



Data Mining Test

2021 - Volcanic paroxysms of Etna



Figure 1 : Map showing the position of Etna volcano along with Giarre and Zafferana Etnea. The distance between Etna and Giarre city is about 30 km.

The volcano 'Etna' is visible from both land and sea and is well known for its long history that spans the ancient Mediterranean civilisations. Located in Sicily, Etna is the highest volcano in Europe (3326 meters). The volcano has a conical shape covering an area of 1200 km². There are dozens of craters on its steep slopes as well as a caldera, the Valle del Bove, facing east.

Etna is a Quaternary volcano. Its frequent eruptions throughout history have changed, sometimes profoundly, the surrounding landscape, repeatedly threatening the populations that have settled around it over the millennia. The area is also at moderate seismic risk due to the volcano's activity.

The volcano was very active during the months of February and March 2021, with several successive paroxysms.

This is what the local population had to say about it:

'The last few days have been filled with wonder and amazement at the eruptive activity that we continue to admire. However, volcanic eruptions can also cause inconvenience, especially for the people on the slopes of the volcano. This is because the wind carries with it all the fine, light material that is blown out of the craters, transporting it hundreds of kilometres away. The paroxysms of the last few weeks have resulted in large ash falls and lava flows ...'.

Main goal of the case study > Geological exploration aims to better understand the volcano and its activity in order to better protect ourselves. We propose to discover the tools and records that researchers have used to study this eruptive period of the volcano.

Resources on line available for this test :

Movies: 2 short films on the eruptive phase of the volcano Replay the volcanic eruption and its different aspects

Ash rain at Zafferana Etnea (little city on East slope of the volcano Etna) https://youtu.be/5LaCQT ph Q

Lava fountains on Etna https://youtu.be/gBGFrGpYMVU

Satellite images (Sentinel 2 and Sentinel 5):

Access to 'Sentinel eo browser' website (European Space Agency) to discover satellite images of the volcano over a period of time. https://apps.sentinel-hub.com/eo-browser/ > Etna

Seismicity and seismograms recorded in Sicily :

Ground motion records from a network of seismological stations installed on Etna, and seismicity catalogues

http://edumed.unice.fr/ieso2021/seismo/

Software tectoglob3D

To display and analyse seismological data (seismograms and seismicity catalogue) accessible from the previous website

GPS time series from Etna INGV-EO (Istituto Nazionale di Geofisica e Vulcanologia)

Data to evaluate the global ground motion of the volcano. https://edumedobs.maps.arcgis.com/apps/dashboards/47d44dbc36af457c9df4f4e6d85527e3

When you see this sign \blacksquare : you have to access and/or to analyse data on line

When you see this sign \mathscr{I} : you must answer the question

28 February 2021, 9:25 am:

'A spectacular eruptive event at the southeast crater occurs on Mount Etna.

The first explosion, which marked the beginning of this new eruptive episode, occurred at 07:55 UTC.

The ashes dispersed and then fell towards the areas of Zafferana Etnea and Giarre (Figure 1). The lava fountains were mainly concentrated in two eruptive vents and reached a height of about 300 meters. The seismic activity of the volcano, which initially remained at a medium level, reached high values within half an hour of the start of the lava fountain event.

At 10:30, the lava fountain in the southeast crater stopped almost suddenly, while the lava flow towards the Valle del Bove remained active ...'

Part 1 : DISCOVER the volcanic eruption with Sentinel satellites images

Sentinel is an Earth observation mission that systematically acquires optical imagery at high spatial resolution (10 m to 60 m) over land and coastal waters. The mission is a constellation with two twin satellites, Sentinel-2 and Sentinel 5.

Access to the Sentinel web site (ESA) > <u>https://apps.sentinel-hub.com/eo-browser/</u>

Search Etna area > 'Etna' Discover image taken by Sentinel 2, February 28, 2021 at 09h50 (UTC)

The North is to the top of the screen in all the satellite images.

Question 1 : [Only one answer is correct] (1 pt)

What is the best combination of spectral bands to visualize, to distinguish and to differentiate old lava flow, current active lava flows, vegetation, clouds and snow in a single image?

1A : True color (based on bands 4,3,2)
1B : False color (based on bands 8,4,3)
1C : Moisture index
1D : SWIR (based on bands 12,8A,4)

Let's take a look at the lava!

