TECTONIC HAZARDS IN ITALY

by John Davidson

IN 2012, TWO major earthquakes occurred in the Bologna area of northern Italy. On 20 May an earthquake measuring 5.9 on the Richter scale destroyed both historic churches and modern buildings, and on 29 May an earthquake measuring 5.8 hit the same area, causing further damage. Buildings collapsed, weakened by the earlier earthquake, 29 people died, and thousands were made homeless. An earthquake risk map for this area was only completed in 2002, and rules about protecting buildings from earthquakes introduced in 2006. Italy is situated where two of the Earth's major tectonic plates meet, and the entire country is at risk from volcanic and earthquake hazards.

Figure 1: **Tectonic hazards that threaten human activities**

Tectonic hazards caused by earthquakes	• Severe ground shaking • Vertical or horizontal movement of the ground • Tsunamis (huge waves produced by underwater earthquakes) • Liquefaction (land becomes waterlogged and weak during earthquake and buildings collapse) • Landslides, especially in hilly areas • Ground subsidence
Tectonic hazards caused by volcanic activity	• Lava flows • Ash clouds • Volcanic bombs (tephra) • Pyroclastic flows (glowing cloud eruptions of very hot gas and ash travelling at high speed) • Release of dangerous gases; sulfur and carbon dioxide • Tsunamis (huge waves produced by collapse of sides of volcanoes) • Lahars (hot volcanic mudflows) • Earthquakes caused by rising magma

What are tectonic hazards?

The Earth's crust is divided up into a number of large and small tectonic plates, which are being moved around slowly by convection currents in the molten mantle below the Earth's crust. Volcanic activity and earthquakes occur where tectonic plates meet, causing the tectonic hazards shown in Figure 1, which threaten human activities.

Italy is located where the African crustal plate is pushing pieces of oceanic crust under the Eurasian plate at rates of up to 10 mm per year. Figure 2 shows where this is happening and how it is linked to active volcanoes and recent earthquakes. Most of Italy lies over a destructive plate boundary. At such boundaries two plates move towards one another and as one of the plates goes under the other it creates a subduction zone under the continental crust, causing frequent earthquakes. There are also many fault lines where the crust has broken and the plates push past each other. In the last hundred years there have been eleven major earthquakes of magnitude 6 or more and a deadly tsunami in 1908.

Earthquake hazards in Italy

Figure 3 shows the major earthquakes that have occurred in Italy since 1900. Many of these earthquakes were in areas of high population density and centres of economic activity. Earthquake hazards not only cause loss of life, serious injuries and homelessness, but also damage to factories with loss of industrial production, and destruction of stock, leading to loss of jobs. Road and rail links may be affected by the collapse of bridges or landslides, cutting off areas and making rescue and recovery more difficult.

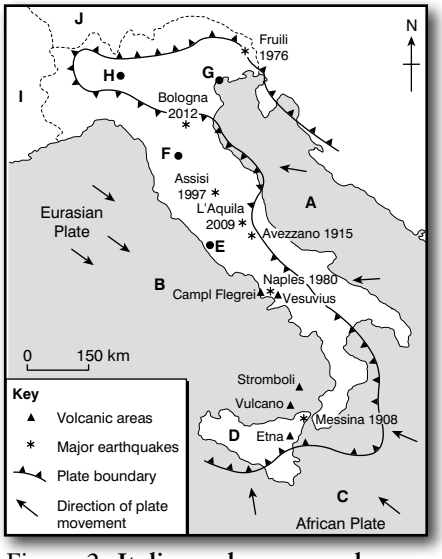

Figure 2: **Italian volcanoes and recent earthquakes**

Case Study

L'Aquila

In April 2009, a powerful earthquake magnitude 6.3 struck the Abruzzo region of central Italy in the middle of the night, with the tremors lasting over 30 seconds. The epicentre (the point directly above the centre of the earthquake, or 'focus') was the historic city of L'Aquila, the regional capital. Over 15,000 buildings were destroyed or damaged beyond repair, and sleeping people were trapped

