Appendix B – Region 1

Country and regional profiles of volcanic hazard and risk:

Mediterranean and West Asia

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This download comprises the profiles for Region 1: Mediterranean and West Asia only. For the full report and all regions see Appendix B Full Download. Page numbers reflect position in the full report. The following countries are profiled here:

Brown, S.K., Sparks, R.S.J., Mee, K., Vye-Brown, C., Ilyinskaya, E., Jenkins, S.F., and Loughlin, S.C. (2015) Country and regional profiles of volcanic hazard and risk. In: S.C. Loughlin, R.S.J. Sparks, S.K. Brown, S.F. Jenkins & C. Vye-Brown (eds) *Global Volcanic Hazards and Risk,* Cambridge: Cambridge University Press.

Region 1: Mediterranean and West Asia

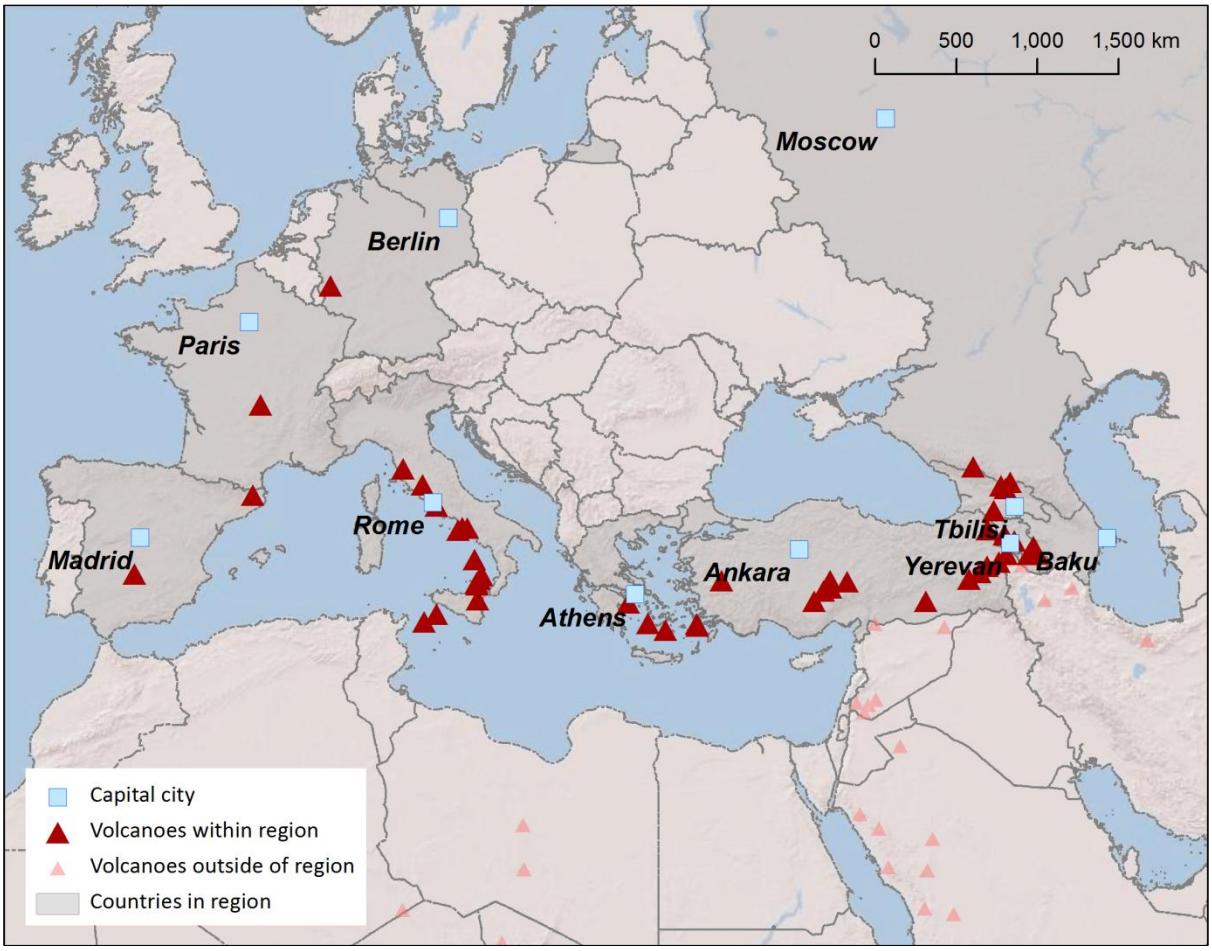

Figure 1.1 The distribution of Holocene volcanoes through the Mediterranean and West Asia region. The capital cities of the constituent countries are shown.

Description

Country	Number of volcanoes
Armenia	5
Azerbaijan	2
France	1
Georgia	4
Germany	1
Greece	5
Italy	14
Russia (see Region 10)	1
Spain	2
Turkey	13

Table 1.1 The countries represented in this region and the number of volcanoes. Volcanoes located on the borders between countries are included in the profiles of all countries involved. Note that countries may be represented in more than one region, as overseas territories may be widespread.

Region 1: The Mediterranean and West Asia comprises volcanoes in ten countries (Table 1.1) from the westernmost Calatrava Volcanic Field in central Spain, to Tskhouk-Karckar on the border of Armenia and Azerbaijan in the east. All of Region 1's volcanoes are included in this regional profile, however for the country profile for Russia see Region 10: Kamchatka and Mainland Asia.

Forty-six volcanoes are located in the Mediterranean and West Asia region. Most of these volcanoes are in Italy. Volcanism here is largely due to the subduction of the African Plate beneath the Eurasian Plate.

A range of volcano morphologies is present throughout this region, however most volcanoes (72%) here are stratovolcanoes and small cones (volcanic fields). A range of rock types are also present, from mafic basalts to felsic rhyolites and a range of alkalis, although the majority of volcanoes (17, 37%) have a dominantly andesitic composition.

As would be expected with such a range of compositions and volcano types, the activity styles throughout the Holocene have varied considerably with eruption magnitudes of VEI 0 to 7 indicating mild activity to very large explosive events. About 60% of eruptions have been small at VEI 0 – 2, however about 9% of eruptions have been large explosive VEI ≥4 events. These VEI ≥4 eruptions have occurred at just five volcanoes in Italy and Greece. 24 of 27 eruptions occurred in Italy, although pyroclastic flows have also occurred in 55 Holocene eruptions throughout France, Spain, Italy, Greece and Turkey. The largest Holocene eruption was the VEI 7 1610 BC Minoan eruption of Santorini in Greece, as recorded in VOTW4.22. This is commonly associated with the downfall of the Minoan civilisation.

Twelve volcanoes have historical records of 220 eruptions, all of which were recorded through direct observations. 92 eruptions (40% of the geological record) were recorded through historical observations prior to 1500 AD, dating back to 1500 BC, demonstrating the effect of a large population on the eruption record. 6% of historical events have involved the production of pyroclastic flows, and 9% have resulted in lahars. Lava flows are recorded in 65% of historical eruptions, one of the highest proportions in all regions.

12% of historical eruptions have resulted in loss of life. The population of this region is high, and most volcanoes have moderate to high local populations. 19 volcanoes (41%) have a high PEI, indicating high local populations. Most classified volcanoes are classed at Risk Level III, however 83% of volcanoes in this region are unclassified with insufficient records to calculate VHI without large uncertainties.

All historical eruptions in this region occurred in Italy, Greece and Turkey. It is these volcanoes where monitoring is focussed by national groups, however not all historically active volcanoes are monitored. The four historically active Risk Level III volcanoes in Italy and Greece are monitored using multi-system monitoring networks.

Volcano facts

Number of Holocene volcanoes	46
Number of Pleistocene volcanoes with M≥4 eruptions	22
Number of volcanoes generating pyroclastic flows	12 (55 eruptions)
Number of volcanoes generating lahars	9 (29 eruptions)
Number of volcanoes generating lava flows	20 (225 eruptions)
Number of eruptions with fatalities	32
Number of fatalities attributed to eruptions	9,294
Largest recorded Pleistocene eruption	The largest Quaternary eruption in region 1 occurred at Vulsini in Italy, with the M7.7 Bolsena eruption of 300 ka.
Largest recorded Holocene eruption	The M6.6 Protohistoric First (AP1) eruption of Vesuvius, Italy at 3.5 ka is the largest recorded Holocene eruption in region 1. The Minoan eruption of Santorini in Greece at 3.56 ka is the second largest eruption in this region during the Holocene, at M6.5.
Number of Holocene eruptions	446 confirmed Holocene eruptions
Recorded Holocene VEI range	0 – 7 and unknown
Number of historically active volcanoes	12
Number of historical eruptions	220

Number of volcanoes	**Primary volcano type**	**Dominant rock type**
4	Caldera(s)	Foiditic (1), Rhyolitic (1), Trachytic/Andesitic (2)
18	Large cone(s)	Andesitic (8), Basaltic (2), Dacitic (3), Phonolitic (1), Rhyolitic (3), Trachytic/Andesitic (1)
4	Lava dome(s)	Andesitic (1), Basaltic (1), Rhyolitic (2)
5	Shield(s)	Andesitic (1), Basaltic (2), Dacitic (1), Rhyolitic (1)
15	Small cone(s)	Andesitic (9), Basaltic (3), Foiditic (1), Unknown (2)
2	Submarine	Basaltic (1), Phonolitic (1)

Table 1.2 The volcano types and dominant rock types of the volcanoes of this region according to VOTW4.0.

Eruption Frequency

VEI	Recurrence Interval (Years)
Small (< VEI 4)	2
Large (> VEI 3)	200

Table 1.3 Average recurrence interval (years between eruptions) for small and large eruptions in the Mediterranean and West Asia.

The eruption record indicates that on average small to moderate sized eruptions of VEI <4 occur in this region with an average recurrence interval (ARI) of about 2 years, whilst the ARI for large eruptions is longer, at about 200 years.

Eruption Size

Eruptions are recorded through the Mediterranean and West Asia region of VEI 0 to 7, representing a range of eruption styles from gentle effusive events, to very large explosive eruptions (Figure 1.2). VEI 2 events dominate the record, with nearly 45% of all Holocene eruptions classed as such. 9% of eruptions here are explosive at VEI ≥4.

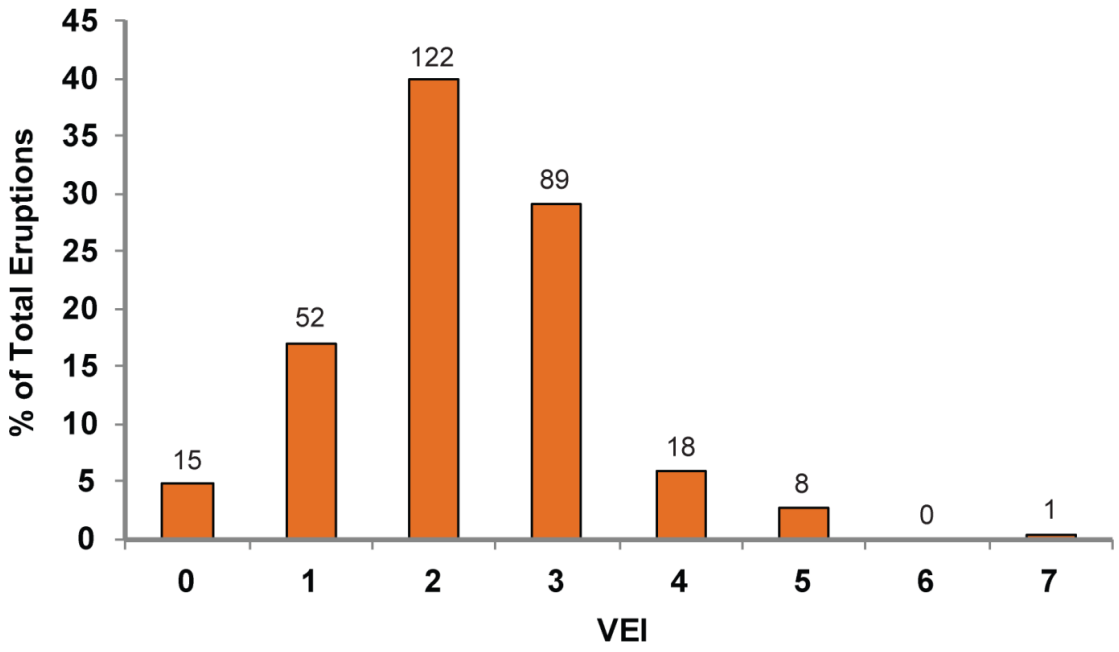

Figure 1.2 Percentage of eruptions in this region recorded at each VEI level; the number of eruptions is also shown. The percentage is of total eruptions with recorded VEI. A further 141 eruptions were recorded with unknown VEI.

Socio-Economic Facts

Total population (2011)	359,039,884
Gross Domestic Product (GDP) per capita (2005 PPP $)	4,826 – 34,437 (Mean 19,249)
Gross National Income (GNI) per capita (2005 PPP $)	5,005 – 35,431

	(Mean 18,970)
Human Development Index (HDI) (2012)	0.722 – 0.920 (High to Very High)

Population Exposure

Number (percentage) of people living within 10 km of a Holocene volcano	2,082,785 (0.58%)
Number (percentage) of people living within 30 km of a Holocene volcano	15,313,847 (4.27%)
Number (percentage) of people living within 100 km of a Holocene volcano	61,703,936 (17.19%)

CLASSIFIED	**Hazard III**				Vulcano; Santorini			Campi Flegrei; Vesuvius
	Hazard II		Nisyros			Etna		
	Hazard I		Ferdinandea	Stromboli				
UNCLASSIFIED	**U – HHR**				Pantelleria; Nemrut Dagi; Tendürek Dagi; Ararat			
	U- HR		Palinuro	Mílos; Elbrus; Kasbek; Porak; Tskhouk-Karckar	Larderello; Methana; Süphan Dagi	Vulsini; Ischia; Lipari; Erciyes Dagi; Dar-Alages	West Eifel Volcanic Field; Calatrava Volcanic Field; Acigöl-Nevsehir	Chaîne des Puys; Ghegam Ridge
	U-NHHR		Yali	**Panarea**; Kabargin Oth Group; Unnamed	Hasan Dagi; Göllü Dag; Karaca Dag; Girekol Tepe; Unnamed; Aragats	Olot Volcanic Field; Kula; Karapinar Field		**Alban Hills**; Kars Plateau
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.4 Identity of the volcanoes in this region in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Population Exposure Index

Number of volcanoes	Population Exposure Index
6	7
3	6
9	5
15	4
9	3
4	2
0	1

Table 1.5 The number of volcanoes in the Mediterranean and West Asia region classed in each PEI category.

Risk Levels

Number of volcanoes	Risk level
4	III
1	II
3	I
38	Unclassified

Table 1.6 The number of volcanoes in the Mediterranean and West Asia region classified at each risk level.

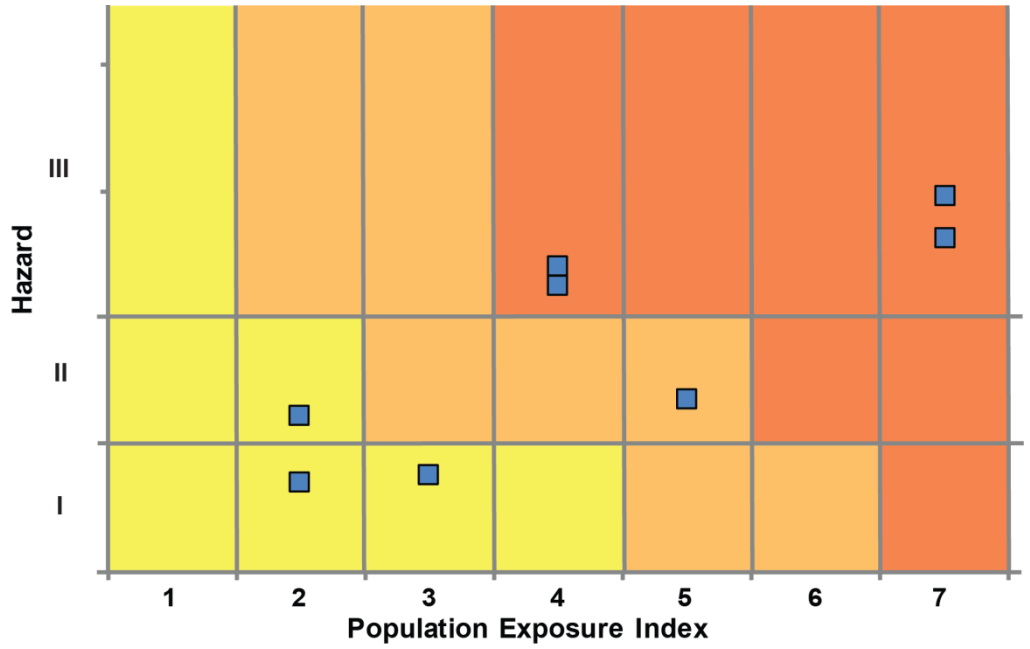

Figure 1.3 Distribution of the classified volcanoes of this region across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing risk levels from Risk Level I - III.

