

1
2
3 **Seismic moment tensors of the April 2009, L'Aquila (Central Italy),**
4
5
6 **earthquake sequence**
7
8
9

10
11
12
13
14
15
16
17
18
19
20
21 Pondrelli S.¹, Salimbeni S.¹, Morelli A.¹, Ekström G.², Olivieri M.³, Boschi E.⁴
22
23

24
25
26 ¹ *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Via D. Creti 12,*
27
28 *40128 Bologna, Italy*
29

30 ² *Lamont-Doherty Earth Observatory, Columbia University, NY, USA*
31

32
33 ³ *Istituto Nazionale di Geofisica e Vulcanologia, CNT, Via di Vigna Murata 605, 00143*
34
35 *Rome, Italy*
36

37 ⁴ *Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata 605, 00143 Rome,*
38
39 *Italy*
40
41

42
43
44
45 Accepted date: Received date ; in original form date
46
47

48
49 **Short Title:** RCMTs for April 2009, L'Aquila (Central Italy), earthquakes
50

51
52 **Corresponding author:** Pondrelli S., Istituto Nazionale di Geofisica e Vulcanologia,
53
54 Sez. di Bologna, Via D. Creti 12, 40128 Bologna, Italy; pondrelli@bo.ingv.it; Fax: +39
55
56 0514151499
57
58
59
60

Summary

On April 6, 2009, the Central Apennines were hit by a $M_w=6.3$ earthquake. The region had been shaken since October 2008 by seismic activity that culminated in two foreshocks with $M_w>4$, one week and a few hours before the main shock. We computed seismic moment tensors for 26 events with M_w between 3.9 and 5.5, using the Regional Centroid Moment Tensor (RCMT) scheme. Most of these source parameters have been computed within one hour after the earthquake and rapidly revised successively. The focal mechanisms are all extensional, with a variable and sometimes significant strike-slip component. This geometry agrees with the NE-SW extensional deformation of the Apennines, known from previous seismic and geodetic observations. Events group into three clusters. Those located in the southern area have larger centroid depths and a wider distribution of T-axis directions. These differences suggest that towards south a different fault system was activated with respect to the SW-dipping normal faults beneath L'Aquila and more to the north. These considerations and other analyses have been possible for the rapid availability of these robust moment tensors.

Key-words: seismic moment tensor, seismotectonics, Apennines, Central Italy

Introduction

The Italian Apennines are seat of extensional deformation, concentrated along the inner part of the mountain belt. This phenomenon is a relict of the process, driven by the rolling back subduction of Adriatic plate, that lead to the opening of the Tyrrhenian back-arc basin (Facenna et al., 2004). This NE-SW trending deformation reaches velocities up to 3 mm/yr (D'Agostino et al., 2008). Seismic activity is well known, both historically and instrumentally, and it is spread along the whole length of the mountain chain. Seismic hazard is high all along the Apennines (MPS Working Group, 2004). Typically, earthquakes along Central-Southern Apennines show normal faulting mechanisms and focal depths in the upper 15 km of crust (Vannucci et al., 2004). The most recent examples are the 1915, M=6.9 Avezzano event (Amoruso et al., 1998); 1930, M=6.7 and 1980, M=6.9, Irpinia events (Pino et al., 2008); the 1979, Mw=5.9 Valnerina quake (Boschi et al., 2000); the 1997-1998 Umbria-Marche sequence, that included two events with Mw=5.7 and Mw=6.0 (Ekström et al., 1998). Another recent sequence — 2002, Mw=5.7, S. Giuliano di Puglia twin events — showed instead strike-slip character. It was located off mountain chain, and it has been attributed to deformation within the Adriatic Plate descending beneath the Apennines (Di Luccio et al., 2005)

On April 6, 2009, a Mw=6.3 earthquake occurred in Central Italy, with shallow hypocenter located at the outskirts of the city of L'Aquila, in the Abruzzo region, causing extensive damage and casualties (Figure 1). It followed a seismic activity that initiated in October 2008 and culminated with the Mw=4.4 event of March 30, and the Mw=4.2 earthquake, a few hours before the main shock (Figure 1 and Tables in supplementary material). Thousands of aftershocks have been recorded. Seismic activity in this region

1
2
3 had been scarce during past few decades, with only three seismic swarms in 1985 (MI
4 4.2), 1994 (MI 3.9) and 1996 (MI 4.1) as reported in *Catalogo della Sismicità Italiana*
5
6 (CSI, Castello et al., 2007). Historical records show instead the occurrence of destructive
7
8 events, with at least two of them — in 1461 and 1703 — reaching intensities up to X
9
10 (Gruppo di Lavoro CPTI, 2004). The epicentral area had been identified before the
11
12 earthquake as a region of higher-than-average earthquake probability, in particular along
13
14 the Apennines axis (Akinci et al., 2009; Faenza et al., 2003).

