnecessarily pedantic. Places in Cairo, for example, may appear as they do on modern maps. Where the same place is spelled in different ways in the book, alternatives are indicated either in brackets or in the index. For Libya and the Sudan, places are spelled as found on modern maps, or on the Geographical Section of General Staff (GSGS) editions of the War Office and Air Ministry maps of 1960. For Ethiopia we generally follow the forms given by Gouin (1979).

Modern Arab authors writing in English spell their names according to a variety of systems and naturally their names appear in the references and the bibliography as they appear on their work.

No reader will be surprised to find both inconsistencies and eccentricities in our spelling. Those who mind will certainly notice; we hope those who notice do not mind, and that all will excuse any shortcomings in this notoriously tedious exercise.

A note on chronology

Perhaps the simplest way of distinguishing one earthquake from another is its date, and yet the single greatest source of confusion and inaccuracy in existing earthquake catalogues is in the realm of chronology.

Arabic chronicles are the main source of information for the present catalogue, and they generally date events according to the Muslim calendar of twelve lunar months (354 days). The Muslim era originated in AD 622, when the Prophet Muhammad left Mecca for Medina on his *hijra* (Migration). This is sometimes called the *hijri* calendar; its use is indicated in the present work by the suffix H. In cases where a conversion is provided, the Muslim year comes first, followed by the Christian equivalent that forms the larger proportion of the Muslim year, e.g. 758/1357. The suffix H is not used when the month of the hijri year is given, since this identifies the calendar concerned.

Three points need to be borne in mind. First, the Muslim day begins at sunset (generally around 6.00 p.m.), so that day follows night. The Muslim 'Monday evening' is equivalent to the preceding Sunday evening according to our reckoning.

A second potential source of dislocation between the two calendars is that, in the past at least, the month began with the sighting of the new moon, particularly Ramadan, the month of fasting. This may account for some local discrepancies over dates. Furthermore, this source of discrepancy is enshrined by the formal existence of two separate hijri calendars, namely the civil or popular reckoning, starting from Friday 16 July 622, and the astronomical reckoning based on the true conjunction of the new moon on Thursday 15 July. It may not be clear which is being used in a given text. Here, for the sake of consistency, all conversions are performed from the tables in Freeman-Grenville (1963), which takes 16 July 622 as the start of the Muslim era.

Thirdly, the Muslim day is divided by the five times for prayer: between dawn and daybreak (*fajr*); shortly after midday (*zuhr*); afternoon (*'asr*); between sunset and dusk (*maghrib*) and night-time (*'isha*). These times are often used as reference points in the dating of earthquake shocks and other events.

The term *daraja* ('degree') is used for the measurement of the passage of time. Since 24 hours is equivalent to 360°, 1° is equivalent to 4 minutes. Although this may be an acccurate definition of *daraja*, it sometimes gives rise to a very long duration of shaking, which cannot always be due to the exaggeration of the observer. In the account of the earthquake of 936/12 November 1529, the shock is said to have occurred 10 *daraja* before dawn, while the muezzin was preparing to give the call to the dawn prayers. Forty minutes seems an inordinately long time for an experienced muezzin to be getting ready. Quatremère (1845, II/2, pp. 216–7), using several examples, says it means a short time, or a minute; at the other extreme, Nejjar (1974, p. 85), says it means five minutes. In view of this uncertainty, we generally leave the term *daraja* untranslated.

Another way of measuring the passage of time is by how long it takes to recite certain verses of the *Qur'an* (Koran). We have not attempted an empirical equivalent to such estimates, which are left as they are found. The whole interesting question of the perception and reporting of time in the mediaeval Islamic world would benefit from the type of analysis undertaken, in a parallel context, by Ferrari and Marmo (1985). It is worth considering the vagueness of time measurement, as well as the large areas sometimes involved, when one reads statements such as 'the shock occurred in all these places at the same time' – which may simply be a convenient judgement by the chronicler. In the case of the large North Arabian earthquake of 18 March 1068, for example, it is unlikely to be true, and may serve to disguise the occurrence of more than one shock.

The other calendar frequently referred to is the Christian Coptic calendar in Egypt and its Ethiopian equivalent. Its use in records of Ethiopian earthquakes is explained by Gouin (1979, pp. 19–20). A detailed

discussion and concordance of this calendar is given by Chaine (1925); Pellat (1986) provides a recent and convenient publication of some mediaeval Egyptian examples.

Various other calendars in use in the Middle East, such as the Syriac, which may be referred to occasionally in our sources, are treated by Grumel (1958). The latter notes that historical events can be dated by reference to earthquakes, comets and eclipses, and gives lists of each (pp. 458–81). After 1500, references to eclipses have been checked in the tables of Th. Oppolzer (English translation, 1962).

The Christian calendar was reformed by Pope Gregory XIII in 1582, although the unreformed Julian calendar remained in use in England until 1752. In the present catalogue, earthquakes are dated according to the Julian (Old Style) calendar up to 1582, and thereafter according to the Gregorian calendar. Dates between 1582 and 1752 are given the suffix NS (New Style).

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It is a shame, in a sense, that there are not more earthquakes to record in Saudi Arabia itself, and that the focus of our attention has thus strayed inevitably to the surrounding regions. Nevertheless, one benefit from our research has been to purge the catalogue of some earthquakes previously located in Arabia – it would be a fitting repayment if we could have a similar effect on the earthquakes of the future.