Should Users Trust or Not Trust Sieberg's *Erdbebengeographie* (1932)?

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ABSTRACT

The 1932 essay *Erdbebengeographie* (earthquake geography) of August Sieberg (1875–1945) has been widely used and quoted by earthquake catalog compilers all over the world. Sieberg's intent to document a global earthquake distribution was accomplished by means of regional lists of earthquakes, complemented by seismic activity maps, and deals with about 2300 earthquakes from 2200 B.C.E. to 1931. The background, distinctive elements, sources, and style of presentation of earthquake data of Sieberg's catalog are presented and commented on in this article in relation to their use in seismology in the last 80 yrs. Our critical analysis has allowed us to advance the most likely motives behind the long-lasting success of Sieberg's *Erdbebengeographie* in the compilation of the pre-1930 sections of current regional and global catalogs. Sieberg's earthquake lists turned out to be a paradigmatic example of an earthquake catalog that is a summary of dates, places, and effects from nonprimary sources of information, not cross checked nor checked versus their original records. However, Sieberg's summaries have often been mistaken for reliable and ready-to-use earthquake data. Finally, the answer to the question posed in the title of this article is not a simple "big no," but reasons are given to suggest that Sieberg's work should today be "handled with great care."

BACKGROUND

Besides being known for his contribution to the 12° Mercalli–Cancani–Sieberg (MCS) macroseismic scale, August Heinrich Sieberg (1875–1945) holds a prominent position and global recognition as the compiler of a worldwide descriptive list of earthquakes. His earthquake list is contained in the 319 pages chapter *Erdbebengeographie* (earthquake geography), included in the 1932 edition of the *Handbuch der Geophysik* by B. Gutenberg (Sieberg, 1932a). Sieberg's comprehensive essay has maintained its fame unaltered for over 80 yrs, has been widely referenced, and has contributed descriptions of the preinstrumental earthquake activity of many countries in quite a number of modern and recent earthquake studies and catalogs.

In the compilation of the "Global Historical Earthquake Catalogue (GHEC)" (Albini *et al.*, 2013, 2014), on more than one occasion the analytical process of tracing back the origin of an earthquake record or a catalog entry has led back to Sieberg's catalog. In a sense and rather unwittingly, these frequent encounters provoked a growing curiosity that could not be quenched but by digging into the folds of Sieberg's elaborate study, well rooted in its own time. After placing Sieberg and his work in the context of the emerging modern seismology of that time—magnitude and Richter's scale were still to come (Richter, 1935)—the results of a close-up analysis of the structure and content of *Erdbebengeographie* are reported here. A few case histories are discussed to show the lights and shadows of an indisputably pioneering work that aimed at compiling a global list of earthquakes of the past before the Internet era. The complex and all-encompassing structure of this earthquake geography impressed so favorably the following generations of seismologists that not even recent sound criticism could succeed in marring the actual importance attributed to Sieberg's data and his seismological interpretations. Finally, addressing Sieberg's work from a global perspective has resulted in a fresh awareness of the necessity of approaching with a critical mind the content and interpretation of earthquake records supplied by the several late nineteenth to mid twentieth century descriptive lists of earthquakes, on which many regional and global catalogs still rely upon today.

INTRODUCING AUGUST SIEBERG'S ERDBEBENGEOGRAPHIE (1932)

In the words of Davison (1927, p. 74), the famous world earthquake map by Robert and John William Mallet (Mallet and Mallet, 1858) "remained for nearly half a century our best representation of the distribution of earthquakes over the world." Behind Mallet's map, there was a list made up of something less than 7000 events for the time window 1606 B.C.E. to the end of 1842 (Mallet, 1853–1855), making its realization "surely one of the great achievements of Victorian seismology" (Musson, 2013, p. 764). Mallet's catalog entries were picked up from a rich set of sources (see the list in Mallet and Mallet, 1858). Among the sources two works emerged as largely used and cited: (1) the world catalog by the German Karl Ernst Adolf von Hoff (1771–1837), published posthumously in volumes four and five of his five-volume history of the Earth (von Hoff, 1840, 1841), and (2) the several regional catalogs and lists of

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annual world earthquakes that the French seismologist Alexis Perrey (1807–1882) had published between 1845 and 1871.

After the global although markedly and inevitably Western vision offered in the catalogs of von Hoff, Perrey, and Mallet, historical and geopolitical circumstances made the preparation of regional catalogs take precedence over worldwide ones. This happened in Italy (Baratta, 1901), in India (Oldham, 1883), in Japan (Milne, 1881; Omori, 1899), in the Philippines (Saderra Masó, 1910), and in Indonesia (Wichmann, 1918, 1922), to name but a few of the numerous regional catalogs published between 1880 and 1930.

In the late 1880s, in a sort of replica of Perrey's style of work, the French seismologist Fernand comte de Montessus de Ballore (1851–1923) began to dive into the compilation of his famous card index, made of "171,434 entries [...] 30 metres of bookshelf" (Ambraseys, 2009, p. 5). In 1884, de Montessus de Ballore started publishing several regional catalogs with his interpretations of earthquake data and distributed them in different books and journals. On such a huge amount of data, he based his *Géographie séismologique* (1906), a work that marked the early twentieth century revival of global earthquake catalogs. In de Montessus de Ballore (1906)'s own words, his seismological geography is the first work in which a "mappamonde séismographique," that is, a seismic world map had been published after Mallet's map (Mallet and Mallet, 1858) and in the wake of John Milne's "Seismic map of the world" (Milne, 1903).

At that time, August Sieberg had already been active in the field of geophysics and seismology in Strasbourg (then in Germany), later in Jena, and had just published his *Handbuch der Erdbebenkunde* (Handbook of Earthquake Science) (Sieberg, 1904). de Montessus de Ballore and Sieberg did not agree on some crucial methodological points, especially on the scientific value of macroseismic intensity and on the estimate of the frequency of earthquakes. Such disagreements turned often into sharp words, openly and mutually expressed in their works to contest the other's opinion. This is what de Montessus de Ballore (1916) did in his paper on "Earthquake intensity scales," in which he strongly objected to the drawing of isoseismals ("What has seismological science to lose in consequence of not drawing these isoseismals?") and the use of intensity scales, by heavily relying on Milne's and Omori's practice. At the same time, he carefully avoided using the name of Sieberg, who unmistakably was his target and antagonist. The confrontation between these two founders of seismology did not decline with the passing of de Montessus de Ballore in 1923.

From the publication of *Géographie séismologique* in 1906, some further 25 yrs had to pass before Sieberg put together his *Erdbebengeographie*. However, there can be no doubt that the title is intentionally chosen to be the translation into German of the title given by de Montessus de Ballore to his 1906 essay. Sieberg's intent to contrast and possibly supersede de Montessus de Ballore's work is plainly expressed in the opening chapter on *Untersuchungsmethoden* (research methods, p. 690), and this becomes apparent by just comparing the two tables of contents. Both works describe the seismicity of the world according to geographical regions characterized by a similar seismic behavior.