Figure 3: **Recent earthquakes in Italy**

Date/ year	Magnitude on Richter scale	Location	Deaths	Homeless	Effects
2012	5.9 and 5.8	Bologna	29	15,000	Major ground shaking; collapse of churches, homes and factories
2009	6.3	L'Aquila	309	65,000	Major ground shaking and vertical movements; collapse of buildings; landslides
1997	5.5	Assisi	13	40,000	Major ground shaking and collapse of buildings
1980	6.9	Eboli near Naples	2,735	30,000	Major ground shaking, damage to buildings and vertical movements of land
1976	6.5	Fruili	976	70,000	Major ground shaking; collapse of buildings and severe damage; landslides
1915	7.0	Avezzano	30,000	Not known	Long period of ground shaking; total destruction of all buildings in town
1908	7.2	Messina	82,000	Not known	Severe ground shaking; 12 metre tsunami along coast; vertical movement of sea bed and underwater landslides

in the rubble. This was Italy's worst earthquake for 30 years, and historic landmarks such as the city's cathedral collapsed into dust. Several modern concrete buildings also collapsed. The new wing of the L'Aquila hospital, only opened in 2000 and built to be earthquake-proof, had to be closed due to extensive damage. Twenty-six towns and villages in the surrounding area were also badly hit. The major hazard at L'Aquila was the violent tremors which shook the ground up and down. The mountainous region nearby was also affected by many landslides, which blocked roads and damaged buildings. The local economy, including tourism, was severely disrupted.

Could the earthquake hazard at L'Aquila have been predicted?

Major earthquakes have hit L'Aquila seven times in the last 600 years and much of the city was destroyed in 1703. In 1915 the severe Avezzano earthquake occurred only 30 km to the south. L'Aquila is located directly over the fault lines where the two plates meet. From January to March 2009 there had been a series of smaller tremors and scientists had suggested that a major earthquake was coming. One week before the earthquake, a meeting of local officials and scientists took place to consider the risks of a major earthquake but no one ordered an evacuation or extra precautions because there is no way to predict the actual date and time of a major earthquake. After the earthquake, seven members of the Italian National Commission for the Forecast and Prevention of Major Risks went on trial, accused of giving 'inexact, incomplete and contradictory' information about the risk of a major earthquake occurring.

The best advice to people who live in the earthquake-risk regions of Italy is to be prepared. The local authorities need to set and enforce strict building codes to protect buildings from movements that could make them collapse. Areas need emergency response plans for rescuing people and for providing temporary housing. Warning signals can now be linked to seismographs which detect the early stages of a major earthquake, providing between 10 and 20 seconds' warning linked to sirens, phones, computers, radios and TVs, which gives people enough time to duck under cover or get out of a building. People can also be trained to take basic precautions, such as ensuring that their property is in good repair, and having an evacuation plan and a survival kit ready. Some areas of Italy have now introduced earthquake drills.

Volcanic hazards

Italy has five areas of volcanic activity, centred on Etna, Stromboli, Vulcano, the Campi Flegrei (Phlegrean Fields) and Vesuvius. Stromboli, an island off the coast of Sicily, is one of the most active volcanoes in the world and is known as 'the lighthouse of the Mediterranean'. Nearby Vulcano is not currently active but has erupted explosively within the last 150 years. At both Vulcano and Stromboli, volcanic activity is closely monitored, and evacuation plans are in place for when an eruption begins.

Etna is a large volcano on Sicily that has erupted over 20 times in the last 30 years, producing producing ash clouds, tephra and large lava flows (Figure 4). Its lower slopes are home to over a million people who farm olive and lemon groves and work in tourist activities including ski resorts and visitor centres. Lava flows in the last 30 years, notably in 1983, 1992 and 2002, have damaged ski areas and farmland and threatened villages with destruction. Catania airport was closed in 2000 after an aircraft carrying over 100 people flew into an ash cloud from Etna and suffered major damage to its windscreen, forcing the pilot to make an emergency landing.

The volcanic activity of Etna also leads to earthquakes, and although building codes have existed since 1980 to make new

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homes earthquake-proof, large numbers of buildings constructed between 1960 and 1980 have little protection against earthquakes.

Case Study

The Bay of Naples

The Bay of Naples is an active tectonic region that has been affected by both earthquake and volcanic hazards (Figure 5).

Italy's most famous volcano Vesuvius, whose eruption destroyed Pompeii and Herculaneum in AD79, is located just east of Naples. Vesuvius has erupted 18 times in the last 400 years and has produced deadly pyroclastic flows on several occasions. At present it is quiet and produces only steam and gases. The last eruption occurred in 1944 when large lava flows led to the evacuation of over 12,000 people, ashfall covered much of the surrounding area, and dangerous gases affected people's homes.

About 20 km from Vesuvius on the west side of Naples is Solfatara. The last lava eruption here was in 1164, and the volcanic crater is now in a housing area and is a tourist attraction. Currently, the main hazards at Solfatara are boiling mud pools (120°C) and vents producing sulfurous gases. These are carefully monitored and the crater is sometimes closed to tourists.

Near Solfatara, 80,000 people live in the town of Pozzuoli which suffers from the tectonic hazards of earthquakes and land movements. Between 1980 and 1985 the land rose 3 metres in a series of earthquakes, damaging many homes and making the harbour too shallow to use. Half the population were moved to temporary housing in a new town nearby. Since 1986, the land has subsided again. These activities are thought to be linked to underground movements of magma and gases.

