Hints on the seismotectonics of the Abruzzi Region from studies of the 6 April 2009, M_W 6.3, L’Aquila earthquake

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1. *L’Aquila earthquake for a reconsideration of the geological and tectonic observations*

Having a potential for shallow M 7 earthquakes, the Abruzzi Apennines comprise one of the most threatening seismogenic areas of the entire Europe. Until recently, the active tectonics of this stretch of the Apennines belt was believed to be especially well understood, which was seen as the basis for an effective mitigation of the local seismic risk. The Abruzzi landscape is criss-crossed by a number of faults of all sizes, and many of them show both evidence for sustained activity and credible relationships with one of the many earthquakes that have struck this region historically.

The 6 April 2009, M_w 6.3 L’Aquila earthquake shattered this belief from its very foundations; the surface expression of its causative source turned out to be a barely visible fault mapped by a minority of workers, while some more visible faults nearby were not even marginally involved. Many were taken by surprise also by the geometry of the fault rupture, as the earthquake was caused by slip over a plane dipping around 45° while most of the faults seen at the surface dip from 60° to sub-vertical, and by its depth which, from seismological data, extended from about 2 to 10 km.

The 2009 L’Aquila earthquake has spurred a number of studies – more than 100 papers have already appeared in the international literature in just three years – focusing on its source and the relationships with the surface geology, and triggered further investigations of nearby faults (e.g. Di Bucci et al., 2011). This earthquake called also for a careful reconsideration of the geological and tectonic observations and models upon which pre-2009 understanding of the seismotectonics of Abruzzi was based, and led to a thorough revision of the seismogenic source model of the region included in the Database of Individual Seismogenic Sources (DISS Working Group, 2010; Vannoli et al., 2012).

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2. *A review of previous geological and seismotectonic studies*

Perhaps the first well informed account on active faulting in Abruzzi is the report written by Emilio Oddone, a physicist who devoted most of his career to the investigation of the Earth geodynamics, following the catastrophic 13 January 1915, M_w 7.0, intensity XI, Avezzano (Fucino, central Apennines) earthquake (CPTI11 earthquake catalogue, Rovida et al., 2011). In the early days of Seismology, when the real nature of earthquakes was still being debated, Oddone (1915) described the formation of several strands of ground breaks that could not be explained as strictly surficial effects and that had to be somehow related with the deep earthquake source.

The Abruzzi Region remained seismically quiet since, and no similar evidence of tectonic surface breaks was reported for any of the earthquakes that punctuated the rest of the peninsula in the following decades (with the exception of the 1980 Irpinia earthquake). Nevertheless, thanks to the vicinity of Rome with its many research centers and to the beautifully exposed geology, Abruzzi became the object of intense geological investigations. In the context of the preparation of the 1:100,000 geological map, the region offered a perfect viewpoint for understanding how the Apennines were constructed, from the initial involvement of open sea sediments of the Tethys ocean to the current fold-and-thrust configuration. In the 1940s Abruzzi had become a playground for developing innovative tectonic models to be used in the booming oil industry, such as the theory of tectonic wedges («cunei composti») by Tuscan geologist Migliorini (1948). Later on, Accordi (1966) used observations from Abruzzi faults and folds to develop a model for the translational tectonics («tettonica traslativa») that would explain the major shortening and the simultaneous creation of thrust and normal faults in a typical fold-and-thrust-belt. In the framework of the new interest for the hazard posed by active fault to major infrastructures, in the 1970s Abruzzi became the target of new investigations on active faulting. Unlike other similarly active areas of the Apennines, where the evidence for tectonic activity is much more subdued, Abruzzi offered a large number and variety of faults that could be easily recognized even by non-geologists. Bosi (1975) and Bertini, Bosi (1978) mapped a number of active or potentially active faults in a large region stretching from the Apennines piedmont east of Rome to the Adriatic coast (Fig. 1). Common characteristics of these faults were the following:

- mostly extensional, striking NW-SE and dipping at 50°-70° to the SW;
- individual strands seldom longer than 10 km;
- seen in bedrock (limestone), often perched at high elevation over the adjacent basin/valley floor and lined by unconsolidated talus (scree);
- often marked by a white ribbon of fresh limestone («nastrino di faglia», fault ribbon) contrasting with the grey colour of the rest of the fault plane and of the adjacent rockmass;
- often seen to mimic the orientation and length of the main thrusts and anticlines.