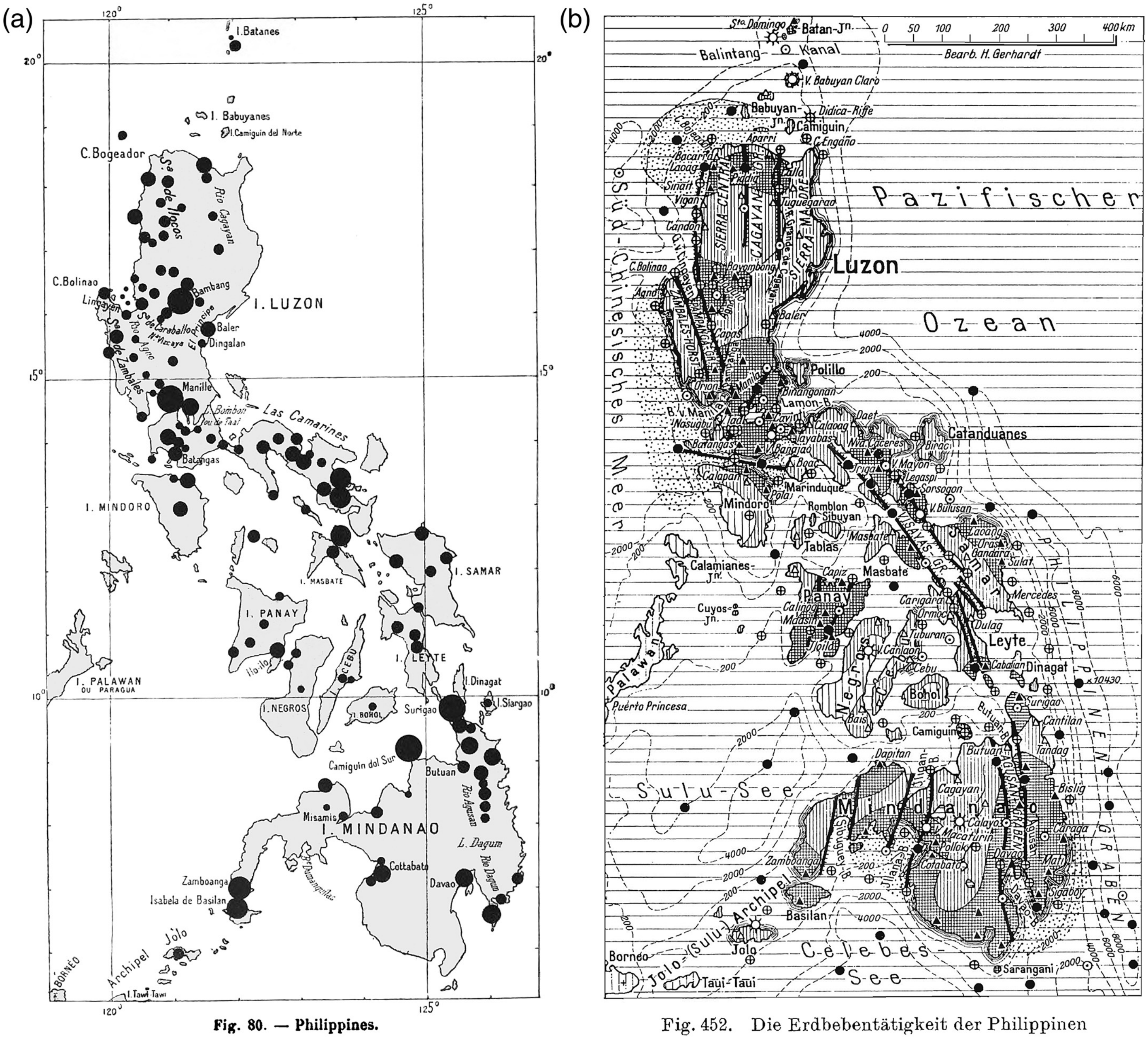
The major difference between the two studies lies in the style of presentation. To complement the textual part, in which he mainly discussed the geological features and a few large earthquakes, de Montessus de Ballore opted for a series of 52 maps, each describing the frequency of earthquakes at quite a number of places (black dots of increasing size in Fig. 1a). The book ends with a final, comprehensive, and global map rendering the world's dominant seismic traits (*géosynclinal*).

Similarly, Sieberg included 57 maps representing regional earthquake activity (*Erdbebentätigkeit*), as in the example of Figure 1b. A detailed legend of maps in the introductory section on tools and methods (Sieberg, 1932a, p. 691) was devised by Sieberg to define (1) seismic foci (*Erbebenherd*), classified according to their size, that is, large, medium, and local or small earthquake, (2) levels of effects at a place, labeled as destructive, damaging, or felt, (3) affected areas, rendered by different shadings to distinguish among earthquakes that are: severely damaging, corresponding to an intensity "≥ 8°" on the Mercalli–Sieberg scale (Sieberg, 1912); strongly damaging or intensity "6°–7°;" and slightly or not damaging, intensity "2°–5°." To add to an already complicated rendering, the maps contained elements indispensable to geologically characterize each region by showing geological boundaries, faults, fractures, and active volcanoes. In Sieberg's words, only the concurrent presence of all these aspects could have made evident the value of these maps to present an overview of the underlying observations, and especially to understand the distribution of seismic activity at a global scale.

However, what made, and still makes, the difference between these two world geographies of earthquakes, and the influence each exerted on later users, are the 98 lists of earthquakes (Table 1) that complement Sieberg's description of seismic activity. Differently from his predecessor Robert Mallet, de Montessus de Ballore never did compile, or in any case it remained in handwritten form, what might be properly called a global list of earthquakes. On the contrary, Sieberg took a stance on the importance of making publicly available the regional lists of earthquakes on which his interpretation of global seismicity was based.

PROFILING THE CONTENTS OF ERDBEBENGEOGRAPHIE

It looks like no appreciation was expressed by contemporary seismologists for either the results of Sieberg's work or his dedication to seismology, and in particular to the macroseismic data on past earthquakes. This distrust did not prevent Sieberg from going on with his project of an earthquake geography, which, he wrote, had to deal "with the geographic distribution of earthquakes and the problems of a theoretical and practical nature that arise from them" (Sieberg, 1932a, p. 687). Sieberg mentioned what specific aspects had to be considered to effectively combine geological and tectonic knowledge with macroseismic and microseismic observations (see also the introduction to



▲ **Figure 1.** Seismicity maps for the Philippines according to (a) de Montessus de Ballore (1906) and (b) Sieberg (1932a).

Sieberg, 1932b), and eventually to draw together a picture of earthquake activity at a global scale.

Distinctive Elements

Geography maintains its primacy throughout Sieberg's essay, which revolves around 10 large geographical areas or macroregions (Table 1). A separate chapter is devoted to each region, opened by a general overview on geological and tectonic features and by a table with numerical description of seismicity. The tables and text are complemented by 57 maps of seismic activity (*Erdbebentätigkeit*) that frame areas according to a geographical subdivision not exactly corresponding to that of one of the 10 macroregions. In their turn, the macroregions are further subdivided into smaller areas, each described in a separate paragraph, with its own geographical definition, again different from that of the seismic activity maps.

The textual presentation of data was alternated with figures and maps and was made according to the following fixed sequence: introduction; geological structure (*Aufbau*); earthquake activity (*Erdbebentätigkeit*) described in tables and maps; a list of the really significant earthquakes (*Wichtigere Erdbeben*) for the area; and further remarks.

For the purpose of this article, the core of Sieberg's work is represented by the 98 regional lists of earthquakes (see an example in Fig. 2) into which the descriptions of global seismic activity have been broken up. In 18 out of the 98 lists, the data were further subdivided according to subareas, making up a total of 150 items. Irregular in extension, for instance one area

Tabelle 146

Wichtigere Erdbeben des Ägäischen Beckens

d) Küsten- und Hellespontinseln

1383, im August. Auf Lesbos zerstörendes Erdbeben, 500 Tote.

1672, Mitte April. Kräftiges Schadenbeben auf Tenedos; das Schüttergebiet reichte bis über Kos und Santorin hinaus.

1845, Oktober, 11. Zerstörendes Erdbeben auf Lesbos, namentlich im Nordwesten. Bis Konstantinopel gefühlt.

1859, August, 21. Auf Imbros zerstörendes Beben mit großem Schüttergebiet, bis über Konstantinopel und Saloniki hinaus gefühlt.

1867, März, 7. Schwere Zerstörungen auf Lesbos, 150 Tote, mit Schüttergebiet bis Konstantinopel, Saloniki und Euböa. Vgl. Fig. 431.

1881, April, 3. Verwüstendes Erdbeben auf Chios, 4181 Tote, besonders auf der Ostseite. Großes Schüttergebiet.