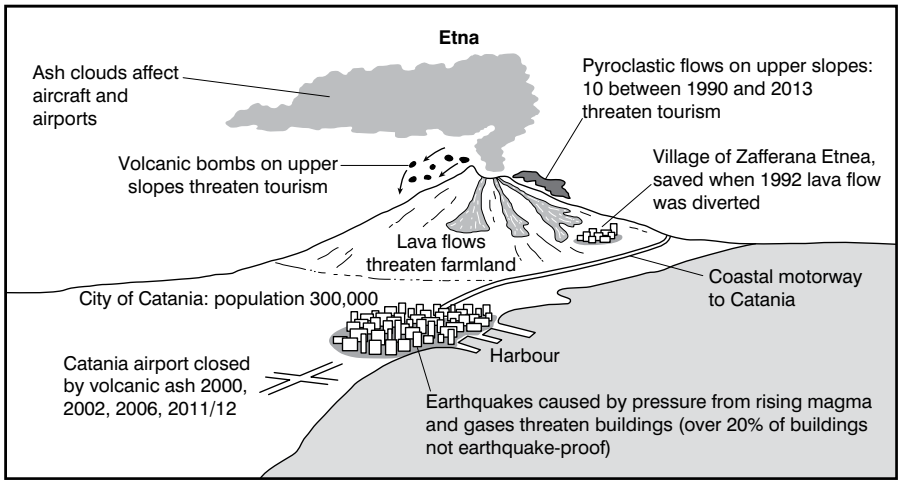

Figure 4: **Tectonic hazards around Etna**

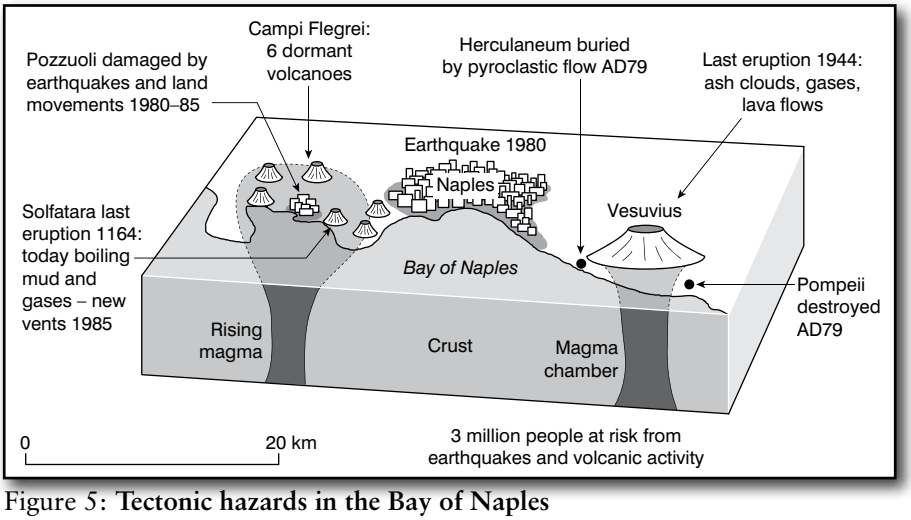

Figure 5: **Tectonic hazards in the Bay of Naples**

Naples itself was hit by an earthquake in 1980. Older buildings made of a building stone called tufa absorbed the shock waves and remained undamaged, but modern concrete blocks of flats and a sports stadium were badly damaged. There is a significant risk around the Bay of Naples from future tectonic hazards. Three million people live in this area, which is also important for tourism, manufacturing and farming. Figure 6 on page 4 shows some of the ways that the hazards around the Bay of Naples are being managed. Figure 7 shows various ways used to monitor earthquakes and volcanic activity in this area. The current plan is that the monitoring equipment will give enough warning for an evacuation of the 600,000 people who live nearest to Vesuvius; people would also be moved from Naples if the eruption became severe. However, this plan does depend on accurate prediction of a forthcoming eruption and sometimes, like earthquakes, volcanoes can erupt with very little warning.

Activities

1 On a copy of Figure 2, name:
(a) the seas at A, B and C
(b) the island D
(c) the Italian cities E, F, G and H
(d) the countries I and J.

2 Referring to Figure 2, explain why Italy suffers from both earthquakes and volcanoes.

3 Use a search engine to find two or three images of *either* the L'Aquila earthquake in 2009 *or* the Bologna earthquake in May 2012. Using the pictures and the information in this unit, describe four main effects of the earthquake on the region.