Regional Monitoring Capacity

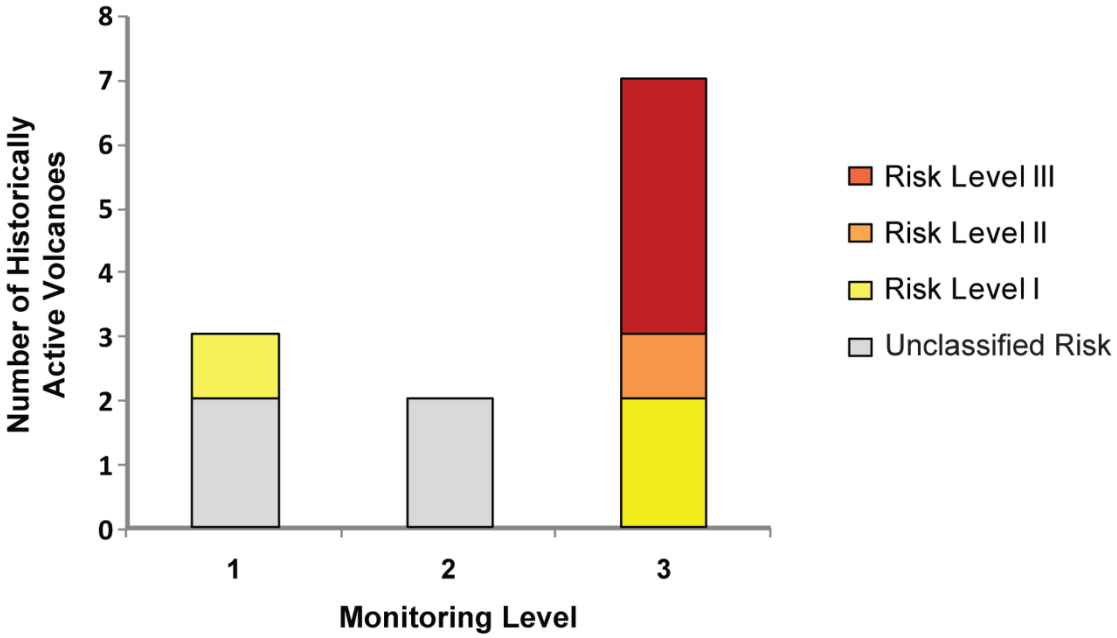

Figure 1.4 The monitoring and risk levels of the historically active volcanoes in the Mediterranean and West Asia. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Armenia

Description

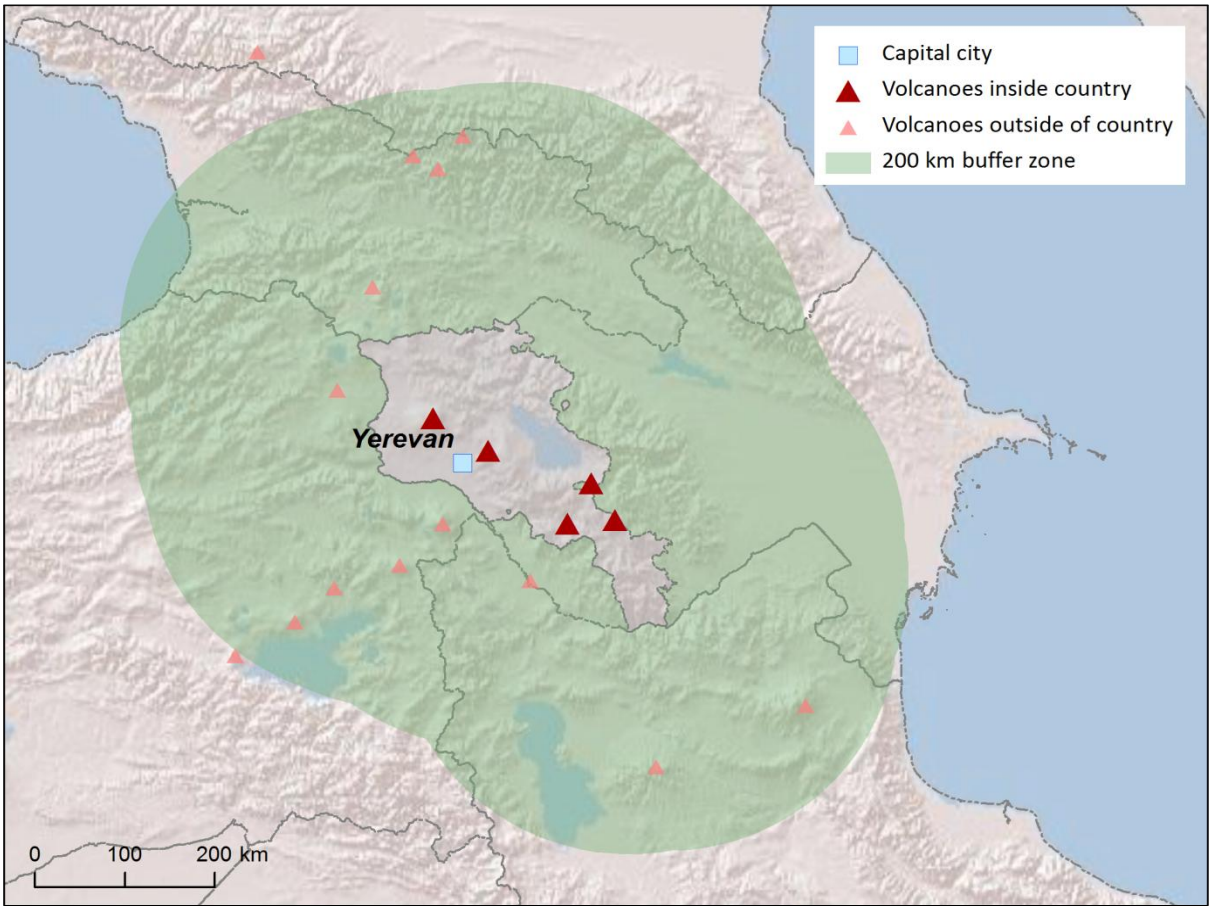

Figure 1.5 Location of Armenia's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Armenia.

Armenia is situated in a region of copious Quaternary-Holocene-Historical volcanism. Yerevan, the capital of Armenia, a city with a population of more than 1 million people, is located between three volcanic systems – Aragats stratovolcano, Ghegam volcanic upland and Ararat stratovolcano in eastern Turkey (just 40 km from the southern suburbs of Yerevan). There are three Holocene volcanoes or groups of volcanoes located wholly in Armenia: Dar-Alages (Vayots-Sar), Smbatasar and other monogenetic centres of Ghegam volcanic ridge and Aragats. Aragats stratovolcano is one of the largest stratovolcanoes in the entire region, and produced central vent (including Plinian eruptions) and monogenetic flank eruptions. Aragats is included here as it is considered in VOTW4.0, however, recent research and K-Ar and Ar-Ar dating indicates that the latest flank and summit activity is mid-Pleistocene at 0.48 - 0.52 Ma (Meliksetian et al. 2014). A further two volcanoes are located on the border: Porak (a group of cones and fissures) and Tskhouk-Karckar (a group of 8 cinder cones).

The volcanism in Armenia is associated with the ongoing collision of the Eurasian and Arabian tectonic plates. Volcano locations are closely linked to major fault locations and small pull-apart basins related to regional tectonic movements. Holocene volcanoes comprise trachyandesite to

basaltic trachyandesitic cinder cones (Tskhouk-Karckar group on Syunik volcanic upland, Dar-Alages (Vayots-Sar), Smbatasar, Porak on Vardenis volcanic upland), a volcanic field (Ghegam Ridge comprising 127 Quaternary cinder cones, some of which are presumably Holocene in age, as Holocene lava flows exist within Ghegham volcanic upland) and the stratovolcano Aragats.

With the exception of Aragats, all of the above listed volcanoes have recorded Holocene eruptions of Strombolian type producing lava flows. The dominant formation of cinder cones suggests that explosive volcanic activity. Fatalities and property damage were reported for the explosive 778 BC eruption of Porak and reports exist of evacuations during the 3000 BC eruption of Tskhouk-Karckar.

Of Armenia's population, more than 99% (nearly 3 million people) live within 100 km of the five Holocene volcanoes. The capital, Yerevan, lies just 23 km from Ghegam Ridge volcanic upland. The 100 km radii of these volcanoes also extend into the surrounding countries of Iran, Turkey, Georgia and Azerbaijan.

No eruptions are recorded since AD 1500 and there is no current knowledge of active volcano monitoring in Armenia. There is however an extensive National Observation Network of seismometers used for monitoring earthquake activity by the Armenian National Survey for Seismic Protection (NSSP).

The Asian Disaster Reduction Center (ADRC) produced a report on the hazards in Armenia in 2012, with a further six such reports dating back to 2001. In this they do not consider volcanic hazards, but list earthquakes as the most common disasters in Armenia. They describe how Armenia has moved from a system of 'reactive relief' efforts to proactive risk reduction, particularly in relation to the seismic hazard. The Ministry of Emergency Situations (MES-Armenia) are described by the ADRC as having developed a national disaster risk reduction strategy based on the Hyogo Framework for Action, and are responsible for national level disaster management. MES-Armenia, however, again do not consider volcanic hazards except for describing these as a potential cause of landslides.

See also:

Armenian National Survey for Seismic Protection: www.nssp-gov.am/index_eng.htm

Ministry of Emergency Situations: www.mes.am/en/

Asian Disaster Reduction Center: Armenia:
www.adrc.asia/nationinformation.php?NationCode=51&Lang=en&NationNum=01

Connor, L.J., Connor, C.B., Meliksetian, K.H. and Savov, I. (2012) A probabilistic approach to modelling lava flow inundation. Lava flow hazard assessment for a nuclear facility in Armenia. Journal of Applied Volcanology, 1:3.

Meliksetian, K. et al. (2014) Aragats stratovolcano in Armenia – volcano-stratigraphy and petrology, Geophysical Research Abstracts, Vol. 16, EGU2014-567-2.

Volcano Facts

Number of Holocene volcanoes (or volcano groups)	5, inclusive of two on the border
Number of Pleistocene volcanoes with M ≥4 eruptions	None are currently listed in LaMEVE, however large magnitude eruptions are indicated by the presence of large volume ignimbrites
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	4
Number of fatalities caused by volcanic eruptions	Unknown number of fatalities
Tectonic setting	Intra-plate (Post-Collisional)
Largest recorded Pleistocene eruption:	-
Largest recorded Holocene eruption	One eruption of VEI 0. Remainder are unknown
Number of Holocene eruptions	5 confirmed eruptions; 2 uncertain eruptions
Recorded Holocene VEI range	Unknown – 0
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
2	Large cone(s)	Andesitic (2)
3	Small cone(s)	Andesitic (3)

Table 1.7 The number of volcanoes in Armenia, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	2,969,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	5,112
Gross National Income (GNI) per capita (2005 PPP $)	5,540
Human Development Index (HDI) (2012)	0.729 (High)

Population Exposure

Capital city	Yerevan
Distance from capital city to nearest Holocene volcano	23.7 km
Total population (2011)	2,967,975
Number (percentage) of people living within 10 km of a Holocene volcano	31,897 (1.1%)
Number (percentage) of people living within 30 km of a Holocene volcano	1,482,611 (50%)
Number (percentage) of people living within 100 km of a Holocene volcano	2,942,003 (99.1%)

Largest cities, as measured by population and their population size:

Yerevan	1,093,485
Gyumri	121,976

Infrastructure Exposure

Number of airports within 100 km of a volcano	3
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	2,301
Total length of railroads within 100 km of a volcano	206

The volcanoes in Armenia are widespread across the country, which measures less than 400 km across, thus, with the exception of a very small area in the north-east, the country in its entirety lies within 100 km of Holocene volcanoes. This places all critical infrastructure including airports and an extensive road and rail network within 100 km of volcanoes. The capital, Yerevan, lies just 23 km from Ghegham Ridge volcano and within 60 km of Ararat, a large stratovolcano in Turkey. The Armenian nuclear power plant (ANPP) is also exposed and volcanic hazard here was quantitatively assessed according to the IAEA SSG-21 safety guide. This report, by Connor, Connor, Meliksetian , Savov and Halama is due for publication soon. Connor et al. (2012) conducted a lava flow hazard analysis for the ANPP and found that lavas from Aragats would be diverted, but that lavas from the Shamiram Plateau could inundate the site, giving an annual probability of approximately 1.0×10^{-7} to 8.8×10^{-7} considering the low recurrence rate of volcanism.

The 100 km radii of the volcanoes in Armenia also extend into the surrounding countries of Iran, Turkey, Georgia and Azerbaijan.

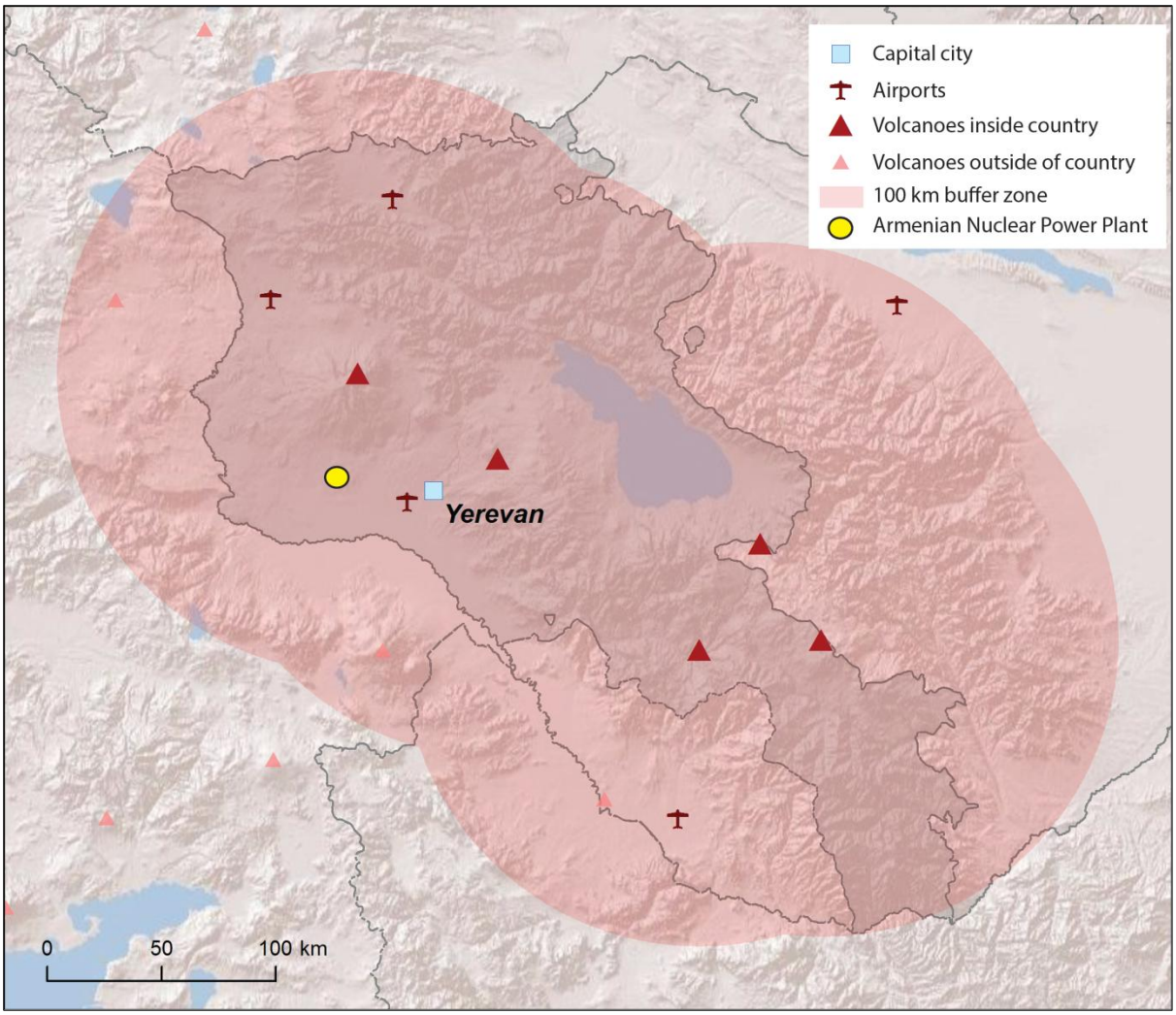

Figure 1.6 The location of Armenia's volcanoes and the extent of the 100 km zone surrounding them. Airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

No volcanoes in Armenia have eruption records comprising sufficient data (four or more eruptions of known size) for hazard classification. These are therefore unclassified. Of these volcanoes, none have records of unrest above background levels or eruption since 1900, and none have historical (post-1500 AD) eruptions recorded. Aragats volcano has no Holocene eruption record, with recent research indicating the most recent activity here was mid-Pleistocene in age.

The PEI in Armenia ranges from PEI 3 to PEI 7, indicative of moderate to large population sizes in close proximity to the volcanoes. Ghegam Ridge in west-central Armenia lies within 30 km of Yerevan, the nation's capital, and thus has a very high proximal population.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR			Porak; Tskhouk-Karckar		Dar-Alages		Ghegam Ridge
	U-NHHR				Aragats			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.8 Identity of Armenia's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified'(top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption. Note that recent research indicates that most recent activity of Aragats was mid-Pleistocene in age.*

National Capacity for Coping with Volcanic Risk

Four volcanoes in Armenia have evidence of Holocene eruptions but no eruptions are reported in the historical record. No regular ground-based monitoring is undertaken at any Holocene volcanoes in Armenia, however some work to study volcanic hazards and minor seismicity in volcanic regions is being undertaken by the Institute of Geological Sciences of the Armenian National Academy of Sciences.

Azerbaijan

Description

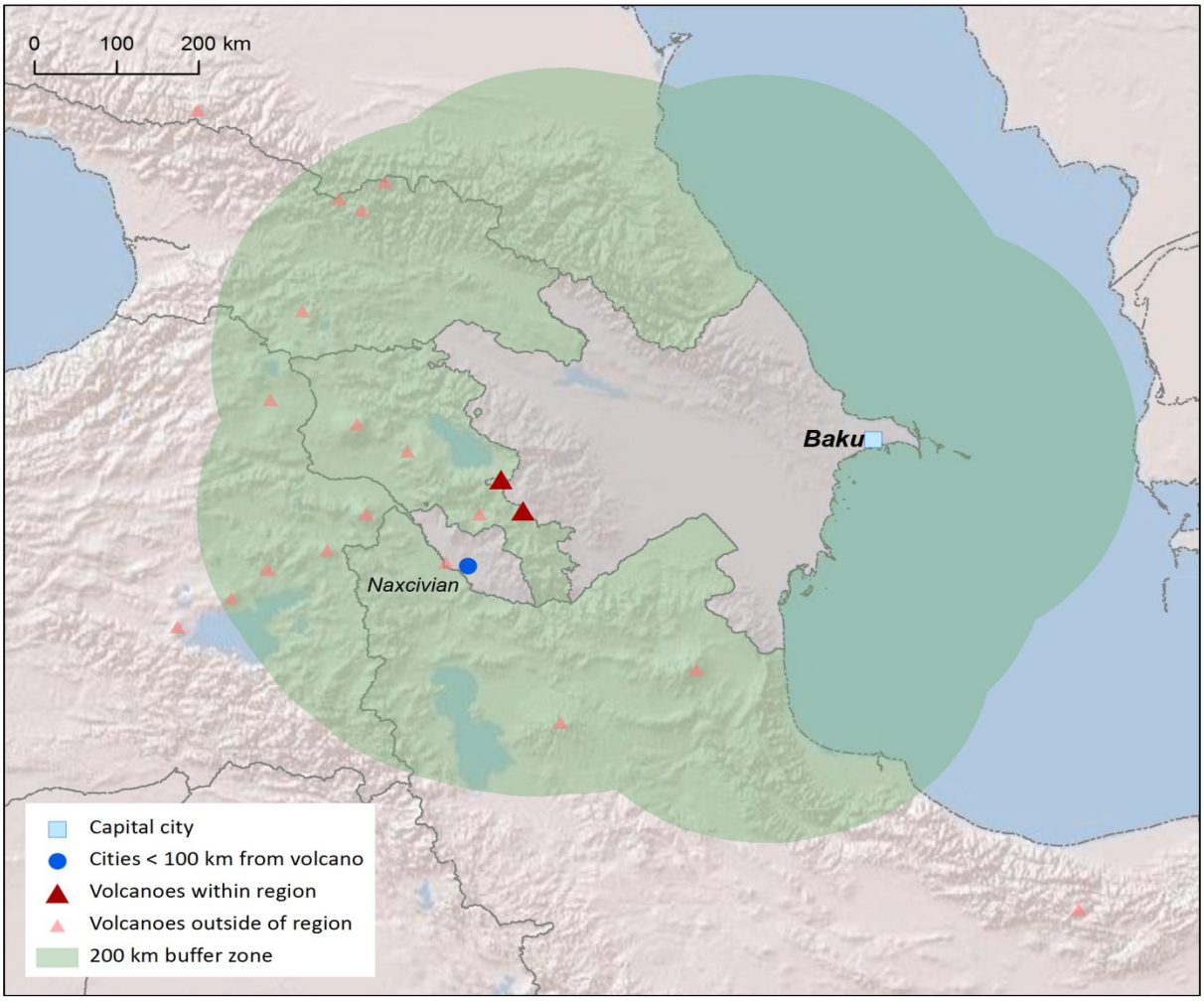

Figure 1.7 Location of Azerbaijan's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Azerbaijan.