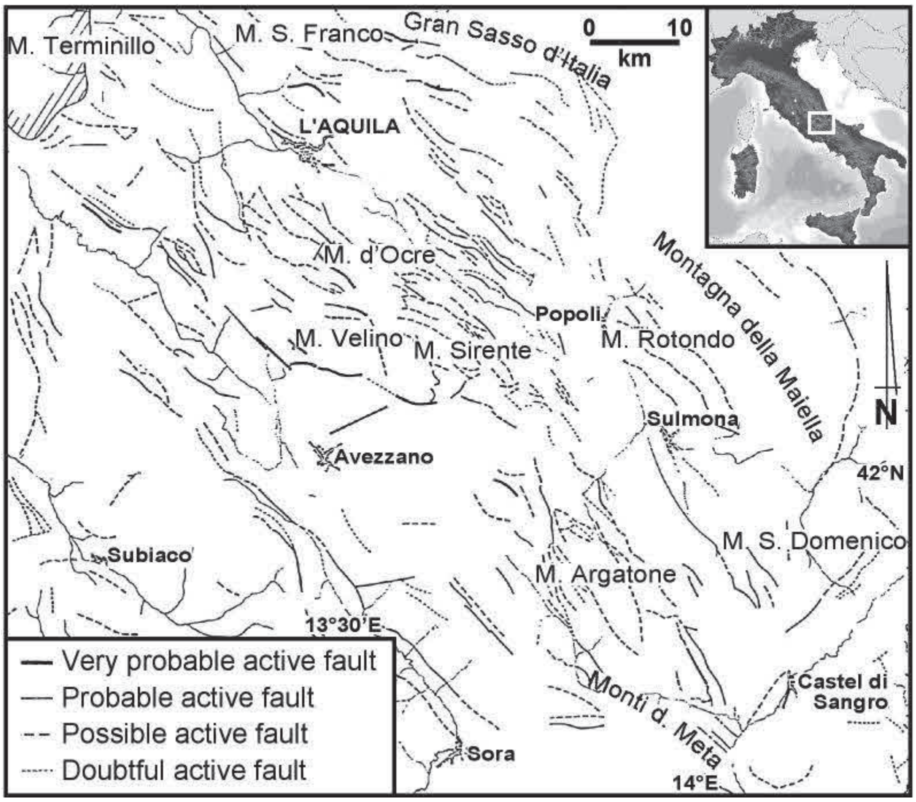

Figure 1. Map of the active or potentially active faults of the Abruzzi Region, compiled by Bosi (1975) (modified and adapted). Note the number of the mapped faults and their mean NW-SE trend. If overlapped on a map with topography, most of these faults would appear to run at the contact between the limestone bedrock and the unconsolidated talus scree.

