Seismic scenarios and assessment of intensity: some criteria for the use of the MCS scale

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Abstract
The macroseismic scale used for the classification of the more than 33 100 seismic effects of the *Catalogue of Strong Italian Earthquakes* (CFTI3) is the Mercalli Cancani Sieberg (MCS). As in all scales, the use of the MCS scale in determining the macroseismic intensity of historical earthquakes involves difficulties regarding the classification of descriptions of a quality nature. These descriptions often lack standardisation as regards levels of information and the semantic value of the statements, and there are also various levels of description of the damage in relation to the various economic and building contexts. As is known, the intensity scales were compiled to classify the effects of earthquakes contemporary to the observers. The scales are therefore classification tools designed to be applied from direct observations. The general criteria used in assessment of the intensity degrees are those of a direct comparison between the descriptive outlines gained from historical research and the descriptions given by the different degrees of the scale. While this is true in a general sense, there are a number of cases where the interpretation may vacillate when the context examined contains no elements of clarification, in relation to the levels of detail of the research or the context. To understand how the many problems connected to the assessment of intensity of seismic scenarios carried out from historical sources have been solved the criteria applied are here described.

Key words *macroseismic scale – macroseismic intensity – MCS scale*

1. Introduction

The macroseismic scale used for the classification of the seismic effects of the *Catalogue of Strong Italian Earthquakes* (CFTI3) is the Mercalli Cancani Sieberg (MCS) with twelve degrees (Sieberg, 1932), plus the annotations F = felt and NF = not felt.

As in all scales, the use of the MCS scale in determining the macroseismic intensity of historical earthquakes involves difficulties regarding the classification of descriptions of a quality nature. These descriptions often lack standardisation as regards levels of information and the semantic value of the statements, and there are also various levels of description of the damage in relation to the various economic and building contexts.

Table I and II present the English version of the MCS scale published by Sieberg in 1932 (figs. 1a-c and 2). The unusual terms used in the translation correspond to the need to leave unmodified the seismological significance of the described effects from Sieberg, 1932).

Sieberg makes reference to «Fachwerkbau», a type of historical housebuilding characterized by walls with wooden framework filled with mud and straw, stones or bricks (fig. 3a) once very diffused in Germany. Numerous examples still survive both in small centers and in important historical centers. This type of housebuild-

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ing in different forms, was diffused in the whole European and mediterranean area (fig. 3b).

As is known, the intensity scales were compiled to classify the effects of earthquakes contemporary with the observers. Throughout history, more than 61 macroseismic scales were made up in order to classify the earthquake effects. Most of them were meant for use on the field and only recently does the guide to the use of the intensity EMS scale (Grünthal, 1993, 1998) mention the problem of the application of the historical data suggesting some warnings. Table III compares the main scales historically used world-wide. The scales are therefore instruments of classification designed to be applied from direct observations. Sieberg himself, in the initial proposal of the MCS (Sieberg, 1912), stressed both the importance of direct observations of the wide variety of seismic effects which could be detected, and the results of this observational practice, applied to a large number of earthquakes in different countries of the world. He observed that both these aspects had inspired his efforts to improve the macroseismic scale previously formulated by Mercalli (1897, 1902).

The application of the scale to the seismic scenarios of the past, reconstructed on the basis of written sources, has occupied many genera-

Table I. Mercalli-Cancani-Sieberg macroseismic scale elaborated by A. Sieberg in 1932 (English translation; see figs. 1a-c for the original German version).

Degree I – Imperceptible: noticed only by seismographs.

Degree II – Very light: felt only by rare, nervous subjects who are perfectly quiet or very sensitive, and more exactly almost only on the upper floors of buildings.

Degree III – Light: even in densely inhabited areas the earthquake is felt as a shock by only a small part of the inhabitants who are inside their houses, like the quick passing of an automobile. By some it is recognised as an earthquake only after a reciprocal exchange of ideas.

Degree IV – Moderate: not many of the people who are outside of the buildings feel the earthquake. Inside the houses it is certainly identified by numerous, but not all, people, in consequence of the trembling or slight oscillatory movement of the furniture and of the glassware and china which, put close to each other, knock against each other, like at the passing of a heavy truck on irregular paving. Windows tinkle, doors, beams and boards bang, the ceilings creak. In open recipients, liquids are lightly moved. One has the impression that, inside of the house, a heavy object (sack, furniture) is being overturned or that one is swaying together with the entire chair or bed etc., like a ship on a rough sea. This movement causes little fear, except in case of persons who became nervous or fearful because of previous earthquakes. The sleeping rarely wake up.

Degree V – Relatively strong: even at the height of daily activity the seism is felt by numerous people in the street or anyway outside. In flats the earthquake is noticed because of the shaking of the entire building. Plants as well as the thin branches of bushes and trees move visibly, as if moved by a moderate wind. Free hanging objects start to oscillate, like for example curtains, suspended traffic lights, hanging lamps, and not too heavy chandeliers; bells start to sound, pendulum-clocks stop or oscillate with a wider movement, depending on whether the direction of the shock is perpendicular or parallel to the direction of the oscillation of the pendulum; thus, stopped pendulum-clocks may start functioning again; mainsprings ring; electric lights flicker or are interrupted according to the contact of the wires; pictures bang against the walls or move; small quantities of liquid spill from open, full recipients; knick-knacks etc. and also objects leaning against the walls may knock over; light furniture may even slightly move from their place; the furniture shakes; doors and shades open and close banging; the glass in the windows breaks. General waking of the sleeping. In some isolated cases the inhabitants run outside.