15
16 Here, we report on source geometries of the L'Aquila seismic sequence. We computed 26
17
18 moment-tensor solutions using the same technique we apply to maintain the European-
19
20 Mediterranean Regional Centroid Moment Tensor (RCMT) Catalog
21
22 (www.bo.ingv.it/RCMT; Pondrelli et al., 2006 and references therein). They are greatly
23
24 in agreement with seismotectonics of the region. Comparing definitive to Quick RCMTs
25
26 computed immediately after the earthquakes, we found really smaller adjustments to
27
28 quick determinations. This highlights the robustness of RCMT solutions, considering that
29
30 timely publication of moment tensors for main events of a sequence is a functional tool to
31
32 support ongoing studies as complex source description and hazard update.
33
34
35
36
37
38
39
40
41
42

43 **Regional CMT solutions: data analysis**

44
45 We compute seismic moment tensors using an extension of the global CMT scheme,
46
47 based on fitting fundamental-mode Rayleigh and Love waves recorded at regional
48
49 distance (Arvidsson and Ekström, 1998). This process is particularly appropriate to study
50
51 intermediate-magnitude events, and produces robust seismic moment tensors and M_w ,
52
53 fully compatible with other source parameters (e.g., Global CMTs, Ekström et al., 2005).
54
55
56
57
58
59
60

1
2
3 We use three-component seismograms, low-pass filtered with cut-off frequencies ranging
4 from 1/30 to 1/50 Hz, depending on magnitude, to select the broadest spectrum with good
5 signal-to-noise ratio. When signal-to-noise ratio allows it, long-period body waves are
6 added in the inversion, as for 9 of the 26 RCMTs computed for this sequence (Figure and
7 Table 2 in Supplementary Material). Data retrieval and pre-processing are done
8 automatically, but each inversion is always controlled and reviewed by an operator. We
9 commonly use 5 to 15 stations with a distance range between 3 to 15 degrees, belonging
10 to MedNet and GEOFON networks. Located closer to the source region, these stations
11 are the most useful to study European-Mediterranean smaller magnitude events, and
12 provide good azimuthal coverage. When new seismograms from other networks become
13 available through ORFEUS (www.orfeus.org), we revise and update the solutions. Here
14 we present the definitive RCMTs for 26 events with a M_w between 3.9 and 6.3, including
15 the two greater foreshocks of March, 30 and April, 5 (Tables in supplementary material).
16 NW-SE striking extensional moment tensors dominate, with tensional axes oriented
17 between 40° and 60° (Figure 2). Only in a few cases, a pronounced strike-slip component
18 characterizes the source geometry as for the April 7, 17:47 aftershock. Most of these
19 solutions have “A” quality flag, that means greatest stability (see Pondrelli et al., 2006 for
20 quality evaluation); only four smaller magnitude events have a “C” flag because their
21 inversion required to fix the location (Table 2 in Supplementary Material). Centroid depth
22 of all solutions is in general agreement with preliminary locations; only two cases have a
23 final location 5 km deeper with respect to initial one. Most events have the typical depth,
24 within the top 15 km, of seismic sequences occurred previously in the Apennines. Only a
25 few of them are deeper, down to 26 km, mainly those located southward and with a more
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 prominent strike-slip component (Tables in Supplementary Material). A comparison with
4 solutions produced by other groups with other techniques (www.csem-eu.org; [http://tdmt](http://tdmt.onearthquakes.rm.ingv.it)
5 on earthquakes.rm.ingv.it) shows an unquestionable similarity of focal
6 geometries. Our M_w values are in good agreement with those from other agencies,
7 mainly for greater events and have a regular behaviour respect to M_L (Figure 2).
8
9 Comparing definitive RCMTs to Quick RCMTs computed (when $M > 4.0$) within one
10 hour after the earthquake occurred, we found really small changes to quick
11 determinations. This promotes the robust reliability of QRCMTs, at least for the Central
12 Mediterranean, where on-line seismograms ensure a fast and good azimuthal coverage.
13
14