The faults mapped by Bosi (1975) and Bertini, Bosi (1978) indeed agreed with the extensional regime currently active along most of the Apennines. Yet, they were not considered to be the source of the largest earthquake but rather «*[…] faults that are believed to be significant for identifying the deeper shear zone that generates earthquakes […]*» (Bosi, 1975). Although in those days the perception of fault scaling relationships was definitely crude, this belief was correct and in fact rather wise. According to current catalogues, the region under investigation suffered at least 5 earthquakes of M 6.0 and larger over the past four centuries, an interval for which the information on damaging earthquakes is considered complete over the entire country (Stucchi et al., 2004). Even assuming that all of these earthquakes were generated by surface-breaking faults, based on current empirical relationships (e.g. Wells, Coppersmith, 1994) each one of them would justify the existence of a single fault in the length range 10-30 km. In contrast, and purely based on fault length, several maps and compilations that discuss active faulting in the extensional core of the Abruzzi Apennines show a number of potential sources for earthquakes of M≥6.0 from two up to perhaps five times larger, depending on the author(s), on the size of the study area and on when the interpretation was presented (more recent papers tend to present fewer large potential sources). Notice that the above reasoning does not take into account: 1) expected fault width from scaling relationships, 2) the 3D geometrical relationships among narrow-spaced faults (i.e., when lateral distance is 2-3 km or less and almost one order of magnitude smaller than fault length), and, consequently, 3) possible fault interaction and mutual stress shadow (see Harris, 1998; Kenner, Segall, 1999). If each one of these faults slips at 0.5 to 1.2 mm/y and has generated its largest earthquake every 1,000-2,000 years, as commonly accepted based on paleoseismological studies (Galli et al., 2008; see also Basili et al., 2008; DISS Working Group, 2010, and references therein), and assuming a characteristic earthquake behavior for simplicity (see Schwartz, Coppersmith, 1984; Wesnousky, 1994), we should have seen 10-15 earthquakes of M 6.0 and larger over the four-century completeness window discussed above – which is not the case. Rather unexpectedly, paleoseismological investigations carried out in the damage area of the 6 April 2009 earthquake (Galli et al., 2010; Cinti et al., 2011) suggest recurrence times of only a few centuries, making the discrepancy delineated above even bigger and harder to explain.

Many investigators followed Bosi's first reconnaissance work. It is now widely accepted that the Central Apennines are cut by a large number of high-angle normal faults, most of which trend NW and dip to the SW (e.g. Galadini et al., 2000, and references therein). Typically these faults have been seen as controlling the location and evolution of the Pleistocene-Holocene intramontane basins filled by continental deposits, and are often characterized by prominent morphological scarps, well-preserved free-faces, and wide cataclasite zones. Nevertheless, the scientific community has contrasting opinions on the state of activity of these otherwise well-evident faults, on their association with historical earthquakes, on the relationship between each seismogenic source and the overlying surface faults, and hence in general on their seismogenic potential.

Although it qualifies as a moderate-size event, the 6 April 2009 makes a unique case for testing and improving our seismotectonic understanding of the Apennines, thanks to the amount and quality of the data collected during and after the event and to the nature of the issues it raised, most of which are shared by other central and southern Apennines earthquakes. Valensise, Pantosti (2001a) outlined discrepancies between geological and seismological evidence for Italian seismicity and discussed four circumstances that make the identification of Italian seismogenic faults particularly difficult: 1) the complexity of the inherited tectonic history; 2) the large number of blind faults; 3) the relatively low rates of tectonic deformation; and 4) the youthfulness of the latest major change in the tectonic regime. The 2009 earthquake highlighted how these circumstances are relevant also to the study of the Abruzzi faults.

3. *The 6 April 2009 earthquake source*

The 6 April 2009 earthquake (M_w 6.3) occurred close to the city of L'Aquila in the Abruzzi Apennines and was followed by more than 20,000 aftershocks (ISIDe, 2010), the two largest ones having occurred on 7 April (M_w 5.6), and on 9 April (M_w 5.4) (Chiarabba et al., 2009; Chiaraluce et al., 2011b). The focal mechanisms of the largest shocks exhibit normal faulting solutions, in agreement with the tectonic regime of the region (Pondrelli et al., 2010; Scognamiglio et al., 2010; Herrmann et al., 2011). In spite of the extraordinary amount of high quality seismological, geodetic, and geological data available for this earthquake sequence that provided insights into the source characteristics and complexity, the different investigators provided an unexpectedly wide range of solutions, yet leaving some key questions unsolved.