Degree VI – Strong: the earthquake is felt by all with fear; therefore many run outside, some think they will fall. Liquids move strongly; pictures, books, and similar, fall from walls and shelves; pieces of china break; rather stable furnishings and even isolated pieces of furniture are moved or fall; smaller bells in chapels and churches, clocks of bell-towers sound. In single, solidly built houses there is small damage; cracks in the plaster, the

Table I (*continued*).

plastering falls from the ceilings and walls. Heavier, but still harmless damage on badly constructed buildings. Some isolated tile or stone of the chimney-pot may fall.

Degree VII – Very strong: remarkable damage is caused to a higher number of furnishings of the flats, even to the very heavy ones, which are thrown over or smashed. The bigger bells toll. Watercourses, ponds and lakes begin to wave and become turbid because of the moving slime. There are isolated slidings of parts of the sand and gravel banks. In the wells the water degree changes.
There is moderate damage to numerous solidly built buildings, like small fissures in the walls. Rather big parts of the plastering and stucco work, and of bricks break off; in general tiles fall. Many chimney-pots are damaged by cracks, by falling tiles and stones; ruined chimney-pots fall on the roof damaging it. Badly fixed decorations fall from towers and high constructions. In houses built with wooden frames the damage to the plastering and the frameworks is already worse. Isolated collapse of badly built or badly preserved houses.

Degree VIII – Destructive: entire tree trunks wave vividly or are even uprooted. Also the heavier furniture is partially moved and turned over. Statues, milestones and the like, connected with the ground, rotate on their pedestal or fall, also in churches, cemeteries and public parks etc. Solid stone boundary walls are opened and knocked down.
About one fourth of the houses reports heavy destructions; some collapse, many become uninhabitable. In the buildings with wooden frames, a big part of the padding falls. Wooden houses crumble or are knocked over. In particular, falling church towers and factory chimneys may cause heavier damage to nearby buildings than the sole action of the earthquake does. Fissures are formed in steep slopes and marshy grounds; sand and slime come out of wet grounds.

Degree IX – Ruinous: about half of the stone houses is heavily destroyed; a certain number of them collapses; the largest part becomes uninhabitable. Houses with wooden frames are pulled up from their own foundations and squashed, this way sometimes the beams of some frames are sheared, thus considerably contributing to their ruin.

Degree X – Annihilating: heavy destruction of about three fourths of the buildings; the largest part collapses. Even solid wooden constructions and bridges undergo heavy damage, some are also destroyed. Embankments and dykes etc. are more or less considerably damaged, rails are lightly bent and pipes (gas, water and waste) are cut off, broken or crushed. Fissures are formed in the paved and asphalted layer of the streets and due to the pressure large waving folds jut out.
In the soft, and especially wet ground, fissures, even more than one decimetre wide, are formed; in particular parallel to the water courses, up to one metre cracks are formed. Not only does soft ground slide from the slopes under the form of a landslide, but also entire boulders role towards the valley under the form of falling rocks. Big rocks break off the river banks and the steep coasts, on the low coasts sand and mud masses are moved; thus the relief of the ground sometimes undergoes not secondary changes. Wells frequently vary in water degree. From rivers, canals and lakes etc,. the water is thrown against the banks or shores.

Degree XI – Catastrophe: collapse of all stone buildings. Solid constructions and resilient wooden joint huts may still resist on their own. Even the bigger and safer bridges collapse due to the breaking of the stone pillars or to the yielding of the iron ones. Embankments and dykes are completely separated from each other, often for a long way; rails are strongly bent and compressed. Tubes in the ground are completely separated from each other and become unusable.
The ground undergoes various, considerable changes, which are determined by the nature of the soil: big cracks and fissures open up; and most of all in wet and marshy grounds there is a considerable horizontal and vertical disruption. Consequently there is an overflow of water that brings with it sand and slime in its different forms. There are numerous cleavages of the ground, and rocks fall.

Degree XII – Big catastrophe: no man-made work resists. The transformation of the ground takes on enormous dimensions. Accordingly water flows, under and above the ground, undergo the most various changes: waterfalls are formed, lakes stagnate, rivers divert.

Table II. Sieberg's summary of its MCS updated version of 1932 (English translation of the table 103; see fig. 2 for the original German version).

Felt	Isolated, in rest, on the upper floors	II
	By few, in the houses	III
	Numerous in the houses, isolated outside	IV
	By all in the houses and outside	V
Waking up of the sleeping	Isolated	IV
	Many	V
Flight	Isolated	V
	Many	VI
Tinkling of windows, banging of doors and the like		IV
Oscillation of free hanging objects		V
Sounding of bells	Of clocks	V
	Small bells	VI
	Big bells	VII
Falling to the ground of objects	Isolated	V
	Many	VI
Falling of tiles and chimney-pots	Isolated	VI
	Many	VII
	Normal stone constructions	
Damage	Light, isolated	VI
	Moderate, many	VII
Destructions	1/4 of all buildings	VIII
	1/2 of all buildings	IX
	3/4 of all buildings	X
Collapse	Isolated	VIII
	More than 1/4 of all buildings	IX
	More than 1/2 of all buildings	X
	All buildings	XI
Collapse of all constructions with all kinds of foundations		XII

tions of researchers since the 1950's. It often presents considerable difficulties, since these scenarios do not always clearly refer to the elements described by the degrees of the scale.

