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The 2009 L'Aquila, Italy Earthquake (M6.3) Damage and Response to a Moderate Event

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Synopsis

The 2009 L'Aquila, Italy earthquake (Mw6.3) caused considerable damage and loss of life in central Italy. There was extensive damage to over 10,000 buildings of both old and new construction, although the ground motions were not exceptionally strong for this size event. There were surface cracks observed in the area that the Paganica fault projects to the surface, however, it is unclear if this deformation represents coseismic faulting. About a week before the mainshock, an earthquake prediction was distributed in this region by an independent non-seismologist. The apparent success of the prediction caused many problems for local officials and raised important issues about appropriate methods to distribute information related to natural hazards.

Keywords: L'Aquila, Italy, Earthquake, Earthquake Prediction

1. Introduction

On April 6, 2009 at 01:32 UTC (03:32 local time) a moderate sized (Mw6.3) earthquake occurred near the town of L'Aquila in central Italy. The earthquake was relatively small by seismological standards with many events of this size every year (about 70 M6.3 or larger earthquakes every year worldwide), however this earthquake caused 295 deaths and significant damage in the local area (estimated US$ 16 billion). Also world news coverage focused on the region, since a G8 summit was scheduled to be held in L'Aquila several months following the earthquake.

The Apennine mountain belt in central Italy is an areas of high seismicity with many historical damaging earthquakes. Typically the events in this region have normal fault mechanisms. This was the case for the April 6 earthquake, which ruptured a northwest striking normal fault. The aftershocks located by the Instituto Nazionale di Geofisicae Vulcanologia (INGV) and modeling of strong motion data (Cirella et al., 2009) and deformation data (Anzidei et al., 2009, Walters et al., 2009) showed that the rupture plane had a length of 10 to 25 km and width of about 10 to 15 km, with a dip downward toward the southwest.

The aftershock activity was quite strong for a Mw6.3 earthquake and spread out over an area that was over twice the size of the mainshock rupture plane. There was a M_L5.6 aftershock in the southeastern part of the aftershock area and a M_L5.4 northwest of the mainshock area during the first week following the mainshock (Chiarabba et al., 2009). With the large number of strong aftershocks, there was concern at INGV that there could be more subsequent damaging events in the following weeks. The normal faulting sequences in the region often have multiple large events, such as the 1997 Umbria sequence (Deschamps et al., 2000). However, there were no further large earthquakes during the following month.

There was also a considerable amount of seismic activity prior to April 6. Many small earthquakes occurred in this region starting in January, three months before the mainshock.

Among these earthquakes, there were numerous felt events, which caused concern in the public and led to a difficult situation regarding an earthquake prediction, which is described later. The largest event prior to the mainshock was a M_L4.1 event on April 30. Also, four hours before the mainshock there was a M_L3.9 foreshock (Chiarabba et al., 2009).

I visited INGV in Rome and the area of the earthquake on April 15 to gather information for this report.

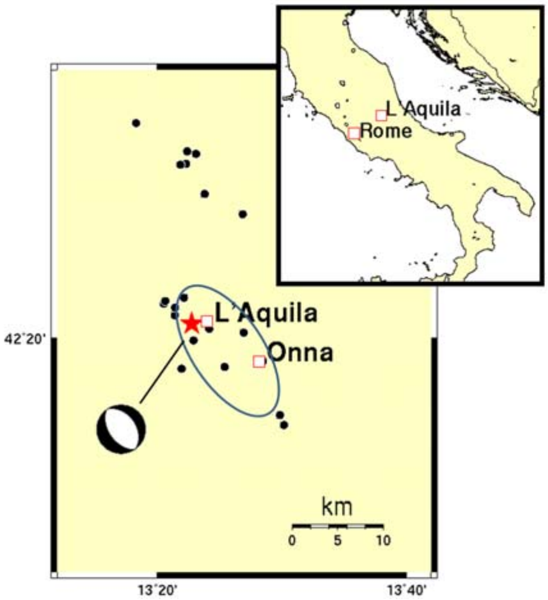


Figure 1. Location of L'Aquila earthquake sequence in central Italy. Ellipse shows the approximate rupture area of the mainshock. Black dots are aftershocks M≥ 4.0.