There is general consensus that the upward prolongation of the subsurface rupture plane would intersect the ground surface near the Paganica Fault, a poorly known tectonic element with feeble surface evidence (Bagnaia et al., 1992; Pace et al., 2006), referred to as an «uncertain or buried fault» in the digital version of the official geological maps (Servizio Geologico d'Italia, 2006). The seismological evidence that aftershocks were confined below 2 km of depth (Chiarabba et al., 2009; Chiaraluce et al., 2011a, 2001b) suggests that only minor slip took place on the shallower portion of the fault, in agreement with surface observations. The fact that the deep seismogenic source may have a complex relationships with the surface Paganica Fault is also suggested by the relatively low dip angle of the rupture plane (between 42° and 55° according to different investigators and methods used to estimate it, see Table 5 in Vannoli et al., 2012) and by its projection in the foot-wall of the Paganica Fault itself, as seen in the seismological sections published by Chiarabba et al. (2009) and Chiaraluce et al. (2011a, 2011b).

The rupture area and slip distribution of the activated fault has been constrained by various investigators through modelling of GPS, SAR and seismological data. The subsurface rupture length varies in the range 12 to 19 km (Anzidei et al., 2009; Atzori et al., 2009; Cheloni et al., 2010; Trasatti et al., 2011), and the maximum slip at depth was about 1 m with only a few centimeters of slip predicted along the shallower portion of the fault (e.g. Cirella et al., 2009). In contrast, field reconnaissance of surface co-seismic ruptures showed only discontinuous ground cracks and surface faulting with few centimeters of ground displacement: the total length and the geometry of the mapped surface breaks also varied greatly according to the different investigators. Accordingly, the surface evidence has been described 1) as a discontinuous 2.5 to 6-km-long segment of the Paganica Fault (Emergeo Working Group, 2009), 2) as three discontinuous 10-km-long en-echelon segments of the Paganica Fault (Falcucci et al., 2009), 3) as three narrow discontinuous 13-km-long fracture zones (Boncio et al., 2010), and 4) as three discontinuous 19-km-long sub-parallel splays of the Paganica-San Demetrio fault system (Galli et al., 2010).

As regards the predecessors of the 2009 event, based on the analysis of historical intensity reports, Tertulliani et al. (2010) suggested that both the 1461, M_w 6.5, and the 1762, M_w 5.9, Aquilano earthquakes were generated by the same source of the 2009 event, or by an antithetic structure cutting through the same seismogenic volume. Palaeoseismological studies across different segments of the Paganica and San Demetrio Faults returned different results: on the one hand Galli et al. (2010) suggested that the Paganica Fault ruptured during the 1461 and the 2 February 1703, M_w 6.7 Aquilano earthquakes, while on the other hand Cinti et al. (2011) recognized five paleo-events which include the 1461 but not the 1703 earthquake. Based on the long-term fault scarp geomorphology, however, they also suggested that the Paganica Fault could occasionally generate larger earthquakes.

This large amount of data and their interpretation have raised several issues, the main ones concerning 1) the deep source geometry and its relationships with surface active faults, 2) the repeat time of 2009-type earthquakes, and 3) the ability of the fault system to generate larger earthquakes implying the contemporary activation of adjoining segments (this last point refers to the geometry of the fault system itself).

The Database of Individual Seismogenic Sources (DISS Working Group, 2010) proposes a solution coming from modelling of most of the geological, geophysical and seismological data published so far, and the parameters of the seismogenic source of the 2009 earthquake, named Paganica, fit well the range of those proposed in the literature. The Paganica Source is a 14-km-long, 9.5-km-wide normal fault (rake 275°), dipping 43° to the south-west and striking 133° (NW-SE). The fault plane is constrained between 3.0 and 9.5 km depth (full parametrical description of the source is available on-line at http://diss.rm.ingv.it/diss/). We believe that the geometry of the Paganica Source highlighted by the occurrence of the 2009 earthquakes should represent a guidance for identifying correctly and parameterizing other nearby sources.