There are two Holocene volcanoes partly located in Azerbaijan: Porak and Tskhouk-Karckar, which are also on the border with Armenia (Figure 1.7). These volcanoes are associated with the ongoing collision of the Eurasian, Arabian and African tectonic plates and their locations are closely linked to major fault locations. Porak is a stratocone and Tskhouk-Karckar a pyroclastic cone. Both produce andesite to basaltic andesite.

Both volcanoes have eruptions recorded in the Holocene: Porak in ~4510 BC and ~778 BC, with an uncertain eruption in ~740 BC, and Tskhouk-Karckar in ~3000 BC. The eruptions produced lava flows and are also described as explosive. There are no records for eruption size. Fatalities and property damage were reported for the explosive 778 BC eruption of Porak and reports exist of evacuations during the 3000 BC eruption of Tskhouk-Karckar.

The capital of Azerbaijan lies nearly 300 km to the east of the volcanoes, however a large city, Naxcivian, lies less than 100 km southwest of Tskhouk-Karckar. Just over 20% of Azerbaijan's population (more than 2 million people) live within 100 km of these Holocene volcanoes and the 100 km radii extends into the surrounding countries of Armenia and Iran.

No eruptions are recorded since AD 1500 and there is no current knowledge of active volcano monitoring in Azerbaijan. There is however an extensive national network of seismometers used for monitoring earthquake activity by the Azerbaijan National Academy of Sciences – Republican Seismological Service Centre.

The Asian Disaster Reduction Center (ADRC) produced a report on the hazards in Azerbaijan in 2011. In this they do not consider volcanic hazards, with the exception of mud volcanoes. They describe how there are over 220 mud volcanoes throughout the country and offshore, and these have had eruptions of mud and gas explosions and related fires. The Ministry of Emergency Situations for the Republic of Azerbaijan (MES-Azerbaijan) are described by the ADRC as the organisation responsible for emergency planning and are addressing the Hyogo Framework for Action (HFA).

See also:

Asian Disaster Reduction Center: Azerbaijan: www.adrc.asia/nationinformation.php?NationCode=31&Lang=en&NationNum=35

Ministry for Emergency Situations: www.fhn.gov.az/

Republic Seismic Survey Centre: www.seismology.az

Volcano Facts

Number of Holocene volcanoes	3, inclusive of two on the border with Armenia and one on the border with Iran
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	2
Number of fatalities caused by volcanic eruptions	Fatalities?
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	
Largest recorded Holocene eruption	All eruptions recorded are of unknown VEI
Number of Holocene eruptions	3 confirmed eruptions; 1 uncertain eruption

Recorded Holocene VEI range	Unknown
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
1	Large cone(s)	Andesitic (1)
2	Small cone(s)	Andesitic (1), Unknown (1)

Table 1.9 The number of volcanoes in Azerbaijan, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	9,316,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	8,890
Gross National Income (GNI) per capita (2005 PPP $)	8,153
Human Development Index (HDI) (2012)	0.734 (High)

Population Exposure

Capital city	Baku
Distance from capital city to nearest Holocene volcano	290.6 km
Total population (2011)	9,397,279
Number (percentage) of people living within 10 km of a Holocene volcano	5,975 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	251,943 (2.7%)
Number (percentage) of people living within 100 km of a Holocene volcano	2,068,272 (22%)

Largest cities, as measured by population and their population size:

Baku	1,116,513
Naxcivian	64,754

Infrastructure Exposure

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	2,107
Total length of railroads within 100 km of a volcano (km)	95

The volcanoes of Azerbaijan are located on the western border with Armenia. The 100 km radii of these volcanoes therefore extend into Armenia and Iran. The capital, Baku, lies nearly 300 km to the east, however one of the largest cities in Azerbaijan, Naxcivian, lies within the 100 km radii, exposing significant infrastructure here including an extensive road network and airports. Being inland volcanoes, no ports are exposed.

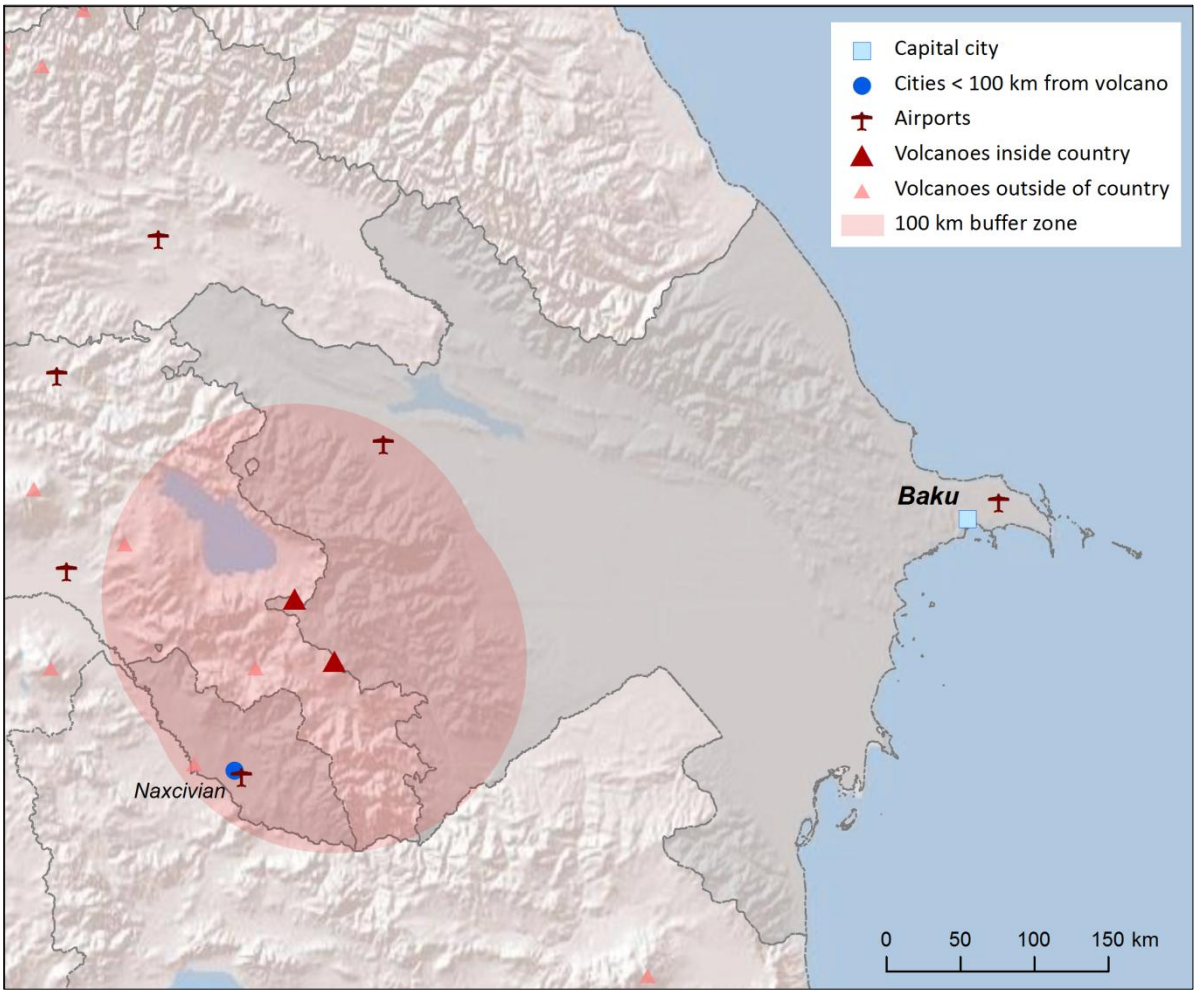

Figure 1.8 The location of Azerbaijan's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

The volcanoes of Azerbaijan have insufficient numbers of eruptions in their eruptive records to classify the hazard without large uncertainties. Therefore, the volcanoes here are unclassified. No volcanoes have post-1500 AD eruptions or post-1900 AD unrest above background levels recorded, and the Unnamed volcano has no Holocene eruptions recorded at all.

With no hazard levels attributed, the risk cannot be derived. However, the PEI indicates moderate to large local populations, with the Unnamed lava field on the border of Azerbaijan-Iran lying about 20 km from the city of Nakhchivan, of population around 75,000.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR			Porak; Tskhouk-Karckar				
	U- NHHR					Unnamed		
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.10 Identity of Azerbaijan's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

No volcanoes in Azerbaijan have recorded historical eruptions, although there are records of Holocene activity. No information is available at the time of the writing of this report to indicate that regular ground-based monitoring is undertaken at any Holocene volcanoes in Azerbaijan.

France – Mainland

Description

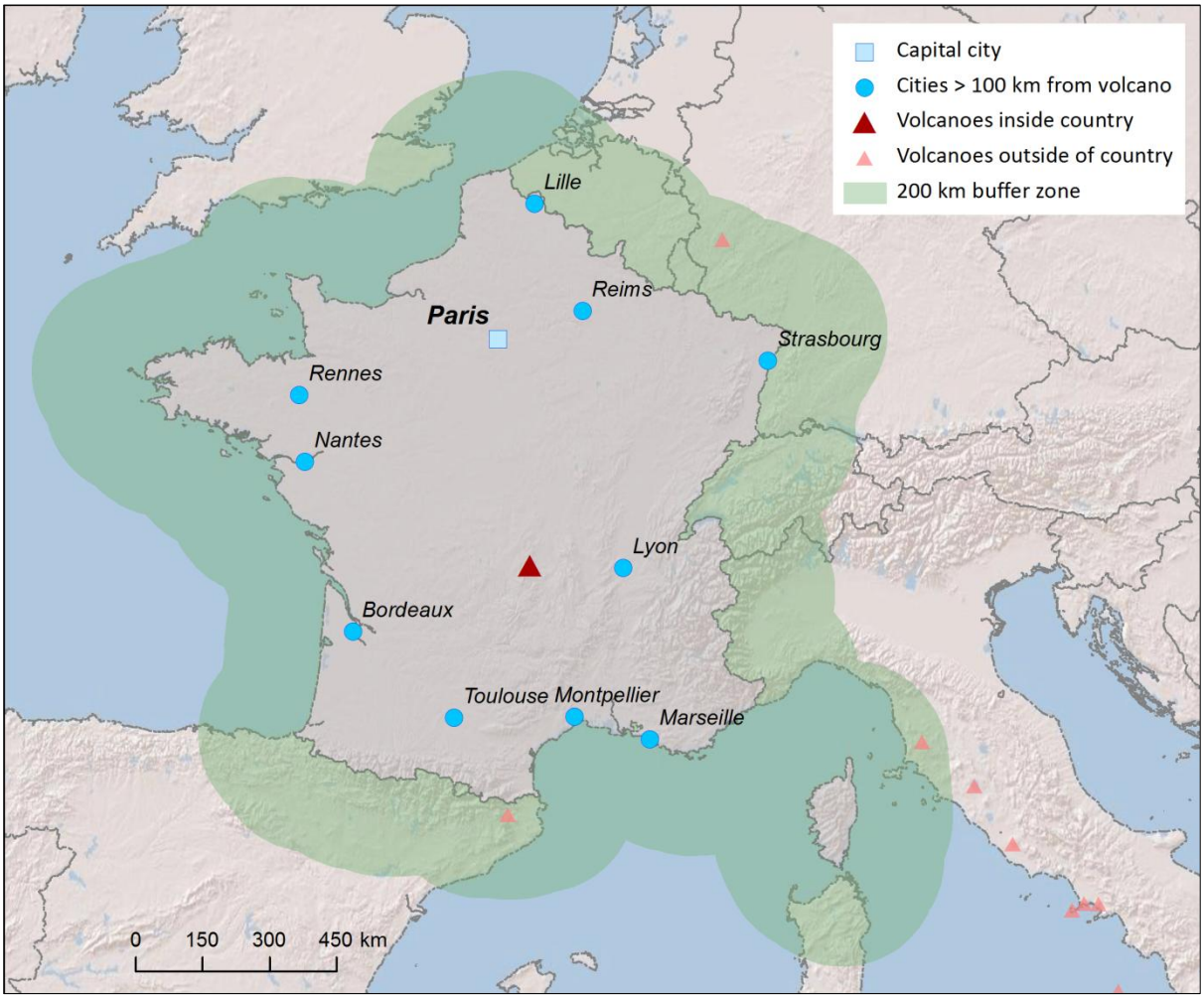

Figure 1.9 Location of Mainland France's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect France.

Only one Holocene volcano is located in mainland France: the Chaîne des Puys volcano in central France. The Chaîne des Puys form an ~40 km N-S trending chain of monogenetic basaltic and trachytic cinder cones, basaltic maars, and trachytic lava domes. The chain is ~ 4 km wide and runs parallel to the Limagne fault; volcanism is related to a rift zone. Construction of the present-day Chaîne des Puys began about 70,000 years ago, and was largely complete by the beginning of the Holocene.

There are eight recorded eruptions in the Holocene but no eruption sizes are recorded. A M4 eruption was recorded prior to the Holocene at about 14,000 years ago. Construction of Holocene lava domes has been accompanied by pyroclastic flows and the formation of explosion craters (maars) and cinder cones that fed lengthy lava flows. The most recent eruption (~4040 BC) included

powerful explosions and the formation of the Lac Pavin maar. The dating of younger tephras has not yet been confirmed, and reports of historical eruptions as late as 1000 years before present have been discredited.

Chaîne des Puys lies nearly 350 km to the south of the capital, Paris, and more than 100 km from the major cities of mainland France. However, nearly two million people (3% of mainland France's population) live within 100 km, including the city of Clermont-Ferrand, an extensive road and rail network and two airports.

Volcano Facts

Number of Holocene volcanoes	1 in mainland France
Number of Pleistocene volcanoes with M≥4 eruptions	1
Number of volcanoes generating pyroclastic flows	1
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	1
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Rift zone
Largest recorded Pleistocene eruption	The M4 eruption of Les Roches Tephra at Chaîne des Puys at 13,872 BP
Largest recorded Holocene eruption	All recorded eruptions were of unknown VEI
Number of Holocene eruptions	8 confirmed eruptions
Recorded Holocene VEI range	0
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
1	Lava dome(s)	Basaltic (1)

Table 1.11 The number of volcanoes in Mainland France, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	63,933,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	29,819
Gross National Income (GNI) per capita (2005 PPP $)	30,277
Human Development Index (HDI) (2012)	0.893 (Very High)

Population Exposure

Capital city	Paris
Distance from capital city to nearest Holocene volcano	347.5 km
Total population (2011)	63,299,650
Number (percentage) of people living within 10 km of a Holocene volcano	52,764 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	427,957 (<1%)
Number (percentage) of people living within 100 km of a Holocene volcano	1,864,864 (3%)

Ten largest cities, as measured by population and their population size (2012):

Paris	2,138,551
Marseille	794,811
Lyon	472,317
Toulouse	433,055
Nantes	277,269
Strasbourg	274,845
Montpellier	248,252
Bordeaux	231,844
Lille	228,328
Rennes	209,375

Infrastructure Exposure

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	2,747
Total length of railroads within 100 km of a volcano (km)	546

Chaine des Puys volcano is located in the Auvergne region of central France, distal to the capital, Paris, which lies nearly 350 km to the north, and the other largest cities in France. However, the city of Clermont-Ferrand lies within 10 km, exposing significant infrastructure here, including an extensive road and rail network and two airports.

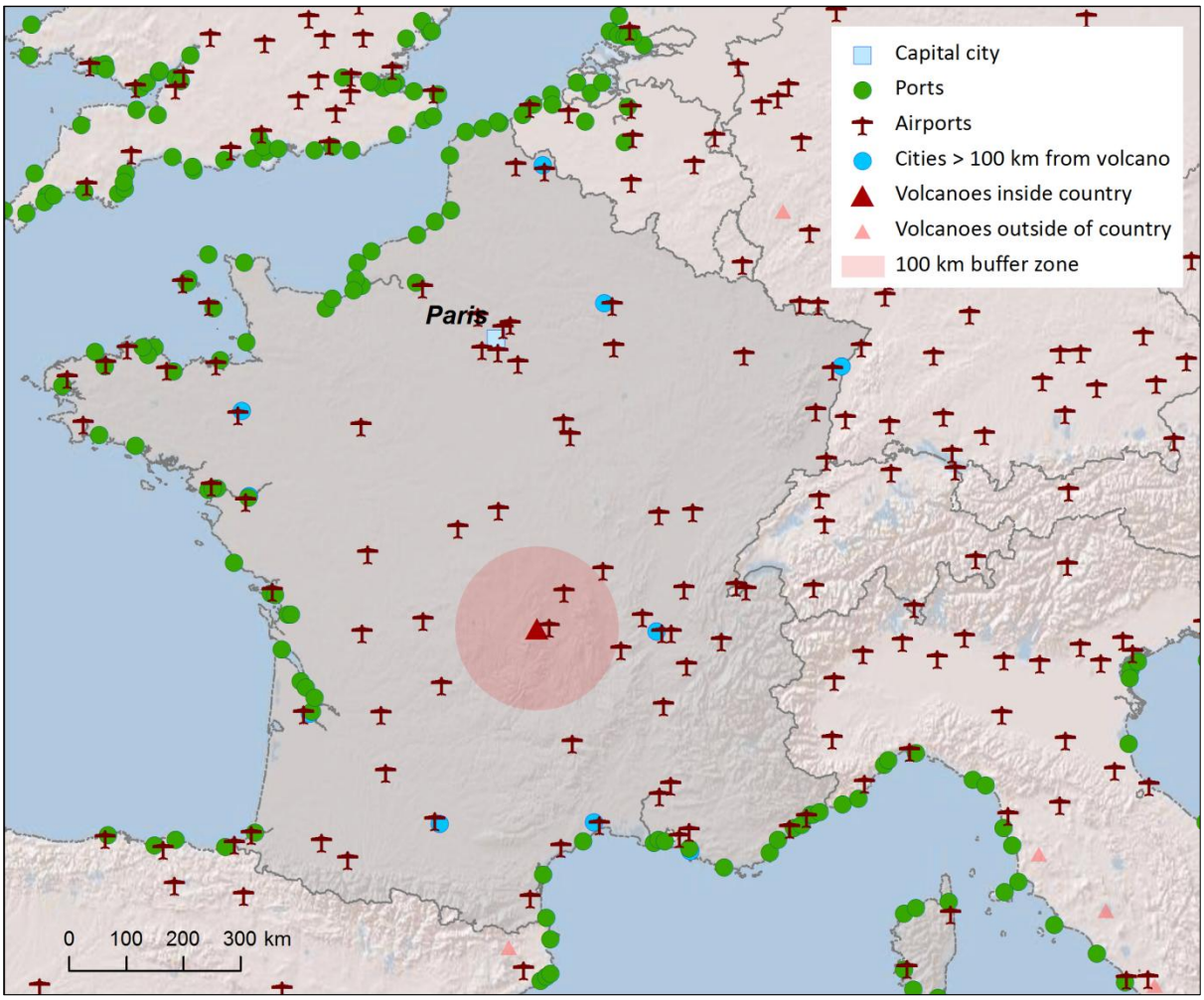

Figure 1.10 The location of Mainland France's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

The Chaine des Puys volcano has eight confirmed Holocene eruptions in the VOTW4.22 record, however as none of these has an attributed size the hazard level cannot be determined and this volcano is therefore unclassified.