25 26 27 **RCMT solutions in a seismotectonic framework**

28
29 The extensional geometry of mechanisms of L'Aquila earthquakes is the same of other
30 important seismic sequences along the Apennines, such as the 1980, $M=6.9$, Irpinia
31 earthquake and the Umbria-Marche seismic sequence in 1997-1998. The seismic
32 sequence started beneath the city of L'Aquila and spread along a 40 km area into three
33 main clusters (Figures 1 and 2). This migration of hypocenters was also seen in the 1997-
34 1998 Umbria-Marche sequence. The foreshocks, the main shock and most of the activity
35 of the first three days are part of the central cloud of seismicity, located beneath the town.
36
37 The seismic activity that preceeded the sequence and the two main foreshocks also
38 occurred in this area (Figures 1 and 2). All RCMTs of this central cluster have a shallow
39 centroid depth (within 14 km). The northern seismicity cluster activated just after the
40 main shock ($M_w=5.1$ on April 6, at 23:15, Table 1 in supplementary material) and
41 continued with its northernmost expression with the two M_w 4.0 and 4.1 events on April
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 14 and 15. Depths for two of these events exceed 15 km. The southern seismicity cluster
4 started later, with the Mw 5.6 aftershock, on April 7. Here are located the deepest events
5
6 of the sequence, with hypocentral centroid locations deeper than 20 km and characterized
7
8 also by a consistent strike-slip component. The T axes distribution is NE-SW, roughly
9
10 perpendicular to the Apennines, in the central and northern seismicity clusters, whereas
11
12 the southern one is more heterogeneous (Figure 2).
13
14
15
16

17
18 The location and focal mechanism for the main shock suggest that this event occurred on
19
20 the Paganica fault, a 10-15 km length, NW-SE striking, SW-dipping structure previously
21
22 identified in the field (Vezzani e Ghisetti, 1998). The geometry of this fault is in
23
24 agreement with our source parameters. This hypothesis was supported also by aftershock
25
26 distribution (Chiarabba et al., 2009), DinSAR analysis (Atzori et al., 2009), geodetic and
27
28 geological surveys (Anzidei et al., 2009; Emergeo Working Group, 2009). The northern
29
30 cluster of the sequence shows a distribution that may be in agreement with an activation
31
32 of the Campotosto fault, another normal fault, NNW-SSE striking and SW dipping (Galli
33
34 et al., 2008; Boncio et al., 2004). Also our focal mechanisms are in agreement with the
35
36 geometry of this fault. The southernmost cluster, where events with deeper location and
37
38 with a greater strike-slip component are located, has a less-clear geometry and appears to
39
40 be connected to a different system of faults. In this area previous studies identified the
41
42 NNW-SSE Mt. Ocre fault system (Salvi et al., 2003). Because of its strike direction, it
43
44 could be related to the present-day seismicity that at south privileges a NNW-SSE trend,
45
46 rotated with respect to the NW-SE distribution of the two other clusters. However, at
47
48 south the poor definition of any structure from hypocentral location makes any relation
49
50 more doubtful.
51
52
53
54
55
56
57
58
59
60

1
2
3 Deeper events also showed relevant strike-slip components in previous Apenninic
4 seismic sequences, such as in the 1997-1998 Umbria-Marche sequence (Ekström et al.,
5
6 1998) or in the 2002 S. Giuliano di Puglia sequence (Di Luccio et al., 2005). This vertical
7
8 distribution of deformation styles is interpreted as an extension working on the thrust and
9
10 fold belt while deeper deformation occurs within the Adria plate located beneath the belt.
11
12
13
14
15
16
17

18 **Conclusions**

19
20 We computed seismic moment tensors for 26 events with Mw between 3.9 and 6.3
21
22 belonging to the 2009 L'Aquila (Central Italy) seismic sequence. RCMTs gave
23
24 immediately the indication that this seismicity, from the seismotectonic point of view, is
25
26 similar to previous extensional activity occurred along this mountain belt, also in the
27
28 vertical distribution of hypocenters and deformation styles. NW-SE striking focal planes
29
30 agree with mapped faults of the region, allowing to infer which tectonic structures have
31
32 been activated. For some events a relevant strike-slip component is observed, mainly
33
34 when the hypocenters are deeper. This occurs mainly at south with respect to the entire
35
36 activated region.
37
38
39

