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Data article

Macroseismic intensity data and effects of significant earthquakes in Colombia based on historical seismicity studies

Datos de intensidad macrosísmica y efectos de los sismos significativos de Colombia a partir de estudios de sismicidad histórica

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Abstract

This article presents data on the macroseismic intensities and the effects of earthquakes that have caused significant damage in Colombia, generated in the historical seismicity reports that are prepared for the seismic hazard and risk projects of the Servicio Geológico Colombiano (SGC). These data are the result of research based on the collection, organization and analysis of information related to the effects of earthquakes, according to the methodology of the European Macroseismic Scale of 1998 (EMS-98), which manages descriptions and degrees of intensity according to the effects on people, objects, buildings and nature.

These data are available to the public through the Historical Seismicity Information System of Colombia (Sistema de Información de Sismicidad Histórica de Colombia [SISHC]), which is an application on the web with free access. There are more than 5000 intensity data points and approximately 4000 reports associated with the effects of historical earthquakes, which can be used in a variety of ways, such as academic, scientific and institutional studies, historical research, and seismic hazard and risk management evaluations.

Keywords: earthquake, intensity scale, EMS-98, information system, seismological parameters, seismic hazard.

Resumen

En este artículo se presentan los datos de las intensidades macrosísmicas y los efectos de los sismos que han causado daños significativos en Colombia, generados en los informes de sismicidad histórica que se elaboran en los proyectos de amenaza y riesgo sísmico del Servicio Geológico Colombiano (SGC). Estos datos son resultado de la investigación basada en la recopilación, organización y análisis de la información relacionada con los efectos de los sismos, de acuerdo con la metodología de la Escala Ma-

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crosísmica Europea de 1998 (EMS-98), que maneja descripciones y grados de intensidad según los efectos ocurridos en personas, objetos, construcciones y naturaleza.

Estos datos se encuentran disponibles al público a través del Sistema de Información de Sismicidad Histórica de Colombia (SISHC), que es un aplicativo en la web de acceso libre, en el cual se encuentran más de 5000 datos de intensidades macrosísmicas y cerca de 4000 datos asociados a efectos de sismos históricos, que pueden ser usados en el ámbito académico, científico e institucional, en investigaciones de historia, amenaza sísmica, gestión del riesgo, entre otros.

Palabras clave: sismo, escala de intensidad, EMS-98, sistema de información, parámetros sismológicos, amenaza sísmica.

1. Description of the data

The macroseismic intensity data of significant earthquakes, as well as the effects they have caused in different populations of the country, are obtained from historical seismicity studies after the collection and analysis of information by the Seismic Hazard and Risk group of the SGC. These data have national coverage since they were evaluated for populations located in 28 of the 32 departments of Colombia, in addition to the Capital District (Figure 1). However, because earthquakes are continuous phenomena and the political-administrative division of the country has changed throughout history, there are also some estimated data for approximately 80 populations in neighboring countries, such as Venezuela, Ecuador, and Panamá.

The *macroseismic intensity* is defined as a classification of the severity of ground shaking based on observed effects in a limited area. It is independent of instrumental measurements, and it can be applied to both, recent and historical events. To evaluate the intensities, an intensity scale is used that consists of a series of descriptions of the effects produced by a seismic movement, taking into account the *sensors* that define the strength of the earthquake and are easily observable in the environment, such as living creatures, objects, buildings and the natural environment. These scales are numerically closed, generally having 12 ascending degrees, where 1 corresponds to a not felt earthquake and 12 to a completely devastating earthquake, as is the case of the Modified Mercalli scale (MM) and the European Macroseismic Scale of 1998 (EMS-98), both used in the studies of historical seismicity of the SGC.

The *effects* correspond to the perceptions, observations, and damage that occur during a ground shake. These effects are classified into the four *sensors* mentioned, and some examples of them are the loss of balance among people, the vibration or fall of objects, the cracking of walls in buildings and the mass movements triggered by earthquakes.