1893, Januar, 28. Schweres Erdbeben auf Samothraki mit Seismischer Woge auf der Nordseite und an der thrakischen Küste. Großes Schüttergebiet.

▲ **Figure 2.** Reproduction of "Tabelle 146d" according to Sieberg's numbering of earthquakes in the Aegean Sea.

may include China and another a single island of the Pacific Ocean, these 98 areas in as many lists are the bricks of the global vision of world seismicity according to Sieberg.

In every list, each entry supplies the date of occurrence and a description of effects caused by a *wichtig Erdbeben* (significant earthquake) with respect to the area named in the title of the list. Sieberg himself informed us that his lists do not include all the earthquakes about which he had some knowledge, but rather these lists are made up of a restricted selection of only those cases he regarded as the most relevant out of the tens of thousands of earthquakes of which he had knowledge. To understand and analyze Sieberg's work, the full content of all the lists has been transcribed respecting the original version, that is, by compiling a comprehensive list entry by entry and preserving the links with the attribution to a specific geographical area as selected by Sieberg.

Data from all the lists have been merged into a single file consisting of 2297 entries, the distribution of which in the 10 macroregions is shown in Table 1. From a further overall analysis, 2121 entries were reckoned to refer to tectonic earthquakes, 120 entries were ascribed to earthquakes associated with volcanic eruptions, and 56 entries describe volcanic eruptions only. In the following remarks, events different from earthquakes are not treated.

For 103 out of the 2121 earthquakes, the synopsis of the event is complemented by an *ad hoc* isoseismal map, as in the example of Figure 3. Many of these isoseismal maps have been reproduced in so many papers and books to become for any seismologist kinds of icons that instantly call to mind Sieberg and his *Erdbebengeographie*.

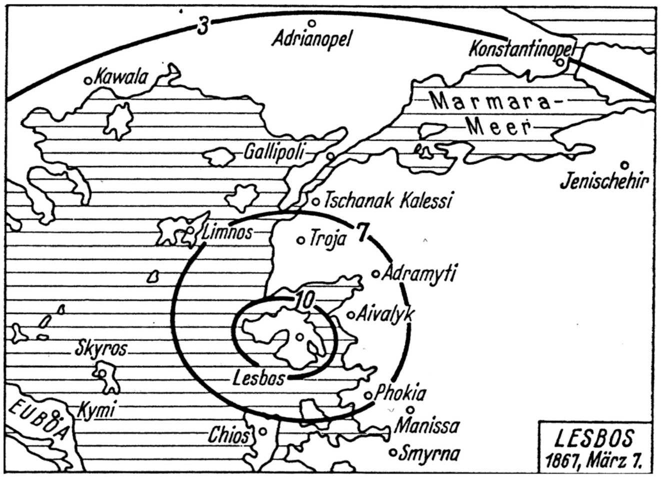
Looking Further Inside

How much the general approach just described affected Sieberg's vision of global seismicity is clearly illustrated by the data in Table 1, from which it emerges that the 2297 entries of *Erdbebengeographie* are without any doubt unevenly distributed in space and time. As shown in Figure 4, most of Sieberg's lists start around the year 1400 apart from a few entries before the Christian era listed for some small areas inside the macroregions of Europe, northern Africa, the Atlantic Ocean, and Asia. Most of the pre-1400 entries are related to earthquakes in the Near East countries then known as Palestine and Syria. Sieberg was likely interested in early twentieth century archaeological expeditions, in which there was competition among French, British, and German scientists for new sites to excavate. The Near East is a long-inhabited region with a well-documented tradition going

Table 1
Summary of Entries in Sieberg's *Erdbebengeographie* According to the 10 Macroregions Defined by the Author

Macroregion According to Sieberg's Order of Presentation	Number of Earthquake Activity Maps	Number of Earthquake Lists	Time Window (From)	Time Window (To)	Total Number of Entries	Number of Isoseismal Maps
Europe	16	18	1890 B.C.E.	1931	586	27
Asia	15	22	about 2000 B.C.E.	1931	581	45
Africa	6	20	2200 B.C.	1928	327	16
Indian Ocean and Islands	1	n.a.	–	–	–	
Australia, Tasmania, and New Guinea	2	4	1643	1929	84	
Pacific Ocean and Islands	3	5	1750	1931	111	
North America (including Mexico)	6	9	1447	1927	157	2
Central America and West Indies	3	8	1541	1927	155	6
South America	3	5	1530	1929	187	6
Atlantic Ocean and its islands	2	7	1013	1928	109	1
Total	57	98			2297	103

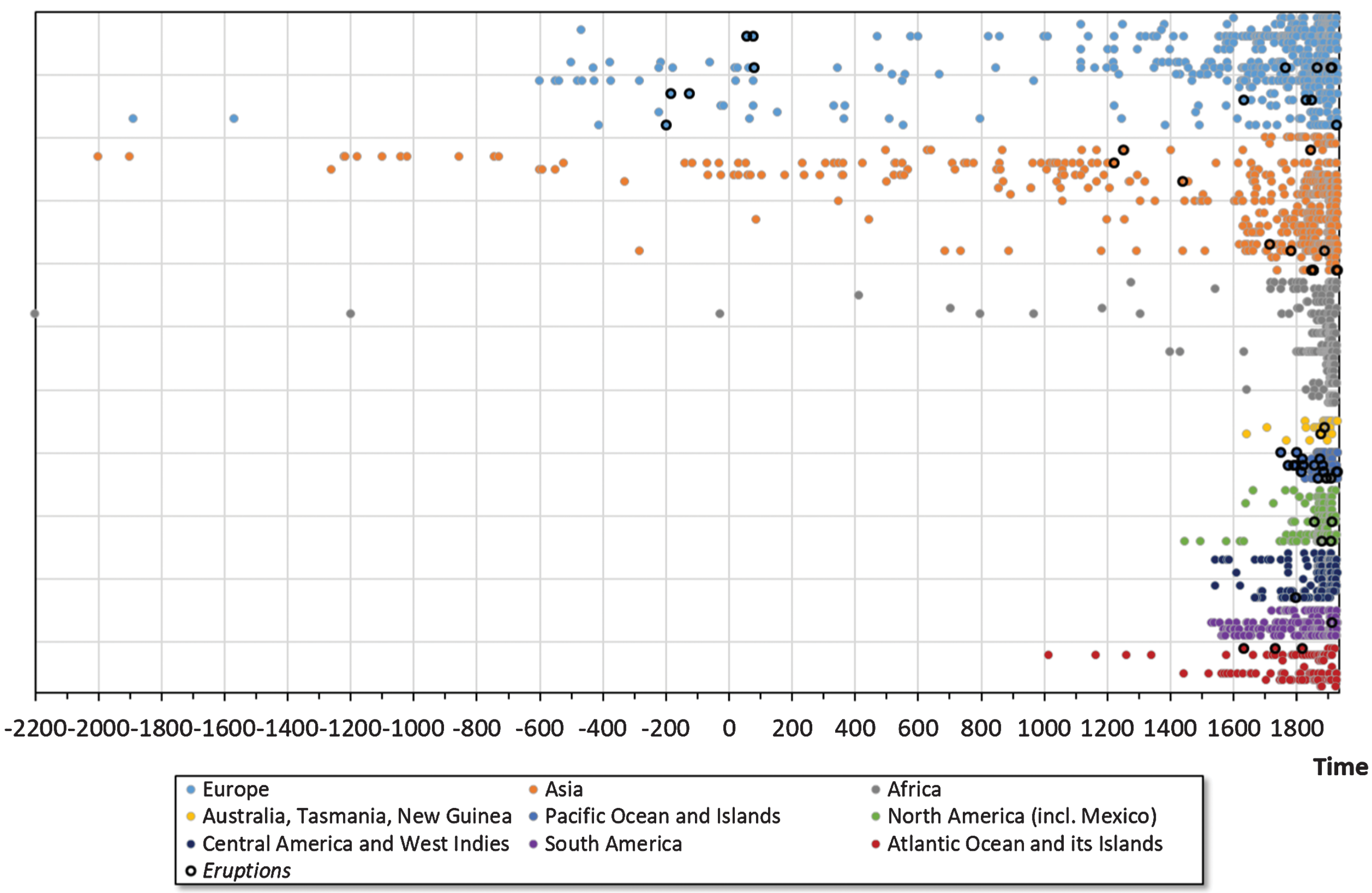
n.a., not available.