40
41 Seismotectonic analysis of the ongoing seismic sequence has been supported by the
42
43 prompt availability of RCMTs, quick solutions first and definitive solutions successively.
44
45 Our results provide crucial information for a number of ongoing studies about different
46
47 aspects of the seismic sources. We conclude on the feasibility and importance of
48
49 application of our inversion scheme for the early and reliable analysis of seismic
50
51 sequences.
52
53
54

55 **Acknowledgments**

56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

We thank all operators involved in station maintenance and data management at MedNet, GEOFON and ORFEUS. Figures are drawn using GMT (Wessel and Smith, 1998).

For Peer Review

References

- 1
2
3
4
5
6 Akinci, A., Galadini, F., Pantosti, D., Petersen, M., Malagnini, L. & Perkins, D., 2009.
7
8 Effect of time dependence on probabilistic seismic-hazard maps and
9
10 deaggregation for the Central Apennines, Italy, *Bull. Seismol. Soc. Am.*, 99(2A),
11
12 585-610.
13
14
15 Amoruso, A., Crescentini, L. & Scarpa, R. 1998. Inversion of source parameters from
16
17 near and far field observations: An application to the 1915 Fucino earthquake,
18
19 Central Apennines, *J. Geophys. Res.*, 103, 29.989-29.999.
20
21
22 Anzidei, M., Boschi, E., Cannelli, V., Devoti, R., Esposito, A., Galvani, A., Melini, D.,
23
24 Pietrantonio, G., Riguzzi, F., Sepe, V. & Serpelloni, E., 2009. Coseismic
25
26 deformation of the destructive April 6, 2009 L'Aquila earthquake (central Italy)
27
28 from GPS data, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL039145.
29
30
31
32 Arvidsson, R. & Ekström, G., 1998. Global CMT Analysis of Moderate Earthquakes
33
34 $M_w \geq 4.5$ using Intermediate Period Surface Waves, *Bull. Seismol. Soc. Am.*, 88,
35
36 1003-1013.
37
38
39 Atzori, S., Hunstad, I., Chini, M., Salvi, S., Tolomei, C., Bignami, C., Stramondo, S.,
40
41 Trasatti, E., Antonioli, A. & Boschi, E., 2009. Finite fault inversion of DinSAR
42
43 coseismic displacement of the 2009 L'Aquila earthquake (Central Italy), *Geophys.*
44
45 *Res. Lett.*, in press.
46
47
48 Boncio, P., Lavecchia, G., Milana, G. & Rozzi, B., 2004. Seismogenesis in Central
49
50 Apennines, Italy: an integrated analysis of minor earthquake sequences and
51
52 structural data in the Amatrice-Campotosto area, *Annals of Geophysics*, 47, 6,
53
54 1723-1742.
55
56
57
58
59
60

- 1
2
3 Boschi, E., Guidoboni, E., Ferrari, G., Mariotti, D., Valensise, G. & Gasperini, P. (eds.),
4
5 2000), Catalogue of Strong Italian Earthquakes from 461 B.C. to 1997, Ann.
6
7 Geofis., 43, 609-868.
8
9
10 Castello, B., Olivieri, M. & Selvaggi, G., 2007. Local and duration magnitude
11
12 determination for the Italian earthquake catalogue (1981-2002), Bull. Seism. Soc.
13
14 Am., 97, 1B, 128-139.
15
16
17 D'Agostino, N., Avallone, A., Cheloni, D., D'Anastasio, E., Mantenuto, S. & Selvaggi,
18
19 G., 2008. Active tectonics of the Adriatic region from GPS and earthquake slip
20
21 vectors, J. Geophys. Res., 113, B12413.
22
23
24 Di Luccio, F., Fukuyama, E. & Pino, N. A., 2005. The 2002 Molise earthquake sequence:
25
26 What can we learn about the tectonics of southern Italy? Tectonophysics, 405, 1-4,
27
28 141-154.
29
30
31 Ekström, G., Morelli, A., Boschi, E. & Dziewonski, A. M., 1998. Moment tensor analysis
32
33 of the central Italy earthquake sequence of September-October 1997, Geophys.
34
35 Res. Lett., 25, 1971-1974.
36
37
38 Ekström, G., Dziewonski, A. M., Maternovskaya, N. N. & Nettles, M., 2005. Global
39
40 seismicity of 2003: Centroid-moment tensor solutions for 1087 earthquakes, Phys.
41
42 Earth Planet. Int., 148, 327-351.
43
44
45
46 Emergeo Working Group, 2009. Rilievi geologici di terreno effettuati nell'area
47
48 epicentrale della sequenza sismica dell'Aquilano del 6 aprile 2009, in italian,
49
50 available at [http://portali.ingv.it/primo-piano/archivio-primo-piano/notizie-](http://portali.ingv.it/primo-piano/archivio-primo-piano/notizie-2009/terremoto-6-aprile/copy_of_la-sequenza-dell-aquilano-aprile-2009/)
51
52 [2009/terremoto-6-aprile/copy_of_la-sequenza-dell-aquilano-aprile-2009/](http://portali.ingv.it/primo-piano/archivio-primo-piano/notizie-2009/terremoto-6-aprile/copy_of_la-sequenza-dell-aquilano-aprile-2009/)
53
54
55 Faccenna, C., Piromallo, C., Crespo-Blanc, A., Jolivet, L. & Rossetti, F., 2004. Lateral
56
57
58
59
60