Historical earthquakes are those that occurred before the implementation of seismological instrumentation that began to operate globally at the beginning of the 20^{th} century and in Colombia, since the 1920s. Even so, the SGC has included in its investigations the study of the intensities of instrumental earthquakes to serve as a comparison to similar historical events. Likewise, the instrumental data of the earthquakes, especially in the first half of the 20^{th} century (except for those of high magnitude), are scarce and of low reliability; for them, the macroseismic intensity data improves the instrumental solutions.

The historical seismicity group of the SGC has studied 81 earthquakes from the 17th century to the present, which have affected the populations of Colombia. The macroseismic data were initially obtained for the most destructive events; that is, those in the seismic catalogs had a maximum intensity ≥ 8. As these events were studied, the investigation was extended to earthquakes with intensities less than 8.

With this information, reports of macroseismic studies were prepared which are available on the internet in the Geoscientific Information Integration Engine of the SGC (MIIG for its acronym in Spanish). Likewise, to make this information available for free access in a simple, agile and organized way, an application hosted on the web portal called "Historical Seismicity Information System of Colombia" was designed and published (SGC, 2016), which allows the consultation, visualization and download of the historical and macroseismic information of the aforementioned events and is described in the section "Access to the data".

Before the publication of the application, several authors worked on the collection and analysis of the historical information about the earthquakes, the evaluation of intensities and the seismological analysis, publishing their research in reports, articles, books, and databases (see Ramírez, 1975; Salcedo and Gómez, 2000; Espinosa, 2003; 2012).

Figure1. Populations with macroseismic intensity data on the EMS-98 scale
Source: modified from SGC (2016), http://sish.sgc.gov.co/visor/

Currently, 2602 intensity points are stored in the SISHC corresponding to the 81 earthquakes, with an assessment regarding their quality and reliability, and 2447 intensity points, corresponding to evaluations made by other authors for those same events, which are presented in Table 1. In addition, there is a section with 3934 reports dedicated to the effects that the earthquakes have caused, classified into people, infrastructure, nature and other effects, which are detailed in Table 2.

Table1. Number of intensity points evaluated by the SGC and other authors stored in the SISHC

Date	Local time	Lat.	Long.	Mag.	Depth	SGC IDP	IDP other authors	Imax	Epicentral area
1644/01/16	05:00	7.37	-72.64	6.5	15	5	12	9	Pamplona, Norte de Santander
1644/03/16	12:00	4.46	-74.04	5.5	15	2	12	7	Chipaque, Cundinamarca
1646/04/03	02:00	5.52	-74.13	6.0	15	2	3	8	Muzo, Boyacá
1736/02/02	09:00	2.5	-76.5	6.0	15	1	5	8	Popayán, Cauca
1743/10/18	09:30	4.44	-73.83	6.2	15	13	11	8	Fómeque, Cundinamarca