Question 2: [Only one answer is correct] (1 pt)
What is the approximate location (in decimal degrees) of the downstream point reached by the lava at 9.50am on that day?

2A : Latitude : 37,750 / Longitude : 14,997 2B : Latitude : 37,650 / Longitude : 15,000 2C : Latitude : 37,740 / Longitude : 15,030 2D : Latitude : 37,710 / Longitude : 15,090

Question 3: [More than one answer is correct] (2 pts)

Knowing that the volcanic eruption started at about 08:00 am. What are the correct answers?

You need to log in* on the web site to use the function 'Measure' *sign in as : mail > ieso2021@geoazur.unice.fr

password > ieso2021

3A: The lava flowed for about 2600 meters at an average speed of 1500 m/h

3B: The lava is fluid because it flowed at a fast speed of more than 1 km/h

3C: The lava flowed for about 2600 meters with an average speed of 500 m/day

3D: The lava is not very fluid because its average flow speed does not exceed a few meters per hour.

Question 4: [Only one answer is correct] (2 pts)

By comparing* various eruptions (08/04/2017, 26/12/2018 and 28/02/2021) visualize the lavas flow emitted,

✓ *For each date, choose a satellite image to use (Visualize), then add the image to compare and then open the Compare tab to enable easy comparison between all 3.

Answer the following question:

4A: All the lava from theses eruptions flowed into the Valle del Bove.

4B: Lava from the 26/12/2018 eruption flowed more than 6 km in distance from the vent.
4C: The volcanic eruption of 26/12/2018 produced lava flowing from a lateral eruptive fissure.
4D: Of all the eruptions seen, the lava flow of the paroxysm of 28/02/2021 appears to be the most worrying for the population.

Once cooled, the lava of the volcano appears dark on the satellite image. Samples collected in the field reveal a particular rock.



Chemical analysis of the sample : amount of SiO_2 in the bulk rock : 45% to 50%

Petrology observation with microscope: glassy matrix and microliths (*tiny crystals only visible in thin section*) with a lot of vesicles



Question 5: [Only one answer is correct] (1 pt) How would you characterize the lava of Etna?

5A: Rock with a aphanitic texture (no grains visible to the naked eye other than phenocrysts), rich in plagioclase and pyroxene, derived from a very fluid lava.

5B: Rock with a phaneritic texture (all grains visible to the naked eye) composed of plagioclase and pyroxene, and a lot of vesicles

5C: Rock with aphanitic texture (no grains visible to the naked eye other than phenocrysts) rich in feldspars, quartz, micas, derived from very viscous lava.

5D: Rock with a lot of vesicles, and without any mineral visible under the microscope

Question 6: [Only one answer is correct] (1 pt)

What is the best hypothesis on the identity of the rock thus formed? The rocks of Etna belong to the family of:

6A : rhyolites 6B : diorites 6C : andesites 6D : basalts

Question 7: [Only one answer is correct] (1 pt)

Every time a volcano erupts, magma can flow out of the mountain at various points. In what situations is the lava flow a real danger to people and infrastructure?

7A : A lava flow outside the Bove valley from a lateral fissure

- 7B : A lava flow inside the Bove valley
- 7C : A Lava flow from a more siliceous magma
- 7D : A strong wind coming from the west

Let us now turn our attention to the ash plume!

You need a break ? ... enjoy watching this video that introduces you to the next section. <u>https://youtu.be/InEQKf4O-Vs</u>

Question 8: [Only one answer is correct] (1 pt)

In which direction did the ash plume disperse into the atmosphere on 28 February 2021?

Do not hesitate to zoom out your satellite image

8A : North 10° 8B : East 90° 8C : South East 110° 8D : South 180°

Question 9: [Only one answer is correct] (1 pt)

Comparing* the images taken by Sentinel-2 over the period 26 February 2021 to 3 March 2021, which is the most appropriate answer?

*For each date, choose a satellite image to use (Visualize), then add the image to compare and then open the Compare tab to enable easy comparison between all 3.