1
2
3 slab deformation and the origin of the western Mediterranean arcs, *Tectonics*, 23,
4
5 TC1012.
6
7

8 Faenza, L., Marzocchi, W. & Boschi, E., 2003. A non-parametric hazard model to
9
10 characterize the spatio-temporal occurrence of large earthquakes; an application to
11
12 the Italian catalogue. *Geophys. J. Int.*, 155, 521-531
13
14

15 Galli, P., Galadini, F. & Pantosti, D., 2008. Twenty years of paleoseismology in Italy,
16
17 *Earth-Science Reviews*, 88, 89-117.
18
19

20 Gruppo di lavoro CPTI, 2004. Catalogo Parametrico dei Terremoti Italiani, INGV,
21
22 Bologna, <http://emidius.mi.ingv.it/CPTI04/>.
23
24

25 MPS Working Group, 2004. Redazione della mappa di pericolosità sismica prevista
26
27 dall'Ord. PCM 3274 del 20/03/2003. Rapporto Conclusivo per il Dip. Prot. Civ.,
28
29 INGV, Milano-Roma, pp 65, <http://zonesismiche.mi.ingv.it>.
30
31

32 Pino, N. A., Palombo, B., Ventura, G., Perniola, B. & Ferrari, G., 2008. Waveform
33
34 modeling of historical seismograms of the 1930 Irpinia earthquake provides
35
36 insight on “blind” faulting in Southern Apennines (Italy), *J. Geophys. Res.*, 113,
37
38 B05303.
39
40

41 Pondrelli, S., Salimbeni, S., Ekström, G., Morelli, A., Gasperini, P. & Vannucci, G.,
42
43 2006. The Italian CMT dataset from 1977 to the present, *Phys. Earth Planet. Int.*,
44
45 159, 286-303.
46
47

48 Salvi, S., Cinti, F. R., Colini, L., D'addezio, G., Doumaz, F. & Pettinelli, E., 2003.
49
50 Investigation of the active Celano-L'Aquila Fault System, Abruzzi (Central
51
52 Apennines, Italy) with combined ground-penetrating radar and palaeoseismic
53
54 trenching, *Geophys. J. Int.*, 155, 805-818.
55
56
57
58
59
60

1
2
3 Vannucci, G., Pondrelli, S., Argnani, A., Morelli, A., Gasperini, P. & Boschi, E., 2004.

4
5 An Atlas of Mediterranean seismicity, *Annals of Geophysics*, 47, 1, 334 pp.

6
7
8 Vezzani, L. & Ghisetti, F., 1998. Carta Geologica dell'Abruzzo, scale 1:100,000.

9
10 S.EL.CA., Firenze.