Date	Local time	Lat.	Long.	Mag.	Depth	SGC IDP	IDP other authors	Imax	Epicentral area
1766/07/09	16:00	3.82	-76.52	6.5	15	5	11	8	Buga, Valle del Cauca
1785/07/12	07:45	2.98	-74.37	7.1	10	17	45	7	Southeast of Cundinamarca
1796/02/15	12:00	7.37	-72.64	5.5	15	1	5	7	Pamplona, Norte de Santander
1805/06/16	03:15	5.37	-74.87	6.1	15	7	14	9	Honda, Tolima
1807/02/17	12:02	6.5	-71.7	5.5	15	1	2	7	Tame, Arauca
1826/06/17	22:30	5.01	-73.59	6.5	15	11	25	8	Úmbita, Boyacá
1827/11/16	18:00	1.8	-75.52	7.1	10	48	141	10	Altamira, Huila
1834/01/20	07:00	1.1	-76.93	6.7	15	29	35	9	Santiago, Putumayo
1834/05/22	03:00	11.5	-74.07	6.4	10	8	4	8	Santa Marta, Magdalena
1869/03/06	06:30	9.0	-74.0	6.0	60	58	0	7/8	El Banco, Magdalena
1875/05/18	11:15	7.86	-72.42	6.8	15	54	50	10	Cúcuta, Norte de Santander
1882/09/07	03:20	10.0	-79.0	6.5	15	17	35	9	Colón, Panamá
1884/11/05	23:45	5.1	-75.5	6.3	120	14	0	8	Herveo, Tolima
1885/05/25	15:05	2.88	-76.54	6.4	15	8	4	8	El Tambo, Cauca
1903/12/01	08:00	6.78	-76.14	5.5	15	2	2	7	Frontino, Antioquia
1906/01/31	10:36	0.99	-79.35	8.8	20	40	51	10	Pacific Coast
1911/04/10	13:42	7.2	-75.3	6.4	120	11	2	7	Yarumal, Antioquia
1917/08/31	06:36	3.78	-74.0	6.7	15	67	44	9	Villavicencio, Meta
1923/12/14	05:31	0.87	-77.78	6.2	10	14	14	9	Cumbal, Nariño
1923/12/22	04:56	4.56	-73.51	5.9	15	29	13	8	Medina, Cundinamarca
1925/06/07	18:41	3.96	-76.31	6.1	120	34	60	7/8	Tuluá, Valle del Cauca
1926/12/18	20:50	0.87	-77.78	6.0	10	9	10	8	Cumbal, Nariño
1928/11/01	11:08	4.95	-73.09	5.9	15	38	23	8	Chinavita, Boyacá
1933/02/10	17:00	1.37	-77.58	5.7	10	5	14	8	Linares, Nariño
1935/08/07	04:00	1.05	-77.31	6.1	10	23	5	8	Tangua, Nariño
1935/09/17	23:58	5.09	-76.08	6.1	15	20	0	8	Pueblo Rico, Risaralda
1935/10/26	20:15	1.07	-77.51	5.9	10	20	0	8	Imues, Nariño
1936/01/09	23:30	1.1	-77.6	5.6	10	16	0	7	Túquerres, Nariño
1936/07/17	12:30	1.17	-77.73	6.3	10	37	3	8	Túquerres, Nariño
1938/02/04	21:23	4.68	-75.69	7.0	150	86	81	8	Colombian Coffee region
1942/05/22	05:30	4.44	-74.64	5.7	15	19	13	7	Girardot, Cundinamarca
1942/12/26	07:30	9.27	-75.52	6.2	15	13	33	8	Lorica, Cordoba
1947/07/14	02:01	1.3	-77.23	6.0	10	60	122	8	Pasto, Nariño
1950/07/08	21:35	7.6	-72.86	6.2	10	41	89	9	Arboledas, Norte de Santander
1952/02/14	16:03	7.36	-76.37	5.9	20	6	10	7	Mutatá, Antioquia
1953/12/22	23:45	1.09	-77.59	5.8	10	17	10	8	Guaitarilla, Nariño
1957/04/21	16:12	6.87	-72.09	6.6	25	53	17	7	Malaga, Santander
1957/05/23	21:37	3.7	-76.75	6.1	52.3	16	8	7	Southwest Valle del Cauca
1958/01/19	09:07	1.01	-79.49	7.6	27.5	21	35	8	Esmeraldas, Ecuador
1961/06/16	05:33	8.88	-73.48	6.5	114	20	39	7	Ocaña, Norte de Santander
1961/12/20	08:25	4.49	-75.51	6.8	163	79	75	8	Colombian Coffee Region
1962/02/18	12:25	7.95	-74.81	5.8	46	13	14	7	Maceo, Antioquia
1962/07/30	15:18	5.17	-76.35	6.5	64	107	112	8	Colombian Coffee Region
1966/09/04	17:15	4.62	-73.98	5.3	15	17	16	7	Choachí, Cundinamarca
1967/02/09	10:24	2.85	-74.8	7.0	55	100	158	10	Colombia, Huila
1967/07/29	05:24	6.75	-73.03	6.8	161	123	92	8	Betulia, Santander
1970/09/26	07:02	6.21	-77.49	6.6	15	13	16	8	Bahía Solano, Chocó
1973/04/03	08:53	4.58	-75.57	6.2	150	33	25	7	Salento, Quindío
1973/08/30	13:25	7.14	-72.76	6.3	180	52	58	8	Convención, Norte de Santander
1974/04/17	20:19	6.95	-72.95	5.2	26	9	13	7	Guaca, Santander
1974/07/12	20:18	7.7	-77.58	7.1	10	13	14	8	Pacific Coast
1975/04/05	15:38	10.2	-75.56	5.7	45	14	10	6	Cartagena, Bolívar
1976/04/09	02:09	0.83	-79.57	6.6	17.4	3	45	8	Esmeraldas, Ecuador
1976/07/11	15:41	7.37	-78.11	7.3	17.5	19	11	8	Darién, Panamá
1977/08/30	19:42	7.35	-76.14	6.5	23.3	13	13	7	Apartadó, Antioquia