4. *Seismogenic Sources of the central Apennines*

This section contains a description of the seismogenic sources included in the DISS database (v. 3.1.1). Over the past 15 years, the DISS Working Group has elaborated a strategy for identifying, parameterizing and storing in a permanent database the main seismogenic sources that occur in and around the Italian peninsula, i.e. those that are believed to be capable of a M 5.5 or larger earthquake (Valensise, Pantosti, 2001b; Basili et al., 2008). This strategy, which was extended to the rest of Europe within the EC-funded project SHARE, is based on two categories of sources, identified on the basis of their hierarchical relationships and of the detailedness and quality of the associated geometrical and kinematic parameters: the *Individual Seismogenic Sources* (ISS) and the *Composite Seismogenic Sources* (CSS) (Basili et al., 2009; see also: http://diss.rm.ingv.it/diss/UserManual.html). The first category consists of well defined individual fault segments that may be associated with a specific historical or instrumental earthquake, and are a portion of longer fault systems that form the second category of sources. The identification and characterization of a seismogenic source are always based on original and bibliographical geological and geophysical data, and on seismological constraints from historical and/or instrumental seismicity and geodynamic considerations. DISS incorporates seismogenic sources capable of generating $M_w \geq 5.5$ earthquakes, thus including the majority of the most damaging earthquakes reported in Italian catalogues.

An Individual Seismogenic Source (ISS) is represented as planar rectangular fault projected onto the Earth's surface, and is characterized by a set of geometric (strike, dip, length, width and depth), kinematic (rake) and seismological parameters (average displacement, magnitude, slip rate, recurrence interval). ISSs are assumed to exhibit «characteristic» behavior with respect to rupture length/width and expected magnitude. These sources are tested against worldwide databases for internal consistence in terms of length, width, average displacement and magnitude, and can be complemented with information on fault scarps and other surface features, when documented. This category of sources can be used for deterministic assessment of seismic hazard, for calculating the probability of the occurrence of strong earthquakes for the sources themselves, for calculating earthquake and tsunami scenarios and for tectonic and geodynamic investigations.

A Composite Seismogenic Source (CSS) is represented as a planar fault system projected onto the Earth's surface, and is characterized by geometric (strike, dip, width and depth) and kinematic (rake) parameters. Its length is equal to the entire fault system and may contain an unspecified number of ISSs. They are not assumed to be capable of a specific earthquake but their potential can be derived by existing earthquake catalogues. A CSS is essentially identified on the basis of regional surface and subsurface geological data. In conjunction with seismicity and modern strain data, CSSs can thus be used for regional probabilistic seismic hazard assessment and for investigating large-scale geodynamic processes.

In the inner extensional sector of the Abruzzi Apennines DISS lists three parallel, about 100-km-long Seismogenic Sources (Fig. 2) each one including two or more ISSs. These Seismogenic Sources straddle the crests of the central Apennines following a regional NW-SE strike delineated by the location of the largest historical earthquakes; they dip to the SW, and are characterized by normal faulting mechanisms. The simple consideration of the distribution of historical earthquake release in the Abruzzi Apennines shows that here tectonic extension is accommodated differently from the adjoining regions to the north and to the south. In particular, seismic release follows three independent trends and affects a much wider area across the mountain belt. The reason for this probably lies in the different rheology of the crust resulting from the presence of the thick and rigid Latium-Abruzzi carbonate platforms.