11
12 Wessel, P. & Smith, W. H. F., 1998. New improved version of the Generic Mapping

13
14
15 Tools Released, *Eos Trans. AGU*, 79, 579.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

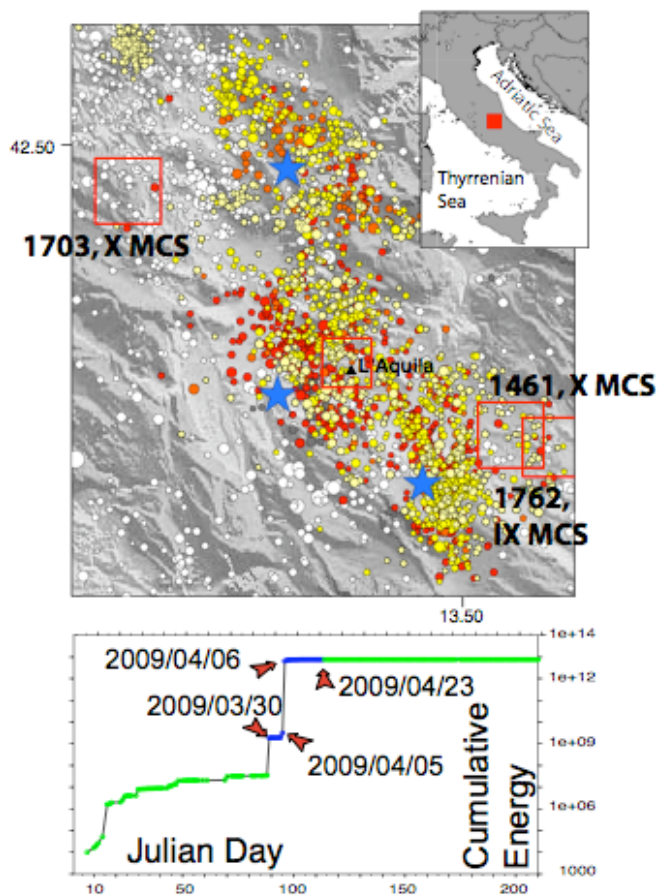
For Peer Review

Figure captions

Figure 1 - Map of seismicity. Blue stars – events of the sequence with $M_I > 5.0$; red square – historical seismicity with $I_{max} > 7.5$ (Gruppo di Lavoro CPTI, 2004); white circles – previous seismicity (Castello et al., 2007); grey circles – events from January to April 2009; red circles – seismicity from April 6 to 9; orange – from 9 to 11; yellow – from 11 to 30; light yellow – from May 1 to July 27 (iside.rm.ingv.it). Upper right: Italy map with L'Aquila as a red square. Below: cumulative seismic energy release (joule) from January to July 2009.

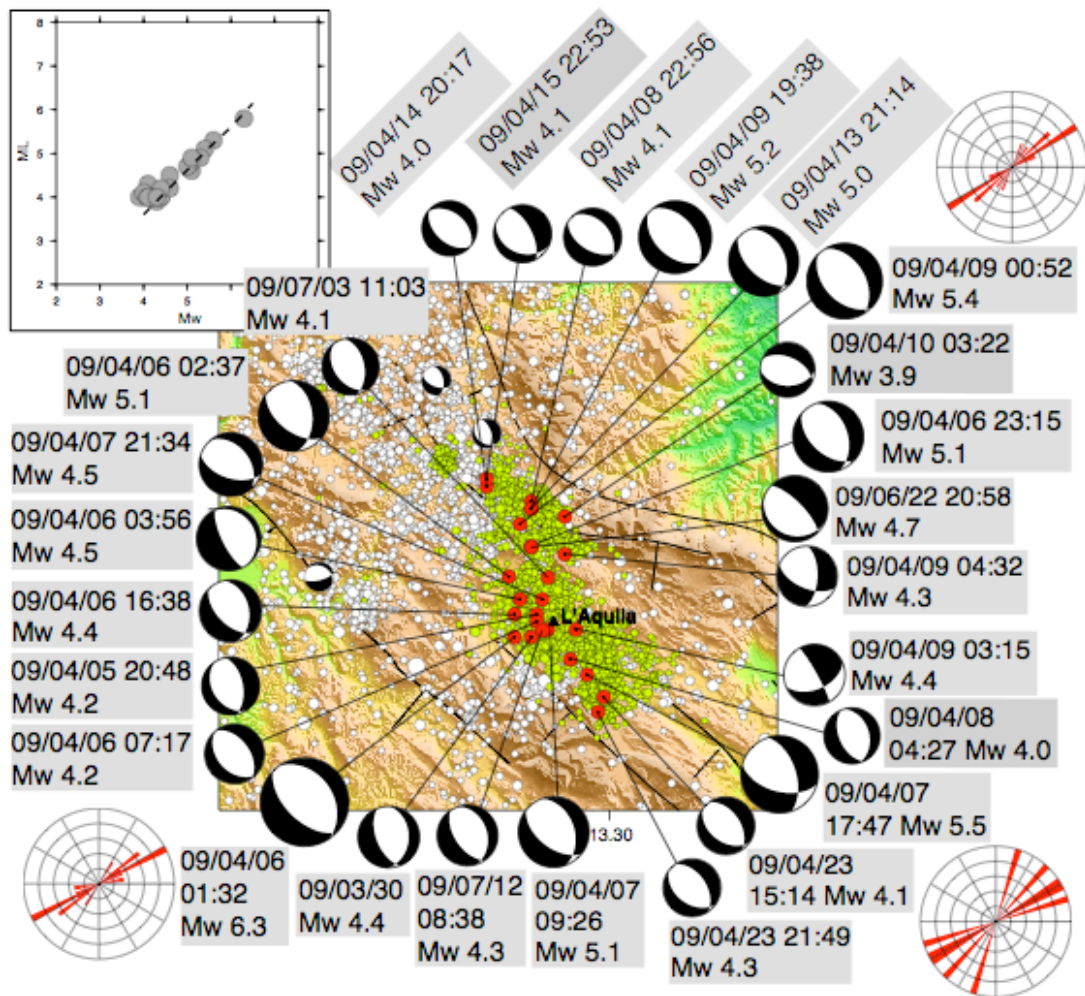
Figure 2 - RCMTs with their epicenters (in red) and the smaller magnitude seismicity of the sequence (in yellow). In the background (white dots) previous seismicity (CSI, Castello et al., 2007) and previous available RCMTs (small focal mechanisms, Pondrelli et al., 2006; <http://www.bo.ingv.it/RCMT/Italydataset.html>). Upper left: M_I vs M_w in comparison to the regression line for these kind of magnitudes (Gruppo di Lavoro CPTI, 2004). Upper right, lower left and right: rose diagrams representing respectively the different T axes distribution in the three areas where seismicity occurred.