Although the hazard level is undetermined which means risk cannot be constrained, this volcano classifies with the highest PEI of 7, with a high local population including the city of Clermont-Ferrand lying within 10 km. This high population would indicate a high level of risk even if the hazard is low.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR							Chaîne des Puys
	U- NHHR							
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.12 Identity of Mainland France's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

The Chaîne des Puys volcanoes have had eight recorded Holocene eruptions but no recorded historical eruptions. Continuous seismic monitoring is undertaken in the region, by the Observatoire de Physique du Globe de Clermont-Ferrand.

Georgia

Description

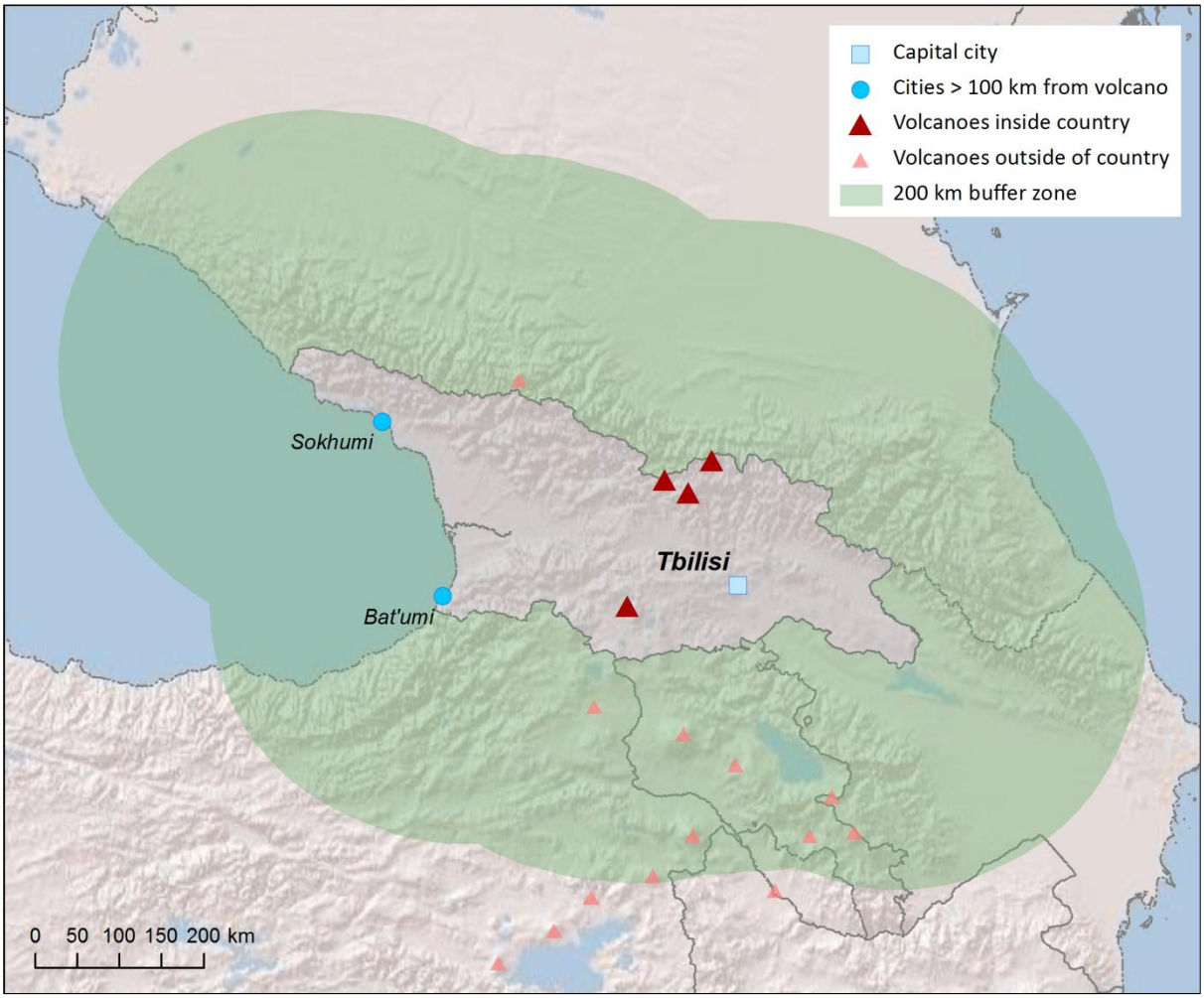

Figure 1.11 Location of Georgia's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Georgia.

Four Holocene volcanoes are located in Georgia: Kasbek, the Karbargin Oth Group, an unnamed volcano in the north of the country, and a further unnamed volcano in the south. Georgia is located on the Eurasian Plate near the collision zone between the Eurasian, Arabic and Anatolian Plates, however the volcanism here is described as intra-plate. These volcanoes comprise andesitic cinder and lava cones, in addition to the andesitic stratovolcano, Kasbek.

Although all four volcanoes are suspected to have had Holocene age activity, only Kasbek has recorded Holocene eruptions. The size of these eruptions is unknown however lava flows are recorded from one eruption. No historical eruptions are recorded. The absence of a detailed eruption history for the volcanoes in Georgia makes assessment of hazard difficult and associated with large uncertainties.

A small population resides within 10 km of the volcanoes in Georgia, however nearly 40% of the population live within 100 km of one or more Holocene volcanoes. The 100 km radii of the Georgian volcanoes extend beyond the country's borders into Russia, Armenia and Turkey.

Volcano Facts

Number of Holocene volcanoes	4
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	1
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	Unknown
Number of Holocene eruptions	2 confirmed eruptions
Recorded Holocene VEI range	Both are of unknown VEI
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
1	Large cone(s)	Andesitic (1)
3	Small cone(s)	Andesitic (3)

Table 1.13 The number of volcanoes in Georgia, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	4,358,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	4,826
Gross National Income (GNI) per capita (2005 PPP $)	5,005
Human Development Index (HDI) (2012)	0.745 (High)

Population Exposure

Capital city	Tbilisi
Distance from capital city to nearest Holocene volcano	92.2 km
Total population (2011)	4,585,874
Number (percentage) of people living within 10 km of a Holocene volcano	7,896 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	96,329 (2.1%)
Number (percentage) of people living within 100 km of a Holocene volcano	1,831,569 (39.9%)

Largest cities, as measured by population and their population size:

T'Bilisi	1,049,498
Bat'umi	121,806
Sokhumi	81,546

Infrastructure Exposure

Number of airports within 100 km of a volcano	0
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	1,646
Total length of railroads within 100 km of a volcano (km)	294

The volcanoes in Georgia are distributed to the north and south of the country, where they are located near the borders; their 100 km radii therefore extend into Russia, Armenia and Turkey. There are no airports located within the 100 km radii in Georgia itself, however three airports beyond its borders are exposed. The capital of Georgia, Tbilisi, lies at just over 90 km from the nearest Holocene volcano (an unnamed volcano in the north), exposing significant critical infrastructure, including an extensive road and rail network.

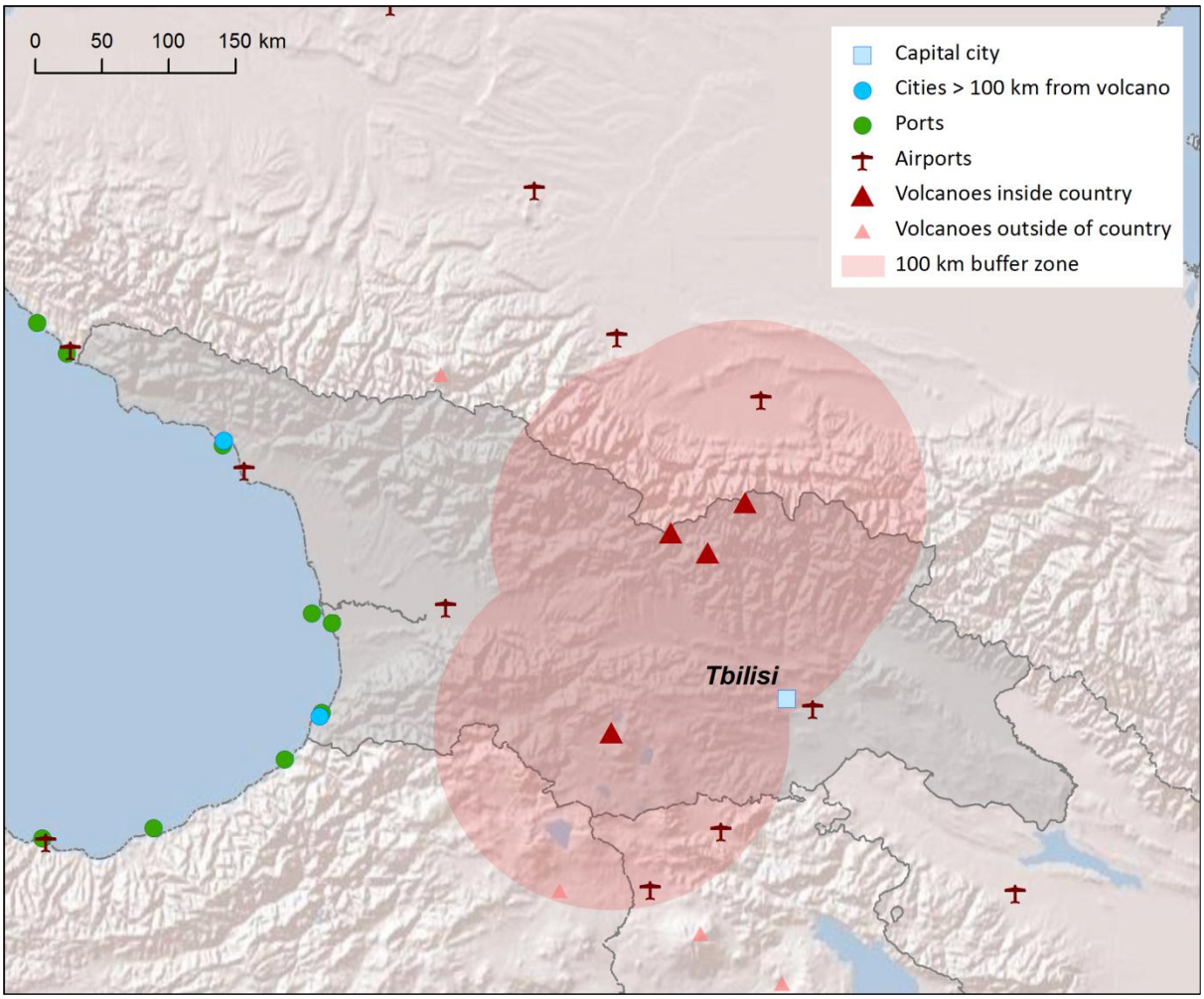

Figure 1.12 The location of Georgia's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

Of the four Georgian volcanoes, only Kasbek has a Holocene record of confirmed eruptions, and these events were of unknown size. No historical eruptions or post-1900 AD unrest above background levels are recorded at any volcanoes. The absence of a detailed eruptive history means that the hazard levels at these volcanoes cannot be determined without large uncertainties and these volcanoes are therefore unclassified. The risk levels therefore cannot be derived, though from the PEI (of 3 to 4), moderate local populations are indicated.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR			Kasbek				
	U-NHHR			Kabargin Oth Group; Unnamed	Unnamed			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.14 Identity of Georgia's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

No volcanoes in Georgia have recorded historical eruptions and no information is available at the time of the writing of this report to indicate that regular ground-based monitoring is undertaken at any Holocene volcanoes in Georgia.

Germany

Description

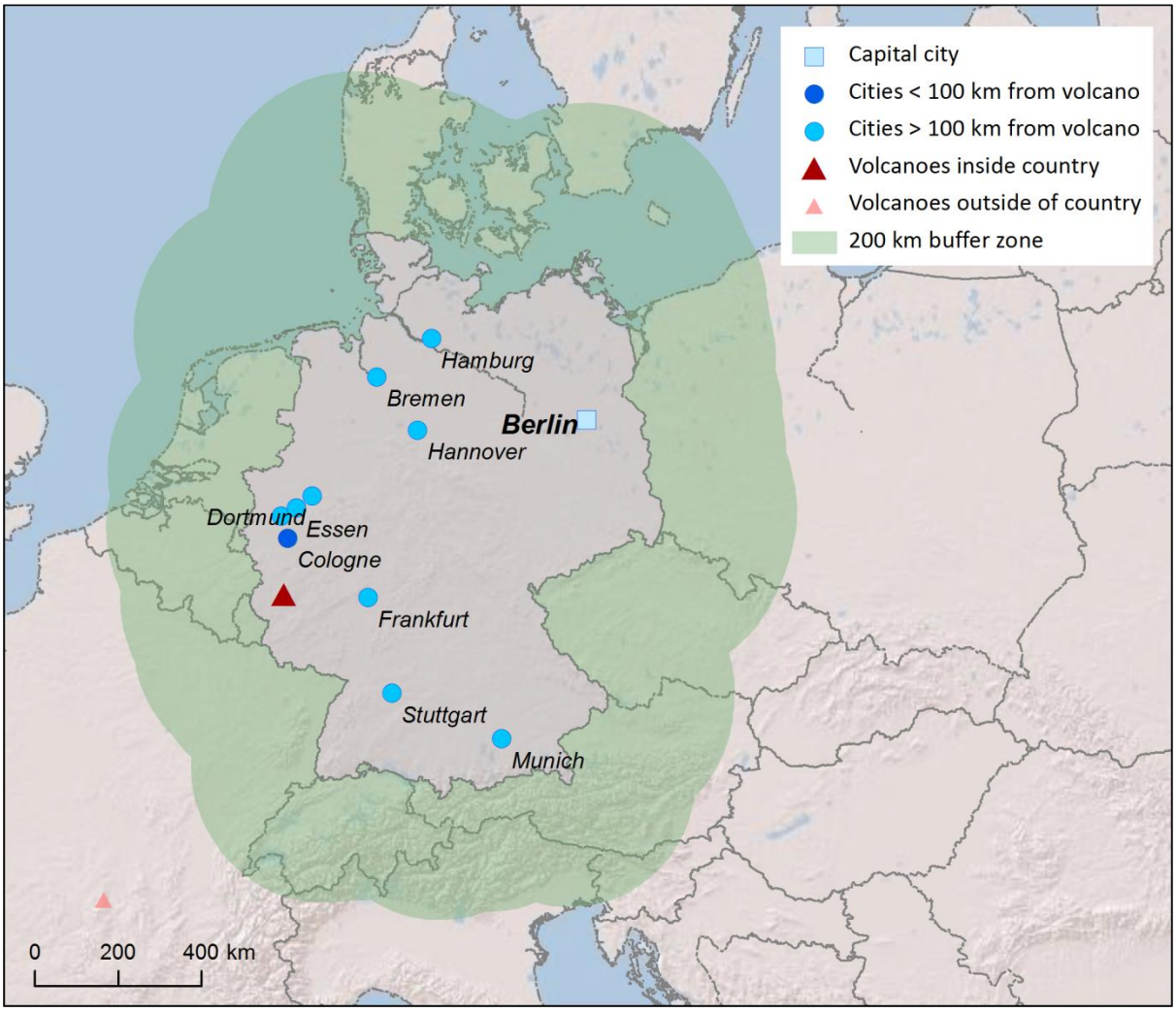

Figure 1.13 Location of Germany's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Germany.

One volcano of Holocene age is recorded in Germany: the West Eifel Volcanic Field. This volcano is located in the west of Germany, near the border with Luxembourg, Belgium and France. Volcanism here is related to a rift zone.

The West Eifel Volcanic Field covers an area of about 600 square kilometres and comprises multiple scoria cones, maars and small stratovolcanoes, indicating that monogenetic activity has been a common feature here.

Just two confirmed eruptions are recorded here, with no eruptions recorded since 8300 BC. The size of the eruptions is unknown, however many of the cones have associated lavas and the formation of these volcanic centres indicates moderate localised explosive activity. The calculation of the hazard at West Eifel is associated with large uncertainties due to the sparse nature of the eruptive record.

Multiple small towns are located close to this volcanic field and several large cities are located within 100 km, with over 4.7 million people residing within this distance. Were eruptions of monogenetic vents to occur forming similar small lava flows and cones, these would likely have dominantly a localised effect, with more explosive events required to extend to the distal populations.

A Pleistocene eruption is recorded at the East Eifel Volcanic Field, approximately 40 km SW of the West Eifel Volcanic Field. No Holocene activity is recorded in the East Eifel Volcanic Field. The eruption of the Laacher See Tephra at nearly 13,000 years ago was a large explosive eruption of magnitude 6.2.

Volcano Facts

Number of Holocene volcanoes	1
Number of Pleistocene volcanoes with M≥4 eruptions	1
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	-
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Rift zone
Largest recorded Pleistocene eruption	The M6.2 eruption of the Laacher See Tephra at 12,916 BP at the East Eifel Volcanic Field
Largest recorded Holocene eruption	Both eruptions were of Unknown VEI
Number of Holocene eruptions	2 confirmed eruptions
Recorded Holocene VEI range	Unknown
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
1	Small cone(s)	Foiditic (1)

Table 1.15 The number of volcanoes in Germany, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	82,760,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	34,437
Gross National Income (GNI) per capita (2005 PPP $)	35,431
Human Development Index (HDI) (2012)	0.920 (Very High)

Population Exposure

Capital city	Berlin
Distance from capital city to nearest Holocene volcano	523.1 km
Total population (2011)	81,471,834
Number (percentage) of people living within 10 km of a Holocene volcano	16,787 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	187,351 (<1%)
Number (percentage) of people living within 100 km of a Holocene volcano	4,720,394 (5.8%)

Ten largest cities, as measured by population and their population size:

Berlin	3,426,354
Hamburg	1,739,117
Munich	1,260,391
Cologne	963,395
Frankfurt	650,000
Essen	593,085
Stuttgart	589,793
Dortmund	588,462
Dusseldorf	573,057
Bremen	546,501

Infrastructure Exposure

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	5,596
Total length of railroads within 100 km of a volcano (km)	378

The West Eifel Volcanic Field is located in the west of Germany. Here the 100 km radius extends beyond Germany's borders, into Luxembourg, Belgium and France. The major city of Cologne is within 100 km and several major cities lie just beyond this radius. Two airports in Germany are located within the 100 km radius, as is Luxembourg airport. Luxembourg in its entirety is located in this radius, exposing all critical infrastructure here. Many towns and cities are exposed within the radius in Germany, as is an extensive road and rail network.