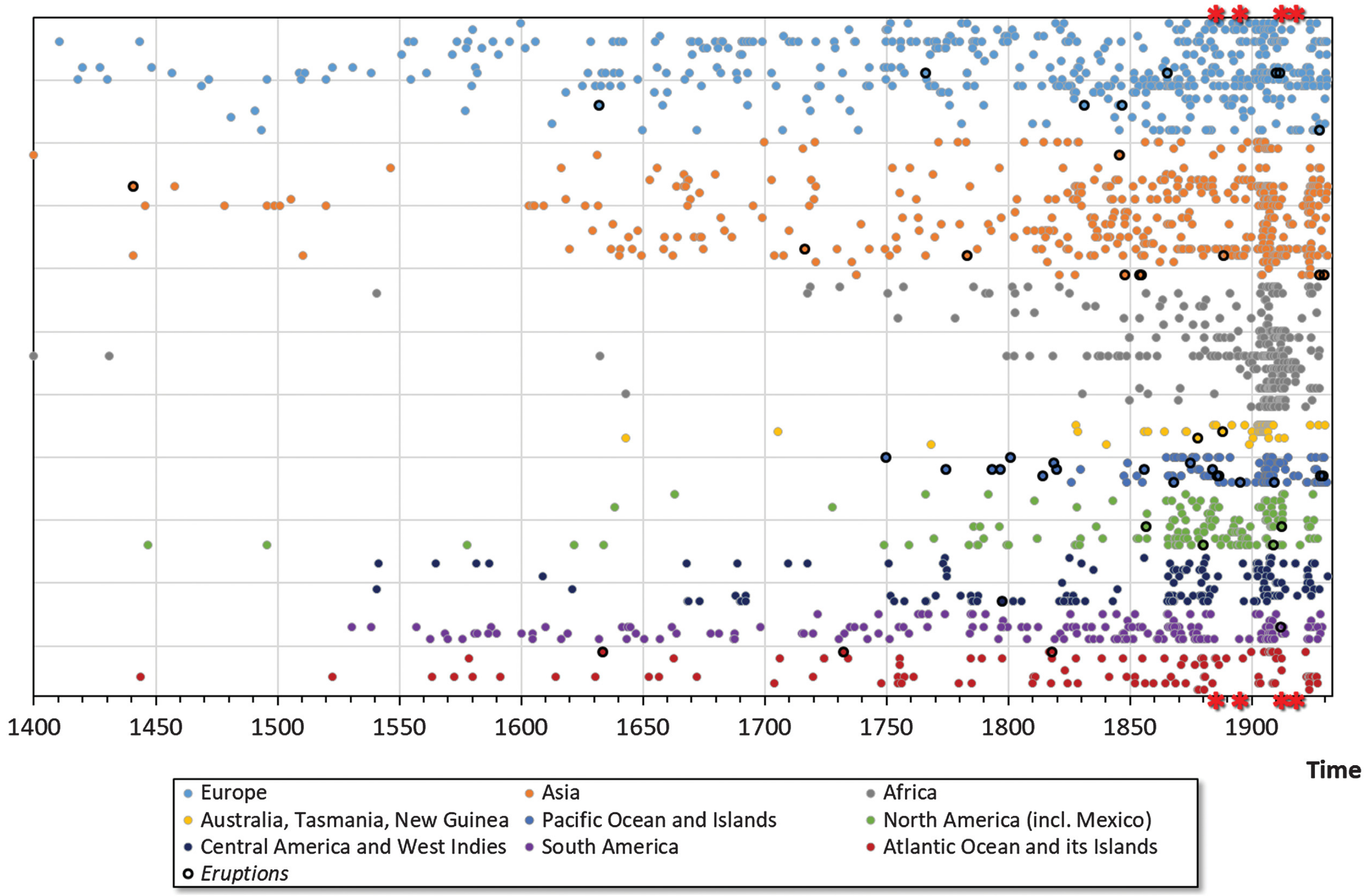
▲ **Figure 3.** Isoseismal map for the 7 March 1867 Lesbos earthquake (Sieberg, 1932a, his fig. 431), which is referred to in the list shown in Figure 2.

back to biblical times and with many historical earthquake accounts, possibly the best test region to confirm Sieberg's vision of long-term seismic activity. However, it was the occurrence of two large events, the 26 June 1926 Rhodes and the 11 July 1927 Jericho earthquakes that urged Sieberg to travel the area, sponsored by the *Notgemeinschaft der Deutschen Wissenschaft* (Emergency Association of German Science) to improve the current knowledge of seismicity and tectonics of the Eastern Mediterranean, as he himself explained in the introduction to another work of his that was published in the same year (Sieberg, 1932b).

Differences of some interest appear when focusing on shorter time windows, such as that from 1400 to 1931 shown in Figure 5, in which the irregular distribution of the entries in time and space becomes even more evident. The distribution of data between 1400 and 1800 is obviously constrained by the world geopolitical situation, and in particular it should be observed that it is distorted by the manifest predominance of Western sources of information in origin and language. It is not surprising, for instance, that Sieberg's reference literature for Far East countries was only the works in languages accessible and understandable to him, such as for China the works by Drake (1912) and Weng Wenhao (1921) in English and that by Hoang (1913) in French, or for Japan the papers (e.g., Milne, 1881) published in English in the *Transactions of the Seismological Society of Japan* (1880–1892) and later in the *Seismological Journal of Japan* (1892–1895).



▲ **Figure 4.** The 2297 entries of Sieberg distributed in time and 10 macroregions. A black empty circle indicates a volcanic eruption rather than a tectonic earthquake.



▲ **Figure 5.** Focus on Sieberg's entries in the time window 1400–1931. The black empty circles indicate a volcanic eruption, whereas the red asterisks point to the four time windows extensively commented at the end of the Looking Further Inside section.

Furthermore, the intertwining of the world political situation and of seismology being in its early stages as an independent discipline can be perceived as considerably affecting the amount and distribution of data in the last 50 yrs covered by Sieberg's essay. The following remarks refer to Figure 5, and give additional insights into this period with the intent to fully place Sieberg and his *Erdbebengeographie* in the historical and scientific context of his time.

1. There is something of a blank period from 1875 to 1895, the start of which corresponds roughly with the stop of the publication of "Note sur les tremblements de terre en [*year*]," due to the death of their author, the French seismologist Alexis Perrey. These global lists of earthquakes were highly considered by Sieberg ("unermüdlich durch zahlreiche Jahresberichte," tirelessly developed in numerous annual reports, p. 692), and the interruption of their publication created a massive gap in Sieberg's set of data sources.
2. The years 1895–1912 are a very packed period, coinciding with one period of Sieberg's intense activity in the field of collection and interpretation of macroseismic data, as shown in the bulletins of the *Hauptstation für Erdbebenforschung* in Strasbourg (Makroseismische Monats- und Jahresberichte, 1908–1913). It is in these same years that Sieberg worked on and published his contribution to amend and develop Mercalli's macroseismic intensity scale (Sieberg, 1912).
3. The First World War (1914–1918) caused a serious halt to the exchange of data at regional and global scales, as is clearly visible in the lesser amount and irregular distribution of data in the 10 macroregions.
4. Although not at the same levels of the pre-World War I period, Sieberg's productivity had an important rebound in the years 1920–1930, the last period in Figure 5. This change in information flow is also attested to by the publication of the bulletins of the *Hauptstation für Erdbebenforschung*, transferred to Jena where Sieberg had moved (Makroseismische Monats- und Jahresberichte, 1920–1924), the preparation of monographic studies on three large earthquakes in 1926 (Rhodes), 1927 (Jericho) (both in Sieberg, 1932b), and 1928 (Corinth) (Sieberg, 1928), and, of course, of his *Erdbebengeographie* (1932a).

