# Montefeltro seismicity: from Serpieri's seismograph to the RSNC seismograph station

## Stefano Santini

Istituto di Fisica, Università di Urbino, Italy

#### Abstract

In recent years, the recovery of some historical documents has permitted us to operate the seismographs used by Alessandro Serpieri (1823-1885) at the Observatory of the University of Urbino in the XIX century. The space-time concept of sensor network was already clear to Serpieri and he tried to apply this concept to the analysis of seismic phenomena in Italy. This paper reviews the history of the Urbino Observatory from Serpieri's age to present times. The historical region of Montefeltro, where Urbino is the main town, is affected by seismicity with typical magnitudes between 2.2 and 2.5. Most of these events occur in the upper 15 km of the crust. The seismicity of the neighbouring regions is mainly concentrated in three zones: Northern Rimini, the Apennine belt and the Sibillini Mountain area. From the overall data, it is possible to infer that there is a basin characterised by microseismicity and essentially dominated by a compressive tectonic regime in the Montefeltro area. Furthermore, seismological data seem to show a "quiet" segment, separating the extension area from the compression area, characterised by a low concentration of seismic events.

**Key words** seismicity – Montefeltro – seismological data – Urbino Observatory

## 1. Introduction

An overall seismic or geodynamic interpretation of the Central-Northern Apennines is difficult, the latter being characterised by complex structures which cannot be defined in the form of a simple, standard model. From the XIX century to the present day, many attempts have been made to explain the evolutionary stages behind the present tectonic structure. The most recent reconstructions interpret the Apennine belt according to the accretionary wedge model (Treves, 1994; Vai, 1994).

The present paper reviews the history of seismological observations in Urbino, from Serpieri's age to the present day. This study is oriented towards the definition of Montefeltro seismicity.

The amount of data and information increased notably over the years and, above all, with the development of better processing systems and techniques.

## 2. Seismology in the XIX century

The study of earthquakes in XIX century in Italy was not only aimed at the study of the seismic paroxysm, an exceptional and destructive event, but also at examining those movements, called microseismic, which could not be perceived by the human senses. This was a purely Italian field of study.

Many accurate observations on the movement of level bubbles were carried out by Mr.

Mailing address: Dr. Stefano Santini, Istituto di Fisica, Università di Urbino, Via S. Chiara 27, 61029 Urbino (PS), Italy; e-mail: santini@fis.uniurb.it

D'Abbadie from 1837 in Brazil, Abyssinia and in France, in which he noted that the Earth's surface is subject to slow small oscillations, and consequent variations of the vertical. Mr. Plantamour, 1878, repeated these experiments in Switzerland and obtained similar results (Serpieri, 1850).

In Italy, in 1855-1856, Canon Parnisetti from Alessandria carried out numerous experiments on the small spontaneous movements of pendulums. Nonetheless, those observations remained isolated and largely unknown until 1870 when Father Bertelli, after observing a simple pendulum seismometer, noted that there were many oscillations in the absence of any earthquake tremors. To be certain that those small movements of the pendulum were really of seismographic origin, he tried to eliminate any cause of

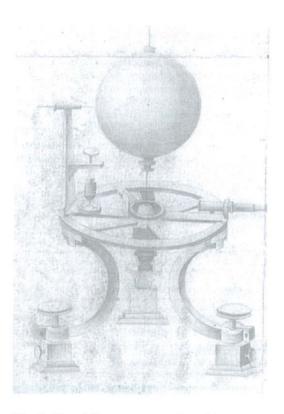


Fig. 1. Bertelli's tromometer, from his original drawing (Ferrari, 1991).

error by isolating the pendulums in order to protect them from vibrations not inherent to seismic movement. Furthermore, in his observations of pendular movements he used a microscope with a metric scale in the eyepiece. Bertelli's first instrument invented for observing not only perceivable earthquakes but all the microscopic movements of the Earth, was called a «Tromosismometro» (fig. 1).

With the «Tromosismometro» Father Bertelli observed not only the minimum oscillation movements and the instantaneous jump of the pendulums, but also the slow upheaval and downheaval of the Earth's surface, shown in the movement of the vertical.

Figure 2 shows a few examples of recordings obtained by Bertelli's tromometer in 1872, and thus the first observations. The dominant period of the signals is in the order of hours and the episodes often follow one another with a more than daily occurrence. Maximum dimensions are of  $100 \ \mu rad$ .

Following the first observations by Parnisetti, Bertelli, Monte, De Rossi, etc., many other Italian seismologists started microscopic observations. Bertelli and De Rossi together designed and built a Normal Tromometer that was adopted by all the observatories in the various microseismic stations, thus making the observations easier to compare. They suggested, for example, that the pendulum was to be 1.50 m in length and weigh 100 grams. Lastly, one must mention the observation made by many Italian seismologists who stated that perceivable earth tremors are usually preceded by extraordinary microseismic activity and specifically by vertical movements (Serpieri, 1854).

## 3. Serpieri's seismograph

The eldest son of a large family, Alessandro Serpieri was born in 1823 at San Giovanni in Marignano, a few kilometres from Rimini. He received the first rudiments of his education at home and later attended school in Rimini where he obtained excellent results. In view of this, his father took him to Urbino, where he studied under the religious order of the Piarists, whose school had been founded in 1699 by Pope

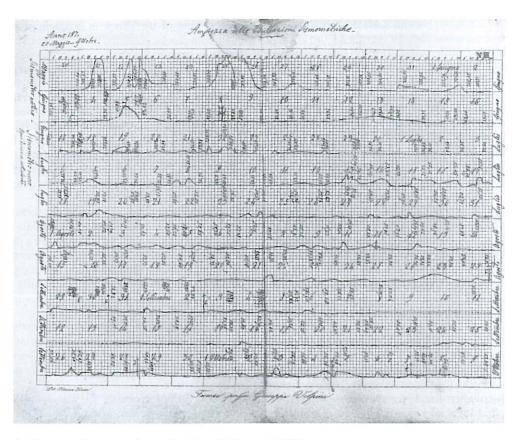


Fig. 2. Tromometric curves obtained by Bertelli (Dragoni, 1991).

Clement XI, also from Urbino. The school, originally assigned to the Piarists of the Province of Rome, came under the jurisdiction of the Province of Tuscany in 1831.

In 1838, at the age of 15, Serpieri left Urbino to continue his education in Florence, again at a Piarist school. The first period of training for young people following the Piarist educational system was carried out in quiet solitude in a house near Florence. On completing this training at the end of 1840, Serpieri went to the Specola Ximeniana, at St. Giovannino, where he immediately started his scientific studies, which were to continue for a period of three years.

Finally, in 1843 Serpieri began his teaching career. The chair of Mathematics and Philoso-

phy at the Tolomei College in Siena, considered to be one of the foremost in Italy, became vacant and was assigned to Serpieri, despite the fact that he was only twenty years old at the time. In the meanwhile, in 1846, the chair of Physics and Philosophy had become vacant at Urbino and was temporarily assigned to Serpieri. Two months later, confirmation of the position arrived from Rome in the form of a decree dated 19th January 1847. Therefore, at only twenty-three years of age, Serpieri became University Professor of Physics, a position which he held until 1884.

Serpieri designed his seismograph on the basis of his experience. The pendulum consisted of a long wire 135 cm in length with a ball on the bottom which had a vertical point on the

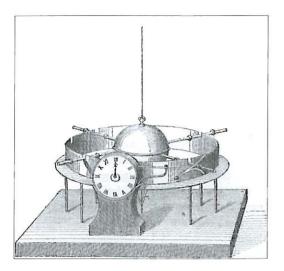


Fig. 3. Serpicri's seismograph, as described in a memory of 1873.

lower side, slightly touching a layer of lycopodium dust (fig. 3).

A horizontal circle is concentric to the ball. This is made of a thin metal sheet fixed on many small columns fixed in a marble surface, covered in a layer of lycopodium dust. The circle has a diameter of 32 cm and the ball 10 cm.

The upper rim of the circle is about 4 cm higher than the equator of the ball. There are small recesses on that circle, 15 mm deep, semicircular, in directions going from N-S, W-E and in the intermediate points. Around the equator of the ball there is a ring made of metal wire. Four or eight small metal bars rest their ends on this equatorial ring. Near the other ends they rest in the recesses in the circle around the ball, jutting out to a large degree from the same and remaining more or less horizontal.

Therefore if the Earth moves from W to E, the bar resting on the W recess falls out, pulling along and then rotating on the edge of that recess. In the same way the side bars of N and S fall inwards as the resting point on the equatorial ring of the ball has been removed. In this way, the bar which has fallen out, will indicate the direction of the first wave. Furthermore, it will be possible to read the tracks left by the point attached to the ball from the powder underneath.

The time of the shock is given by a small pendulum clock connected to one of the bars and placed in front of the apparatus. In this way, the clock indicates only the time that has passed since the first shock. It is necessary to subtract this time interval from the real time to obtain the correct time.

From the information supplied by Serpieri himself (Serpieri, 1879), we know that this instrument was located in a niche dug into a large wall, many metres high, built on the land of the «Collegio dei Nobili» in Urbino, and the instrument was protected by glass doors. To date this instrument has never been found

Two other instruments were more fortunate. These were used by Serpieri at a later date than the one previously described. These are a protoseismograph designed in 1875 by the seismologist M.S. De Rossi and a recording seismograph designed and built around 1882 by Achille Scateni, assistant to the Cabinet of Physics at the University of Urbino (see fig. 4).

From what can be seen from various studies, including those by Serpieri on buildings or monuments in Urbino, earthquakes, at least the stronger ones, always shake the Earth in the same direction.

Observations covering 23 years show that, out of 100 earthquakes, 33 have directions covering the line NNW to SSE and the remaining 67 fall near the line WSW-ENE and what is more, the two lines are perpendicular one to the other, as set forth in the theory.

Examining all the small and large earthquakes recorded from 1850 to 1873 Serpieri obtained the data shown in table I.

As a result, certain walls in buildings in Urbino are cracked and others perpendicular to those are intact, and vaulted ceilings become disconnected due to undulations perpendicular to their axes.