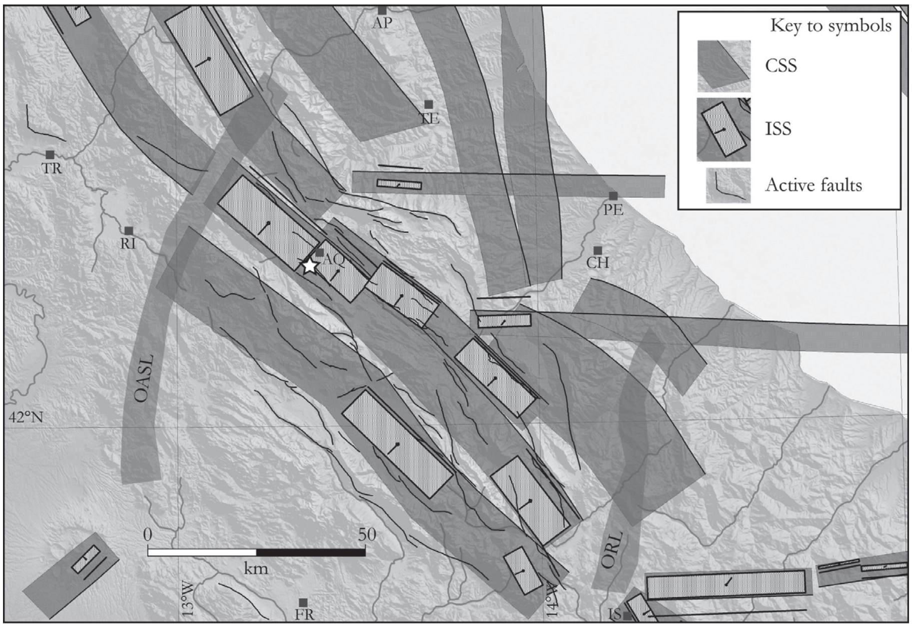

Figure 2. Seismotectonic setting of the Central Apennines. The map shows the projection onto the ground surface of the seismogenic sources included in DISS. The black lines close to the ISSs are the up-dip projection of the ISS onto the surface; the ticks on the source surface show the relative direction of movements of the faulted blocks. The black lines delimiting the CSSs highlights the upper edges of the sources (data from DISS Working Group, 2010). The main active faults are a compilation from various Authors. OASL: Olevano-Antrodoco-Sibillini Line; ORL: Ortona-Roccamonfina Line. The epicenter of the 6 April 2009 L'Aquila earthquake is shown with a white star.

The along-strike continuity of the three CSS is interrupted to the northwest and to the southeast by the transverse Olevano-Antrodoco-Sibillini and Ortona-Roccamonfina lines (Fig. 2). These are two NNE-striking, inherited tectonic lineaments that delimit the Mesozoic paleogeographic domains and define a change in the surface geology. They are supposed to act as effective boundaries to the dynamic earthquake propagation, segmenting also the Quaternary extensional fault systems (Pizzi, Galadini, 2009). The Olevano-Antrodoco-Sibillini Line to the north separates the Abruzzi extensional domain from the structures related to the Alto Tiberina normal fault system developed in the Umbria-Marche Apennines, and marks a change in strike and in the direction of dip of the master fault (Fig. 2). The Ortona-Roccamonfina Line defines the boundary with the Southern Apennines extensional belt just southeast of the 1984 earthquake epicentral area, and close to the intersection with the E-W Molise-Gondola Shear Zone (Di Bucci et al., 2010). In contrast with the configuration of the Abruzzi Region, in the Southern Apennines one system of NE-dipping seismogenic sources follows the hinge of the mountain chain, and is segmented by regional E-W shear zones responsible for the earthquakes located east of the divide (e.g. the 1456 seismic sequence, Fracassi, Valensise, 2007).

The basic line of evidence to detect earthquake-generating faults in the Abruzzi Region has always been the mapping of active features. The main active fault systems associated with the shallower portion of the CSS are shown in bold in Fig. 2. There exists a complex relationship between the deep sources of large earthquakes and the surface active faults that was exemplified by the coseismic effects of the two larger instrumental and perhaps best known earthquakes: the M_w 7.0, 1915 Avezzano and M_w 6.3, 2009 L'Aquila events. The first was explicitly a surface faulting event, activating different parallel synthetic fault strands falling in the source hanging-wall (i.e. in the area of maximum coseismic surface deformation), and not basin-bounding and directly related to the basin opening (e.g. Valensise, Pantosti, 2001a). The second event was caused by a fault having a subdued morphology (not classified among the main active faults by most investigators) and producing mainly secondary faulting and few centimetres of surface breaks along the Paganica Fault. In both cases the seismogenic sources activated more than one surface faults, none of which were correctly scaled in length with the magnitude of the earthquake. The lesson that must be learned from these two earthquakes is that in areas of complex geology such as the Abruzzi Apennines, where the current structural grain results from the superposition of different tectonic regimes, the equation that directly relates the most visible active fault to the major seismogenic fault is often misleading. In fact the main active fault systems are discontinuous and fragmented in segments with various orientations and lengths, are often accompanied by synthetic and antithetic secondary faults, and their map traces cannot be taken alone to draw a geometrically coherent seismogenic model. Following these lines of reasoning to fully define the parameters of the Seismogenic Sources contained in the DISS database we always make a complete analysis of the structural and geologic setting at seismogenic depth and of the morphotectonic phenomena at the scale of the entire investigated structures, to unveil the long-term activity of the source.