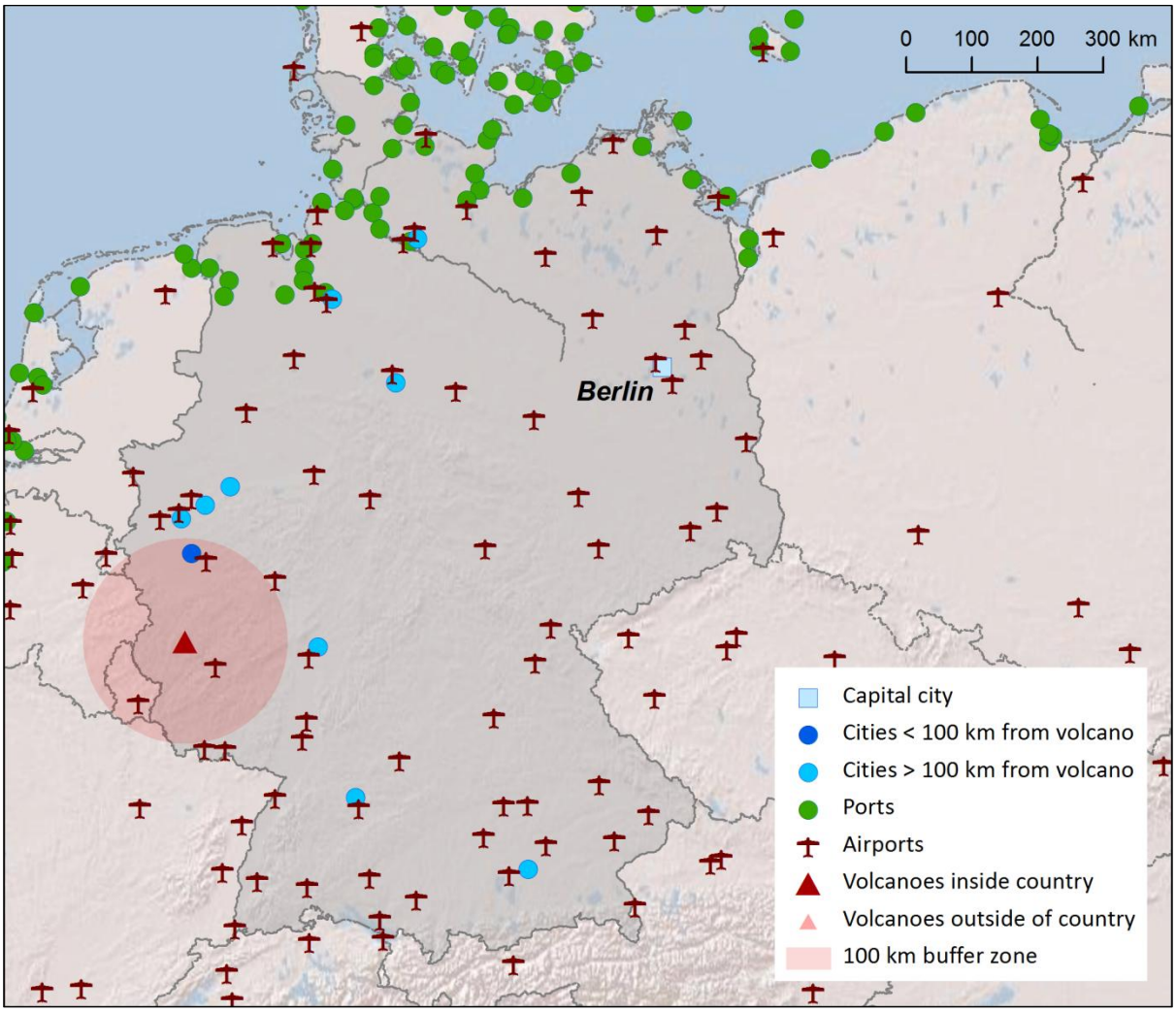

Figure 1.14 The location of Germany's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

The West Eifel Volcanic Field has two confirmed eruptions recorded during the Holocene, both of unknown size. The hazard level cannot therefore be determined for this volcano without significant uncertainties, and this is therefore unclassified.

There are multiple small towns located in close proximity to this volcano and several large cities within 100 km distance. The resulting high PEI would indicate that this would classify as a Risk Level II to III volcano dependent on the hazard level.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR						West Eifel Volcanic Field	
	U- NHHR							
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.16 Identity of Germany's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

No volcanoes in Germany have recorded historical eruptions and no information is available at the time of the writing of this report to indicate that regular ground-based monitoring is undertaken at any Holocene volcanoes in Germany.

Greece

Description

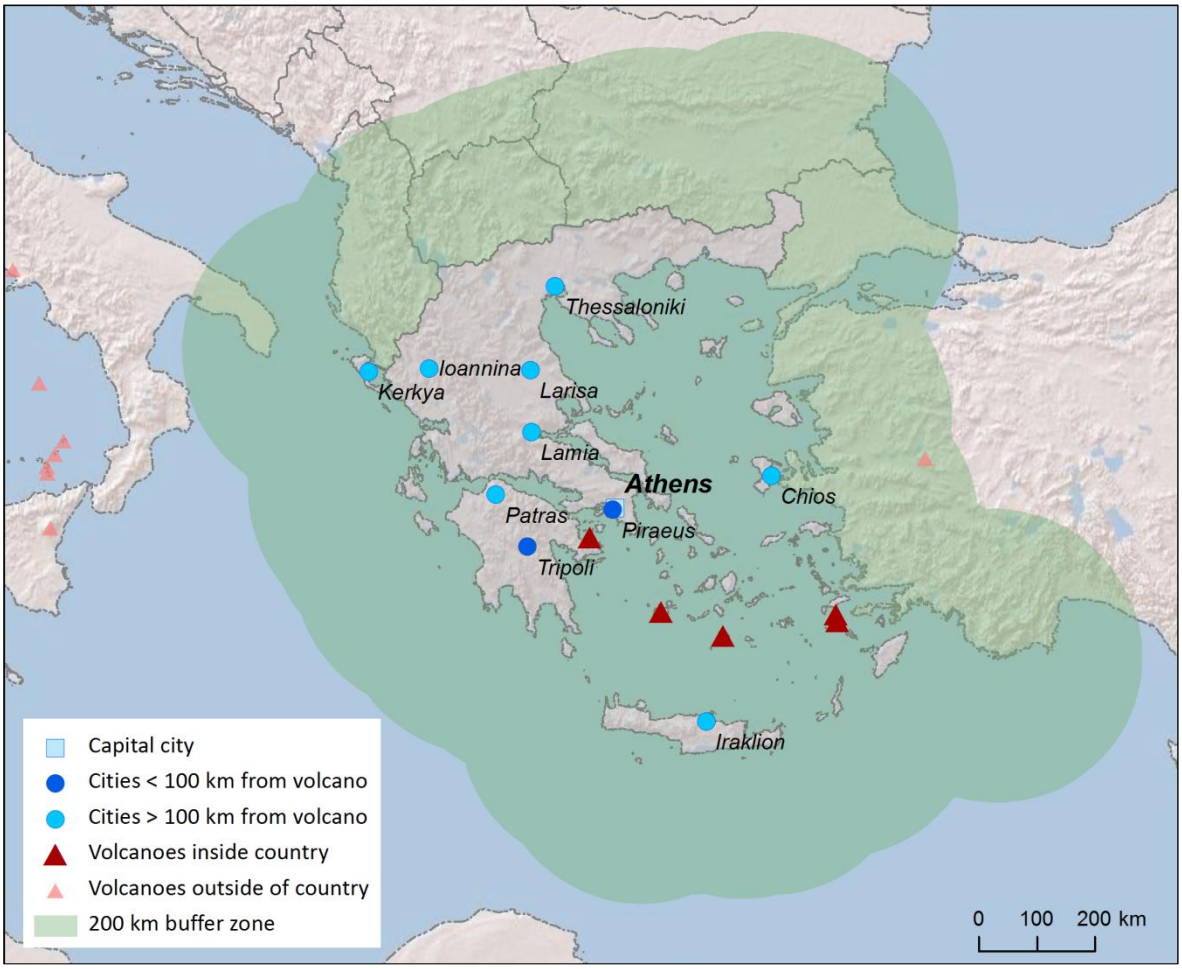

Figure 1.15 Location of Greece's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Greece.

Five Holocene volcanoes are located in the Hellenic Arc in Greece, stretching from Methana in the east to Yali and Nisyros in the west. Volcanoes here result from the subduction of the African Plate under the Eurasian Plate. The volcanoes range in composition from andesitic to rhyolitic, with such felsic compositions often associated with explosive activity. The morphology of the volcanoes varies: Santorini is a complex of shield volcanoes and calderas, Methana is a lava dome complex, Yali is a system of lava domes related to the submarine Kos caldera, and Mílos and Nisyros are stratovolcanoes.

Eighteen eruptions of VEI 1 to 7 are recorded from four volcanoes during the Holocene, including eleven eruptions from Santorini and Nisyros in historical times. The range in VEI indicates that activity has varied widely during the Holocene, from mild eruptions to very large explosive events. The largest Holocene eruption was the 1610 BC Minoan eruption of Santorini. This eruption measured VEI 7 and produced extensive pyroclastic flows, ash fall, lahars and a tsunami implicated in

the fall of the Minoan civilisation. Large explosive eruptions are also recorded in Greece in the Pleistocene, with four volcanoes having records of M≥4 eruptions.

The activity of Santorini, which is the most frequently active volcano in Greece, is not restricted to large explosive eruptions, with a record of five VEI 2 eruptions since 1866.

The capital, Athens, lies about 54 km from Methana volcano and two of the most populous cities in Greece, Tripoli and Piraeus, also lie within about 80 km. The total population residing within 100 km of one or more volcanoes in Greece is over 4.6 million.

The assessment of hazard at Methana and Milos is difficult with only one Holocene eruption record at each volcano. Given the proximity to large cities, focussed research to better understand the hazard may be beneficial. Santorini and Nisyros are more fully understood, and with a history of large explosive eruptions, frequent events and a population of nearly 70,000 within 100 km, Santorini is classed here at Risk Level III, the highest in Greece.

The Institute for the Study and Monitoring of Santorini Volcano (ISMOSAV) and the Nisyros Volcano Observatory monitor the historically active volcanoes of Greece. The latter also monitors Yali. Multiple dedicated ground-based monitoring systems are used, including seismic and deformation surveillance. The seismic monitoring is continuous and the background baseline data is known for both Santorini and Nisyros, which should permit identification of anomalous activity. Few resources are available to extend monitoring to other volcanoes.

The monitoring institutions are responsible for both monitoring and scientific research, and personnel include seismologists, volcanologists, experts in remote sensing, geochemistry and ground deformation. None of the staff have experience of responding to an eruption.

Unrest was detected at Santorini in 2011-2012 comprising seismic activity and deformation. A National Committee for volcano monitoring was formed and contact was established with the Secretary General of Civil Protection. International scientific and technical support was given and this could be advantageous in future crises.

Were unrest to increase or eruption to occur, protocols exist to notify and advise national and local authorities. ISMOSAV provides risk assessments and engages within the public providing a hazard education programme. Alert levels are not directly released, instead the scientific committee advises the Secretary General of Civil Protection to release alerts.

Although monitoring is undertaken at Santorini and Nisyros, a fully funded state national monitoring institution responsible for monitoring and hazard and risk assessments would be beneficial to Greece.

See also:

Santorini volcano, santorini.earth.ox.ac.uk/home for discussion of the 2011-12 unrest and monitoring.

Nisyros Volcano Observatory,
nisyros.igme.gr/nisyros_en/index.php?option=com_content&task=view&id=48&Itemid=65

Volcano Facts

Number of Holocene volcanoes	5
Number of Pleistocene volcanoes with M≥4 eruptions	4
Number of volcanoes generating pyroclastic flows	1
Number of volcanoes generating lahars	3
Number of volcanoes generating lava flows	2
Number of fatalities caused by volcanic eruptions	?>184
Tectonic setting	Subduction zone
Largest recorded Pleistocene eruption	The M7.1 Kos Plateau Tuff (KPT) eruption of Kos at 161 ka
Largest recorded Holocene eruption	The M6.5 Minoan eruption of Santorini at 3,560 BP
Number of Holocene eruptions	18 confirmed eruptions. 1 uncertain and 1 discredited eruption
Recorded Holocene VEI range	1 – 7
Number of historically active volcanoes	2
Number of historical eruptions	11

Number of volcanoes	Primary volcano type	Dominant rock type
2	Large cone(s)	Dacitic (1), Rhyolitic (1)
2	Lava dome(s)	Andesitic (1), Rhyolitic (1)
1	Shield(s)	Dacitic (1)

Table 1.17 The number of volcanoes in Greece, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	11,118,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	22,558
Gross National Income (GNI) per capita (2005 PPP $)	20,511
Human Development Index (HDI) (2012)	0.860 (Very High)

Population Exposure

Capital city	Athens
Distance from capital city to nearest Holocene volcano	53.3 km
Total population (2011)	10,760,136
Number (percentage) of people living within 10 km of a Holocene volcano	26,006 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	115,808 (1.1%)
Number (percentage) of people living within 100 km of a Holocene volcano	4,633,833 (43.1%)

Ten largest cities, as measured by population and their population size:

Athens	729,137
Thessaloniki	354,290
Piraeus	172,429
Patras	163,360
Iraklion	137,154
Larisa	128,758
Ioannina	64,012
Lamia	47,246
Kerkya	27,003
Tripoli	26,561

Infrastructure Exposure

Number of airports within 100 km of a volcano	6
Number of ports within 100 km of a volcano	21
Total length of roads within 100 km of a volcano (km)	2,189
Total length of railroads within 100 km of a volcano (km)	594

The Holocene volcanoes in Greece are located in the Aegean island arc between Greece and Turkey. The 100 km radii surrounding these volcanoes therefore extends into both countries and many islands are located here. Being island volcanoes numerous ports are exposed to the volcanic hazard, as are a number of airports in both Greece and Turkey. The capital, Athens, lies within 100 km of Methana volcano, as do the major cities of Tripoli and Piraeus, therefore exposing much critical infrastructure here, including an extensive road and rail network.

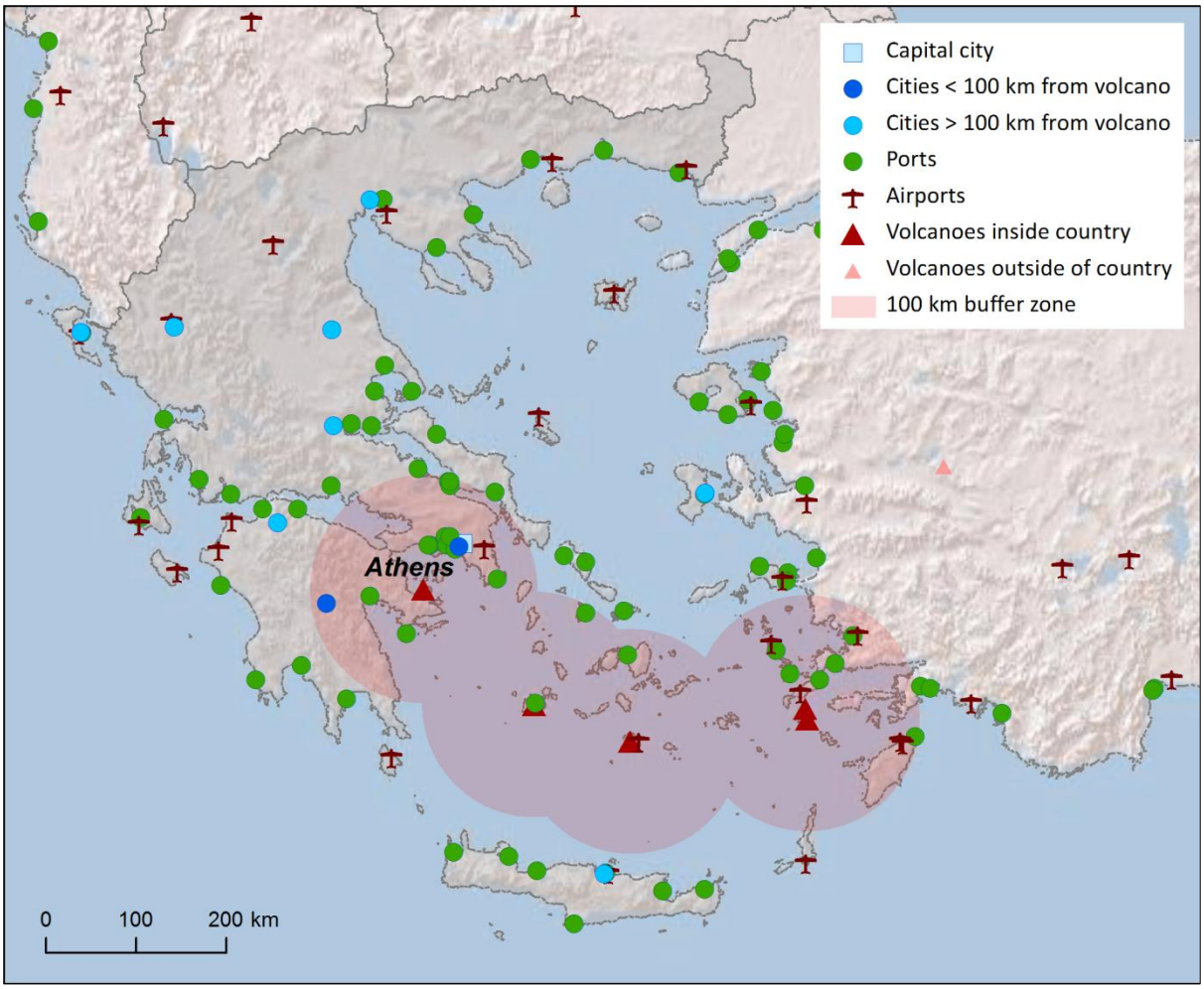

Figure 1.16 The location of Greece's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

The volcanoes of Greece have varying levels of data available in the eruption record. Just two out of the five have appropriate eruptive histories to define the hazard level: Santorini and Nisyros. Of these, Santorini has erupted four times since 1900, whilst Nisyros has a historic eruption record. Santorini is classified at Hazard Level III, whilst Nisyros is at Level III.

Milos, Methana and Yali are unclassified, with just one eruption at Milos and one at Methana in the Holocene. Yali has no confirmed eruptions in the Holocene.

All Greek volcanoes have low to moderate PEI levels. With a population of nearly 70,000 within 100 km and a hazard level of III, the risk here is classed at Risk Level III. Nisyros is classified at Risk Level I, with a much smaller local population.

CLASSIFIED	**Hazard III**				Santorini			
	Hazard II		Nisyros					
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR			Mílos	Methana			
	U-NHHR		Yali					
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.18 Identity of Greece's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified'(top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Volcano	Population Exposure Index	Risk Level
Santorini	4	III
Nisyros	2	I

Table 1.19 Classified volcanoes of Greece ordered by descending Population Exposure Index (PEI). The Risk Level as determined through the combination of the Hazard Level and PEI is given. Risk Level I – 1 volcano; Risk Level II – 0 volcanoes; Risk Level III – 1 volcano.