Sources and Style of Presentation

Background information on the 98 regional lists of earthquakes is clearly explained in the introduction (Sieberg, 1932a, p. 692).

1769 May 1 Baghdad. During a damaging thunderstorm a number of shock were felt in the city
Ambraseys and Melville 1982, p.53

1769 A.D. May 1. Strong destruction in Baghdad (Sieberg 1932, p.804)
Alsinawi and Ghalib 1975, p.544

1769, Mai 1. Große Erdbebenzerstörungen in Bagdad
Sieberg 1932, p.804

1769 May 1 Turkey, Bagdad - III - (Mallet 1854). Partly hurricane
Milne 1912, p.45

1769 May 1, 2 p.m., Bagdad. Several shocks. Accompanied by a terrible hurricane.
2,000 or […] 4 000 houses were thrown down (Jour. Histor., 1769; **Gazette de France, 1769**; Richard, 1771)
Mallet 1854, p.165

1769 – 1° mai, 2 heures du soir. A Bagdad, ouragan terrible, accompagné de secousses souterraines:
2,000 maisons (suivant d'autres 4,000) furent renversées (Jour. Histor., 1769; **Gazette de France, 1769**; Richard, 1771)
Perrey 1850, p.33

De Bagdad, le 20 Mai 1769
Le 1er de ce mois, à deux heures aprés-midi on essuya en cette Ville un ouragan terrible accompagné de secousses de tremblement de terre & d'un déluge de pluie mêlée de grosse grêse, lequel dura plus de deux heures […]
Gazette de France, 1769 Nov 3

▲ **Figure 6.** The 1769 Baghdad case. Omitting any specific reference, Sieberg (1932a) summarized in four words the interpretation of this event given by Milne (1912), who instead clearly quoted Mallet (1854). Mallet had used the same sources of Perrey (1850), for example, the periodical Gazette de France (1769). Alsinawi and Ghalib (1975) relied upon Sieberg but forgot to mention that a damaging storm was associated with this presumed seismic event, a storm that may have been at the origin of the damage caused to buildings.

Sieberg traced his data to quite a number of published items that supplied observations of the effects of earthquakes (*Beobachtungsmaterial*), which he described as catalogs, macroseismic surveys, and studies of individual earthquakes. He also mentioned the difficulties he encountered to get hold of these scattered and obscure publications. However, besides citing a few authors dealing with earthquakes at a global scale, such as von Hoff (1840, 1841), Perrey (1850–1871), and Fuchs (1886), Sieberg did not exhaustively detail his sources of information. This means that, except for a very few events of the late nineteenth to early twentieth century, there is no direct reference to the origin of the record of a specific earthquake. Sieberg's style of providing only a loose connection between the original records and the data he published has made it almost impossible to trace back his steps in reappraising hundreds of earthquakes. The case of the 1769 Baghdad event (Fig. 6) may help in illustrating this last consideration. Retracing the possible sources used by Sieberg for this event, one finds Milne (1912), who quoted Mallet (1854), who in his turn used the same sources as Perrey (1850). For both Perrey and Mallet, the source closest in time and space to the event is a report from Baghdad dated 20 May 1769 and published in the 3 November issue of Gazette de France (1769).

Some similar sample checks were performed on the entire *Erdbebengeographie*, and they made quite evident that for earthquakes up to 1875 Sieberg only considered and republished earthquake data (i.e., date, affected places, and effects) derived from concise and ready-to-use descriptions in the literature available to him. Not a single source contemporary to an earthquake is cited, not even for early twentieth century earthquakes, the descriptions of which were mostly based on intensity data extracted from macroseismic bulletins. Considering that his predecessors von Hoff (1840, 1841), Perrey (1850), and Mallet (1853–1855) had adopted an opposite style by carefully referencing the sources they had relied upon for each earthquake, Sieberg's approach to this aspect represents an unfortunate setback in the practice of investigating and interpreting data on earthquakes of the past.

Although Sieberg put forward his difficulties in retrieving data about the earthquakes as a good reason to clear himself for using a shortcut when it came to properly referencing his sources of information, conversely he was sure and proud of the style of presentation he had adopted. Both explicitly in the introduction to *Erdbebengeographie* and especially in the way by which he structured and presented his results, Sieberg claimed that the summary description of each earthquake in his regional lists was to be considered trustworthy and original because (1) it was based on a thorough investigation and cross-check of the available and newly retrieved sources; (2) it supplied the ultimate reappraisal of the records for any earthquake selected to be included in his lists.

If these summaries are surely a peculiar aspect of Sieberg's work, they do not necessarily represent an improvement in the style of his predecessors and sources. A simple comparison between Mallet's and Sieberg's full texts shown in Figure 6 to describe the 1769 Baghdad earthquake makes clear that the four words used by Sieberg are really a meagre account of the event. Unfortunately, this is not an isolated case. The great majority of Sieberg's summaries are made of a few words, according to the format "date + earthquake + adjective hinting at the intensity of effects + (one) location," the last in many cases was not even a settlement but a region. With respect to Mallet's or Perrey's style, Sieberg transformed proper earthquake descriptions into snippets of information, especially on those (many) occasions when the format was reduced to "date + earthquake + location." Sieberg's choice of such a style of presentation should not be seen as unintentional. On the contrary, his familiarity with the definitions of effects in MCS macroseismic scale made him consciously adopt a standardized presentation and lexicon, easily referable by any seismologist, then as today, to an intensity degree. Although this may be considered an extra value in communication with respect to the diverse descriptions of effects used by his predecessors, in Sieberg's case this style was so excessive to cause a leveling of the seismological content of the earthquake records coming from varied sources, of different historical periods and geographical areas as well as from various linguistic and cultural contexts.

Together with this oversimplified descriptions of earthquake effects, Sieberg's way of distributing earthquake data according to his geographical view (see the Distinctive Elements section) is another aspect to consider when evaluating the reliability of the earthquake interpretations given in his summaries.

The extreme geographical fragmentation of the global seismicity proposed by Sieberg in his 98 lists may seem to be the result of an accurate investigative work ending in a sound spatial distribution of the listed earthquakes. In reality, this complicated geographical distribution of data (macroregion, region, subregion) significantly affected the possibility of providing a comprehensive view of each individual earthquake in its larger context. For example, the 16 February 1861 Sumatra earthquake (modified Mercalli intensity [MMI] X, according to Harris and Major, 2017, who consider it as a twin of the 26 December 2004 Sumatra event), is included by Sieberg in list number 160 (Sumatra and Nicobares), as follows: "Destruction in Tapanuli to Pengabungan, Batang and Singkel. Earth opened and cracked with coastal changes in the west. There was a tsunami wave. 50 dead. Felt also on the Malacca Peninsula and Java" (Sieberg, 1932a, p. 835). This same earthquake is also mentioned independently in list number 157 (India), as "A very strong earthquake on the peninsula of Malacca, reported from Pulo Pinang and Singapore" (Sieberg, 1932a, p. 818). Because the attribution of effects due to the same earthquake to two geographical subregions is a lead to Sieberg's style of data handling, a question suggested by this easily explained case is how many other, more ambiguous data may have been turned into duplicate earthquakes by a regional, fragmented reading of *Erdbebengeographie*.

Sieberg adopted this new style of presenting in a standard format the information concerning the size and location of more than 2000 earthquakes with the evident purpose of modeling such data to fit his vision of the global earthquake distribution. He pretended his summaries to be much more accurate with respect to their seismological content than they actually are, especially if used at a regional instead of at a global scale.