Fig.1



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Fig.2



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1 - Centroid locations and difference from preliminary information (dlat, dlon, ddep), preliminary MI (INGV), Mw computed for events reported here (R=RCMT) and those computed by other agencies (G=: Global CMT Catalog, E=ETHZ, U=USGS from www.emsc-csem.org, T=TDMT from earthquake.rm.ingv.it).

Date	Time	CMT Lat.	dlat	CMT Lon.	dlon	CMT depth	ddep	MI	Mw R	Mw G	Mw E	Mw U	Mw T
03/30	13:38	42.33	0.00	13.26	0.10	14.0	-3.0	4.0	4.4	---	---	---	4.0
04/05	20:48	42.45	-0.09	13.36	0.01	10.0	0.0	4.0	4.2	---	---	---	3.9
04/06	01:32	42.30	0.03	13.31	0.02	11.6	-1.6	5.8	6.3	6.3	---	6.3	6.1
04/06	02:37	42.29	0.12	13.39	-0.07	12.9	-2.9	4.6	5.1	---	---	4.9	4.8
04/06	03:56	42.38	0.00	13.34	0.00	10.0	0.0	4.5	4.5	---	---	---	4.3
04/06	07:17	42.39	-0.04	13.30	0.07	10.0	0.0	3.9	4.2	---	---	---	---
04/06	16:38	42.29	0.07	13.29	0.04	10.8	-0.8	4.0	4.4	---	---	4.7	4.2
04/06	23:15	42.37	0.08	13.36	0.00	11.8	-1.8	4.8	5.1	---	5.2	4.9	5.0
04/07	09:26	42.26	0.08	13.41	-0.02	13.6	-3.6	4.7	5.1	---	5.2	4.8	4.9
04/07	17:47	42.31	-0.03	13.48	-0.02	20.5	-5.5	5.3	5.5	5.5	5.6	5.5	5.4
04/07	21:34	42.33	0.05	13.29	0.09	11.7	-1.7	4.2	4.5	---	4.7	---	4.3
04/08	04:27	42.23	0.07	13.41	0.02	12.2	-2.2	4.0	4.0	---	---	---	---
04/08	22:56	42.42	0.09	13.33	0.03	14.1	-4.1	4.3	4.1	---	---	---	4.0
04/09	00:52	42.48	0.00	13.34	0.00	15.4	-0.4	5.1	5.4	5.4	5.5	5.3	5.2
04/09	03:14	42.26	0.08	13.43	0.01	26.0	-8.0	4.2	4.4	---	---	---	4.3
04/09	04:32	42.41	0.03	13.35	0.07	12.8	-2.8	4.0	4.3	---	---	---	4.2
04/09	19:38	42.51	-0.01	13.26	0.10	15.6	1.4	4.9	5.2	5.2	5.2	5.0	5.0