9A: The plume has changed direction

- 9B: The plume is still dispersing ash towards the cities on the eastern slope
- 9C: There was only an ash plume on 28 February
- 9D: The plume forms a column of ash that only rises vertically

Sentinel is a family of satellites. Sentinel-5 is a satellite that provides atmospheric measurements to be used for air quality, ozone monitoring, UV radiation, and climate monitoring and forecasting. Spatial resolution: 7×3.5 km (that is, only details bigger than 7×3.5 km can be seen). Revisit time: Maximum 1 day to revisit the same area. Common usage: Monitoring the concentration of carbon monoxide (CO), nitrogen dioxide (NO₂) and ozone (O₃) in the air. Monitoring the UV aerosol index (AER_AI) and various geophysical parameters of clouds (Cloud).

Question 10: [More than one answer is correct] (2 pts)

Looking at Sentinel-5 images, what elements appear to be present in the high-altitude ash plume of 28 February?

Do not hesitate to zoom out your satellite image

10 A : SO₂ 10 B : O₃ 10 C : CH₄ 10 D : aerosols

Question 11: [Only one answer is correct] (1 pt)

In the days following 28 February, in which countries could we expect to see the most ash from the volcano in the atmosphere:

11 A: Greece and Turkey11 B: Tunisia and North Africa11 C: Northern Italy and Europe11 D: Malta (Valetta) and Libya

In CATANIA TODAY (Sicilian newspaper): The wind carries with it all the fine and light material that is thrown up by the craters, transporting it hundreds of kilometres away. The paroxysm of this Sunday 28 February caused a huge ash fall on the eastern side of Etna, between Giarre and Acireale ...

You should watch the video 'Ash rain at Zafferana (Sicily, Etna)'. <u>https://youtu.be/5LaCQT_ph_Q</u>

The measurement of particles in the atmosphere is made possible with a photometer. This sensor, pointed at the sun, can investigate the particles present in the atmosphere using two parameters: the AOD (Atmospheric Optical Depth) and the ALPHA (Angström exponent)*. *Alpha is inversely correlated with particle size.

Each measurement can therefore be interpreted using the diagram below, which indicates the nature and size of the particles likely to be present in the atmosphere.



A series of measurements were made with a photometer from Bronté city (on the west slope of Etna), with the photometer pointing towards Etna Summit, at sunrise for 20 minutes.



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Date	UTC	T °c	elevation (°)	AOD 465(blue)	alpha
2019-10-12	06:00:03	18	09.5	0,4567	0,63
2019-10-12	06:00:45	18	09.6	0,6058	1,15
2019-10-12	06:01:06	18	09.7	0,5485	1,19
2019-10-12	06:01:33	18	09.8	0,4943	1,15
2019-10-12	06:02:09	18	09.9	0,4812	1,33
2019-10-12	06:03:24	18	10.1	0,4407	1,03
2019-10-12	06:04:10	18	10.2	0,5284	0,95
2019-10-12	06:05:15	18	10.5	0,449	1,1
2019-10-12	06:05:54	18	10.6	0,4564	1,16
2019-10-12	06:07:16	18	10.8	0,4289	0,89
2019-10-12	06:08:14	18	11.0	0,4355	1,08
2019-10-12	06:09:14	18	11.2	0,4278	0,91
2019-10-12	06:10:14	18	11.4	0,4234	0,91
2019-10-12	06:11:18	18	11.6	0,4262	0,88
2019-10-12	06:13:54	19	12.1	0,428	0,96
2019-10-12	06:17:46	19	12.8	0,4407	0,92
2019-10-12	06:21:12	19	13.4	0,4344	0,94
2019-10-12	06:23:46	19	13.9	0,451	0,95

Question 12: [More than one answer is correct] (2 pts) Which are the most correct answers?

12A : Some of the volcanic ash is a big particle (> 10 μ m)

12B : Most of the volcanic ash is a particle of the order of 2,5 μm

12C : The ash consists exclusively of fine lava fragments

12D : A mask (anti-covid FFP2) with a mesh size of 0.1 μm is effective in protecting the lungs from ash

Dataset

Questions 13: [Only one answer is correct] (1 pt)

Once ash falls to the ground, it solidifies over time and turns into rock. What rock can be produced by the deposit and the consolidation the volcanic ash?