Despite these limits, which are of course common to other analyses of an empirical nature, macroseismic scales are applied and propagated as a valid instrument which allows seismic effects to be classified for which no instrumental measurements are available. In this way it is possible for a comparison to be made of the local seismic response for a wide range of events in time and for a large number of sites. In addition, it is well known that even for earthquakes occurring in an era in which instruments were used, macroseismic data provide fundamental elements of the local seismic response which are indispensable to various sectors of application.

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die Praxis bedeutungslosen beiden ersten Stärkegrade beibehalten werden. Auch der III. Grad hat heutzutage, wenigstens in größeren Ortschaften von Kulturländern, kaum mehr Bedeutung, weil reger Fuhrwerksverkehr, namentlich von Kraftwagen, oft noch stärkere Erschütterungen bedingt als manches Erdbeben.

Tabelle 102

Ausführliche Mercalli-Sieberg-Skala zum Bestimmen der relativen Erdbebenstärken

I. Grad. Unmerklich: Bloß von *Erdbebeninstrumenten* angezeigt.

II. Grad. Sehr leicht: Nur von ganz *vereinzelten*, in vollkommener Ruhe befindlichen, nervösen oder sehr empfindlichen Personen gefühlt und zwar fast ausschließlich in den *oberen Stockwerken* der Häuser.

III. Grad. Leicht: Selbst in dichter besiedelter Gegend wird das Beben *nur von einem kleinen Teile der im Hausinnern befindlichen Bevölkerung* verspürt als Erschütterung, wie beim schnellen Vorüberfahren eines Wagens. Von manchen erst nachträglich durch den gegenseitigen Gedankenaustausch als Erdbeben erkannt.

IV. Grad. Mäßig: Von den *im Freien* befindlichen Personen verspüren nicht viele das Erdbeben. *Im Innern der Häuser* wird es zwar von zahlreichen, jedoch nicht von allen Personen erkannt an zitternden oder leicht wankenden Bewegungen von Möbelstücken, infolge deren dicht beieinander stehende Gläser und Geschirre leise gegeneinanderschlagen wie beim Vorbeifahren eines schweren Lastwagens auf holperigem Pflaster, *Fenster klirren*, Türen, Balken und Dielen krachen, Zimmerdecken knistern. Flüssigkeiten in offenen Gefäßen werden leicht bewegt. Man hat das Empfinden, als falle im Hause ein schwerer Gegenstand (Sack, Möbelstück) um, oder man schwankt samt Stuhl, Bett usw. wie im Schiff bei bewegter See. Schrecken ruft diese Bewegung so gut wie gar nicht hervor, es sei denn, daß Bewohner durch andere Erdbeben bereits nervös oder ängstlich geworden sind. *Vereinzelt erwachen* Schlafende.

V. Grad. Ziemlich stark: Selbst *während des vollen Tagesbetriebes wird das Erdbeben von sehr zahlreichen auf der Straße* oder sonst *im Freien* befindlichen Personen verspürt. In den Wohnungen gelangt es infolge der Erschütterung des ganzen Gebäudes allgemein zur Beobachtung. Gewächse sowie Zweige und schwächere Äste von Sträuchern und Bäumen bewegen sich sichtbar, wie bei einem mäßigen Winde. *Frei hängende Gegenstände geraten in pendelnde Bewegungen*, z. B. Vorhänge, Ampeln, Hängelampen und nicht zu schwere Kronleuchter; Klingeln ertönen; Uhrpendel werden angehalten oder schwingen in größerem Bogen, je nachdem die Stoßrichtung senkrecht zur oder in die Schwingungsrichtung fällt; dementsprechend können stehende Pendeluhren wieder in Gang kommen; Uhrfedern tönen; elektrisches Licht zuckt oder versagt infolge der Berührung der Leitungsdrähte; *Bilder schlagen klappernd gegen die Wände oder verschieben sich*; geringe Flüssigkeitsmassen werden aus wohlgefüllten offenen Gefäßen verschüttet; Nippsachen usw. *können umfallen*, desgleichen gegen die Wand gelehnte Gegenstände; leichte Geräte können sogar etwas von der Stelle verschoben werden; Rasseln der Möbel; *Türen und Fensterläden schlagen auf oder zu*; Fensterscheiben zerspringen. Die Schlafenden *erwachen allgemein*. *Vereinzelt flüchten* sich die Einwohner ins Freie.

VI. Grad. Stark: Das Erdbeben wird *von jedermann mit Schrecken* verspürt, so daß *sehr viele sich ins Freie flüchten*; manche glauben umfallen zu müssen. Flüssigkeiten bewegen sich recht stark; *Bilder, Bücher* u. dgl. *fallen* von den Wänden und von Regalen herab; Geschirr wird zerbrochen; recht standfeste Hausgeräte, sogar vereinzelte *Möbelstücke werden von der Stelle gerückt oder fallen um*; kleinere Glöckchen in Kapellen und Kirchen, Turmuhren schlagen an.