4 Search the internet to find:
(a) three ways that a building can be designed to withstand major earthquakes
(b) what warning systems are used in places like Japan and California to tell people that an earthquake has begun.

5 Find out about the 'Duck, cover and hold' way of surviving an earthquake used in the USA. Design an earthquake leaflet for Italy using three headings:
(a) How to prepare your family and house for an earthquake
(b) What warning signs might tell you an earthquake is starting
(c) What to do when an earthquake begins.

6 Referring to Figure 4, describe four different types of hazard that affect local people when Etna erupts. You can use a search engine to find video footage of recent eruptions on Etna.

7 Study Figures 5 and 6 and re-read the case study on the Bay of Naples.
(a) State three ways that people are preparing for a future eruption of a volcano such as Vesuvius in this region.
(b) Suggest reasons why it might be difficult to manage a major evacuation in a region with over 3 million inhabitants.

8 From Figure 7 choose three ways of monitoring earthquakes and volcanoes.
(a) Using a search engine, find pictures of your chosen equipment.
(b) Draw a diagram or make a poster of a volcano or earthquake region to show how this equipment would help to monitor earthquakes or volcanic activity.

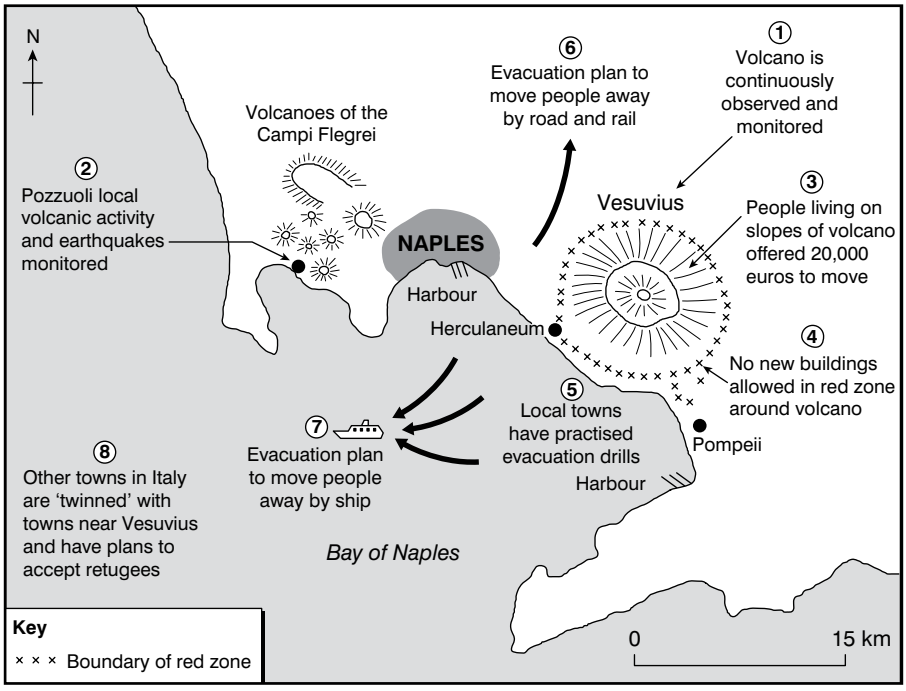

Figure 6: **Managing tectonic hazards in the Bay of Naples**

Figure 7: **Monitoring tectonic hazards**

Hazard	Monitoring method	How it works
Earthquakes	Seismographs	Very sensitive sensors detect ground movements.
Ash clouds	Wind vanes and anemometers	These instruments monitor wind speed and direction to predict where ash clouds will go.
	Aircraft	Planes collect particles from ash clouds for analysis.
	LiDAR	Light and radar sensors pick up the density and height of ash.
Volcanic eruptions	Gas samples	Increased amounts of gas, especially sulfur and carbon dioxide, may be a sign of a possible eruption.
	Temperature sensors	Temperatures around the volcano are measured. A sudden increase suggests an eruption is possible.
	Video cameras	Video cameras detect changes in the volcano and the start of eruptions, lava flows or pyroclastic flows.
	GPS	Satellites can detect the movement of special sensors around volcanoes from space. If the volcano is swelling up, an eruption could occur.
	Tide gauges	Changes in tide level are evidence that the sea bed is swelling, a sign that a nearby volcano may erupt.
	Tilt meters	Meters detect the sides of volcanoes swelling up when magma is rising. Continuous swelling is a sign that an eruption is likely.
Earthquakes and volcanoes	Groundwater levels	Changes in the levels of water in wells or boreholes can be a sign of changes in pressure and increased risk of an eruption or earthquake.

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