13A: A sandstone13B: A tuff13C: An oolitic limestone13D: A volcanic bomb

Ash and lava are therefore material resulting from the magma produced by the volcano. A volcano produces a lot of magma, often accumulated several years before in magma chambers.

Part 2 : STUDY the eruption from ground motion at different scales

Let's take a look at the tracking of ground movement recorded by GPS!

GPS sensors (GNSS network) track the ground movement on Etna. By measuring the speed of movement of the different beacons we can follow the evolution of the magma chambers of the volcano.

Access to GPS data of Etna: times series of some sensors https://edumedobs.maps.arcgis.com/apps/dashboards/47d44dbc36af457c9df4f4e6d85527e3

Question 14: [Only one answer is correct] (2 pts)

The comparative speeds of the beacons in horizontal movement (longitude and latitude) and in vertical movement show one of these 4 situations.

You can study only some of the sensors : <u>For example</u> > EDAM, ECRI, ECPN, EMGL, EPED, EMFN

Center and zoom in on the beacon you want to study, and the diagram of the GPS movement will appear on the left window.

Comparing the state of Etna on the 13/2 and the 25/3, which graph best represents the changes that occured.

RED : horizontal movement (Latitude/Longitude) - BLUE : Vertical movement





Question 15: [More than one answer is correct] (2 pts)

By examining the evolution of the beacons <u>between 13 February and 25 March</u>, choose the correct conclusions:

15A : Data from beacons, close to the summit, show inflation of the volcano magma chambers 15B : Due to the successive eruptions, the volcano shows deflation

15C : The vertical movement of the beacons at the top of the volcano is of the order of 35 mm

15D : All the beacons on the volcano show the same speed of vertical movement

The deformations observed lead us to imagine that the region regularly records local earthquakes, particularly during eruptive phases. The seismometers installed around Etna bear witness to this.

Let's look at the ground motion recorded by seismometers!

There are several distinct seismic signals recorded by seismometers:

- Telluric vibrations caused by the propagation of seismic waves following a rupture of the lithosphere. These can be local (Sicily), regional (Mediterranean basin) or distant (high magnitude faraway events) earthquakes

- Other signals correspond to the vibrations of the walls of volcanic chimneys when the magma under pressure is in motion. These signals are called volcanic tremors and are clearly visible on stations close to the volcano (on the slopes of the volcano).

Access to data:

http://edumed.unice.fr/ieso2021/seismo/ > tab : 'dayplots'*

*Dayplot explanation : The figure below is an example of ground vibrations recorded by a seismological station. This image is called a dayplot. The Y axis is composed of 24 lines corresponding to each hour of the day. On each line corresponding to an hour, the ordinate corresponds to vertical ground motion speeds. On the X axis, the values indicate the number of minutes of recording for each line. The alternating blue and red colours make the graph easier to read.



This database archives the signals recorded on seismometers in the Mediterranean basin. We propose to work on three stations: BRO1 (Bronté, a town northwest of the volcano), RAN1 (Randazzo, a town on the northern slopes of the volcano) and CEL (Celeste, a town in Calabria, 100 km faraway from Etna).



Location of the 3 seismic stations (BRO, RAN, CEL)

Make a request to find the dayplot for the seismic event in three seismometers (BRO1/Bronte, RAN1/Randazzo and CEL/Celeste): > Past dayplots, choose the stations, select the date (from 26/02/2021 to 21/03/2021).

Question 16: [Only one answer is correct] (1 pt)

Discover the ground motion recorded (dayplot) at these three stations from 26 February to 21 March 2021. By comparison, identify the signals described as 'volcanic tremors' which indicate the movement of magma towards the surface. Be aware that the sensors also record other types of terrestrial vibrations.

Choose the correct answer:

16A: Only one eruption occurred, on 28 February 2021

- 16B: The sensors recorded one eruption per day during this period
- 16C : The volcanic activity was marked by about ten eruptions (paroxysms)
- 16D : The strongest volcanic tremor was recorded on 3 March

On the dayplots, during this period, we also note signals relating to telluric tremors, either very short (i.e. local earthquakes) or longer (i.e. remote earthquakes)

Let's look at the local seismicity recorded between 19 and 22 March 2021.