2. Earthquake Damage

The town of L'Aquila has a population of about 73,000 people and there was reported damage to over 10,000 buildings in the area. Many of the damaged buildings were old structures that were built several hundred years ago. However, many modern buildings were also severely damaged. There was much publicity in the Italian media about a collapse in the San Salvatore hospital which was built in 2000, and collapse of modern buildings on the campus of the University of L'Aquila where a number of students were killed. These failures in newly built structures raised questions about the quality of their construction.

Photo 1. Damage to an old church in Paganica

Some of the most severe damage was in the village of Onna located about 7 km southeast of L'Aquila. Almost all buildings in this small town were destroyed. The severe ground shaking in this locale can probably be attributed to close proximity to the area of large slip on the fault combined with soft soil conditions.

There was a good set of strong motion records with 19 stations recording the mainshock within 50 km (Ameri et al., 2009a, Ameri et al., 2009b). These records show peak accelerations in the range of 327 to 656 cm/s^2 and peak velocities of 30 to 50 cm/s, for stations near the fault. These data show that the ground motions were not unusually high.

Photo 2. Tents for housing displaced people.

Photo 3. Severe building damage in the village of Onna.

There were over 15,000 persons displaced by earthquake. People left their homes that were damaged and also vacated relatively undamaged structures because of the fear of possible future strong events.

3. Ground Cracks

Geologists from INGV and other institutions carried out extensive surveys looking for surface displacements from the earthquake. Ground fissures were found in the region where the projected Paganica fault should surface (Photo 4). There is still debate whether these features represent co-seismic rupture or cracking in response to shaking or down slope subsidence (Falcucci et al., 2009). In either case, the amount of surface rupture would be several centimeters or less.

Large ground cracks due to local spreading were also seen at Lake Sinizzo were (Photo 5).

Photo 4. Fissure located at the surface position of the Paganica fault.

Although no large surface faulting was observed, the pattern of surface deformation is shown very clearly from the inSAR data (Walters et al., 2009). These data show maximum displacements of about 25 cm (in the direction of the satellite) of subsidence on the hanging wall and several centimeters of uplift on the foot wall.

Photo 5. Ground cracking due to subsidence at Lake Sinizzo.

4. Earthquake Prediction

A social/scientific problem associated with this sequence of seismic events in Italy, arose when an earthquake prediction was issued in late March by Gioacchino Giuliana. He is a technician at the National Physical Laboratory of Gran Sasso. Over the last several years he has been monitoring and interpreting radon gas anomalies to predict earthquakes. He has been doing this work as an independent project, and it is not associated with any earthquake research institute in Italy.

On March 28, Giuliana announced an earthquake prediction for the town of Sulmona which is located about 50 kilometers southeast of L'Aquila. The prediction was posted on a webpage and also vehicles with speakers broadcast the prediction on the streets of Sulmona. Since felt earthquakes had been occurring in the region since January, the announcement of this prediction caused much unrest and anxiety among the people in the community.

Because of the fear being generated in the public, local government officials ordered Giuliana to stop distributing the information about the prediction. On March 31, a public meeting was held in L'Aquila, the administrative center for the region. At the meeting, officials of Civil Protection Agency announced that there was no scientific basis for the prediction.

The M6.3 earthquake occurred six days later on April 6 in L'Aquila.

The occurrence of the earthquake was not exactly consistent with the prediction. The location was 50 km from the target area of Sulmona and the occurrence was one week later than the prediction. However, the location and time were relatively close. Furthermore, since official information was being released from L'Aquila, when the earthquake occurred there, the perception is that the prediction was correct.

Most seismologists that have looked at this prediction and the associated data, think that there was not a clear signal in the radon data that justifies the prediction. This situation of an earthquake prediction that is issued without the support of the scientific community raises difficult public policy issues.

Was there any validity to this prediction ?