An *vereinzelten Häusern* solider Bauart entstehen *leichte Schäden*: Risse im Verputz, Abfall von Bewurf der Decken und Wände u. dgl. Kräftigere, aber noch harmlose Schäden an schlecht gebauten Häusern. Vereinzelt können Dachpfannen und Kaminsteine herunterfallen.

Fig 1a. Original version of the Mercalli-Cancani-Sieberg macroseismic scale in German (from Sieberg, 1932, 552-554; see English translation in table I).

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VII. Grad. Sehr stark: An den Einrichtungsgegenständen der Wohnungen wird durch *Umwerfen und Zertrümmern selbst schwerer Gegenstände in großer Zahl* erheblicher Schaden angerichtet. *Größere Kirchenglocken schlagen an.* Die Wasserläufe, Teiche und Seen werfen Wellen und trüben sich infolge des aufgerührten Schlammes. Vereinzeltes Abgleiten von sandigen und kiesigen Uferpartien. Brunnen verändern ihren Wasserstand.

Mäßige Schäden an zahlreichen Häusern solider Bauart: Leichte Risse in den Mauern, Abbröckeln größerer Partien des Bewurfes und der Stuckverzierungen, von Ziegeln, allgemeines *Heruntergleiten von Dachpfannen.* Viele *Schornsteine* werden durch Risse, Abstürzen der Deckplatte, Herausfallen von Steinen beschädigt; schadhafte Schornsteine brechen bis zum Dach ab und beschädigen es. Von Türmen und hohen Gebäuden fallen schlecht befestigte Verzierungen ab. An Fachwerkbauten sind die Beschädigungen des Bewurfes und der Rahmenfüllungen schon stärker. *Vereinzelt Zerstörungen* an schlecht gebauten oder erhaltenen Häusern.

VIII. Grad. Zerstörend: Ganze Baumstämme schwanken lebhaft oder brechen sogar ab. Selbst die schwersten Möbelstücke werden teils weit von der Stelle gerückt, teils umgeworfen. Statuen, Steinmale u. dgl. nahe dem Boden, also in Kirchen, auf Friedhöfen, in öffentlichen Anlagen usw., drehen sich auf ihren Sockeln oder fallen um. Solide steinerne Einfriedigungen werden auseinandergerissen und zu Boden gelegt.

An etwa ¼ der Häuser erfolgen schwere Zerstörungen; vereinzelte Häuser stürzen ein, viele werden unbewohnbar. Bei Fachwerkbauten fällt die Rahmenfüllung größtenteils heraus. Holzhäuser werden verdrückt oder umgeworfen. Namentlich werden Kirchtürme und Fabrikkamine in Mitleidenschaft gezogen, deren Einsturz allerdings benachbarte Häuser stärker beschädigen kann, als es die Bebenwirkung allein getan hätte.

Bodenrisse entstehen an steilen Hängen und in nassem Erdreich; in nassem Boden kommt es zum Austreten von Sand oder Schlamm führendem Wasser.

IX. Grad. Verwüstend: *Etwa ½ der Steinhäuser wird schwer zerstört, verhältnismäßig viele stürzen ein, die meisten werden unbewohnbar.* Fachwerkbauten werden auf dem steinernen Unterbau verschoben, in sich verdrückt und damit die Zapfen mancher Rahmen abgeschert, wodurch sie unter Umständen erheblicher in Mitleidenschaft gezogen werden.

X. Grad. Vernichtend: *Schwere Zerstörungen an etwa ¾ der Gebäude, die meisten davon stürzen ein.* Selbst gut konstruierte hölzerne Gebäude und Brücken erleiden schwere Beschädigungen, einzelne werden auch zerstört. Deiche und Dämme usw. werden mehr oder minder erheblich beschädigt, Eisenbahnschienen leicht verbogen und Leitungsröhren (Gas- und Wasserleitungen, Kanalisationen) im Boden abgeschert, zerrissen oder gestaucht. Im Pflaster und Asphaltbelag der Straßen entstehen Risse und durch Stauchung hervorgerufene breite, wellenförmige Falten.

In lockerem und namentlich feuchtem Erdreich entstehen *Bodenrisse* bis zu mehreren Dezimetern Breite; namentlich treten nahe den Wasserläufen parallel zu diesen verlaufende Spalten auf, die bis etwa 1 m Breite haben können. Nicht allein gleitet lockerer Boden als Landschlipf von den Felsengehängen ab, sondern auch Felspartien können als Felsstürze zu Tale gehen. Von Flußufern und auch wohl an Steilküsten brechen ganze Partien ab, an Flachküsten kommt es zu gleitenden Verschiebungen der Sand- und Schlickmassen, wodurch das Bodenrelief mitunter nicht unwesentliche Veränderungen erfährt. Brunnen ändern häufig ihren Wasserstand. Aus Flüssen, Kanälen, Seen usw. wird das Wasser an die Ufer geschleudert.