Date	Local time	Lat.	Long.	Mag.	Depth	SGC IDP	IDP other authors	Imax	Epicentral area
1979/11/23	18:40	4.73	-76.16	7.2	110	99	173	8	Colombian Coffee Region
1979/12/12	02:59	1.56	-79.28	8.1	23.6	56	49	10	Pacific Coast
1981/10/17	23:35	8.14	-72.52	5.9	30	42	150	8	Cúcuta, Norte de Santander
1983/03/31	08:12	2.36	-76.7	5.6	15	10	37	9	Popayán, Cauca
1983/11/22	09:21	0.53	-79.73	6.7	25	7	0	5	Pacific Coast
1988/03/19	23:08	4.41	-73.67	5.0	10	8	0	6	El Calvario, Meta
1991/11/19	15:28	4.52	-77.33	7.2	20	45	25	8	Pacific Coast
1992/10/18	11:12	7.07	-76.8	7.1	10	119	12	10	Murindó, Antioquia
1993/07/21	23:57	6.42	-71.08	6.0	20	7	8	8	Puerto Rondón, Arauca
1994/06/06	15:47	2.89	-75.95	6.8	10	34	0	8	Páez (Belalcázar), Cauca
1995/01/19	10:05	5.1	-72.89	6.5	15	78	95	8	Tauramena, Casanare
1995/02/08	13:40	4.06	-76.56	6.4	71	60	87	8	Calima, Valle del Cauca
1995/02/11	17:45	12.6	-81.52	5.7	15	5	0	6	Archipelago of San Andrés
1995/03/04	18:23	1.25	-77.26	5.0	20	23	11	7	Pasto, Nariño
1999/01/25	13:19	4.43	-75.7	6.1	15	46	12	9	Armenia, Quindío
2004/11/15	04:06	4.69	-77.47	7.2	15	49	4	8	Bajo Baudó, Chocó
2008/05/24	14:20	4.44	-73.81	5.9	10	21	0	8	Quetame, Cundinamarca
2013/02/09	09:16	1.11	-77.56	7.0	162	75	0	7	Guaitarilla, Nariño
2014/10/20	14:33	0.76	-77.95	5.8	10	33	0	6	Chiles, Nariño
2015/03/10	15:55	6.83	-73.13	6.3	157.7	97	0	7	Los Santos, Santander
2016/10/30	19:20	3.41	-74.64	5.2	13.2	62	0	6	Colombia, Huila

Notes: Date: date of the earthquake; Local time: Colombian time (UTC +5); Lat.: Latitude of the epicenter; Long: Longitude of the epicenter; Mag.: Magnitude; Depth: depth in kilometers; SGC IDP: number of intensity data points evaluated by the SGC; IDP other authors: number of intensity data points evaluated by other authors; Imax: maximum intensity evaluated by the SGC; Epicentral area: population or region where the epicenter or the highest intensity was reported.
Source: SGC (2016), http://sish.sgc.gov.co/visor/