## 4. The 12th March 1873 earthquake

An important seismological analysis was made by Serpieri with a study of the 12th March 1873 earthquake, whose epicentral zone was the Southern Marche area and the epicentral intensity was between VIII and IX degrees on the Mercalli scale.

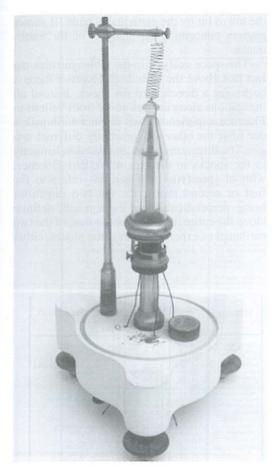


Fig. 4. Scateni's seismograph, for horizontal oscillations (photo by R. Persi).

Serpieri wrote the following (Serpieri, 1873a): «Il giorno 13 Marzo, quando ancora l'impressione lasciata dallo strepitoso fatto era vivissima in tutti e le sue particolarità erano argomento dei comuni discorsi, mandai una circolare ai primari nostri Osservatorii e a molti distinti professori, pregandoli di precise risposte a una breve serie di quesiti che credetti più opportuni per giungere a fissare gli elementi principali del fenomeno. Ben presto, favorito dalla gentilezza di tutti, mi trovai in possesso di molte ben fatte relazioni. Queste prime relazioni mi suggerirono nuove ricerche, e mi fecero conoscere che alcuni dati, massime quello dei tempi, erano ben difficili a stabilirsi con certezza, e richiedevano nuove pazienti indagini. D'altro canto io vedeva bene che senza avere giustamente stabilito in che ora e a che minuto preciso il terremoto traversava le varie stazioni, non si sarebbe mai giunti a formarsi un esatto criterio sull'andamento del fenomeno.» («On 13th March, when the thunderous event was still fresh in everyone's minds and every detail was being discussed by all, I sent a circular to our leading Observatories and to many distinguished professors, asking for exact replies to a short series of questions which I thought most opportune to establish the principal features of the phenomenon. Favoured by the kindness of all concerned, I was soon in possession of many well-written reports. These first reports gave me ideas for new research and informed me that some data, especially those on the times, were difficult to establish with certainty and required patient new

Table I. Earthquakes recorded from 1850 to 1873 by Serpieri (Gambuti, 1990).

Legenda	P-way	ve dir	ection	Nu	nber of ev	ents
Shocks from	S	to	N	8	out of	100
Shocks from	SSW	to	NNE	0	out of	100
Shocks from	SW	to	NE	38	out of	100
Shocks from	WSW	to	ENE	4	out of	100
Shocks from	W	to	Е	25	out of	100
Shocks from	WNW	to	ESE	0	out of	100
Shocks from	NW	to	SE	25	out of	100
Shocks from	NNW	to	SSE	0	out of	100

studies. On the other hand, I could well see that without having rightly established at what hour and what exact minute the earthquake had struck the various stations, we would never have been able to formulate an exact criterion as to the trend of the phenomenon.»).

Having stated this fundamental fact, Serpieri once again invited observers to clarify the hour and minute in which the earthquake was noticed, in order to know for certain whether the time given referred to real time, average time of the area or average time in Rome (Serpieri, 1873b).

A general outline analysis of the earthquake is shown below, consisting of two tables: table II is an organisational chart of the latitudes of the towns hit by the earthquake, table III shows matters concerning an analysis of the earthquake.

The space analysis in the tables justifies the fact that above the latitude of Florence there is no longer a direction to the shock. Instead all the stations along an area going from Velletri to Florence experienced two distinct earthquakes one after the other, of apparently different origin. The directions noted and dated indistinctly in the shocks in the area of Velletri-Florence, without specifying whether this refers to the first or second shock, *i.e.* the two directions being perpendicular, are evident and definite along the entire line. This means that, of the two earthquakes experienced in some places, either

STAZIONI	LATITUD.	LONGITUD, in t. m. da Roma	NOMI DEGLI OSSERVAT.	STAZIONI	LATITUD.	LONGITUD. in t. m. da Roma	NOMI DEGLI OSSERVA
Cosenza	39°. 19 <sup>1</sup>	14'. 58" E.	Prof. Domenico Conti.	Città di Castello.	1	o.' 52" W.	Martine Court (1990)
Napoli	40. 52	7. II E.	Prof. Luigi Palmieri.	Cantiano	43° - 27	0. 52 11.	Prof. Saverio Santini.
Velletri	41. 41	1. 18 E.	D. Ign. Galli e Ing. P. Ditucci.	Castelplanio	43. 28	0. 42 E. 2. 30 E.	Antonio Giordani.
Sora	41. 43	4. 59 E.	Prof. Nicolucci.	Spalatro	43. 29	2. 30 F.	Giacomo Angeli.
Anagni	41. 45	2. 49 E.	Dottor Zappasodi,	Jesi	43. 30	15. 54 E.	I. R. Istituto Meteor, di Vien Prof. V. Mattioni.
Castel Gandolfo	41. 45	0. 47 E.	Luigi Marazzi.	Livorno	43. 31	3. 8 E. 8. 37 W.	Prot. V. Mattioni.
Rocca di Pana . I	41. 46	1. 2 E.	Salvatore Fondi ed altri.	Daywell	43.32	8. 37 H.	Prof. Pictro Monte.
Frascati	41. 48	0. S4 E.	P. Lavaggi.	Pergola	43. 33	3. 30 E.	P. Raffaele Piccinini.
Monte Porzio	41. 49	1. ; E.	T. Ricci.	Cagli	43. 33	6. 47 E.	Prof. Gregorio Mei.
Piglio	41. 50	2. 46 E.	I. Ricci.	Ancona	43. 37	4. II E.	Prof. Francesco De Bosis.
Roma	41. 54	o. 6 E.	Ing. Ed. Lupi. P. Angelo Secchi.	5. Angelosity also	43. 39	o. 12 W.	Prof. Ernesto Antonini.
n	41. 54	0. 0 E.	r. Angelo Secon.	Mondavio	43. 40	2, 1 E.	Giuseppe Monti.
Ciciliano	41. 57	1. 57 E.	Prof. Michele Stefano De Rossi.	Fassambrone	43. 41	1. 22 E.	Prof. Gluseppe Ceccarelli.
Tivoli	41. 58	1. 37 E. 1. 22 F.	R. Riccardi.	Urbino	43- 43	o. 44 E.	P. Alessandro Serpieri.
Avezzano	42. 2	3. 54 E.	Canon, Coccanari.	Cartoceto	43. 46	1. 12 E.	Camillo Marcolini.
Monte Rotondo.			Ing. Ludovici.	Pontassieve	43. 46	4. 1 W.	Guido Libri.
Civitavecchia . ,	42. 3 42. 6	o. 39 E. 1. 58 E.	Giuseppe Gatti.	Firenze	43. 46	4. 49 W.	Prof. G. B. Donati.
Aquila	.12. 21	1. 58 E.	Ing. Giuseppe De Andreis. Ing. Partim e B. Bonanni.	ъ	43. 46	4. 17 W.	P. Filippo Cecchi.
Chieti		3. 317 E.	Ing. Partini e B. Bonanni,	D	43. 47	4. 42 W.	P. Timoteo Bertelli.
Rieti	42. 21	6. 50 E.	Prot. Enrico Cristini.	Sebenico	43. 48	13. 36 E.	I. R. Istituto Meteor, di Vieni
Viterbo	42. 24	1. 37 E.	Dottor Riccardo Gamba.	Pennabilli	43. 49	o. 44 W.	Prof. Dario Mattei.
Pescara	42, 25	1. 24 W.	Prof. G. Barbieri, e D. S. Medi-	Fano	13. 51	2. 14 E.	Prof. Avoni.
Orte	12. 26	7. 13 E.	Dott. Girolamo Orsi. (chini.	S. Marino	43. 56	o. 1 W.	Palamede Malpeli.
Ragusa	42. 27	0. 17 W.	Agostino Ralli,	Rimini	4.1. 3	o. 33 E.	Osservatorio e P. T. Bertell
lagnorea	42- 37	22. 40 E.	Prof. G. Podielm.	Savignano	44. 6	0. 14 1/.	Ing. Lucio Fellini.
Emplored	42, 38	1. 26 W.	Carlo Raffaele Gualterio.	Zara	41. 7	11. 4 E.	I. R. Istituto Meteor, di Vient
l'eramo	42, 40	4. 49 E.	Prof. Carlo Fracassa.	Porretta	44. 9	5. 5; W.	P. Timoteo Bertelli.
Drvieto	42. 41	o. 22 E.	E. Achillini,	Forli	44. 13	1. 39 W.	Antonio Merlini.
Arvieto	42. 43	I. 22 W.	Prof. Luigi Chatel.	Genova	11. 26	14. 4 W.	Prof. G. M. Garibaldi.
poleto	42. 44	1. 8 E.	Prof. Arpago Ricci.	Bologna	41. 30	4. 24 W. 6. 6 W.	Prof. Alessandro Palagi.
rosseto	12. 16	5. 21 W.	Prof. Andrea Bongini.	Modena	44. 39	6. 6 W.	Prof. Domenico Ragona,
our	42. 47	0. 12 W.	Prof. Enrico Ippoliti,	Pola	44. 52	5. 32 E.	I. R. Istituto Idrografico.
iorcia	42. 47	2. 33 E.	Prof. Santoni e Prof. Colantoni.	Alessandria	41.54	15. 21 W.	Can, Pietro Parnisetti.
scoli	42. 51	3. 51 E.	Prof. G. Tranquilli e A. Saladini.	Moncalieri	45. 0	15. 21 W. 18. 55 W.	P. Francesco Denza.
Trevi	42. 53	1. 10 E.	Prof. Arpago Ricci.	Mantova	45. 10	6. 37 W.	Prof. Agostini.
some Portino .	42. 56	3- 33 E.	Luigi Antonini.	Pisino	45. 13	j. 48 E.	I. R. Istituto Meteor, di Vicnu
oligno mandola	42- 57	1. o E.	Prof. Giovanni Salvatori.	Lodi	45. 19	11, 47 W.	Prof. Stanislao Belli.
mandola	42. 59	3. 38 E.	L Antonini e V. Astorri.	Fiume	45. 20	7. 56 E.	Prof. Stahlberger dell'I, R. Ac
pello enna S. Giov	12. 59	o. 52 E.	Prof. Luigi Gaspari.	Padova	45. 24	2. 20 W.	R. Osservatorio. (Mil
eima 5. Giov.	43. 3	3- 52 E.	Vincenzo Astorri.	Umago	45. 25	4. 17 E.	I. R. Istituto Meteor, di Vienn
anginesio	43. 6	3. 27 E.	Signor Sindaco.	Venezia	45. 26	0 3- W	Prof. Chicappa Managura
erugia	43. 7 43. 8	o. 16 W.	Prof. DalPozzo e Prof. Bellucci.	Milano	45. 28	0, 27 W. 13, 0 W.	Prof. G. V. Schlangrolli
amerino	43. 8	2. 27 E.	Prof. Luigi Berti.	Trieste	45. 39	5. 16 E.	Prof. Giuseppe Meneguzzi. Prof. G. V. Schiaparelli. I. R. Istituto Meteor. di Vienn
ermo	43. 10	5. 2 E.	Prof. Giulio Ageliui Ugolini.	Aosta	45. 44	20. 25 W.	Prof. P. G. Volante.
latelica	43- 15	2. 13 E.	Prof. Filippo De Sanctis.	Varallo	15. 48	16. 41 W.	Prof. Pietro Calderini.
lacerata	43. 18	5. 59 E.	Prof. Piero Giuliani.	Lugano	16. 0	14. o W.	Osservatorio.
livitanova	45. 18	5. 6 E.	Prof. F. Mici e Prof. G. Cecca-	Udine	46. 1	3. 7 E.	Prof. Gio. Clodig.
iena	43- 19	4. 28 W.	Prof. Cesare Toscani. relli.	Belluno	16. S	0. 17 W.	A. De Fulcis.
igillo	43. 20		Ubaldo Colini.	Grubbof		0. 37 W.	
abriano	43. 20		Prof. C. Morbelli e Prof. A. Zon-	(nel Salisburgh.)	47- 35	U. 55 F	Contessa Von Almasy,
ingoli	13. 22		Gaetano Castiglioni, ghi.	a (mer cantaring in )		<u>.</u>	
ofterra	43- 24		P. Prospero Loui.				