FOLLOWERS

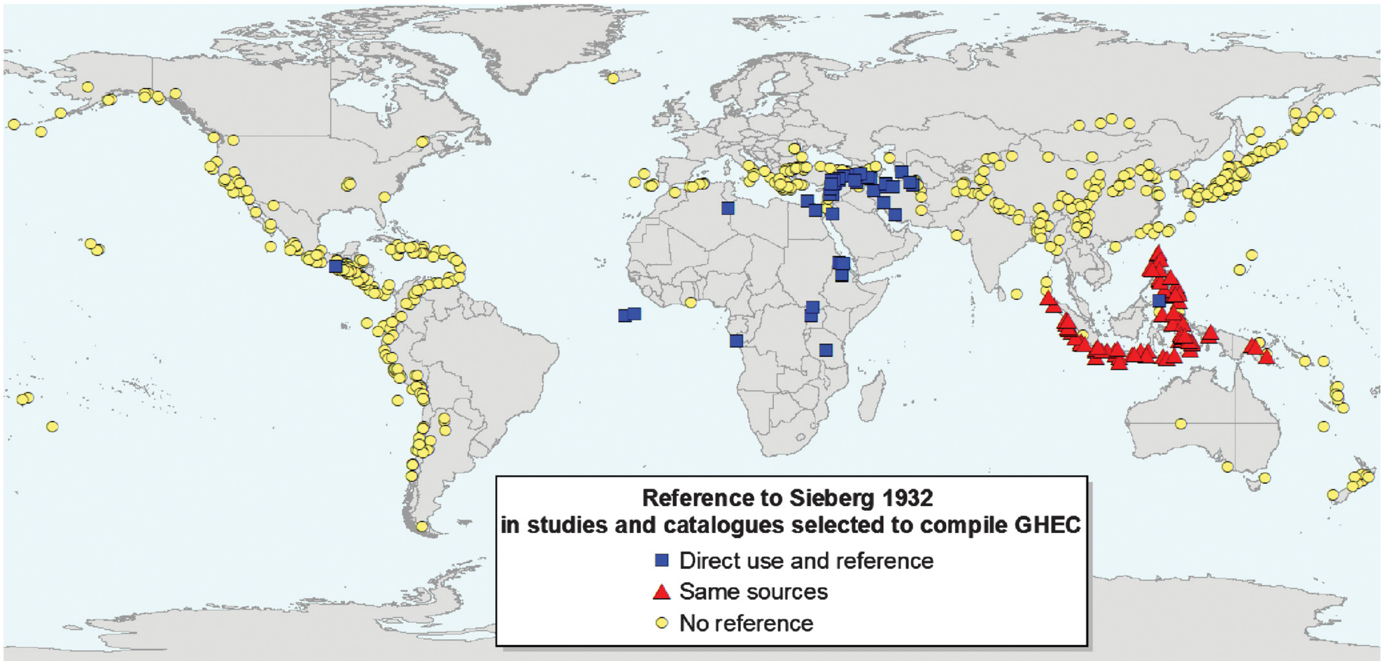
Early followers of Sieberg and his style of earthquake catalog were Gutenberg and Richter (1949), who in their "Seismicity of the Earth" wrote (the "Material" section, p. 8): "Macroseismic data have been used to supplement instrumental results in the regional discussion. An important source is the catalog by Milne (1912). Sieberg (1932a, with many references) has been consulted throughout." In particular for some regions, as is the case of Borneo, Gutenberg and Richter (1949, p. 82) faithfully relied just upon Sieberg: "Borneo is part of a stable mass, separated from Celebes by the active fracture of the Strait of Macassar. […] Macroseismic data are reported by Sieberg (1932a, p. 833)." Because Gutenberg and Richter's choice may still appear valid and up-to-date, it is worth remembering that Sieberg's fame had stemmed from his expertise on the MCS macroseismic scale and on compilation of contemporary macroseismic data.

Since its publication in 1932, the popularity of Sieberg and his *Erdbebengeographie* in the field of macroseismic studies of earthquakes assured to this work a mention in more than one overview of early twentieth century earthquake catalogs. Listed among "numerous regional and global macroseismic catalogs" in Ambraseys and Melville (1982, p. 20), Sieberg (1932a) is later on described in a footnote as "oversimplified and misleading, containing gross errors and duplications in entries" for Persia. Cited also in the case of Turkey and surrounding areas, "Sieberg's annotated world catalogue" is said to contain "a considerable amount of information, including isoseismal maps […] However, his catalog gives no indication as to his sources of information" (Ambraseys and Finkel 1995, p. 28). Included in a survey of the principal earthquake catalogs for the Mediterranean area (Guidoboni *et al.*, 1994, pp. 18–20), Sieberg is presented as the last representative of the compilers of nonparametric catalogs, and a catalog collector in that he contributed to "the stratification of a great deal of often unchecked information" taken from previous catalogs.

Although Sieberg's *Erdbebengeographie* was considered a "highly inaccurate work [that] has for many years been the standard reference on the subject" and the perfect example of "the twentieth-century trend towards undiscriminating cataloguing" (Ambraseys, 2008, 2009), modern seismologists have not been easily discouraged from using it. They have used indiscriminately Sieberg's data on earthquakes, often in combination with studies using a completely different method, such as studies in which priority is given to searching for primary and original sources, contemporary to the events.

To illustrate this aspect it is worthwhile going back to the example of the 1 May 1769, Baghdad event from the point of view of post-Sieberg studies (Fig. 6). Some late twentieth century catalog compilers (e.g., Alsinawi and Ghalib, 1975) did not seek the original information about the earthquake but rather relied upon Sieberg, ignoring the detail of a storm that had been reported by Perrey, Mallet, and Milne. A description of this same event is included in Ambraseys and Melville (1982) and in Ambraseys (2009), who used the same sources as Perrey (1850) and Mallet (1854) but without referencing any of them in relation to the 1769 event. To further highlight the uncertainty of the record for the 1769 earthquake, in their table 5.1 Ambraseys and Melville (1982) attributed to it an epicentral intensity 5 and defined Baghdad as a very approximate location (quality "e"). In the list of "Significant Earthquakes" of National Oceanic and Atmospheric Administration (NOAA) (see Data and Resources), the 1769 earthquake is included on the basis of an untraceable report (Alsinawi *et al.*, 1985), which appears to summarize the contents of the already mentioned paper of Alsinawi and Ghalib (1975). In NOAA's list, this event has an intensity of VII MMI and an epicentral location in Baghdad, both of which are supported only by the four word description in Sieberg (1932a; Fig. 6). Although NOAA also referenced Ambraseys and Melville (1982) for this earthquake, the interpretation and the uncertainty that Ambraseys and Melville (1982) had expressed about the reliability of Sieberg's record were disregarded.

To further check whether or not Sieberg's *Erdbebengeographie* still maintains, nowadays, its leading position among the descriptive lists of earthquakes used to compile current



▲ **Figure 7.** Sieberg's influence on the 92 studies and catalogs supporting the "Global Historical Earthquake Catalogue (GHEC)," which includes 825 earthquakes of **M** ≥ 7 covering the time window 1000–1903 (see Data and Resources; Albini *et al.*, 2013, 2014).

parametric catalogs, we have thoroughly consulted the studies and catalogs supporting the "GHEC," which includes 825 earthquakes of **M** ≥ 7, in the time window 1000–1903 (see Data and Resources; Albini *et al.*, 2013, 2014).