Table2. Number and description of the effects of earthquakes stored in the SISHC

Category	Effect	Number of associated data
People	Fatalities	204
	Injured people	275
	Victims	9
	Missing	2
Infrastructure	Destruction of public or private buildings	508
	Very heavy damage to public or private buildings	288
	Substantial Damage to public or private buildings	429
	Moderate damage to public or private buildings	829
	Slight damage to public or private buildings	319
	Damage to essential buildings	236
	Damage to road infrastructure	30
	Impact on the provision of public services	46
	Population relocation	15
Nature	Mass movements	192
	Cracks in the ground	97
	Liquefaction	74
	Tsunami/Abnormal waves	76
	Subsidence/Uplift	12
	Hydrological anomalies	13
	Shaking of trees	5
Other effects	Foreshocks	27
	Aftershocks	199
	Waves on the ground	15
	Earthquake sound	33
	Earthquake lights	1

Source: Modified from SGC (2016), http://sish.sgc.gov.co/visor/

2. Importance of the data

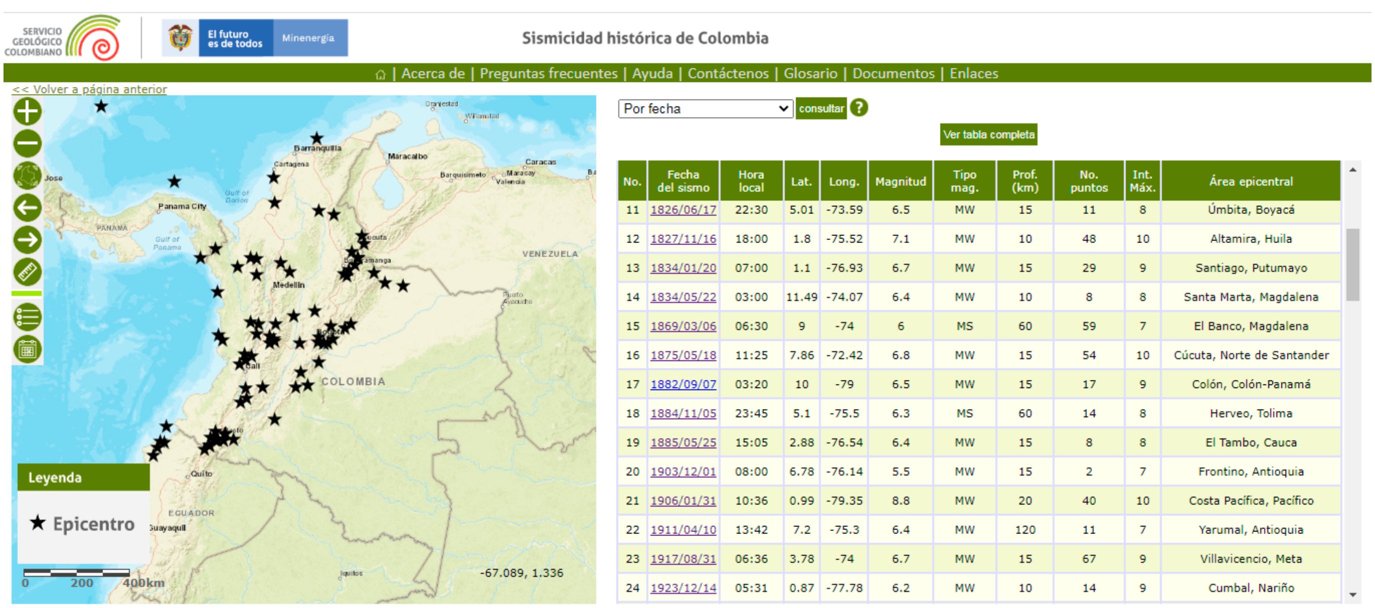
- Knowing in detail the intensities and effects of the earthquakes that have caused severe damage in different regions of the country contributes to the evaluation of the seismic hazard on different scales.
- Obtaining seismological parameters of historical earthquakes allow expansion of the temporal window of earthquake measurement in the country and complement the seismic catalogs.
- Making evaluations of the intensities available in the two intensity scales most used today in the world: Modified Mercalli and European Macroseismic Scale of 1998.
- Disseminating appropriate geoscientific knowledge, since the intensity is a qualitative measure based on the damage caused and the extent of the effects, facilitates communication of the seismic risk between the population and the decision-making entities, contributing to the management of the comprehensive risk.
- Having the data of the intensities and the effects of significant historical earthquakes enables any researcher interested in the subject can make their analyses and interpretations.
- Investigating historical earthquakes is considered a permanent task since the finding of a new document can modify the intensity data, including the maximum intensity, which directly affects the evaluation of the seismological parameters; for this reason, the authors are invited to continue with this activity.