Table II. Locations hit by the 12th March 1873 earthquake (Serpieri, 1873a).

	1	Ora in	DIMINUZIONE	5 o dove andavano le ondulazioni				ı J		
STAZIONI	OSSERVATORI	tempo medio di	GENERE DEL MOVIMENTO	o	DURALIA IN SECONDI		DIREC			I ORZ V
	1	Roma	}	TREGUA	31.0	prima	seconda	terza	unica	
-	D. Costi		Sussultorio — ondulat			111.0000000	l'		NW.	debole
Cosenza Napoli Velletri	F. Brioschi I. Galli	9. 0		2.2.2.2.1	12	111		111	- "	deholissimo
Velletri id.	I. Galli P. Dirucci	9. 5	Ondulatorio	dimin.	30	WNW	SW		1	forte forte
Sora			Ondulatorio	tregua				0.00	w.	ntediocre forte
Anagni Castel Gandolfo	Zapparodi	9.7	Due scosse and.	lunga tregua	13			888	ZW.	mediacre
Rocca di Papa	Zapparodi L. Marazzi S. Fondi P. Lavaggi E. Lupi T. Ricci		Due scosse ond Ondulatorio	ninga iregan	j 10			1 1 1 1	SW	
Frascati Piglio	P. Lavaggi	9. 2?		98558	10				ZII.	mediacre
Munto Porrio	T. Ricci	9. 3	Ondulatorio		16				WSW	debale mediacre
Roma id.	A. Secchi M. De Rossi	9. 3 9. 5 9. 6	Tre moti ondosi	tregua	18	'viv'	sir.	1 - 1	10 10 10 10	forte
Tivoli	Coccanari R. Riccardi	1 1 1 1 1 1	Ondulatorio		tб	NW N	ZW.		NW.	fortíssimo
Ciciliano Avezzano	Indovice	9- 3	Ondulatorio		22.2			1000	N N	fortissimo forte
Monte Rotondo	G. Gatti		Ond sussul ond	no	60	' sw'	1 4 6	0.00	10.00	forte
Civitavecchia Aquila		9.72	Ondulatorio	111111	7.7.				W	debate
Aquila Chieti Rieti	E. Cristini R. Gamba		Ondulatorio .	ca	3	. viv.	SW.	200	NW	debale
Viterbo id.		9. 6 9. 0 — 9. 10	s ond legg., s forti		6					mediacre mediacre
id. Pescara	G. Barbieri	4 4 4 4		tregua	9	211.	7.11.		1 2 1 1	forte debale
Orte	A. Ralli R. Gualterio	9- 3	Ondulatorio						SW	
Bagnorea	R. Gualteria		Suss. — end	tregua no	15		1 4 4 4 1	2 2 2 1	7.II. 7.II.	forte mediacre
Ragrana Teramo id.	G. Podřelm C. Fracarsa R. Bonanni	8. 55 9. 4 1/e	Suss. — ond	dimin.	ŝ	111	1.1.1		100000	mediacre
id.	B. Bonanni		Ondulatorio	1 1 1 1 1	1	. W	'viv'	100	SSW	leggicto fortissimo
Acquasparta Orvieto	Achillini	9-4 1/3	Suss. — ond		25 25 14	7 7 7	11 11 22		NW	forte
Spoleto Grosseta Todi	A. Ricci	9. 2	Suss. — ond Ondulatorio	dienin.		8 5 5	11 11 12.		SSW.	debalissimo
Todi	F. Ippoliti	9.0	Ondulatorio	100000	30	0.00		5 5 5 5	M. N.	Iertissimo
Norcia id.	A. Ricci A. Bongini E. Ippoliti Santoni Colartoni	9. 2 1/2	Tre serie di ondulazioni . Suss. — ond Ondulatorio	due tregue	30 17 23 16	. <i>ii.</i> .	ZW.	1.5.1		forte forte
Ascoli		9. 3 1/4	Ondulatorio		16		111		NW NW	forte fortissimo
id. Trevi	A. Saladíni A. Ricci	9. 4 9. 0 circa	Susa. — and.		1;	2 2 2				
Foligno Monre Fortino Amandola	G. Salvatori	9. 6 circa 9. 5	Due scosse ond	dimin.	78	2 2 3	18 18 18	2 2 2	11.211.	forte forte
Amandola	V Astorri		Suss. — ond			1.00		1 1 1	ZZM, ZZM,	forte fortissimo
Spello Penna	L. Gaspari V. Astorri	9. 3 ?	Suss. — ond. Suss. — ond.		6	NW3	SW?	w	4 4 4	fortissimo
San Ginesio	Sindaco		Suss. — ond.	diction.	16		1 20 20 20 20		ZW	fortistimo
Perugia id	F Dal Posto	9. 2	Susa — end	no	20 25 13 38	N. 30s M.	S. 25 W	S. 5* W		fortissimo fortissimo
Camering	L. Berti	9.5 1/2	Suss. — end. — suss	dintin.	11		ssiv		ZZH	fortissimo forte
Fermo Matelica	A. Ugolini	9. 0 9. 5 <sup>1</sup> / <sub>3</sub> 8. 59 9. 5 <sup>1</sup> / <sub>3</sub>			38	1 1 1 1			ZW.	forte
Macerata	P. Giuliani	9. 3 9. 7 / <sub>2</sub>	Suss. — ond. Ondulatorio	1000	15	Ň	WSW.	0.00	de er er e	forte mediacre
Macerata Siena Sigillo	F. De Sanctis P. Giuliani C. Toscani U. Colini		Ondulatorio		9 7 21				SW	forte
Fabriano	C. Morbelli	9.5	Ond. — suss. — ond	- Maria - 11			SW Donde	venivano	la vari	fortissinto
		Ora in		DIMENTALONE	DUZATA	0	dove andava			FORZA
STAZIONI	OSSERVATOR	tempo medio	GENERE DEL MOVIMENTO		1 5 = 8	1	DIRE	ZIONE	100000	FORZA
		Roma		TREGUA	1 3 %				1 0	
			100	TREGUA		prima	seconda	terza	unica	
Fabriano	A. Zonghi		Scossa a 3 ziprese	TREGUA		prima WNW		ferza		fornissimo
Fabriano Cingoli Volterra	A. Zonghi G. Castiglioni P. Loni			TREGUA	20 12 11		seconda	terza	NW SW	fortissimo debolissimo
Cingoli Volterra Cini di Castella	A. Zanghi G. Castiglioni	9- 7 V <sub>3</sub>			20 12 11		wsw.	terza	NW SW	fortissimo debolissimo forte
Cingoli Volterra Città di Castella Cantiano Castelplanio	A. Zonghi G. Castiglioni P. Lotti S. Santini A. Giordani Stax, ferrovia	9- 7 V <sub>3</sub> 9- 7 V <sub>3</sub>	Scossa a 3 riprese . Ond. — suss. — ond. Ondulatorio Suss. — ond. Ondulatorio	no	20 12 14 25 12		seconda	ferza	NW SW	fortissimo debulissimo forte forte
Cingoli Volterez Città di Castello Cantiano Castelplanio Soulatro	A. Giordani Staz. ferrovia	9-7-1/3 9-7-1/3 9-4 9-2-1/3	Ond. — suss. — ond. Ondulatorio	no	20 12 11	WNW	wsw .	ferza	NW SW	fortissimo debalissimo fatte forte forte
Cingoli Volterta Città di Castello Cantiano Castelplanio Spalatro Jesi Livorno	A. Giordani Staz. ferrovia	9-7-1/3 9-7-1/3 9-4 9-2-1/3	Ond. — suss. — ond	no	20 12 14 25 12		wsw.	terza	NW SW SW NW	fortissimo debalissimo forte forte forte forte
Cingoli Voltera Città di Castello Cantiano Cantelplanio Spalatro Jesi Livorno Percola	A. Giordani Staz. ferrovia V. Mattioni P. Monte	9-7-1/3 9-7-1/3 9-4 9-2-1/3	Ond. — suss. — ond. Ondulatorio Suss. — ond. Ondulatorio Ondulatorio Ond. con sussuhi Ondulatorio	no	20 12 14 25 12	WNW	wsw ssw ssw ssw ssw	terza	NW SW SW NW W	fortissimo debalissimo forte forte forte forte
Cingoli Volterta Città di Castello Cantiano Castelplanio Spalatro Jesi Livorno	S. Santini A. Giordani Staz. ferrovia V. Mattioni P. Monte R. Piccinini G. Mei F. De Rosis	9-7 1/2 9-7 1/3 9-7 1/3 9-2 1/2 9-81 9-9-181/2 9-9-9-1	Ond. — suss. — ond. Ondulatorio Suss. — ond. Ondulatorio	no	20 12 14 25 12 12 4	WNW	wsw NSW SSW NW	terza	NW SW SW NW	fortissimo debolissimo forte forte forte debolissimo fortissimo mediocre
Cingoli Volterra Città di Castello Cantiano Castelplanio Spalatro Jesi Livorno Pergola Cagli Ancona	S. Santini A. Giordani Staz. ferrovia V. Mattioni P. Monte R. Piccinini G. Mei F. De Rosis	9-7-1/3 9-7-1/3 9-4 9-2-1/3	Ond. suss. ond. Ondulatorio Suss. ond. Ondulatorio Ond. con sussaili Ondulatorio Suss. ond suss. Ondulatorio	no	20 12 14 25 12 11 4 4	WNW	wsw ssw ssw ssw ssw		NW SW SW NW W	fortissimo debellissima farte forte forte debellissimo fortissimo fortissimo mediocre mediocre
Cingoli Voherra Città di Castello Cantiano Castelplanio Spalatro Jesi Livorno Pergola Cagli Ancona S. Angelo in Vada	S. Santini Staz. ferrovia V. Martioni P. Monte R. Piccinini G. Mei F. De Bosis G. Orsi E. Antonini G. Monte	9. 7 1/3 9. 7 1/3 9. 4 9. 2 1/2 9. 81 - 9. 181/2 9. 5 9. 5	Ond. suss. ond. Ondulatorio Suss. ond. Ondulatorio Ond. con sussaili Ondulatorio Suss. ond suss. Ondulatorio	no dimin.	20 12 14 25 12 11 4 4 4 9 9	WNW WSW SW	wsw NSW SSW NW		NW SW SW NW W	fortissimo debalissima farte forte forte debalisimo fortissimo mediocre mediocre forte
Cingoli Voherra Città di Castello Cantiano Castelplanio Spalatro Jesi Livorno Pergola Gagli Ancona S. Angelo in Vada Mondavio Urbino Pomtassieve	S. Santini Staz. ferrovia V. Martioni P. Monte R. Piccinini G. Mei F. De Bosis G. Orsi E. Antonini G. Monte	9-7-1/3 9-7-1/3 9-2-1/3 9-2-1/3 9-8-1-9-181/2 9-3-1/4	Ond. suss. ond. Ondulatorio Suss. ond. Ondulatorio Ond. con sussaili Ondulatorio Suss. ond suss. Ondulatorio	dimin. tregus tregus tregus	20 12 14 25 12 12 12 14 17 4 4 35 9 4 28 35	WNW WSW SW	SSW SW		NW SW SW NW W SSW	fortissimo debalissima forte forte forte debalisimo fortissimo mediocre mediocre forte forte forte forte forte forte forte
Gingoli Voherra Città di Castella Cantiano Castelplanio Spalatro Jesi Livorno Pergola Cagli Ancora S. Angelo in Vada Mendavio Urbino Pontassicva Frense id.	S. Santini S. A. Giordani Staz, ferrovia V. Mattioni P. Monte R. Piscelmin G. Mei F. De Bosis G. Orsi E. Antomini G. Monti A. Serpleri G. Libri G. R. Dunni	9.71/3 9.71/3 9.4 9.21/2 9.81 s 9.181/2 9.9 s 9.1	Ond subs. ond. Ond-terms Subs. end. Ond-terms Ond-terms Ond-terms Subs. ond. subs. Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Date or tre scose.	dimin. Hegul Tregus Tregus	20 12 14 25 12 12 4 4  35 9 4 28 35 35	WNW WSW SW NNW NW NW NW	wsw ssw ssw ssw ssw ssw ssw ssw ssw ssw		NW SW SW NW W SSW	fortissimo debelissimo forte forte forte debelissimo fortissimo fortissimo mediocre mediocre forte for