Our examination looked at all data sources directly quoted in the 92 studies and catalogs selected for GHEC, and this made it possible to ascertain that:

- The majority of the works make no direct reference to Sieberg (yellow dots in Fig. 7), especially those chosen in the compilation of the GHEC for China, Japan, and the Americas.
- Quite a number of studies and catalogs used the same sources used by Sieberg (red triangles in Fig. 7), and this pertains mainly to events in the Philippines and Indonesia. The reference studies for the long-term seismicity of the Philippines in modern studies and catalogs (e.g., Bautista and Oike, 2000) are the same works of Miguel Saderra Masó of the Weather Bureau in Manila quoted by Sieberg (e.g. Saderra Masó, 1910). To describe the past seismicity of Indonesia, Sieberg relied upon the two volumes of Wichmann (1918, 1922) in German. That Wichmann's compilation is still unique in dealing with past earthquakes in Indonesia is confirmed by the recent full translation and reconsideration proposed in Harris and Major (2017).
- There are regions where Sieberg was referenced and directly used as the source of the "macroseismic data" (blue squares in Fig. 7). Apart from a study on a single event in Mexico, these regions are the Near and Middle East, the Philippines, and Africa. The last continent deserves special consideration because it is the only one for which Sieberg (1932a) has turned out to be at the root of all the most recent studies (e.g., Ambraseys and Adams, 1991, 1992). In this particular case, the author's access to local sources is directly related to the geopolitical situation of his time. Sieberg (1932a, p. 895) himself informed us of the important part that the "deutschen kolonialen Erdbebendienst" (German colonial seismological service) had played in the discovery of the seismic activity of the German colonies in sub-Saharan Africa, namely *Deutsche Kolonie Kamerun*, 1868–1916; *Deutsche Kolonie Togo*, 1884–1916; *Deutsch-Ostafrika* (corresponding to today Burundi, Rwanda, mainland Tanzania), 1885–1919; *Deutsch-Südwestafrika* (Namibia), 1884–1915.

There exists another category, probably the largest, that may be identified with the unknowing followers and users. These are mostly authors of studies and catalogs that used studies and catalogs that gave no full reference of their sources, which in their turn had used Sieberg (1932a) as their reference study. Although what we carried out is a check of the time window 1000–1903 and the earthquakes included in the GHEC, what is evident from the map in Figure 7 is that Sieberg's *Erdbebengeographie* has been greatly respected and used by seismologists over the last 80 yrs.

SIEBERG'S LEGACY AND INSTRUCTIONS FOR USE

In the foregoing discussion, we proposed good reasons to explain why Sieberg's *Erdbebengeographie* significantly contributed earthquake data to regional catalogs compiled in the last decades of the twentieth century.

On the one hand, it was noted that Sieberg's personal selection of the post-Mallet (1853–1855) compilations of historical earthquake records and macroseismic data included works that are still unsurpassed with respect to the set of primary sources they used, in particular for some regions of Asia and Africa. On the other hand, because of his great expertise in dealing with the macroseismic data for contemporary twentieth century earthquakes, Sieberg presumed that with the same methods and means he could approach the investigation and interpretation of earthquakes of the previous centuries at a global scale. With a blind faith in his predecessors, Sieberg adopted a process of uncritical accretion of previous regional lists of earthquakes, merged them, and finally unpacked the obtained lists by distributing earthquakes according to his own geographical vision into a seismologist friendly version of regional lists of earthquakes. He produced a recompilation of many compilations of historical earthquake data, without the minimum critical competence needed to discriminate among exaggerations and duplications often involuntarily created in past centuries by the nonseismologist authors of the original descriptions of earthquakes. Sieberg's earthquake activity lists are a paradigmatic example of a summary of dates, places, and effects from nonprimary sources of information, not cross-checked nor checked versus their original records.

After having comprehensively analyzed Sieberg's *Erdbebengeographie*, we went back to the initial question that gave start to all this, "Why is this work of Sieberg still at the origin of many records in different catalogs?" We reckoned that the appeal of Sieberg's digests of the available knowledge on thousands of earthquakes lies in the lexicon he used, loaded of catchphrases evoking the descriptions of intensity degrees in macroseismic scales. Although Sieberg's style of presenting data may seem to embrace the complexity of the earthquake phenomenon, in reality his average description of a single earthquake ranges between four words to one or two lines of text. His summaries of summaries were mistaken for reliable earthquake records, presented in a standard format not dissimilar to a set of earthquake parameters expressed in words instead of figures as in modern parametric catalogs. These earthquakes in a nutshell were destined to be the actual legacy of Sieberg's *Erdbebengeographie*.

Finally and on the grounds of our previous considerations, it is our opinion that Sieberg's earthquake data should never be used directly as "a source," either in the form of the cursory summaries of the Lists in *Erdbebengeographie* (1932a) (some of which he republished under the title of Catalogs in Sieberg, 1932b) or—especially—in the form of his isoseismal maps, which are a clear attempt at resolving his simplified interpretations into supposedly reliable intensity data.

At this point, one may correctly think that our answer to the question posed in the title is a kind of "big no." Such a simple and irrevocable answer would mean to entirely distance ourselves not only from the results of Sieberg's work, but also from any responsibility we users have had in thoughtlessly translating the earthquake data he supplied into seismic parameters to fill in modern catalogs, especially for remote times and regions. It would be very easy to put all the blame on Sieberg, when in reality his style of digested and standardized descriptions has been greatly appreciated by its followers, essentially because his format saved users from the time-consuming job of checking the original sources and comparing the descriptions of effects. Consequently, we prefer to avoid such a curt answer, which would mean to merely argue that Sieberg's *Erdbebengeographie* is surpassed. By answering "yes, but handle with great care," we would like to maintain ourselves with an open mind with respect to what may still be usefully derived from the last twentieth century attempt that Sieberg made to propose a global earthquake distribution.

Our suggested critical approach to Sieberg's *Erdbebengeographie* and its use might be hopefully extended to other nineteenth to early twentieth century authors who compiled, before Sieberg, lists of regional and global earthquakes of the previous centuries. Tracing back, rereading and increasing the amount and quality of primary sources of information for the earthquakes that were included in descriptive catalogs similar to Sieberg's would allow researchers to get rid of summaries of already interpreted earthquake data. In its turn, this change of tack would hopefully stop the process of the indiscriminate accumulation of unchecked information that still creeps into current catalogs and would reduce the impact of preinstrumental seismicity data based on their inevitably outdated interpretations of historical earthquake records.

DATA AND RESOURCES

The Global Historical Earthquake Catalogue (GHEC) and the Global Historical Earthquake Archive (GHEA) are available at https://www.emidius.eu/GEH/ (last accessed May 2018). The National Oceanic and Atmospheric Administration (NOAA) Significant Earthquakes database is available at https://www.ngdc.noaa.gov (last accessed May 2018).

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REFERENCES

Albini, P., R. M. W. Musson, A .A. Gomez Capera, M. Locati, A. Rovida, M. Stucchi, and D. Viganò (2013). Global historical earthquake archive and catalogue (1000–1903), *GEM Technical Rept. 2013-01 V1.0.0*, GEM Foundation, Pavia, Italy, 202 pp., doi: 10.13117/GEM.GEGD.TR2013.01.

Albini, P., R. M. W. Musson, A. A. Gomez Capera, M. Locati, A. Rovida, and D. Viganò (2014). The global earthquake history, *Earthq. Spectra* **30,** no. 2, 1–18, doi: 10.1193/122013EQS297.

Alsinawi, S., and H. A. A. Ghalib (1975). Historical seismicity of Iraq, *Bull. Seismol. Soc. Am.* **65,** no. 5, 541–547.

Alsinawi, S., S. G. Baban, and A. S. Issa (1985). Historical seismicity of the Arab region, *IASPEI-UNESCO Working Group on Historical*

Seismograms and Earthquakes, Tokyo, Japan, 27–28 August 1985, Preliminary Proceedings, 59–84.

Ambraseys, N. N. (2008). Descriptive catalogues of historical earthquakes in the Eastern Mediterranean and the Middle East; revisited, in *Historical Seismology Interdisciplinary Studies of Past and Recent Earthquakes*, J. Fréchet, M. Meghraoui, and M. Stucchi (Editors), Springer Science+Business Media B.V., Dordrecht, The Netherlands, 25–39.

Ambraseys, N. N. (2009). *Earthquakes in the Mediterranean and Middle East: A Multidisciplinary Study of Seismicity up to 1900*, Cambridge University Press, Cambridge, United Kingdom, 968 pp.