3. Access to data

The reports of macroseismic studies that have been carried out during the past 15 years in the SGC are available on the internet through the Geoscientific Information Integration Engine (MIIG), which is part of the web portal of the Servicio Geológico Colombiano. In the supplementary data, the published reports are detailed in chronological order, and a direct link to each document that is available for download is included.

Likewise, to access in a simple and agile way the data of intensities and effects of the most significant earthquakes that have affected the country, an application published on the website of the SGC called "Historical Seismicity Information System of Colombia" was developed. SISHC, presents the interface observed in Figure 2. The system was published in 2012 (decommissioned version) and had significant visualization and performance improvements in 2016, which is the current version. Access to the data is presented in Table 3.

This system allows for five queries through which it is possible to access the specific information on each earthquake, and the results of each are shown on a map and in a table:



No.	Fecha del sismo	Hora local	Lat.	Long.	Magnitud	Tipo mag.	Prof. (km)	No. puntos	Int. Máx.	Área epicentral
11	1826/06/17	22:30	5.01	-73.59	6.5	MW	15	11	8	Úmbita, Boyacá
12	1827/11/16	18:00	1.8	-75.52	7.1	MW	10	48	10	Altamira, Huila
13	1834/01/20	07:00	1.1	-76.93	6.7	MW	15	29	9	Santiago, Putumayo
14	1834/05/22	03:00	11.49	-74.07	6.4	MW	10	8	8	Santa Marta, Magdalena
15	1869/03/06	06:30	9	-74	6	MS	60	59	7	El Banco, Magdalena
16	1875/05/18	11:25	7.86	-72.42	6.8	MW	15	54	10	Cúcuta, Norte de Santander
17	1882/09/07	03:20	10	-79	6.5	MW	15	17	9	Colón, Colón-Panamá
18	1884/11/05	23:45	5.1	-75.5	6.3	MS	60	14	8	Herveo, Tolima
19	1885/05/25	15:05	2.88	-76.54	6.4	MW	15	8	8	El Tambo, Cauca
20	1903/12/01	08:00	6.78	-76.14	5.5	MW	15	2	7	Frontino, Antioquia
21	1906/01/31	10:36	0.99	-79.35	8.8	MW	20	40	10	Costa Pacífica, Pacífico
22	1911/04/10	13:42	7.2	-75.3	6.4	MW	120	11	7	Yarumal, Antioquia
23	1917/08/31	06:36	3.78	-74	6.7	MW	15	67	9	Villavicencio, Meta
24	1923/12/14	05:31	0.87	-77.78	6.2	MW	10	14	9	Cumbal, Nariño

Figure 2. Input interface to the historical seismicity information system
Source: SGC (2016), http://sish.sgc.gov.co/visor/

a) By date is the default query when accessing the system. It simultaneously displays a map with the epicenters of the earthquakes, including tabular information in chronological order with the general parameters of each earthquake.
b) By site, a map is displayed with all the intensities evaluated for the 81 earthquakes, and the intensities evaluated for a department or a municipality, according to the EMS-98 intensity scale, are shown. When reviewing a municipality, a histogram is also generated that shows the intensities that have been reported at that site on a temporal scale.
c) By effects categorizes the impact of the earthquakes on people, infrastructure, nature, etc. According to the selected item, the consequences in fatalities, destruction of buildings, mass movements, tsunami, and other effects are identified.
d) By large earthquakes, is an query that identifies the most destructive earthquakes in Colombia throughout its history, that is, those that have been classified in intensity greater than or equal to 8 on the EMS-98 scale.
e) By quadrant identifies earthquakes based on the delimitation of a quadrant demarcated by coordinates.