Cingoli Volkerra Cintà di Castello Cantalano Castelplanio Spalatro Jesi Livorno Pergolx Cagli Ancont S. Angelo in Vado Mendavia Urbino Pontassicve Frence id. id.	S. Santini S. A. Giordani Star, Ferrovia V. Martioni P. Mante R. Piccheini G. Mei G. De Bosis G. Ora G. Ora G. Santini G. Monti A. Serpleri G. Libri G. B. Donati F. Cecchi T. Bernelli	9. 7 1/2 9. 7 1/2 9. 4 9. 2 1/2 9. 8 1, 9, 18 1/2 9. 5 9. 5 9. 1 9. 1 9. 1 9. 1	Ond subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-lateria Ond-lateria Ond-lateria Ond-subs.	dimin. tregus tregus tregus	20 12 14 25 12 12 14 4 4 35 9 4 28 35	WNW WSW SW	SNW 2 SSW SW SW		NW SW SW NW W SSW	fontissimo debalissimo forte forte forte debalissimo fortissimo fortissimo mediocre mediocre mediocre mediocre mediocre mediocre mediocre
Gingoli Veshera Cintà di Castello Cantiano Castelplanio Spalatro Jesi Livorno Pergoli Cagli Ameorat S. Angelo in Vada Mondavio Crivino Portansivo Firmo di di di Stbennio	S. Santini S. A. Giordani S. A. Giordani S. A. Gerrovia V. Mantieni P. Moane R. Picchnin G. Mei F. De Bosis G. Orai G. Monti A. Seepleri G. Seepleri G. B. Donati F. Cecchi T. Bernelli Uff. Telegr.	9. 7 1/2 9. 7 1/2 9. 4 9. 2 1/2 9. 8 1, 9, 18 1/2 9. 5 9. 5 9. 1 9. 1 9. 1 9. 1	Ond subs. ond. Ond-terms Subs. end. Ond-terms Ond-terms Ond-terms Subs. ond. subs. Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Date or tre scose.	dimin. Hegul Tregus Tregus	20 12 14 25 12 12 14 4 4 35 9 4 28 35	WNW WSW SW NNW NW NW NW	wsw ssw ssw ssw ssw ssw ssw ssw ssw ssw		NW SW SW NW W SSW	fortissimo deballissima fotte forte forte deballisimo fortissimo fortissimo fortissimo mediocre mediocre forte forte forte forte mediocre mediocre mediocre mediocre mediocre mediocre mediocre mediocre mediocre mediocre mediocre mediocre
Gingoli Vesteria Gină di Castella Camtiano Castelplanio Spalutro Jeoi Livono Pergola Cagli Monora S. Angelo in Vado Mendavia Urbino Pontassicv Frenue J. L. L	S. Santini Star, ferrovia Star, ferrovia Star, ferrovia V. Manteni P. Mane R. Ficelini G. Mei F. De Bois G. Orsi E. Antonini G. Monti A. Serpleri G. Libri G. B. Donati F. Cecchi T. Bernelli Lift, Telegr.	9.7 1/2 9.7 1/2 9.4 9.4 9.2 1/2 9.8 1.9 181/2 9.5 9.5 9.5 9.1 1/4 9.5 9.1 1/4 9.5	Ond subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-lateria Ond-lateria Ond-lateria Ond-subs.	dmin. tregus tregus	20 12 14 21 12 12 12 12 14 4 4 28 33 4 35 4 4 5 14 15 16 17 16 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18	WNW WSW SW NNW NW NW NW	wsw ssw ssw ssw ssw ssw ssw ssw ssw ssw		NW SW SW NW W SSW	fortissimo debalissima fatte fotte forte mediocre mediocre mediocre mediocre forte forte forte
Gingoli Vesteria Gină di Castello Caminano Castelplanio Spalutro Jesi Hyorno Pergola Cagli Amonta S. Angelo in Vado Mendavio Urbino Pomtassicv Frenue id Li St beniaca Pemadelli Endo	S. Santini Star, ferrovia Star, ferrovia Star, ferrovia V. Manteni P. Mane R. Ficenini G. Mei F. De Bois G. Orsi E. Antonini G. Monti A. Serpleri G. Libri G. B. Donati F. Cecchi T. Bernelli Lift, Telegr.	9.7 1/2 9.7 1/2 9.4 9.4 9.2 1/2 9.8 1.9 181/2 9.5 9.5 9.5 9.1 1/4 9.5 9.1 1/4 9.5	Ond. subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-lateria Ond-lateria Ond-lateria Ond-subs.	mo dimin. tregus tregus tregus	20 12 14 25 12 14 25 12 1 1 1/1, 4 28 35 4 28 35 5 17 5 17 5 18 18 18 18 18 18 18 18 18 18 18 18 18	WNW WSW SW NNW NW NW NW	wsw wsw ssw sw wsw wsw		NW SW SW NW W SSW	fortissimo debalissima fatte de la contra fatte forte farte forte mediocre mediocre mediocre mediocre mediocre forte forte forte forte forte forte forte debale
Gingoli Veshera Gina di Castella Caminano Camelphania Sepia Livorno Pergolx Gagli Ancont S. Angelo in Vado Mendavia Erbino Pontansivo Firense di Stemnaodi Fana S. Marino Pemnaodi Fana S. Marino Phaniai	S. Santini Star, ferrovia Star, ferrovia Star, ferrovia V. Manteni P. Mane R. Ficenini G. Mei F. De Bois G. Orsi E. Antonini G. Monti A. Serpleri G. Libri G. B. Donati F. Cecchi T. Bernelli Lift, Telegr.	9.7 1/2 9.7 1/2 9.4 9.4 9.2 1/2 9.8 1.9 181/2 9.5 9.5 9.5 9.1 1/4 9.5 9.1 1/4 9.5	Ond subs. ond. Ond-terns Suss. end. Ond-terns Ond can sussalti Ondoltonia  Suss. end. subs. Ondulatoria  Ondoltonia  Ondoltonia  Ondoltonia  Ondoltonia  Ondoltonia  Ondoltonia  Date of the Subs. end. Minto ond. ends. subs. Subs. end. e rotat.	dmin. tregus tregus	20 32 14 25 12 12 13 4 4 28 35 35 4 28 5 4 60 60	WNW WSW SW NNW NW NW NW	wsw ssw ssw ssw ssw ssw ssw ssw ssw ssw	N.º	NW SW SW NW W SSW	fortissimo debellissima forte destreta forte for
Gingoli Veshera Gina di Castella Caminano Camelphania Sepia Livorno Pergolx Gagli Ancont S. Angelo in Vado Mendavia Erbino Pontansivo Firense di Stemnaodi Fana S. Marino Pemnaodi Fana S. Marino Phaniai	S. Smittell S. Smittell Star, Ferrovia Star, Ferrovia F. Monte F. Monte F. Monte F. Monte F. De Bosis G. Ord F. Antomai G. Ord F. Antomai G. Smittell F. Cocchi T. Bernell U.S. Telegr D. Mattel Avoni OSs. & Bernell Cos. & Bernell Co	9. 7 1/2 9. 7 1/2 9. 4 9. 2 1/2 9. 8 1, 9, 18 1/2 9. 5 9. 5 9. 1 9. 1 9. 1 9. 1	Ond subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-rotat, subs. Subs. ond. rotat.	mo dimin tregus tregus tregus tregus	20 12 14 21 12 12 12 12 14 4 4 28 33 4 35 4 4 5 14 15 16 17 16 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18	WNW WSW SW NNW NW NW NW	wsw wsw ssw sw wsw wsw	N.º	NW SW SW NW W SSW	fortissimo debelissima forte develissima forte forte forte debelis mino producere mediocre mediocre mediocre mediocre mediocre forte forte forte forte forte forte mediocre me
Gingoli Veshera Gua di Castella Camiano Candiano Castella Camiano Castella Castella Livorno Pergola Cagli Amcont S. Angelo in Vado Mendavia Crivino Pontassivo Fina di di Sebenica Permabelli Saignano Zara di Saignano Zara	5. Switters A. Giordani Star, Gerenti Star, Gerenti Star, Gerenti F. Manteel F. Manteel F. Manteel F. Melli F. De Bosis G. Oroi G. Abri G. B. Domai F. Gerenti G. Libri Litters Litters D. Matteel Wanteel Litters D. Matteel D.	9.7 1/2 9.7 1/2 9.8 1/2 1/2 9.8 1/2 9.5 1/2 9.5 2 9.5 2 9.5 3 9.5 4 9.5 4 9.5 4 9.5 4 9.5 4 9.5 4 9.5 4 9.6 1/2	Ond. subs. ond. Ond-lateria Suss. ond. Ond-lateria Ond-lateria Ond-lateria Ond-lateria Ond-subs.	mo dimin. uegus tregus tregus tregus tregus	20 12 12 14 25 12 12 14 4 4 35 9 4 28 35 4 5 7 60 6	WNW WSW SW NNW NW NW NW	wsw wsw ssw ssw wsw wsw ssw wsw	Ňž	NW SW NW W SSW NW W SSW NW SSW NW SSW NW SW NW NW SW NW NW SW NW NW SW NW NW NW SW NW NW NW SW NW NW NW SW NW NW NW NW NW SW NW	fortissimo debelissima forte describe de la contra forte describe de la contra forte de la contra forte de la contra forte de la contra medio cre medio cre medio cre medio cre forte de la contra de la contra forte de la contra del la contra de la contra del la contra
Gingoli Veshera Gua di Castella Camiano Candiano Castella Camiano Castella Castella Livorno Pergola Cagli Amcont S. Angelo in Vado Mendavia Crivino Pontassivo Fina di di Sebenica Permabelli Saignano Zara di Saignano Zara	5. Switterl A. Giordani Stat. Gerentia Stat. Gerentia Stat. Gerentia V. Mattieri R. Mante R. Mante R. Mante G. Mei F. De Bosis G. Mei G. Donali G. Monti A. Sexpleri G. Libri T. Herrelli Lif. Telegr. D. Mattes Avont P. Malpeli Oxo. e Bertill L. Felhi L. Felhi T. Retrelli L. Felhi T. Retrelli L. Felhi T. Retrelli	9.71/5 9.71/5 9.4 9.21/2 9.81 9.181/2 9.51 1/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4	Ond subs. ond. Ond-terms Suss. end. Ond-terms Ond-terms Ond-terms Ond-terms Suss. end. subs. Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Ond-terms Suss. end. Misto ond-terms Suss. end. Suss. end. ends. Ond-terms Suss. end. ends. Due out subs. Suss. end. ends. Due scosse ondulatorie Due scosse ondulatorie Ond-balatorie	mo dimin tregus tregus tregus tregus	20 12 14 25 12 13 14 4 28 35 4 28 35 4 28 5 16 17 60	WNW WSW SW NNW NW NW NW	WSW  WSW  SSW  SSW  WSW  WSW  WSW  WSW	N?	NW SW NW W SSW NW W SSW NW NW N SSW NSW N	fortissimo debellosima debellosima debellosima debellosima forte mediocre mediocre mediocre mediocre mediocre forte forte debello mediocre debello mediocre debello mediocre forte forte debello mediocre forte debello mediocre forte forte forte forte forte debello mediocre forte forte forte debello mediocre forte