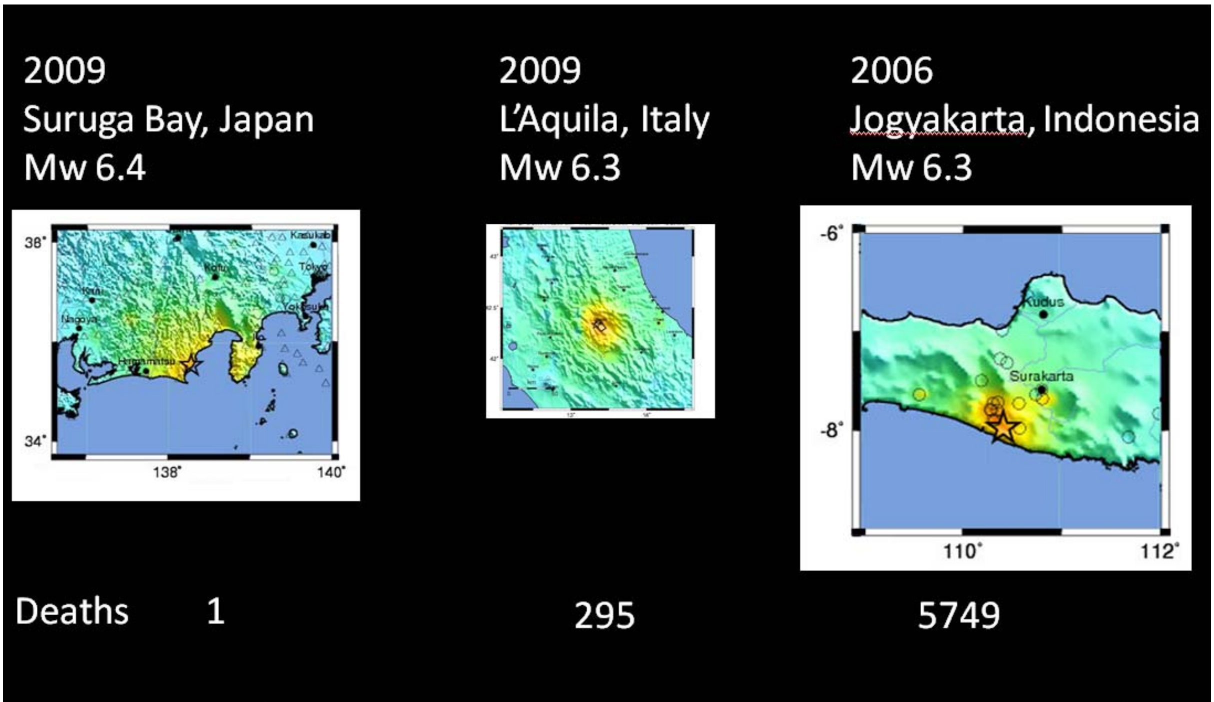
What should be done about 'non-expert' predictions ? Should they be presented to the public ?

How should important hazard information be made available to the public ?

These concerns will arise in other earthquake prone regions, such as Japan, where there are non-seismologists making earthquake predictions. A well thought out system for providing public information about earthquake predictions is a necessary part of a hazard mitigation program.

5. Conclusions

The 2009 L'Aquila earthquake was a moderate event that caused a significant amount of damage. It was not surprising that old masonary buildings that were several hundred years old sustained much damage. However, there were also modern structures that collapsed which raises concern about the present building practices. The quality of building design and construction is the most important factor in mitigating seismic damage. Countries such as Iran and Indonesia where the



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
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Figure 2. Death tolls for similar size earthquakes in Japan, Italy and Indonesia. Intensity distributions are taken from the USGS webpage, http://earthquake.usgs.gov/earthquakes/.

level of seismic resistant construction is relatively low, sustain very heavy losses in earthquakes. The damage in the US and Japan, where there are higher standards, is much less for the same size earthquake. The situation in Italy is somewhere between these two end members. Figure 2 shows the intensity pattern for three similar size earthquakes in Japan, Italy and Indonesia. All three earthquakes are shallow events that occurred in areas of relatively high population. The death tolls from these three events (Japan 1, Italy 295, Indonesia 5749) largely reflect the respective quality of building construction in the countries.

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2009年イタリア・ラクイラ地震（M6.3）中規模地震の被害と対応について

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要　旨

2009年，イタリア・ラクイア地震（Mw6.3）は中部イタリアにたいへんな被害をもたらし，人命も失われた。この規模の地震にしては揺れは特に大きくはなかったにもかかわらず，新旧合わせて１万棟以上の建物に大きな損害が出た。Paganica断層が地表に出ている地域で地割れが観察されたが，これが断層のすべりによるものかどうかははっきりしない。本震の１週間ほど前に，地震学者ではない個人によって地震予知が行われ，この地域一帯に流布された。一見成功したかに見える予知情報は当局にたいへんな問題を引き起こし，自然災害の情報をいかに伝えるかについて多くの重要な課題を提起した。

キーワード：イタリア，ラクイラ，地震，地震予知