Access to data:

http://edumed.unice.fr/ieso2021/seismo/ > Use the search engine 'Seismicity'

Make a request for a list of local earthquakes that occurred in Sicily between 19 and 22
 March 2021. Select the Sicily area, select the date, choose all the magnitude and depths.

After you refocus your Tectoglob3D on the study area, you can get a better resolution for your image with this button.

Question 17: [More than one answer is correct] (2 pts) Which statements are correct?

17A: About 30 local earthquakes in Sicily have been recorded

- 17B: The strongest of them does not exceed a magnitude of 3
- 17C: The majority of these earthquakes are all very shallow (less than 15 km deep)

17D: The major (highest magnitude) earthquake occurred on 19 March 2021

Let's look at the location of this seismicity in relation to the volcano Etna. Download the result of your query with the Tectoglob3D software (you may have to refresh the query on your computer).

Click the Display with Tectoglob 3D button. Adjust your view of the map to show Sicily.

Question 18: [Only one answer is correct] (1 pt) Which statements are correct?

18A: Seismicity is uniformly distributed on the island of Sicily18B: Most earthquakes are concentrated on the volcano18C: Most earthquakes are located at sea

18D: All earthquakes have the same location

Let's take a look at one of the earthquakes studied, that of 21 March, which occurred at 9h22m01s (UTC Time).

Access to data: <u>http://edumed.unice.fr/ieso2021/seismo/</u> > tab 'seismograms'

 Download <u>on your computer</u> the seismograms of this seismic event (zip file), recorded by the seismometers installed in Sicily.

Back to Tectoglob3D and import the downloaded zip file > File > Import > Import seismogram(s) (.sac, .zip)

Refocus your Tectoglob3D globe on Sicily. You will see the recording stations (in white), and the epicentres of the earthquakes (previous request) for the period from 19 to 22 March 2021.

Now, on the virtual globe of Tectoglob3D, you can see the recording stations (in white), and the epicentres of the earthquakes (blue stars) for the period from 19 to 22 March 2021.



Using the software, locate the epicentre of the 21 March earthquake. You have to analyse the time arrival of the seismic waves for some stations and determine the area of the epicentre.

For each seismic station, double-click on the name of the station **in the output window**. A circle will appear, indicating the distance to the epicentre from that station.

Question 19: [Only one answer is correct] (1 pt)

19A: Epicentre occurred at point 1

19B: Epicentre occurred at point 2

19C: Epicentre occurred at point 3

19D: Epicentre occurred at point 4

By analysing the seismogram recorded at EVRN station (located in the town of Santa Venerina), find out how long it took for the first seismic wave train to reach the station from its focus.

Display the earthquake event origin time (T0) on your seismograms using Seismograms >
 Display event T0, and evaluate the arrival time of the first seismic waves.

Question 20: [More than one answer is correct] (2 pts)

The velocity of seismic waves in the globe depends on various parameters such as density and temperature of the areas crossed by the waves. A velocity model called PREM model (Preliminary Reference Earth Model) makes it possible to consider the velocity of the waves as a function of the waves passing through the Earth. This model is only valid on a large scale and does not take into account regional geological particularities.

Using Tectoglob3D, from the analysis of the seismograms, and the PREM model , which statements are correct?

20A: The seismic waves propagated with a speed of about 2.5 km/s, a slow speed for seismic waves.

20B: The waves arrived at the station very quickly with a speed of 5 km/s, a speed consistent with the continental crust and the PREM model.

20C: The waves arrived at the station very quickly, they have crossed the Earth's mantle because the focus of the epicentre was deep.

20D : The volcano's structure hosts a lot of magma and interstitial fluids, which explains the slow progression of seismic waves.

Question 21: [upload your screenshot] (3 pts)

Finally, make a screenshot of your work. Make sure it shows the virtual globe, the epicenter location indicated by circles, the local seismicity, and the seismograms recorded. Upload your work on the answer sheet : screenshot (.jpg file)

To conclude:

Question 22: [More than one answer is correct] (2 pts)

The presence of a volcano like Etna is a source of natural risk for the population living around it. According to your study, indicate the events that can directly impact the population.

22A : Lava flow in Bove valley like on 28 February 2021

22B : Ash plume dispersion like on 28 February 2021

22C : Very low altitude lava flow outside the Bove Valley

22D : An earthquake similar to 21 March 2021