Ambraseys, N. N., and R. D. Adams (1991). Reappraisal of major African earthquakes, south of 20° N, 1900–1930, *Nat. Hazards* **4,** 389–419.

Ambraseys, N. N., and R. D. Adams (1992). Reappraisal of major African earthquakes, south of 20° N, 1900–1930, *Tectonophysics* **209,** 293–296.

Ambraseys, N. N., and C. Finkel (1995). *The Seismicity of Turkey and Adjacent Areas. A Historical Review, 1500–1800*, Eren, Istanbul, Turkey, 240 pp.

Ambraseys, N. N., and C. Melville (1982). *A History of Persian Earthquakes*, Cambridge University Press, Cambridge, United Kingdom, 219 pp.

Baratta, M. (1901). *I Terremoti d'Italia. Saggio di Storia, Geografia e Bibliografia Sismica Italiana con 136 sismocartogrammi*, Fratelli Bocca Editori, Turin, Italy, 950 pp. (in Italian).

Bautista, M. L. P., and K. Oike (2000). Estimation of the magnitudes and epicenters of Philippine historical earthquakes, *Tectonophysics* **317,** nos. 1/2, 137–169.

Davison, C. (1927). *The Founders of Seismology*, Cambridge University Press, Cambridge, United Kingdom, Reprint edition by Arno Press, New York, New York, 1978, 240 pp.

de Montessus de Ballore, F. (1906). *Les tremblements de terre - Géographie séismologique*, Armand Colin, Paris, France, 475 pp. (in French).

de Montessus de Ballore, F. (1916). Earthquake intensity scales, *Bull. Seismol. Soc. Am.* **6,** no. 4, 227–231.

Drake, N. F. (1912). Destructive earthquakes in China, *Bull. Seismol. Soc. Am.* **2,** no. 1, 40–91.

Fuchs, C. W. C. (1886). Statistik der Erdbeben von 1865–1885, *Sitz. der kais. Akad. der Wissensch.*, Vienna, Austria, 215–625 (in German).

Gazette de France (1769). *De Bagdad, le 20 Mai 1769*, Vendredi 3 Novembre, Paris, France, n. 88, p. 355 (in French).

Guidoboni, E., A. Comastri, and G. Traina (1994). *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century*, Istituto Nazionale di Geofisica, Bologna, Italy, 504 pp.

Gutenberg, B., and C. F. Richter (1949). *Seismicity of the Earth and Associated Phenomena*, Princeton University Press, Princeton, New Jersey, 273 pp.

Harris, R., and J. Major (2017). Waves of destruction in the East Indies: The Wichmann catalogue of earthquakes and tsunami in the Indonesian region from 1538 to 1877, *Geol. Soc. Lond. Spec. Publ.* **441,** 9–46, doi: 10.1144/SP441.2.

Hoang, P. (1913). *Catalogue des tremblements de terre signalés en Chine d'après les sources chinoises*, Observatoire de Xujiahui, Zikawei, Shanghai (in French).

Makroseismische Monats- und Jahresberichte (1908–1913). *Hauptstation für Erdbebenforschung*, Strasbourg, France (in German).

Makroseismische Monats- und Jahresberichte (1920–1924). *Hauptstation für Erdbebenforschung*, Jena, Germany (in German).

Mallet, R. (1853–1855). Third report on the facts of earthquakes phenomena, catalogue of recorded earthquakes from 1606 B.C. to A.D. 1850, *Report of the 22nd Meeting of the British Association for the Advancement of Science*, 1–176; Report of the 23rd Meeting of the British Association for the Advancement of Science, 117–212; Report of the 24th Meeting of the British Association for the Advancement of Science, 1–326.

Mallet, R., and J. W. Mallet (1858). The earthquake catalogue of the British association, with the discussion, curves, and maps, etc., Taylor and Francis, London, United Kingdom, 1–176, 117–212, 1–326 pp.+136 pp.+maps.

Milne, J. (1881). Notes on the great earthquakes of Japan, *Trans. Seismol. Soc. Japan* **3,** 65–102.

Milne, J. (1903). Seismological observations and earth physics, with 3 illustrations and map, *Geogr. J.* **21,** 1–25.

Milne, J. (1912). *A Catalogue of Destructive Earthquakes A.D. 7 to A.D. 1899*, British Association for the Advancement of Science, London, United Kingdom, 92 pp.

Musson, R. M. W. (2013). A history of British seismology, *Bull. Earthq. Eng.* **11,** 715–861, doi: 10.1007/s10518-013-9444-5.

Oldham, T. A. (1883). A catalogue of Indian earthquakes from the earliest time to the end of AD 1869, *Memoir. Geol. Surv. India* **19,** 163–215.

Omori, F. (1899). Overview of large earthquakes of Japan, *Publ. Earthq. Invest. Committee in Foreign Languages* **68B,** 1–180.

Perrey, A. (1850). Mémoires sur les tremblements de terre ressentis dans la peninsule Turco-héllenique et en Syrie, *Mémoires couronnées et mémoires des savant etrangers*, Academie Royale des Sciences, des Lettres et des Beaux Arts de Belgique, Bruxelles, Belgium, Vol. 23**,** 73 pp. (in French).

Perrey, A. (1850–1871). Note sur les tremblements de terre en [1850–1871], *Mémoires de l'Académie des sciences, arts et belles-lettres de Dijon*, 2e série (in French).

Richter, C. F. (1935). An instrumental earthquake magnitude scale, *Bull. Seismol. Soc. Am.* **25,** no. 1, 1–32.

Saderra Masó, M. (1910). *Catalogue of Violent and Destructive Earthquakes in the Philippines 1599–1909*, Manila Bureau of Printing, Manila, Philippines, with maps.

Sieberg, A. H. (1904). *Handbuch der Erdbebenkunde*, Verlag, Jena, Germany, 362 pp. (in German).

Sieberg, A. H. (1912). Über die makroseismische Bestimmung der Erdbebenstärke - Ein Beitrag zur seismologischen Praxis, *Gerlands Beiträge zur Geophysik*, Vol. XI, 227–239 (in German).

Sieberg, A. H. (1928). Das Korinter Erdbeben vom 22. April 1928 in seinen Beziehungen zu den Erdbeben und dem geologischen Aufbau des östlichen Mittelmeergebietes, *Jenaische Zeitschr. f. Naturwiss.*, N.F. 57 (in German).

Sieberg, A. H. (1932a). *Erdbebengeographie - Handbuch der Geophysik*, Vol. IV, no. 3, Verlag, Berlin, Germany, 687–1005 (in German).

Sieberg, A. H. (1932b). Untersuchungen und Bruchschollenbau im Östlichen Mittelmeergebiet, ergebnisse einer Erdbebenkundlichen Orient Reise unternommen im Frühjahr 1928 mit Mitteln der Notgemeinschaft der Deutschen Wissenschaft, *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena*, Vol. 18, Fischer, Jena, Germany, 161–272 (in German).

von Hoff, K. E. A. (1840). *Chronik der Erdbeben und Vulkan Ausbrüche*, Vol. IV, Perthes, Gotha, Germany, 470 pp. (in German).

von Hoff, K. E. A. (1841). *Chronik der Erdbeben und Vulkan Ausbrüche*, Vol. V, Perthes, Gotha, Germany, 406 pp. (in German).

Weng, W. (1921). On historical records of earthquakes in Kansu, *Bull. Chin. Geol. Surv.* no. 3, 27–44.

Wichmann, A. (1918). Die Erdbeben des Indischen Archipels von bis zum Jahre 1857, *Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam*, Tweede sectie, Amsterdam, **20,** no. 4, 3–193 (in Dutch).

Wichmann, A. (1922). Die Erdbeben des Indischen Archipels von 1858 bis 1877, *Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam*, Tweede sectie, Amsterdam, **22,** no. 5, 3–209 (in Dutch).

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