04/10	03:22	42.49	0.00	13.42	0.00	10.0	0.0	4.0	3.9	---	---	---	---
04/13	21:14	42.47	0.03	13.29	0.07	11.8	-1.8	4.9	5.0	---	5.1	---	4.8
04/14	20:17	42.61	-0.08	13.14	0.14	10.0	0.0	4.1	4.0	---	---	---	3.7
04/15	22:53	42.54	0.00	13.28	0.00	10.0	0.0	4.0	4.1	---	---	---	---
04/23	15:14	42.22	0.03	13.54	-0.05	11.0	-1.0	4.0	4.1	---	---	---	3.9
04/23	21:49	42.24	-0.01	13.35	0.13	10.0	0.0	4.0	4.3	---	---	---	4.2
06/22	20:58	42.45	0.00	13.36	0.00	12.0	-2.0	4.5	4.7	---	---	---	4.5
07/03	11:03	42.41	0.00	13.39	0.00	10.0	0.0	4.1	4.1	---	---	---	3.6
07/12	08:38	42.34	0.09	13.38	0.12	10.0	0.0	4.0	4.3	---	---	---	4.2

Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 2 - Qf is the Quality flag (Pondrelli et al., 2006), data used (S: only surface waves, C: body and surface waves; * for RCMT recovered later), focal plane parameters and T and P axes directions.

Date	Time	Qf	Data	str1	dip1	sl1.	str2	dip2	sl2	T az	T dip	P az	P dip
03/30	13:38	A	S	2	35	-70	158	57	-104	258	11	31	74
04/05	20:49	A	S*	147	37	-108	349	55	-77	70	9	300	76
04/06	01:32	A	C	326	35	-80	134	56	-97	229	10	20	78
04/06	02:37	A	S	355	46	-53	128	55	-122	240	5	341	64
04/06	03:56	C	S*	340	25	-103	175	66	-84	260	21	96	68
04/06	07:17	A	S*	138	41	-93	323	49	-87	51	4	261	86
04/06	16:38	A	C	348	40	-64	135	55	-111	239	8	353	72
04/06	23:15	A	C	341	44	-68	132	50	-109	236	3	339	75
04/07	09:26	A	S	341	41	-64	128	54	-111	233	7	344	72
04/07	17:47	A	C	105	53	-134	342	55	-48	44	1	312	57
04/07	21:34	A	C	321	41	-64	108	54	-110	213	7	325	72
04/08	04:27	A	S*	344	38	-84	156	52	-95	250	7	39	82
04/08	22:56	A	S	319	40	-76	121	51	-101	219	5	340	80
04/09	00:52	C	C	329	45	-81	136	46	-99	233	0	326	84
04/09	03:14	A	S	67	50	-170	331	83	-40	25	21	281	33
04/09	04:32	A	C	113	57	-144	2	61	-39	58	2	326	47
04/09	19:38	A	C	321	44	-83	132	46	-97	227	1	331	85
04/10	03:22	C	S*	91	41	-108	294	51	-75	14	5	260	77
04/13	21:14	A	C	337	38	-71	133	54	-104	233	8	359	76

04/14	20:17	A	S	309	42	-92	132	48	-88	221	3	65	87
04/15	22:53	C	S*	113	33	-126	333	64	-69	48	17	279	65
04/23	15:14	A	S	126	43	-105	326	49	-76	46	3	301	79
04/23	21:49	A	S	323	27	-95	149	63	-87	237	18	65	72
06/22	20:58	C	S	113	19	-112	315	72	-83	29	27	236	62
07/03	11:03	C	S	144	42	-108	348	50	-74	67	4	318	77
07/12	08:38	A	S	342	35	-76	146	56	-99	243	11	26	77

For Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Data (blue) and synthetics (red) for some of seismograms used for the inversion of April 6, 2009 Mw 6.3 event. In the upper group of stations body and surface waves are used, in the lower only surface waves.