XI. Grad. Katastrophe: *Einsturz sämtlicher Steingebäude.* Solide Holzbauten und nachgiebige Flechtwerkshütten vermögen nur noch vereinzelt standzuhalten. Unter den Brückenbauten werden selbst die großen und sicher konstruierten dadurch zerstört, daß massive Steinpfeiler abbrechen oder die eisernen Pfeiler durchknicken. Deiche und Dämme werden, oft auf weite Strecken hin, ganz auseinandergerissen. Eisenbahnschienen stark verbogen und gestaucht. Leitungsröhren im Boden werden völlig auseinandergerissen und unbrauchbar gemacht.

Fig 1b. See fig. 1a for caption.

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Im *Erdboden* zeigen sich mannigfaltige und bereits recht umfangreiche Veränderungen, die durch die Bodenbeschaffenheit näher bestimmt werden: Breite Risse und Spalten öffnen sich, und besonders in weichem oder gar wasserhaltigem Boden sind die Zerrüttungen in wagerechter und senkrechter Richtung bedeutend. Dazu kommt noch das Austreten von Sand oder Schlamm führendem Wasser mit seinen verschiedenen Erscheinungsformen. Die *Landschlipfe* und *Felsstürze* sind zahlreich.

XII. Grad. Große Katastrophe: *Kein Werk von Menschenhand hält stand.*

Die *Umgestaltungen des Bodens* nehmen die großartigsten Maße an. Dementsprechend erleiden die unterirdischen und oberirdischen Wasserläufe die mannigfachsten Beeinflussungen: Es entstehen Wasserfälle, Seen werden aufgestaut, Flüsse abgelenkt usw.

Fig 1c. See fig. 1a for caption.

This renewed interest for the macroseismic data has favored scientific debate on two aspects: the formalization of macroseismic scales that take into account more modern building typologies (Grünthal, 1993, 1998) and the standardisation of the application of the intensity scales in use (Molin, 1995; Giuffrè, 1995; Moroni *et al.*, 1996).

2. From interpretation to suggestion: towards a playing-down of the degree of intensity?

There are more than 33 100 seismic effects assessed in the CFTI3. Although we have tried to maintain some limited general criteria of evaluation, described below, the user might sometimes encounter what could be defined as «a subjective leap». Implicit contextual situations or correlation with particular features of the sources or the human contexts – to which the interpreter could have paid particular attention – may sometimes have affected judgement.

Although the user should be aware of this aspect as an element worthy of attention, it should not be overlooked that the problem of parameterisation of historical catalogues today appears in different and more dynamic terms than in the past. We are sceptical about the success of attempts to «regulate» the subjective oscillations of the interpreter, controlling only the mental processes. By this we do not mean to underestimate the value of the estimation of intensity, which produces the main seismic parameters, such as the epicentral intensity and the macroseismic equivalent of the magnitude, or the search for transparency in operating codes, the clarity of which should certainly be encouraged.

Indeed, alongside the catalogue, new interpretative methods have been explored, such as the application of the fuzzy sets theory, entrusting statistics with the relation between the descriptive semantic elements of the historic seismic scenario and the elements described in the degrees of the scale (Ferrari *et al.*, 1995; Vannucci *et al.*, 2000). However, we consider that the difficulty of making an objective evaluation of the effects of historical earthquakes may today be «played-down» to a great extent by the direct availability of the historical sources and by a more sensitive historiographic interpretation. It was perhaps the very lack of a direct access to the original texts and to their historiographic evaluation which has made the role of interpreter irreplaceable up till now. The availability of exclusively parametrical catalogues has in fact tended to burden the interpreter with a primary role with respect both to the data structured within the parameters themselves, and to the data excluded from these parameters, thus giving an unhelpful rigidity to the catalogue. With a touch of irony, earthquake catalogues have been compared to a «Procrustean bed»: indeed, as you will recall, the robber of the Greek legend stretched or shortened the limbs of his captives to fit the size of the bed, thus intervening on the contents rather than the container.

Tabelle 103

Vereinfachte Übersicht über die wichtigsten Kennzeichen der Mercalli-Sieberg-Skala

Kennzeichen		II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Gefühlt	vereinzelt, in Ruhe, in oberen Stockwerken	II										
	von wenigen, in Häusern		III									
	zahlreich in Häusern, vereinzelt im Freien			IV								
	von allen in Häusern und im Freien				V							
Erwachen Schlafender	vereinzelt			IV								
	zahlreich				V							
Flucht	vereinzelt				V							
	zahlreich					VI						
Klirren von Fenstern, Krachen von Türen u. dgl.				IV								
Pendeln frei hängender Gegenstände					V							
Ertönen von Glocken	an Uhren				V							
	kleinen					VI						
	großen						VII					
Umfallen von Gegenständen	vereinzelt				V							
	zahlreich					VI						
Herabfallen von Dachpfannen, Schornsteinen	vereinzelt					VI						
	zahlreich						VII					
	Normale Steinbauten:											
Schäden	leicht, vereinzelt					VI						
	mäßig, zahlreich						VII					
Zerstörungen	¼ aller Gebäude							VIII				
	½ aller Gebäude								IX			
	¾ aller Gebäude									X		
Einstürze	vereinzelt							VIII				
	mehr als ¼ aller Gebäude								IX			
	mehr als ½ aller Gebäude									X		
	sämtlicher Gebäude										XI	
Einsturz sämtlicher *Bauwerke jeglicher Art* bis auf die Fundamente												XII

Fig 2. Quantitative synthesis of the effects described in the original version of the MCS scale (from Sieberg, 1932, p. 555; see English translation in table II).