5. *Conclusion*

The numerous studies that followed the 6 April 2009 earthquake have yielded a new and updated portrait of the distribution of extensional seismogenic sources in the Abruzzi Region, and supplied an updated look at the seismotectonics of the Central Apennines. The first insight that can be derived by the seismogenic sources is the regularity in the pattern of present tectonic deformation. Most of the seismic moment is released along three parallel extensional SW-dipping CSSs that follow the regional divide, and have similar depth of faulting and slip rate. These extensional sources are delimited by two well-known, pre-existing major tectonic lineaments that have credibly played an important role in the evolution of the Abruzzi Apennines that one can consider as a broad and rather uniform area at least from a paleogeographic and tectonic viewpoint.

The main improvements and novelties included in the DISS database following the 2009 earthquake include:

1) an improved understanding of the three parallel extensional fault systems – thus implying the need to define their most credible geometry and extent and to understand the possible kinematic relationships among them, also as a function of their respective arrangement;
2) the greater depth of the Campotosto Source highlighted by the newly-available seismological data, leading to a careful reconsideration of the geological evidence that in the past has been considered crucial for this source;
3) the updating of the geometric properties of seismogenic sources, new geological data, and new interpretations of faults that are thought to have generated a number of historical earthquakes. In particular, we believe that the relatively shallow dip, the depth of the upper tip at 1-2 km below the ground surface, and the complex relationships with surface active faults shown during the 2009 earthquake sequence are not exceptional but instead are be seen as common features of the seismogenic sources responsible for moderate earthquakes in the region;
4) the role (passive, active – any at all?) of two regional tectonic lineaments perpendicular to the whole central Apennines, as the Olevano-Antrodoco-Sibillini Line, to the North, and the Ortona-Roccamonfina Line, to the South;
5) the identification of seismic gaps along the three main CSSs. For example the Sulmona Basin and the Subequana Valley have not been the locus of major historical earthquake at least over the past seven centuries, and can be considered as two independent seismic gaps.

The revised seismogenic sources increase the degree of completeness of the seismotectonic framework of the Abruzzi Region, yielding a synoptic view of seismogenic processes in the central Apennines area. They also comprise a homogeneous database for quantifying the tectonic strain and the seismogenic potential at regional scale.

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Riassunto - Nuove interpretazioni sulla sismotettonica dell'Abruzzo derivanti dallo studio del terremoto di Mw 6,3 del 6 aprile 2009 de L'Aquila