Gingoli Vosherra Gini di Castella Castelpanio Spalutro Lori Lori Lori Lori Lori Lori Lori Lo	5. Switterl A. Giordani Stat. Gerentia Stat. Gerentia Stat. Gerentia V. Mattieri R. Mante R. Mante R. Mante G. Mei F. De Bosis G. Mei G. Donali G. Monti A. Sexpleri G. Libri T. Herrelli Lif. Telegr. D. Mattes Avont P. Malpeli Oxo. e Bertill L. Felhi L. Felhi T. Retrelli L. Felhi T. Retrelli L. Felhi T. Retrelli	9.71/5 9.71/5 9.4 9.21/2 9.81 9.181/2 9.51 1/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4	Ond subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-subs. ond. Due otre score Aliato. ond rotat. Subs ond rotat.	mo dimin tregus tregus tregus tregus tregus tregus tregus	20 12 12 14 25 12 12 14 4 4 35 9 4 28 35 4 5 7 60 6	WNW SW NNW NW NW NW	WSW  WSW  SSW  SSW  WSW  WSW  WSW  WSW	Ňž	NW SW SW KW KW KW SSW SW SW SW SW NW SW SW	fortissimo debellissima forte corre forte forte debellismo por fortistamo mediocre mediocre mediocre mediocre mediocre forte debellismo forte forte forte forte forte debellismo debe
Cingoli Vosherra Gua di Castella Castelplanio Spalatro Lori Lori Pergola Cagli Amonta S. Angelo in Vado Mindavio Urbino Pomtassivo Fili Li	S. Swifferl S. S. Mirrier Star, Gerenta Star, Gerenta Star, Gerenta Star, Gerenta F. Monte F. Monte F. Monte G. Mei F. De Bosis G. Oroi G. Abri G. B. Domai F. Gerenta L. Arconomi L. Telegar, D. Marce D. Marce S. G. Bertill L. Fellin L. Fellin F. M. Garbaldi F.	9.71/5 9.71/5 9.4 9.21/2 9.81 9.181/2 9.51 1/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4 9.51/4	Ond subs. ond. Ond-term substitution Ond can substitution Ond can substitution Ond can substitution Ond can substitution Ond-term substitution Ond-term substitution Ond-term ond. Ond-term ond. Ond-term ond. Ond-term ond. Ond-term ond. Substitution Ond - rotat. Substitution Substitution Substitution Substitution Ond-term ond-t	mo dimin. uegus tregus tregus tregus tregus	20 12 14 25 12 13 13 14 4 28 35 4 28 35 4 4 28 5 4 4 6 6 6	WNW WSW SW NNW NW NW NW	WSW  NNW 7  SSW NW  WSW  WSW  WSW	Ňž	NW SW SW KW KW KW SSW SW SW SW SW NW SW SW	fortissimo debellosima debellosima debellosima debellosimo forte mediocre mediocre mediocre mediocre forte forte forte forte forte forte debellosimo debello
Cingoli Vosherra Gua di Castella Castelplanio Spalatro Lori Lori Pergola Cagli Amonta S. Angelo in Vado Mindavio Urbino Pomtassivo Fili Li	S. Smitter S. Smitter Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte F. Monte F. Monte F. De Boits G. Oroi G. Abant G. Monte G. Libri G. B. Donati F. Cocchi T. Bernelli U.S. Telegra Avoni D. Mattei F. Malbali L. Felli L. Felli L. Felli L. Felli L. Felli F. Malbali L. Felli L. Felli L. Felli L. Felli L. Felli L. Recold F. M. Garbaldi D. Magent L. F. Malbali L. F. Malbal	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-lateria Subs. ond. Ond-lateria Ond-subs. ond. Due otre score Aliato. ond rotat. Subs ond rotat.	mo dimin tregus tregus tregus tregus tregus tregus tregus	20 12 14 25 12 13 14 4 28 35 4 28 35 4 28 5 16 17 60	WNW SW NNW NW NW NW	WSW  WSW  SSW  SSW  WSW  WSW  WSW  WSW	Ňž	NW SW SW KW W SSW SSW SW SW SW SW SW SW SW SW SW S	fortissimo debellissima forte de la constanta
Cingoli Vosherra Gua di Castella Castelplanio Spalatro Lori Lori Pergola Cagli Amonta S. Angelo in Vado Mindavio Urbino Pomtassivo Fili Li	S. Smitter S. Smitter Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte F. Monte F. Monte F. De Boits G. Oroi G. Abant G. Monte G. Libri G. B. Donati F. Cocchi T. Bernelli U.S. Telegra Avoni D. Mattei F. Malbali L. Felli L. Felli L. Felli L. Felli L. Felli F. Malbali L. Felli L. Felli L. Felli L. Felli L. Felli L. Recold F. M. Garbaldi D. Magent L. F. Malbali L. F. Malbal	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-term subs. ond. Ond-term substitution Ond can assault Ondobrona  Ond can assault Ondobrona  Ond can assault Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Date or tre scoss  Subs. ond totat.  Subs end rotat.	mo dimin tregus tregus tregus tregus tregus tregus tregus	20 12 14 25 12 13 13 14 4 28 35 4 28 35 4 4 28 5 4 4 6 6 6	WNW SW NNW NW NW NW	WSW  NNW 7  SSW NW  WSW  WSW  WSW	Ňž	NW SW SW NW W SSW SSW SSW SSW SSW SSW SS	fortissimo debellosima debellosima debellosima debellosimo forte farte debellosimo fortissimo fortissimo fortissimo forte forte forte forte forte forte mediocre mediocre mediocre mediocre debellosimo debellosim
Gingoli Vosherra Gina di Castella Cartelplanio Spalatro Lorio Lori	S. Smitter S. Smitter Star, Gerraria Star, Gerraria Star, Gerraria Star, Gerraria F. Monne F. Monne F. Monne F. Monne F. De Boits G. Oroi G. Oroi G. Horonia G. Libri G. B. Domai F. Cocchi G. Libri G. B. Domai F. Cocchi G. B. Domai F. Domai F. D. Ragon F. D. Paralici F. Domai F	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-term substitution Ond can substitution Ond can substitution Ond can substitution Ond can substitution Ond-term substitution Ond-term substitution Ond-term ond. Ond-term ond. Ond-term ond. Ond-term ond. Ond-term ond. Substitution Ond - rotat. Substitution Substitution Substitution Substitution Ond-term ond-t	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 201 21 21 21 21 21 21 21 21 21 21 21 21 21	WNW SW NNW NW NW NW	WSW  NNW 7  SSW NW  WSW  WSW  WSW	Ňž	NW SW NW W SSW SSW NW W SSW NW NW NW NW NW NW NW NW NW NW NW NW NW	fortissimo debelissima debelissima debelissima defore defore defore defore forte forte forte forte forte forte forte forte forte mediocre mediocre mediocre mediocre debelissimo debelissimo debelissimo debelissimo debelissimo debelismo d
Cingoli Veshera Citta di Castello Carrelplanin Spelatro Jesi Livorno Pergoli Carrelplanin Spelatro Jesi Livorno Pergoli Ancien S. Angelo in Vado Ancien Citteno Pontassieve Frence id d. d. Schemico Pemassili Fano Sasignano Zara Ferent Genova Bologna Modena Menocalieri Mantova Pinion Pinion Pinion Finion	S. Switterl S. A. Giordan Star, Germin Star, Germin Star, Germin Star, Germin Star, Germin R. Mante R. Mante R. Mante R. Mante R. Mante R. Men G. Mei G. Mei G. Mei G. Mei G. Mei G. Men G. Men G. Men G. Mante A. Seppleri G. Libri T. Herrelli U.H. Telegr D. Matte Avoni P. Malgeil O.S. e Benefil L. Felhi A. Palagi G. Agouta L. R. Ht. Idropt L. R. Ht. Idropt G. Agouta G. Agoutla L. Felhi G. Agoutla L. R. Ht. Idropt G. Agoutla	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-terms substitution of the control of the contro	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 201 21 21 21 21 21 21 21 21 21 21 21 21 21	WNW SW NNW NW NW NW	WSW  NNW 7  SSW NW  WSW  WSW  WSW	Ňž	NW SW SW NW W SSW SSW SSW SSW SSW SSW SS	fortissimo debelissima debelissima debelissima debelissimo fortissimo fortissimo fortissimo fortissimo mediocre forte forte forte forte forte mediocre mediocre mediocre mediocre mediocre debelissimo debelissimo debelissimo debelis debelissimo debelis debelissimo debelis
Cingoli Vosherra Città di Castella Castelplanio Spalatro Lorio Lor	S. Smitter S. Smitter Star, Gerraria Star, Gerraria Star, Gerraria Star, Gerraria F. Monne F. Monne F. Monne F. Monne F. De Boits G. Oroi G. Oroi G. Horonia G. Libri G. B. Domai F. Cocchi G. Libri G. B. Domai F. Cocchi G. B. Domai F. Domai F. D. Ragon F. D. Paralici F. Domai F	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-term subs. ond. Ond-term substitution Ond can assault Ondobrona  Ond can assault Ondobrona  Ond can assault Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Ondobrona  Date or tre scoss  Subs. ond totat.  Subs end rotat.	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 121 121 121 121 121 121 121 121 121	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW NW W SSW SSW NW W SSW NW NW NW NW NW NW NW NW NW NW NW NW NW	fortissimo debellosima debellosima debellosima debellosimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo mediocre forte forte debellosimo debell
Gingoli Vosherra Gina di Castella Cartelplanio Spalatro Josephanio Spalatro Josephanio Spalatro Josephanio Spalatro Josephanio Spalatro Josephanio Spalatro Gagli Amonta Samonta Samon	S. Smittel S. Smittel Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte F. Monte F. Monte F. Monte F. De Bosis G. Orsi F. De Bosis G. Orsi F. Astronomi G. Monte F. G. Life G. Monte F. G. Life F. Malgoi Olse F. Malgoi F. Monte F. Malgoi F. G. Life F. Malgoi F. Monte F. Malgoi F. M. F. Life F. Malgoi F. M. F. Life F. Malgoi F. M. F. Life F. F. Malgoi F. M. F. Life F. F. Parishen F. F. Doua G. Aguilta F. Stallberger Observators	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.8 1/2 9.1 1/2 9.1 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.3 1/2 9.5 1/2 9.5 1/2 9.5 1/2 9.7 9.1 1/2	Ond subs. ond. Ond-attents Suss. — end. Ond-attents	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 201 21 21 21 21 21 21 21 21 21 21 21 21 21	WNW SW NNW NW NW NW	WSW  NNW 7  SSW NW  WSW  WSW  WSW	Ňž	NW SW SW SSW SSW SSW SSW SW SW SW SW SW S	fortissimo debellosima debellosima debellosima debellosimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo mediocre forte forte debellosimo debell