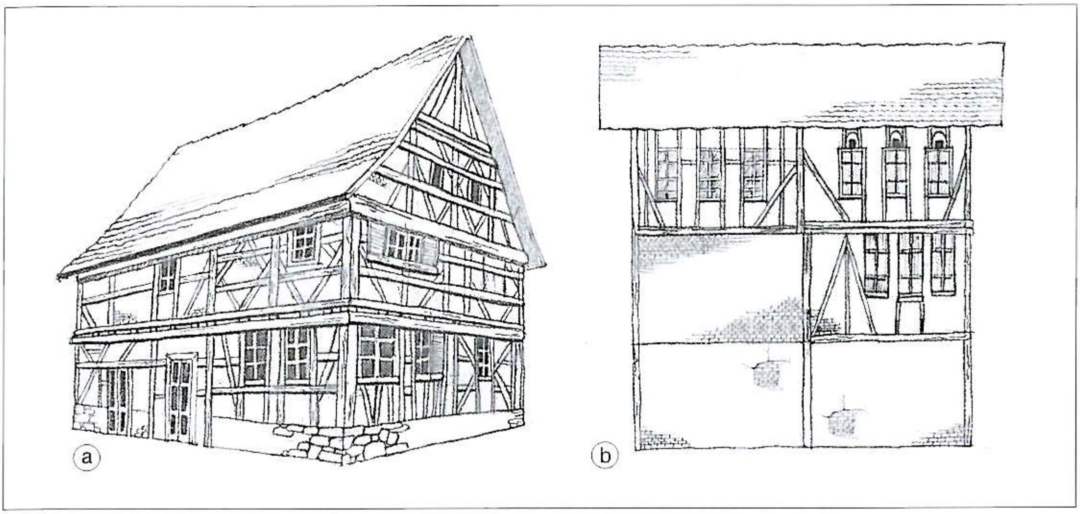

Fig. 3a,b. a) Example of the «Fachwerkbau» to which Sieberg refers: a type of historical housebuilding characterized by walls with wooden framework filled with mud and straw, stones or bricks (Germany); b) example of Turkish historical housebuilding like the «Fachwerkbau» type to which Sieberg reports. Housebuilding of this type, but with different forms spread since ancient times in the whole Mediterranean area (drawing by Stefania Traietta, SGA).

A contribution is given to a new scientific sensitivity also by a different conception of historical research in a seismological framework. This is seen not as a means for the «reconstruction» of situations which are entirely and positivistically recognisable, but as a dynamic relation between real seismicity (what historically occurred) and apparent seismicity (deduced from historical research), contributed to by a complex network of references and extra-textual elements which varies according to the quality and breadth of the research.

In this sense, the hypertextual structure of the CFTI3 facilitates not only the responses to demands which are more numerous and qualitatively new than those included in traditional catalogues – thus extending the possible range of users – but also permits specific routes of evaluation. From this viewpoint, the parametrical catalogue is just one of the possible products of the research. It is no coincidence that in CFTI3 it acts almost as «index» instead of a text in itself. It is in this context that the assessment of the degree of intensity takes on the role of a suggestion rather than a rigid interpretation in the strict sense. This suggestion should as far as possible be qualified and motivated, but is no longer the only filter between the basic historical data and their interpretation.

3. The criteria applied

The set of criteria expressed below on the estimates of the effects have guided macroseismic interpretation since the first research studies of the Eighties, whose results have been reprocessed and collected in this catalogues. Beginning we have tried to make these brief comments autonomous, a complementary reading of other sections of comments is advisable in order to provide a better and more complete picture of the earthquake effects. The user may make a further «check» of the interpretations through the archive of the sources, an integral part of the catalogue (for the availability of these data, see Boschi, this volume).

The general criteria used in assessment of

Table III. Comparison among the degrees of the most important macroseismic scales compiled in the world from the 16th century to 1998 (from Ferrari and Postpischl, 1979, with update). Each degree of the listed scales is compared with the MCS degrees. This comparison, based on the effects described for different degrees, is not intended to be a conversion table for different macroseismic scales, but only a summary of historical development of this important tool for classifying seismic effects. Despite their differences, from the second half of the 20th century onwards these scales reflect comparable categories of effects.