Il distruttivo terremoto de L'Aquila del 6 Aprile 2009 (M_W 6,3) ha fornito importanti lezioni agli studiosi dei terremoti, alcune delle quali anche sorprendenti. Nonostante che dal punto di vista del rilascio energetico questo terremoto non sia stato tra i più forti, se confrontato con altri eventi recenti a scala mondiale e con altri forti eventi della storia sismica italiana, esso ha permesso la raccolta di una mole notevole di dati che hanno portato ad una revisione approfondita della geometria e in alcuni casi dello stile che caratterizza la fagliazione cosismica della regione abruzzese. Una delle osservazioni principali emerse a seguito degli studi condotti è che il terremoto è stato associato ad una fagliazione della superficie terrestre molto limitata, lanciando così un campanello d'allarme per quelli che sono i classici strumenti geologici tradizionalmente e più diffusamente utilizzati per l'identificazione delle faglie attive e sismogenetiche. L'Abruzzo è una regione che dal punto di vista della geologia dei terremoti mostra alcuni paradossi, il primo fra tutti è rappresentato dal fatto che nonostante esista una documentazione storica molto lunga sull'attività sismica, e che per i forti terremoti essa sia molto attendibile, il numero dei terremoti incluso nei cataloghi appare di molto inferiore al numero di eventi che ci si sarebbe attesi di registrare considerando il numero e la lunghezza delle faglie attive mappate, potenziali sorgenti di terremoti di M≥6,0. Se si considera poi il fatto che recenti indagini paleosismologiche hanno mostrato che il tempo di ritorno di alcune faglie può anche essere breve, dell'ordine di alcune centinaia di anni, questa discrepanza diviene ancora più accentuata. Bisogna quindi chiedersi se tutte le grandi faglie mappate come attive possono rappresentare potenziali sorgenti di forti terremoti. Ma occorre anche chiedersi, derivando dall'esperienza del terremoto de L'Aquila dove la sorgente profonda ha riattivato limitatamente numerose faglie superficiali, quali siano i rapporti tra le sorgenti sismogenetiche profonde e i sistemi di faglie superficiali. Questo lavoro è focalizzato sul dominio estensionale degli Appennini Centrali in Abruzzo e descrive il modello sismo-tettonico aggiornato di questa regione, derivato dai numerosi studi che hanno fatto seguito al terremoto del 2009. Questo modello costituisce l'ossatura dell'ultima versione del Database of Individual Seismogenic Sources (DISS Working Group, 2010; http://diss.rm.ingv.it/diss/).

Parole chiave

Abruzzo, faglie attive, sorgenti sismogenetiche, terremoto de L'Aquila del 6 aprile 2009.

Résumé - Nouvelles interprétations sur la séisme-tectonique des Abruzzes tirées de l'étude du tremblement de terre de Mw 6,3 du 6 Avril 2009 de L'Aquila

Le tremblement de terre destructif qui a frappé L'Aquila le 6 avril 2009 (Mw 6,3) a donné des importantes leçons aux spécialistes des tremblements de terre, dont quelques-unes sont surprenantes. Malgré ce tremblement de terre n'ait pas été particulièrement fort du point de vue du relâchement énergétique, il a permis de recueillir une masse considérable de données qui ont suggéré une révision approfondie de la géométrie et dans certains cas du style qui caractérise les fractures cosismique de la région des Abruzzes. Une des observations principales émergées grâce aux études menées est que le tremblement de terre a été associé à des fractures de la surface terrestre très restreintes, ce qui a fait douter de l'efficacité des moyens géologiques classiques, traditionnellement et plus diffusément utilisés pour l'identification du failles actives et sismogénétiques. Les Abruzzes sont une région qui du point de vue de la géologie des tremblements de terre montre quelques paradoxes. Le premier paradoxe est représenté par le fait qui le nombre des tremblements de terre inclus dans les catalogues résulte inférieur par rapport au nombre d'événements qu'on aurait pu s'attendre d'enregistrer, en tenant compte du nombre et de la longueur des failles actives recensées, origines potentielles de tremblements de terre M≥6,0. Si l'on considère en plus que des récentes enquêtes paléosismologiques ont montré que le temps de retour de certaines failles peut être bref dans l'ordre de quelques centaines d'années, cette discordance s'accentue. Cet article est focalisé sur la domination extensionnelle des Appennini Centraux en Abruzzes et décrit le modèle sismotectonique ajourné de cette région qui dérive des nombreuses études qu'on a mené à l'occasion du tremblement de terre de 2009. Ce modèle constitue l'ossature de la dernière version du Database of Individual Seismogenic Sources (DISS Working Group, 2010; http://diss.rm.ingv.it/diss/).

Mots-clés

Abruzzes, failles actives, sources sismogénétiques, tremblement de terre de L'Aquila du 6 avril 2009.