There is an additional query called "For false or doubtful earthquakes", which presents a list of events recorded in various seismological catalogs and compilations, which are considered false or doubtful due to errors in the date or location or because they simply did not exist.

To find the detailed information on each earthquake, you can select the hyperlink of the date; in this way, you can access the visualization of this information, with the possibility of downloading most of the content in.pdf and.xls formats, as follows:

a) Summary: The seismological parameters of the earthquake are presented, as well as a summary of the most relevant effects and some observations that include information related to uncertainties in the seismological parameters, availability of historical documentation, and macroseismic evaluation, among others.
b) Documentation: In this section, previous studies of earthquakes, and the archives and libraries consulted are available. Also, documents are listed according to their typology and there is a genealogical tree, which is an image that presents primary documentation of the investigation in chronological order as well as the dependence of the secondary documents with the primary ones (Gisler et al., 2003).
c) Intensities: Maps with intensity data points evaluated by the SGC using the EMS-98 scale are presented in this section with a graph that shows the behavior of these intensity values, according to the distance to the hypocenter, a table with the intensities evaluated by multiple authors (including the SGC), the description of the effects occurred in all the sites classified by sensor and a graph that presents the number of sites that reported the same degree or interval of intensity for the earthquake of interest.
d) Audiovisual: Images, audio, infographic and videos related to the effects of the earthquake are shown.

4. Materials and methods

Historical seismicity studies, which have been carried out in the SGC, have allowed us to evaluate the effects and intensities of 81 significant earthquakes that occurred in the country from the 17th century to today, taking into account the adequate development of two components:

Table 3. Data specifications

Area	Earth Sciences
Specific subject area	Seismic hazard
Data type	Macroseismic intensity data and associated effects
How the data were acquired	Reports of historical seismicity studies (SGC group)
Data format	Primary and analyzed data
Parameters for data collection	Earthquakes that have caused significant effects in the Colombian territory
Description of data collection	- Rigorous search for information in historical archives and libraries - Collection of data on effects on people, objects, buildings and nature - Evaluation of intensity in the EMS-98 and MM scales
Location of the data source	Database and information system at the headquarters of the Servicio Geológico Colombiano, Bogotá, Colombia
Data accessibility	- Historical seismicity reports available on http://sish.sgc.gov.co/visor/

a) Historical component: Documentary research in archives and libraries includes the initial review of historical and seismological compilations, the identification of the sources and records that have contributed to the compilations and, later, the review of contemporary sources of information about the event and the search for new documents to complement the information and improve the quality of the data. In some cases, surveys are also completed for the evaluation of intensities, which are addressed to the populations.

   The most relevant studies on which the search for information has been based were those prepared by Ramírez (1975), Espinosa Baquero (2003 and 2012) and Salcedo and Gómez (2000), as well as the Catalog of Earthquakes for South America (Ceresis, 1985), which constitutes the most complete macroseismic study in South America and in which the intensities of the most significant events on the continent were evaluated and estimated.

   The collected documents are scanned and organized according to their typology (book, newspaper, report, magazine, etc.) and, subsequently, a "transcription sheet" for each is prepared according to the practice established by Salcedo and Gómez (1998) in which basic bibliographic information of each source is recorded: author, title and date, as well as the literal transcription of the text that mentions the effects caused by the earthquake.

b) Macroseismic component: includes the analysis and interpretation of the effects mentioned in the documents, taking into account the geographical context of the time, the typology of the construction, and the quality of the information, among others, to evaluate the intensities of the earthquake at each site from which the data were obtained. These effects are classified into the four sensors that usually handle the intensity scales: living beings, objects, buildings and the natural environment.