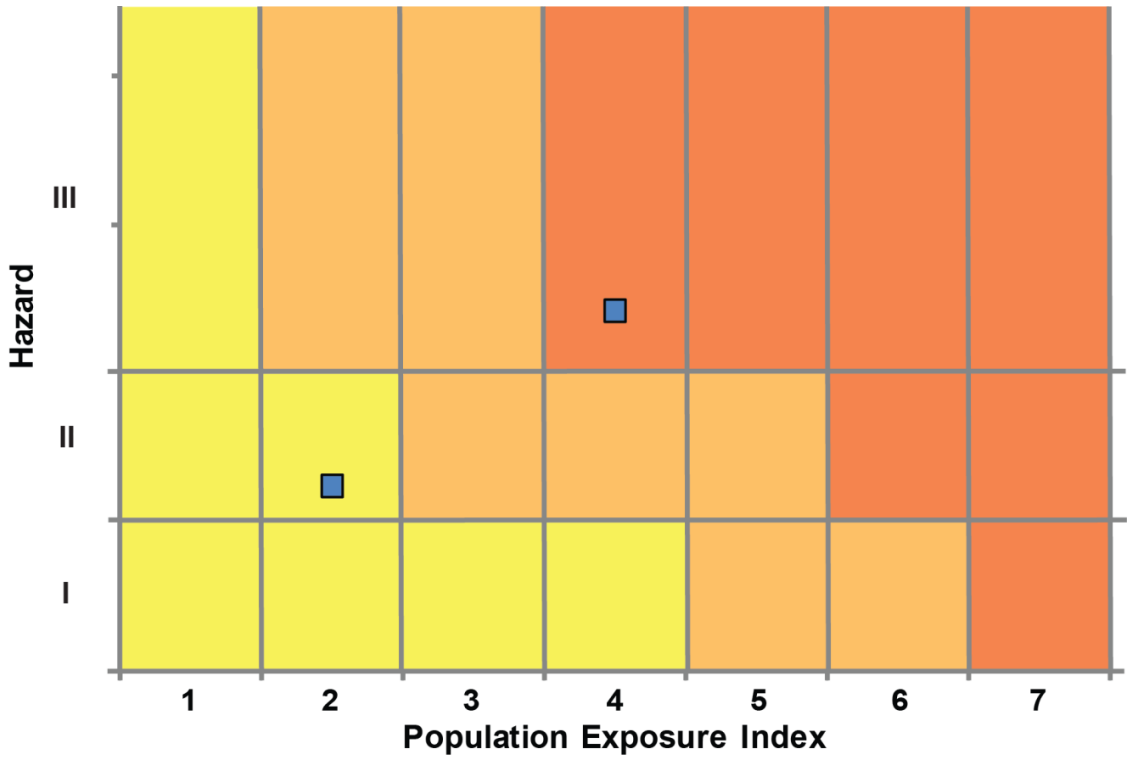

Figure 1.17 Distribution of Greece's classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Both Nisyros and Santorini have recorded historical activity and both are monitored by the Nisyros Volcano Observatory and the Institute for the Study and Monitoring of Santorini Volcano (ISMOSAV) respectively. Both volcanoes have multi-system ground based monitoring, including seismic, gas and deformation surveillance. With the highest Risk Level assigned in Greece, Santorini has a dedicated monitoring network and institution that should permit episodes of unrest to be detected and some forecasts of activity to be made. Despite no recorded historical activity, Yali is also monitored by the Nisyros Volcano Observatory.

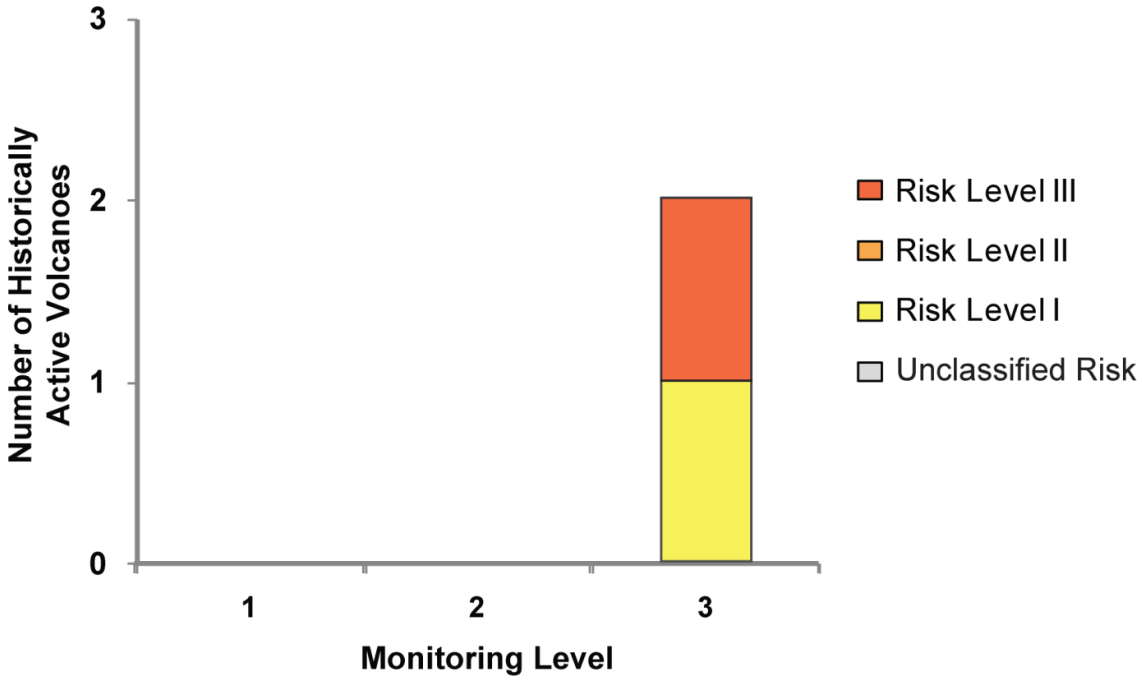

Figure 1.18 The monitoring and risk levels of the historically active volcanoes in Greece. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Italy

Description

There are 14 Holocene volcanoes in Italy according to VOTW4.0 (see footnotes), although two of these (Panarea and Alban Hills) have no known Holocene eruptions. Larderello and Vulsini are included in VOT4.0, but are removed from this analysis. Volcanoes are distributed throughout the west of the country, extending through the Aeolian Islands, Sicily and beyond. Most volcanism is related to complex compressional tectonics associated with the convergence of the European Plate with the northward moving African Plate, including the Aeolian island arc. However, the active volcanism of the Sicily Channel related to the Pantelleria island and the submarine Ferdinandea[1] and other submerged volcanoes of the Sicily Channel, is associated with tensional continental regimes linked to rotation and stretching of the continental crust in the region behind the Afro-Eurasian collision zone. Volcanoes range in compositions from mafic to felsic, with felsic compositions usually associated with explosive activity. The morphology of the volcanoes includes seven large stratovolcanoes (Etna, Ischia, Lipari, Panarea, Stromboli, Vesuvius and Vulcano). Pantelleria is described as a shield volcano with sub-types of caldera, lava domes and pyroclastic cones and can also be described as a polygenetic stratovolcano. In addition to these, there are two[2] calderas (Alban Hills and Campi Flegrei), three submarine volcanoes (Ferdinandea, Marsili[3] and Palinuro). VOTW4.0 includes Larderello (explosion craters) however this is considered a relic of phreatic explosions unrelated to volcanism. Some volcanoes are best described by more than one volcano morphology. During the Holocene Campi Flegrei has produced about 70 explosive eruptions from monogenetic vents distributed in a wide area within the Campi Flegrei caldera, however the last caldera-forming eruption here occurred about 15,000 years ago.

There are 371 confirmed Holocene eruptions in VOTW4.22 with a range of VEI from unknown, to 0 through to 5. The range in VEI indicates that activity has varied widely during the Holocene, from mild persistent activity (e.g. Stromboli) to large magnitude explosive eruptions (e.g. Vesuvius). The largest magnitude Holocene eruptions in Italy (VEI 5) have been produced by Campi Flegrei in ~2150 BC, by Vesuvius in ~6940 BC, ~2420 BC, 79 AD, 472 AD and 1631 AD, and by Etna in ~1500 BC and ~122 BC. In addition to the 371 Holocene eruptions, there are 43 uncertain eruptions in VOTW4.22. Alban Hills and Panarea have no confirmed recorded Holocene eruptions but are suspected to have had activity of Holocene age. Seven of the 14 Italian volcanoes have historical records of eruptions. However, all 14 volcanoes listed in VOTW4.0 have records of explosive eruptions of M≥4 in the Pleistocene.

The capital of Italy, Rome, lies less than 25 km from the nearest Holocene volcano (Alban Hills) and more than one third of Italians (>20 million people) live within 100 km of a Holocene volcano. Evacuations of at-risk populations have been recorded for eruptions at Campi Flegrei, Vesuvius, Ischia and Etna. 26 eruptions at Campi Flegrei, Vesuvius, Ischia, Strombolia and Etna have resulted in

[1] The submarine Ferdinandea volcano is called Campi Flegrei Mar Sicilia in VOTW4.0, but is known locally as Ferdinandea. Here we use the name Ferdinandea to describe the submerged volcanoes of the Sicily Channel.
[2] Vulsini is also included in VOTW4.0, however the youngest products dated are 127 ka (Palladino et al. 2010), so it is removed from the Holocene record here.
[3] Marsili seamount developed through effusive and low energy explosive eruptions between 0.78 Ma and 3 ka BP (Iezzi et al., 2014). This volcano is not currently included in VOTW4.0.

fatalities and 107 eruptions have reports of property damage. Vesuvius, Campi Flegrei and Vulcano are classified at Hazard Level III; the high local populations around Vesuvius and Campi Flegrei mean that the Neapolitan region is assessed to have the highest volcanic risk level in Italy.

The Instituto Nazionale di Geofisica e Vulcanologia (INGV) monitors active volcanoes in Italy via integrated multiparametric systems. In particular, the INGV Observatories Vesuviano and Etneo are responsible for the surveillance of the Campi Flegrei, Vesuvius, Ischia, Etna, Stromboli, Panarea, Lipari, Vulcano and Pantelleria volcanoes. INGV is responsible for both monitoring and scientific research, and personnel include seismologists, volcanologists, experts in remote sensing, geochemistry and ground deformation and numerical modellers. There is a wealth of experience within INGV of responding to eruptions and eruption crises and INGV works alongside the Dipartimento della Protezione Civile (DPC) in carrying out hazard assessments, then used as an input in risk assessments, as well as outreach and educational activities for the population.

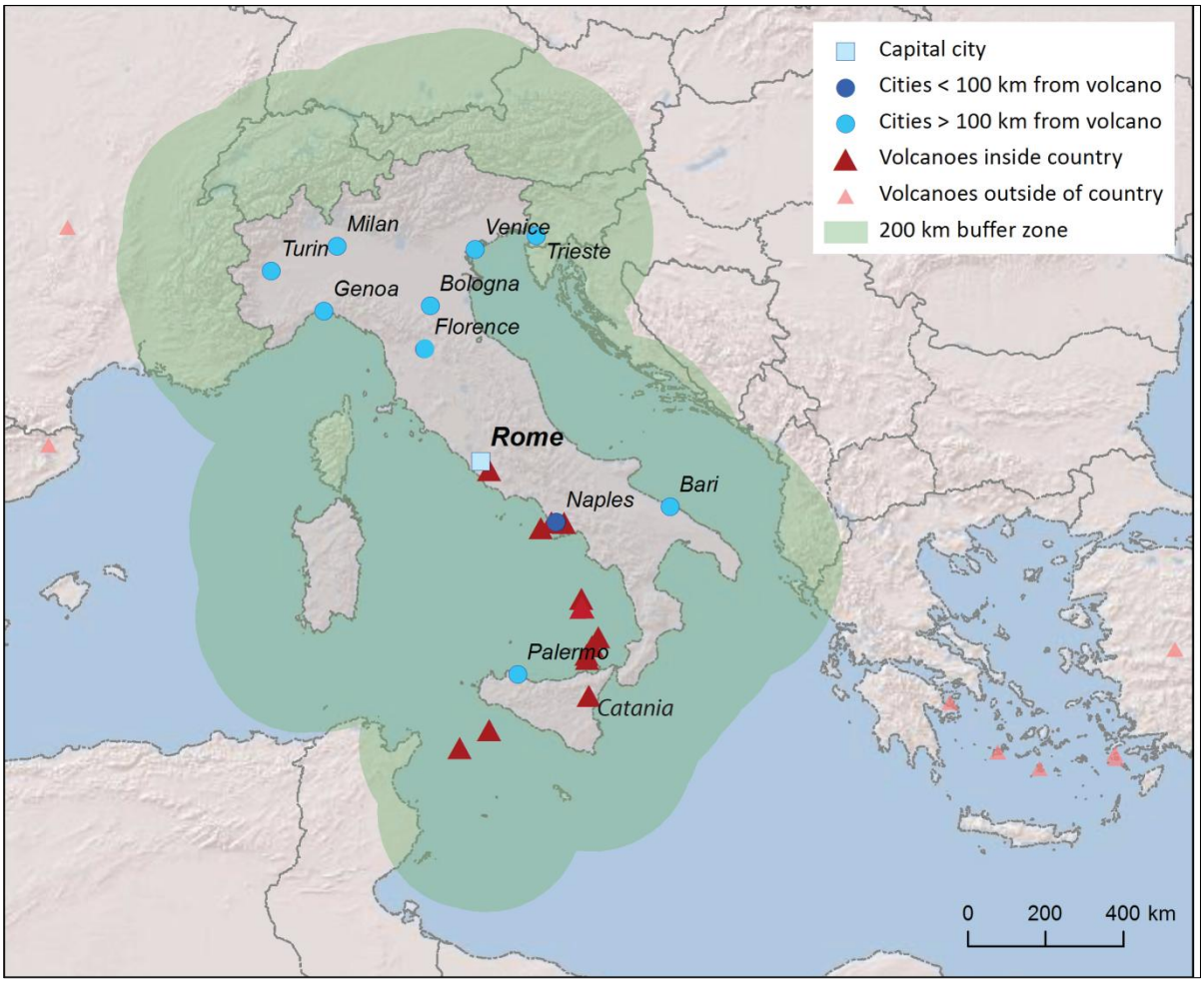

Figure 1.19 Location of Italy's volcanoes, the capital and largest cities. Note that Vulsini and Larderello are not included in this map as they are no longer considered Holocene volcanoes. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Italy.

Volcano Facts – amended with the exclusion of Vulsini and Larderello, and inclusion of Marsili

Number of Holocene volcanoes	13
Number of Pleistocene volcanoes with M≥4 eruptions	10
Number of volcanoes generating pyroclastic flows	7
Number of volcanoes generating lahars	4
Number of volcanoes generating lava flows	8
Number of fatalities caused by volcanic eruptions	?>7,210
Tectonic setting	Rift zone (2), Subduction zone (11)
Largest recorded Pleistocene eruption	The M7.7 Bolsena eruption at Vulsini at 300 ka
Largest recorded Holocene eruption	The M6.6 AP1 eruption of Vesuvius at 3.5 ka
Number of Holocene eruptions	371 confirmed eruptions. 43 uncertain and 26 discredited eruptions
Recorded Holocene VEI range	Unknown – 5
Number of historically active volcanoes	7
Number of historical eruptions	205

Number of volcanoes	**Primary volcano type**	**Dominant rock type**
3	Caldera(s)	Foiditic (1), Trachytic/Andesitic (2)
8	Large cone(s)	Andesitic (2), Basaltic (2), Phonolitic (1), Rhyolitic (2), Trachytic/Andesitic (1)
1	Small cone(s)	Unknown (1)
3	Submarine	Basaltic (2), Phonolitic (1)

Table 1.20 The number of volcanoes in Italy, their volcano type classification and dominant rock type according to VOTW4.0. This has been amended based on advice from INGV to include Pantelleria as a large rhyolitic cone, not a shield as described in VOTW4.0, and to include the submarine Marsili volcano.

Socio-Economic Facts

Total population (2012)	60,828,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	27,069
Gross National Income (GNI) per capita (2005 PPP $)	26,158

Human Development Index (HDI) (2012)	0.881 (Very High)

Population Exposure

Capital city	Rome
Distance from capital city to nearest Holocene volcano	24.3 km
Total population (2011)	61,016,804
Number (percentage) of people living within 10 km of a Holocene volcano	1,621,403 (2.7%)
Number (percentage) of people living within 30 km of a Holocene volcano	8,363,679 (13.7%)
Number (percentage) of people living within 100 km of a Holocene volcano	20,372,127 (33.4%)

Ten largest cities, as measured by population and their population size:

Rome	2,563,241
Milan	1,306,661
Naples	988,972
Turin	865,263
Palermo	672,175
Genoa	601,951
Florence	371,517
Bologna	371,217
Bari	316,532
Catania	315,576

Infrastructure Exposure

Number of airports within 100 km of a volcano	8
Number of ports within 100 km of a volcano	30
Total length of roads within 100 km of a volcano (km)	11,678
Total length of railroads within 100 km of a volcano (km)	2,708

The Italian volcanoes are distributed through the west of much of the country, extending through the Aeolian Islands, Sicily and beyond. The 100 km radius of Pantelleria in the far south extends to Tunisia, exposing ports and towns here. Being located near the coast throughout much of Italy, numerous ports are located within the 100 km radii, as are a number of the major Italian cities,

including the capital, Rome, airports, an extensive road and rail network and other critical infrastructure here.

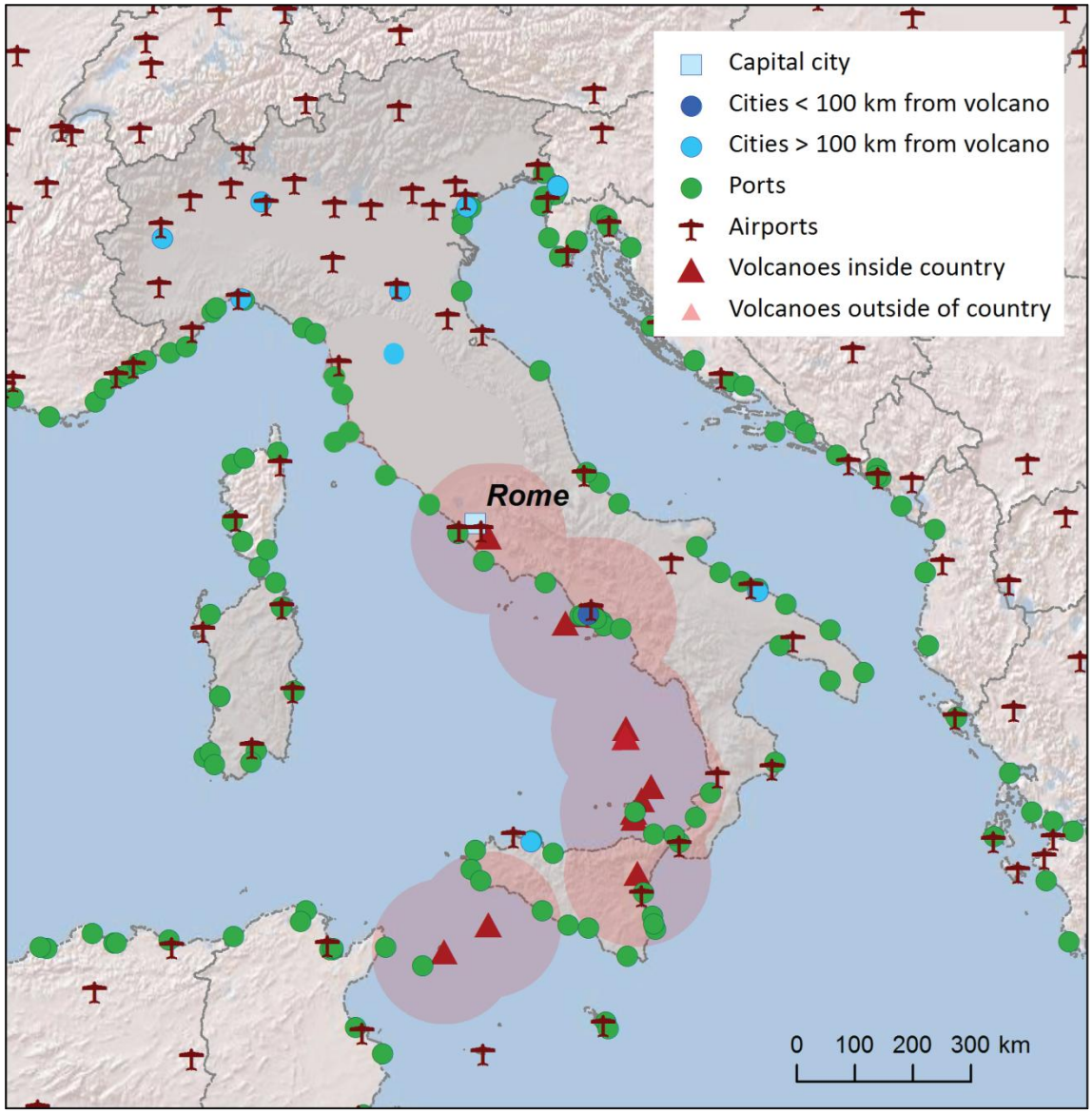

Figure 1.20 The location of Italy's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

Six of the Italian volcanoes have sufficient information available in their records to allow the classification of a Hazard Level. These plot across all three hazard levels: Ferdinandea (Sicilia Channel) and Stromboli are classified at Hazard Level I; Etna at II, and Vulcano, Campi Flegrei and Vesuvius at Hazard Level III.