Cingoli Vesteralo Cini di Castello Camiano Camiano Camiano Cicaliano Cicalia	S. Smitter S. Smitter Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte R. Monte R. Monte R. Monte R. Technin R. Technin R. Technin R. De Bosts G. Oral G. Abant G. Cabr G. Abant G. Labr G. Labr G. B. Donai F. Cecchi T. Bernelli L. T. Hernelli L. T. Hernelli C. Monte Avoni R. Malpeil O.N. e. Bentlil L. Fellin L. R. H. Horger P. Malpeil D. Marco R. Monte R. Monte R. Malpeil D. Marco L. R. H. Horger P. Earnisett L. R. H. Horger P. Earnisett G. Agentla S. Belli I. Stabberger Observatorio G. Mengurai G. V. Schiaparcki G. V. Schiapar	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.5 1/2 9.6 1/2 9.7 1/2 9.7 1/2 9.7 1/2 9.8	Ond subs. ond. Ond-terms substitution of the control of the contro	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 214 214 215 217 4 4 218 318 318 318 318 318 318 318 318 318 3	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW NW NW NW NSSW SSW NSW NW NW NW NW NW NW NW NW NW NW NW	fortissimo debellissima forte de la contra del contra de la contra dela contra del la contra de
Cingoli Voshera Città di Castella Carelplanio Sapalatro Lorio Pergoli Carelplanio Sapalatro Lorio Pergoli Carelplanio Sapalatro Lorio Pergoli Carelplanio Sangelo in Vado Northero Pontassieve Lorio Lorio Pontassieve Lorio Lorio Lorio Pontassieve Lorio L	S. Smitter S. Smitter Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte R. Monte R. Monte R. Monte R. Technin R. Technin R. Technin R. De Bosts G. Oral G. Abant G. Cabr G. Abant G. Labr G. Labr G. B. Donai F. Cecchi T. Bernelli L. T. Hernelli L. T. Hernelli C. Monte Avoni R. Malpeil O.N. e. Bentlil L. Fellin L. R. H. Horger P. Malpeil D. Marco R. Monte R. Monte R. Malpeil D. Marco L. R. H. Horger P. Earnisett L. R. H. Horger P. Earnisett G. Agentla S. Belli I. Stabberger Observatorio G. Mengurai G. V. Schiaparcki G. V. Schiapar	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.5 1/2 9.6 1/2 9.7 1/2 9.7 1/2 9.7 1/2 9.8	Ond can sussaint Ondulatoria  Ond can sussaint Ondulatoria  Ond can sussaint Ondulatoria  Suss. — ond. — suss. Ondulatoria  Ond — suss. — ond. Ondulatoria  Ond — suss. — ond. Ondulatoria  Die of the suss. — ond. Ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 121 124 225 125 127 137 147 157 157 157 157 157 157 157 157 157 15	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW SW SSW SSW SSW SSW SW SW SW SW SW S	fortissimo debellissima forte de la contra del contra de la contra dela contra del la contra de
Gingoli Veshera Gua di Castello Castelpasio Castelpasio Castelpasio Castelpasio Castelpasio Castelpasio Castelpasio Pergoli Castelpasio Pergoli Amcoma S. Angelo in Vado Mondavasio Fontassieve id. 12. Stheraio Fernale id. 2. Stheraio Fernale id. 2. Stheraio Fernale id. 2. Stheraio Fernale id. Pano S. Marino Fernale id. Pano S. Marino Fernale id. Porretta Kenh Allessanderi Mondena Polia Mondena Pisino Lodi Finino	S. Smitter S. Smitter Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte R. Monte R. Monte R. Technin F. De Boits G. Orai G. Abant G. Calbr G. Calbr G. Labr G. Monte G. Magnet G. Naghet G. Naghet G. Naghet G. Naghet G. Naghet G. Naghet G. Agunta G. Monte G. Agunta G. V. Schiaparc G. V. Schiap	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.5 1/2 9.6 1/2 9.7 1/2 9.7 1/2 9.7 1/2 9.8	Ond subs. ond. Ond-subs. ond. Ond-subs. Suss. ond. Ond-subs. Ond-consussabi Ondulatorio Suss. ond. subs. Ondulatorio Ond-subs. Ondulatorio Ond-subs. Ondulatorio	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 121 124 225 125 127 137 147 157 157 157 157 157 157 157 157 157 15	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW NW NW NW NSSW SSW NSW NW NW NW NW NW NW NW NW NW NW NW	fortissimo debellosisima debellosisima debellosisima del forte mediocre mediocre mediocre debellosisimo debello debellosisimo debello debellosisimo debello
Cingoli Voshera Città di Castella Castelpanio Spalatro Lori Lori Lori Lori Lori Lori Lori Lo	S. Smitter S. S. Mitter Star, Gerenta Star, Gerenta Star, Gerenta Star, Gerenta P. Mante P. Mante P. Mante P. Mante G. Mei G. Mei G. Mei G. Mei G. Mei G. Mei G. B. Domai F. Cecchi G. Libri G. Libri G. B. Domai F. Cecchi G. Libri G. B. Domai F. Cecchi G. B. Domai F. G. Septell L. Felin F. Mercell A. Palagea F. M. Garbaldi F. M. B. Librogr. F. Demacratorio G. Agoulta G. V. Schiaparch	9.7 1/1. 9.7 1/1. 9.4 1/2. 9.8 1/2. 9.8 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.6 1/2. 9.7	Ond can sussaint Ondulatoria  Ond can sussaint Ondulatoria  Ond can sussaint Ondulatoria  Suss. — ond. — suss. Ondulatoria  Ond — suss. — ond. Ondulatoria  Ond — suss. — ond. Ondulatoria  Die of the suss. — ond. Ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 214 214 215 217 4 4 218 318 318 318 318 318 318 318 318 318 3	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW SW SSW SSW SSW SSW SW SW SW SW SW S	fortissimo debelissimo debelissimo debelissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo fortissimo mediocre mediocre mediocre mediocre forte debelissimo debelissim
Cingoli Veshera Citta di Castella Cartelplanio Spalatro Jesi Licono Fernola Cargelplanio Spalatro Jesi Licono Cargelplanio Spalatro Jesi Licono Cargelplanio Sancona Sancona Sancona Cargel Anacona L'rieno Pomassieve Frenue Li Li Li Li Li Li Sabeniica Permandii Savijenano Zara Permandii Savijenano Zara Porretta Food Logg Porretta Pola Lingiano Lodi Frimme Lodi Frimme Lodi Frimme Lodi Frimme Lodi Luggano Lodi Lugdano Lodi	S. Smitter S. S. Mitter Star, Ferravita Star, Ferravita Star, Ferravita Star, Ferravita P. Mante R. Mante R. Mante R. Mante R. Technini R. De Boits G. Oroi G. Oroi G. A. Seppler G. Libri G. B. Domai F. G. Sch J. Telergel L. Telle D. Matte Avon T. Revel S. Media L. Telle L. Telle L. Telle D. Matte R. M. Garbaldi L. Telle D. Matte T. Revel L. Telle L. Telle D. Matte T. Revel L. Telle D. Matte T. Revel L. Telle L. Telle T. Media R. M. Garbaldi R. M. Garbaldi R. M. Garbaldi R. M. Garbaldi F. M. Garbaldi G. Agustaf E. Denace F. Saliberger Ostervatorio G. Menguag G. V. Schiaparel G. Weller G. V. Schiaparel G	9.7 1/1. 9.7 1/1. 9.4 1/2. 9.8 1/2. 9.8 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.5 1/2. 9.6 1/2. 9.7	Ond con sussaint Ondulatoria  Ond con sussaint Ondulatoria  Ond con sussaint Ondulatoria  Suss. — ond. — suss. Ondulatoria  Ond — suss. — ond. Ondulatoria  Ond — suss. — ond. Ondulatoria  Die of the suss. — ond. Ondulatoria  Die of the suss. — ond. Sussaint. — ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria  Due scosse ondulatoria	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 121 124 225 125 127 137 147 157 157 157 157 157 157 157 157 157 15	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW NW NW NW NSSW SSW NSW NW NW NW NW NW NW NW NW NW NW NW	fortissimo debellosima debellosima debellosimo fortisdano fortisdano fortisdano fortisdano mediocre mediocre mediocre mediocre forte forte forte debellosimo debello debellosimo debello debellosimo debello debellosimo debello mediocre mediocre mediocre forte debellosimo debello debellosimo
Cingoli Voshora Città di Castelalo Castelapanio Spalatro Latelapanio Spalatro Latelapanio Spalatro Latelapanio Spalatro Latelapanio Latela	S. Smittell S. Smittell Star, Ferrovia Star, Ferrovia Star, Ferrovia Star, Ferrovia F. Monte R. Monte R. Monte R. Monte R. Technin R. Smittell R. Starbin R. Scholl R. Smittell Lift, Telegra Ludi Lift, R. Ludi Lift,	9.7 1/2 9.7 1/2 9.8 1/2 9.8 1/2 9.5 1/2 9.6 1/2 9.7 1/2 9.7 1/2 9.7 1/2 9.8	Ond can sussaid Ond can sussai	mo dimin tregus tregus tregus tregus tregus tregus tregus	200 121 124 225 125 127 137 147 157 157 157 157 157 157 157 157 157 15	WSW SW SW SW SW SW	SSW SW SSW SW	Ňž	NW SW SW SSW SSW SSW SSW SW SW SW SW SW S	fortissimo debellosisima debellosisima debellosisima del forte mediocre mediocre mediocre debellosisimo debello debellosisimo debello debellosisimo debello