   To evaluate the intensity, the methodology proposed by Grünthal (2009) was followed, when the *European Macroseismic Intensity Scale of 1998* (EMS-98) was developed, making it possible to include various construction typologies with an associated vulnerability and with the classification of the degree of damage, as well as the management of statistical values to minimize subjective interpretations and personal criterion that authors may give when assigning an intensity. In addition to the EMS-98 scale, the working group has evaluated the intensities by using the Modified Mercalli scale, historically recognized worldwide.

   The intensity values estimated at each site are classified with a criterion of the quality of the assignment as good, acceptable or insufficient since there are uncertainties inherent to the available information, the degree of detail obtained and the reliability of the source.

   The results obtained are shown in a table and a map of intensity points. The historical seismicity group of the SGC decided to work with maps of intensity points, unlike most of the authors who had done macroseismic studies in the country and who developed isosist maps that join points of equal intensity value, which, unlike point maps, generalize information, mask relevant data for studies of local effects and prevent the heterogeneous behavior of the intensity distribution from being seen.

5. Use of the data

The intensity and effect data of earthquakes can be used for several purposes:

- Complementing the seismic catalog: It is possible to increase the number of earthquakes in the catalogs, including pre-instrumental earthquakes that have occurred since the time of the Conquest, in the 16th century, when the recording of written information began. Seismic catalogs constitute a basic tool for the evaluation of seismic hazards.
- Proposing macroseismic intensity attenuation models: Through mathematical and statistical processing and calibrations with recent earthquakes, it is possible to develop macroseismic intensity attenuation models that allow estimating and improving the evaluation of parameters such as magnitude (standardized at the Mw scale) and depth and location of historical earthquakes (e.g., Sarabia Gómez, 2016; Gómez et al., 2020, among others).
- Improving the reliability of the solutions: An adequate record of historical seismicity and its integration with instrumental information constitutes an important tool for the characterization of seismic activity. A recent example, in which macroseismic data contributed to improving the seismological parameters of events in Colombia, is found in Di Giacomo and Sarabia Gómez (2021).
- Expanding the knowledge of the potential of seismogenic sources: The estimation of the seismological parameters (date, location, magnitude) of the most destructive earth-

quakes is an indispensable element in the characterization of seismogenic sources, especially for the assignment of maximum magnitudes and information, which is fundamental in seismic hazard assessments.

- Evaluating the seismic hazard: In addition to the contributions mentioned above, such as the expansion of the seismic catalog or seismotectonic characterization, knowledge of the frequency and recurrence of intense earthquakes and their effects is essential for seismic hazard assessments.
- Developing maps of maximum observed intensity: These maps allow a rapid identification of the areas of the country that have been affected to a greater or lesser extent by earthquakes. A couple of examples of these maps for Colombia were prepared by Estrada and Ramírez (1977) and Sarabia Gómez (2015).
- Studying local effects and seismic microzoning: Knowledge of the macroseismic intensity data and the detailed effects that historical earthquakes have caused in populations are essential for the development of seismic microzoning studies, as well as for identifying localities or sectors susceptible to presenting local effects.
- Modeling damage scenarios: Using data of observed macroseismic intensity and the construction typologies in a locality, percentages of the degree of damage to the buildings are established, and in this way, earthquake damage scenarios are defined and serve to formulate response strategies.
- Knowing the structural behavior of buildings: Knowledge of the behavior of buildings before a shock, taking into account their structure and materials used, are important variables in the determination of macroseismic intensities. This has been essential to raise seismic resistant building codes. Likewise, this information has been essential for the construction of the intensity scales that exist and to propose new scales that have a relationship more in line with the constructive reality of this region, since those currently used come from Europe and the United States.
- Analyzing the impact of earthquakes: Reviewing the effects of the SISHC allows the preparation of reports related to the social, economic and environmental impact of earthquakes since there is quick access to data such as fatalities, missing persons, victims, damage to road infrastructure, impact on the provision of public services, mass movements, liquefaction, etc.

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7. Conflict of interest

The authors declare that they have no economic interests or competing personal relationships that could have influenced the work reported in this document.

Supplementary Data

Supplementary data for this article can be found online at https://doi.org/10.32685/0120-1425/bol.geol.49.2.2022.638

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