			MCS degrees											
Scales	Year	Degrees	1	2	3	4	5	6	7	8	9	10	11	12
Gastaldi	1564													
De Poardi	1627													
Pignataro	1788													
Brooks	1811	6	6		5	4	3		2			1		
Egen	1828	6		1-2	3-4	5	6							
McFarlane	1839	10	1---	---	---	---	---	---	---	---10				
Petermann	1856	5			5		4		3		2	1		
Mallet	1858	3					3			2		1		
Mallet	1862	5	5			4			3			2	1	
Willianson	1870	6		1		2		3		4		5	6	
Saderra - Maso	1870	6		1		2		3		4		5	6	
De Rossi	1874	10	1	2	3		4-5	6-7	8	9		10		
Neumann	1874	9					1	2	3	4-5	6	7-8-9		
Forel	1881	10	1-2	3		4	5	6-7	8	9	10			
Heim - Forster	1882	10	1	2		3 4 5	6	7	8	9		10		
Mercalli	1883	6			1		2	3	4	5		6		
De Rossi - Forel	1884	10	1	2	3	4-5	6	7	8	9		10		
Johnston - Lavis	1885	3							3		2		1	
Roockwood	1886	6		1		2	3	4	5			6		
Powell	1886	5	1		2		3	4	5					
Holden	1888	9	1	2	3	4-5	6	7	8	9		10		
Taramelli - Mercalli	1888	10		1	2	3-4	5	6	7-8	8		10		
Davison	1889	9	1	2	3	4-5	6	7	8-9					
Baratta	1892	7	1	2		3	4	5		6-7				
Masato	1892	4		1	2		3			4				
Riccò	1893	6	1		2		3		4	5			6	
Masò	1895	6		1		2-3	4		5	6				
Bassani	1895	16	1-3	4-5	6	7-8	9	10	11 12	13 14	15 16			
Suess	1896	10	1	2		3	4 5 6	7	8	9			10	

Table III (*continued*).

Scales	Year	Degrees	MCS degrees 1	2	3	4	5	6	7	8	9	10	11	12
Mercalli	1897	10	1	2	3	4	5	6	7	8	9	10		
Oldham	1897	6		1		2	3		4	5	6			
Oldham	1899	6		6		5	4		3	2	1			
Sekiya	1899	3		1			2			3				
Japanese scale	1900	4	1		2		3							
Omori	1900	7					1		2	3	4	5	6	7
Forel Mercalli	1904	10	1	2	3	4	5	6	7	8	9	10		
Mercalli Cancani	1904	12	1	2	3	4	5	6	7	8	9	10	11	12
Japanese scale	1906	5	1	2		3		4		5				
Hall	1907	6		1		2	3		4	5		6		
Wood	1908	5						5	3-4	2		1		
Cornish	1908	11	1	2	3	4-5	6	7	8-9	10		11		
Baratta	1910	10						10-----------------------------------1						
Milne	1911	3									1	2	3	
MCS	1912	12	1	2	3	4	5	6	7	8	9	10	11	12
Adie	1915	10	1			2	3	4	5	6	7	8	9	10
Raid Taber	1919	10	1	2	3	4-5	6	7	8	9	10			
Omori	1920	6	1			2		3		4	5	6		
IMO	1920	6			1		2		3		4	5	6	
Wong	1923	11	1	2	3	4-5	6	7	8	9	10	11		
MM	1931	12	1	2	3	4	5	6	7	8	9	10	11	12
OST VKS - 4537	1931	12	1	2	3	4	5	6	7	8	9	10	11	12
MCS	1932	12	1	2	3	4	5	6	7	8	9	10	11	12
Ramirez	1933	3	1			2			3					
JMA	1949	7	0	1	2	3		4		5	6		7	
GEOFIAN	1953	12	1	2	3	4	5	6	7	8	9	10	11	12
Chinese scale	1956	12	1	2	3	4	5	6	7	8	9	10	11	12
MSK-64	1964	12	1	2	3	4	5	6	7	8	9	10	11	12
Brazee	1979	12	1	2	3	4	5	6	7	8	9	10	11	12
MSK-76	1964	12	1	2	3	4	5	6	7	8	9	10	11	12
MSK-81	1964	12	1	2	3	4	5	6	7	8	9	10	11	12
EMS-92	1992	12	1	2	3	4	5	6	7	8	9	10	11	12
EMS-98	1998	12	1	2	3	4	5	6	7	8	9	10	11	12

the degrees are those of a direct comparison between the descriptive outlines gained from historical research and the descriptions given by the different degrees of the scale. While this is true in a general sense, there are a number of cases where the interpretation may vacillate when the context examined contains no elements of clarification, in relation to the levels of detail of the research or the context.

Where research has permitted it, the intensity values have been assessed by identifying convergence in contemporary sources alone. In the case of contradiction, experience dictated the choice on the level of significance of the single effects associated with the various degrees of intensity.

More specifically, the scale has been applied in consideration of the following criteria:

– *I degree*: this has never been attributed.

– *II, III and IV degree*: these do not present particular problems in interpretation, since they contain a gradual increase in effects which is easily recognised.

– *V degree*: this is the upper limit of the use of human behaviour and sensitivity. After this degree, evaluation of the damage begins.

– *VI degree*: evaluation of the damage is now used; the mention of damage therefore presumes an intensity not lower than the VI level.

– *VII degree*: this has been attributed when damage to buildings has been reported without explicit mention of widespread collapse, or where this is given as very sporadic.

– *VIII degree*: we have in general considered this as the threshold beyond which the construction system seen as a whole shows serious structural subsidence. From this viewpoint, it has been attributed when the collapse is of minor statistical importance but the set of buildings as a whole have been widely and seriously affected;

– *IX degree*: this was attributed when the majority of buildings have suffered damage such as to make them unfit for habitation (collapse of the outer walls, damage to the supporting framework, subsidence of the structure). This level has been attributed even where there is no specific description of the damage but there are indirect reports of housing situations congruent with general unfitness for habitation.