Of the remaining eight volcanoes, two, Alban Hills and Panarea have no confirmed eruptions during the Holocene from which to calculate a VHI. The remaining volcanoes have sparse histories with eruptions of unknown size.

Throughout this work, we use the term 'historical' to mean events since 1500 AD. This is the time at which records around much of the world improved significantly, with many causes including the expansion of the population, global trade and colonisation and improvements in record keeping. Prior to this time, most of our eruption knowledge comes from geological study, rather than contemporary eruption records. Of course, in Italy, written records stretch back much further in time than in much of the world, and indeed the historical record for Etna goes back to about 1500 BC. The term 'historical' could therefore be extended beyond our definition of 1500 AD, however for consistency we maintain the definition here. This does mean that volcanoes such as Ischia are classified in the U-HR category, when strictly this does have a historical record. Ischia has erupted numerous times in the recent Holocene, with at least eight eruptions since 1 AD including at least one VEI 3 eruption and most recently the production of the Arso lava flow, through what is now a highly populated area. Ischia is the site of significant degassing and presents potential flank instability hazards including tsunamigenic potential.

CLASSIFIED	**Hazard III**				Vulcano			Campi Flegrei, Vesuvius
	Hazard II					Etna		
	Hazard I		Ferninandea	Stromboli				
UNCLASSIFIED	**U – HHR**				Pantelleria			
	U- HR		Palinuro			Ischia, Lipari		
	U-NHHR			**Panarea**				**Alban Hills**
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1 Identity of Italy's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Volcano	Population Exposure Index	Risk Level
Campi Flegrei	7	III
Vesuvius	7	III
Etna	5	II
Vulcano	4	III
Stromboli	3	I
Ferdinandea	2	I

Table 1.21 Volcanoes of Italy ordered by descending Population Exposure Index (PEI). The Risk Level as determined through the combination of the Hazard Level and PEI is given. Risk Level I – 2 volcanoes; Risk Level II –1 volcano; Risk Level III – 3 volcanoes.

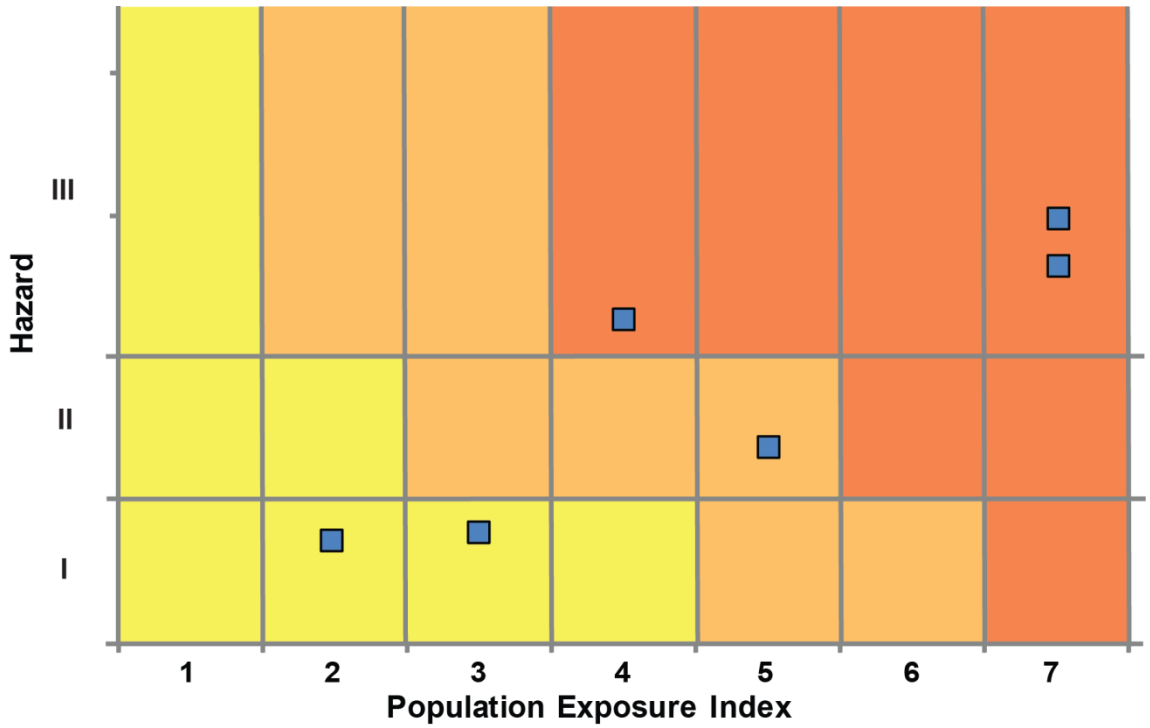

Figure 1.21 Distribution of Italy's volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

The PEI levels of the Italian volcanoes range from low to very high, with PEIs of 2 to 7. Nine Italian volcanoes have a high PEI of 5 – 7, including Vesuvius, which with a Hazard Level of III is classed as Risk Level III.

National Capacity for Coping with Volcanic Risk

Seven Italian volcanoes have records of historical eruptions. The Istituto Nazionale di Geofisica e Vulcanologia (INGV) is responsible for monitoring these volcanoes. The only historical Italian volcanic area with no dedicated ground-based monitoring is the submarine volcanoes of Sicilia Channel and Tyrrhenian Sea. All others are monitored through seismic stations, with deformation monitoring (GPS, levelling, tiltmeters, strain-meters) in place at the Risk Level III volcanoes: Campi Flegrei and Vesuvius, and the frequently active Etna and Stromboli. The active volcanoes of the Aeolian Islands are entirely covered with permanent GPS stations. The unclassified volcano Pantelleria, which last

erupted in 1891 in a submarine portion located about 5 km NE of the island named Foerstner, has seismic and deformation monitoring in place. There are, additionally, permanent visible and infrared cameras in place at Etna and Stromboli; permanent gravity stations at Etna; a number of other permanent stations to measure geochemical parameters at fumaroles and from soil diffuse degassing at Etna, Stromboli, Campi Flegrei, Vulcano, Pantelleria, Ischia (temperature, soil CO_2 flux, acidity of ground waters, etc.); permanent geochemical stations to measure parameters (SO_2 flux, C/S ratio) at Etna and Stromboli; permanent radar to detect ash in the atmosphere at Etna; permanent mareographic stations along the Campanian coast; and others. Periodic multi-parametric surveys are performed at all sub-aerial active volcanoes.

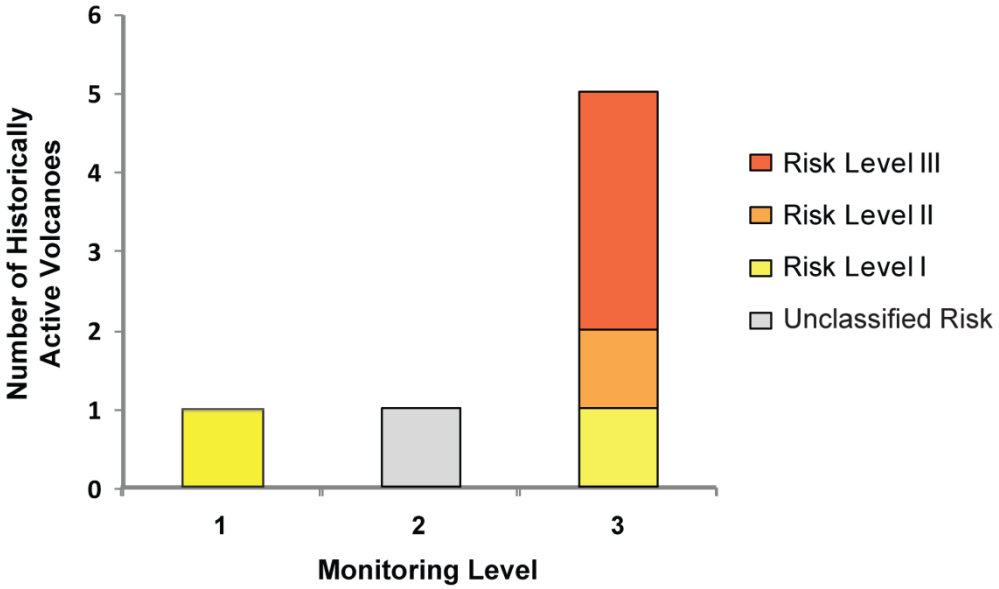

Figure 1.22 The monitoring and risk levels of the historically active volcanoes in Italy. Monitoring Level 1 indicates no known dedicated ground-based monitoring (the submarine Ferdinandea volcano); Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

References

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Iezzi G., Caso C., Ventura G., Vallefuoco M., Cavallo A., Behrens H., Mollo S., Paltrinieri D., Signanini P., Vetere F. (2014). First documented deep submarine explosive eruptions at the Marsili Seamount (Tyrrhenian Sea, Italy): a case of historical volcanism in the Mediterranean Sea. Gondwana Research, doi: 10.1016/j.gr.2013.11.001.

Gail A.M., Wes H., 1986, Geology of the peralkaline volcano at Pantelleria, Strait of Sicily. Bull Volcanol, 48:143-172

Spain – Mainland

Description

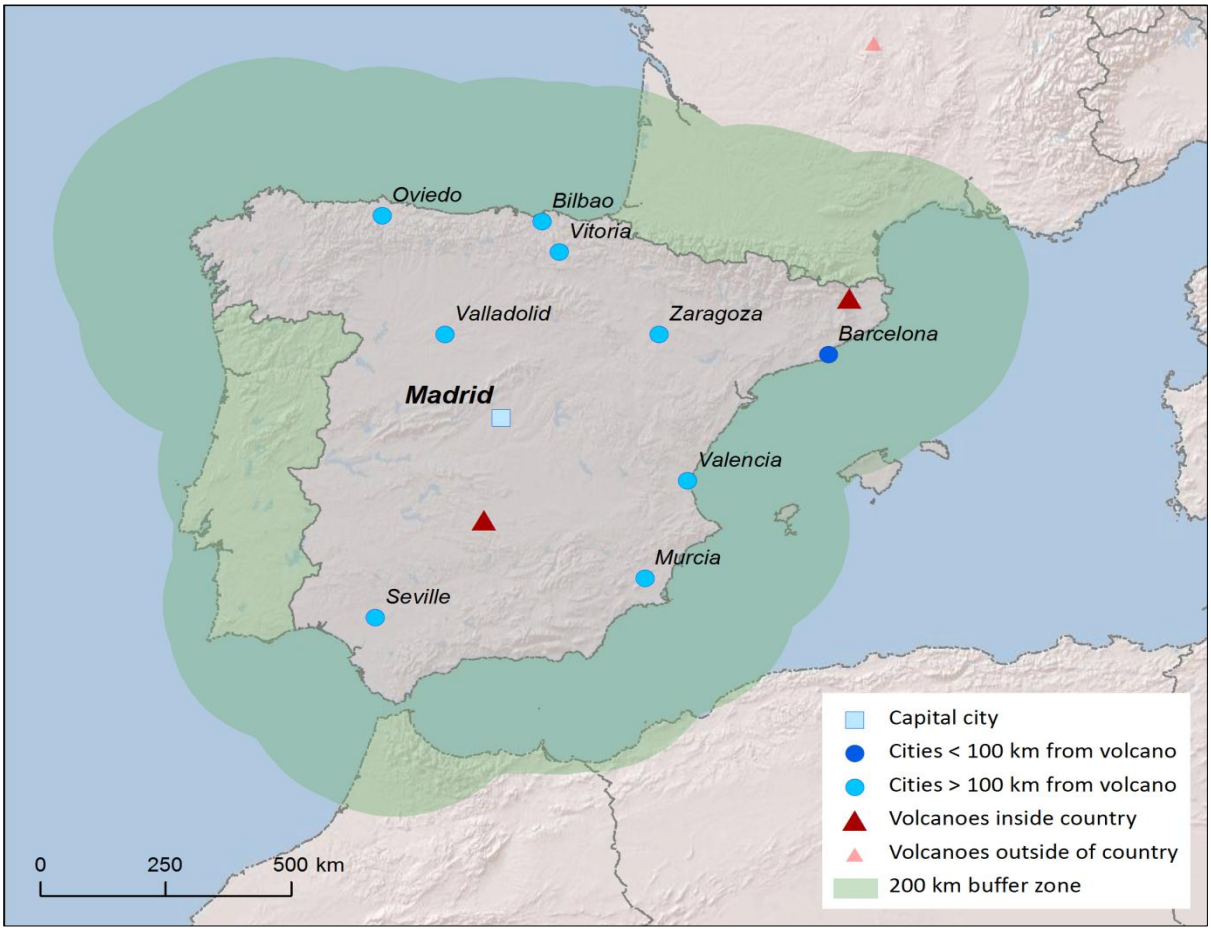

Figure 1.23 Location of Spain's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Spain.

There are two Holocene volcanoes located in mainland Spain: the Olot Volcanic Field, approximately 90 km north-east of Barcelona and near the French border, and the Calatrava Volcanic Field, ~175 km south of Madrid in the centre of the country. Both volcanic fields lie in a continental rift setting. The dominantly Pliocene Calatrava Volcanic Field hosts more than 300 basaltic-to-foiditic pyroclastic cones, maars, and lava domes and covers an area of more than 5000 square km. Late-stage phreatomagmatic activity in the Calatrava Volcanic Field at Columba volcano was dated as mid-Holocene and fumarolic activity has been recorded in the Sierra de Valenzuela area during the 16th-18th centuries. The Olot Volcanic Field (also known as the Garrotxa Volcanic Field) consists of a large number of strombolian pyroclastic cones and associated alkali basaltic lava flows. The pyroclastic cones are preferentially located at the intersection of E-W and NW-SE faults. There are no recorded Holocene eruptions at Olot but stratigraphic evidence suggests that Holocene eruptions have occurred.

The only recorded eruption in the Holocene is of unknown VEI and produced by the Calatrava Volcanic Field in ~3600 BC; no historical records exist.

More than 7.5 million people live within 100 km of the two volcanic fields. The 100 km radius around Olot Volcanic Field in the north is the more populated (5.2 million people) of the two fields, including parts of France and Andorra, exposing the city of Barcelona and other towns, ports and airports. The Calatrava Volcanic Field in central Spain is more remote (0.7 million people within 100 km), with no airports or major cities lying within 100 km.

Volcano Facts

Number of Holocene volcanoes	2 (Mainland)
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	1
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	-
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	Unknown VEI eruption of 3600 BC at the Calatrava Volcanic Field
Number of Holocene eruptions	1 confirmed eruption
Recorded Holocene VEI range	Unknown
Number of historically active volcanoes	0
Number of historical eruptions	0

Number of volcanoes	Primary volcano type	Dominant rock type
2	Small cone(s)	Basaltic (2)

Table 1.22 The number of volcanoes in Mainland Spain, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	46,712,000

Gross Domestic Product (GDP) per capita (2005 PPP $)	27,063
Gross National Income (GNI) per capita (2005 PPP $)	25,947
Human Development Index (HDI) (2012)	0.885 (Very High)

Population Exposure

Capital city	Madrid
Distance from capital city to nearest Holocene volcano	174.4 km
Total population (2011)	46,754,784
Number (percentage) of people living within 10 km of a Holocene volcano	163,931 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	1,750,883 (3.7%)
Number (percentage) of people living within 100 km of a Holocene volcano	7,569,747 (16.2%)

Ten largest cities, as measured by population and their population size:

Madrid	3,117,977
Barcelona	1,581,595
Valencia	805,304
Seville	701,894
Zaragoza	649,404
Murcia	406,807
Las Palmas	378,495
Palma De Mallorca	375,773
Bilbao	351,409
Valladolid	322,304

Infrastructure Exposure

Number of airports within 100 km of a volcano	1
Number of ports within 100 km of a volcano	5
Total length of roads within 100 km of a volcano (km)	3,514
Total length of railroads within 100 km of a volcano (km)	637

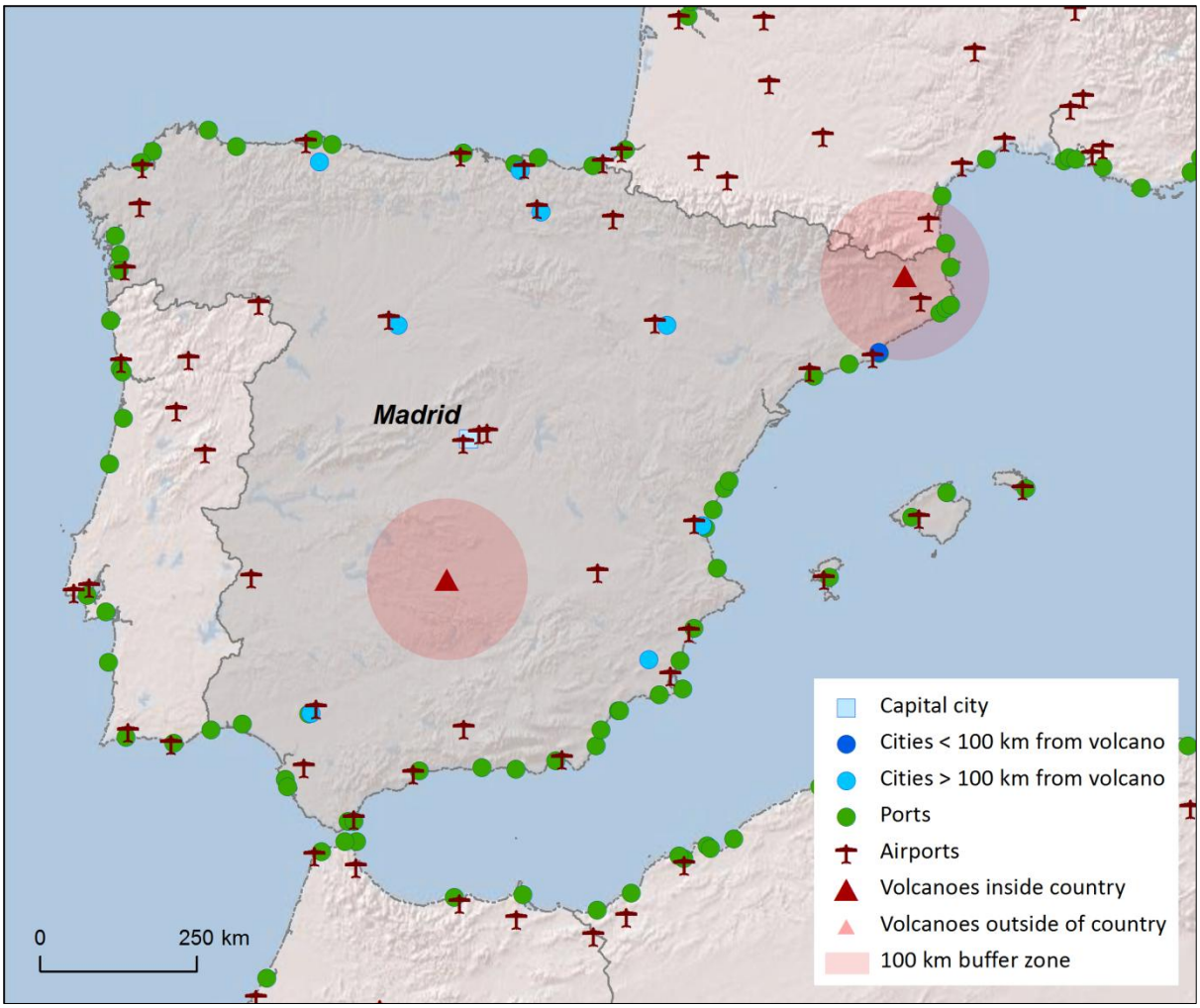

Figure 1.24 The location of Spain's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

The two Holocene volcanoes of mainland Spain are located in the north and centre of the country. Olot Volcanic Field in the north, is located near the border with France, therefore parts of France and Andorra lie within the 100 km radius of this volcano, exposing towns, ports and airport here. Indeed much of Andorra falls in this zone. The city of Barcelona lies within this 100 km radius, and several ports, an airport and extensive road network is exposed. The Calatrava Volcanic Field in central Spain is more remote, with no airports or major cities lying within 100 km.