Table III. Observations of the 12th March 1873 earthquake (Serpieri, 1873a).

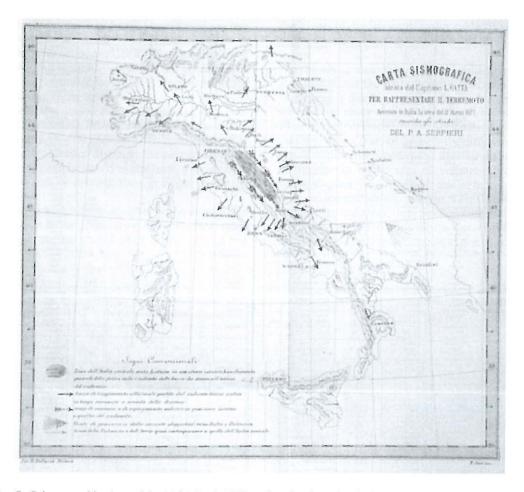


Fig. 5. Seismographic chart of the 12th March 1873 earthquake, from Serpieri's studies (photo by R. Persi).

one or the other was also noted in the intermediate areas. Furthermore it can be stated that the shock occurred around the axis of the peninsula and was concentrated along the axis itself.

The time analysis of the tables clearly shows that the clocks in the central area shook, on average, 3 min before those in the lateral areas and it is as if the earthquake in the central axis of the peninsula branched out to the sides.

This space/time analysis which Serpieri recorded of the earthquake on 12th March 1873 was a superb demonstration of the De Rossi theory, as shown by the graphic representation of the seismographic chart in fig. 5.

## 5. Instrumental recent developments in the Montefeltro area

The FB9 seismographic station installed at Cesane near Urbino in 1995, initially with the vertical component only, was the result of collaboration between the University of Urbino, Institute of Physics and the National Institute of Geophysics (ING) at Rome. This station is part of a network scattered throughout the national territory operated by ING with the purpose of monitoring and recording seismic phenomena in the interests of research and civil defence.

To ascertain that the system undertook a speedy acquisition and an accurate reproduction of seismic waves, particular attention was paid to the collection of data, used, not only in the formulation of statistics, but above all in the interpretation of tectonic phenomena underway and the study of the structure of the Earth's crust.

This necessity has led to the adoption of an A/D data collection system which is fast, with a high resolution (80000 readings/s and 12 bit resolution) and able to store a large quantity of data on the main memory of a PC as well as being able to view all seismic events transmitted by the station in real time.

An automatic method of continual monitoring over the twenty-four hours has been set up to detect seismic events, determine the magnitude and record on file. The data is stored in the form of files which can be copied onto floppy disks, ready for processing by the user.

The choice of a system most suited to our requirements was made on the basis of careful

documentary research, with particular attention to software available and the hardware necessary for the development of the various applications. The objective was to have flexible, simple software available which could also be used by people with no programming experience.

Since December 1997 the Cesane seismographic station has been equipped with two further sensors (two horizontal components) having a frequency band from 0.1 Hz to 1.1 Hz. As a result it is now possible to collect a quantity of data that, when properly processed, will be of considerable help in achieving a better understanding and a more in-depth analysis of seismic phenomena.

## 6. Instrumental data analysis

Historical and instrumental data on seismicity in the Montefeltro area are considered. It is well known that the use of historical data involves considerable problems, largely connect-

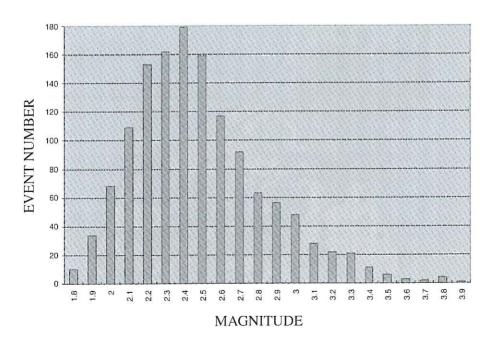


Fig. 6. Bar chart of the number of events in the period January 1990-April 1996 in the considered area; the abscissa axis shows the duration magnitude, while the ordinate axis shows the event number.

ed to their strongly subjective nature, the difficulty in locating and differentiating real and apparent epicentres, or the assessment of effects and damage caused by an earthquake.