– *X degree*: this was attributed where reports mentioned the destruction of three quarters of the buildings, with the majority, or at least a large percentage, in a state of total collapse. Where no detailed description of the damage was given, this level was attributed when housing situations congruent with this picture were reported.

– *XI degree*: this was attributed when sources have allowed us to presume almost total destruction of the buildings. Where no detailed description of the damage was given, this degree was attributed when housing situations congruent with this picture were reported. Scenarios of effects of the type described in the X and XI degree, in the period prior to the twentieth century, in Central Southern Italy, are often associated with the abandonment of inhabited sites and reconstructions in other sites. Where there is no explicit information about the damage in historical contexts with little available documentation, this indirect indicator has been used. However, when the degree of the revision has made it possible, the conditions of the abandonment have been described as well as the significance assumed in the general human context.

– *XII degree*: this has never been attributed.

Damage – the effects of damage have been interpreted with reference to all the buildings of a site.

– Effects on buildings have been evaluated without taking into account their vulnerability and construction type. Particularly damaged or crumbling buildings are mentioned in the analytical comments (see in the CD-ROM) and thus the user is free to make deductions or use the testimonies of the damage in a different way if necessary.

– The extra-textual information used directly in evaluating the intensity is relative to the total number of the houses in order to evaluate the percentage of the construction heritage damaged. When the documentation has permitted it, the summary of information on local effects has also described the type and amount of damage, with absolute and percentage data (according to Sieberg's table 103; see fig. 2 and table II).

Table IV. Classification scale of the earthquake effects on single buildings has been used for the interpretation of the data collected in the *Catalogue of Strong Italian Earthquakes.*

A	Collapse and/or extensive damage to the bearing walls
B	Collapse limited to the top of the building (lantern, cupola, gable, etc.)
C	Partial collapse of the roof, vaults, apsidal vault, etc.
D	Falling eaves, cracking
E	General indication of damage to the building

– Where there are no other contextual indications and in relation to particular situations of habitation (of the medieval period, for example), testimonials of damage relative only to a single building of a certain type (churches and parish churches, cathedrals, etc.), have not been considered in evaluating the effects in degrees. In fact a number of factors influence the seismic response of a building, especially where the structure is of particular complexity or there are particular situations linked to the surface geology. As is known, it is not uncommon for two neighbouring buildings to suffer degrees of damage which may be very different from each other. Thus, since the effects suffered by one building alone cannot be representative of the effects on all the buildings of a town, we preferred not to lose the particular value of the data by using a quality classification, indicated by letters of the alphabet (A, B, C, D, E) to sort types of damage according to a criterion of severity (see table IV).

Uncertainty – On certain occasions, the descriptions of the effects have been so general or contained such evident contradictions that it has not been possible to make a clear assessment of just one level of intensity. In these cases the uncertainty has been indicated by assessing two different consecutive degrees. This obviously does not mean that an intermediate degree, not contemplated by the macroseismic scale, has been attributed, but that the intensity of the effects could be equal to one or the other degree. When the most serious effects refer to a single building of a site, for which there are no other indications than those of the type A or B or C or D or E, the maximum intensity has been indicated with a question mark to indicate that the assessment is uncertain.

Deaths – An indirect clue to the collapse of buildings comes from the number of deaths following a destructive quake. This figure however is not part of the set of effects included in the macroseismic scales. Indeed, the number of deaths is strongly conditioned by at least two important factors: the time of the main shock and the preceding tremors giving prior warning to the population, following which the houses are abandoned. Only in some cases can the number of victims be indirectly correlated to types of widespread serious damage, although such data should always be treated with particular caution.

Aftershocks – The aftershocks of major earthquakes have been evaluated through the degree of intensity, though with evident interpretative ambiguity. We have in any case preferred not to make use of data resulting from laws of attenuation so as not to include mathematical data in the macroseismic catalogue. In evaluating the effects of shock occurring after a destructive, or in any case stronger, mainshock, the dispersal of information has been avoided, overcoming the temptation of a certain theoretic purism, which would have advised against the use of the scale. The effects of shock following one which has previously damaged the buildings of an inhabited area either wholly or in part are obviously impossible to evaluate. This is due to the vulnerability induced in the buildings which have not yet fallen, and to the low statistical value of the number of houses remaining in the town. However we have tended to apply the degree of intensity, although well aware of the considerable approximations, which are indeed already implicit in the scale. We are consoled for this in part by the knowledge that the user of the

CFTI3 – not only parametrical – may in any case refer directly to the descriptive indicators.

It is not uncommon for a major earthquake to be described as the outcome of two or more strongly destructive earthquakes very close together, for which no separate description of effects exists even in contemporary sources. In these cases the overall damage has been evaluated, with a reference to the special dynamics of the physical phenomenon in the general comment.

Environmental effects – Crevices, chasms, landslides, fallen rocks and boulders have not been considered in themselves direct indicators for use in the assessment of intensity, though we acknowledge their considerable importance in delineating the general seismic scenario and for knowledge of the physical phenomenon. We have preferred to make these data available to the user, who may then process them according to the different targets of the research study.

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