Hazard, Uncertainty and Exposure Assessments

Of the volcanoes in Mainland Spain, only the Calatrava Volcanic Field has a confirmed eruption on record during the Holocene, but of unknown size. Holocene activity at Olot Volcanic Field is suspected from stratigraphic studies, however this is unconfirmed. The absence of extensive eruption records means that the hazard levels cannot be determined for the volcanoes here without significant associated uncertainties. No post-1900 AD unrest has been recorded at these volcanoes, however unrest was recorded in the 16th to 18th centuries at Calatrava Volcanic Field.

Both Spanish volcanoes have high local populations and hence PEI values of 5 and 6.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**							
	U- HR						Calatrava Volcanic Field	
	U- NHHR					Olot Volcanic Field		
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.23 Identity of Mainland Spain's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

No volcanoes in mainland Spain have recorded historical eruptions and no information is available at the time of the writing of this report to indicate that regular ground-based monitoring is undertaken at any Holocene volcanoes in mainland Spain.

Turkey

Description

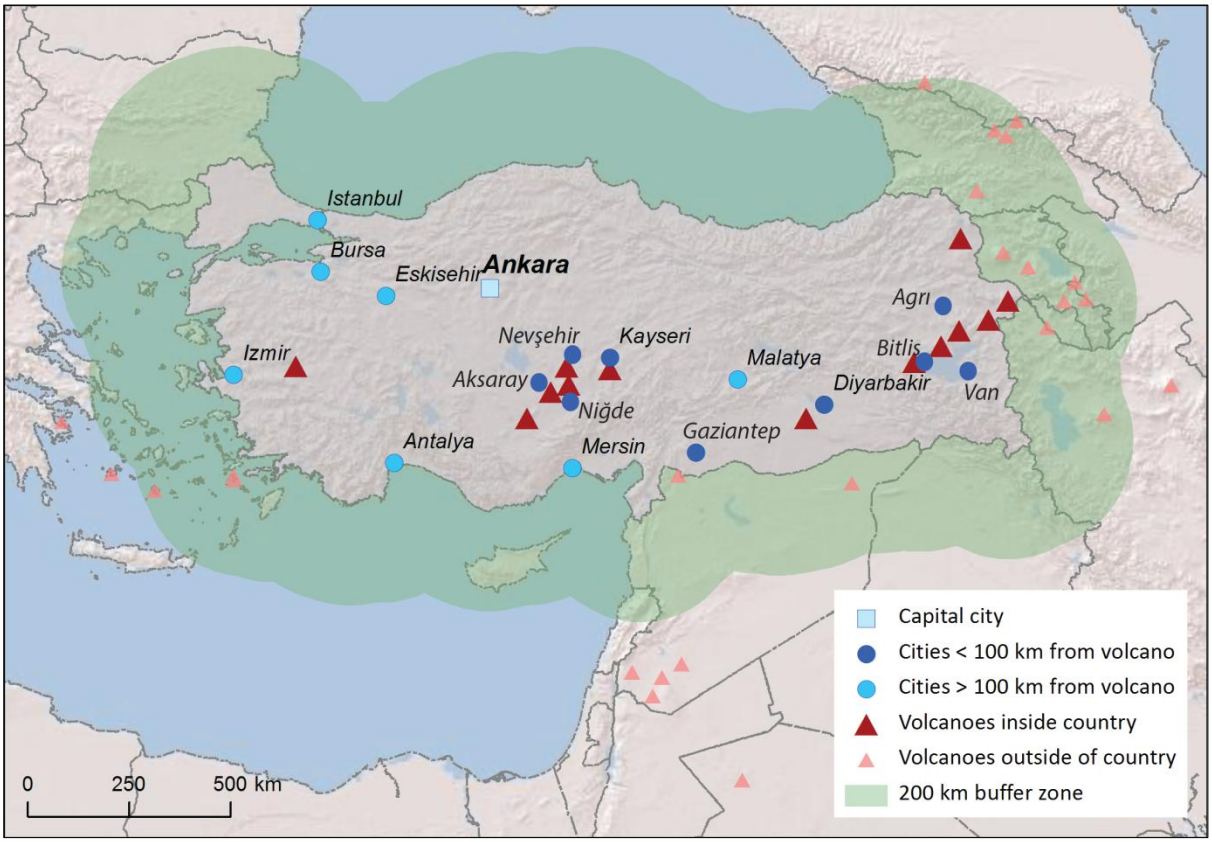

Figure 1.25 Location of Turkey's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Turkey.

Thirteen Holocene volcanoes are located throughout Turkey, from Kula in the west to Ararat (Turkish name: Agri Dagi) in the east. Two main clusters of volcanoes lie in the centre and east of the country. The origin of volcanism in Turkey is not fully understood, with a complex system of plate interaction and intra-plate and subduction processes postulated. The morphology of the volcanoes ranges from small cones in volcanic fields, shield volcanoes and large stratovolcanoes. The magma composition here is dominantly intermediate to felsic with andesitic and rhyolitic features.

Thirty-eight Holocene eruptions are recorded from six volcanoes, including four historical eruptions from three volcanoes. The size of the eruptions is largely unknown, with just one historical eruption of Ararat (Agri Dagi) in 1840 being attributed a VEI of 3. Large explosive eruptions are recorded in the Pleistocene at two volcanoes, the largest eruption being the M6.2 eruption of the Upper Acigöl Tuff at Acigöl-Nevsehir in 110 ka. The absence of detailed eruption histories with known eruption sizes makes hazard assessment at Turkey's volcanoes difficult, and focussed research would be beneficial to expand the knowledge of past activity.

Nemrut Dagi has the most eruptions recorded in the Holocene and has had two historical eruptions in 1597 and 1650. The only other historical activity was at Ararat (Agri Dagi) with the 1840 VEI 3 eruption and the 1855 eruption of Tendürek Dagi. Unrest has been reported at Ararat since 1900.

Loss of life is recorded in two eruptions of Ararat. The 1840 eruption resulted in about 1,900 fatalities due to pyroclastic flows.

Although the capital, Ankara, lies distal to the Holocene volcanoes, two of the most populous cities in Turkey, Kayseri and Diyarbakir, fall within 100 km of Erciyes Dagi and Karaca Dag volcanoes. A large population resides within 10 km of four of Turkey's volcanoes, and across the country over 15.7 million people live within 100 km of one or more Holocene volcanoes.

The Turkish National Commission for Volcanology and Chemistry of the Earth's Interior (TUVAK) has coordinated efforts to research volcanism in Turkey. No official monitoring institutions are currently operational, though Holocene monitoring research projects are undertaken at Hacettepe University Department of Geological Engineering. Plans are being developed for development of monitoring institutions. Three seismic stations are in place at Nemrut Dagi, and baseline seismic data is available which should allow anomalous activity to be identified. This seismic network is maintained by scientists at the Hacettepe University. No plans or protocols are currently in place for handling developing unrest and eruption.

See also:

TUVAK: www.mta.gov.tr/v2.0/eng/birimler/tuvak/index.php

Volcano Facts

Number of Holocene volcanoes	13
Number of Pleistocene volcanoes with eruptions M>=4	2
Number of volcanoes generating pyroclastic flows	1
Number of volcanoes generating lahars	1
Number of volcanoes generating lava flows	3
Number of fatalities caused by volcanic eruptions	1,900
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	The M6.2 eruption of the Upper Acigöl Tuff at Acigöl-Nevsehir in 110 ka
Largest recorded Holocene eruption	The VEI 3 eruption of Ararat in 1840 AD
Number of Holocene eruptions	38 confirmed eruptions. 8 uncertain eruptions
Recorded Holocene VEI range	Unknown – 3
Number of historically active volcanoes	3
Number of historical eruptions	4

Number of volcanoes	Primary volcano type	Dominant rock type
1	Caldera(s)	Rhyolitic (1)
5	Large cone(s)	Andesitic (2), Dacitic (2), Rhyolitic (1)
1	Lava dome(s)	Rhyolitic (1)
3	Shield(s)	Andesitic (1), Basaltic (2)
3	Small cone(s)	Andesitic (2), Basaltic (1)

Table 1.24 The number of volcanoes in Turkey, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2013, from Turkish Statistical Institute)	76,667,864
Gross Domestic Product (GDP) per capita (2005 PPP $)	13,466
Gross National Income (GNI) per capita (2005 PPP $)	13,710
Human Development Index (HDI) (2012)	0.722 (High)

Population Exposure

Capital city	Ankara
Distance from capital city to nearest Holocene volcano	209.1 km
Total population (2011)	78,785,548
Number (percentage) of people living within 10 km of a Holocene volcano	>3.3 million
Number (percentage) of people living within 30 km of a Holocene volcano	>4.5 million
Number (percentage) of people living within 100 km of a Holocene volcano	>15 million

Ten largest cities, as measured by population and their population size (2013; Turkish Statistical Institute):

Istanbul	14,160,467
Ankara	5,045,083
Izmir	4,061,074
Bursa	2,740,970
Antalya	2,158,265
Adana	2,149,260
Konya	2,079,225
Gaziantep	1,844,438
Şanlıurfa	1,801,980
Mersin	1,705,774

Infrastructure Exposure

Number of airports within 100 km of a volcano	4
Number of ports within 100 km of a volcano	0
Total length of roads within 100 km of a volcano (km)	8,432
Total length of railroads within 100 km of a volcano (km)	1,825

The volcanoes of Turkey are widespread through the country, though are located inland away from the coast, therefore no ports are located within 100 km radius of these volcanoes. The volcanoes in the east lie near the borders with Armenia, Azerbaijan and Iran, and the 100 km radii extend into these countries. Volcanoes in these countries likewise expose parts of Turkey to volcanic hazard. The major cities of Kayseri and Diyarbakir fall within 100 km of Erciyes Dagi and Karaca Dag respectively, exposing critical infrastructure here including road and rail networks.

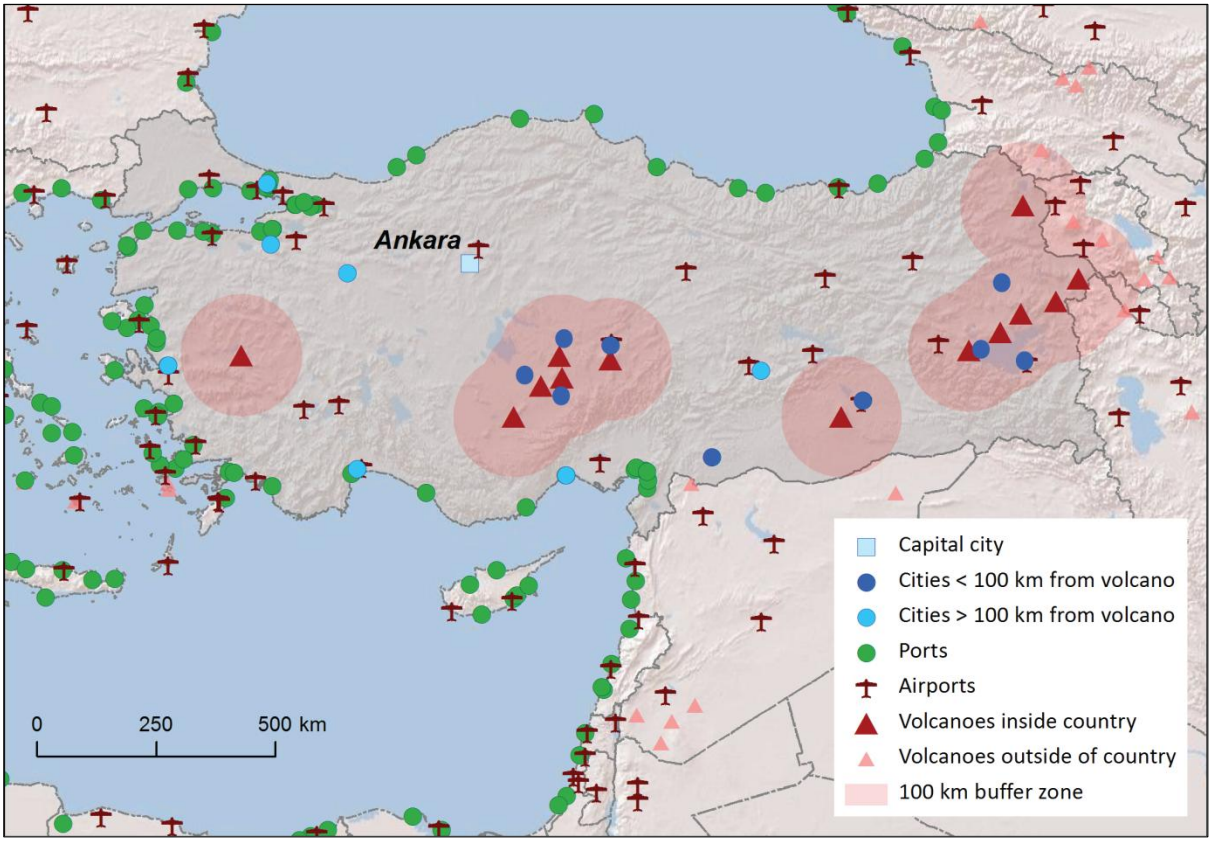

Figure 1.26 The location of Turkey's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

Despite records of 38 confirmed eruptions during the Holocene in Turkey, the eruption size is only known in one event, and thus the hazard levels cannot be determined at Turkey's volcanoes without significant uncertainties. Nemrut Dagi, Tendürek Dagi and Ararat all have confirmed historical

eruptions (since 1500 AD), whilst Süphan Dagi, Erciyes Dai and Acigöl-Nevsehir have Holocene eruption records. The remaining seven volcanoes have suspected Holocene activity only. No unrest above background levels is recorded at any Turkish volcano since 1900 AD.

The PEI levels of Turkish volcanoes range from a moderate PEI 4 to a very high PEI 7 at Kars Plateau. The risk levels cannot be determined without the hazard, however with such large local populations, the risk is not insignificant.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**				Nemrut Dagi; Tendürek Dagi; Ararat			
	U- HR				Süphan Dagi	Erciyes Dagi	Acigöl-Nevsehir	
	U-NHHR				Hasan Dagi; Göllü Dag; Karaca Dag; Girekol Tepe	Kula; Karapinar Field		Kars Plateau
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 1.25 Identity of Turkey's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since*

National Capacity for Coping with Volcanic Risk

The Turkish National Commission for Volcanology and Chemistry of the Earth's Interior and Hacettepe University undertake some monitoring in Turkey. Three volcanoes have records of historic activity – Nemrut Dagi, Ararat (Agri Dagi) and Tendürek Dagi. Of these, only Nemrut Dagi, has three seismometers dedicated to the monitoring of the volcano.

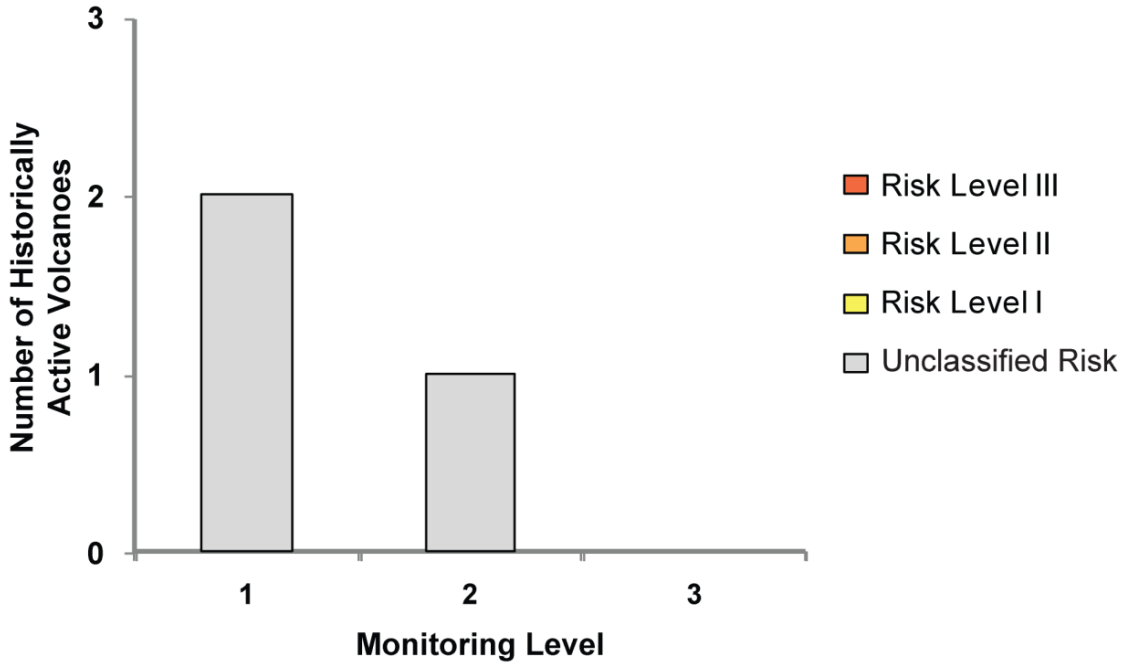

Figure 1.27 The monitoring and risk levels of the historically active volcanoes in Turkey. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.