Instrumental data (from 1990 to 1996) were extracted from the Italian Seismic Data Bank which stores data of events recorded from 1986 by the National Centralised Seismic Network (RSNC), in which «FB9» is the Urbino station of approximately 85 stations distributed nation-wide.

The statistical analysis of instrumental data foresees dividing the events distributed in classes of magnitude. The analysis indicates that the North-East Apennine area is marked by frequent microseismicity.

Relative to the bar chart of division in accordance with class of magnitude with variation of 0.1 (fig. 6), the events occur in an interval of magnitude between 2.2 and 2.5. The events are cut off below a value of 1.8 (the minimum magnitude recorded by the ING network and below which the signal is considered to be background noise).

From the diagram of epicentre distribution (fig. 7), it is possible to observe that the region being studied is characterised by widespread activity and also that it has no assismic areas. The areas with the highest concentrations of activities, as shown by red ellipses, are:

- The Romagna sector, around the provincial town of Forli.
- The Apennine Tusco-Umbro-Marchian sector, which extends from NW-SE following the general direction of the mountain range.

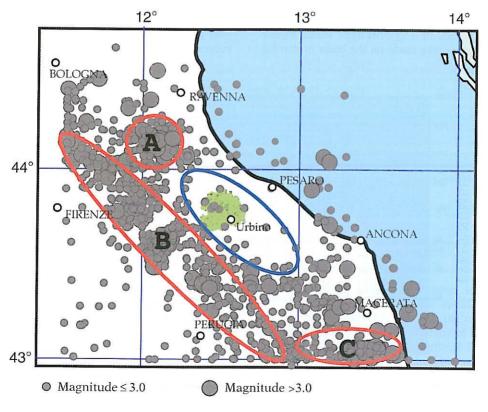


Fig. 7. Epicentre distribution of the events recorded by the Centralised National Seismic Network (RSNC) in the period January 1990-April 1996.

 The Southern Marche sector, including the Sibillini Mountains and thereby the highest elevations of the area under examination.

The Montefeltro area (coloured in green in fig. 7) lies between areas marked by notable seismic activity and is characterised by limited values in terms of intensity and frequency (Console *et al.*, 1992). Until a short time ago, this area was considered to be totally aseismic. The Umbria-Marche area is affected by dual seismic activity which makes it possible to identify areas with distinctive tectonic styles. The areas of the Apennine ridge are, in fact, affected by a distensive tectonic phase, as is also shown by the focal mechanisms of the earthquakes in the Val Nerina (1979) and in Perugia (1984), both of which are characterised by a normal fault

mechanism with a distension axis in an anti-Apennine direction and a vertical axis of maximum compression. On the contrary, the areas of Forlì and Ancona are characterised by seismicity that is essentially associated with transpressive and compressive type deformation (Lavecchia and Pialli, 1981; Gasparini and Praturlon, 1981; Frepoli and Amato, 1997), in spite of the fact that focal mechanisms relative to the event of Ancona (1972) and the sequence of Porto San Giorgio (1987) are still not yet clear (due to the scarce number of stations installed and of the fact that the epicentres were located in the sea).

It is important to note that the microseismicity of the portion of the Central-Northern Apennines studied is characterised by repeated event

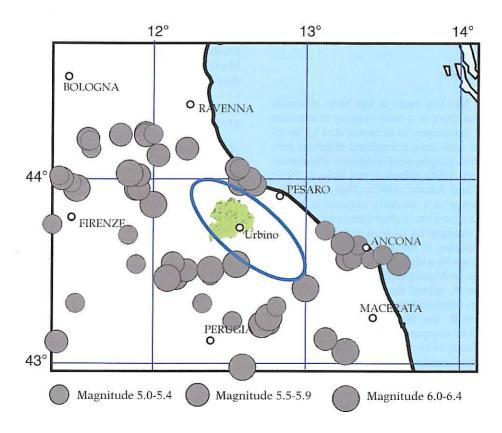


Fig. 8. Historical seismicity of the examined zone, with a magnitude  $M \ge 5$ .

sequences (swarms) which occur in the same zone and are separated by extremely reduced time intervals. This response to stresses can be attributed to a particular crustal structure at more superficial levels, since the events occur for the most part in the first 15 km. This is in agreement with the hypothesis that the presence of subcrustal earthquakes, distributed along a plane dipping from the Adriatic towards the Tyrrhenian with a slope of approximately 40°-45°, is related to the subduction process of the Adriatic lithosphere under the Apennine arc (Amato and Selvaggi, 1991). A hypothesis of this nature is confirmed by further seismological evidence such as the anomalous propagation of surface waves as well as tomographic studies. In spite of this particularity, it is easy to observe a seismogenetic level between 0 and 15 km, inside which practically all earthquakes are concentrated. Activity, therefore, results as being mostly due to surface sources.

## 7. Conclusions

In the last few years it has been generally agreed that there is a west-verging subduction under the Apennines, as demonstrated by several authors who have considered different geological and geophysical evidence (Spakman, 1989; Serri, 1990; Giardini and Velonà, 1991; Selvaggi and Amato, 1992). This subduction has its motor in a westerly expansion, whose easterly progression is obstructed and the deeper part is dragged by its own weight.

In particular, in the area considered (fig. 7) three zones with a high concentration of seismic events can be highlighted as follows:

- Zone A, inland Romagna, corresponding to the area surrounding the town of Faenza;
- Zone B, the central pedeapennine belt, which can be compared to the epicentral area of the 12 March 1873 earthquake (fig. 5);
- Zone C, north of the Sibillini Mountains, defined by the neotectonics of the Southern Marche.

The absence of macroseismic events in the Montefeltro area, is confirmed by the absence in the examined zone of historical events, with magnitude  $M \ge 5$  (Boschi *et al.*, 1997), as shown by the blue ellipse (fig. 8).

Further, from the overall data, it is possible to infer the presence of a microseismic basin in the Montefeltro area. This basin is essentially dominated by compressive tectonic structures. Furthermore, the seismological data seem to define a "quiet" segment, separating the extensive and compressive zones, with a low concentration of seismic events.

In conclusion, the considered area is characterised by low values of the magnitude and frequency of seismic events; but it is placed between areas with an appreciable seismic magnitude and then it can be affected by events with epicentres in the border zones.

## Acknowledgements

I would like to thank Flavio Vetrano (director of the Seismic Observatory of the University of Urbino) for his scientific support, Roberto Mantovani for his logistic support, and Aldemiro Martellini for his help in the installation of the data acquisition system.

#### REFERENCES

AMATO, A. and G. SELVAGGI (1991): Terremoti crostali e sub-crostali nell'Appennino settentrionale, *Studi Geologici Camerti*, **1** (special issue), 75-82.

BOSCHI, E., E. GUIDOBONI, G. FERRARI, G. VALENSISE and P. GASPERINI (1997): *Catalogo dei Forti Terremoti in Italia dal 461 a.C. al 1990* (ING, Roma - SGA, Bologna), vol. 2, pp. 644.

CONSOLE, R., R. DI GIOVAMBATISTA, P. FAVALI and G. SMRIGLIO (1992): Seismogenic structures activated during the 1987 seismic sequences along the Adriatic coast, *Geophys. J. Int.*, 1, 379-386.

DRAGONI, M. (1991): I moti lenti della terra nelle osservazioni tromometriche, in *Tromometri Avvisatori* Sismografi (SGA, Bologna), 42-50.

FERRARI, G. (1991): Origini e sviluppi di un metodo di rivelazione, in *Tromometri Avvisatori Sismografi* (SGA, Bologna), 9-31.

- FREPOLI, A. and A. AMATO (1997): Contemporaneous extension and compression in the Northern Apennines from earthquake fault plane solutions, *Geophys. J. Int.*, 129, 368-388.
- GAMBUTI, G. (1990): La sismologia in Italia e l'opera di Alessandro Serpieri, *Graduation Thesis, University of Bologna* (unpublished).
- GASPARINI, C. and A. PRATURLON (1981): Modelli sismotettonici e geologia classica a confronto nell'Italia centrale, *Rend. Soc. Geol. It.*, 4, 557-562.

- GIARDINI, D. and M. VELONÀ (1991): Deep seismicity of the Tyrrhenian Sea, *Terra Nova*, **3**, 57-64.
- LAVECCHIA, G. and G. PIALLI (1981): Appunti per uno schema strutturale dell'Appennino Umbro-Marchigiano. 1) Il basamento, Geol. Romana, 20, 183-195.
- SELVAGGI, G. and A. AMATO (1992): Subcrustal earthquakes in the Northern Appennines (Italy): evidence for a still active subduction?, *Geophys. Res. Lett.*, 19 (21), 2127-2130.
- SERPIERI, A. (1850): Sull'Osservatorio Meteorologico del Collegio dei Nobili in Urbino, al Sig. Conte Domenico Paoli, Urbino.
- SERPIERI, A. (1854): Sulla Riduzione delle Osservazioni Meteorologiche e Specialmente delle Osservazioni Triorarie (Edizioni Nobili, Pesaro).
- SERPIERI, A. (1873a): Nuove riflessioni sul terremoto avvenuto in Italia il 12 marzo 1873, in *Rend. R. Ist. Lomb.*, Milano.
- SERPIERI, A. (1873b): Rapporto delle osservazioni fatte sul

- terremoto avvenuto in Italia la sera del 12 marzo 1873, in *Supplemento alla Meteorologia Italiana*, Roma.
- SERPIERI, A. (1879): Il Terremoto di Rimini della Notte 17-18 Marzo 1975 (Edizioni Nobili, Pesaro).
- SERRI, G. (1990): Neogene-Quaternary magmatism of the Tyrrhenian region: characterization of the magma sources and geodynamic implications, *Mem. Soc. Geol. It.*, 41, 219-242.
- SPAKMAN, W. (1989): Tomographic images of the upper mantle below Central Europe and the Mediterranean, *Terra Nova*, 2, 542-553.
- TREVES, B. (1994): Guide geologiche regionali: Appennino Tosco-Emiliano, Soc. Geol. It., 78-85.
- VAI, G.B. (1994): Guide geologiche regionali: Appennino Tosco-Emiliano, Soc. Geol. It., 14-15.

(received August 25, 1999; accepted December 18, 1999)